FISHERY ECOSYSTEM PLAN
OF THE SOUTH ATLANTIC REGION

April 2009

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THIS IS A PUBLICATION OF THE SOUTH ATLANTIC FISHERY MANAGEMENT COUNCIL PURSUANT TO National Oceanic and Atmospheric Administration Award No. FNA05NMF4410004

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ABBREVIATIONS AND ACRONYMS

ABC	Acceptable Biological Catch
ACCSP	Atlantic Coastal Cooperative Statistics Program
ACE	Ashepoo-Combahee-Edisto Basin National Estuarine Research Reserve
APA	Administrative Procedures Act
AUV	Autonomous Underwater Vehicle
B	A measure of stock biomass either in weight or other appropriate unit
B_{MSY}	The stock biomass expected to exist under equilibrium conditions when fishing at F_{MSY}
B_{OY}	The stock biomass expected to exist under equilibrium conditions when fishing at F_{OY}
B_{CURR}	The current stock biomass
CEA	Cumulative Effects Analysis
CEQ	Council on Environmental Quality
CFMC	Caribbean Fishery Management Council
CPUE	Catch per unit effort
CRP	Cooperative Research Program
CZMA	Coastal Zone Management Act
DEIS	Draft Environmental Impact Statement
EA	Environmental Assessment
EBM	Ecosystem-Based Management
EEZ	Exclusive Economic Zone
EFH	Essential Fish Habitat
EFH-HAPC	Essential Fish Habitat - Habitat Area of Particular Concern
EIS	Environmental Impact Statement
EPAP	Ecosystem Principles Advisory Panel
ESA	Endangered Species Act of 1973
F	A measure of the instantaneous rate of fishing mortality
$F_{30\%SPR}$	Fishing mortality that will produce a static SPR = 30%.
$F_{45\%SPR}$	Fishing mortality that will produce a static SPR = 45%.
F_{CURR}	The current instantaneous rate of fishing mortality
FMP	Fishery Management Plan
F_{MSY}	The rate of fishing mortality expected to achieve MSY under equilibrium conditions and a corresponding biomass of B_{MSY}
F_{OY}	The rate of fishing mortality expected to achieve OY under equilibrium conditions and a corresponding biomass of B_{OY}
FEIS	Final Environmental Impact Statement
FMU	Fishery Management Unit
FONSI	Finding Of No Significant Impact
GOOS	Global Ocean Observing System
GFMC	Gulf of Mexico Fishery Management Council
IFQ	Individual fishing quota
IMS	Internet Mapping Server
IOOS	Integrated Ocean Observing System
M	Natural mortality rate
MARMAP	Marine Resources Monitoring Assessment and Prediction Program

MARFIN	Marine Fisheries Initiative
MBTA	Migratory Bird Treaty Act
MFMT	Maximum Fishing Mortality Threshold
MMPA	Marine Mammal Protection Act of 1973
MRFSS	Marine Recreational Fisheries Statistics Survey
MSA	Magnuson-Stevens Act
MSST	Minimum Stock Size Threshold
MSY	Maximum Sustainable Yield
NEPA	National Environmental Policy Act of 1969
NMFS	National Marine Fisheries Service
NMSA	National Marine Sanctuary Act
NOAA	National Oceanic and Atmospheric Administration
NRC	National Research Council
OY	Optimum Yield
POC	Pew Oceans Commission
R	Recruitment
RFA	Regulatory Flexibility Act
RIR	Regulatory Impact Review
SAFE	Stock Assessment and Fishery Evaluation Report
SAFMC	South Atlantic Fishery Management Council
SEDAR	Southeast Data, Assessment, and Review
SEFSC	Southeast Fisheries Science Center
SERO	Southeast Regional Office
SDDP	Supplementary Discard Data Program
SFA	Sustainable Fisheries Act
SIA	Social Impact Assessment
SSC	Scientific and Statistical Committee
TAC	Total allowable catch
T_{MIN}	The length of time in which a stock could rebuild to B_{MSY} in the absence of fishing mortality
USCG	U.S. Coast Guard
USCOP	U.S. Commission on Ocean Policy
VMS	Vessel Monitoring System

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Introduction

1.0 Background Supporting Move to Ecosystem Based Management

Moving to Ecosystem-Based Management

Development of a South Atlantic Council Fishery Ecosystem Plan (FEP) provides a significant opportunity to review biological, ecological, social, and economic information for fisheries in the South Atlantic ecosystem. The Council views habitat conservation as the core of its move to ecosystem based management (EBM). The FEP significantly expands and updates the SAFMC Habitat Plan (SAFMC 1998) by providing comprehensive details on all managed species (SAFMC, South Atlantic States, ASMFC, and NOAA Fisheries Highly Migratory Species and Protected Species), including their biology, ecology, and food web dynamics and the economic and social characteristics of the fisheries. The FEP also updates the information for designating Essential Fish Habitat (EFH) and EFH-Habitat Areas of Particular Concern (HAPC). In addition, it summarizes existing research programs and identifies biological, social, and economic research needed to fully address EBM in the region. The FEP will serve as a source document that will, over time, present more detailed information describing the South Atlantic ecosystem and the impact of the fisheries on the environment. As a living document (primarily through expansions to Volume IV Threats and Recommendations), the FEP will provide a greater degree of guidance on incorporation of fishery, habitat, or ecosystem considerations into management actions, such as bycatch reduction, prey-predator interactions, maintenance of biodiversity, and identification of spatial management needs.

Evolving from a Habitat Network to an Ecosystem Network

Starting with its Habitat and Environmental Protection Advisory Panel, the Council fostered a network of stakeholders to develop the SAFMC Habitat Plan, which was completed in 1998 to support the EFH rule. The Council further expanded this network to support development of the FEP and Comprehensive Ecosystem-Based Amendment (CE-BA) 1 and their coordination with other regional efforts. The Council has worked with the Southeast Coastal Regional Ocean Observing Association (SECOORA) to guide identification of priority needs for observation and modeling to support fisheries oceanography and integration of the stock assessment process through the Southeast Data and Assessment Review (SEDAR). The Council is a member of the Southeast Aquatic Resource Partnership (SARP), and its Southeast Aquatic Habitat Plan (SARP 2008) provides watershed conservation restoration targets for the FEP and several habitat, water quality, and water quantity conservation needs identified in the FEP are directly addressed on the ground by projects supported through SARP. These cooperative efforts contribute to fish habitat restoration and conservation efforts needed to increase the viability of fish populations and fishing opportunities, including efforts to protect and conserve EFH. Lastly, the Council has cooperated with South Atlantic states in the formation of a South Atlantic Governors' Alliance, which will provide additional guidance and resources for efforts by the states and Council to achieve broad habitat and ecosystem conservation goals.

Building Tools to Support EBM in the South Atlantic Region

To support EBM in the South Atlantic Region, the Council added a Habitat and Ecosystem section to its website http://www.safmc.net/ecosystem/Home/EcosystemHome/tabid/435/Default.aspx and, in cooperation with the Florida Wildlife Research Institute (FWRI), developed a Habitat and Ecosystem Internet Map Server (IMS) http://www.safmc.net/EcosystemManagement/EcosystemBoundaries/MappingandGISData/tabid/62/Default.aspx. Many groups contributed to the IMS, including NOAA Fisheries Service, state and local management authorities, universities, conservation organizations, and recreational and commercial fishers. Further development of ecosystem information systems to support Council management should build on existing tools (e.g., Ecosystem IMS) and provide funding to the Council and other regional cooperating partners to address long-term Council needs.

Implementing EBM

The Council has implemented ecosystem-based principles through existing fishery management actions including establishment of deepwater Marine Protected Areas for the Snapper Grouper fishery, proactive harvest control rules on species not overfished (e.g., dolphin and wahoo), extensive gear/area closures that in most cases eliminate the impact of fishing gear on EFH, and Special Management Zones. Through CE-BA 1, the Council is taking an ecosystem approach to protect deepwater ecosystems while providing for traditional fisheries for golden crab and royal red shrimp in areas where they do not impact deepwater coral habitat. The Council's stakeholder-based process taps an extensive network of scientific, management, and fishery professionals within the region, and the Council has invested significantly in tools to maintain this engagement over the long term.

Ecosystem Approach to Deepwater Ecosystem Management

The Council manages coral, coral reefs, and live/hard bottom habitat, including deepwater corals, through the Fishery Management Plan for Coral, Coral Reefs and Live/Hard Bottom Habitat of the South Atlantic Region (Coral FMP). Mechanisms exist in the FMP, as amended, to further protect deepwater coral and live/hard bottom habitats. The Council's Habitat and Environmental Protection Advisory Panel and Coral Advisory Panel have supported proactive efforts to identify and protect deepwater coral ecosystems in the South Atlantic region. Management actions proposed in CE-BA 1 include the establishment of deepwater coral HAPCs (C-HAPCs) to protect over 23,000 square miles of habitat that is thought to be the largest continuous distribution of pristine deepwater coral ecosystems in the world.

Scope of FEP Development
While the FEP will support and guide EBM, most of the Council's implementation steps will be through CE-BAs. This approach will build on the biological, economic, and social information presented in the FEP, and provide the Council with the opportunity to evaluate needed actions across multiple fisheries and facilitate development of FMP amendments or measures that apply across FMPs. The Council has proposed updating the FEP every five years.

Future Challenges and Needed Resources to Fully Implement EBM in the Region
One of the greatest challenges to the long-term move to EBM is funding high priority research, including comprehensive benthic mapping, ecosystem modeling, and management tool development. In addition, collecting detailed information on fishing fleet dynamics, including defining fishing operation areas by species, species complex, and season, as well as catch relative to habitat, is critical for assessment of fishery, community, and habitat impacts and for use of place-based management measures. Additional resources need to be dedicated to expand coordination of modeling, mapping, and characterizing habitat use and to fully fund regional fishery independent surveys (e.g., MARMAP and SEAMAP). One high-priority need is completion of the mapping of near-shore, mid-shelf, shelf edge, and deepwater habitats in the South Atlantic region.

The combined FEP and CE-BA development process complements, but does not replace, existing FMPs. The FEP serves as an evolving source document that, in combination with the development of future CE-BAs, consider individual management needs as well as needs across fisheries in the South Atlantic Region. It is anticipated that in the development of future FEPs, the Council will draw on Stock Assessment and Fishery Evaluation (SAFE) reports, which NMFS is required to provide the Council for all FMPs implemented under the Magnuson-Stevens Act. The FEP, serving as the source document for CE-BAs, could also meet NMFS SAFE requirements if information is provided to the Council to update necessary sections.

Guiding Principles and Recommendations
In closing this section of the FEP, the Council notes the U.S. Commission on Ocean Policy and the Pew Oceans Commission describe EBM as a process that allows ocean and coastal resources to be managed to reflect the relationships among all ecosystem components, including humans (USCOP 2004). Using the Commission's guiding principles for EBM, the Council notes the following efforts to implement those guidelines:

Guiding principles for EBM

- Sustainability – the Council's goal is to conserve and manage South Atlantic fishery resources. In addition, the Council provides for the long-term conservation of benthic and pelagic habitats and has reduced or eliminated the impact of fishing activities on EFH
- Stewardship – the Council strives to balance different uses of fishery resources in the South Atlantic EEZ

- Ocean-Land-Atmosphere Connections – the Council actively engages partnerships that aim to characterize ocean-land connections (e.g., Ocean Observing Systems) in order to integrate findings into management
- Ecosystem-Based Management – the Council has been working with partners since 2002 to develop the FEP and CE-BA
- Multiple Use Management – the Council uses diverse management strategies to ensure sustainability of regional resources
- Preservation of Marine Biodiversity – examples of actions include EFH, EFH-HAPCs, Oculina Bank HAPC, Oculina Experimental Closed Area, proposed deepwater coral HAPCs, MPAs, and Special Management Zones
- Best Available Science and Information – the Council is directed to use best available science and stock assessments developed through SEDAR. In addition, guidance is provided by the Council's Scientific and Statistical Committee (SSC) and Species and Technical Advisory Panels
- Participatory Governance – the Council relies on its Habitat, Coral, and many other Advisory Panels whose members represent all stakeholders; scoping meetings, public hearings, workshops, and Council meetings provide the public numerous opportunities to participate in the process

Specific recommendations on EBM

- Develop Regional Ecosystem Assessments – the Council's FEP consolidates best available scientific information on the South Atlantic ecosystem into a single document that will be updated periodically
- Employ Marine Protected Areas as a Management Tool – the Council has undertaken an extensive process to design and implement MPAs under its Snapper Grouper FMP; Amendment 14 established a network of MPAs
- Improve Habitat Conservation and Restoration – the Council emphasizes the conservation of habitat through several FMPs (e.g., direct gear prohibitions, EFH, and EFH-HAPCs) and through habitat policies and commenting on projects that impact EFH and EFH-HAPCs
- Develop Prioritized Management Information Needs – the FEP contains Research and Monitoring Plans for the Oculina Closed Area and Deepwater Coral Ecosystems as well as identifying fish, habitat, and human information needs in the South Atlantic region
- Enhance Data Needs for Recreational Fisheries – the Council is evaluating requiring permits for all commercial and recreational fishermen to fish for, harvest, or possess any resource in the EEZ
- Enhance Cooperative Research – the Council is directly involved in the cooperative research program in the South Atlantic and is pushing to fill our data gaps
- Establish Dedicated Access Privileges – the Council employs this approach to manage wreckfish in the EEZ and is evaluating implementing a Limited Access Privilege Program (LAPP) for the golden tilefish fishery
- Maximize the Use of VMS for Fishery-Related Activities – the Council requires VMS on rock shrimp vesselsand will evaluate the need to require VMS on other fishing vessels in future amendments

- Expand EFH designations – the Council is exploring available analytical methods to refine and expand EFH designations and will address the possible designation of new EFH-HAPCs as has been proposed by the Habitat Advisory Panel through CE-BA 2
- Address Environmental Impacts of Aquaculture – the Council approved a Policy Statement on Marine Aquaculture developed through its Habitat Advisory Panel
- Address Environmental Impacts of Offshore Oil and Gas Production – the Council updated its policy on energy development and transportation (and offshore renewable energy development) with advice from its Habitat and Coral Advisory Panels
- Regulate Destructive Fishing Gear – the Council already has regulations in place to protect habitat from destructive fishing gear:prohibition on use of all fish traps, black sea bass pots south of Cape Canaveral Florida, roller-rig trawls, and entanglement nets in the snapper grouper fishery; prohibition on use of longlines shallower than 50 fathoms; and prohibition of bottom longlines in the wreckfish fishery. The Council intends to further protect habitat from damaging gear by prohibiting the use of bottom trawls, mid-water trawls, bottom longlines, fish traps and pots, and anchors chains and grapples in deepwater CHAPCs
- Reduce Bycatch – the Council strongly supports the continued implementation of ACCSP to have better bycatch data to inform management decisions; bycatch reduction devices (BRDs) are required in penaeid and rock shrimp fisheries; use of fish traps, trawls and entanglement nets is prohibited in the snapper grouper fishery; use of drift gill nets is prohibited in the coastal migratory pelagic fishery; and use of bottom longlines is prohibited inshore of 50 fathoms and retention of anything but deepwater snapper grouper species when using the gear
- Improve the Management of U.S. Coral Resources – the Council protects coral, coral reefs, and live/hard bottom habitat in the South Atlantic EEZ through harvest and gear restrictions in the Coral and Snapper Grouper FMPs and Amendments. All coral harvest is prohibited except allowable octocorals (small quota) and aquacultured live rock. The Council is now proposing designation of deepwater Coral HAPCs to protect vulnerable deepwater coral communities
- Commit to Creation of the IOOS – the Council, as a member of the SECOORA Steering Committee and recently elected member of the Board of Directors, is facilitating expanding the observing system's ability to meet fishery oceanography monitoring and assessment needs that will support an ecosystem approach to the management of fishery resources in the South Atlantic
- Enhance Data and Information Management – the Council has developed, in cooperation with the Florida Fish and Wildlife Conservation Commission, a Habitat and Ecosystem Internet Mapping Server and Section of the Council's website to support the move to ecosystem management and disseminate data and information to a broad user body

1.1 Habitat protection and ecosystem management responsibilities as defined in the Magnuson-Stevens Act

Essential Fish Habitat and Essential Fish Habitat Areas of Particular Concern
The Magnuson-Stevens Act defines EFH as "all waters and substrates necessary to fish for spawning, breeding, feeding or growth to maturity." Regional Fishery Management Councils are directed to describe and identify EFH for each federally managed species, attempt to minimize the extent of adverse effects on habitat caused by fishing and non-fishing activities, and identify actions to encourage conservation and enhancement of those habitats. It is required that EFH be based on the best available scientific information. EFH may include habitat for an individual species or an assemblage of species, whichever is appropriate within each FMP. "Waters" includes aquatic areas and their associated physical, chemical, and biological properties that are utilized by fish; when appropriate, "waters" includes areas used historically. Water quality includes turbidity and concentrations of nutrients and dissolved oxygen. Examples of "waters" that may be considered EFH, include open waters, wetlands, estuarine habitats, riverine habitats, and wetlands hydrologically connected to productive water bodies.

"Necessary" means the habitat required to support a sustainable fishery and a healthy ecosystem, while "spawning, breeding, feeding, or growth to maturity" covers the full life cycle of a species. "Substrate" includes sediment, hard bottom, structures underlying the waters, and associated biological communities. These communities could encompass mangroves, tidal marshes, mussel beds, cobble with attached fauna, mud and clay burrows, coral reefs, and submerged aquatic vegetation. Migratory routes, such as rivers and passes serving as passageways to and from anadromous fish spawning grounds, should also be considered EFH. If appropriate, "substrate" may include artificial reefs, shipwrecks, and partially or entirely submerged structures, such as jetties. The Councils also must identify EFH-HAPCs, which are to be subsets of EFH and be based on ecological function, sensitivity to human-induced environmental degradation, likelihood of development activities stressing the habitat type, or rarity.

Habitat Responsibilities as Defined in the Magnuson-Stevens Fishery Conservation and Management Act
The Magnuson-Stevens Act provides the Secretary of Commerce and Fishery Management Councils with authority and responsibility to protect EFH. Section 305 (b) Fish Habitat, directed the Secretary (through NOAA Fisheries Service) to establish by regulation guidelines to assist the Councils in the description and identification of EFH in fishery management plans (including adverse impacts on such habitat). In addition, the Secretary (through NOAA Fisheries Service) was directed to set forth a schedule for the amendment of fishery management plans to include the identification of EFH and for the review and updating of such identifications based on new scientific evidence or other relevant information. Lastly, the Magnuson-Stevens Act directed the Secretary to coordinate with and provide information to other federal agencies to further the conservation and enhancement of EFH. The Magnuson-Stevens Act specifies that each federal agency shall consult with the Secretary with respect to any action authorized,

funded, or undertaken, or proposed to be authorized, funded, or undertaken, by such agency that may adversely affect EFH. Additional provisions specify that each Council:

1. May comment on and make recommendations to the Secretary and any Federal or State agency concerning any activity authorized, funded, or undertaken, or proposed to be authorized, funded, or undertaken, by any Federal or State agency that, in the view of the Council, may affect the habitat, including essential fish habitat, of a fishery resource under its authority.
2. Shall comment on and make recommendations to the Secretary and any Federal or State agency concerning any such activity that, in the view of the Council, is likely to substantially affect the habitat, including essential fish habitat, of an anadromous fishery resource under its authority.

If the Secretary receives information from a Council or federal or state agency or determines from other sources that an action authorized, funded, or undertaken, or proposed to be authorized, funded, or undertaken, by any state or federal agency would adversely affect EFH, the Secretary shall recommend agency measures that can be taken to conserve such habitat. Within 30 days after receiving a recommendation, a federal agency shall provide a detailed response in writing to any Council commenting and the Secretary regarding the matter. The response shall include a description of measures proposed by the agency for avoiding, mitigating, or offsetting the impact of the activity on such habitat. In the case of a response that is inconsistent with the recommendations of the Secretary, the federal agency shall explain its reasons for not following the recommendations. The Council's current process for reviewing and commenting on projects is described in the Appendix A of the Council's Habitat Plan (SAFMC 1998).

On January 17, 2002, the final rule was published in the Federal Register to implement the EFH provisions of the Magnuson-Stevens Act; the effective date of the rule was February 19, 2002. This rule supersedes the interim final rule published on December 19, 1997. The final rule establishes guidelines to assist the Regional Fishery Management Councils and the Secretary of Commerce in the description and identification of EFH in FMPs, including identification of adverse impacts from both fishing and non-fishing activities on EFH and identification of actions required to conserve and enhance EFH. The final rule provided procedures for consultation, coordination, and recommendations on permit activities and guidelines for EFH information in FMPs. The final rule also provided clearer guidelines for prioritizing and analyzing habitat effects for managed species and allows informed decisions based on similar species and other life stages.

The FEP updates EFH information in the Council's Habitat Plan (SAFMC 1998) and refines information on habitat requirements (by life stage where information exists) for species managed by the Council. To develop this information, the Council worked with its Habitat and Coral Advisory Panels, and through a series of workshops, identified available environmental and fisheries data relevant to describing and identifying EFH. In addition, the EFH workshops tapped habitat experts at the state, federal, and regional levels. In assessing the relative value of habitats, the Council is taking a risk-averse approach. This approach will ensure that adequate areas are protected as EFH in the

South Atlantic. Habitat loss and degradation may be contributing to species being identified as overfished; therefore, all habitats used by these species are considered essential.

The distribution and geographic limits of EFH is described and where information exists presented by life history stage in maps that are part of the Council's online Habitat and Ecosystem IMS http://ocean.floridamarine.org/efh_coral/ims/viewer.htm. Maps developed to date by Council staff, Florida Marine Research Institute, NOAA Fisheries Service Southeast Fisheries Science Center, North Carolina DENR, and South Carolina DNR encompass appropriate temporal and spatial variability in presenting the distribution of EFH. Where information exists, seasonal changes are represented.

The Council's Habitat Plan (SAFMC 1998) and Volume IV of this FEP present information on adverse effects from fishing and describe management measures the Council has implemented to minimize adverse effects on EFH from fishing. Conservation and enhancement measures implemented by the Council may include ones that eliminate or minimize physical, chemical, or biological alterations of the substrate, and loss of, or injury to, benthic organisms, prey species, and other components of the ecosystem. The Council has implemented restrictions on fisheries to the extent that no significant activities were identified in the review of gear impact conducted for the NOAA Fisheries Service by Auster and Langton (1998), which presented available information on adverse effects of all fishing equipment types used in waters described as EFH. The Council has already prevented, mitigated, or minimized most adverse effects from most fisheries prosecuted within the South Atlantic exclusive economic zone (EEZ).

The Council has considered evidence that some fishing practices may have an identifiable adverse effect on habitat, and the Council is addressing those pertaining to deepwater coral ecosystems in CE-BA 1. The Council, as indicated in the previous section, already uses many options recommended in the guidelines for directly or indirectly managing adverse effects from fishing including: fishing equipment restrictions; seasonal and areal restrictions on the use of specified equipment (e.g., time/are closure); equipment modifications to allow the escape of particular species or particular life stages (e.g., juveniles); prohibitions on the use of explosives and chemicals; prohibitions on anchoring or setting equipment in sensitive areas; prohibitions on fishing activities that cause significant physical damage in EFH; time/area closures including closing areas to all fishing or specific equipment types during spawning, migration, foraging, and nursery activities; designating zones for use as marine protected areas to limit adverse effects of fishing practices on certain vulnerable or rare areas/species/life history stages, such as those areas designated as habitat areas of particular concern; and harvest limits.

Volume IV of this FEP identifies non-fishing activities that have the potential to adversely affect EFH quantity or quality. Examples of these activities are dredging, filling, mining, impounding waters, diverting waters, thermal discharges, non-point source pollution and sedimentation, introduction of hazardous materials or exotic species, and modifying/converting aquatic habitat in ways that eliminate, diminish, or disrupt the functions of EFH. The FEP includes an analysis of how fishing and non-fishing activities influence habitat function on an ecosystem or watershed scale. An assessment of the cumulative and synergistic effects of multiple threats, including the effects of natural stresses (such as storm damage or climate-based environmental shifts), and an assessment of the ecological risks resulting from the impact of those threats on EFH is included. General conservation and enhancement recommendations are included in Volume IV of the FEP. These include enhancement of rivers, streams, and coastal areas; protection of water quality and quantity; minimization of the destruction/degradation of wetlands; restoration and maintenance of the ecological health of watersheds; and replacement of lost or degraded EFH.

1.2 Fishery Ecosystem Plan and Comprehensive Fishery Ecosystem Plan Amendment development process

A 1999 Congressionally-mandated report set the stage for subsequent federal efforts to implement EBM. In response to a Congressional request, the National Marine Fisheries Service (NMFS) convened a panel of experts to assess the extent to which ecosystem principles are currently applied in fisheries research and management, and recommend how best to integrate these principles into future activities. This Ecosystem Principles Advisory Panel (EPAP) concluded that NMFS and the regional Fishery Management Councils do apply some EBM principles, goals, and policies, but don't apply them comprehensively or evenly. They attributed this to the lack of a clear mandate and resources to carry out EBM, and the "considerable gaps in knowledge and practice" of this new concept. EPAP recommended that Councils continue to use Fishery Management Plans (FMPs) for single species and species complexes, but amend these to incorporate ecosystem approaches consistent with an overall Fishery Ecosystem Plan (FEP). The objectives of the FEP are:

- To provide Council members with a clear description and understanding of the physical, biological, and human/institutional context of ecosystems;
- Direct how that information should be used within FMPs; and
- Set policies by which management options would be developed and recommended.

EPAP outlined eight elements that should be included in each FEP and recommended that the Magnuson-Stevens Act be amended to require FEPs. It urged the development of an initial demonstration FEP as a model to facilitate rapid implementation of a full FEP when ultimately required under Magnuson-Stevens. It also called on NMFS and the Fishery Management Councils to establish guidelines for FEP development.

The Council developed the South Atlantic FEP with the long-term vision of embracing the 8 elements presented by the EPAP:

1. Delineate the geographic extent of the ecosytem(s) that occur(s) within Council authority, including characterization of the biological, chemical, and physical dynamics of those ecosystems, and "zone" the area for alternative uses. The Council's management jurisdiction and the core area of the South Atlantic Ecosystem is shown in Figure 1. Building on the scope of the Habitat Plan the area of consideration extends from the coastal watersheds including anadromous and catadromous species to off the continental shelf through the extent of the Councils' jurisdiction. However, the South Atlantic ecosystem is invariably linked to other systems and cooperation and collaboration to link research efforts and share management considerations will be pursued. Appendix B presents a table summary of managed areas developed by the Council.

2. Develop a conceptual model of the food web.

3. Describe the habitat needs of different life history stages for all plants and animals that represent the "significant food web" and how they are considered in conservation and management measures.

4. Calculate total removals – including incidental mortality – and show how they relate to standing biomass, production, optimum yields, natural mortality, and trophic structure.

5. Assess how uncertainty is characterized and what kind of buffers against uncertainty are included in conservation and management actions.

6. Develop indices of ecosystem health as targets for management.

7. Describe available long-term monitoring data and how they are used.

8. Assess the ecological, human, and institutional elements of the ecosystem which most significantly affect fisheries and are outside of Council/Department of Commerce authority, and include a strategy to address those influences.

The South Atlantic Fishery Management Council has developed the first regional FEP to serve as a source document of biological, economic, and social information for all FMPs and CE-BAs:

Fishery Ecosystem Plan for the South Atlantic Region (SAFMC 2009) volume structure:

FEP Volume I	Introduction and Overview
FEP Volume II	South Atlantic Habitats and Species
FEP Volume III	South Atlantic Human and Institutional Environment
FEP Volume IV	Threats to South Atlantic Ecosystem and Recommendations
FEP Volume V	South Atlantic Research Programs and Data Needs
FEP Volume VI	References and Appendices

Evolution of the Habitat Plan into the FEP and transition from single species management to ecosystem-based management will require a greater understanding of the South Atlantic Bight ecosystem and the complex relationships among humans, marine life, and EFH. Over 25 workshops were held to develop the FEP. These workshops brought together Habitat and Coral Advisory Panel members and a core group of resource and habitat experts from cooperating federal, state, and academic institutions as well as conservation organizations that participated directly in development of the Habitat Plan. Updated life history and stock status information on managed species and the characteristics of the food web they exist within will be incorporated as well as social and economic research needed to fully address ecosystem-based management. Topics of workshops included wetlands, oyster/shell habitat, seagrass, pelagic habitat (including *Sargassum* and the water column), coral and live/hard bottom, artificial reefs, GIS to support EFH and ecosystem-based management, water issues affecting fishery habitat and production, marine zoning, fishing impacts on habitat, food web modeling (Ecopath with Ecosim), and social and economic data needs. In addition, a regional workshop was held in November 2005 to identify research and monitoring needs to support ecosystem-based management in the South Atlantic. Nationally and internationally recognized experts participated and provided guidance to determine the most significant needs to be addressed in development of ecosystem-based management.

An outline for the FEP was developed and approved by the Council in June 2005. Writing Teams (composed of Advisory Panel members, experts from state and federal agencies, universities and Council staff) reviewed, updated, and expanded chapters of the Habitat Plan and developed new chapters for the FEP. Information compiled through this process will help the Council meet the mandate to update EFH and EFH-HAPC designations. This information will also help the Council meet the National Environmental Policy Act (NEPA) mandate to update Environmental Impact Statements (EIS) for all fishery management plans under Council jurisdiction.

EFH and EFH-HAPC Designations Translated to Cooperative Habitat Policy Development and Protection

The Council actively comments on non-fishing projects or policies that may impact fish habitat. Appendix A of the Comprehensive Amendment Addressing Essential Fish Habitat in Fishery Management Plans of the South Atlantic Region (SAFMC 1998b) outlines the Council's comment and policy development process and the establishment of a four-state Habitat Advisory Panel. Members of the Habitat Advisory Panel serve as the Council's habitat contacts and professionals in the field. Advisory Panel members bring projects to the Council's attention, draft comment letters, and attend public meetings. With guidance from the Advisory Panel, the Council has developed and approved policies on: energy exploration, development, transportation, and hydropower re-licensing; beach dredging and filling and large-scale coastal engineering; protection and enhancement of submerged aquatic vegetation; alterations to riverine, estuarine, and nearshore flows; and marine aquaculture. In 2005, the Council's policy on energy exploration, development, and transportation was revised and updated to address impacts related to Liquefied Natural Gas (LNG) terminals and renewable energy technologies, such as wind farms. The NOAA Fisheries Service, State, and Federal agencies apply EFH and EFH-HAPC designations and protection policies in the day-to-day permit review process.

South Atlantic Bight Ecopath Model

The Council developed strawman and preliminary food web models (Ecopath with Ecosim) to characterize the ecological relationships of South Atlantic species, including those managed by the Council. This effort will help the Council and cooperators in identifying available information and data gaps while providing insight into ecosystem function. More importantly, the models aid in identifying research necessary to better define populations, fisheries, and their interrelationships. The model included the area between the North Carolina/Virginia border through the Florida Keys and extends from the upper wetlands to the 300-meter isobath. The preliminary model used catch data from 1995 to 2004. The Council has been coordinating with the Lenfest Ocean Program to expand and refine the South Atlantic Ecopath with Ecosim Model to complete a fully parameterized model with development of embedded sub-models.

Cooperative Research to Support Ecosystem-Based Management
As an example of cooperative research to support EBM, the Council partnered with the National Undersea Research Center at the University of North Carolina at Wilmington (NURC/UNCW) by providing seed money to begin multi-beam sonar mapping of the outer continental shelf and upper continental slope. This region of the EEZ from just north of Cape Hatteras (North Carolina) to Cape Canaveral (Florida), covering a depth range of 100 to 500 m, includes important habitat for current and future economically valuable species (e.g., groupers, wreckfish, crabs, tilefish, etc.). Habitats used by these species include soft bottoms of various types and a wide range of hard bottom lithotypes. This area includes important and unique features such as "The Point" canyon system (just north of Cape Hatteras, North Carolina) and the "Charleston Bump" (off of Cape Romain, South Carolina). The features of these two EFH-HAPCs result in significant oceanographic effects in the region (e.g., upwelling) and also represent productive fishery areas. Throughout the region, and toward the deeper end (350 to 450 m), are scattered but extensive deep reef systems composed of delicate, slow growing ahermatypic corals (e.g., *Lophelia*). All of these habitats are poorly mapped. In addition, the Council has established deepwater MPAs. High-resolution (1 to 2 m resolution) bathymetry maps are required for these areas.

1.3 Ecosystem Management Goals

The Council adopted three broad goals to support the move to EBM in the South Atlantic Region:

- Maintaining/improving ecosystem structure and function
- Maintaining/improving economic, social, and cultural benefits from resources
- Maintaining/improving biological, economic, and cultural diversity

2.0 Overview of the South Atlantic Ecosystem

2.1 Geographic Boundaries

For the purpose of the FEP, the South Atlantic ecosystem is the region under the jurisdiction of the Council (Figure 1) inland through the region's coastal watersheds. The South Atlantic ecosystem area intersects two Large Marine Ecosystems and interacts with the Gulf of Mexico and Mid Atlantic Regions and the Bahamas and Sargasso Sea (see species migrations and oceanographic characteristics in FEP Volume V Section 9.3).

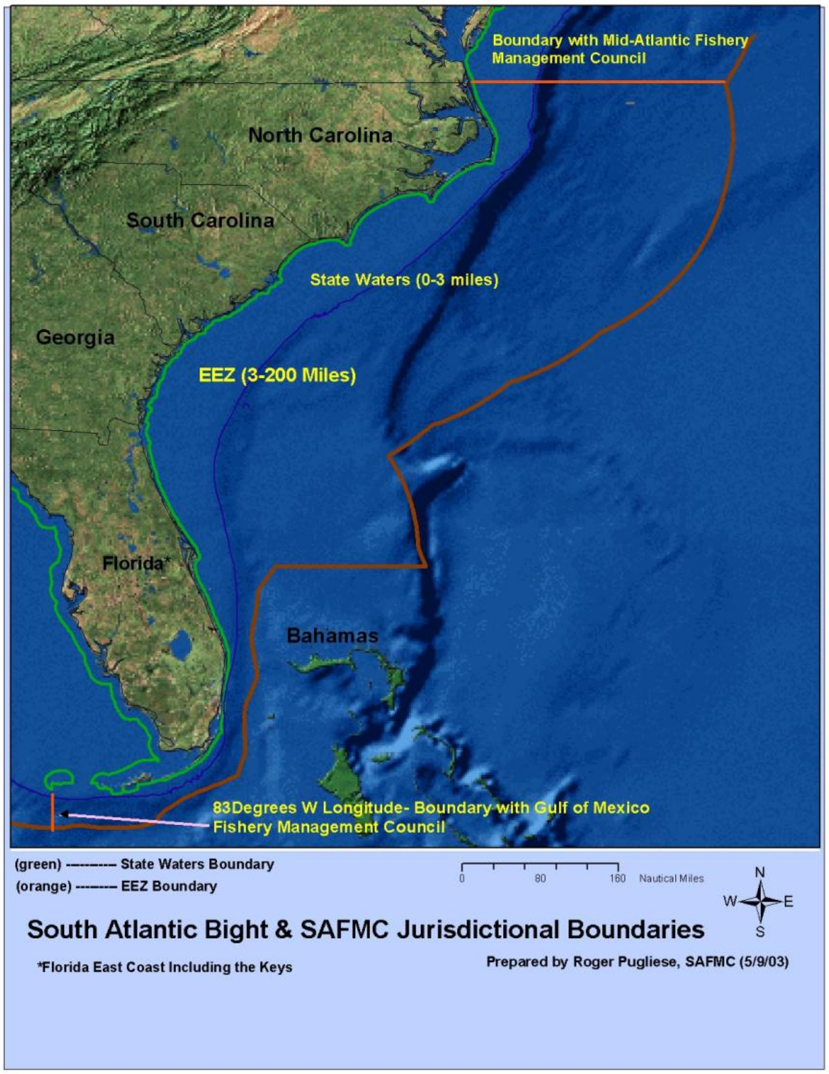

Figure 1. Jurisdictional boundaries of the South Atlantic Fishery Management Council.

2.2 Climate and weather

Section 9.3.1 of FEP Volume V, Fisheries Oceanography in the South Atlantic Region, summarizes the atmospheric and oceanographic characteristics of the Southeast Coastal

Ocean. In addition, a detailed review of the region climate data *Monthly climatology of the continental shelf waters of the South Atlantic Bight* (B. Blanton, A. Aretxabaleta, F. Werner and H. Seim, 2003), is presented in Appendix B

2.3 Habitat and Food Web

Detailed descriptions of species and habitat essential to their survival which constitute the South Atlantic food web are presented in Volume II. Designations of EFH and EFH-HAPCs are included in Volume IV.

2.4 Current Area-based Approaches to Managing Fisheries in the South Atlantic

Traditional Management Practices
Traditional management practices in the South Atlantic have focused on minimum size, bag limits, trip limits, closed areas and seasons, and annual quotas. In 1998, a limited entry system was implemented for the snapper grouper fishery where landings of a minimum amount qualified individuals to remain in the fishery. These efforts were followed up with a 2-for-1 rule that required anyone buying a permit to purchase two permits and retire one of them. The goal of the 2-for-1 program was to decrease the number of permits in the fishery and thereby decrease capacity. Recent years have seen the Council explore Marine Protected Areas and Limited Access Privilege Programs as new techniques that may help them better manage the South Atlantic stocks.

Special Management Zones
Since 1983, the Council has allowed the designation of Special Management Zones (SMZs) as an incentive to create artificial reefs and fish attraction devices to increase the numbers of fish in an area and/or create fishing opportunities that would not otherwise exist. Designation of an area as an SMZ allows for gear restrictions in the area to prevent overexploitation. Many of these areas have been established through cooperation with fishing organizations and local governments and serve as a means to promote localized conservation and positive fishing experiences. A total of 51 SMZs have been designated off South Carolina, Georgia, and Florida.

Marine Protected Areas: Oculina Experimental Closed Area
The shelf-edge *Oculina* coral reef, located off the central east coast of Florida, is unique among coral reefs and exists nowhere else on earth. The area takes its name after the slow-growing, ivory-tree coral, *Oculina varicosa*, which forms massive thickets supporting dense and diverse communities of finfish and invertebrates over a 90-mile strip of reefs.

In 1984, the Council established the 92-square-mile, Oculina Bank HAPC in order to protect the fragile coral reefs. The Oculina HAPC was designed to protect the area from damage caused by bottom-tending fishing gear including bottom trawls, bottom longlines, dredges, and fish traps. Subsequent management measures provided further protection to the Oculina HAPC by prohibiting anchoring, trawling for rock shrimp, and by requiring the use of vessel monitoring systems (VMS) on rock shrimp vessels. Expanded in 2000, the HAPC now encompasses 300 square miles.

In 1994, the original 92-square-mile HAPC was declared the Oculina Experimental Closed Area and was closed to fishing for snapper/grouper species for a period of 10 years to allow for scientific studies in an area closed to fishing. Designation of an area where deepwater species, such as snowy grouper, golden tilefish, speckled hind, and Warsaw grouper can grow and reproduce without being subjected to fishing mortality provides a unique opportunity for study. The Council took action in 2003 to extend the closure indefinitely with periodic review for further protection and research.

History of the Council's Consideration of Marine Protected Areas for the Snapper Grouper Fishery

The Snapper Grouper Fishery Management Unit (FMU) is a complex of 73 species managed by the Council under the Snapper Grouper Fishery Management Plan. The FMU is diverse and contains snappers, groupers, jacks, porgies, tilefishes, grunts, and sea basses. Seven snapper grouper species make up the "deepwater complex": snowy grouper, misty grouper, speckled hind, yellowedge grouper, Warsaw grouper, golden tilefish, and blueline tilefish. The fishery has been under management since 1983, and the original FMP has been amended 19 times. Management measures currently in place include bag limits, size limits, gear prohibitions, seasonal closures, a commercial limited entry program, and quotas.

The potential for using Marine Protected Areas (MPAs) as a management tool for the snapper grouper fishery first originated with the Council's Snapper Grouper Plan Development Team (PDT). This technical group prepared a report (PDT 1990a) entitled "*The Potential of Marine Fishery Reserves for Reef Fish Management in the U.S. South Atlantic*." The PDT offered this approach because they believed it was the only viable option for maintaining optimum size, age, and genetic structure of slow growing, long-lived species over the long term. The Council received an extensive briefing on marine reserves at the February 1990 Council meeting. This provided an opportunity for the Council to discuss marine reserves as a concept and to hear about experiences with reserves in other parts of the world.

Marine reserves were initially considered as a management option in early discussions on Amendment 4 to the Snapper Grouper Fishery Management Plan. However, the Council determined the reserve concept should be addressed separately and scheduled scoping meetings in each of the States. During the 1992 scoping process, support for and against the concept surfaced. The Council reviewed the scoping information during the January 1993 meeting and decided to recommend to NOAA Fisheries Service that a Scientific Review Panel be convened to review the concept of MPAs. Until that review was completed the Council chose to drop consideration of the marine reserves.

In 1995, a scientific review panel completed its review of the 1990 Snapper Grouper Plan Development Team report (NOAA 1995). The panel consisted of international experts with different experience in fishery science, marine reserves, ecology, fish genetics, sociology, and economics. The scientific review panel concluded that properly designed marine reserves, in combination with other management measures, can be an effective management tool for reef fish resources in the U.S. South Atlantic region provided biological, ecological, social, and economic objectives of the marine reserves were clearly specified; the relative biological, ecological, and economic impacts of marine reserves in the context of other fishery management measures were estimated for various constituents; and development of marine reserve proposals proceeded with involvement of all stakeholders. Lastly, given the alarming declines in stocks of key fishery species, the panel urged that marine reserves be considered immediately as part of a comprehensive fisheries management plan to prevent irreversible loss to species and fisheries.

In further developing Snapper Grouper Amendment 8 (and later Amendment 9), the Council realized that severe impacts would be felt by fishermen if necessary percentage reductions in catches of overfished species were imposed to achieve the mandated fishery management goals. Marine reserves once again surfaced as a potential alternative to fisheries closures.

In 1998 after deciding to reconsider the possibilities of marine reserves, the Council proceeded to take steps to initiate a fact-finding process using the Marine Reserves Committee and Advisory Panel. An action plan was then developed that included three phases. During Phase I, Planning/Criteria Development, criteria were developed and questions were raised about the proper size, placement, and regulations within any potential marine reserves. During Phase II, Decision Phase, the Council, drawing on input from three rounds of scoping meetings, a marine reserves workshop, and the Marine Reserves Committee and Advisory Panel, decided that marine reserves were a necessary management tool for snapper grouper management. Phase III, Implementation, includes the Council's development of Amendment 14 to the Snapper Grouper FMP (SAFMC 2007).

When the informal meetings were held in 2000, the Council's intent was to begin a dialogue with stakeholders about the possibilities of using marine reserves as a management tool for snapper grouper species and not discuss specific management measures or specific sites. The meetings were not held by the Council, but Council members and staff made themselves available to meet with any group that made a request. Between January and March of 2000, Council members and staff attended 15 meetings including commercial fishing groups, recreational fishing groups, and conservation organizations. A total of 291 people attended these meetings. Through the informal meeting process, the Council was able to gauge public support for marine reserves and discuss all possible options for managing overfished snapper grouper species to determine whether marine reserves were a tool the Council should consider using.

During May and June 2000, the Council held another round of eight scoping meetings on marine reserves to give the public an opportunity to comment before the Council developed a position on whether or not to move forward with developing marine reserves as a management tool. As with the informal meetings, the Council had not yet discussed specific boundary options but was ready to make a decision on the general concept of marine reserves. Stakeholders voiced many different opinions on the use of marine reserves. There was an equal amount of support and opposition for no-take marine reserves, but many different variations were offered from all sides. Many groups were in support of protecting known spawning areas from fishing and creating artificial habitats and prohibiting fishing in these areas. The Council then voted to move forward with using marine reserves.

After deciding that marine reserves were a management measure needed to help recover overfished snapper grouper species, the Council then needed to determine the appropriate locations to site marine reserves and the appropriate regulations within the boundaries. Continuing with the Council's philosophy of building support for marine reserves from the ground up, the Council looked to stakeholders to suggest where marine reserves should be placed (scoping process). In the spring of 2001, the Council held a final set of nine scoping meetings. The public were provided charts that showed known hardbottom areas off the South Atlantic coast and were asked to use their experience and knowledge of snapper grouper species (specifically deepwater snapper grouper species) to suggest areas the Council may want to consider designating as marine reserves. As a part of this scoping process, the Marine Reserves Advisory Panel was asked to also suggest areas. As a result of this process, over 40 sites were suggested and originally considered as potential marine reserves (sites not analyzed in detail and proposed as management measures are listed and discussed briefly in Appendix A of Amendment 14).

At their February 2001 meeting, the Council's Marine Reserves Committee discussed the difficulty managers and stakeholders were facing given that many different agencies were looking at marine reserves, marine sanctuaries, or marine protected areas. The different nomenclature associated with this management tool made things confusing to the public and managers. The Committee determined that the term "marine reserves" was coming to imply an area that allowed no fishing. This was contrary to the Council's intent. In order to be more consistent with national definitions, the Council adopted the term Marine Protected Areas (MPAs). As defined in Presidential Executive Order 13158, an MPA is any area of the marine environment that has been reserved by federal, state, territorial, tribal, or local laws or regulations to provide lasting protection for part or all of the natural and cultural resources therein. The Council further defines MPAs within its jurisdiction as a network of specific areas of marine environments reserved and managed for the primary purpose of aiding in the recovery of overfished stocks and to ensure the persistence of healthy fish stocks, fisheries, and habitats. Such areas may be over natural or artificial bottom and may include prohibition of harvest on a permanent or lesser time period to accomplish needed conservation goals.

Another aspect of the development of appropriate MPA alternatives was deciding which activities, if any, would be allowed within an MPA. The PDT report presented to the Council in 1990 suggested that these areas be set aside for non-consumptive uses. Later when the Council began seriously looking at the use of MPAs as a management tool, the Council purposely crafted a broad definition of the tool (marine reserves are specific areas of marine environment managed for the primary purpose of aiding in the recovery of overfished stocks and to ensure the persistence of healthy fish stocks, fisheries, and habitats), which allowed the Council, its advisors, and the public to discuss and analyze the costs and benefits of allowing varying activities in the future proposed MPAs. The Council presented to the public the following alternatives for designating MPAs:

- Type 1 - Permanent closure/no-take
- Type 2 - Permanent closure/some take allowed
- Type 3 - Limited duration closure/no-take
- Type 4 - Limited duration closure/some take allowed

Ultimately, the Council narrowed its focus for Amendment 14 MPAs and determined the greatest need for this management tool was to protect deepwater snapper grouper species. After that decision was made, the Council determined that both the social and economic costs of prohibiting all fishing were greater than the benefits (more effective law enforcement). The majority of the proposed MPAs (designed to protect deepwater snapper grouper species) are also popular trolling spots for the pelagic fisheries. Therefore, the Council choose to move forward with designating the proposed MPAs as Type 2 MPAs where the harvest and possession of snapper grouper species would be prohibited within their borders (however, the prohibition on possession does not apply to a person aboard a vessel that is in transit with fishing gear appropriately stowed as defined in Appendix F).

Considerations for Type 1 vs. Type 2 Marine Protected Areas

Benthic-pelagic linkages

The net ecological effect of allowing fishing for pelagic species (e.g., billfish, tunas, dolphin, wahoo, and others) in a Type 2 MPA designated to protect deepwater snapper grouper species (e.g., snowy grouper, tilefish, queen snapper, and others) is anticipated to be minimal for two reasons. First, there may not be a strong ecological link between pelagic species and benthic top predators in the proposed Type 2 MPAs, as those fish in one depth stratum rarely consume fish from another (Wahle et al. 2006). Deepwater snapper grouper species are generally found less than two meters from the substrate. Pelagic species are usually found in the top 30 meters of the water column and their interaction with benthic species is minimal. While there may not be a direct, strong ecological link between pelagic species and deepwater snapper grouper, food web models indicate there are trophic relationships between the two groups (Weaver and Sedberry 2005).

Furthermore, some pelagic species, such as greater amberjack, occur throughout the water column, including the benthos and are taken with trolling and bottom tending gear. Greater amberjack have been collected in many of the proposed Type 2 MPAs and have been observed on the bottom from a submersible in several of the proposed Type 2 MPAs (Sedberry et al. 2005). While greater amberjack is not a direct predator of deepwater snapper grouper species, it probably shares food resources. There is also evidence other pelagic species, such as swordfish, bluefin tuna, yellowfin tuna, and various shark species, follow isolumes and occur in deepwater during daylight hours; however, these species are usually found offshore of the proposed Type 2 MPAs (Brill and Lutcavage 2001; Loefer et al. 2005). Although there is some trophic interaction, pelagic species and deepwater snapper grouper species generally take advantage of spatially distinct food and habitat resources and usually remain in close proximity to their set of resource needs.

Pelagic species such as marlins and tunas are not likely to be strongly affected by the proposed Type 2 MPAs because these species may swim in and out of the small protected areas frequently and would continue to be vulnerable to fishing outside of the closed area. Any impacts pelagic species such as marlins and tunas may indirectly have on the deepwater snapper grouper species is therefore unlikely to be affected by the establishment of the proposed Type 2 MPAs, even if fishing for the former were still allowed in the closed area (Wahle et al. 2006).

Bycatch of snapper grouper species in a fishery for pelagic species

Pelagic species are generally captured by trolling (i.e., towing artificial or live bait behind the wake of a vessel) at depths of 10 to 30 meters from the surface (Everhart and Youngs 1981). The proposed Type 2 MPAs are at depths ranging from 60 to 700 meters. However, methods used to troll for coastal migratory pelagics can access deep reef fishes. NOAA Fisheries Service researchers used a variety of gear types and techniques to assess the susceptibility of reef fish to trolling using downriggers at 200 to 400 feet in the Madison-Swanson MPA in the Gulf of Mexico (David 2003). Reef fish (gag, speckled hind, red snapper, Warsaw grouper, scamp, and greater amberjack) were captured at a rate of one fish every 100 minutes. Therefore, a Type 2 MPA where fishing for non-snapper grouper pelagic species is allowed could result in bycatch of snapper grouper species, including some deepwater species targeted for protection in this amendment.

Problems with enforcement of the proposed Type 2 MPAs

The main enforcement concern with the proposed MPAs is their Type 2 status. When no fishing is allowed in an area (as in a Type 1 MPA or marine reserve), and a vessel monitoring system (VMS) shows a vessel has been in the closed area, enforcement can potentially use this information along with other information to determine whether a violation has occurred. However, in a Type 2 MPA where some fishing is allowed, it is more difficult to determine whether a violation has occurred. In this situation, the only purpose served by VMS is to alert the agent that someone is in the area, not to document wrongdoing. Because the proposed MPAs are far offshore, the transit time required from when law enforcement learns someone is in an MPA to when law enforcement arrives at the site in question may be substantial, and the violator may be gone before enforcement is able to respond to a potential violation.

During 2001 and into 2002 the Council, with help from its advisors, began working to determine which of the 40 sites suggested through scoping would best meet the Council's management objective to protect deepwater snapper grouper species. In August of 2001 the Council held an unprecedented "Mega-AP" meeting of the Habitat, Coral, Snapper Grouper, MPA, Law Enforcement, and Wreckfish Advisory Panels. The Advisory Panels were asked to help the Council select sites that would be the most beneficial to the overfished, deepwater snapper grouper species using their various and vast knowledge, understanding that the Council's intent was to look at sites that protect more inshore snapper grouper species further down the line.

Later in 2001 the Snapper Grouper Assessment Group, the Scientific and Statistical Committee (SSC), and the Snapper Grouper Advisory Panel met with the Council's Snapper Grouper Committee to provide additional input on the possible MPA sites. Based on input from the SSC, Advisory Panels, and the Snapper Grouper Committee, the Council then instructed staff to develop an options paper for Snapper Grouper Amendment 14 with an initial level of analysis of sites the Council felt met the criteria of protecting overfished, deepwater snapper grouper species.

The sites that met the criteria of protecting overfished, deepwater snapper grouper species were included in the Informational Public Hearing Document and taken out to public hearings in early 2004. At those public hearings social and economic data were collected to help staff refine sites and analyze the impacts of the proposed sites. The information gathered at the informational public hearings helped staff assess the social and economic impacts of each individual site and is summarized under the discussion of each management measure in Amendment 14 Section 4.0.

The Council produced a source document that includes much of the material prepared during development and consideration of MPAs (SAFMC 2005). This material is available on the Council's website.

Considerations for MPA Design

There is a large body of literature regarding designs of marine reserves and MPAs. Specific design considerations are summarized in the report of the Plan Development Team (1990). Questions about the proper size, placement, and regulations for potential reserves were considered by the Scientific Review Panel convened by NOAA in 1990 to review the concept of MPAs, and by the Council's Marine Reserves Committee and Advisory Panel in writing their Action Plan in 1998. The Council has focused on the presence of deepwater snapper grouper species and their habitat as the primary biological criteria for a deepwater Type 2 MPA.

While biological considerations alone may suggest certain MPA design characteristics, the social and economic impacts of MPAs on fishing communities must also be taken into consideration, for two reasons. First, National Standard 8 of the Magnuson-Stevens Act requires the Council to "take into account the importance of fishery resources to fishing communities in order to (A) provide for the sustained participation of such communities, and (B) to the extent practicable, minimize adverse economic impacts on such communities." Second, research shows "a fundamental lesson learned from experience throughout the world is that attempts to implement MPAs in the absence of general community support invariably fail. Inclusion of "bottom-up" or "grass-roots" approaches to planning, design, and implementation of MPAs offers the best opportunity to develop plans with the endorsement of local communities (NRC 2001)." This type of "bottom-up" approach has been the goal of the Council since the outset of their deliberations on MPAs in the South Atlantic, and its implementation has allowed them to successfully balance biological considerations with public concerns when determining the characteristics of their proposed MPAs.

Due to the complex nature of ecosystems and the limitations of traditional fisheries management methods, fisheries management may benefit from multiple management components as part of an overall plan. The Type 2 MPAs are intended to augment, not replace, existing management. Lauck et al. (1998) suggests ". . . MPAs can serve to hedge against inevitable uncertainties, errors, and biases in fisheries management." The Type 2 MPAs are expected to perform this function, among others, for the management of deepwater snapper grouper species in the South Atlantic.

Rights-based systems

Property Rights in fisheries, and elsewhere, are often defined as a 'bundle of attributes' and exist as a continuum in terms of their characteristics. Scott (1996) refers to the most important of these as: a) transferability, b) exclusivity, c) security and d) durability.

These four conceptual elements provide a basis for looking at the characteristics of existing fisheries property rights systems. These attributes are mediated, or conditioned, by the need to manage the fishery. Transferability requires ownership registries plus the rules and means to make them function; exclusivity requires monitoring and enforcement systems; and security of title requires an effective and honest legal system; durable rights are those that the possessor holds for a long time, perhaps in perpetuity. Many of these management needs may exist, irrespective of whether the fishery is considered to have weak or strong property rights.

The strongest fisheries property rights systems will be those in which Scott's (1996) characteristics are the least constrained, and by looking at how different national and regional management regimes have developed and, or, constrained these attributes, an understanding of the development of 'strong' property-rights fisheries systems can be gained.

In many areas of the world, there exist property rights systems in fisheries that depend on unwritten, traditional, or customary agreements about who may fish in a particular location, and sometimes, what type of gear they are allowed to use (e.g. Foale 1996). While unwritten, these rights may be well accepted and fiercely enforced and be just as effective in achieving their objectives as those that have been legislated into existence. In these situations, social, or cultural, traditions will determine the nature of the property rights in terms of the criteria mentioned above.

The following is excerpted from: *Use of Property Rights Systems in Fisheries Management* - R. Shotton, FAO (1999)

> Depending on which criterion is to be given greatest weight, property rights systems in fisheries may be structured as follows:

"Individual" Transferable Harvest Quotas
These are commonly called ITQs - the famous, or perhaps infamous term, which is now well known if not so commonly understood. Various terms have been used to describe these depending on the circumstances of their application and some writers use the term ITQ in a general sense. For example, ICES 1997 in their characterization of ITQs uses the term 'Individual' to include when rights are held by a person, a vessel, a community, an enterprise, or some other form of collective. They assume that the 'quota' can be either an output unit - tons caught - or an input unit - the amount of fishing gear that can be used. Non-transferable quota management systems are commonly termed (Individual Quota) IQ systems.

ITQs may be stinted in various ways and to various degrees. If the harvest right is attached to a fishing boat, they may be referred to as IFQs - Individual Fishing Quotas, but in other ways they may have no operational differences to an ITQ (See e.g. Grafton 1996, for a detailed review on their conceptual characteristics).

Community Quota
Community quotas may share most of the characteristics of ITQs except that there are additional constraints on who may own them - this may be perceived as a constraint on their transferability - they cannot be sold (or even leased) to someone who is not a member of the community. The existence of a community quota may have a legal basis: in this case a condition attached to the quota may be that it legally must remain 'in' the community. However, municipalities, for example, may buy quota in the market as other quota holders do and then lease them to fishermen they deem to be part of their community, as is the case in the Shetland Islands.

Another issue relates to how the community is defined. Conventionally, communities have a geographical context, but in some management regions, a different approach has been adopted. In these, a community has been taken to mean a collection of people with similar interests, now often referred to in a fisheries management context as a virtual community. In the Maritime Region of Canada for example, two of nine communities that have been awarded quota to manage themselves are defined in terms of the type of fishing gear they use.

Territorial User Fisheries Rights
Conventionally called TURFs, these convey to the 'owners' some fishing rights to a specific area. There is no reason why they need not have all the attributes of for example an ITQ system, except the right is to undertake fishing in a defined area, rather than remove an amount of fish. The rights may be transferable and of variable durability, exclusivity, etc. Christy (1982) and Panayotou (1984) provide further details.

Fishing Input Rights
These may be exactly analogous in the sense of their property-rights attributes to ITQs, except that the right relates to the amount of fishing gear that can be used. A particularly well known example is the Western Australia lobster fishery where the unit

of ownership is an individual lobster trap. Another Australian example is found in the Northern Prawn Fishery. Originally, when input control was introduced into this fishery, the measure of vessel capacity used was based on vessel gross registered tonnage and engine power. This input unit subsequently changed to a unit length (one foot - 12 inches) of the shrimp trawl ground rope because the vessels started towing four trawls rather than just two.

Resource management may be the most important functional attribute relating to fisheries property rights systems. With few exceptions, the total desirable catch in terms of obtaining the maximum benefits from the fishery will change from year to year, either to avoid growth overfishing or because of an expectation of excessive declines in recruitment. In this case the stock may fall below some minimum biological acceptable level unless fishing mortality is reduced. In output, i.e. quota controlled fisheries, the amount of fish a rights holder is entitled to remove is usually defined as a percentage of the total allowable catch. Thus the rights holder's absolute catch each year will vary as does the total allowable catch (TAC). How the TAC is determined is usually independent of the type of rights system used in the fishery (though in rights-based fisheries management systems the quota holders are often formally involved in the TAC-setting process). Thus, monitoring and enforcement is necessary to ensure quotas are not exceeded, as in any fishery where catch in limited.

In input-controlled fisheries, adjustments are required to the amount of effort that is exerted to control fishing mortality. In the case of trap fisheries this may mean adjusting the number of traps by removal of a percentage of the traps that are fished (though varying the length of fishing seasons remains an option). In the case of a ground-rope rights-based fishery, e.g. the Australian Northern Prawn Fishery, fishermen may be required to forfeit a percentage of their foot-rope length entitlements if the TAC is to be reduced. This in turn requires that they either purchase the difference from other rights holders to maintain their level of effort in the fishery, or they become unable to participate.

The South Atlantic Wreckfish ITQ Program

Prior to implementation of the Wreckfish ITQ, a classic fishing derby had evolved where approximately 80 vessels were in competition for the 2 million pound quota. A substantial number of vessels added wreckfish reels to catch fish faster, thereby garnering more of the available TAC, while others began to use bottom longline gear to catch wreckfish more rapidly, despite reportedly significant gear conflicts and losses using bottom longlines.

As the pace of wreckfish landings increased in 1990, ex-vessel prices decreased substantially. The fact that as many as 80 vessels were fishing for wreckfish on the relatively small rock ridge areas known to have concentrations of wreckfish created a potential for conflicts among harvesters and vessel safety problems.

Although still one of the most profitable fishing opportunities in the southeast in 1990, the wreckfish fishery had already begun to show signs of excess capacity and overcapitalization by the end of the year. Public comment stressed the detrimental effects of continued entry and competitive fishing practices under a restrictive TAC. Along with the economic problems of overcapitalization and excess capacity common to open access fisheries managed by TAC, public comment stressed the absence of conservation incentives and probably lack of regulatory compliance in the fishery. Comments from wreckfish dealers pointed to the tendency for markets to become flooded as the pace of wreckfish harvest increased beyond their ability to move the product through the market chain. Other marketing problems resulting from inconsistent supply when TAC was met were also identified.

Amendment 3 had been developed to add wreckfish to the Snapper Grouper management unit, define an optimum yield for wreckfish, establish a control date, and, among other things, identify a TAC for the wreckfish resource. The Wreckfish ITQ (Amendment 5) was implemented in March 1992. The overall goal of implementing the South Atlantic Wreckfish ITQ was to "manage the wreckfish sector of the snapper-grouper fishery so that its long-term economic viability will be preserved." Other objectives and stated in Amendment 5 included:

- Develop a mechanism to vest fishermen in the wreckfish fishery and create incentives for conservation and regulatory compliance whereby fishermen can realize potential long-run benefits from efforts to conserve and manage the wreckfish resource.
- Provide a management regime which promotes stability and facilitates long-range planning and investment by harvesters and fish dealers while avoiding, where possible, the necessity for more stringent management measures and increasing management costs over time.
- Develop a mechanism that allows the marketplace to drive harvest strategies and product forms in order to maintain product continuity and increase total producer and consumer benefits from the fishery.
- Promote management regimes that minimize gear and area conflicts among fishermen.
- Minimize the tendency for overcapitalization in the harvesting and processing/distribution sectors.
- Provide a reasonable opportunity for fishermen to make adequate returns from commercial fishing by controlling entry so that returns are not regularly dissipated by open access, while also providing avenues for fishermen not initially included in the limited entry program to enter the program.

Although not an explicit objective at this time, the Council believes that portions or all of management and administrative costs should be recovered from those who hold individual quota shares in the wreckfish fishery, should recover of those costs become permissible under future Magnuson Act (MFCMA) revisions. Those costs, or portions of them, would be recovered through such means as transfer fees or ad valorum taxes or other means available (Snapper Grouper Amendment 5, page 9).

Eligibility for participation required that an applicant needed to own a vessel or vessels that landed at least 5,000 pounds (dressed weight) of wreckfish in aggregate between 1987 and September 1990. Initial allocations were made such that 50 of the 100 available shares were divided equally among eligible participants. The remaining 50 shares were divided based on an applicant's documented historical catch divided by the total catch of all eligible participants over the same period. Documented historical catch was calculated based on landings of wreckfish made between January 1989 and September 1990 when a control date was issued.

For approximately one month after initial allocation, an Application Oversight Committee considered requests from persons wishing to contest the initial allocations. The Committee was empowered to consider only allegations of improper calculations or improper determinations based on documentation submitted with application. Hardship circumstances were not considered.

Following initial allocation, coupons were distributed representing shares. Coupons could be sold, leased, or loaned, but only to a person who holds a percentage share in the wreckfish fishery. Fishermen were required to possess a wreckfish vessel permit, logbook, and ITQ coupons equaling the approximate weight of catch in their possession. The coupons had to be signed and dated by the time of landing. Penalties for significant violations included forfeitures of shares, forfeitures of individual quotas, and/or vessel or dealer permit sanctions.

Dealers were required to obtain a Federal wreckfish dealer's permit. The requirements to obtain a dealer's permit were a state wholesaler's permit and a physical facility at a fixed location in the state where the wholesaler's permit is held.

Limited Access Privilege Program (LAPP) for the Snapper Grouper Fishery
Since the original Snapper Grouper Fishery Management Plan was implemented over 2 decades ago, the fishery has seen many changes. Population increases along the South Atlantic coast have contributed to loss of habitat and increased fishing pressure. Economically, seafood imports have driven domestic market prices downward while waterfront property prices have skyrocketed, limiting waterfront accessibility. Meanwhile, management requirements have led to a litany of complex regulations, including size and bag limits, trip limits, and seasonal closures to protect stocks from overfishing or becoming overfished.

These and other factors have decreased the ability of fishermen to maintain profitability in the South Atlantic snapper grouper fishery. Management options that enable fishermen increased flexibility may help increase individual profitability - and options that enable a reduction in fleet size while maintaining status quo landings are expected to increase total fleet profitability. Any new management tool considered for the fishery will need to support maintenance of landings within the commercial quota and minimize discarded fish. With these goals in mind, the Council is considering creating a LAPP for the commercial snapper grouper fishery.

The recently reauthorized Magnuson-Stevens Act (2006), the primary legislation outlining national fishery policy, contains language supporting creation of LAPPs for fisheries and provides specific guidelines and requirements for implementation of such programs.

For several years, the Council and Controlled Access Committee have received presentations from academics, Council staff, and NOAA Fisheries Service regarding the use of IFQs in various fisheries of the U.S. and other countries. In December, 2006, the Council approved a motion to consider application of a LAPP for the South Atlantic snapper grouper fishery.

The Controlled Access Committee met January 23-24, 2007 to begin development of an action plan to outline how the Council might go about exploring the use of LAPP for the commercial snapper grouper fishery. The Committee also developed recommendations for the structure and membership of a LAPP Exploratory Workgroup to aid in this process.

In March 2007 the Controlled Access Committee, now called the Limited Access Privilege Program Committee, met during the Council meeting to finalize membership to a LAPP Exploratory Workgroup. The Council approved the Workgroup membership and the Action Plan for LAPP consideration. The Workgroup was composed of fishery stakeholders including fishermen from each gear group (longline, hook and line, and dive) and state, fish house owners, an environmental representative, Sea Grant staff, and NMFS staff. The Workgroup met nine times and compiled a report on the appropriateness of LAPPs for the South Atlantic commercial snapper grouper fishery and what characteristics the Workgroup thought a LAPP should have. The Workgroup also expressed the possible positive and negative impacts they could foresee of a LAPP, prerequisites for a LAPP, and goals and objectives for a LAPP. These were incorporated into the document. The document also contains background information on various aspects of a LAPP.

In early March 2008, the South Atlantic Fishery Management Council received the LAPP Exploratory Workgroup's Final Report and discussed whether to move ahead with development of an amendment that would explore the potential impacts of a LAPP for the commercial snapper grouper fishery. The Council decided not to move ahead with development of an amendment at this time. However, the Council directed Council staff to contact tilefish fishermen to ask about their interest in a possible LAPP for the tilefish fishery. In June 2008, the Council decided to develop a Golden Tilefish LAP Program Exploratory Workgroup to design a LAP for the golden tilefish fishery and provide advice to the Council on this management consideration.

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Spiny Lobster FMP and Amendments
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Monthly climatology of the continental shelf waters of the South Atlantic Bight

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Abstract. Monthly circulation of the South Atlantic Bight is diagnosed using a 3-D, shallow water, finite element model forced with monthly wind stress and hydrographic climatology. Temperature and salinity observations from the period 1950-99 are objectively interpolated onto the model domain, and Comprehensive Ocean-Atmosphere Data Set (COADS) wind velocities from 1975-1999 are used to prescribe the model surface wind stress. The resulting monthly temperature and salinity fields compare favorably to existing shelf climatology. River discharge maxima are evident in the spring temperature and salinity fields, and the rapid heating and cooling of the shelf are captured. The diagnostic circulation is largely wind-driven in the inner and midshelf, and the Gulf Stream is apparent in the solutions on the outer shelf. We present the monthly fields, including the temporal and spatial distribution of available hydrographic data, the regional COADS data that provide surface wind stress forcings, the objective analysis, and the model response to these forcings. The hydrographic and velocity fields provide best-prior-estimates of the circulation for data assimilation studies in the region, as well as initial conditions for process-oriented prognostic model studies in the Georgia coastal region.

1. Introduction

The South Atlantic Bight (SAB) (Figure 1) region of the eastern United States coast extends from Cape Hatteras, North Carolina to about Cape Canaveral, Florida. The continental shelf (shoreward of the 200-m isobath) is narrow on the northern and southern extremes (10-30 km) and broadens to about 120 km off the middle Georgia coast. The depth contours are largely parallel to the coast. The coast is permeated with rivers and tidal inlets, particularly from middle South Carolina to northern Florida. The coastal waters (shoreward of the 100-m isobath) are significantly influenced by atmospheric fluxes, buoyancy fluxes from rivers, tides, and the Gulf Stream. The Gulf Stream lies generally seaward of the 100-m isobath, but can influence the outer to midshelf (45-100-m isobath) region on weekly time scales [*Lee et al.*, 1981; *Lee and Atkinson*, 1983]. During spring, river discharge into the coastal waters is significant, generating less dense near-shore frontal zones with equatorward flows [*Blanton*, 1981]. While these general topographic and coastal features are not unique to the SAB, the presence of the Gulf Stream imposes a complicating influence on the SAB hydrographic and circulation characteristics.

The seasonal temperature and salinity (TS) and wind field characteristics in the SAB have been well characterized in previous studies. *Atkinson et al.* [1983] derived monthly fields of surface temperature and salinity and bottom temperature based on hydrographic observations accumulated over 1946-80. (This study is our primary point of comparison.) Their results indicate that cross-shelf hydrographic properties can be broken into inner, mid-, and outer shelf regions depending on the mechanisms determining the property distributions. The Gulf Stream dominates the outer shelf; the midshelf signals are dominated by influences from the tides, wind field, and density forcing with frequent contributions from the Gulf Stream; the inner shelf is dominated by atmospheric fluxes, river discharge, and tidal mixing.

The primary wind field climatology is that derived by *Weber and Blanton* [1980], and enhanced by *Blanton et al.* [1985], who split ship-of-opportunity records of wind speed and direction in the SAB into months and classified the results into seasons based on similarity of resulting surface wind stress patterns. They developed 5 seasonal wind field periods. Winter (November-February) mean winds are southeastward in the northern SAB and southward over the southern SAB. Spring (March-May) is a transition period for the hemispheric surface atmospheric pressure distribution with winds rotating toward the north in the central and northern SAB, while the winds in the southern SAB (central and south Florida coast) are westward. Summer (June-July) winds are generally along-shelf and poleward over the entire SAB. August appears to be a rapid transition month during which mean winds are weak. Autumn (called “mariner’s fall” by *Weber and Blanton* [1980]) spans September-October. The wind stress pattern has shifted to primarily southwestward over the SAB, which is along-shelf in the northern SAB and cross-shelf in the southern SAB.

Over the past several decades, numerous field programs (including GABEX [*Lee and*

Atkinson, 1983; *Lee and Pietrafesa*, 1987], GALE [*Blanton et al.*, 1987; *Bane*, 1989], FLEX [*Werner et al.*, 1993]) have accumulated observations that enable the description of a seasonal circulation climatology. *Lee et al.* [1991] provides schematics of this circulation. The outer shelf (seaward of the 45-m isobath) is dominated by the Gulf Stream, which transports shelf edge waters poleward, except just poleward of a region known as the Charleston Bump which induces a semi-permanent gyre causing occasional equatorward flow along the shelf break [*Bane and Dewar*, 1988]. This is seasonally independent. Midshelf flow is generally poleward, presumably driven by an along-shelf pressure gradient induced by an offshore pressure field and supplemented by seasonal wind-driven flow. The inner shelf is influenced primarily by the seasonal wind stress patterns. Drifter paths from *Bumpus* [1973] were analyzed by *Weber and Blanton* [1980] to account for the time difference between drifter release and recovery, with the conclusion that surface flows in the SAB generally follow the seasonal wind regime; offshore in winter (November-February), poleward in summer (June-July), and equatorward in fall (September-October).

There have been several relevant numerical model studies of the SAB. *Kantha et al.* [1982] used a diagnostic transport model solving geostrophic equations to compute annual and seasonal streamfunctions and elevation in the SAB driven by 3-D temperature and salinity (TS) fields from hydrographic archives. *Blumberg and Mellor* [1983] computed winter climatological SAB solutions forced by ideal winds and observed TS fields. These two studies focused on circulation seaward of the shelf break, particularly Gulf Stream transport and the realism of the baroclinically induced flows.

Shelf studies include *Kourafalou et al.* [1984], who used a vertically integrated model limited to the continental shelf to examine unstratified winter-time velocity and surface elevation shelf response to observed winter wind forcing. Modeled velocities agreed well with observations in the inner and midshelf, regions previously established as having a significant wind-driven component. However, outer shelf agreement was less successful due to offshelf influences on the outer shelf observations. *Lorenzzetti et al.* [1987] and *Lorenzzetti et al.* [1988] used a two-layer shelf-scale model to examine the shelf upwelling response to summer conditions. They included an along-shelf elevation gradient in conjunction with upwelling-favorable summer winds; both forcings were responsible for the observed mean northward midshelf flows. The model-based study of *Werner et al.* [1993] examined the SAB fall shelf response to tides, periodic winds, idealized density fronts, and along-shelf pressure gradients. The main result was that during this season, the wind field is generally downwelling-favorable and responsible for the equatorward flows observed. The along-shelf pressure gradient produced a similar response to that in *Lorenzzetti et al.* [1988], but during fall, the wind-driven equatorward flows dominate the inner and midshelf.

To our knowledge, there are no model-based climatologies of the SAB shelf or Georgia coastal region that include a 3-D hydrographic component. However, similar model-based climatologies have been established in other geographical regions using techniques similar to those used herein. See, for example, *Naimie et al.* [1994] (Georges Bank/Gulf of Maine), *Han et al.* [1997] (Scotian Shelf), *Foreman et al.* [2000] (Vancouver Island), *Naimie et al.* [2001] (Yellow Sea), and *Hannah et al.* [2001] (Scotian Shelf).

In this study, we combine updated hydrographic observations and the Comprehensive Ocean-Atmosphere Data Set (COADS) wind fields to derive diagnostic density- and wind-driven model solutions in the SAB on a monthly basis. We use a linear, shallow-water, 3-D finite element model formulated in the frequency domain, forced by specified elevation on open water boundaries, imposed internal density variation, and surface momentum flux. Objective analysis is used to map hydrographic observations onto the model domain. We focus on the continental shelf region, although the model domain extend well beyond the shelf limits. This represents an extension of previous modeling efforts in the SAB to 3-D physics that include climatological, objectively derived mass fields.

We are particularly interested in the shelf response in the region of an observation program centered around a set of midshelf towers which are the focus of a limited-area synoptic observation system [*Seim*, 2000]. The towers provide part of the observational data set for a shelf-scale forecasting effort using assimilating versions of the model described herein. The monthly mass and flow fields provide one version of best-prior-estimates of the circulation and mass field upon which to base an error between model and observations. Assuming a lack of more up-to-date hydrographic information to use as a model initial condition, climatology might be the best information available.

2. Models, Domains, and Boundary Conditions

We use the frequency-domain model FUNDY5SP [*Lynch and Werner*, 1987] with spherical-polar extensions [*Greenberg et al.*, 1998] to compute solutions to the monthly climatological wind stress and TS distributions (described below). FUNDY5SP solves the linearized, harmonic-in-time shallow-water wave equation, subject to surface wind stress, specified elevation or geostrophic outflow on the open boundary, and baroclinic pressure gradients associated with internal density structure, with hydrostatic and Boussinesq assumptions. The vertical eddy viscosity (mixing) is externally specified. The model solutions in this context are the zero-frequency diagnostic response in the region to the wind stress and density gradients.

Two nested model domains are used. We compute the barotropic response (not shown) to the monthly wind stress fields on a large-scale domain that includes the entire North Atlantic west of $60°\mathrm{W}$. This domain contains 31435 nodes and 58369 elements, and the only open water boundary is along the longitude $60°\mathrm{W}$ where the elevation is specified to be zero. The vertical discretization uses 21 unequally spaced nodes, with higher resolution in the surface and bottom layers. These model wind solutions are used to obtain the open water boundary elevations for the regional higher-resolution domain on which the climatological solutions are computed.

The second finite element domain, on which the regional (SAB) climatological solutions are computed, is of higher resolution and contains 9606 nodes and 18691 elements (Figure 1) The domain extends from the coast offshore to about the 1000-m isobath. The elevation on the eastern and northern open water boundaries is specified. A geostrophic outflow condition is specified on the southern boundary [*Naimie and Lynch*, 1993], in which neither the elevation nor transport are known, but it is assumed that a geostrophic balance exists between the two along this boundary. The vertical discretization is 21 unequally spaced nodes. This domain is subsequently referred to as the climatology domain. **Figure 1.**

We do not explicitly include tides in this study except for estimating the magnitude and structure of the vertical eddy viscosity and bottom stress. Tidal solutions in the SAB are being investigated separately. The tidal environment in the SAB is a semi-diurnal (primarily M_2) co-oscillation with the North Atlantic deep ocean tide, with significant amplification occurring along the widest part of the continental shelf (off Georgia). The tidal velocity ellipse major axis is generally oriented cross-shelf, with a minor axis length about half that of the major axis length [*Redfield*, 1958; *Clarke and Battisti*, 1981; *Werner et al.*, 1993, among others]. The tidal Eulerian residual velocity is weak, with shelf break flow toward the equator, and poleward near-shore flow at about 0.01 $\mathrm{m\,s^{-1}}$ [*Werner et al.*, 1993].

The contribution of the tides to the total vertical mixing and bottom stress is included by specifying the eddy viscosity computed with a fully nonlinear, time-dependent 3-D model ([*Lynch and Werner*, 1991; *Lynch et al.*, 1996]) driven by M_2 tidal elevations on the open water boundary, using the same climatology domain described above. This model includes advanced turbulence closure through *Mellor and Yamada* [1982]. The model is spun up over 10 M_2 tidal periods, and the 3-D vertical eddy viscosities $N_z(x, y, z)$ and root-mean-square bottom speed $u_{b,rms}$ are averaged over the last period. The tidally averaged vertical mixing coefficient and bottom speed are subsequently input into the linear model to more realistically reflect the vertical mixing and bottom stress environment. The linearized bottom stress coefficient A_k is then expressed as $A_k = c_d\, u_{b,rms}$ where c_d is a drag coefficient (0.005). A minimum A_k of $5 \times 10^{-5}\ \mathrm{m\,s^{-1}}$ is prescribed.

Figure 2 shows the spatial distribution of $u_{b,rms}$. The maximum M_2 tidal bottom speeds are greatest (>0.1 $\mathrm{m\,s^{-1}}$) in the midshelf region off the Georgia coast (the widest part of the shelf), and taper off in both the along-shelf and cross-shelf directions. Figure 2 also shows a sequence of profiles of N_z along the cross-shelf transect shown in Figure 1. Midshelf maxima reach 0.03 $\mathrm{m^2\,s^{-1}}$ at mid-water column depths. These values are consistent with the levels of tidal mixing derived from ADCP observations in the region (in preparation). The profiles shown represent the background level of vertical mixing due to the main tide (M_2) over the tidal cycle and for this study is presumed independent of month. **Figure 2.**

For the wind-driven computations, the monthly COADS wind velocities are converted to stress via *Large and Pond* [1981] and applied to the model surface layer. The elevation along the northern and eastern boundaries of the climatology domain is specified by computing the surface elevation response on the large-scale domain, driven by the monthly COADS wind stresses, and sampling the large-scale solutions at the climatology domain boundary node locations.

For the baroclinic solutions, the steric elevation along the northern and eastern boundary is computed directly from the derived monthly mass fields. The elevation is computed to compensate for the baroclinic flow normal to the boundary at the bottom, as in *Naimie et al.* [1994] and *Hannah et al.* [2001]. The baroclinic pressure gradients are evaluated on level surfaces and interpolated onto the model's vertical sigma-coordinate grid. The following level surfaces are used, onto which the temperature and salinity fields are interpolated: 0, 3, 6, 9, 12, 20, 40, 60, 80, 100, 150, 200, 250, 300, 350, 400, 450, 500, 600, 700, 800-m. The elevation in the northwest corner of the domain is (arbitrarily) set to zero and pressure gradients evaluated relative to this value.

3. Data Sources and Processing

3.1. Surface Winds

Ten-meter east and north wind speeds are acquired from the COADS data set [*Woodruff et al.*, 1998]. The COADS data sets are comprised of *in situ* observations of wind speed, atmospheric pressure, water/air temperature, etc., mainly from ships of opportunity, that have been acquired, quality-controlled, and summarized statistically on a monthly basis on 1 degree squares. These monthly summary groups (MSGs) from the years 1975-97 are taken for the northwest Atlantic region and split into months. The resulting data are block averaged onto a $1° \times 1°$ grid (using data for which the sample size is greater than 20), smoothed with a 9-point Laplacian filter, and then linearly interpolated onto both the large-scale and climatology model grids for computations.

3.2. Hydrography

Temperature and salinity (TS) profiles for the region were acquired from the National Oceanographic Data Center (NODC) for the SAB region. Figure 3 shows NODC profile locations available by month for the region. Our "quality control" method is as follows: profiles whose bottom depth is less than 400 m are manually inspected for TS values grossly out of range, based on the established SAB shelf climatology of *Atkinson et al.* [1983]; for data whose bottom depth is greater than 400 m, TS diagrams (Figure 4) are constructed on half-degree squares and TS pairs that deviate by $\pm$ 2 standard deviations from the computed TS curves are eliminated.

The spatial distribution of the TS curves in the SAB is presented in Figure 4. The previously observed [*Emery and Dewar*, 1982] consistent character of TS properties in the offshelf region is noted. The upper water column variability of the Gulf Stream offshelf position is evident along the shelf break, particularly downstream of the Charleston Bump. Further offshelf, the TS relationship is tighter. However, the shelf region exhibits no well defined TS relationship, indicating that it is critical to observe both temperature *and* salinity to define the shelf mass field.

The resulting available data are presented in Figures 3 and 5. There are about 45,000 TS pairs from 5,000 NODC profiles available for this region, spanning 1950 to 1999. For the purposes of our optimal interpolation of the available data to produce monthly TS fields, we have gathered the data into 50 day blocks, centered about day 15 of each month (for example, for the January TS field estimates data are averaged across the period 20 December to 10 February). Even with this procedure, significant data gaps in both space and time are apparent in the monthly data; note particularly shelf gaps in June, October, and December. All months exhibit a significant gap near $79°\mathrm{W}$, $30°\mathrm{N}$. However, our primary focus is on shelf climatology and the resulting shelf temporal and spatial coverage is largely adequate. We therefore do not focus further on the offshelf characteristics of the forcing or the model solutions.

Figure 3.

Figure 4.

Figure 5.

3.3. Objective Analysis

In order to compute monthly climatological solutions for elevation and velocity, the TS fields defined by the TS data must be mapped onto the model domain, both horizontally and vertically. We use an objective analysis (OA) technique [*Bretherton et al.*, 1976] to map the spatially and temporally irregular TS data onto a specific set of coordinates (the model nodes). This method requires the definition of a set of correlation scales at each model node, from which the method computes a set of nearest neighbors and interpolation weights. The general OA method is 4-D (x,y,z,t); however, due to the irregular temporal distribution of the NODC data in time (see Figure 5), it is difficult to choose a time per month about which to center the temporal average. We have therefore eliminated the temporal dependence by lumping all data for a given month (the 50-day window previously described) to the month center. Our OA uses 50 nearest neighbors and with correlation scales that are largely isotropic; 100 km on the shelf and offshore for both the cross- and along-isobath directions, and 100 km cross-isobath and 200 km along-isobath along the shelf break (100 m $<$bottom depth $<$500 m). The scales vary smoothly over these ranges according to the steepness of the bottom topography. We have used a smoothed version of the bathymetry for the scale definition to avoid local abrupt changes in the correlation scale directions. The vertical scales are: 10 m for depths $<$100 m, 25 m for depths between 100 m and 500 m, and 50 m deeper than 500 m. Using the above scales, the monthly TS fields are interpolated onto the climatology domain level surfaces. Finally, the data contain density inversions and so each vertical TS profile is adjusted to remove static instabilities using a vertical mixing model based on *Mellor and Yamada* [1982].

4. Monthly Forcing and Response

Two sets of monthly solutions are computed from the COADS wind fields. First, the wind stress is applied to the large-scale domain that covers the western North Atlantic ocean. This is done solely to determine the elevation along the climatology domain boundary that results from far-field wind setup effects on the boundary. Otherwise the elevation on the climatology domain boundaries would be set to zero. Second, for the climatology domain, we compute the monthly mean wind response with elevation boundary conditions as just described and with the monthly COADS wind stresses. Results on the large-scale domain are not shown. The response on the climatology domain due to the objectively analyzed monthly mass fields is computed separately. Since the model is linear, these solution sets can be added together to obtain the total flow for each month.

For the climatological forcing and response, we illustrate important differences between monthly regimes with results for selected months: January, April, July, and October. We describe below the general meteorological and oceanic forcings, restricting our attention to the shelf region shoreward of the 300 m isobath. Display of horizontal fields of both the forcing and model response are shown on the shelf region as in Figure 1b. Observations of coincident TS pairs are spatially and temporarily sparse in the offshore region. The resulting TS objective analysis reveals the basic expected offshore density structure of the Gulf Stream region, but the transport is generally too weak, and some months (December and January, particularly) do not contain enough data to define the expected cross-stream structure.

4.1. COADS Forcing

Figure 6 shows the COADS surface wind velocity and surface atmospheric pressure for the representative months for a portion of the western North Atlantic that includes the Caribbean Sea, SAB, the lower MAB and extending off shore to Bermuda ($66°W$). The large perspective reveals the strong and persistent westward trade winds below about $27°N$. The following wind field climatology is consistent with that of *Weber and Blanton* [1980] and *Blanton et al.* [1985]. Winter conditions (January) show the high pressure ridge in place extending across the mid-latitudes, and steering the mean winds cross-shelf in most of the MAB and SAB. Winds are generally offshore with increased strength toward the MAB.

Spring (April) is a transition period where the strength of the high pressure region has decreased, and the ridge no longer extends westward into the SAB. The corresponding SAB wind field is largely variable and weakly poleward and along-shelf in the SAB region and generally weak and offshore over the lower MAB. From May to July (summer), the offshore high strengthens with winds strengthening in response. The Bermuda high dominates the region, with winds largely upwelling-favorable, being along-shelf and poleward along the entire eastern US coast. In August (not shown), the high pressure weakens with weak winds beginning to shift counterclockwise from the along-shelf poleward upwelling-favorable summer regime toward the along-shore equatorward, downwelling-favorable fall. Fall (October) shows along-shelf equatorward winds in the upper SAB, and onshore winds along the Florida coast. The high-pressure ridge has returned. **Figure 6.**

4.2. Hydrography

Surface and bottom salinities and temperatures from the monthly objective analysis are shown in Figures 7 and 8. Winter (December-March) shelf surface temperatures are generally uniform along isobath, ranging from shelf edge temperatures of about 20°C, to 10°C along the upper SAB coast. The Florida coast experiences an along-shelf temperature gradient of about 6°C. Salinity ranges from 36.5 to 33, with isohalines largely parallel to isobaths. In spring, shelf temperatures increase only marginally along the shelf break and by 5-10°C along the coast, causing the strong cross-shelf temperature gradient to be greatly reduced. Salinity increases slightly along the shelf break and decreases by about 1 along the coast. River discharge peaks in late March-early April [*Atkinson et al.*, 1983], and the offshore extent of the fresher water is evident along the Georgia coast. The surface salinity minimum of 32 occurs nearshore just south of the Savannah River entrance. Surface waters warm rapidly and by July surface temperature is relatively uniform at 28°C. Surface salinity is also more uniform at 35-36, with river discharge still evident near 32°N. Cooling of shelf waters occurs rapidly between September (not shown) and October. October isotherms lie along-shelf with a cross-shelf difference of about 4°C.

Bottom temperatures and salinities are shown in Figure 8. January bottom temperatures are generally along-shelf, except along the north Florida coast, with a strong cross-shelf difference of 10-12°C. Cooler shelf break waters are evident, with a bottom temperature maximum near 20°C occurring along the 100-m isobath. April bottom waters warm significantly by 6-8°C. By July, bottom temperatures reach their maximum near the coast, and upwelling of cooler water along the shelf break is evident. Unlike the July surface temperatures, the bottom temperature exhibits strong cross-shelf structure and is relatively constant along-shelf. October bottom temperatures range from about 21-25°C. Bottom salinity is generally along-shelf, with shelf break salinity constant at 36, and cross-shelf temperature differences ranging from 5°C in January to 2°C in July. In all months the cooler, more saline shelf break water is evident.

The surface density (σ_t) is shown in Figure 9 (top). January and October results indicate an along-shelf density difference of about 2 σ_t, with denser water in the northern part of the bight. The surface density gradient in April is mostly cross-shelf, with a small along-shelf component. July surface density is relatively constant with a small (1 σ_t) cross-shelf gradient in the middle of the domain.

Figure 9 (bottom) shows the density difference between the surface and bottom (σ_t^{s-b}). This difference is an indication of the strength of stratification, with more negative values indicating stronger stability of the water column. The bulk of the SAB shelf in January (winter) is marginally stable with $\sigma_t^{s-b} < -.5$, except along the shelf break where the warmer Gulf Stream water in the upper layers imposes slight thermal stratification. By April, the fresher water discharge from the Savannah River and surrounding rivers provides a less dense layer forming a strongly stratified region (-2 σ_t difference) at 32°N . The remainder of the shelf is also stratified. There is a general tendency for the midshelf to be stratified to a weaker extent than the inner and outer shelf. By July, the stratification is strong throughout the shelf, aligning along isobath and strongest at the shelf break. The strength of the stratification decreases by October with the near-shore inner shelf becoming weakly unstratified. In all months, the shelf break is permanently stratified. **Figure 7.**

Figure 8.

Figure 9.

Figure 10 shows the cross-shelf structure of the temperature, salinity and density fields for January, April, July, and October, along the transect shown in Figure 1b. In January, shelf waters are largely weakly stratified; temperature and salinity are well-mixed in the upper half of the water column, in the inner and midshelf. Warmer, saltier waters are evident in the lower part of the water column, in the mid- to outer shelf. The resulting σ_t shows a midshelf denser pool (>26 σ_t units). Freshwater river discharge from local rivers peak in March-April [*Atkinson et al.*, 1983], apparent in the April hydrography. The cross-shelf temperature difference is about 4°C ; the inner shelf has started to more strongly stratify. The fresher water front extends to about the 30-m isobath. As the summer progresses, strong stratification develops throughout all but the near-coast region of the shelf (July is representative of July-October); salinity is largely constant, and the temperature is strongly stratified, except in the midshelf upper 20 m of the water column. Surface temperatures are >28°C , with the upwelling of cooler (<26°C) waters at the shelf break. The increased storm activity in the fall begins (along with decreasing air temperature) to break down the stratification that developed over the summer. By October, the upper 10-20 m have become well-mixed but lower depths retain some stratification, particularly in salinity.

Along this transect, the vertically integrated cross-shelf density gradient $R_x = \int_{-h}^{0} \partial\rho/\partial x$ is positive inshore and negative in the outer shelf. The sign change (where $R_x = 0$) occurs at about midshelf in January, moves offshore in April and July, and moves back to midshelf by October. **Figure 10.**

4.3. Monthly Response to Wind Forcing

The model was run on the large-scale domain using the monthly wind stress fields (shown in Figure 6) to compute the large-scale response to the wind fields (not shown). The surface elevation for the climatology domain is extracted from the monthly large-scale solutions along the eastern and northern open water boundaries. The solutions to the wind fields (for the SAB shelf region) with the imposed boundary elevation from the large-scale domain are shown in Figure 11a where the surface elevation and surface velocity are given. January winds have a large cross-shelf component in the northern SAB, and turn more along-shelf toward the south. The along-shelf flow is equatorward ranging from 0.05 $\mathrm{m\,s^{-1}}$ in the inner shelf to near zero $\mathrm{m\,s^{-1}}$ on the widest part of the shelf. The Ekman-driven elevation setup is maximum along the Georgia coast (at about 31°N) at 0.025 m. April winds are significantly weaker and poleward. The resulting wind-driven flow is very weak; the flow is confined to the inner shelf where velocities are less than 0.02 $\mathrm{m\,s^{-1}}$ and the elevation response is flat. By July, the summer winds have strengthened and the shelf flow is poleward, with the associated coastal elevation setdown most negative in the southern SAB. This is effectively the reverse of the January (winter-time) situation. The winter-time atmospheric pattern is re-established by October, where the winds are along-shelf in the northern SAB and essentially onshore along the north Florida coast. The flow is equatorward at 0.025 $\mathrm{m\,s^{-1}}$. Coastal elevations are highest in the southern SAB. In all months for which the along-shelf flow is firmly established, the elevation response generally follows depth contours. Additionally, the steepest elevation response is along the north Florida coast, where the shelf is narrowest. **Figure 11.**

Figure 12 shows the January and July wind-driven solutions sampled along the 70-m isobath. The vertically averaged velocity has been subtracted from the total velocity. During January, downwelling winds drive surface Ekman flow onshore with surface elevation setup at the coast and compensating offshore flow in the lower water column. This is a persistent feature along the length of the shelf with the normal-component flow decreasing in intensity toward the north. The zero normal flow line is at about mid-depth (≈35 m) along the entire shelf break. The vertical velocity along the shelf break is negative at about $-5 \times 10^{-5}\ \mathrm{m\,s^{-1}}$ (not shown). The reverse (upwelling) scenario occurs in July. In all cases, the larger response is concentrated at the narrowest part of the shelf. In the summer-time upwelling numerical experiments of *Lorenzzetti et al.* [1987], a similar pattern was found despite the along-shelf component of windstress being stronger in the northern SAB. **Figure 12.**

4.4. Monthly Response to OA Hydrography

The monthly shelf depth-averaged flow and surface elevation responses to the monthly climatological TS distributions are shown in Figure 11b . Recall that this is the diagnostic response to the imposed, data-derived mass field. The presence of the Gulf Stream is evident, where the climatological signal of the jet dominates the response in the southern portion of the SAB shelf. In January, July, and October, the entire shelf flow is poleward, with inner and midshelf speeds of 0.01-0.1 $\mathrm{m\,s^{-1}}$. January flows are the strongest. The surface elevation generally is higher at the shelf break than at the coast location, and there is an elevation difference along the shelf break of 0.05-0.15 m. Figure 13 shows the elevation for January along the 70-m isobath. **Figure 13.**

4.5. Combined Solutions

The separate monthly solutions indicate that the density-driven flow is generally weaker in magnitude than the wind-driven flow in the inner shelf, and of the same magnitude in the midshelf. The combined (wind- plus density-driven flow) result (shown in Figure 11c) is that during October and January, there is net equatorward flow in the inner shelf, there is little net flow in the midshelf, and there is net poleward flow on the outer shelf. In July the winds are northeastward and thus the wind- and density-driven flows reinforce each other. The net result is that there is shelf-wide poleward flow. Finally, in April the net flow is very weak. In all cases, the effects of the Gulf Stream along the north Florida shelf appear to reach midshelf.

4.6. Comparison to Observations

As noted in the introduction, the accumulated current meter observations in the SAB have allowed the characterization of the mean circulation in schematic terms. Among the observation programs in the SAB, the Georgia Bight Experiments (GABEX I [*Lee and Atkinson*, 1983; *Lee et al.*, 1985] and GABEX II [*Lee and Pietrafesa*, 1987]) provide the broadest simultaneous spatial and temporal coverage. These programs occupied a series of cross-shelf transects from about 29°N to Cape Romain, South Carolina, at the locations shown in Figure 1. The offshelf extent of each transect terminated on the 75-m isobath, and the transects were occupied from 16 February-2 July, 1980, in GABEX I, and from 1 June-15 October, 1981, in GABEX II. Our model solutions have been averaged over the same months as the GABEX periods and sampled at the same horizontal positions. The results are shown in Figure 14.

Consistent with the 4-month means provided in *Lee et al.* [1985, see their figure 7] and *Lee and Pietrafesa* [1987, see their figure 3], along-shelf flows decrease in strength toward the coast, with surface flows stronger than bottom flows. The presence of the Gulf Stream along the shelf break is evident, including weaker shelf break flows in the northern part of the domain that are consistent with a more variable Gulf Stream frontal position downstream of the Charleston Bump [*Singer et al*, 1983]. There is also evidence in the model solutions of onshelf flow with depth on the north Florida shelf in both seasons. Midshelf flows are significantly weaker and with less vertical shear. Along-shelf flows in the diagnostic solutions are generally weaker than the observations. The averaged model solution for the GABEX I period shows weaker (and at one station equatorward) shelf break flow around 30 °N. This is most likely due to the aliasing of temporal variability into spatial variability in the objective analysis of the TS fields. The same cause may also explain the equatorward flow at the northern shelf break GABEX I station, although we note that persistent equatorward flows in this region are observed [*Singer et al*, 1983, among others], associated with seaward Gulf Stream deflection in the region. **Figure 14.**

Longterm (multi-year) stationary observations of velocity in the SAB have only recently become available. A set of platforms off the Georgia coast has been instrumented with meteorological and oceanographic sensors [*Seim*, 2000]. From this installation an acoustic Doppler current profiler (ADCP) data set (from the R6 tower location shown in Figure 1) and a wind velocity record (from the R2 tower location) are available from the period 01 May, 2000, through 30 June, 2002. The towers are about 20 km apart. The records were separated into winter and summer periods that correspond to periods when the COADS wind fields are generally (locally) in the same direction. These periods are December-February when the local winds are generally cross-shelf in the observation location and May-August when the winds have a strong along-shelf (poleward) component. Table 1 compares the along-shelf and cross-shelf winds at the tower location R2 with the COADS winds at the same location. The R2 along-shelf winds are stronger than the climatological (COADS) winds; and both are poleward during summer and equatorward during winter. The cross-shelf component is weaker in the R2 winds; both are onshore (negative) during summer and offshore during winter. There is little difference in the R2 observations between the averaging periods.

The R6 ADCP velocity was low-pass filtered at 40 h, rotated into along- and cross-shelf (the principal axis is 31° toward east from true north) and averaged over the two periods. The results are shown in Figure 15, for the depth-dependent flow, and the vertical averages are given in Table 2. Poleward flows and offshore flows are positive, and equatorward flows and onshore flows are negative.

The summer vertically averaged along-shelf flows at the R6 tower location are poleward at 0.02-0.03 $\mathrm{m\,s^{-1}}$ for both the model climatology and the two summer periods of observations. This is the result of generally wind-driven flow in the midshelf. The cross-shelf component is an order of magnitude smaller. Winter along-shelf flows in the combined model solutions are poleward at about 0.01 $\mathrm{m\,s^{-1}}$. The observed flow for the first winter period (December 2000 - February 2001) is equatorward, while for the second winter period it is poleward.

The observed cross-shelf flow (left panels in Figure 15) shows a reversal of flow with season. The surface flow is onshore (offshore) and the bottom flow is offshore (onshore) in winter (summer). Although the model cross-shelf flow is very weak ($<.01\ \mathrm{m\,s^{-1}}$), it exhibits the same flow reversal with season (see also Figure 17).

The winter along-shelf flow at R6 shows an interesting difference between the two winter time averaging periods. Based on the combined model solutions, R6 is situated near the edge of the "no net flow" region. The observed mean flow for the first winter period is actually equatorward and highly sheared. This is contrary to the model solution, but consistent with the winds during this period. However, the along-shelf current speed is stronger at the bottom than at the surface. This is a feature of the observations that is being investigated separately (H. Seim, personal communication). The average current for the second winter period is poleward, suggesting that despite the wind direction, baroclinic effects can control the net flow.

Figure 15.

Table 1.

Table 2.

5. Discussion

The results show the seasonal heating and cooling of the SAB shelf waters. In conjunction with the net heat flux estimates from *Atkinson et al.* [1983], who examined the net heat flux for the SAB by computing the temperature change in the top 10 m of shelf water, the following (previously observed) cycle is evident. Winter stratification on the inner to midshelf is weak at less than 0.5 σ_t . The shelf break is permanently stratified, with the strongest stratification in summer. Surface waters warm significantly between March and April, as the net heat flux becomes positive (into the ocean). The *net* heat flux peaks in May-June at about 80-90 Wm^{-2} [*Atkinson et al.*, 1983], but surface waters continue to warm until July where they remain at about $28^{\circ}\mathrm{C}$ through September. Stratification is maximum during these months. The net heat flux becomes negative (cooling) by September and the shelf cools rapidly until weak stratification returns in November. A main result, based on the TS diagram distribution (Figure 4) and the cross-shelf transects, is that both temperature and salinity observations are necessary to specify the density distribution on the shelf.

A consequence of the long-term averaging of the TS climatology is that the SAB shelf is essentially permanently stratified on long timescales, even during winter when the heat loss [*Atkinson et al.*, 1983] and extra-tropical storm activity [*Weisberg and Pietrafesa*, 1983] are maximum. The denser water in the northern SAB subducts under the lighter water in the southern SAB. Figure 16 shows the monthly top-bottom σ_t difference from the monthly TS climatology at the tower R2 location. The winter months (December-February) have small yet still negative top-bottom σ_t differences. This difference increases through June to about $-1.8\ \mathrm{kg\,m^{-3}}$. As the deeper shelf waters continue to warm, this density difference decreases, and continues to decrease through the winter. Recent observations from the R2 tower indicate that monthly average stratification may not be as strong as in the climatology (H. Seim, personal communication).

The along-shelf poleward flow seen in the density-driven solutions (except in April), which is strongest in January and October, results from the along-shelf elevation gradient that is set up by the offshelf Gulf Stream and density structure. The elevation decreases in January by about 0.12 m in 6° latitude, which results in an along-shelf slope of about -2×10^{-7}. For July and October, the elevation decrease is about 0.05 m in 6° latitude, or a slope of -1×10^{-7}. These values are in agreement with the range of values from previous studies in the SAB [*Sturges*, 1974; *Atkinson et al.*, 1983; *Lee et al.*, 1984; *Lee and Pietrafesa*, 1987]. The resulting poleward shelf flow decreases in speed toward the coast. The smaller value is the same as that imposed in *Werner et al.* [1993], who found that a slope of -1×10^{-7} drove the shelf-wide flow poleward, with speeds ranging from 0.05 to 0.01 $\mathrm{m\,s^{-1}}$ toward the coast. This is consistent with our July and October results. Unlike previous model studies of the SAB (as noted in the Introduction) which imposed this gradient as a shelf edge boundary condition, the gradient arises from the specified mass fields and model response, with the elevation on the northern boundary having been specified. The southern boundary elevation is computed to geostrophically balance the transport that arises from the density field.

Figure 17 shows vertical profiles from the separate model solutions averaged over the ADCP observation period described previously at the R6 tower location. Over both periods, cross-shelf flows are weak (<.01 $\mathrm{m\,s^{-1}}$) in both the wind- and density-driven solutions. Along-shelf flows are stronger (.01-.02 $\mathrm{m\,s^{-1}}$), with the wind-driven flow being poleward during the summer period and equatorward in the winter period. The density-driven flow is poleward during both periods (.02-.03 $\mathrm{m\,s^{-1}}$). The total along-shelf flow at this location is also poleward, with the density-driven flow compensating for the wind-driven component in winter and reinforcing the wind-driven flow in summer.

Figure 16.

Figure 17.

The derived density fields have significant cross-shelf structure. Despite the presence of cross-shelf density gradients, the contribution of the baroclinic pressure gradient force terms is small. Momentum term estimates (not shown) from the model density-driven solutions indicate that the along-shelf flow seen in July, October, and particularly January is driven primarily by the cross-shelf elevation gradient. The direct contribution from the density field is an order of magnitude smaller than the barotropic pressure gradient component. In the outer shelf, the cross-shelf baroclinic term is of equal importance to the cross-shelf elevation gradient.

The April shelf break density-driven flow (Figure 11b) poleward of the Charleston Bump is probably not representative of the climatological mean, although we expect larger variability in this region. In fact, it is evident (not shown) from the offshelf objective analysis that the TS observations were biased toward a more offshelf Gulf Stream position. The resulting along-shelf elevation slope along the 70-m isobath is smaller than that during other months, thus not providing the dominant component to the force balance. The result is that the baroclinic pressure gradient terms are locally more important. In periods when the Gulf Stream is in a more offshelf position, the local mass field distribution may play a more important role in circulation. On shorter timescales, strong cross-shelf density gradients set up by freshwater river discharge have been shown to be a significant feature in the inner shelf [*Blanton*, 1981; *Kourafalou et al.*, 1996; *Chen et al.*, 1999].

The combined solutions for the monthly SAB response (Figure 11) are in general agreement at the shelf break with the schematic seasonal circulation of *Lee et al.* [1991]; the flow is poleward along the SAB outer shelf, except for the Charleston Bump gyre, which is marginally present in our climatology. Our solutions in the midshelf indicate that the flow is composed of approximately equal contributions from wind- and density-driven components. In summer these components reinforce each other; in winter, they are largely equal but opposite. Observations of the midshelf flow, however, suggest that the mean midshelf flow is generally poleward [*Lee et al.*, 1991]. The inner shelf is dominated by wind-driven flow.

The most significant difference from the *Atkinson et al.* [1983] climatology appears in the October surface salinity. Inner and midshelf salinities reach 32 in their results. This is as low as the salinities during the spring river discharge maxima. Our objectively derived October surface and bottom salinity does not show such low salinity. Rather, a relatively smooth transition between months occurs. The source of the low salinity water is not clear. There is generally not enough river discharge in fall to produce a large volume of low salinity water in October.

The qualitative character of the diagnostic solutions is relatively insensitive to alternative specifications of bottom stress and vertical mixing. Horizontally constant bottom stress and vertically constant vertical mixing affect the strength of the diagnostic response and shift the position of the "no net flow" regions in the midshelf on and offshore. However, the primary sensitivity of the solutions developed here is likely to be stratification effects on the vertical mixing and bottom stress regime. The vertical eddy viscosity is affected by stratification [*Mellor and Yamada*, 1982], which appears to be present in all months on climatological timescales. Generally, the presence of a pycnocline (stratification) tends to decouple upper and lower layers of the water column. *Naimie et al.* [1994] and *Han et al.* [1997] (among others) have shown the sensitivity of model solutions to levels of stratification in tidally driven flows; tidally-driven mixing is confined to the lower layers with increased velocities in the upper layers. *Weisberg et al.* [2001] have recently shown the sensitivity of the subtidal wind-driven coastal water levels to the presence of stratification in a numerical experiment of spring-time circulation on the west Florida shelf. Considerable improvement in the comparison between modeled and observed water level was demonstrated by inclusion of an appropriate level of stratification with basic spring-time characteristics, as opposed to the homogeneous case.

We thus consider our results to be an initial climatology consisting of a diagnosis of the objectively analyzed TS fields with specified mixing. The coupling of the mixing environment to stratification will require prognostic simulations, forced by tides, climatological heat flux and winds, and river discharge (a significant fresh water source in spring-time [*Atkinson et al.*, 1983]).

6. Conclusions

We have developed monthly temperature and salinity fields for the South Atlantic Bight shelf based on the objective analysis of available NODC data that show good agreement with the published climatology of *Atkinson et al.* [1983], with the exception of the month of October. The annual heating and cooling of the shelf waters and freshwater river outflow is captured in the monthly TS fields. The associated climatological solutions for the SAB shelf, forced by monthly averaged observed winds and temperature and salinity distributions were computed with a steady-state finite element model, made separable due to the linearity of the model. The model solutions confirm previous results in that the wind-driven dynamics are primarily Ekman-like, with strong upwelling and downwelling along the north Florida shelf. The density-driven flow on the inner shelf is generally weak and dominated by the wind-driven along-shelf flow, except when the wind is weak (April). A more important forcing in the outer shelf is the along-shelf elevation field associated with the offshelf density field. This provides an cross-shelf elevation gradient that, in conjunction with the baroclinic pressure gradient, generally drives poleward flow.

Historical observational data and observations from the permanent tower installations are not long enough to represent climatological estimates of the flow. The comparison to recent *in situ* observations is encouraging, as is the general agreement with previous models of SAB circulation and the GABEX current meter data. However, the observations also show that the fluctuating current is highly variable and due to mechanisms not represented in the climatological wind and TS fields. We expect, however, that the long timeseries from the tower installations that will eventually cover a large portion of the Georgia coast, will be valuable in assessing the character of these and future model solutions.

One immediate use of the monthly TS fields and resulting baroclinic circulation we have derived is for initialization of 2-10 day prognostic model simulations for process-oriented studies on the Georgia shelf. Additionally, the TS climatology will be used to initialize a limited-area domain for an operational system designed for real-time hindcasting and forecasting of currents and water levels on the Georgia shelf. Of particular interest is hindcasting the weather-band (subtidal) response on the shelf.

A more complete offshelf database with XBT data and derived salinity from appropriately defined TS curves will improve the offshelf climatology. The current level of temporal and spatial resolution of the data is not adequate enough to provide an unbiased estimate of the offshelf climatology. In some months, there is insufficient data in the offshelf region to adequately represent the Gulf Stream isopycnic structure and resulting transport. However, the shelf resolution appears adequate.

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Figure Captions

Figure 1. Finite element model climatology domain used for climatological computations. a) The mesh contains 9606 nodes, 18691 elements. The 25, 50, 100, 500, 750, and 1000-m isobaths are shown. b) The SAB continental shelf region used to display model forcing and response. This is a subregion of the mesh shown in a) that covers the shelf out to the 300-m isobath. The thick line is the location of the cross-shelf transect discussed later. The locations of two observation stations (R2 and R6) are shown with triangles, and the positions of the Georgia Bight Experiment (GABEX) mooring array are shown with diamonds. The 25, 50, 100, and 200-m isobaths are shown.

Figure 2. Left: Profiles of vertical eddy viscosity N_z ($\mathrm{m^2\,s^{-1}}$) generated by a tidally driven numerical model and specified as the vertical mixing parameterization on the steady-state model FUNDY5SP. The profiles are taken along the transect shown in Figure 1. Right: RMS M_2 bottom speed ($\mathrm{m\,s^{-1}}$) used to compute the linearized bottom slip coefficient A_k.

Figure 3. NODC station locations in the SAB by month. The data for each month spans 50 days centered on day 15. For example, January data are from the range 20 December through 10 February. The climatology domain boundary is also shown.

Figure 4. TS diagram distribution. Salinity is on the abscissa; temperature is on the ordinate. The TS curve axis scales for all squares are shown with the separate diagram in the lower-left. Shelf data ($<$400 m) are in green; deeper water ($>$400 m) data are in red. For the deep squares, the average TS curve is drawn in blank. The 50, 100, 500, 750, 1000, 2000, 3000, 4000-m isobaths are shown.

Figure 5. NODC monthly temporal distribution. The middle of each month is marked by the vertical line, and the abscissa is in Julian days. The numbers in the upper right of each panel are the total TS pairs available for the month.

Figure 6. Monthly COADS surface wind velocity ($\mathrm{m\,s^{-1}}$) and atmospheric pressure (mb) for a portion of the western North Atlantic. The climatology domain boundary is included.

Figure 7. SAB monthly surface temperature (top) and salinity (bottom) objective analysis.

Figure 8. SAB monthly bottom temperature (top) and salinity (bottom) objective analysis.

Figure 9. Top: SAB monthly surface σ_t. Bottom: SAB monthly top-bottom σ_t difference. More negative values indicate stronger stratification, and zero indicates neutral stability.

Figure 10. Monthly temperature (a), salinity (b), and σ_t (c) along cross-shelf transect shown in Figure 1. The contour intervals are 2°C, 1 PSU, and .5 σ_t units, respectively.

Figure 11. SAB monthly response to forcings. In all cases, velocities exceeding .5 $\mathrm{m\,s^{-1}}$ are not shown. The velocity has been interpolated to an equally spaced grid for clarity. a) Surface elevation and depth-averaged velocity response to the COADS monthly wind fields, with imposed open boundary elevation from large-scale solutions. The elevation range and contour interval are given next to each month. Elevations nearest to zero are at the shelf break. b) Surface elevation and depth-averaged response to the climatological mass fields. Elevation contours start at .025 m near the coast with a contour interval of .025 m. Largest elevations are at the shelf break and the elevation at the northwest corner of the domain is set to 0 m for the density-driven solutions. c) Combined (wind- plus density-driven) solutions. Elevation is not shown. The R6 tower location is indicated with an asterisk. Note that the vector scale in a) is .05 $\mathrm{m\,s^{-1}}$, and in b) and c) it is .1 $\mathrm{m\,s^{-1}}$.

Figure 12. Model wind-driven horizontal velocity ($\mathrm{m\,s^{-1}}$) normal to the shelf break (along the 70-m isobath) for January (a) and July (b). The depth-averaged normal velocity has been removed. In the local rotation, flow onshelf is POSITIVE. The white lines indicate zero $\mathrm{m\,s^{-1}}$.

Figure 13. Along-shelf free-surface elevation along the 70-m isobath for the diagnosis of the January mass field. The resulting along-shelf elevation difference is about $-.12$ m in 6° latitude giving an along-shelf slope of -2×10^{-7}.

Figure 14. Combined climatological solutions sampled at the a) GABEX I and b) GABEX II mooring locations. Upper level (17 m below surface) velocities are shown with thin vectors; lower level (3 m above bottom) are shown with thick vectors. The GABEX moorings shown were stationed at the 28, 40, and 75-m isobath. The model bathymetry is not completely coincident with that reported in the GABEX programs.

Figure 15. Comparison of ADCP and climatology velocity profiles. “Seasonal” and averaged ADCP velocity profiles from tower R6 shown in Figure 1. Data have been rotated into along-shelf (right) and cross-shelf (left) directions. The winter season (top) is over the periods December through February for 2000-01 (solid, thin) and 2001-02 (dashed, thin). Summer (bottom) is defined as May through August for 2000 (solid, thin) and 2001 (dashed, thin). Thick lines are the model solutions; thin lines are the ADCP averaged profiles with one standard deviation. For the along-shelf panels, poleward flow is positive and equatorward flow is negative. For the cross-shelf panels, offshore flow is positive and onshore flow is negative.

Figure 16. Monthly vertical σ_t difference at the tower location R2 from the monthly climatology.

Figure 17. Model climatological velocity profiles at the R6 tower location shown in Figure 1. Velocities have been rotated into along-shelf (right) and cross-shelf (left) directions. The winter season (top) is over the period December through February and summer (bottom) is defined as May through August. The density-driven flow is shown with circles, the wind-driven flow with plus symbols, and the combined profiles (the same as in Figure 15) with solid line. For the along-shelf panels, poleward flow is positive and equatorward flow is negative. For the cross-shelf panels, offshore flow is positive and onshore flow is negative. Note that the scale on the abscissa is different than that in Figure 15.

Tables

	Dec-Feb		May-Aug	
	CS	LS	CS	LS
COADS	1.94	-0.62	-0.93	1.61
R2,1	1.63	-1.61	-0.51	2.40
R2,2	1.46	-1.01	-0.35	1.89

Table 1. Comparison of mean wind velocity ($\mathrm{m\,s^{-1}}$) at location of tower R2. The data have been rotated into cross-shelf (CS) and along-shelf (LS) orientation of the R6 station (31° clockwise from true north). Top row is from the COADS monthly summary groups over the years 1975-1999. Middle row is from the tower R2 meteorological station over the periods December through February for 2000-01 and May through August 2000. Bottom row is from the tower R2 meteorological station over the periods December through February for 2001-02 and May through August 2001. For the along-shelf values, poleward flow is positive and equatorward flow is negative. For the cross-shelf values, offshore flow is positive and onshore flow is negative.

	Dec-Feb		May-Aug	
	CS	LS	CS	LS
CLIM	0.002	0.011	0.001	0.023
R6,1	-0.004	-0.013	0.003	0.033
R6,2	-0.003	0.008	-0.001	0.021

Table 2. Comparison of mean cross-shelf (CS) and along-shelf (LS) depth averaged velocity ($\mathrm{m\,s^{-1}}$) at the offshore tower location shown in Figure 1. The data have been rotated into cross-shelf and cross-shelf orientation of 31° clockwise from true north. Top row is from the combined (wind- plus density-driven) climatology solutions. The middle (R6,1) and bottom (R6,2) rows are from the R6 tower for summer 2000 and winter 2000-01 (middle) and summer 2001 and winter 2001-02 (bottom). For the along-shelf values, poleward flow is positive and equatorward flow is negative. For the cross-shelf values, offshore flow is positive and onshore flow is negative.

Figures

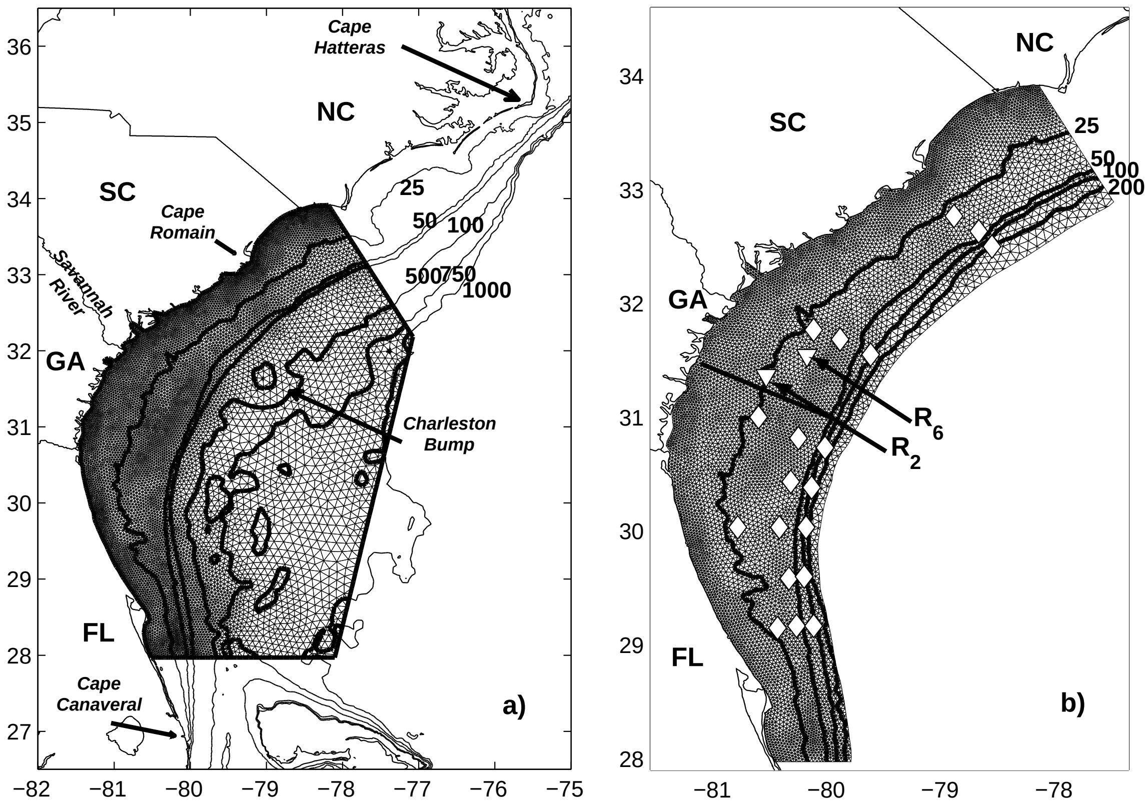

Figure 1. Finite element model climatology domain used for climatological computations. a) The mesh contains 9606 nodes, 18691 elements. The 25, 50, 100, 500, 750, and 1000-m isobaths are shown. b) The SAB continental shelf region used to display model forcing and response. This is a subregion of the mesh shown in a) that covers the shelf out to the 300-m isobath. The thick line is the location of the cross-shelf transect discussed later. The locations of two observation stations (R2 and R6) are shown with triangles, and the positions of the Georgia Bight Experiment (GABEX) mooring array are shown with diamonds. The 25, 50, 100, and 200-m isobaths are shown.

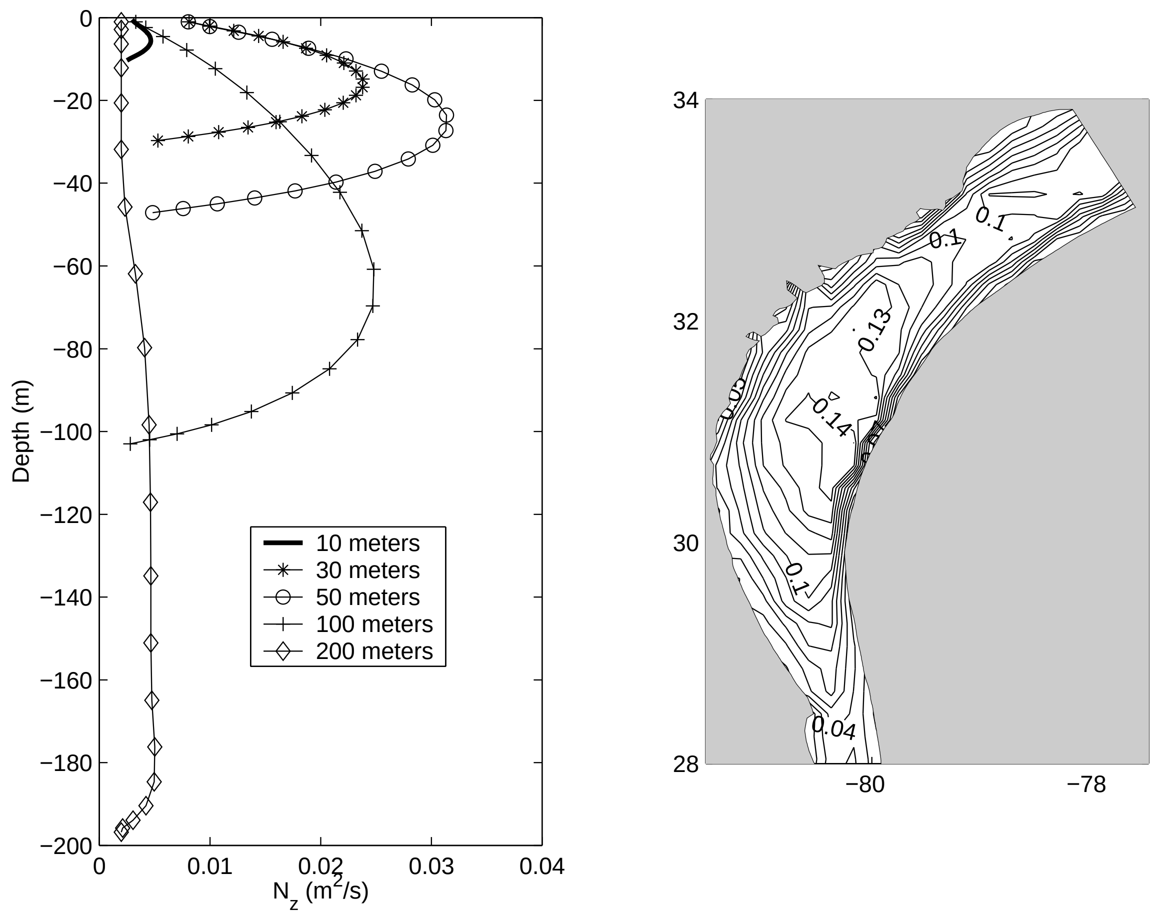

Figure 2. Left: Profiles of vertical eddy viscosity N_z ($\mathrm{m}^2\,\mathrm{s}^{-1}$) generated by a tidally driven numerical model and specified as the vertical mixing parameterization on the steady-state model FUNDY5SP. The profiles are taken along the transect shown in Figure 1. Right: RMS M_2 bottom speed ($\mathrm{m\,s}^{-1}$) used to compute the linearized bottom slip coefficient A_k .

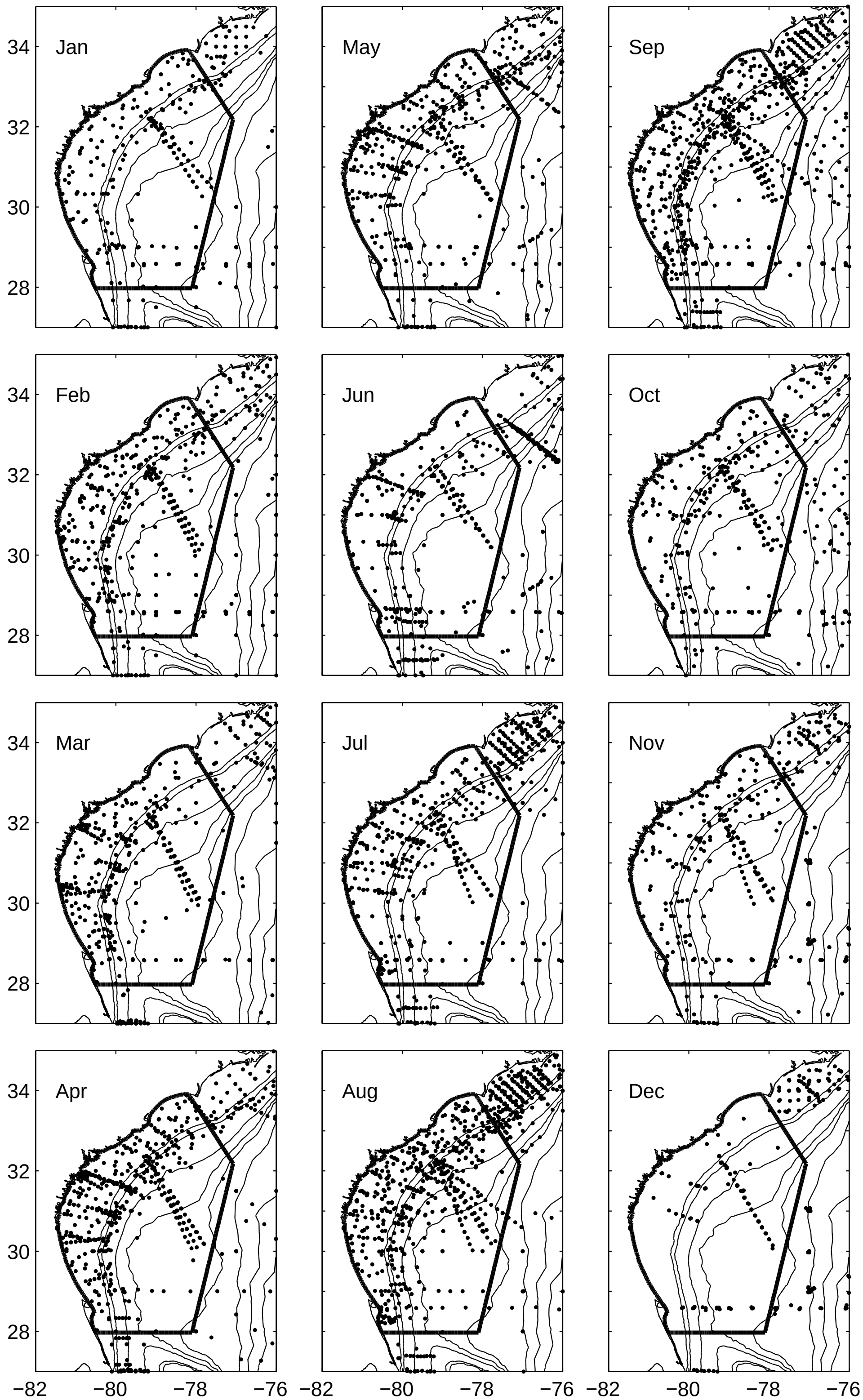

Figure 3. NODC station locations in the SAB by month. The data for each month spans 50 days centered on day 15. For example, January data are from the range 20 December through 10 February. The climatology domain boundary is also shown.

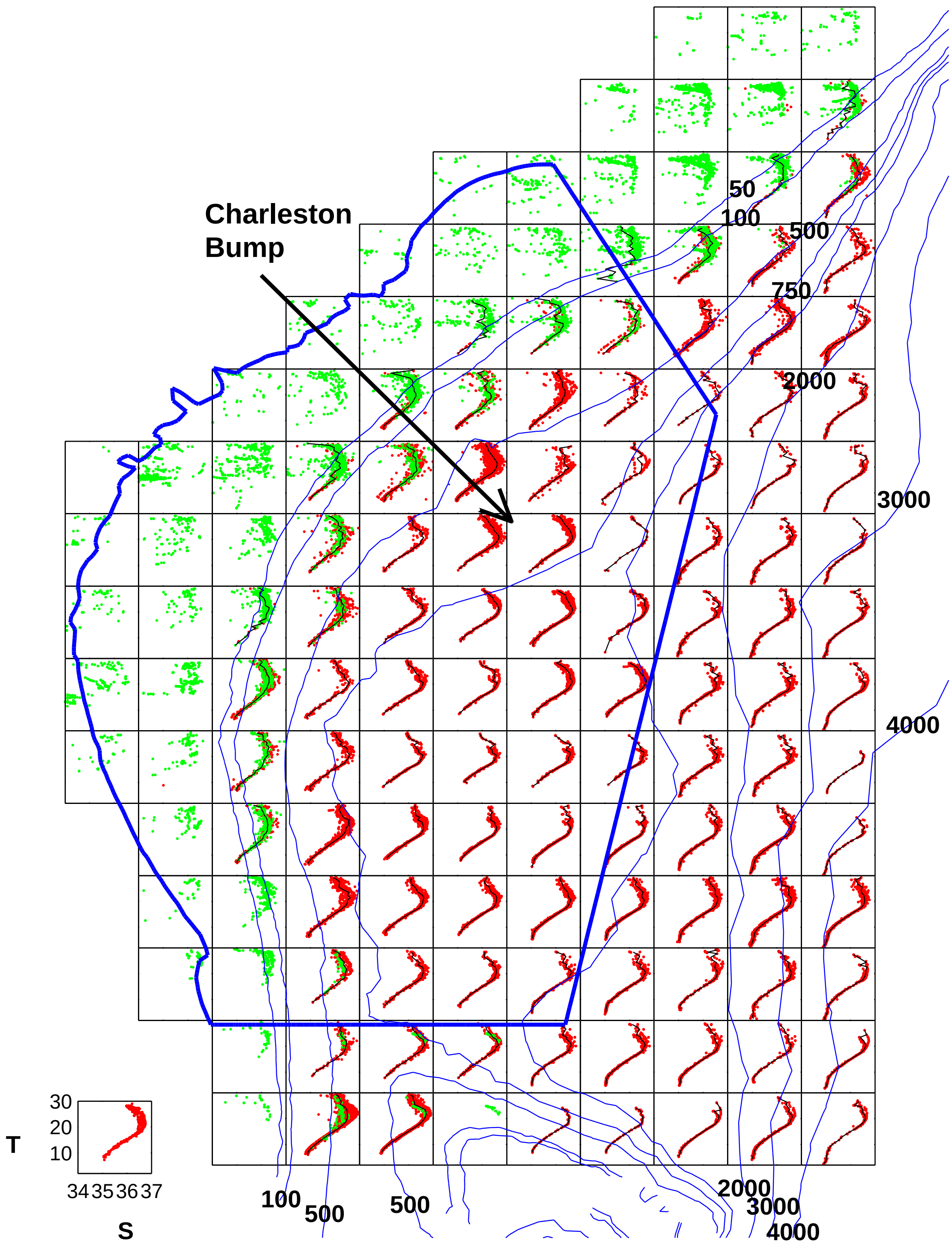

Figure 4. TS diagram distribution. Salinity is on the abscissa; temperature is on the ordinate. The TS curve axis scales for all squares are shown with the separate diagram in the lower-left. Shelf data (<400 m) are in green; deeper water (>400 m) data are in red. For the deep squares, the average TS curve is drawn in blank. The 50, 100, 500, 750, 1000, 2000, 3000, 4000-m isobaths are shown.

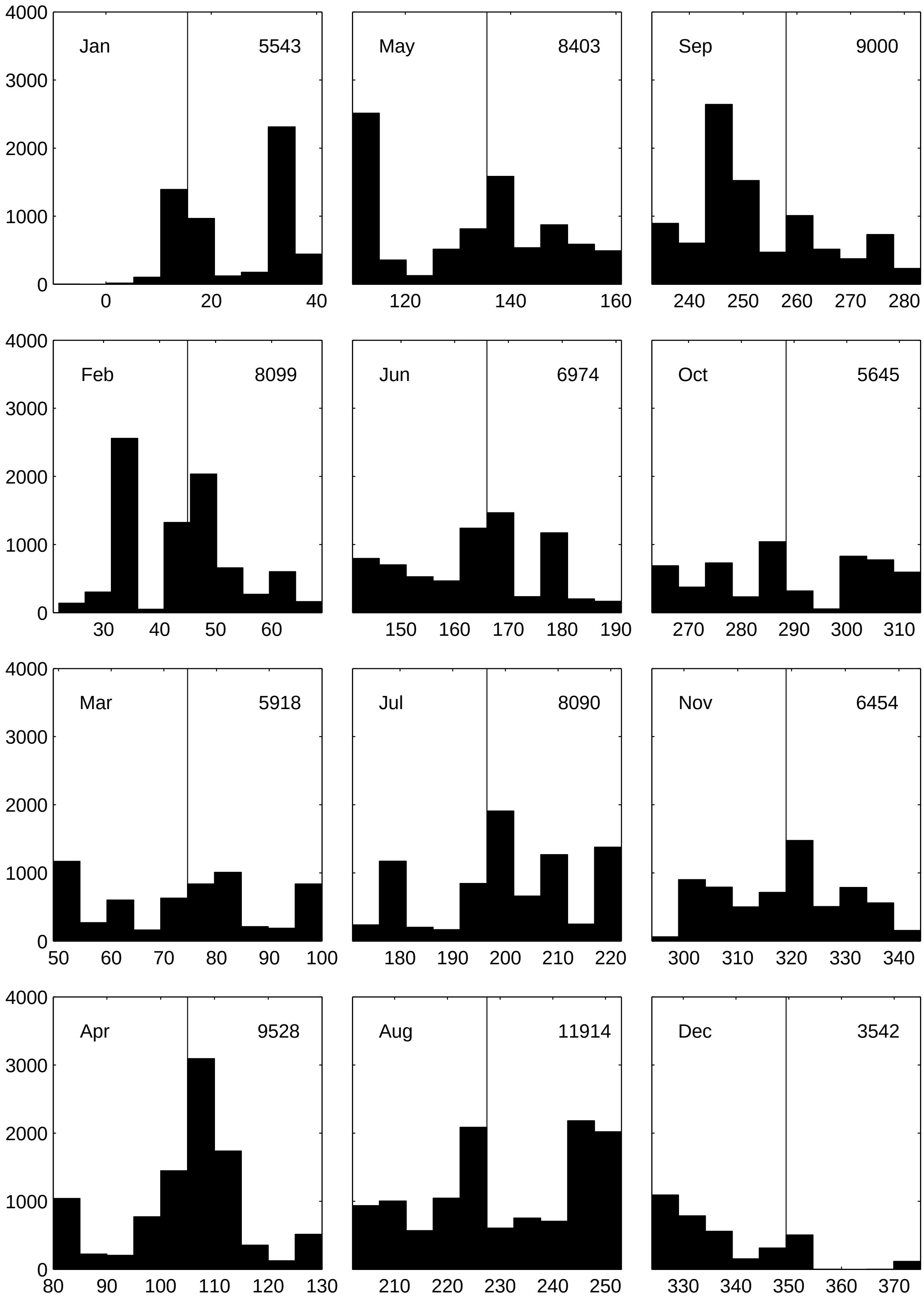

Figure 5. NODC monthly temporal distribution. The middle of each month is marked by the vertical line, and the abscissa is in Julian days. The numbers in the upper right of each panel are the total TS pairs available for the month.

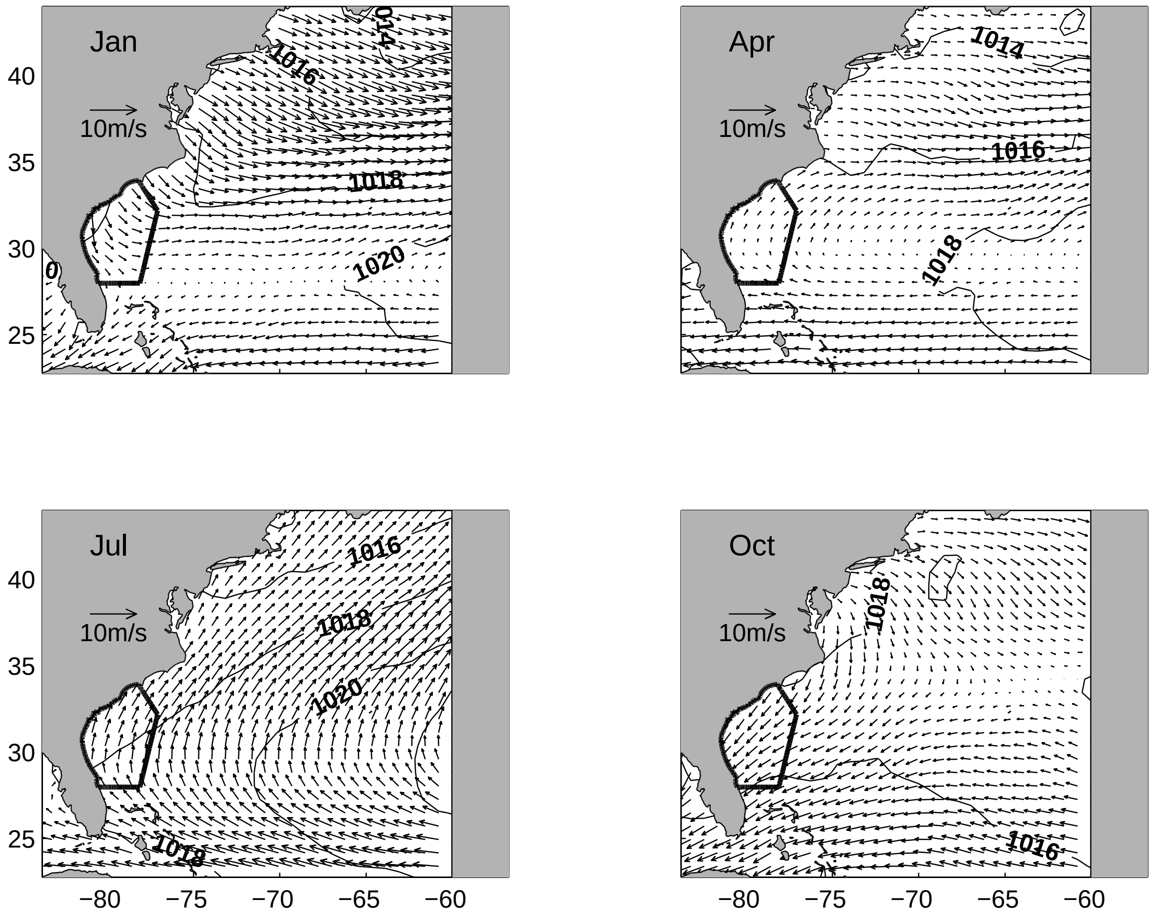

Figure 6. Monthly COADS surface wind velocity ($\mathrm{m\,s^{-1}}$) and atmospheric pressure (mb) for a portion of the western North Atlantic. The climatology domain boundary is included.

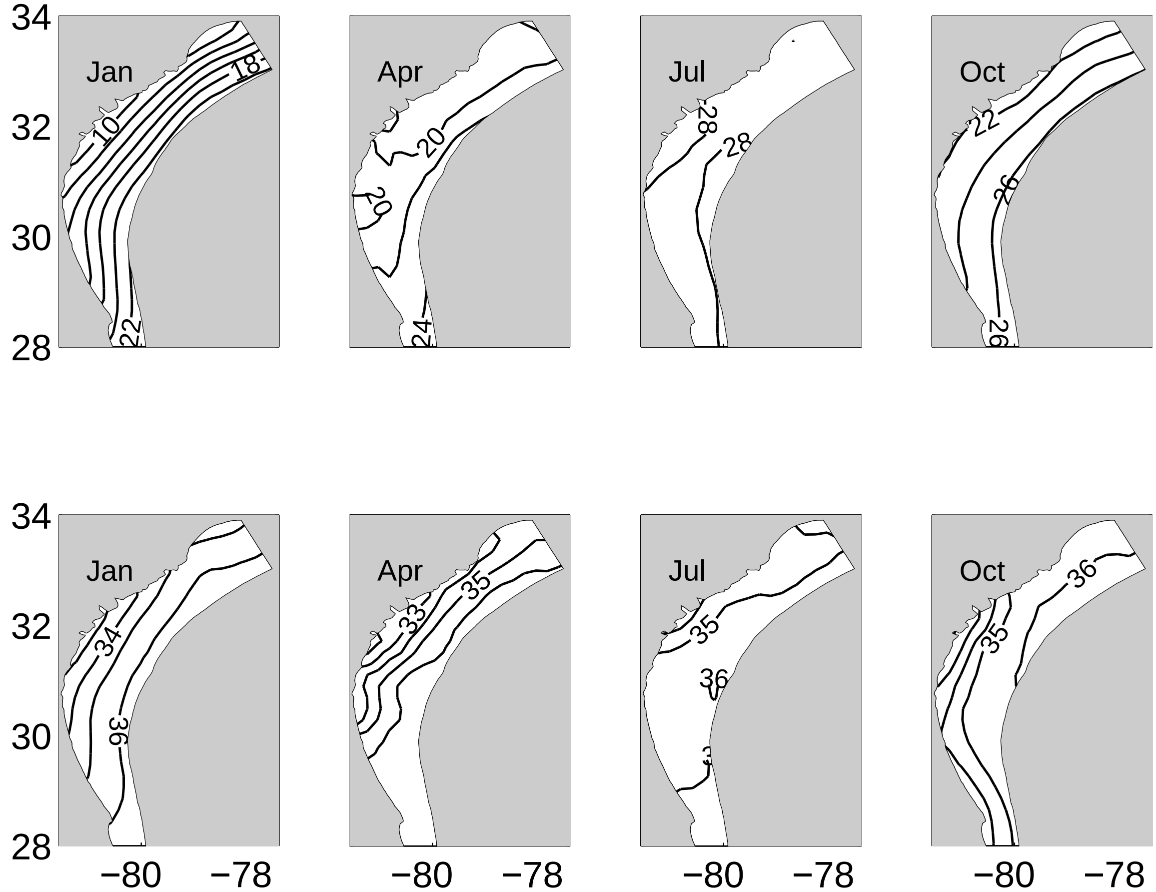

Figure 7. SAB monthly surface temperature (top) and salinity (bottom) objective analysis.

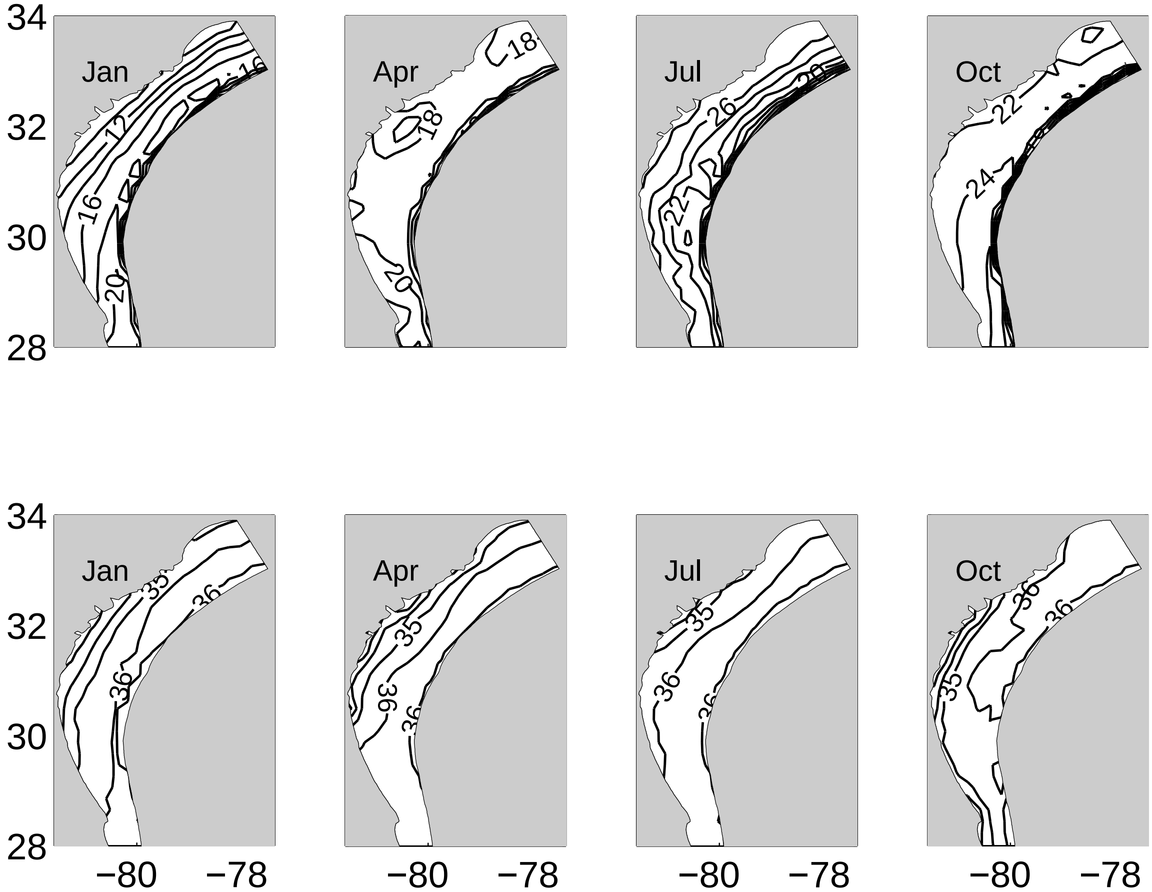

Figure 8. SAB monthly bottom temperature (top) and salinity (bottom) objective analysis.

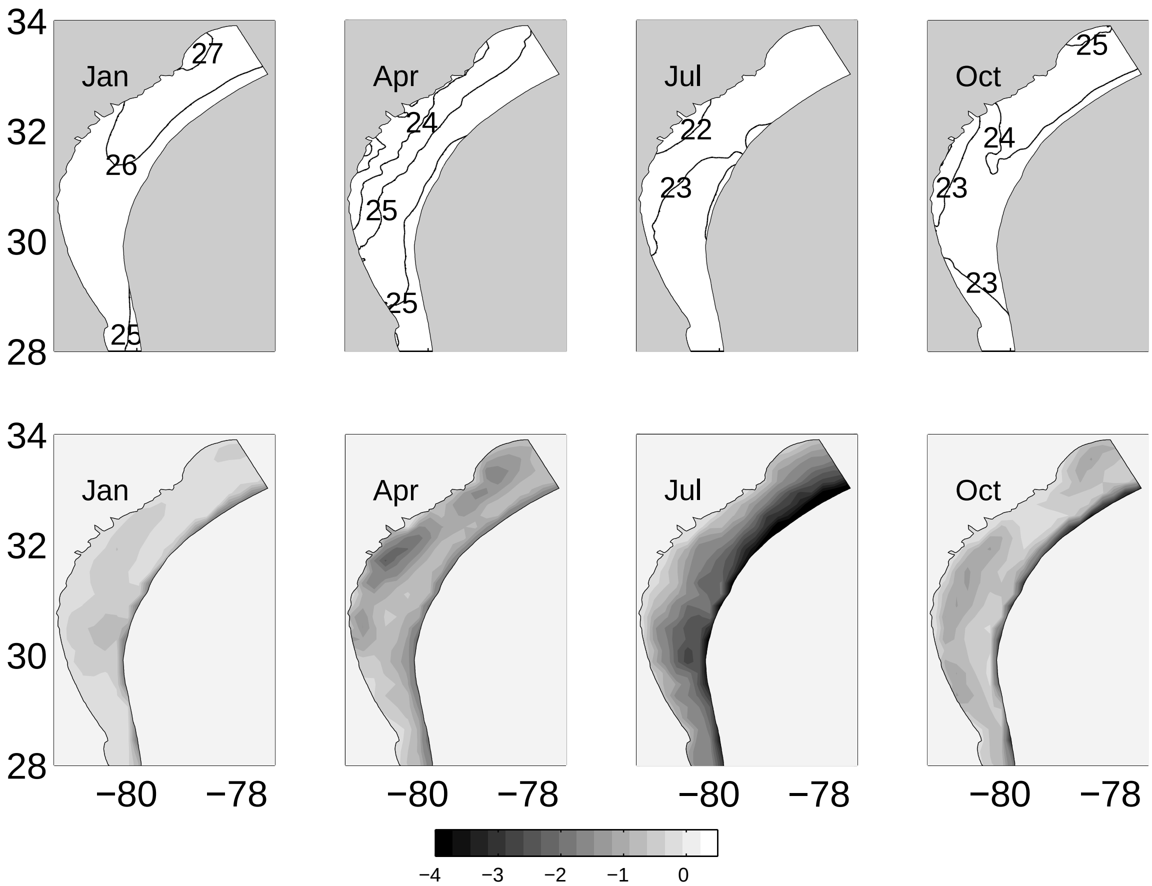

Figure 9. Top: SAB monthly surface σ_t. Bottom: SAB monthly top-bottom σ_t difference. More negative values indicate stronger stratification, and zero indicates neutral stability.

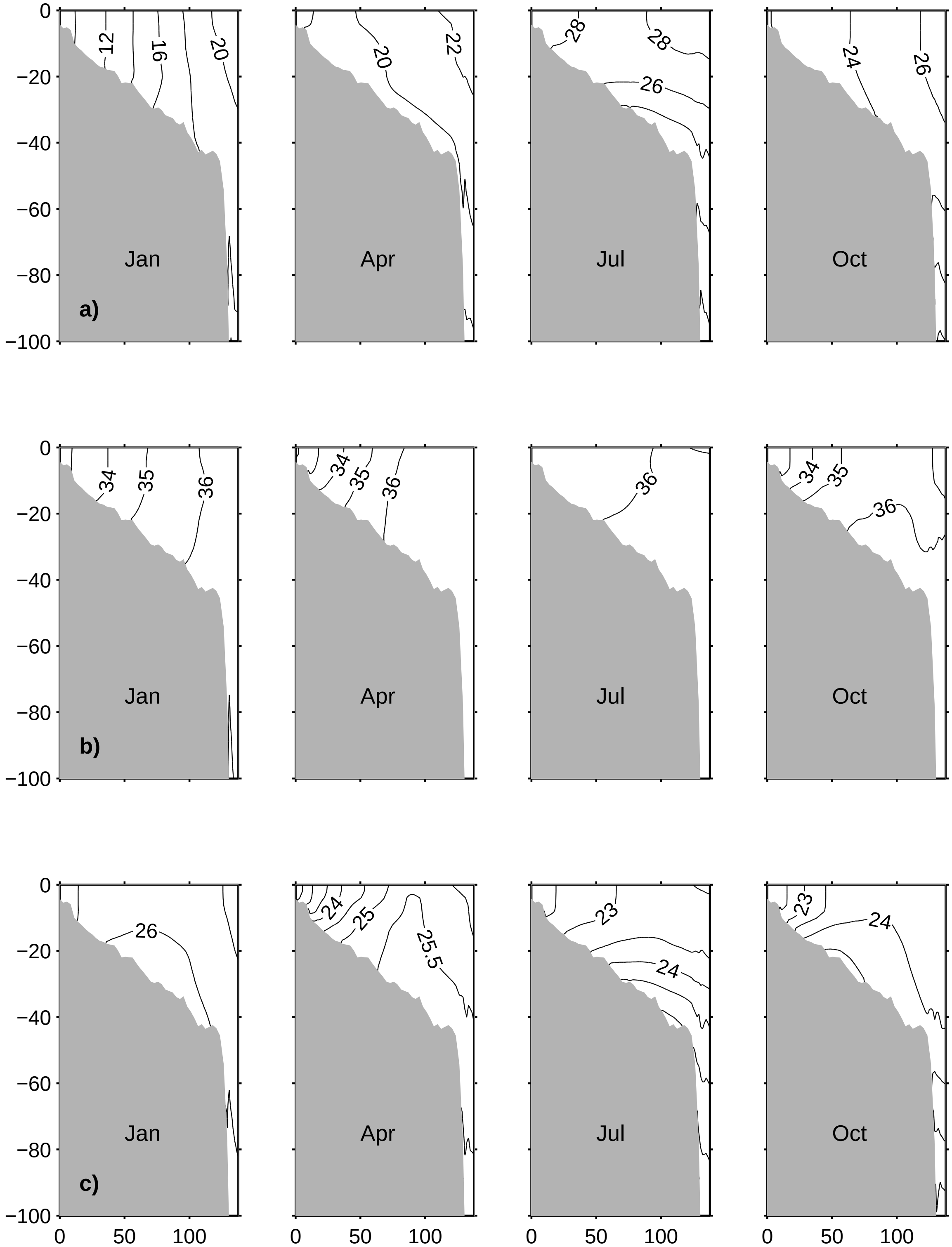

Figure 10. Monthly temperature (a), salinity (b), and σ_t (c) along cross-shelf transect shown in Figure 1. The contour intervals are 2°C, 1 PSU, and .5 σ_t units, respectively.

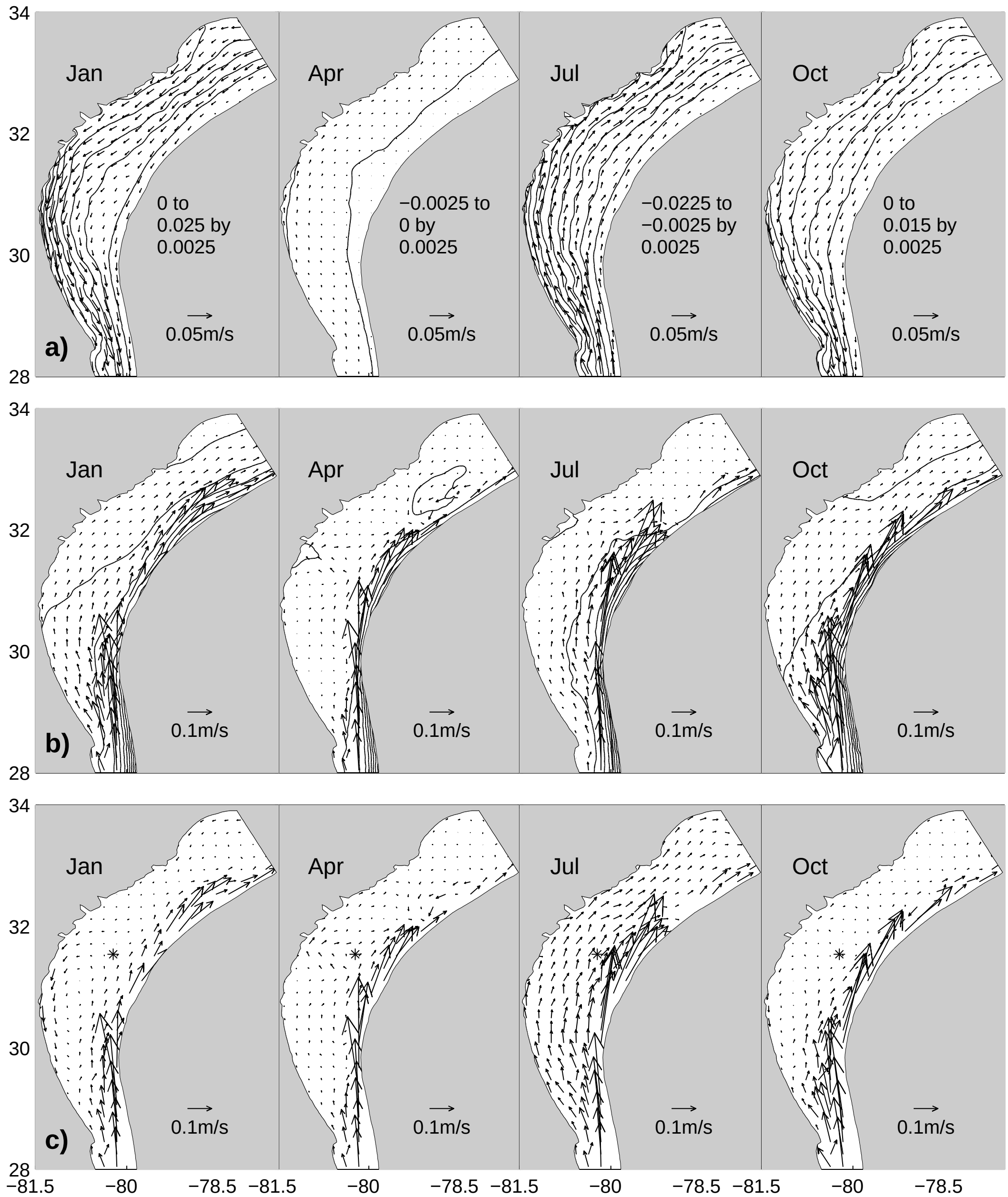

Figure 11. SAB monthly response to forcings. In all cases, velocities exceeding .5 $\mathrm{m\,s^{-1}}$ are not shown. The velocity has been interpolated to an equally spaced grid for clarity. a) Surface elevation and depth-averaged velocity response to the COADS monthly wind fields, with imposed open boundary elevation from large-scale solutions. The elevation range and contour interval are given next to each month. Elevations nearest to zero are at the shelf break. b) Surface elevation and depth-averaged response to the climatological mass fields. Elevation contours start at .025 m near the coast with a contour interval of .025 m. Largest elevations are at the shelf break and the elevation at the northwest corner of the domain is set to 0 m for the density-driven solutions. c) Combined (wind- plus density-driven) solutions. Elevation is not shown. The R6 tower location is indicated with an asterisk. Note that the vector scale in a) is .05 $\mathrm{m\,s^{-1}}$, and in b) and c) it is .1 $\mathrm{m\,s^{-1}}$.

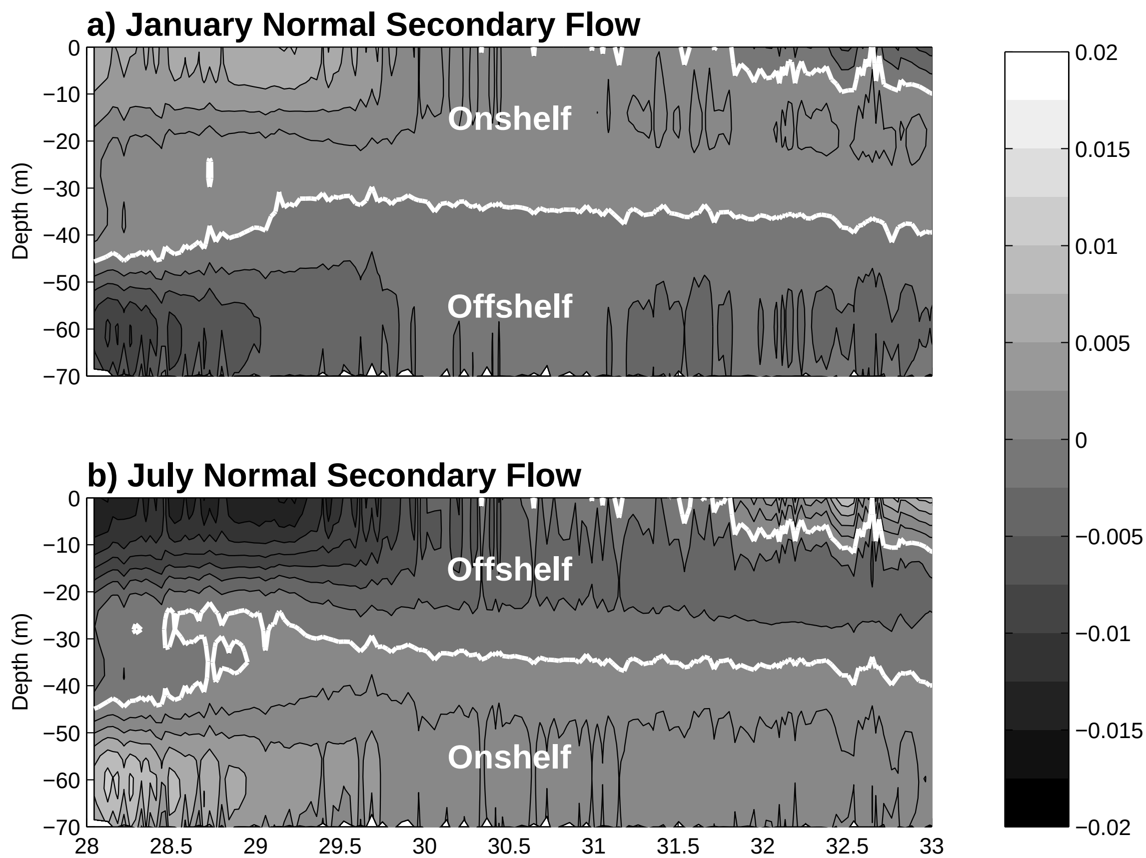

Figure 12. Model wind-driven horizontal velocity ($\mathrm{m\,s^{-1}}$) normal to the shelf break (along the 70-m isobath) for January (a) and July (b). The depth-averaged normal velocity has been removed. In the local rotation, flow onshelf is POSITIVE. The white lines indicate zero $\mathrm{m\,s^{-1}}$.

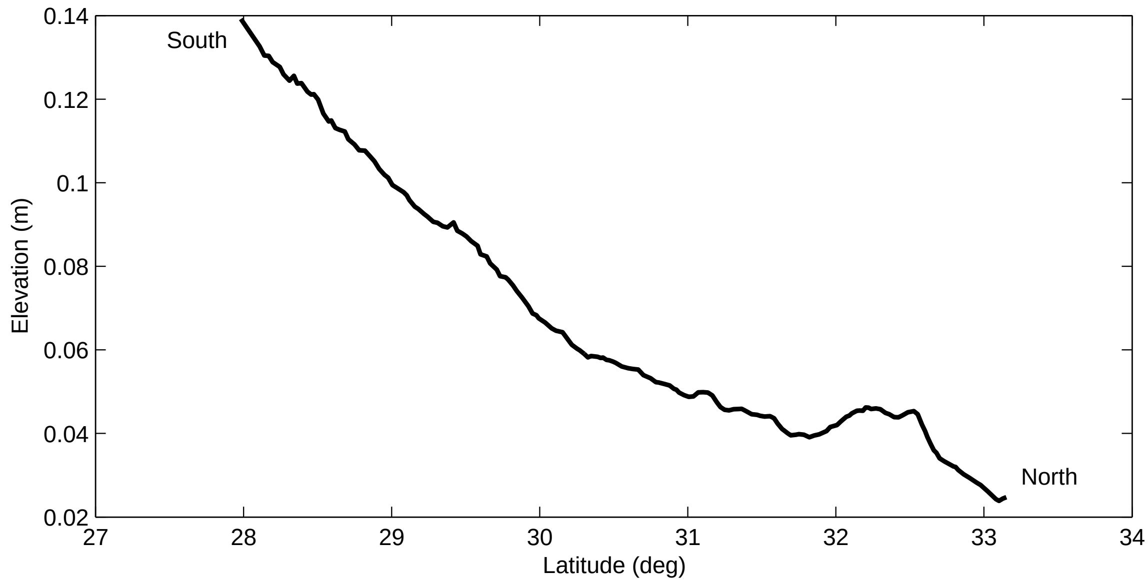

Figure 13. Along-shelf free-surface elevation along the 70-m isobath for the diagnosis of the January mass field. The resulting along-shelf elevation difference is about $-.12$ m in 6° latitude giving an along-shelf slope of -2×10^{-7}.

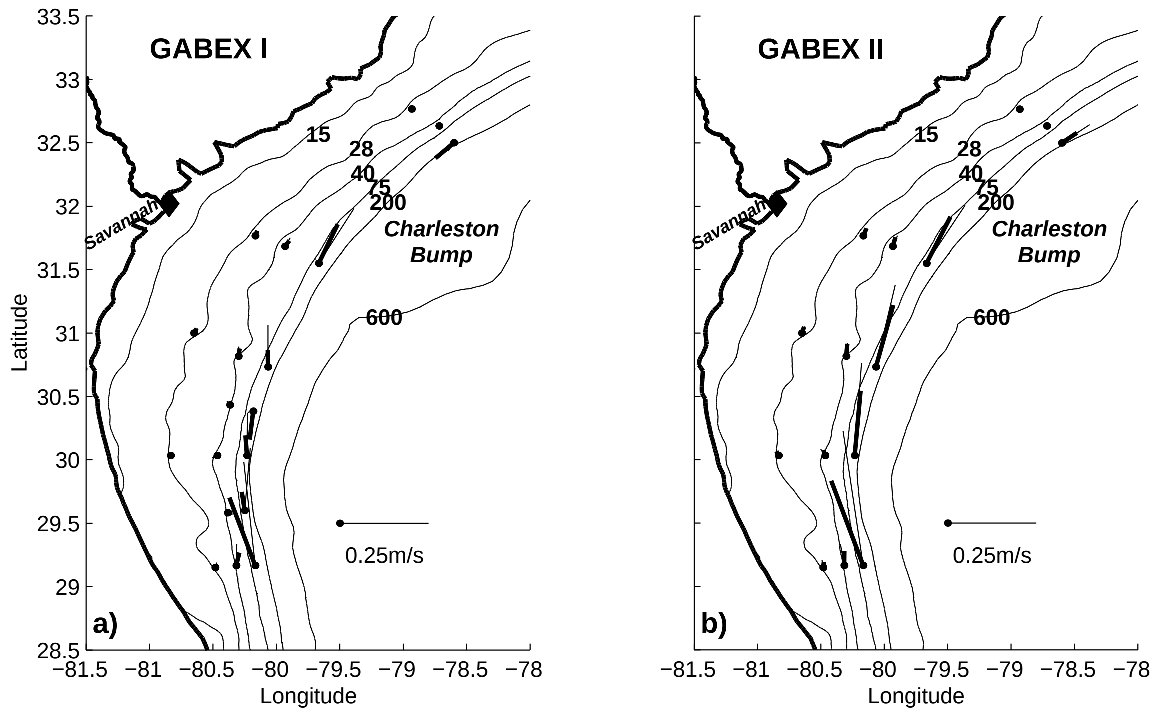

Figure 14. Combined climatological solutions sampled at the a) GABEX I and b) GABEX II mooring locations. Upper level (17 m below surface) velocities are shown with thin vectors; lower level (3 m above bottom) are shown with thick vectors. The GABEX moorings shown were stationed at the 28, 40, and 75-m isobath. The model bathymetry is not completely coincident with that reported in the GABEX programs.

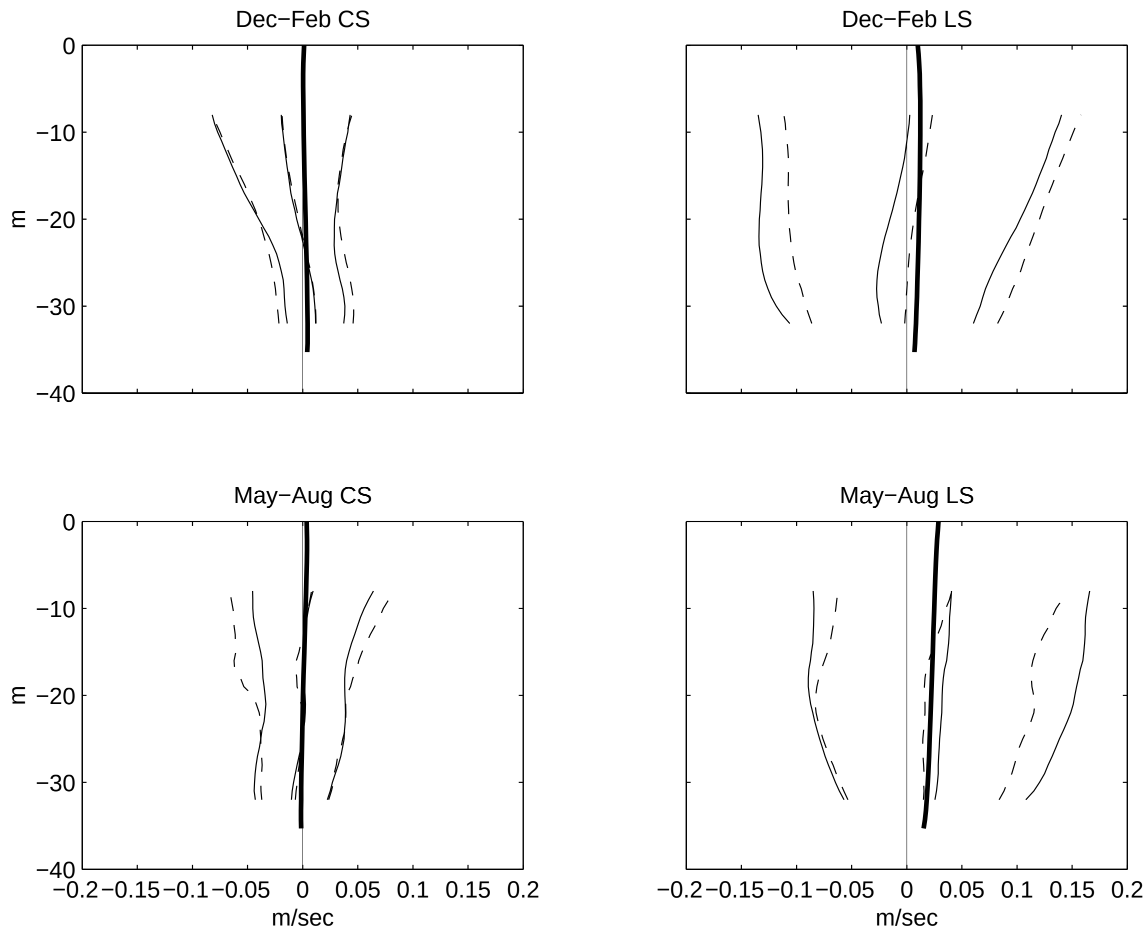

Figure 15. Comparison of ADCP and climatology velocity profiles. “Seasonal” and averaged ADCP velocity profiles from tower R6 shown in Figure 1. Data have been rotated into along-shelf (right) and cross-shelf (left) directions. The winter season (top) is over the periods December through February for 2000-01 (solid, thin) and 2001-02 (dashed, thin). Summer (bottom) is defined as May through August for 2000 (solid, thin) and 2001 (dashed, thin). Thick lines are the model solutions; thin lines are the ADCP averaged profiles with one standard deviation. For the along-shelf panels, poleward flow is positive and equatorward flow is negative. For the cross-shelf panels, offshore flow is positive and onshore flow is negative.

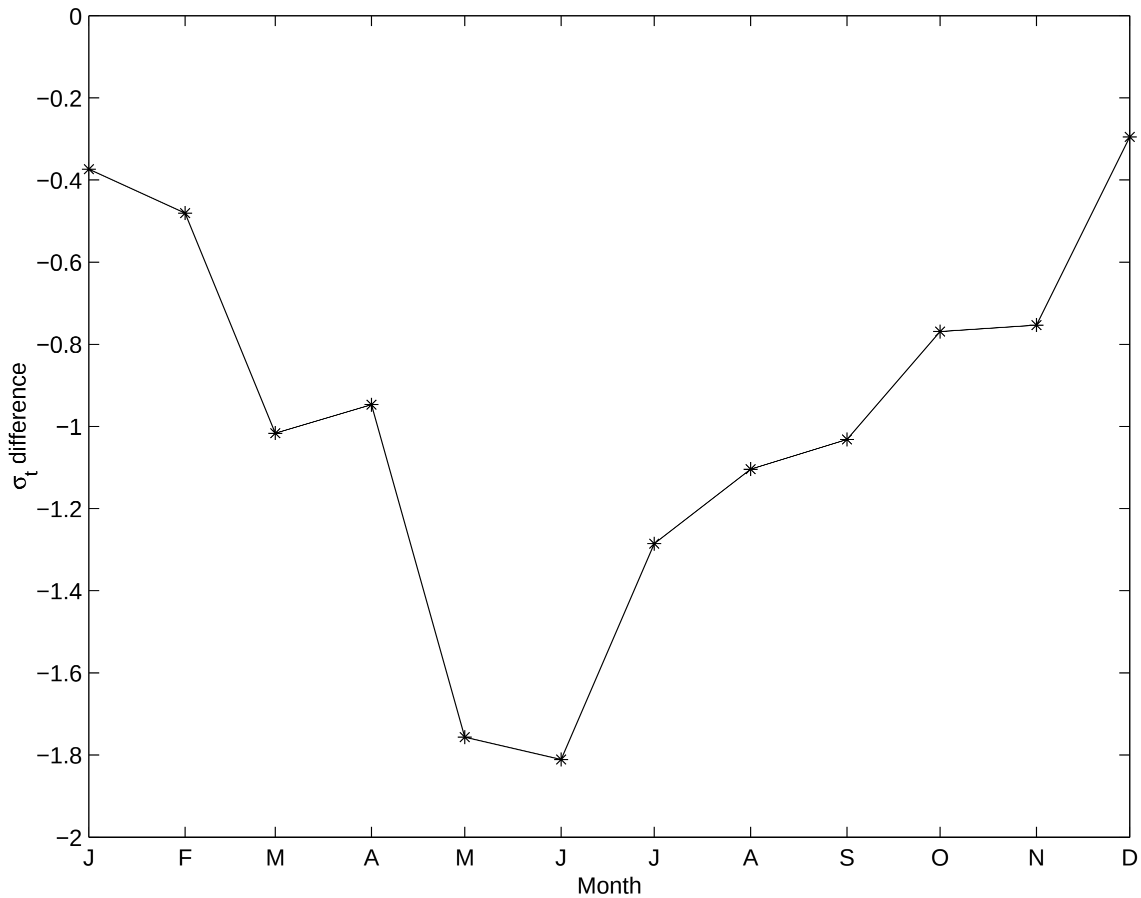

Figure 16. Monthly vertical σ_t difference at the tower location R2 from the monthly climatology.

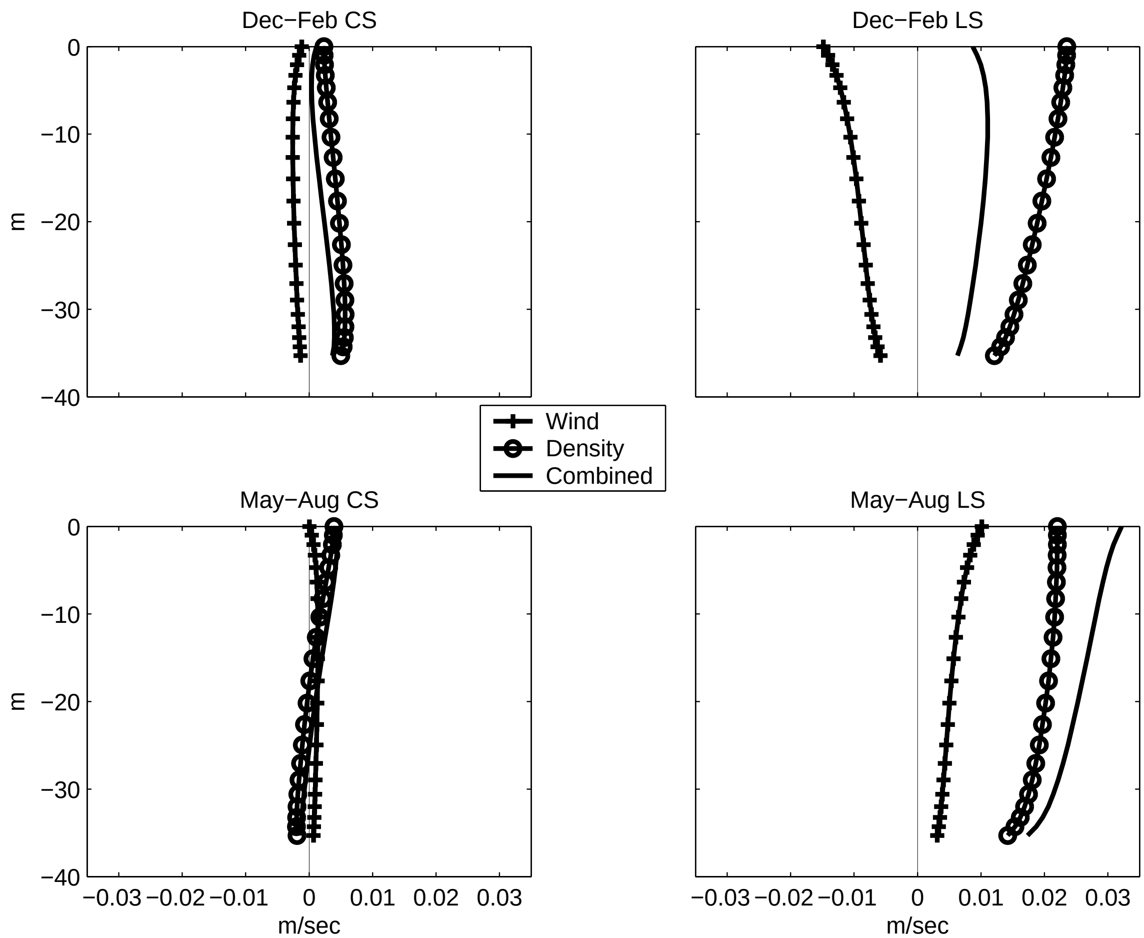

Figure 17. Model climatological velocity profiles at the R6 tower location shown in Figure 1. Velocities have been rotated into along-shelf (right) and cross-shelf (left) directions. The winter season (top) is over the period December through February and summer (bottom) is defined as May through August. The density-driven flow is shown with circles, the wind-driven flow with plus symbols, and the combined profiles (the same as in Figure 15) with solid line. For the along-shelf panels, poleward flow is positive and equatorward flow is negative. For the cross-shelf panels, offshore flow is positive and onshore flow is negative. Note that the scale on the abscissa is different than that in Figure 15.

South Atlantic Fishery Management Council Managed Areas (January 2009)

[Prepared by Roger Pugliese, SAFMC- Source: Habitat and Ecosystem Internet Mapping Server - http://www.safmc.net/EcosystemManagement/EcosystemBoundaries/MappingandGISData/tabid/62/Default.aspx]

Special Management Zones

Rec	SMZ_	SMZ_ID	NUMBER	AREA_NAME	AREA_METR2	AREA_MILE2	#SHAPE#	#ID#
1	2	15	xxii	Little River Offshore Reef	1999706.69	0.77209106937589	[polygon]	1
2	3	1	I	Paradise Reef	4018556.81	1.55157345839587	[polygon]	2
3	4	2	ii	Ten Mile Reef	10018340.4	3.86810285302775	[polygon]	3
4	5	3	iii	Pawleys Island Reef	2231941.39	0.86175738832449	[polygon]	4
5	6	21	xxviii	Bill Perry Jr. Reef	3151725.53	1.21688803013256	[polygon]	5
6	7	16	xxiii	BP-25 Reef	2294262.01	0.885819514225549	[polygon]	6
7	8	26	xxxiii	North Inlet 45 Foot Reef	3441654.07	1.32883006523731	[polygon]	7
8	9	23	xxx	Murrel's Inlet 60 Foot Reef	3759570.36	1.45157823102862	[polygon]	8
9	10	4	iv	Georgetown Reef	3617835.76	1.39685419603449	[polygon]	9
10	11	24	xxxi	Georgetown 95 Foot Reef	4395476.65	1.69710302220135	[polygon]	10
11	12	25	xxxii	New Georgetown 60 Foot Reef	6467511.31	2.49712007691416	[polygon]	11
12	13	27	xxxiv	CJ Davidson Reef	3221016.4	1.2436413846039	[polygon]	12
13	14	18	xxv	Cape Romaine Reef	878127.485	0.339046917396676	[polygon]	13
14	15	17	xxiv	Vermilion Reef	1152045.3	0.44480717701978	[polygon]	14
15	16	28	xxxv	Greenville Reef	2880669.14	1.11223257287834	[polygon]	15
16	17	5	v	Capers Reef	5735666.34	2.21455315430979	[polygon]	16
17	18	29	xxxvi	Charleston 60 Foot Reef	3471980.05	1.34053899157394	[polygon]	17
18	19	19	xxvi	Y-73 Reef	867966.652	0.335123797843218	[polygon]	18
19	20	6	vi	Kiawah Reef	8638454.35	3.33532587063871	[polygon]	19
20	21	22	xxix	Comanche Reef	1158706.66	0.447379142494326	[polygon]	20
21	22	31	xxxviii	Edisto 40 Foot Reef	3129224.79	1.20820044585071	[polygon]	21
22	23	30	xxxvii	Edisto 60 Foot Reef	4639329.1	1.79125497950186	[polygon]	22
23	24	9	ix	Fripp Island Reef	4347042.76	1.6784025927278	[polygon]	23
24	25	7	vii	Edisto Offshore Reef	4876913.41	1.8829867944186	[polygon]	24
25	26	8	viii	Hunting Island Reef	7298504.85	2.81796847640772	[polygon]	25

More Records   Zoom to these records

South Atlantic Fishery Management Council Managed Areas (January 2009)

Proposed Deepwater Lophelia Coral HAPCs

Rec	NAME	AREA_METR2	AREA_MILE2	#SHAPE#	#ID#
1	Cape Lookout Lophelia Banks	316415782.339	122.16832647979	[polygon]	1
2	Cape Fear Lophelia Banks	133493143.731	51.541784185309	[polygon]	2
3	Stetson/Savannah and East Florida Lithoherms/Miami	58105591676.7	22434.6043733531	[polygon]	3
4	Pourtales Terrace	1319439648.48	509.436452740482	[polygon]	4
5	Blake Ridge Diapir	10355524	3.99	[polygon]	5

Zoom to these records

Marine Protected Areas

Rec	NAME	AREA_METR2	AREA_MILE2	IMAGE	VIDEO
1	East Hump/Un-named Hump MPA	163645813.968	63.1837485479	_	_
2	St. Lucie Hump MPA	24491211.8022	9.45607180912125	_	_
3	Georgia MPA	264105029.364	101.971112862	2006_GA1_2.jpg	GA_02_2004.mpg
4	Edisto MPA	199500024.275	77.0270810077	2004_SCB1_3.jpg	SCB_01_2004.mpg
5	Northern South Carolina MPA	177391908.348	68.491123969	2004_SC2_2.jpg	SCA_02_2004.mpg
6	Snowy Grouper Wreck MPA	499969915.02	193.038689021	2004_NC1.jpg	NC_01_2004.mpg
7	North Florida MPA	355445147.402	137.237588127	2004_FL1_3.jpg	FL_01_2004.mpg
8	Charleston Deep Artificial Reef MPA	69338489.8114	26.7716331919	_	_

Zoom to these records

Additional Gear and Species Year Round Area Closures

190,441.846 square miles	Fish Trap Prohibition
36,569.276 square miles	Bottom Long-line prohibition
190, 441.846 square miles	Roller-Rig Trawl prohibition
18,669.766 square miles	Black sea bass pot prohibition
171, 772.08 square miles	Octocoral harvest prohibition
161,658.597 square miles	Sargassum harvest prohibition
190, 441.846 square miles	Coral and live rock (minus allowable octocorals)

FISHERY ECOSYSTEM PLAN
OF THE SOUTH ATLANTIC REGION

VOLUME II: SOUTH ATLANTIC HABITATS AND SPECIES

April 2009

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ABBREVIATIONS AND ACRONYMS

ABC	Acceptable Biological Catch
ACCSP	Atlantic Coastal Cooperative Statistics Program
ACE	Ashepoo-Combahee-Edisto Basin National Estuarine Research Reserve
APA	Administrative Procedures Act
AUV	Autonomous Underwater Vehicle
B	A measure of stock biomass either in weight or other appropriate unit
B_{MSY}	The stock biomass expected to exist under equilibrium conditions when fishing at F_{MSY}
B_{OY}	The stock biomass expected to exist under equilibrium conditions when fishing at F_{OY}
B_{CURR}	The current stock biomass
CEA	Cumulative Effects Analysis
CEQ	Council on Environmental Quality
CFMC	Caribbean Fishery Management Council
CPUE	Catch per unit effort
CRP	Cooperative Research Program
CZMA	Coastal Zone Management Act
DEIS	Draft Environmental Impact Statement
EA	Environmental Assessment
EBM	Ecosystem-Based Management
EEZ	Exclusive Economic Zone
EFH	Essential Fish Habitat
EFH-HAPC	Essential Fish Habitat - Habitat Area of Particular Concern
EIS	Environmental Impact Statement
EPAP	Ecosystem Principles Advisory Panel
ESA	Endangered Species Act of 1973
F	A measure of the instantaneous rate of fishing mortality
$F_{30\%SPR}$	Fishing mortality that will produce a static SPR = 30%.
$F_{45\%SPR}$	Fishing mortality that will produce a static SPR = 45%.
F_{CURR}	The current instantaneous rate of fishing mortality
FMP	Fishery management plan
F_{MSY}	The rate of fishing mortality expected to achieve MSY under equilibrium conditions and a corresponding biomass of B_{MSY}
F_{OY}	The rate of fishing mortality expected to achieve OY under equilibrium conditions and a corresponding biomass of B_{OY}
FEIS	Final Environmental Impact Statement
FMU	Fishery Management Unit
FONSI	Finding Of No Significant Impact
GOOS	Global Ocean Observing System
GFMC	Gulf of Mexico Fishery Management Council
IFQ	Individual fishing quota
IMS	Internet Mapping Server
IOOS	Integrated Ocean Observing System
M	Natural mortality rate

MARMAP	Marine Resources Monitoring Assessment and Prediction Program
MARFIN	Marine Fisheries Initiative
MBTA	Migratory Bird Treaty Act
MFMT	Maximum Fishing Mortality Threshold
MMPA	Marine Mammal Protection Act of 1973
MRFSS	Marine Recreational Fisheries Statistics Survey
MSA	Magnuson-Stevens Act
MSST	Minimum Stock Size Threshold
MSY	Maximum Sustainable Yield
NEPA	National Environmental Policy Act of 1969
NMFS	National Marine Fisheries Service
NMSA	National Marine Sanctuary Act
NOAA	National Oceanic and Atmospheric Administration
NRC	National Research Council
OY	Optimum Yield
POC	Pew Oceans Commission
R	Recruitment
RFA	Regulatory Flexibility Act
RIR	Regulatory Impact Review
SAFE	Stock Assessment and Fishery Evaluation Report
SAFMC	South Atlantic Fishery Management Council
SEDAR	Southeast Data, Assessment, and Review
SEFSC	Southeast Fisheries Science Center
SERO	Southeast Regional Office
SDDP	Supplementary Discard Data Program
SFA	Sustainable Fisheries Act
SIA	Social Impact Assessment
SSC	Scientific and Statistical Committee
TAC	Total allowable catch
T_{MIN}	The length of time in which a stock could rebuild to B_{MSY} in the absence of fishing mortality
USCG	U.S. Coast Guard
USCOP	U.S. Commission on Ocean Policy
VMS	Vessel Monitoring System

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3.0 Description and Distribution of Habitats Comprising the South Atlantic Ecosystem

3.1 Freshwater systems

3.1.1 Riverine and Freshwater Wetlands System

Description and Distribution

Freshwater ecosystems are increasingly recognized as vitally linked to the ecological function and health of estuarine and marine ecosystems, essential fish habitats, and food webs supporting valuable fisheries. While freshwater environments account for less than 2.5 percent of the earth's total volume of water they are indispensable to the health, function, and fishery production of the world's marine ecosystems (Rosenberg et al. 2000, World Commission on Dams 2000). In simple terms, freshwater systems including wetlands and deepwater habitats form a vital boundary between land and the sea. Inland watersheds and their freshwater systems are vitally linked with estuarine and marine waters through an inter-connected web of ecological functions and processes (Lambou and Hearn 1983, Odum et al. 1983).

The South Atlantic Shelf Ecosystem is contiguous with ten large Piedmont river basins (those with watershed boundaries extending from the ocean through the Coastal Plain to the Piedmont physiographic province), and many smaller coastal rivers, bays, and sounds located wholly within the Coastal Plain. The major Piedmont river basins are associated with some of the most productive estuarine and coastal marine systems of the continental shelf including the Albemarle-Pamlico Sound (fed by the Roanoke, Chowan, Pamlico, and Neuse River basins), the Cape Fear estuary (fed by the Cape Fear Basin), the Bulls Bay-Santee Delta-Winyah Bay estuarine system (fed by the Yadkin-Pee Dee, Waccamaw, and Santee Basin), the Savannah estuary, the Altamaha, and the St. Johns – St. Marys Basin and estuarine system. The influences of these large river basins and their substantial freshwater inflows extend well beyond their estuarine deltas, many kilometers onto the nearshore continental shelf during seasonal high flow periods. The watersheds described contain a broad diversity of freshwater wetland and deepwater habitat classifications.

Freshwater ecosystems of the South Atlantic watersheds above the normal limits of saline waters may be conceptualized into two major categories: deepwater habitats and wetlands. In each category are many sub-classifications depending upon presence and characteristics of vegetation, substrate composition, and water flow or tidal characteristics (Cowardin et al. 1979). Major freshwater systems include riverine flowing water and lacustrine deepwater habitats, tidal and non-tidal palustrine emergent marsh, extensive tidal and non-tidal forested floodplain wetlands, and submersed rooted vascular aquatic bed habitats. The systems described are continuously connected and functionally inseparable from coastal estuarine and marine habitats for federally managed species.

A detailed discussion of freshwater wetland and deepwater habitats, their diverse flora and fauna, and ecological interactions is beyond the scope of this document. With respect to their importance to marine and estuarine fisheries, intact freshwater systems collectively provide many vital ecological functions as described previously.

Ecological Role and Function

Among the more important functions and processes are continuous export of habitat-building substrates including clay, gravel and sand from inland areas; export of essential mineral nutrients, dissolved and particulate organic carbon and living biomass from watersheds to estuarine and coastal marine systems. The abundance, distribution, and movements of migratory fauna (migratory diadromous and potamodromous fishes, estuarine fishes and crustaceans) reflect significant transports of nutrients, carbon, and biomass to and from marine ecosystems and inland freshwater systems (Garman 1992, Polis et al. 1997, Gross et al. 1998).

In addition to the ecological biomass and nutrient transfers between marine and inland waters illustrated by diadromous species, seasonal freshwater inflows to estuaries and nearshore marine environments have influenced the synchrony of reproductive cycles and peak periods of growth and migration of many important fish, shellfish, and marine mammal species. Among the more well-known Atlantic coast species whose life cycles are in part dependent upon estuaries and the many inputs such as organic carbon and nutrients from inland waters are penaeid shrimp, blue crabs, oysters, menhaden, mullet, gag grouper, cobia, king and Spanish mackerel, red drum and seatrouts, bluefish, flounder, bottlenosed dolphin, and many others (Odum et al. 1983).

Riverine habitats form the flowing freshwater connection linking watersheds and their extensive wetland habitats with estuarine and marine systems. The natural flow regime is the key driving physical variable for the riverine system (Anderson et al, 2006). The timing, duration, and frequency of naturally occurring river flows are critical for maintenance and survival of plant and animal communities downstream that have evolved in synchrony for millennia. Seasonal flow pulses act as biological triggers for fish and invertebrate migration; and flood events create and maintain riverine, estuarine, and coastal marine habitats by scouring and transport of sediments. The riverine food web is based predominantly on respiration rather than primary production directly from photosynthesis occurring within the river itself. The primary production supporting riverine fauna is allocthonous, or originating elsewhere in the form of dissolved and particulate organic carbon from decaying terrestrial vegetation or adjacent palustrine wetlands. Except in very large rivers phytoplankton is absent, and the attached diatoms and filamentous algae, aquatic mosses and rooted vascular plants contribute only a small fraction of the total primary and secondary productivity supporting riverine fauna. Decaying vegetation from land is exported by surface runoff directly to flowing waters, or may be stored in palustrine wetlands before export through surface or subsurface flow. River-borne dissolved and particulate organic carbon and nutrients are exported in large quantities to estuarine and coastal marine waters, providing direct support for food webs and marsh building processes (Lambou and Hearn 1983, Russell-Hunter 1970, Turner 1977, Odum 1984.

Migratory fauna play strong roles in nutrient and biomass cycling and connectivity among marine and estuarine, riverine, palustrine, and terrestrial habitats. Diadromous fishes including

American shad and river herring make long ocean migrations from the North Atlantic to ascend South Atlantic Rivers to spawn each year. Conversely, juveniles complete early development and growth in inland waters then migrate to sea in large numbers, representing a major export of biomass and nutrients to estuarine and marine food webs. Spawning and outmigration of diadromous species represent major ecological pathways for exchange of nutrients and biomass, interconnecting watersheds, estuarine, and marine ecosystems (Freeman et al. 2003). A review of historic accounts and records from the 19th century reveals that huge spawning runs (likely in the millions in each major river basin) of alosines ascended to the Piedmont to spawn in mainstem rivers and tributaries (Baird 1887, Limburg et al. 2003). Shad spawning migrations are naturally timed to coincide with periods of increased riverine zooplankton populations, which provide vital food for larval and post larval shad. Late winter and spring zooplankton populations follow the increase in allocthonous energy-rich organic detritus and dissolved complex organic carbon compounds exported from adjacent freshwater wetlands (Lambou and Hearn 1983, Crecco et al. 1981). Conversely, imports of marine derived biomass, nutrients and carbon by migratory diadromous fishes provide important trophic support for riverine and adjacent wetland and terrestrial food webs (Garman 1992). Anadromous shad and other alosines subsidize upper trophic levels in riverine, estuarine, and coastal marine waters including predatory fishes and marine mammals (Garman and Macko 1998, MacAvoy et al. 2000, Odum 1983). Nutrient and energy subsidies afforded by anadromous shad and river herring are comparable to the salmon of the Pacific Northwest, where the nutrient and energy subsidies have been well documented in recent years (Ben-David et al. 1998, and Gresh et al. 2000). Large runs of salmon have been shown to provide important inputs of marine derived prey and nutrients to coastal and inland waters. Similarly, Garman (1992) estimated that the James River, Virginia, received significant annual inputs of nutrient-rich biomass from anadromous shad and herring of approximately 155 kg/ha before blockage of spawning runs by dams in the 1870s. Although not estimated by Garman, the outmigration of juvenile alosines to estuarine and oceanic waters is likely to be at least comparable in trophic significance. Anadromous shad and herring provide important energy and biomass subsidy for higher trophic levels containing recreationally and commercially important predatory fish species in both inland and coastal marine waters. Garman and Macko (1998) reported that predatory fishes taken in tidal waters after alosine spawning runs had greater than 35% and up to 84% (MacAvoy et al. 2000) of their biomass carbon derived from marine sources, based on stable isotope analyses. The ecological contribution of anadromous alosines and the catadromous American eel to both inland and marine ecosystems and fisheries is likely to be substantial, although greatly reduced from historical levels due to documented declines in populations. Baird, in his landmark report of the Commissioner of Fish and Fisheries in 1887 hypothesized the connections among inland river basins, migratory diadromous fishes and support for commercially valuable marine fish and mammalian species populations.

Species composition and community structure

Freshwater ecosystems of the South Atlantic watersheds above the normal limits of saline waters may be conceptualized into two major categories: deepwater habitats and wetlands. In each category are many sub-classifications depending upon presence or absence of vegetation, substrate composition, and water flow or tidal characteristics.

Deepwater Habitats: The Riverine and Lacustrine Ecosystems

Freshwaters in this category may be further subdivided into lentic, or lacustrine habitats; and lotic or flowing riverine habitats. Lacustrine habitats of South Atlantic river basins may be both natural and man-made, with manmade impoundments by far the more prominent features of the landscape compared with natural lakes. The following discussion on deepwater habitats will focus primarily on the riverine environment. Riverine habitats extend from the inland limit of estuarine waters to the southern Appalachian highlands, gradually dividing into a myriad of successively smaller streams highly integrated with the terrestrial landscape, both ecologically and geologically. Coastal Plain sections are predominantly low-gradient, slower flowing meandering rivers with broad, level floodplains and many backwaters, sloughs, and oxbows. Approaching the Piedmont, the floodplain narrows as the gradient increases at the fall-line, which marks the inland limit of ocean submersion during past interglacial periods. Through the fall-line zone the stream gradient increases gradually with rapids sections containing bedrock, boulder and cobble-gravel substrates becoming more common. Piedmont sections characteristically contain reaches of rocky substrates and rapids interspersed with lower-gradient slow flowing run and pool habitat. The variety of flow and substrate characteristics in fall-line and Piedmont river sections provides habitat niches for diverse assemblages of aquatic species including invertebrates, resident and diadromous fishes.

Fall zone and Piedmont rapids sections are important spawning habitat for many migratory anadromous fish including American shad and other alosines, striped bass, shortnose and Atlantic sturgeon. Construction of dams during the past century has resulted in blockage of anadromous fish spawning migrations at or below the fall line, with consequent reductions in production capability for anadromous fish including alosine species important as prey for many federally managed estuarine and marine fish species. The trophic effects of apparent large reductions in anadromous prey species on managed fisheries during the preceding century is potentially significant, although further study is needed to establish the magnitude of those effects.

<u>Rivers and streams (fauna)</u>

Most diadromous fishes of interest to the SAFMC inhabit the Coastal Plain for some portion of their life cycle. Anadromous species, such as sturgeons, alosids, and striped bass, historically made upstream migrations up to above the fall line to spawn (Menhinick, 1991; Jenkins and Burkhead, 1993). It is unclear as to if these species feed during their spawning migration. However, American shad (*Alosa sapidissima*) consume a variety of invertebrates during each life stage and may consume small fishes as adults. American eels prey on American shad eggs, larvae, and juveniles in freshwater, and striped bass (*Morone saxatilis*) consume juvenile American shad (ASMFC, 1999).

Striped bass feed on mobile planktonic invertebrates in the larval stage, larger invertebrates and small fishes in the juvenile stage, and on schooling clupeid fishes as adults. They serve as prey for other piscivorous fishes and non-fish predators (ASMFC, 2003). Young-of-year shortnose sturgeon (*Acipenser brevirostrum*) have been found to feed on insect larvae and amphipods, whereas a major prey item for adults is freshwater mussels (NMFS, 1998). Atlantic sturgeon (*Acipenser oxyrhynchus*) similarly feed on mussels, worms, shrimp, and small bottom-dwelling fishes (ASFMC, 1998).

The catadromous American eel (*Anguilla rostrata*) adults migrate to the ocean to spawn, but during the resident (yellow eel) stage they occupy a diversity of habitats within river systems, including headwater streams (Helfman et al., 1984). This phase of the American eel is able to reach the extreme upper portions of the river it inhabits. Eel are opportunistic feeders, feeding on phytoplankton, insects, snails, worms, crustaceans, and a multitude of fish species (ASMFC, 2000). Of all the diadromous fish species, only American eel gets significantly above the fall line.

In the upper Coastal Plain, the most common resident fishes in a Georgia river were largemouth bass (*Micropterus salmoides*), spotted sucker (*Minytrema melanops*), and bowfin (*Amia calva*), followed by chain pickerel (*Esox niger*), black crappie (*Pomoxis nigromaculatus*), spotted sunfishes (primarily *Lepomis* spp.), warmouth, yellow bullhead (*Ictalurus natalis*), American eel, lake chubsucker (*Erimyzon sucetta*), flat bullhead, channel catfish (*Ictalurus punctatus*), and madtom catfish (*Noturus* sp.) (Wharton, 1978). The most numerous resident fishes in lower Coastal Plain river in Georgia were the silvery chub (*Hybognathus nuchalis*), shiner species (*Notropis* spp.), the channel catfish, flat bullhead (*I. platycephalus*), pirate perch (*Aphredoderus sayanus*), largemouth bass, warmouth (*Lepomis gulosus*), bluegill (*Lepomis macrochirus*), redbreast (*Lepomis auritus*), and two crappies (*Pomoxis* spp.)

<u>Rivers and streams (flora)</u>
The only vascular plants found in Coastal Plain rivers and streams are aquatic bed species growing along the shallow perimeter of channels near of the estuarine end of the riverine system. The tidal fresh- and freshwater aquatic bed communities are diverse, with numerous plant species that vary in dominance depending upon the influence of salinity, turbidity, and other environmental factors. The aquatic bed communities of southeastern United States blackwater streams, medium rivers, and low-salinity backbays and lagoons are described to varying degrees in Hackney et al. (1992).

In tidal freshwater, aquatic beds generally grow in a zone extending approximately from mean low water to depths of several meters depending upon water clarity (Odum et al., 1984). This zone often lies adjacent to emergent low marsh and can encompass the entire channel of small, shallow tidal fresh creeks. Studies indicated that while aquatic beds occurred from 10 to 160 cm in depth, maximum density occurred at 60 cm (Davis and Brinson, 1976; Ferguson and Wood, 1994). Most aquatic bed species establish roots in soft benthic muds, and produce herbaceous outgrowths perennially. Stand density and extent are extremely variable, and many species are subject to drastic fluctuations in their populations from year to year, or in some cases within a given season (Southwick and Pine, 1975; Bayley et al., 1978).

The presence of aquatic beds appears to diminish in southeastern rivers with distance traveled inland and upstream. They have been rarely reported in Piedmont streams (Mulholland and Lenat, 1992); are considered locally abundant in some larger blackwater streams and rivers but rare in small blackwater streams (Smock and Gilinsky, 1992); may be abundant in some medium-sized rivers (Garman and Nielson, 1992); and can be extensive in some low-salinity (the term "low-salinity as employed herein is synonomous with the term "oligohaline") backbays and lagoons (Moore, 1992). Larger Piedmont rivers may support a greater variety of plant forms than the smaller streams because of the presence of different substrate types, greater stability of fine-grain sediments and greater light availability.

Water-weeds (*Elodea* spp.), pondweeds (*Potamogeton* spp.) and water-milfoils (*Myriophyllum* spp.) are some of the prevalent species in littoral zones of the Atlantic Coast (Odum et al., 1984 and literature therein). In Virginia, some freshwater aquatic beds are composed of various naiads (*Najas* spp.) and wild celery (*Vallisneria americana*). Macroscopic algae found growing amid these vascular plants include species of the genera *Nitella*, *Spirogyra* and *Chara*. In North Carolina, species present in the oligohaline and freshwater portions of Albemarle and Currituck Sounds were recorded by Ferguson and Wood (1994). Species present, in order of frequency of occurrence were: widgeon grass (*Ruppia maritima*), wild celery, Eurasian water-milfoil (*Myriophyllum spicatum*), bushy pondweed (*Najas quadalupensis*), sago pondweed (*Potamogeton pectinatus*) and redhead grass (*Potamogeton perfoloiatus*). The presence of these species and others was also documented by Davis and Brinson (1976) for the Pamlico River estuary. Investigations in the upper portion of the Pamlico River estuary and a tributary, Durham Creek, documented the presence of wild celery, naiad (*Najas* spp.), pondweeds, widgeon grass, and also macroalgal muskgrasses (*Chara* spp. and *Nitella* spp.). Wild celery and pond weed were the dominant species present.

Species present in Florida (St. Johns River) include water milfoil and wild celery (Garman and Nielson, 1992) and water weed (*Elodea* spp.) and *Hydrilla* (freshwater portions of Indian River Lagoon, Gilmore, 1977). Estuarine tributaries of Pamlico Sound, specifically Jacks and Jacobs Creeks of the South Creek system, were surveyed over 17 months for distribution and biomass of submerged macrophytes by Davis, Bradshaw, and Harlan (1985). The rooted macrophytes present were *Ruppia maritima* and *Zannichellia palustris*. *Ruppia* was present primarily during the warm season, while *Zannichellia* was present primarily during the cool season; both species were present in June. Davis et al. (1985) concluded that the contributions of aquatic macrophytes to community structure in these creeks should be highly variable since their biomasses are highly variable.

Freshwater Marshes

In lower regions of the Coastal Plain, there is an increasing importance of floodplain wetlands (Junk et al. 1989), including freshwater marshes, riverine swamp forest, bottomland hardwood forests, off-channel sloughs and other floodplain features. Tidal and non-tidal freshwater marshes have much greater plant diversity than that found in salt marshes occurring in the more saline portions of estuaries (Johnson et al., 1974, Odum et al. 1984). Typical communities include various species of sedges, millets, rushes, giant cane (*Arundinaria gigantea*), arrowhead (*Sagittaria* spp.), pickerelweed (*Pontederia cordata*), arrow arum (*Peltandra virginica*), and smartweed (*Polygonum* spp.)(Street et al., 2005). Marshes of the Mid-Atlantic and Georgia Bight regions can contain as many as 50 to 60 species at a single location, and are comprised of a number of co-dominant taxa (Odum 1978, Sandifer et al. 1980). Among the more conspicuous species which occur in both regions are arrow-arum, pickerelweed, wild rice (*Zizania aquatica*), and cattails (*Typha* spp.). In South Carolina and Georgia, marshes are often nearly a monospecific stand of giant cutgrass or a mixed community dominated by one or more species described in the Odum et al. (1984) description of community types listed below, plus sawgrass

(*Cladium jamaicense*), alligatorweed (*Alternanthera philoxeroides*), plumegrass (*Saccharum* sp.), giant cordgrass (*Spartina cynosuroides*) or soft-stem bulrush (*Scirpus validus*).

Freshwater marshes may extend for some distance up the rivers before being replaced by cypress (*Taxodium distichum*)-gum (*Nyssa* sp.) or hardwood swamps. Shallow freshwater marshes contain a variety of species including cattails, several bulrushes (*Scirpus* spp.), smartweeds, aneilema (*Aneilema* sp.), arrowhead, arrow arum, and others. The deeper freshwater marshes are more extensive; in the mid-1970s they occupied approximately 25,000 acres along the Georgia coast. In many areas this marsh type is comprised almost exclusively of giant cutgrass (*Zizaniopsis miliacea*), with stands of sawgrass occurring intermittently. Around the deeper margins of the marsh, stands of cattail are common and wild rice occurs in sporadic stands. In the deeper creeks and potholes, submersed and floating–leaved plants are dominant (Johnson et al., 1974).

Most tidal fresh marsh flora consists of: 1) broad-leaved emergent perennial macrophytes such as spatterdock (*Nuphar luteum*), arrow-arum, pickerelweed and arrowheads; 2) herbaceous annuals such as smartweeds, tear-thumbs (*Polygonum sagittatum* and *P. arifolium*), burmarigolds (*Bidens* spp.), jewelweed (*Impatiens* sp.), giant ragweed (*Ambrosia trifida*), water-hemp (*Anaranthus cannabinus*), and water-dock (*Rumex verticillatus*); 3) annual and perennial sedges, rushes and grasses such as bulrushes (*Scirpus* spp.), spike-rushes (*Eleocharis* spp.), umbrella-sedges (*Cyperus* spp.), rice cutgrass (*Leersia oryzoides*), wild rice, and giant cutgrass; 4) grasslike plants or shrub-form herbs such as sweetflag (*Acorus calamus*), cattail, rose mallow (*Hibiscus moscheutos*) and water parsnip (*Sium suave*); and 5) a handful of hydrophytic shrubs, including button bush (*Cephalanthus occidentalis*), wax myrtle (*Myrica cerifera*), and swamp rose (*Rosa palustris*).

The nine community types of riverine and palustrine wetlands are:
1) Spatterdock Community: Spatterdock can occur in pure stands, especially in late spring, in areas of marsh adjacent to open water. These areas may be below the level of mean low water, so that the stands are submerged during high tide. They may occur on submerged point bars on the meanders of tidal creeks. Later in the growing season, some of the spatterdock may be overtopped by other species which commonly inhabit the low intertidal zone, including arrow-arum, pickerelweed and wild rice.

2) Arrow-arum/Pickerelweed Community: Arrow-arum is an extremely cosmopolitan species which grows throughout the intertidal zone of many marshes. This species forms its purest stands in the low intertidal portions of the marsh in spring or early summer (Odum et al. 1984). Pickerelweed is equally as likely to dominate or co-dominate this lower marsh zone, although its distribution is usually more clumped than arrow-arum. Both species tolerate long periods of inundation. Other species which may be associated with this community type include burmarigolds and wild rice, and less frequently, arrowhead, sweetflag and smartweeds.

3) Wild Rice Community: Wild rice is conspicuous and distributed widely throughout the Atlantic Coastal Plain. It can completely dominate a marsh, producing plants which exceed 4 m (13 ft) in height in August and September. It may not be noticeable until mid-summer when it begins to overtop the canopy of the shorter plants, which usually consist of arrow-arum, pickerelweed, spatterdock, arrowhead, smartweed and burmarigolds.

4) Cattail Community: Cattails are among the most ubiquitous of wetland plants and are principal components of many tidal freshwater marshes (Odum et al. 1984). Cattails are mostly confined to the upper intertidal zone of the marsh. They are usually found with one or more associates, including arrow-arum, rose mallow, smartweeds, jewelweed and arrowhead. They will also form dense, monospecific stands, especially in disturbed areas where they may co-occur with common reed (*Phragmites communis*).

5) Giant Cutgrass Community: Giant cutgrass, also called southern wild rice, is an aggressive perennial species confined predominantly to wetlands south of MD and VA. It dominates many of the tidal freshwater marshes, excluding other species. If it occurs in a mixed stand, other species present include sawgrass, cattails, wild rice, alligatorweed, water parsnip and arrow-arum.

6) Mixed Aquatic Community: The mixed aquatic community consists of an extremely variable association of freshwater marsh vegetation. It generally occurs in the upper intertidal zone of the marsh and is composed of a number of co-dominant species which form a mosaic over the marsh surface. Species present include arrow-arum, rose-mallow, smartweeds, water-hemp, burmarigolds, sweetflag, cattails, rice cutgrass, loosestrife (*Lythrum* spp.), arrowhead and jewelweed.

7) Big Cordgrass Community: Big cordgrass (*Spartina cynosuroides*) is often seen growing in nearly pure stands in narrow bands along tidal creeks and sloughs, or on levee portions of low-salinity marshes. Arrow-arum and pickerelweed are associated with big cordgrass in these locales, but when stands extend further up onto the marsh, this species will intermix with cattails, common reed, rice cutgrass and wild rice.

8) Bald Cypress/Black Gum (Riverine Swamp) Community: The bald cypress/black gum (*Nyssa sylvatica*) community generally is ecotonal between the marsh itself and wooded swamp or upland forest. Situated in the most landward portions of the tidal freshwater marsh at approximately the level of mean high water, this community consists of a mixture of herbs, shrubs and trees. Additional overstory species present include tupelo gum, red maple and ash, and shrubs such as wax myrtle and buttonbush. The understory may contain typical marsh plants, although they may be reduced in number and quantity due to shading by the canopy.

9) Bottomland Hardwood Community: Bottomland hardwood forests contain mostly oaks (*Quercus* sp.) [overcup (*Q. lyrata*), water (*Q. nigra*), laurel, (*Q. laurifolia*) swamp (*Q. palustris*), chestnut (*Q. prinus*)], sweet gum (*Liquidambar styraciflua*), green ash, cottonwoods (*Populus* sp.), willows (*Salix* sp.), river birch (*Betula nigra*), and occasionally pines (*Pinus* spp.) (Street et al., 2005).

<u>Biota of freshwater marshes</u>

In freshwater marshes, the microbenthos is primarily composed of amoebae and the slightly larger macrobenthos is composed of amphipods, oligochaete worms, freshwater snails, and insect larvae (such as midge, mosquito, and crane fly larvae). Midge larvae, for example, serve as food for fishes, frogs, and diving birds. When the pupae emerge as adults, they are additionally exploited by surface-feeding birds and fishes. Copepods and cladocerans are abundant in tidal creeks. The Asiatic clam (*Corbicula fluminea*) has spread throughout the coastal marshes of the southern states.

Fishes that use tidal freshwater marshes can be classified into four groups: freshwater, estuarine, diadromous, and estuarine-marine. The freshwater fishes are species that spawn and complete their lives within freshwater areas. The three main families of these freshwater fishes are cyprinids (minnows, shiners, carp), centrarchids (sunfishes, crappies, bass), and ictalurids (catfish). Juveniles of all of these species are most abundant in the shallows, often using submerged vegetation for protection from predatory fishes. Predatory species include the sunfishes, largemouth bass (*M. salmoides*), black crappie (*Pomoxis nigromaculatus*), gars (Lepisosteus spp.), pickerels (*Esox* spp.), and bowfin (*Amia calva*).

The estuarine fishes complete their entire life cycle in the estuary and extend their range into the freshwater marshes. Abundant estuarine fishes include the bay anchovy (*Anchoa mitchilli*), tidewater silverside (*Menidia beryllina*), and schools of killifishes (*Fundulus* sp.) that utilize the shallow marsh areas. Juvenile hogchokers (*Trinectes maculatus*) and naked gobies (*Gobiosoma bosci*) use tidal freshwater areas as nursery grounds.

The diadromous fishes include both anadromous and catadromous species. The adult life stage of the anadromous and semi-anadromous species moves through the freshwater marshes during their upstream spawning migration. The tidal freshwater areas are major nursery grounds for juveniles for many of these species, such as striped bass (*Morone saxatilis*). The young of the majority of the Atlantic Coast clupeids such as the *Alosa* spp. and *Dorosoma* spp. are found in peak abundance in tidal fresh waters, where they feed on small invertebrates and serve as important forage fish for striped bass, white perch (*Morone americana*), and catfish (*Ictalurus* sp.). Juvenile Atlantic (*Acipenser oxyrhynchus*) and shortnose sturgeon (*Acipenser brevirostrum*) may spend several years in freshwater before moving into more saline waters. Catadromous American eel (*Anguilla rostrata*) are habitat generalists that inhabit coastal freshwater areas, marsh creeks, and the marsh itself.

The estuarine-marine fishes include marine spawners having juveniles that move into the freshwater marshes. These fishes that move into the tidal freshwater marshes include menhaden (*Brevoortia tyrannus*), spot (*Leiostomus xanthurus*), croaker (*Micropogonias undulatus*), silver perch (*Bairdiella chrysoura*), spotted seatrout (*Cynoscion nebulosus*), black drum (*Pogonium cromis*), summer flounder (*Paralichthys dentatus*), snook (*Centropomus undecimalis*), and tarpon (*Megalops atlanticus*) (Mitsch and Gosselink, 1993).

Coastal freshwater marshes may support the largest and most diverse populations of birds. Wading birds such as the great blue heron (*Ardia herodias*), green heron (*Butorides striatus*), and bitterns (*Ixobrychus exilis* and *Botaurus lentiginosus*) feed on fishes and benthic invertebrates (Mitsch and Gosselink, 1993). The king rail (*Rallus elegans*) occurs in freshwater marshes, is known to nest in giant cutgrass and bulrush, and feeds on freshwater insects, fishes, crustaceans, and amphibians that are abundant in mats of alligator-weed (Johnson et al., 1974). Gulls (*Larus* spp.), terns (*Sterna* spp.), and kingfishers (*Megaceryle alcyon*) are common. Piscivorous birds of prey using freshwater marshes include eagles (*Haliaeetus leucocephalus*) and ospreys (*Pandion haliaetus*) (Mitsch and Gosselink, 1993).

The American alligator (*Alligator mississippiensis*) is known to move between freshwater and brackish marshes, but its preferred habitat is the tidal freshwater marsh (Johnson et al., 1974; Mitsch and Gosselink, 1993). Piscivorous mammals that are most closely associated with coastal freshwater marshes include muskrat (*Ondatra zibethicus*), otter (*Lutra canadensis*), mink (*Mustela vison*), raccoon (*Procyon lotor*), and marsh rice rat (*Oryzomys palustris*) (Mitsch and Gosselink, 1993).

<u>Biota of Riverine Swamp Forests</u>
The production of wood in deepwater swamps results in an abundance of substrate for invertebrates to colonize. High abundance and diversity of invertebrates have been found in permanently flooded swamps. These organisms are very dependent, directly or indirectly, on the abundant detritus in these systems. Such species include crayfish, clams, oligochaete worms, snails, freshwater shrimp, midges, amphipods, and various immature insects.

Fishes represent both temporary and permanent residents of riverine swamp forests in the Southeast. The sloughs and backswamps are valuable to fishes for spawning and feeding during the flooding season. When flooding ceases, the deepwater swamps often serve as a reservoir for fishes, although fluctuating water levels and sometimes low dissolved oxygen levels can be less than optimal for aquatic life. Some species, such as bowfin, gar, and certain top minnows (*Fundulus* spp. and *Gambusia affinis*) are better adapted to periodic anoxia because of their ability to utilize atmospheric oxygen. Often several species of minnows dominate the riverine swamp forests, while most larger fishes are temporary residents of these wetlands (Mitsch and Gosselink, 1993). The most characteristic fauna of this habitat are top minnows, killifishes (*Heterandria formosa*, *Lucania parva*), swamp darter (*Etheostoma fusiforme*), pirate perch (*Aphredoderus sayanus*), lake chubsucker (*Erimyzon sucetta*), yellow bullhead (*Ictalurus natalis*), flier (*Centrarchus macropterus*), warmouth (*Lepomis gulosus*), and top predators represented by bowfin and pickerels (*Esox* spp.) (Wharton et al., 1982). Estuarine-dependent species that are found on river floodplains include hickory shad (*Alosa mediocris*), blueback herring (*Alosa aestivalis*), and alewife (*Alosa psuedoharengus*) (Street et al., 2005). Yellow-crowned night heron (*Nycticorax violacea*), green heron, great blue heron, great egret (*Casmerodius albus*), and white ibis (*Eudocimus albus*) occur in this habitat (Wharton et al., 1982). These riverine swamp forests also serve as suitable habitat for the American alligator, as well as several species of snakes (*Agkistrodon piscivorus*; *Natrix* sp.) that feed primarily on frogs, small fishes, salamanders, and crayfish (Mitsch and Gosselink, 1993). Mink, raccoon, rice rat, and otter are also associated with this habitat (Wharton et al., 1982).

<u>Biota of Bottomland Hardwood Forests</u>
The most important local environmental condition is the hydroperiod, which determines the "moisture" or "anaerobic" gradient. This varies in time and space across the floodplain and is a determining factor in the species of vegetation that are present. Upslope from the deep swamps the soils are semipermanently inundated or saturated and support species such as black willow (*Salix nigra*), silver maple (*Acer saccharinum*), cottonwood, overcup oak, water hickory (*Carya*

aquatica), green ash, red maple, and river birch. Fish use of bottomland hardwoods is restricted to periods of inundation. Other inundation fauna include oligochaetes, copepods, isopods, ostracods, nematodes, midge fly larvae, amphipods, water mites, and collembola (minute wingless arthropods). Some crayfish species use bottomland hardwoods throughout the entire year (Wharton et al., 1982).

Riverine and Freshwater Wetlands as Essential Fish Habitat

At the upstream borders of estuarine systems lies a vast network of freshwater rivers and streams that drain a mosaic landscape. Managed species spending part of their life cycle in this region include river herrings, American shad, sturgeon, striped bass, hickory shad, American eel, and Atlantic menhaden. The particular portion of their life cycle spent in freshwater areas varies by species. One species (*Atlantic menhaden*) is only a peripheral user of the lowermost freshwater areas, while the majority is anadromous species (herrings, shads, sturgeons, and striped bass) that use riverine channels and/or their wetland borders as spawning and nursery habitat. American eel is a catadromous species that spends nearly its entire adult life in either freshwater (females) or estuarine areas (males); only leaving to visit its spawning grounds in the Sargasso Sea.

Of all the species comprising the commercial harvest, anadromous species are likely the most stressed. Both river herring and sturgeon have experienced major declines in harvest and have not recovered along the Atlantic coast (ASMFC 1998; Street et al. 2005). Striped bass have also experienced a period of very low abundance followed by restoration efforts that have brought the species back to viability in the Albemarle Sound. Achieving a viable population level for river herring and sturgeon will depend on the spawning stock entering and leaving the system, as well as the conditions encountered within the system. Those conditions include variable temperature, chemical composition, and flow conditions determined by geology, elevation gradient, size and morphology of the channel formations, tidal influence, climatic patterns, land cover characteristics, and inhabiting biological communities (including fishing activities).

While some managed species rely directly upon conditions within freshwater systems, the majority of commercial species inhabit the downstream estuarine system. Therefore, the water and materials transported to estuarine systems from upstream freshwater sources is a vital component of the larger ecosystem. This is where freshwater habitat types can be distinguished based on their role in ecosystem production. There are riparian swamp forests, off-channel sloughs, marshlands, submerged aquatic beds, channels, and unvegetated stream margins. The proportion of each habitat comprising freshwater systems varies by region of the southeast. In some regions, tidal freshwater marshlands cover relatively more area than riparian swamp forests (SAFMC 1998). In these systems, there can be less woody structures for attachment by river herring eggs, but there is more primary production available for downstream consumers in the form of labile organic matter (Van Dyke 1978; Turner 1978).

The recurrent flooding in riparian swamp forests and off-channel sloughs during late winter and spring is of direct importance to river herring. The vegetation made available by rising flood waters provides an ideal attachment site for herring eggs (Wharton et al. 1982). The timing and duration of flooding are also important in the successful spawning of river herring and other anadromous species. During prolonged periods of elevated flow and floodplain inundation, the dissolved oxygen levels in backwater areas can plummet, creating a drain of hypoxic water from the swamps (Junk et al. 1989). Seasonal flooding can also contribute a great deal to production in downstream areas, in the form of dissolved and particulate organic matter (i.e. detritus). As a general rule, watersheds with greater riparian wetland coverage export more organic carbon to downstream estuaries than watersheds with less riparian wetlands (Mitsch and Gosselink 1993). Other indirect benefits of riparian wetlands to downstream fisheries were described in the ecological role and function section above.

Channels transport the majority of water in riverine systems and provide a basic corridor function for diadromous fish species. The channel also contains spawning habitat for striped bass, American shad, and sturgeon during late winter to early spring (Street et al. 2005). In freshwater systems regulated by hydropower facilities, suitable flow patterns can be disrupted. In North Carolina, the Roanoke River Water Flow Committee was established in 1988 specifically to address the issue of flows on the lower Roanoke River. As a result, operation of the dam on Roanoke River was changed to meet the flow requirements of striped bass during their spawning period from April to June (DMF striped bass FMP 2004). Other management actions demonstrating actual returns, in terms of American shad and river herring populations, have included the bypassing of major obstructions and the stocking of fry (SRAFRC 2005).

In summary, the production of diadromous fishery species from freshwater riverine systems appears closely linked to riparian wetland area, unobstructed reach of stream network, and flow regulations.

3.1.2 Submersed Rooted Vascular (aquatic bed-oligohaline, tidal fresh and freshwater)

Description and Distribution

Throughout this section, the term "aquatic bed" is used to describe areas of submersed rooted aquatic vascular vegetation which occur in oligohaline (0.5 to 5 ppt salinity), tidal fresh or freshwater portions of estuaries and their tributary rivers. This term is employed in the Cowardin et al. (1979) classification of wetland and deepwater habitats of the United States, accompanied by the modifier "rooted vascular," to define areas of such vegetation. Such aquatic beds may occur in the estuarine (for beds in oligohaline areas), riverine (tidal fresh or freshwater portions of rivers) or palustrine (oxbow lakes, backswamps) systems as defined in Cowardin et al. (1979). "Aquatic bed" is also the term employed in the land cover classification system developed for use in the national Coastal Change Analysis Program (Clamus et al. 1993) to describe such habitat.

In tidal freshwater, aquatic beds generally grow in a zone extending approximately from mean low water to depths of several meters depending upon water clarity (Odum et al., 1984). This zone often lies adjacent to emergent low marsh and can encompass the entire channel of small, shallow tidal fresh creeks. Most aquatic bed species establish roots in soft benthic muds, and produce herbaceous outgrowths perennially. Stand density and extent are extremely variable, and many species are subject to drastic fluctuations in their populations from year to year, or in some cases within a given season (Southwick and Pine, 1975; Bayley et al., 1978).

The presence of aquatic beds appears to diminish in southeastern rivers with distance traveled inland and upstream. They have been rarely reported in Piedmont streams (Mulholland and Lenat, 1992); are considered locally abundant in some larger blackwater streams and rivers but rare in small blackwater streams (Smock and Gilinsky, 1992); may be abundant in some medium-sized rivers (Garman and Nielson, 1992); and can be extensive in some low-salinity (the term “low-salinity as employed herein is synonomous with the term “oligohaline”) backbays and lagoons (Moore, 1992). Macrophytes may be more abundant in larger rivers of the Piedmont, especially along river margins where sediments are more stable (J.J. Haines, personal communication as cited in Mulholland and Lenat, 1992). Larger Piedmont rivers may support a greater variety of plant forms than the smaller streams because of the presence of different substrate types, greater stability of fine-grain sediments and greater light availability.

Limited information is available on the distribution and extent of aquatic beds in Estuarine Drainage Areas (EDAs) of the South Atlantic. Much of the general distribution information in this section is derived from several of the chapters in Hackney et al. (1992), and from Odum et al. (1984). Distribution in EDAs of the South Atlantic region is discussed from the headwaters to the estuaries. Additional information is available from review of National Wetland Inventory (NWI) maps, although much of the aquatic bed habitat may have been overlooked as a consequence of the small size of individual meadows or beds, presence of tree canopy over the stream which precluded detection, or turbid waters present at the time aerial photographs were taken. On those maps which do include aquatic bed, it is mapped as one of the following: Estuarine, intertidal or subtidal aquatic bed in low-salinity backbays and lagoons; riverine, intertidal or subtidal aquatic bed in the tidal fresh portions of rivers; and lacustrine, limnetic aquatic bed in the case of Lake Mattamuskeet (Cowardin et al., 1979). The State of North Carolina is presently conducting aerial photography of SAV for mapping.

<u>North Carolina</u>
Ferguson (Ferguson and Wood 1994; and unpublished data) identified species (Table 3.1-1) and mapped the distribution and extent of aquatic beds in Currituck, Albemarle, Croatan, Roanoke and Pamlico Sounds in NC. With the exception of Currituck Sound and certain Albemarle Sound sub-estuaries, the shallow portions of the Neuse and Pamlico Rivers and Croatan and Roanoke Sounds are largely devoid of aquatic bed habitat due to physiological stress from variable salinity, chronic turbidity and highly colored water from coastal swamp drainage. Salinities greater than 5 ppt can be too high for low salinity species. Historical meadows of aquatic bed habitat in these low salinity waters are largely missing or reduced in aerial extent, based on anecdotal accounts, having been heavily impacted by development of coastal lands and eutrophication. Total acreage for the low salinity aquatic bed habitat mapped is approximately 11,000 acres, of which 55% is in Currituck Sound. Forty percent is in sub-estuaries associated with Albemarle Sound (R. Ferguson, National Ocean Service, Beaufort, NC, unpublished data).

Table 3.1-1. Low salinity tolerant and low salinity requiring plant species of North Carolina estuaries (Source: Ferguson and Wood, 1994).

Taxonomic Name	Common Name	Salinity Range ------‰-------
Rupia maritima	widgeon grass	0 - 36
Vallisneria americana	wild celery	0 - 10
Myriophyllum spicatum	eurasian water milfoil	0 -10
Najas guadalupensis	bushy pondweed	0 - 10
Potamogeton perfoliatus	redhead grass	0 - 20
Potamogeton pectinatus	sago pondweed	0 - 9
Zannichellia palustris	horned pondweed	0 - 20
Alternantheria philoxeroides	alligatorweed	0 - ?
Nuphar luteum	spatterdock	0 - ?
Ultricularia sp.	bladderwort	0 - ?

(1990) For photographs and general ecological information on these species. Species of SRV thrive in fresh and oceanic water which has been classified according to salinity by Cowardin et al. (1979). Two species, eel grass (*Zostera marina*) and shoal grass (*Halodule wrightii*) are true seagrasses, requiring salinities >5.0 ‰ to survive. One species, widgeon grass (*Ruppia maritima*), is euryhaline. The remaining ten species are most frequent at salinities < 5.0 ‰ (ibid; Batuik et al., 1992).

South Carolina

Species of aquatic bed vegetation recorded in South Carolina blackwater streams include *Sparganium americanum*, which is tolerant of low-light conditions. It is found in fully canopied, second-order Cedar Creek in the Congaree Swamp National Monument, SC. Wild celery and pondweed (*Potamogeton epihydrus*) were common in Upper Three Runs Creek, a tributary of the Savannah River located at the Savannah River Plant site in South Carolina (Morse et al., 1980).

Georgia

Nelson and Scott (1962) reported that river weed (*Podostemum ceratophyllum*) dominated the benthic flora of a rock outcrop reach of the Middle Oconee River, GA.
Free-flowing sections of the Savannah River hosted *Potamogeton*, *Callitriche*, and *Najas*, as well as *Podostemum*. Aquatic moss, *Fontinalis*, and large growths of the macroalga, *Nitella*, have also been observed in some areas of the Savannah River.

Large beds of macrophytes often occur in the backwaters of large, uncanopied rivers such as the Ogeechee River, GA, and Chowan River, NC (Dennis, 1973; Twilley et al., 1985; Wallace and O'Hop, 1985).

Florida

Aquatic macrophytes, both aquatic beds and emergent, are abundant and diverse throughout the floodplain of the St. Johns River (Garman and Nielson 1992). Species which dominated the freshwater portions of the river included pondweeds (*Pontederia* spp.), water milfoil (*Myriophyllum*) and wild celery (*Vallisneria*) (Cox et al. 1976).

Freshwater aquatic bed also occurs in the fresh portions of the Indian River Lagoon (Gilmore 1977). Species present included water weed, hydrilla (*Hydrilla verticillata*), water hyacinth (*Eichornia crassipes*), water lettuce (*Pistia stratiotes*) or pickerel weed (*Pontederia lanceolata*).

Ecological Role and Function

Although macrophytes have rarely been reported in Piedmont stream tributaries of EDAs (Mulholland and Lenat 1992), because vascular plants usually do not occur in the shaded portions of Piedmont streams, species such as wild celery may grow in areas exposed to direct sunlight. Some researchers believe that the lack of vascular plants in Piedmont streams is the result of unstable sediments, moderate to high stream gradients, and the large variations in streamflow typical of most Piedmont streams (M.G. Kelly, personal communication as cited in Mulholland and Lenat 1992). An exception to this is the river weed (*Podostemum ceratophyllum*). This species grows attached to rock surfaces and is therefore not dependent on stable sediments. Productivity of river weed was greatest during moderate and stable streamflow, when the stream bed was completely flooded but the water velocities were not great.

In blackwater streams, light intensity is an important limiting factor to aquatic bed growth. Incident light is affected by both canopy development over small streams during the growing season, and by light attenuation in larger rivers (Smock and Gilinsky 1992). Discharge pattern is also probably important. Highly developed macrophyte beds in Upper Three Runs Creek, South Carolina, were attributed to that stream's more constant discharge versus others with more fluctuating discharges (W.R. English, personal communication as cited in Smock and Gilinsky 1992). Many aspects of the dynamics of aquatic beds in the upper Pamlico River estuary are reviewed in Davis and Brinson (1976). They and other authors (Harwood 1976; Reed 1976a,b; Zamuda 1976a,b; Vicars1976a-c) documented the density, depth and distance from shore; seasonal dynamics; growth dynamics; biomass; areal and temporal distribution; macrophyte decay dynamics; and total macrophyte production and nutrient accumulation.

Submerged aquatic beds (especially the floating-leaf variety) present during warmer months serve as nursery habitat for young diadromous fish (herring, shad, striped bass, and American eel) looking for both microinvertebrate food and refuge within the vegetation (Paller 1987; Cooper et al. 1994). Numerous studies have also documented higher abundances of macro- and microinvertebrates food sources in freshwater aquatic beds than in adjacent unvegetated areas (literature review in SAFMC 1998). The use of freshwater marshlands as nursery habitat for young diadromous fish has not been well documented. However, Yosso and Smith (1997) found that larvae and juvenile fish accounted for 79% of the total number of fish collected in a tidal freshwater marsh of Virginia. Another study found that freshwater shrimp densities were significantly higher in tidal marsh creeks with aquatic beds than creeks without aquatic beds (Rozas and Odum, 1987a), suggesting the importance of a low-tide refuge for small aquatic organisms (including young diadromous fish). Freshwater aquatic beds and marshlands thus seem very important as nursery and foraging habitat for diadromous species. The net community production in tidal freshwater marshes has been estimated to surpass that of saltmarshes (Odum 1978). The autumn dieback and decomposition of freshwater marsh plants and aquatic beds vegetation undoubtedly provides organic material for productivity in downstream estuaries of the southeast.

Species composition and community structure

The tidal fresh- and freshwater aquatic bed communities are diverse, with numerous plant species that vary in dominance depending upon the influence of salinity, turbidity and other environmental factors. It is likely that such communities occur to some extent in the tidal fresh and freshwater portions of most rivers in the South Atlantic, as far inland as the Piedmont reaches of main stem rivers and larger tributaries. The aquatic bed communities of a portion (GA, NC, SC) of the states under jurisdiction of the South Atlantic Fishery Management Council are described in Odum et al. (1984). The aquatic bed communities of southeastern United States Piedmont streams, blackwater streams, medium rivers and low-salinity backbays and lagoons are described to varying degrees in Hackney et al. (1992).

Water-weeds (*Elodea* spp.), pondweeds (*Potamogeton* spp.) and water-milfoils (*Myriophyllum* spp.) are some of the prevalent species in tidal freshwater wetlands of the Atlantic Coast (Odum et al. 1984 and literature therein).

In North Carolina, species present in the oligohaline and freshwater portions of Albemarle and Currituck Sounds were recorded by Ferguson and Wood (1994). Species present, in order of frequency of occurrence were: widgeon grass (*Ruppia maritima*), wild celery, Eurasian water-milfoil (*Myriophyllum spicatum*), bushy pondweed (*Najas quadalupensis*), sago pondweed (*Potamogeton pectinatus*) and redhead grass (*Potamogeton perfoloiatus*). The presence of these species and others was also documented by Davis and Brinson (1976) for the Pamlico River estuary. Investigations in the upper portion of the Pamlico River estuary and a tributary, Durham Creek, documented the presence of wild celery, naiad (*Najas* spp.), pondweeds (*Potamogeton foliosus* and *P. perfoliatus*), widgeon grass, and also macroalgal muskgrasses (*Chara* spp. and *Nitella* spp.). Studies indicated that while aquatic beds occurred from 10 to 160 cm in depth, maximum density occurred at 60 cm. Wild celery and pond weed were the dominant species present.

Estuarine tributaries of Pamlico Sound, specifically Jacks and Jacobs Creeks of the South Creek system, were surveyed over 17 months for distribution and biomass of submerged macrophytes by Davis et al. (1985). The rooted macrophytes present were *Ruppia maritima* and *Zannichellia palustris*. *Ruppia* was present primarily during the warm season, while *Zannichellia* was present primarily during the cool season; both species were present in June. Davis et al. (1985) concluded that the contributions of aquatic macrophytes to community structure in these creeks should be highly variable since their biomasses are highly variable.

Species present in Florida (St. Johns River) include water milfoil and wild celery (Garman and Nielson 1992), water weed (*Elodea* spp.) and *Hydrilla* (freshwater portions of Indian River Lagoon, Gilmore 1977).

Submersed Rooted Vascular as Essential Fish Habitat

The review of the literature conducted for this document suggests that relatively few studies have been performed in the South Atlantic region to specifically investigate use of this habitat by managed species or their prey (with the notable exception of the work done in the Northeast Cape Fear River, NC by Dr. Courtney Hackney and students at the University of North Carolina-

Wilmington, and in estuarine tributaries of the Pamlico River by faculty and students at East Carolina University).

In other regions, such as the Chesapeake Bay and northern Gulf of Mexico, use of tidal freshwater aquatic beds by managed species and their prey is better documented. It seems likely, therefore, that tidal fresh aquatic beds serve directly as EFH in the South Atlantic region because they are used as nursery habitat. Freshwater aquatic beds also provide functions which support species and other EFH in the South Atlantic region through two primary avenues: 1) provision of functional attributes which maintain downstream EFH value in the estuarine portions of South Atlantic EDAs, such as binding substrates, facilitating sediment deposition, conducting nutrient uptake, and generating detritus in a manner similar to seagrasses; and 2) providing shelter and forage for species which serve as important prey for managed species, such as Atlantic menhaden (*Brevoortia tyrannus*), mullet (*Mugil* spp.), alosids (*Alosa* spp.), grass shrimp (*Palaemonetes* spp.) and others. Davis and Brinson (1980, 1983) reported that submerged rooted plants are often temporary features of the littoral zone, disappearing and perhaps reappearing with changing environments. They concluded that information on the seasonal and yearly variations in standing biomass of various aquatic macrophytes was needed to assess the potential contribution of these plants to ecosystem structure and function (Davis et al. 1985).

Submersed rooted vascular vegetation in tidal fresh- or freshwater portions of estuaries and their tributaries performs the same functions as those described for seagrasses (see Section 3.2.3). Specifically, aquatic bed meadows possess the same four attributes: 1) primary productivity; 2) structural complexity; 3) modification of energy regimes and sediment stabilization; and 4) nutrient cycling. Primary production forms complex, three dimensional physical structures which consist of a canopy of leaves and stems and roots and rhizomes buried in the sediments or attached to rocky substrate (in Piedmont stream tributaries). The physical structure provides substrate for attachment of macroalgae and macroinvertebrates, shelter from predators, frictional surface area for modification of water flow and current turbulence, sediment and organic matter deposition, and the physical binding of sediments. Aquatic bed organic matter, like that of seagrasses, cycles and stores nutrients, providing direct and indirect nutritional benefits to macroinvertebrate herbivores and detritivores.

Two of the potential benefits derived from aquatic beds were tested in field experiments conducted by Rozas and Odum (1988). They conducted studies to determine whether relative predation pressure is less in aquatic beds than in unvegetated areas, and whether fish food availability is greater in aquatic bed than in nearby unvegetated areas. They found that aquatic beds in tidal freshwater marsh creeks not only afford protection from predators, but also provide a rich foraging habitat. By foraging in aquatic bed habitat, fish consume larger prey and may have higher growth rates, lower mortality, and higher fecundity (Rozas and Odum 1988).

While the information on the use of aquatic beds in tidal fresh- and freshwaters appears scant, additional information should be generated in the future due to the development of new techniques (Rozas and Minello 1997). Enclosure devices, including throw traps and drop samplers, generally produce less variability in sampling and their catch efficiency does not appear to vary substantially with the type of habitat. These devices should be employed in aquatic beds to collect additional data to document the role which brackish, tidal fresh and freshwater submersed rooted macrophytes play in sustaining managed species and to clarify their EFH role.

Tidal fresh- and freshwater aquatic beds serve as an important substratum and refuge for macroinvertebrates which serve as prey for fish. In the Middle Oconee River, GA, river weed hosted *Simulium* pupae and *Calopsectra* (*Tarytarsus*) larvae (Nelson and Scott 1962). Nelson and Scott concluded that much of the river weed was not used directly as a food source by invertebrates, but entered the detrital food chain after being dislodged from rock surfaces during high flow or drying out when exposed to air during low flow. Approximately one-half of the total plant detritus on the bottom of this reach of the Middle Oconee was river weed.

The macroinvertebrates upon which some fish species feed exhibit seasonality in Piedmont streams which corresponds to the presence of species of importance to managed species. In Piedmont streams, studies of seasonal fluctuations in macroinvertebrate abundance show peaks in spring and autumn in both density (Stoneburner and Smock 1979; Reisen and Prins 1972) and taxa richness (Lenat 1988). These peaks correspond with the periods when spring-spawning alosids (shads and herrings) and their fall out-migrating juveniles are most likely present. Pre-spawning hickory shad, *Alosa mediocris*, gathering in Albemarle Sound in late winter, commonly eat fish prey, primarily of the Family Clupeidae; hickory shad migrating upstream in the Roanoke River to spawn consume fish and insects (Batsavage and Rulifson 1998). In some cases, macroinvertebrates may serve not only as a direct source, but also an indirect source of sustenance as well. In blackwater rivers which contain beds of water lily (*Nuphar luteum*), much of the production enter the food chain through grazing by water lily beetles (*Pyrrhalta nymphaea*) (Wallace and O'Hop 1985). At least one investigator believes that the annual cycle of water lily abundance in many Coastal Plain rivers may be the major factor influencing seasonal variation in macroinvertebrate abundance (D.R. Lenat, personal communication as cited in Smock and Gilinsky 1992). Since alosids, herrings in particular, spawn in such beds, spawning adults and emerging larvae may benefit from the availability of prey in the form of macroinvertebrates themselves, or in the form of zooplankton or other species which make use of the detritus produced by invertebrate grazing.

Macroinvertebrate abundance is higher in macrophyte beds and on their fronds or leaves than in sandy substrates (Smock et al., 1985; W.R. English, personal communication as cited in Smock and Gilinsky, 1992). This abundance is attributed to the fact that aquatic beds stabilize sediment and are an important substrate, and upon their death, become food for invertebrates, a role similar to that played by seagrasses (see Section 3.2.3). Thorp et al. (1997) determined that macroinvertebrate density in Potomac River aquatic beds was two orders of magnitude higher and substantially more diverse than at open water sites. They interpreted their results to support the hypothesis that water-column macroinvertebrates are greatly enhanced in the presence of aquatic bed habitat. Rozas and Reed (1994) found that nekton habitat segregation with depth was largely influenced by submersed aquatic vegetation and salinity as well as water depth. Paller (1987) determined that larval fish assemblages in macrophyte beds were 160 times higher in standing stock than those in adjacent open channels, and that larvae concentrated in the interior of aquatic beds rather than at the ecotone between the aquatic beds and open channels.

Macrophyte beds can also be a source of increased zooplankton prey. Cooper et al. (1994) documented the extent of water lily (*Nuphar lutea*) beds in the lower Roanoke River and their use by larval fishes. They found that the formation of water lily beds is dependent upon water temperature and level of the river but generally begins in early April, with die-back at the end of August or early September. Coverage in the estuary can be substantial; the Roanoke River delta contained about 314,000 m^2 of surface area, representing anywhere from 3% to 40% of river surface area. Cooper et al. (1994) determined that these beds offered important refuge for young fish while allowing them to have access to adjacent open-water zooplankton. *Daphnia*, *Bosmina*, and copepods were found more frequently in adjacent open-water samples, while other cladocerans were more common in water lily beds. Cladocerans and rotifers were the primary prey taxa of larval fishes in water lily beds and cladocera and copepods were the primary taxa in open water. Fish taxa utilizing this habitat included, in order of abundance, sunfishes (centrarchids), shads and herrings (clupeids), minnows (cyprinids), white perch, darters, juvenile menhaden, carp (*Cyprinus carpio*), American eel juveniles (*Anguilla rostrata*), pirate perch (*Aphredoderus sayanus*), Atlantic needlefish (*Strongylura marinus*), brown bullhead (*Ictalurus natalis*) juveniles, striped bass (*Morone saxatilis*), suckers (*Moxostoma* spp.), inland silverside (*Menidia beryllina*), and yellow perch (*Perca flavescens*).

Overall, macroinvertebrate abundance in blackwater streams is much higher than historically believed (Smock and Gilinsky 1992). Species richness is comparable to other types of southeastern streams previously viewed as more diverse. Blackwater streams and other Coastal Plain streams and their associated aquatic beds are important spawning and nursery areas for many fish species, including anadromous species which serve as prey for at least one managed species (bluefish) and likely for others. Use of blackwater streams by anadromous species as spawning sites and as nursery areas is widespread and documented by field observations (Davis and Cheek 1966; Baker 1968; Pate 1972; Gasaway 1973; Frankensteen 1976; Smock and Gilinsky 1992). Highest numbers of fish are present generally from April through June, although fish may arrive earlier in the south and later in the north. Arrival of adults corresponds with the highest flows, thus the greatest area of inundated floodplain (see Section 3.1.1). Both anadromous and resident species move onto the floodplains to spawn, and those species which have adhesive eggs undoubtedly use aquatic bed vegetation as a substrate.

The life history aspects of anadromous alewife and blueback herring in freshwater along the Atlantic Coast was reviewed by Loesch (1987). The two species occur together (i.e., are sympatric) from New Brunswick and Nova Scotia to upper South Carolina. Alewives alone occur north of Nova Scotia and bluebacks alone south to Florida. Both species are important prey species for managed species, and both use aquatic bed habitats for spawning in different parts of the range. Where the two species occur together, alewife preferentially uses habitats likely to contain aquatic beds, while blueback use swifter main channel areas. In the South Atlantic, bluebacks use aquatic bed habitats in oxbow lakes and other backwaters. Both species travel far upstream when access permits, increasing the likelihood that they would use riverine aquatic bed habitats. Loesch (1987) does not address microhabitat requirements for spawning, and does not provide any information about whether juveniles use aquatic beds during their nursery residence in freshwaters.

Studies conducted by Rozas and Hackney (1983,1984), and Rozas and Odum (1987a, b), have documented the importance of oligohaline and freshwater creeks and associated aquatic beds as nurseries for species of significance as prey to managed species. Oligohaline wetland habitats were found to be likely of equal importance as higher salinity marshes for two important estuarine species, spot (*Leiostomus xanthurus*) and Atlantic menhaden (*Brevoortia tyrannus*). Additional species significant as prey were also dominant in oligohaline tidal creeks and associated aquatic beds, including grass shrimp (*Palaemonetes pugio*) and bay anchovy (*Anchoa mitchilli*). Recruitment of small juvenile fishes was found to correspond with the period of greatest aquatic bed areal cover. Average densities of fauna were significantly greater in aquatic beds than over nearby unvegetated creek bottoms in the fall. The aquatic beds of tidal freshwater marsh creeks were considered most important as habitat for forage fishes. In experiments where the aquatic bed vegetation was removed from tidal fresh creeks, the number of grass shrimp on adjacent marshes decreased, but the average density of fishes was not reduced. The authors concluded that the proximity of aquatic beds and the depth of adjacent creeks are the most important factors that influence the abundance of nekton on tidal freshwater marshes (Rozas and Odum 1987a).

Anadromous species are also important seasonal components of main stem rivers which originate in the mountains or Piedmont. These include rivers such as the Roanoke, Tar-Pamlico, Neuse and Cape Fear in NC; Pee Dee, Santee, and Cooper in SC; Savannah, Ogeechee and Ocmulgee in GA, and St. Johns in FL. Other rivers not included in this list primarily drain the Coastal Plain and are blackwater rivers. Since their presence seasonally overlaps with the presence of aquatic beds in these systems, it is likely that adults may use these areas for spawning and perhaps feeding. The eggs, larvae and juveniles which are present in these systems from spring through the fall are much more likely to use aquatic bed habitat for cover and foraging.

The river with the highest potential for EFH designation due to both indirect and direct use by Council-managed species may be the St. Johns in FL (Tagatz, 1967; Cox and Moody, 1981; Hocutt et al., 1986; Swift et al., 1986; Garman and Nielson, 1992). Tagatz (1967) reported 115 euryhaline species (species which tolerate a wide range of salinity), including clupeids (shads and herrings) and sciaenids (such as red drum, weakfish, spot, croaker and others). These species occurred at great distances upstream from the river mouth, presumably because of the extended tidal influence due to the St. Johns low gradient, and also to the presence of refugia in the form of salt springs which occur in the river.

Many of the macroinvertebrates which occur in the oligohaline (low salinity) portions of the backbays and lagoons of the South Atlantic region may use the aquatic beds which occur there, especially the crustaceans. These species in some cases constitute important species managed by the Council (e.g. the penaeid shrimps) or are important prey for other managed species (e.g., blue crabs which are prey for red drum, grass shrimp which are prey for many other species). Because many of the shrimps and crabs have well-developed osmoregulatory capabilities (the ability to adjust to changing salinity), the low and often variable salinities that occur in areas such as Currituck Sound, Albemarle Sound, Pamlico Sound, Core and Bogue Sounds, and SC and GA sounds and backbays, do not pose the stress which they do for other organisms (Moore, 1992). On the South Atlantic coast, the penaeid shrimp species which appears most likely to use aquatic beds in tidal fresh and freshwater areas is the white shrimp (*Litopenaeus setiferus*), although it does not apparently penetrate fresh waters as far on the South Atlantic Coast as it does in the Gulf of Mexico (Odum et al. 1984). Although brown shrimp (*Farfantepenaeus aztecus*) do occasionally occur in the fresher areas of lagoons such as Albemarle Sound (R. Eager, R.W. Laney, J.W. Kornegay and S.W. Winslow, unpublished data) they are not abundant in such areas.

Perhaps the most abundant macrocrustaceans which may use aquatic beds in tidal fresh and freshwater areas of southeastern EDAs are the grass shrimp, species of the genus *Palaemonetes*. There are four species which occur along the South Atlantic Coast: *P. paludosus*, restricted to freshwaters of rivers and which is abundant in tidal fresh areas; *P. pugio* which occurs in low-salinity areas; *P. intermedius*, also present in low-salinity areas; and *P. vulgaris*, which generally remains in areas of greater than 10 ppt salinity, but which presumably could move into areas occupied by aquatic beds during dry periods when salinities are higher and freshwater flows diminished. Williams (1984) notes that the three estuarine species all occur preferentially in beds of submersed aquatic vegetation, hence the name “grass” shrimp. Freshwater shrimp of the genus *Macrobrachium*, and freshwater crayfish (*Procambarus* spp.) also occur in tidal fresh- and freshwater portions of South Atlantic rivers (Rozas and Hackney 1984); however, their importance in the diet of Council-managed species or their prey is unknown.

Another significant crustacean which occurs in tidal fresh- and freshwater aquatic bed is the blue crab (*Callinectes sapidus*). Fully grown blue crabs, especially males, occur not uncommonly far upstream in coastal rivers and at least one large coastal lake, Lake Mattamuskeet in North Carolina (Moore 1992; Rulifson and Wall 1998). Whether the lake was historically isolated or was connected to the nearby estuary is somewhat in doubt, but it was unquestionably altered in the mid-1800s by the construction of a drainage canal dug by slaves (Lake Landing Canal), and then later in the early part of this century by additional canals which facilitated access by estuarine species (Forrest 1998). During one week (April 23 - May 2, 1997), over 1,300 blue crabs with an average carapace width of 1.5 inches migrated into the lake, documenting its value as a nursery for this species (Rulifson and Wall 1998). Juvenile blue crabs characteristically occur at the lowest salinities in estuarine ecosystems (Tagatz 1968).

Other euryhaline species which currently use Lake Mattamuskeet and its extensive aquatic bed habitats include Atlantic needlefish (*Strongylura marina*), striped mullet (*Mugil cephalus*) and tidewater silverside (*Menidia menidia*). The anadromous alewife and white perch (*Morone americana*) also use the lake for spawning (Rulifson and Wall 1998).

3.2 Estuarine/inshore systems

3.2.1 Estuarine Emergent (salt marsh and brackish marsh)

Description and Distribution

One of the dominant features of the Coastal Plain of the southeastern U.S. is its extensive saltmarshes. Saltmarshes are transitional areas between land and water, occurring along the intertidal estuarine shorelines where salinity ranges from near ocean strength to near fresh in upriver marshes.

The saltmarsh is a type of wetland. Wetlands are classified on the basis of their hydrology, vegetation and substrate. The most widely used classification system, that proposed by Cowardin et al. (1979), classifies wetlands into five ecological systems, one of which is the “Estuarine System.” The Estuarine System is further divided into the “Subtidal” and “Intertidal” subsystems. “Emergent Wetland” is one of eight classes of wetlands within the Estuarine Intertidal Subsystem. Estuarine emergent wetlands are characterized by the presence of erect, rooted, herbaceous hydrophytes dominated by salt-tolerant perennial plants. In the southeastern U.S., saltmarsh cordgrass (*Spartina alterniflora*), saltmeadow cordgrass (*S. patens*), big cordgrass (*S. cynosuroides*), needlerush (*Juncus roemerianus*), and narrow-leaved cattail (*Typha angustifolia*) are major components of the estuarine emergent plant community.

In this section, the term “saltmarsh” encompasses “brackish marsh,” as well. Although there is no clear distinction between the commonly used terms “saltmarsh” and “brackish marsh,” the latter typically refers to estuarine emergent wetlands with salinities near the lower end of the mixohaline range, which includes oligohaline (0.5-5.0 ppt), mesohaline (5.0-18.0 ppt), and polyhaline (18.0-30.0 ppt) salinity regimes. By contrast, “saltmarshes” can also occur in salinity regimes that are fully marine or “euhaline” (30.0-40.0 ppt), as well as in hyperhaline (>40 ppt) environments. Characteristic plant species vary along a continuum from high salinity “saltmarshes,” which are typically dominated by *S. alterniflora* in the southeast, to lower salinity “brackish marshes,” where species such as *S. cynosuroides* and *J. romerianus* achieve greater dominance. Because tidal brackish marshes are transitional areas between saltmarshes and tidal freshwater marshes, brackish marshes include species from both habitats, and, therefore, have relatively high plant diversity.

Saltmarshes occur in each of the states in the South Atlantic Region. The total area of saltmarshes in this region is approximately 894,200 acres (Field et al. 1991). It is estimated that saltmarshes in the South Atlantic account for 21% of the nation’s total salt marshes (Field et al. 1992). Unlike the Gulf Coast states, particularly Louisiana, which have lost thousands of acres of estuarine emergent marsh due to a variety of causes including erosion, saltwater intrusion, subsidence sea-level rise, sediment deprivation and physical alteration, the acreage of estuarine emergent marsh throughout the remainder of the southeastern U.S. has remained relatively stable from the mid-1970s to mid-1980s (Hefner et al. 1994).

In the southeastern U.S., South Carolina has the greatest saltmarsh acreage (365,900 acres), followed by North Carolina (212,800 acres) and Georgia (213,200 acres). Florida (east coast) has the least saltmarsh acreage (106,000 acres). The Albemarle-Pamlico Sound (NC) and the St. Andrews-Simons Sounds are the estuarine drainage areas (EDA) with the greatest marsh habitat.

Table 3.2-1 presents baseline estimates of coastal wetland acreage by estuarine drainage area in the South Atlantic region compiled through a cooperative effort of NOAA and USFWS (NOAA, 1991a). Figure 3.2-1 shows the estuarine drainage areas in the South Atlantic Region for which the estimates have been compiled.

Table 3.2-1. Coastal wetlands by estuarine drainage area in the South Atlantic (Source: NOAA 1991a).

	(Acres X 100)				
Estuarine Drainage Area[a]	Salt Marsh[b]	Fresh Marsh[b]	Forested and Scrub[b]	Tidal Flats[b]	Total[b]
1 Albemarle/Pamlico Sounds (8)	1,576 (14)	365 (3)	9,062 (80)	311 (3)	11,314
2 Bogue Sound (65)	211 (22)	11 (1)	616 (64)	118 (12)	956
3 New River (46)	41 (16)	5 (2)	203 (81)	45 (1)	252
4 Cape Fear River (13)	90 (6)	97 (6)	1,291 (86)	20(1)	1,498
5 Winyah Bay (30)	124 (2)	308 (5)	5,472 (93)	6 (0)	5,910
6 North and South Santee Rivers (88)	129 (7)	174 (9)	1,613 (84)	1 (0)	1,916
7 Charleston Harbor (10)	268 (14)	169 (9)	1,540 (78)	8 (0)	1,985
8 St. Helena Sound (100)	916 (21)	321 (7)	3,036 (71)	25 (1)	4,299
10 Savannah Sound (100)	322 (11)	141 (5)	2,428 (84)	9 (0)	2,900
11 Ossabaw Sound (82)	245 (10)	40 (2)	2,282 (89)	4 (0)	2,571
12 St. Catherine's/ Sapelo Sounds (29)	352 (40)	46 (5)	461 (53)	13 (2)	872
13 Altamaha River (35)	79 (7)	81 (7)	976 (86)	2 (0)	1,138
14 St. Andrews/ Simmons Sounds (66)	1,134 (20)	157 (3)	4,420 (77)	59 (1)	5,771
15 St. Marys R./Cumberland Sound	N/A	N/A	N/A	N/A	N/A
16 St. Johns River (96)	168 (2)	2,646 (25)	7,665 (73)	2 (0)	10,481
17 Indian River (95)	24 (2)	591 (57)	368 (36)	45 (4)	1,028
18 Biscayne Bay (79)	104 (3)	1,556 (41)	2,059 (55)	49 (1)	3,769
South Atlantic Total	6,666 (11)	6,743 (11)	44,615 (76)	747 (1)	58,770

a. Values in parentheses represent the percent of county grid sampled by NOAA. Areas with less than 100 percent coverage may not be completely mapped by the U. S. Fish and Wildlife Service.
b. Values in parentheses represent the percent of total Estuarine Drainage Area wetlands grid sampled by NOAA.

Saltmarshes occur in the intertidal zone in coastal and estuarine waters. The coastal physiography of the northern and southern part of the South Atlantic Bight (e.g. North Carolina and Florida) is dominated by shallow water lagoons behind sand coastal barrier shoreline. In the central portion (e.g. South Carolina and Georgia) there are depositional marsh-filled lagoons. In both these systems, marshes may occur in vast expanses, in narrow fringing bands, or as small "pocket marshes" interspersed among higher elevation areas. Although marshes may develop in sandy sediments, especially in high-energy areas, marsh development typically leads to sediments with fine particle-size (mud) and high organic matter content. In most physical settings, marshes can accrete sediments, and thus maintain their elevation in relation to the rising sea level that is occurring over most of the South Atlantic Coast. Salt marshes persist longest in low-energy protected areas where the rate of sediment accretion is greater than or equal to the rate of subsidence (Mitsch and Gosselink 1986).

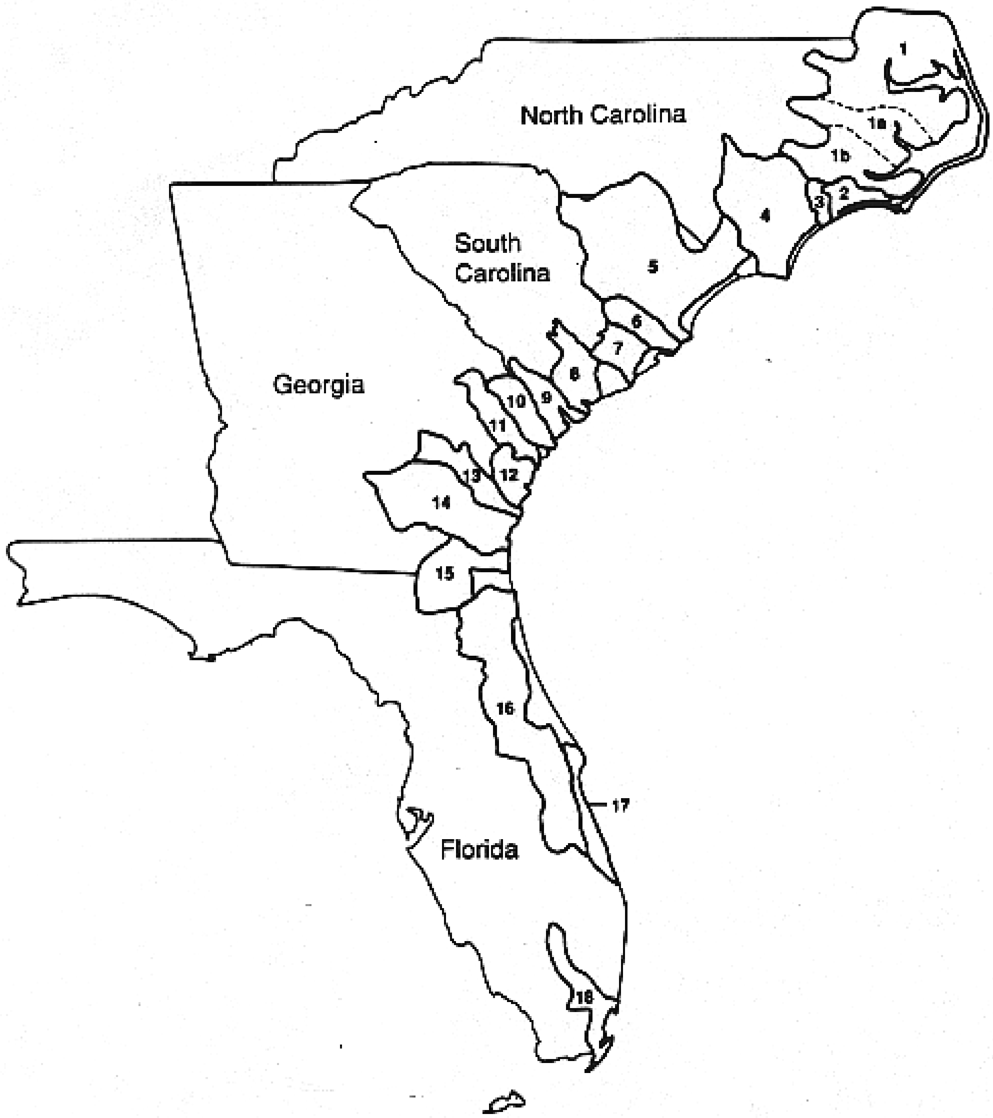


Figure 3.2-1. Estuarine drainage areas in the South Atlantic Region (Source: NOAA 1991a).

Ecological Role and Function

Structure and function of a saltmarsh are influenced by tide, salinity, nutrients and temperature. The saltmarsh can be a stressful environment to plants and animals, with rapid changes occurring in these abiotic variables (Gosselink 1980; Gosselink et al. 1974). Although species diversity may be lower than in other systems, the saltmarsh is one of the most biologically productive ecosystems in the world (Teal 1962; Teal and Teal 1969). The high primary productivity that occurs in the marsh, and the transfer of detritus throughout the estuary from the marsh, provides the base of the food chain supporting many marine organisms.

Few aquatic species feed directly on living plant tissue in salt/brackish marsh (i.e., periwinkle), and their productivity is very low compared to that of detritivores and consumers of microalgae

(Wiegert and Freeman 1990; Steel 1991; SAFMC 1998a). However, biotic interactions with primary consumers can result in degradation or loss of wetlands. Recent study results from the southeastern United States suggest that blue crab predation on plant-eating snails may prevent the snail from overgrazing the marsh grass (Silliman and Bertness 2002).

Detrital and bacterial production from salt/brackish marsh exhibits some of the highest recorded values per unit area of any ecosystem in the world (Wiegert and Evans 1967). Slow-moving or sessile species residing in salt/brackish marsh and contributing to secondary production include fiddler crabs, mud snails, amphipods, oysters, clams, and ribbed mussels (Wiegert and Freeman 1990). Based on data from Georgia marshes, biomass of these resident species exceeded 15 g carbon/m2, and consisted of 80-200 fiddler crabs, 400-700 periwinkle snails or mud snails, and 7-8 mussels (Wiegert and Freeman 1990). The resident estuarine fishes (i.e., killifish, grass shrimp, sheepshead minnow) are an important link between estuarine production and transient predatory fish populations (Wiegert and Freeman 1990; Kneib 1997). Salt-brackish marsh edge also provides important feeding areas for blue crabs, red drum, flounder, seatrout and other large predators searching the edge of complex structure near deeper water, as illustrated by greater predation on grass shrimp with increasing depth in shallow-estuarine water (Clark et al. 2003).

It has been estimated that 45% of salt marsh production is exported to the estuarine system in the form of detritus, dissolved organic matter, and transient nekton (i.e., grass shrimp and killifish; Teal 1962). The biomass of secondary production going in and out with the tide (fish, shrimp) is less well known than resident species biomass (Kneib and Wagner 1994). The exported production of brown and white shrimp is probably the best known and most significant to coastal fisheries (Turner 1977; Wiegert and Freeman 1990). The estimated yield of shrimp from North Carolina was 107 lb per acre of intertidal vegetated bottom (Turner 1977), where intertidal vegetation included "salt marsh macrophytes, *Spartina* spp. [and] *Juncus* spp." However, recent research suggests that wetlands vary greatly in their role as exporters or importers of organic matter (Wiegert and Freeman 1990). This variation could be the result of variable erosion or deposition rates among seasons or wetland areas.

Primary production in salt/brackish marshes is converted into fish production through several pathways. Using sulfur, carbon, and nitrogen isotopes to trace organic matter flow in the salt marsh estuaries of Sapelo Island, Georgia, Peterson and Howarth (1987) found two major sources of organic matter used in fish production: *Spartina* (detritus) and algae. The relative importance of each source is determined by the feeding mode, size, location, and trophic position of the marsh and estuarine consumers (Peterson and Howarth 1987). For example, benthic microalgae probably support herbivorous snails, whereas detritus supports sheepshead minnows, mummichogs, and their prey. Attached algae can be found on the marsh grass itself, the intertidal mudflats, and the shallow subtidal bottom near the marsh. Pinckney and Zingmark (1993) compared production rates of benthic microalgae in various bottom types in an estuarine system (North Inlet, South Carolina). Short *Spartina* marsh accounted for the greatest amount of microalgal productivity (44.6%) in the system, followed by intertidal mudflats (22%), tall *Spartina* marsh (18%), and shallow subtidal bottom (<1 m mean low water) (13%). Sand flats accounted for only 3% of the total annual microalgal production (Pinckney and Zingmark 1993).

Many saltmarshes are drained by an intricate network of tidal creeks. These creeks and the adjacent marsh function as nursery areas for larval and juvenile finfish, crustaceans, and mollusks, and as a critical fisheries habitat to adult species. Greater than 95% of the commercial species in the United States are estuarine dependent species (Feierabend and Zelazny 1987 as cited in Mitsch and Gosselink 1993). Most of the juveniles of fishery species found in salt/brackish marsh nurseries were spawned offshore during winter. The larvae were transported through inlets and into estuarine waters where they settled in the upper (low salinity) or lowermost (high salinity) reaches of estuarine creek systems (Ross 2003). The peak of juvenile settlement generally occurs in spring through early summer, although the peak is correlated more with water temperature (Ross and Epperly 1985). Settlement in upper reaches is particularly beneficial to spot and croaker, where growth and survivorship are enhanced compared to lower reaches (Ross 2003). If movement to general regions of the estuary is largely passive (Pietrafesa et al. 1986; Pietrafesa and Janowitz 1988), the viability of spot and croaker stocks could be reduced by hydrodynamic conditions resulting in more settlement to lower regions of the estuary (Ross 2003). This settlement pattern could also occur in other estuarine-dependent species.

The marsh not only provides food, structure, and refuge from predators to fishery organisms, but also regulates the amount of freshwater, nutrient and sediment inputs into the estuary. In addition to its function as an essential fisheries habitat, the marsh plays a vital role in the health and water quality of the estuary. The position of saltmarshes along the margins of estuaries and their dense stands of persistent plants make them valuable for stabilizing the shoreline and for storing floodwaters during coastal storms.

Species composition and community structure

Flora

There are more than one hundred species of vascular flora and algae that compose the various intertidal macrophytic communities that are common to the estuaries of the South Atlantic Bight (SAB) (Beccasio et al. 1980). Most of those communities are tidally influenced marshes and, to a lesser degree, tidally influenced shrub and forest communities. South of the St. John River estuary in northern Florida the wetland communities of the lagoonal estuaries of the lower Florida peninsula gradually change from a marsh dominated landscape to a shrub community dominated by mangroves.
The macrophytes identified in this section are all influenced in their growth characteristics by salinity in the water. Salinities in south Atlantic estuaries generally range from 30.0 ppt or above (essentially sea strength) at the mouths of coastal inlets to less than 0.5 ppt at the upper reaches of the estuaries under the influence of freshwater outflow from coastal plain streams and rivers (Odum et al. 1984).

The tolerance of salinity in the water column and in the soils that serve as substrate directly influence the composition of the plant community. Salinity in combination with the periodicity of inundation due to tidal action and downstream discharge, soil chemistry, soil type, shading and erosion all result in a predictable model of the zonation of individual species and, at times, discrete plant communities.

Because salt marshes in the southeastern U.S. are influenced by the twice daily rise and fall of tides, they are subject to rapid changes in salinity, temperature and water depth. Salinity, frequency and extent of flooding of the marsh determine the types of plants and animals found there. The low marsh zone floods twice daily, while the high marsh floods only during storms and unusually high tides. One plant, smooth cordgrass (*Spartina alterniflora*), dominates the regularly flooded lowmarsh. Smooth cordgrass is the most abundant plant in southeastern marshes and is responsible for much of the marsh's productivity. *S. alterniflora* is able to tolerate salinities from sea strength to freshwater, as well as the saturated soils that are characteristic of twice-daily tidal inundation. *S. alterniflora*, a true grass, commonly occurs in vast stands growing on the fine grained soils that have been deposited in the low energy coastal lagoons and drowned river valleys behind the barrier islands that fringe the oceanic shoreline. Within the vertical zonation of the tidal amplitude *S. alterniflora* occurs from an elevation that generally equates to mean tide level up to mean high water. *S. alterniflora* exhibits three growth forms, tall, medium and short. The tall form dominates the immediate shorelines of the tidal stream banks at an elevation from mean tide level up to slightly below the mean high tide level and to a horizontal depth shoreward of about two meters. The stem height commonly attains one to one and a half meters. The medium form is found from the stream side levee horizontally into the interior of the marsh. Stem density is less dense that the tall form and stem height averages up to about one meter. The short form grows in the interior portion of the marsh where sediments are finer and less well-drained. Stem density can be higher than the medium growth form and stem height averages about 0.2 to 0.3 meters or shorter. This growth pattern is attributed to a combination of periodicity of tidal inundation, soil salinity, soil saturation, nutrient availability and other less predictable factors. The zonation and stem density, however, play a key role in the use of *Spartina* marshes by consumer organisms.

The second most common marsh plant that occurs in the region is *Juncus roemerianus*. *J. roemerianus*, like *Spartina alterniflora*, is found in all of the estuaries of the SAB. Less salt tolerant and not as well adapted to longer periods of inundation as *S. alterniflora*, *J. roemerianus* is found in the higher elevations of tidal coastal marshes. In salinity regimes higher that 15 ppt *J. roemerianus* is found in dense monospecific stands often in a zone between the *Spartina* and high ground. Stem height averages one meter but may approach two meters.

Diversity of the vascular plant community increases at higher tide elevations and at lower salinities. In the outer portions of the estuary, *Spartina patens* or saltmeadow cordgrass, occurs between mean high water and spring high water. Other plants characteristic of the high marsh are *Salicornia virginica* and *Distichlis spicata*. In more brackish portions of the estuary, *S. alterniflora* is replaced by *Spartina cynosuroides* and *Scrirpus olneyii*.
Several species of macroalgae may become abundant within salt marsh tidal creeks and on the marsh surface, particularly in early spring. These include *Ulva*, *Codium*, *Gracilaria* and *Enteromorpha*. These macroalgal communities, although ephemeral, can provide both refuge and food resources to marsh consumer organisms. Additionally, a diverse community of benthic and epiphytic microalgae inhabits the marsh surface and the stems of marsh plants. This community is composed of diatoms, cyanobacteria, and photosynthetic bacteria, and may represent a significant portion of marsh primary production. The primary production of this algal community also plays an important role in supporting fisheries production in salt marsh habitats.

Fauna

Estuarine intertidal marshes provide habitat for Council-managed species, other fish, shellfish, and invertebrates, as well as endangered and threatened species, furbearers and other mammals, waterfowl, wading birds, shorebirds and other birds, and reptiles and amphibians. Beyond the estuaries, exported marsh nutrients, detritus, and prey species contained in the food web ultimately add to the ecosystems supporting additional managed species such as coastal migratory pelagics (i.e., mackerels) and species in the snapper grouper complex.

In contrast to freshwater marshes, salt marshes have low species diversity of the higher vertebrates, but high species diversity of invertebrates. The invertebrate community in salt marshes is composed of various macrofaunal and mesofaunal species. The macrofaunal community is dominated by various species of crabs (e.g., fiddler and blue crabs), gastropod molluscs (such as *Littorina irrorata*), polychaetes and amphipods. These are the primary foragers of marsh vegetation, detritus and mesofauna. The mesofaunal community consists of protozoa, nematodes, copepods, annelids and rotifers. These organisms primarily feed on the microbial population, which chiefly consists of various species of bacteria and fungi. *Spartina alterniflora* supports a large number of epiphytic fungi, which not only contribute carbon and nutrients, but also participate in decomposition of standing biomass.

The number of macroinvertebrate species in southeastern salt marshes is limited due to the often extreme changes in salinity, temperature, drainage and exposure that can occur. Although species diversity may be limited, densities for some taxa can be quite high. Zonation affects number of species as well with numbers generally increasing from the marsh surface to the subtidal areas. Among the more conspicuous and numerous inhabitants of salt marshes are the decapod crustaceans and mollusks.

Salt marshes provide habitat for several decapod species along the southeastern coast. Rapid fluctuations in water quality variables such as salinity, temperature, and dissolved oxygen restrict the number of decapods that occur in the salt marsh. The protection afforded by marsh grass stem structure and the abundant food supply of salt marshes make them important nursery habitats for larval and juvenile stages of decapod species such as blue crab, white shrimp, and grass shrimp. Subadult stages move into intertidal marshes along the creek edge on incoming tides and penetrate the interior marshes during flood tide (Kneib and Wagner 1994). Resident species such as fiddler crabs (*Uca* spp.) burrow preferentially in sediments with intermediate densities of *Spartina* root mats (Bertness and Miller 1984). Fiddler crabs and grass shrimp are important prey of piscine, avian, and mammalian marsh inhabitants.

Table 3.2-2 reviews examples of fishes and crustaceans common to southeastern U.S. marshes. These organisms utilize the marsh structure (including the stems of emergent vascular plants, attached macroalgae, substrate materials such as shells and sediments, attached living oysters and mussels, residual tidal pools, and accumulated woody flotsam). Some feed directly on the vegetation, especially decapods and gastropods. Some species, are not found within the marsh, but derive substantial food resources from marsh plants as detritus.

Table 3.2-2. List of select macrofaunal species observed in collections from some marsh habitats located in the southeastern United States (Source: NMFS, 1998).

Species	Common Name	Resident Status	Macrophyte Genera	Fisheries Value
FISH				
Anchoa spp.	anchovy	M	Sp, Sc, Ty	P
Anguilla rostrata	American eel	M	Sp, Ju	C/P
Archosargus probatocephalus	sheepshead	M	Sp	R/C/P
Bairdiella chrysoura	silver perch	M	Sp, Sc, Ty, Ju	R/P
Brevootia tyrannus	Atlantic menhaden	M	Sp, Sc, Ty	R/C/P
Cynoscion nebulosus	spotted seatrout	M	Sp, Ju	R/C/P
Cyprinodon variegatus	sheepshead minnow	R	Sp, Ju	P
Dorosoma cepedianum	gizzard shad	F	Sc, Ty	C/P
Eucinostomus sp.	mojarra	M	Sp, Sc, Ty, Ju	P
Fundulus spp.	killifish	R	Sp, Sc, Ty, Ju	R/P
Gambusia affinus	mosquito fish	R	Sc, Ty, Ju	P
Gobiidae	gobies	R	Sp, Sc, Ty, Ju	P
Ictalurus catus	white catfish	F	Sc, Ty	R/C/P
Lagodon rhomboides	pinfish	M	Sp, Sc, Ty, Ju	R/P
Leiostomus xanthurus	spot	M	Sp, Sc, Ty, Ju	R/C/P
Lepomis gibbosus	pumpkinseed	F	Sc, Ty	R/P
Lutjanus griseus	gray snapper	M	Sp	R/C/P
Lutjanus synagris	lane snapper	M	Sp	R/C/P
Lucainia parva	rainwater killifish	R	Sp, Ju	P
Menidia spp.	silversides	R	Sp, Sc, Ty, Ju	P
Micropogonias undulatus	Atlantic croaker	M	Sc, Ty	R/C/P
Micropterus salmoides	largemouth bass	F	Sc, Ty	R/C/P
Morone saxatilis	striped bass	F	Sp, Sc,Ty	R/C/P
Mugil spp.	mullet	M	Sp, Sc, Ty, Ju	R/P
Orthopristis chrysoptera	pigfish	M	Sp	R/P
Paralichthys spp.	flounder	M	Sp, Sc, Ty, Ju	R/C/P
Pogonias cromis	black drum	M	Sp	R/C/P
Pomatomus saltatrix	bluefish	M	Sp, Sc, Ty	R/C/P
Pomoxis nigromaculatus	black crappie	F	Sc, Ty	R/C/P
Sciaenops ocellatus	red drum	M	Sp	R/C/P
Sphyraena barracuda	great barracuda	M	Sp	R/P
Symphurus plagiusa	black cheek tonguefish	M	Sp	P
Urophycis spp.	hake	M	Sp	R/C/P
DECAPODS				
Callinectes sapidus	blue crab	M	Sp, Sc, Ty, Ju	R/C/P
Menippe mercenaria	stone crab	R	Sp	R/C/P
Palaemonetes spp.	grass shrimp	R	Sp, Sc, Ty, Ju	P
Penaeus spp.	penaeid shrimp	M	Sp, Sc, Ty, Ju	R/C/P
Uca spp.	fiddler crabs	R	Sp, Ju	R/C/P

Letter codes for the Resident Status heading are R = resident, M = transient (marine spawner), F = transient (freshwater spawner); for the Macrophyte Genera heading are Sp = *Spartina* spp., Sc = *Scirpus* sp., Ty = *Typha* spp., Ju = *Juncus* spp.; and for the Fisheries Value heading are R = recreational, C = commercial, P = prey species.

The protection afforded by the stem structure and intertidal water levels provides spawning habitat for some fish species, such as killifish, atherinids and gobiids, but most fishes associated with the marsh are recruited as larvae or early juveniles (Boesch and Turner 1984).
Taxa spawning in or near the marsh are considered residents, but the most of the fish species (but not necessarily most of the biomass) are seasonally transient (Weinstein 1979). Transients spawn elsewhere, either upstream in freshwater (e.g., striped bass), or downstream in the coastal waters (e.g., flounders) (Schreiber and Gill 1995), and occupy the marsh habitat primarily as juveniles in the warmer months. Some of these species do not penetrate into the marsh, but are strongly linked to it in the adjacent fringing water.

Marshes as Essential Fish Habitat

It is estimated that over 95% of the finfish and shellfish species harvested commercially in the United States are wetland-dependent (Feierabend and Zelanzy 1987). Coastal wetlands are implicated when you consider the huge majority of commercial fishing occurs in estuarine and marine systems. Within the coastal wetlands category, there are a relative small number of anadromous species that are dependent on riverine forested wetlands for spawning and nursery habitat rather than estuarine marsh. But they only account for a small fraction of species in the commercial catch. The vast majority of finfish and shellfish could thus be considered dependent on estuarine wetlands.

The detritus and attached microalgae made available to secondary consumers by the presence of marsh grass forms the contribution of estuarine marsh production to commercial fisheries production. However, the environment creating individual salt marshes can differ such that more or less production is exported and available for consumption. Species associated with adjacent mud flats and channels benefit more from the presence of marsh plants as more production is exported. There are also species that use marsh grass more directly as refuge and/or foraging areas. Of all the SAFMC managed species, red drum and shrimp are considered most dependent on salt marsh habitat (SAFMC 1998).

Turner (1977) demonstrated the association between shrimp and intertidal habitat (defined as salt marsh or mangroves) at a regional scale. The study compared the commercial harvest of shrimp in various locations with areal estimates of salt/brackish marsh coverage. The results indicated a strong correlation between shrimp yield and area of estuarine vegetation, with little correlation between yield and estuarine area, average depth, and volume. The relationship between shrimp harvest (y) and area of estuarine marsh (e) was quantified in the following equation (where x is degrees latitude):

$$Y = 159e\text{-}0.070(x)$$

However, it should be noted that annual shrimp abundance is highly dependent on weather conditions, in addition to fishing mortality and habitat changes (DMF shrimp management plan – draft 2005).

The relationship between red drum production and estuarine marsh areas has not been quantified to the same level as that of shrimp. Juvenile red drum are found year-round over a wide array of salinity and habitats, although they seem to prefer sheltered, nearshore areas of coastal rivers and submerged aquatic vegetation (SAV) growing near marsh grass behind barrier islands (Ross and Stevens 1992). However, there is substantial evidence for the association of red drum with salt marsh habitat from diet studies. A summary of study results in DMF (2000) found the diet of juvenile red drum was comprised of predominantly mud crabs and fiddler crabs, the latter being closely associated with marsh habitat (Weigert and Freeman 1990).

3.2.2 Estuarine Shrub/Scrub (Mangroves)

Description and Distribution

Mangroves represent a major coastal wetland habitat in the southeastern United States, occupying in excess of 200,000 hectares along the coastlines of all Gulf coast states, Puerto Rico, and the U. S. Virgin Islands; small areas of introduced species are also present in southern California and in Hawaii. In the southeastern U.S., collectively three species comprise true "mangrove" forest: the red (*Rhizophora mangle* L), black (*Avicennia germinans* L. Stearn), and white (*Laguncularia racemosa* L. Gaertn.f.) (Figure 3.2-2); the buttonwood (*Conocarpus erectus* L.), although frequently referred to as a mangrove, does not meet the definition proposed by Tomlinson (1986). The growth of mangroves appears limited by inter-specific competition to coastal and estuarine systems and more inland areas subject to saline intrusions. The largest areas of mangrove forests are found along the coastal areas of Florida south of Latitude 28^{o} 00 N. About 90% of this is located in the four southernmost counties of the Florida peninsula: Miami-Dade, Monroe, Collier, and Lee Counties (Gilmore and Snedaker 1993; Figure 3.2-3).

The three mangrove species of the southeastern U.S. exhibit unique productivity maxima that vary with local soil salinity and flooding regimes. Consequently the composition, and even growth forms of mangrove forests are a function of the interplay between static topography and dynamic hydrology. In recognition of this interplay, several classification systems for mangrove forests have been proposed. While the first such systems were based on differences in mean water depth (Provost 1973, Tabb et al. 1974), that of Lugo and Snedaker (1974) was based on physiogamy. The classification scheme originally proposed by Lugo and Snedaker (1974) has undergone several revisions (i.e., Snedaker 1989, Gilmore and Snedaker 1993) and is the most widely cited mangrove classification system today. A brief description of these types follows.

Mangrove fringe forests occur along sheltered coastlines with exposure to open water of lagoons and bays and are almost exclusively dominated by red mangrove. The tree canopy foliage forms a vertical wall. The characteristics of this mangrove habitat type are related to the patterns of tidal inundation through which detrital materials and propagules are exported from the system during ebb tides. These fringe forests commonly have a shoreline berm or an interior wrack line (i.e., build up of detritus).

Overwash mangrove islands are ecologically similar to fringe forests because of their high frequency of tidal inundation, but here the entire area is completely covered by tidal waters on almost every tidal cycle. Because of the overwash phenomenon there is an infrequent build up of a detrital berm or development of a shoreline berm.

Riverine mangrove forests occur in riverine areas that have estuarine water exchange. This is the most productive of the forest types (Table 3.2-3). The high productivity is attributed to reduced salinity and the fact that freshwater runoff from land mixes with minerals in seawater to provide complete mineral nutrients required for growth. This high production contributes organic detrital material to the adjoining low-salinity system.

Table 3.2-3. Characteristics of mangrove forest types of southern Florida (Source: Gilmore and Snedaker, 1993).

	Mangrove Types				
Characteristics	Fringe Forest	Overwash Forest	Riverine Forest	Basin Forest	Dwarf Forest
Forest height (m)	7.65	6.37	12.64	12.14	<1.0
Mean stand diameter (cm)	8.31	11.12	19.37	10.53	1.75
Complexity Index[b]					
Trees	26.44	13.17	38.77	18.41	1.5
Saplings	1.54	2.17	22.76	4.09	--
Litter production (mg/ha/yr.)	9.00	9.00	12.98	6.61	1.86

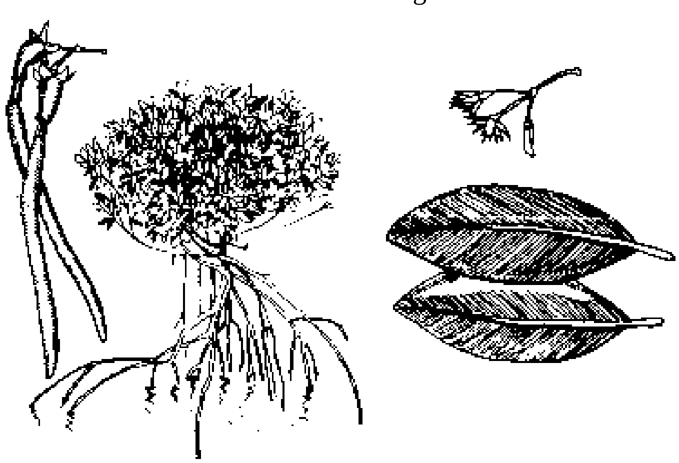
[a] Data are averages.
[b] Complexity Index utilizes tree height, density, and number of species as independent variables and the sum of present contribution of individual species (Pool et al. 1977).

Basin mangrove forests exist in inland topographic depressions not flushed by all high tides. This habitat type may experience seasonal periods of hypersaline soil water, which can limit mangrove growth and induce mortality. Black mangroves normally dominate, but invasion by Australian pine (*Casuarina equisetifolia*) and Brazilian pepper (*Schinus terebinthifolius*) is very common.

Dwarf mangrove forests occur in areas where nutrients, freshwater inflow and tidal activity limit tree growth. Although all of the species can exist in a dwarf form, in southeast Florida large areas of the southeastern Everglades are dominated by dwarf red mangrove forest, and this area has increased in recent years (Ross et al. 2000).

Black Mangrove

White Mangrove



Red Mangrove

Figure 3.2-2. Illustrations of red mangroves, black mangroves, and white mangroves with propagules, flowers, and leaves (Source: Odum et al. 1982).

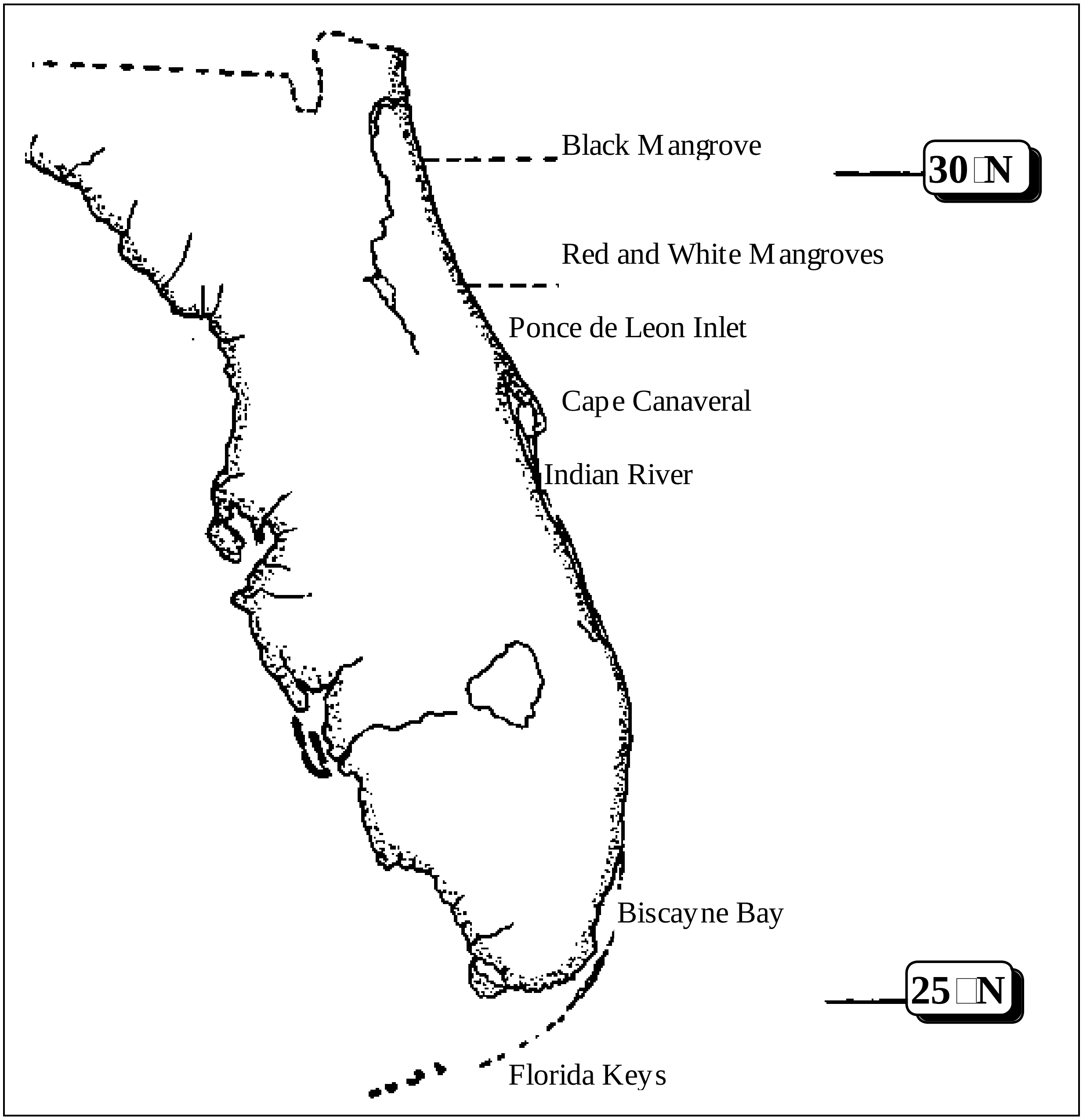


Figure 3.2-3. Approximate northern limits for the red mangrove, black mangrove, and white mangrove in Florida (in Odum et al. 1982 based on Savage 1972).

Ecological Role and Function

Odum et al. (1982) provided a detailed account of the ecology of mangroves in South Florida. More recent publications provide updated summaries of ecology, fishery value, and research information from the limited literature that exists on mangrove habitat (Baran & Hambrey 1998, Alongi 2002, Manson et al. 2005a, Manson et al. 2005b, Faunce & Serafy 2006). Cintron-Molero (1992) provided a succinct summary of the functional values of mangrove ecosystems. Mangrove ecosystems provide many goods and services beneficial to humans. In Asia and

South America, mangroves have been managed for lumber, firewood and charcoal. Mangrove habitats, particularly riverine, overwash, and fringe forests, provide shelter for juvenile and adult fish and invertebrates. In addition, they contribute dissolved and particulate organic detritus to adjacent waters in support of estuarine food webs. Because they are occupied by high proportions of juveniles belonging to fishery species, and these individuals eventually leave mangroves to join the exploited adult phase inhabiting adjacent estuaries or coral reefs, mangroves possibly enhance secondary production in fishes. Mangroves also support the secondary production of birds. For example, the foraging and reproductive success of wading birds such as Roseate Spoonbills (*Ajaia ajaia*) greatly depends on the availability, quantity, and quality of mangrove forests and their associated fauna (Lorenz 2001). In addition to their direct biological value, mangroves help shape the geomorphology of the coastline, retard land loss through erosion, and contribute to the heterogeneity of landforms that provide shelter, foraging grounds and nursery areas for terrestrial organisms. The structure of the mangrove forest buffers interior coastal areas from gale winds and storm surge, protecting human settlements (UNEP 2006).

Species composition and community structure

Gilmore and Snedaker (1993) divided mangrove faunal communities into seven spatial guilds that are defined by microhabitat associations. These are dynamic groupings with species often moving from one guild to another during ontogeny or with changes in environmental conditions (Table 3.2-4). The aquatic components of the community, both fish and invertebrates, are contained in fish and invertebrate use, spatial guilds I, III, IV and V are most relevant, but Guilds II, VI and VII cannot be discounted because they contain the arboreal and terrestrial components of the community, many of which are predators or scavengers on the fish and invertebrate fauna. Various life stages of fish and invertebrates are found in mangrove habitat, with occurrence determined by accessibility and body depth relative to water depth. Fishery species, both fish and invertebrates, are primarily represented as transients commonly using the fringe, riverine, and overwash island mangrove forests (Guild I). Adults of the same species are, in most cases, found in adjacent seagrass meadows, in reef structures, or elsewhere offshore. In Florida, spiny lobsters (*Panulirus argus*) and pink shrimp (*Farfantepenaeus duorarum*) are the most important commercial and recreational invertebrates commonly found among the prop-roots of red mangroves. Fish species listed as mangrove transients in Table 5 that are important in Florida recreational or commercial fisheries include common snook (*Centropomus undecimalis*), sheepshead (*Archosargus probatocephalus*), black drum (*Pogonias cromis*), red drum (*Sciaenops ocellatus*), gray snapper (*Lutjanus griseus*), and dog snapper (*Lutjanus jocu*). Tarpon (*Megalops atlanticus*) is found in mangrove creek habitat. Many small species make up the rest of the fish and invertebrate communities found in mangrove areas of the southeastern U.S. This list also includes the goliath grouper, *Epinephelus itajara*; presently under “no-take” protected status. Other protected species found in one or more type of mangrove habitat include the West Indian manatee (*Trichechus manatus*), American crocodile (*Crocodyllus acutus*) American alligator (*Alligator mississippiensis*), juvenile bull sharks (*Carcharhinus leucas*), lemon sharks (*Negaprion brevirostris*), and Atlantic stingray (*Dasyatis sabina*).

Mangroves as Essential Fish Habitat

For economically important fishery species in the U.S., flooded mangrove habitats provide feeding opportunities and increased refuge from predation relative to open habitat. A quantitative understanding of the use of mangroves by fish and invertebrates is still being developed, hampered by difficulties in quantitative sampling in mangroves, where red mangrove prop roots and black mangrove pneumatophores pose formidable obstacles to most quantitative sampling approaches (Faunce and Serafy 2006).

In a review of the pertinent literature, Faunce and Serafy (2006) found that roughly one in five purported "mangrove-fish" surveys failed to sample this habitat per se. This has undoubtedly produced unrepresentative data in specific cases and has probably led to unfounded conclusions about the nature and extent of fish utilization of mangroves in general. It may, for example, have led to inclusion of a few species on the Gilmore and Snedaker (1993) (Table 3.2-4) list that do not belong there. Despite these drawbacks, generalizations can be made regarding the importance of U.S. mangrove habitat to fisheries.

Evidence linking mangrove habitat to fisheries production mainly has been based on a simple correlative approach relating fisheries to mangroves (Manson et al. 2005, and references therein). Fishery production is appreciably higher in coastal areas off estuarine mangrove forests than off non-mangrove coasts (Marshall 1994). Similarly, greater densities of several species have been recorded adjacent to bays containing mangroves than those without them (Nagelkerken et al. 2001, Dorenbosch et al. 2004, Mumby et al. 2004). Heald and Odum (1968) may have been the first to propose the role of fringe and overwash mangrove forests as nurseries for a variety of economically valuable species in the U.S. This paradigm has been largely based on repeated observations that mangroves contain greater densities of juvenile fishes compared to adjacent habitats. However, the mangrove fringe typically occupies a smaller area than those habitats to which it is often compared (e.g. seagrass beds or mud flats), and the differences may not reflect overall abundance. Furthermore, few studies have been made comparing faunal density in mangrove habitat to that in adjacent habitat, and some of these have used different sampling methods in the two habitats, making the comparison somewhat questionable. On the other hand, the same gear may differ in efficiency when applied to different habitats, so this also is an issue.

Nurseries are habitats whose inhabitants exhibit greater growth, survival, density, and successful export to adult populations relative to surrounding habitats (Beck et al. 2001, Adams et al. 2006). By this definition, despite decades of work, there is little empirical evidence that mangroves are nursery habitats for fishery species. Manson et al. (2005) noted a deficiency in survival and growth information worldwide. Studies of growth of individual species in U.S. mangroves may be limited to the work of Robertson and Duke (1990) and Faunce (2005). A meta-analysis of comparative data on density in mangrove and alternate habitat by Sheridan and Hays (2003) suggested that faunal density was significantly higher in alternate habitats than in mangrove habitat, but survival was significantly higher in mangrove habitat. They considered these results preliminary because of the small number of data sets covered.

Food availability may be enhanced within mangrove habitat. Experimental manipulations have found that structure with attached epibionts attracted significantly more fish than bare stakes

(Laegdsgaard and Johnson 2001), suggesting that structure may increase the availability of potential food items. Greater densities of a planktonic crab larvae actively selected by predatory fishes have been found in Queensland mangroves (Robertson et al. 1988). The work of Odum and Heald (1975) provided convincing evidence that nutrient export from estuarine mangroves supports a “detrital food web” that propagates to forage items for juveniles of exploited species. Species such as common snook (*Centropomus undecimalis*), goliath grouper (*Epinephelus itajara*), sheepshead (*Archosargus probatocephalus*), black drum (*Pogonias cromis*) and red drum (*Sciaenops ocellatus*) likely benefit from the presence of large expanses of mangrove forests (Lewis et al. 1985). A recent study reports that juvenile Goliath grouper prefer well-developed fringing red mangrove shorelines with high spatial complexity (Frias-Torres 2006).

The mangrove-forage association of other exploited species in South Florida is more tenuous. Species such as gray snapper (*Lutjanus griseus*), schoolmaster snapper (*L. apodus*), bluestriped grunt (*Haemulon sciurus*), and sailors choice (*H. parra*) occupy reefs as adults and also occur in those mangroves that frequently experience clear, marine waters (Ley and McIvor 2001). Stable-isotope and observational data have demonstrated that the majority of food items for these species is derived from foraging on adjacent seagrass beds at night (e.g. Rooker and Dennis 1991, Loneragan et al. 1997, de la Moriniere et al. 2003, Kieckbusch et al. 2004). Therefore, any observed growth of these species occupying mangroves during daylight hours is a result of foraging on adjacent habitats and not the mangrove habitat per se.

Assimilation of mangrove products into food webs has been shown to be minimal in a number of stable isotope studies (Sheridan and Hays 2003). For example, Fry and Smith (2002) examined stable isotopes of carbon, nitrogen, and sulfur along a salinity gradient in a riverine mangrove forest, the Shark River estuary of South Florida. Looking at mussels and barnacles, they found the strongest influence of mangrove in the food web in the middle estuary, where mixing models based on sulfur isotopes suggested that as much as 60% of filter-feeder production was mangrove-based. They concluded, however, that, overall, the food web of mangrove estuaries is based primarily on phytoplankton and benthic microalgae. In another South Florida study, Fry et al. (1999) found evidence of a mangrove diet in some pink shrimp newly recruited to the Tortugas fishing grounds; however the predominant stable isotope signature indicated a seagrass food base. While the export of dissolved and particulate materials to coastal areas may be substantial (Lee 1995), evidence of its incorporation and use in coastal waters is lacking.

The repeated observation that mangroves harbor more individuals during the day than at night is strong evidence that mangroves serve as daytime refuges from predation, and thus act as a nursery in this sense, even though some species may not feed there. It has been experimentally demonstrated that the structurally heterogeneous root habitat of mangroves reduces the effectiveness of larger-bodied predators (Primavera 1997, Laegdsgaard and Johnson 2001). Mangroves also produce shade, allowing inhabitants greater visual range than they would have in more brightly lit areas (Helfman 1981). Frias-Torres (2006) noted that shade is an important characteristic in habitat selection by goliath grouper. Because the degree of predation is dependent on light levels, the combination of root structure and inherent low light levels is an additional benefit with regard to avoiding predation (Chittaro et al. 2005).

Not all mangrove stands—even those of the same type, as defined by Gilmore and Snedaker (1993)—are the same in terms of support for fauna. Three Florida studies have compared the associated fauna of mangrove stands and found differences. In the first study, conducted in the upper reaches of northeastern Florida Bay, several distinct fish assemblages were evident within mangroves bordering basins of varying distance from freshwater and saltwater sources (Ley et al. 1999). In the second study, the fringing mangroves of the Biscayne Bay (Florida) mainland contained a significantly lower overall taxonomic richness and density of four out of five reef fishes compared to fringing forests located across the bay on the leeward side of oceanic barrier islands (Serafy et al. 2003). In the third study, density and frequency of occurrence of five reef fishes declined precipitously as a function of increasing distance from oceanic inlets, and distinct shoreline selection was exhibited (Faunce 2005). The availability of certain types of structure as microhabitat might also influence mangrove usage. For example, Frias-Torres (2006) found that juvenile goliath grouper were associated with erosional, concave shorelines of sufficient water depth (i.e., > 80 cm) containing overhangs and undercuts, as opposed to depositional shorelines without these features. Lee (2004) concluded that tidal amplitude and extent of intertidal area, rather than amount of mangrove area per se, influenced prawn catch in tropical nearshore environments across 37 countries. These results point out that the use of mangrove shorelines will be species, season, and location dependent.

Several physical features of mangroves make them especially favorable as fish habitats. Mangrove creeks and ditches, although not as well studied as fringing mangroves, are widely used by fishes. Because creek edges within fringe mangrove habitat are flooded most of the time, they provide low-water refugia during periodic dry-downs. Not surprisingly, the largest-bodied aquatic organisms, e.g., the West Indian manatee (*Trichechus manatus*), American crocodile (*Crocodyllus acutus*) American alligator (*Alligator mississippiensis*), juvenile bull sharks (*Carcharhinus leucas*), lemon sharks (*Negaprion brevirostris*), Atlantic stingray (*Dasyatis sabina*), tarpon (*Megalops atlanticus*), common snook (*Centropomus undecimalis*), and goliath grouper (*Epinephalus itajara*) have been observed within mangrove creeks and ditches (Tabb 1974, sources within Odum et al. 1982). Ley and McIvor (2001) and Faunce et al. (2004) reported a positive relationship between water depth in mangrove forests and the density of gray snapper in southeast Florida.

Mangrove creeks are important conduits between expansive coastal marshes and downstream embayments. Faunce et al. (2004) linked hydrologic regime to change in density of 12 taxonomic groups of fishes and found that the nature of the response was linked to body-size. Small bodied (< 10 cm total length) resident fishes were negatively correlated with changes in water levels within 90 days, while larger fishes, including predatory species, were positively correlated with changes over this and longer time periods (Faunce et al. 2004). The authors concluded that these results represented the concentration of small fish into the creek and their resulting exploitation by larger predators. These results highlight the importance of deepwater habitats as refugia from desiccation for forage species and as feeding areas for larger species. For prey-predator interactions to occur, both groups of fishes must have access to the same habitat.

Just as the area and depth of the creeks influence the degree to which fishes are concentrated during low water events, the flooding of basin mangrove habitats influences the amount of forage fish produced. The mangrove basin habitat (Spatial Guild V) is characterized by separation from tidal water by a berm and seasonal changes in water level and thus availability to fishery resources. The more abundant fishes found in this habitat are cyprinodontiform species such as killifish, mosquitofish, and mollies, which grow and reproduce rapidly. These “r” type species are able to quickly colonize newly flooded mangrove basin habitat during flooded periods, and their growing season is directly related to hydroperiod. In a unique long-term study, Lorenz (1999) demonstrated that basin forests that underwent longer hydroperiods possessed a greater density of demersal “prey-base” fishes than locations that experienced a shorter hydroperiod. The findings of Lorenz (1999) echoed those of similar studies conducted within the adjacent freshwater Everglades (Loftus and Eklund 1994, Trexler 2001). Because basin habitats typically cover great spatial areas, relative to other forest types, and are occupied by numerous r-type species, they have the potential to support immense biological production (biomass= area x time). The time period that adjacent basins are flooded determines the quantity of forage items that potentially can become available to higher consumers, and the rate of decline in water levels relative to the local topography (especially the slope of creek banks) enables the production to be realized by these consumers, including predatory fishes and wading birds. For this reason, both Lorenz (1999) and Faunce et al. (2004) advocated a hydroperiod of ca. 240 days followed by a dry-down of ca. 90 days.

Mangrove stands and seagrass beds and/or coral reefs may play supporting roles in providing nursery habitat for fishery species and other fish and invertebrates, and the documentation and quantification of linkages among these habitats is an emerging avenue of investigation for mangrove researchers. Approaches range from correlative analyses to elemental signatures and tagging (Gillanders et al. 2003). Skilliter et al. (2005) found that the abundance of *Penaeus plebejus* and *Metapenaeus bennettae* was significantly and consistently greater in dense seagrass proximal to mangroves than in other types of habitat. Additionally, sparse seagrass close to mangroves supported more of these species than dense seagrass farther away, indicating that the spatial arrangement of habitats was more important than structural complexity alone. Mumby et al. (2004) found that the community structure of coral reefs off Belize was influenced by the presence of mangroves in the vicinity, and the total adult biomass of several species was higher. In acknowledgement of the linkage between mangroves and adjacent habitats, research is now evolving to focus on which mangrove systems contribute most to offshore fisheries production. For example, Mumby (2006) prepared algorithms identifying the relative importance of mangrove nursery sites, the connectivity of individual reefs to mangrove nurseries, areas of nursery habitat that have unusually large importance to specific reefs, and priority sites for mangrove reforestation projects. These four algorithms should be considered for use in coastal ecosystem and fishery management and planning.

The first international symposium on mangrove habitat, organized by Joseph Serafy, NOAA, National Marine Fisheries Service, Miami, was held in Miami in spring of 2006, and peer-reviewed papers from that conference will be published within the next year, providing further information on mangroves as nurseries. The website is:
http://www.rsmas.miami.edu/conference/mangrove-fish-habitat/
A special issue of the Bulletin of Marine Science (Volume 80, Number 3, May 2007) devoted to the symposium contains keynote papers by Stephen J. M. Blaber and Ivan Nagelkerken, 19 full articles, and 4 notes. Guest editors of this special issue were Joseph E. Serafy and Rafael J.

Araujo. Papers were not available for review in time for development of this mangrove section of the FEP, therefore the volume advances the science of mangrove importance to fisheries beyond that discussed above.

3.2.3 Seagrasses

Description and Distribution

Out of the estimated 250,000 flowering plants existing on earth today, only about 50-60 species have adapted to life in the marine environment (den Hartog 1970; Hemminga and Duarte 2000; Green and Short 2003; Larkum et al. 2006). Collectively, we refer to this group of submersed aquatic vascular plants (SAV) as seagrasses. Seagrasses are clonal plants which reproduce and disperse by means of sexual and asexual reproduction. Seaweeds (macroalgae) are often mistakenly referred to as "grasses." Despite the fact that they frequently co-occur and provide similar ecological services, these two plant taxa have distinctly different growth forms and contrasting environmental requirements, the most important of which is the fact that seagrasses anchor themselves in unconsolidated sediments with an extensive root and rhizome system, thus have a very significant influence on sedimentary processes and nutrient cycling. Only one seagrass genus, *Phyllospadix*, does not require unconsolidated sediments and this species does not grow in the South Atlantic.

Taxonomically, seagrasses are divided into two families and 12 genera (den Hartog 1971; Phillips and Meinez 1988; Green and Short 2003). At least 13 species of seagrass occur in United States waters. In the south Atlantic region, with the exception of Georgia and South Carolina where highly turbid freshwater discharges, suspended sediments and large tidal amplitude combine to prevent their permanent establishment, there are 6 genera of seagrasses represented by 8 species. These species range in size from the three smallest, *Halophila decipiens* (paddle grass), *Halophila engelmannii* (star grass) and *Halophila johnsonii* (Johnson's seagrass), to the relatively larger species, *Zostera marina* (eel grass), *Ruppia maritima* (widgeon grass), *Halodule wrightii* (shoal grass), *Syringodium filiforme* (manatee grass) and *Thalassia testudinum* (turtle grass) (Figure 3.2-4).

In the South Atlantic, seagrass habitat occurs in North Carolina and Florida, with Florida having the greatest amount of seagrass habitat (Figure 3.2-5). Along the Atlantic Peninsula and South Florida regions of Florida, there are an estimated 29,769 hectares (ha) and 574,875 ha of seagrass beds, respectively (Madley et al. 2003). The South Florida total includes seagrass in Florida Bay and the continental shelf off of the Keys (Florida Straits). Seagrass estimates in the Florida Straits include areas with continuous SAV as well as areas where SAV is patchy and intermixed with hardbottom. Along the Atlantic Peninsula, seagrasses are most concentrated in the Indian River Lagoon system. This area, while only supporting approximately 3% of the total seagrass coverage along all of Florida, has the highest seagrass diversity, with seven species present (*Zostera mariana* does not occur in Florida), including the federally threatened species, *Halophila johnsonii* (Johnson's seagrass) (FFWCC 2003). Over half of all seagrass habitat in Florida occurs in South Florida and Florida Bay supports the largest contiguous seagrass beds in the world with *Thalassia testudinum* (turtle grass) being the most dominant species. On the Atlantic side of the Florida Keys, seagrass habitat is closely associated with hardbottom, patch reefs, and mangroves (FFWCC 2003). North Carolina has the second largest seagrass distribution in the continental United States with an estimated 54,230 ha mapped (Ferguson and Wood 1994). This number includes primarily seagrasses and a small amount of visible oligohaline SAV along the western Pamlico and Albemarle tributaries. Unlike Florida, the seagrass species growing in North Carolina, *Z. marina*, *H. wrightii* and *R. maritima*, are all found within coastal lagoons, protected inland waterways and river mouths all protected by barrier islands. A unique feature of NC seagrasses is the overlap in distribution of a temperate species (*Z. marina*) and a tropical species (*H. wrightii*). Where these species co-occur there is a bimodal seasonal abundance, which extends the total annual abundance of seagrasses for a longer period of time (Thayer et al. 1984).

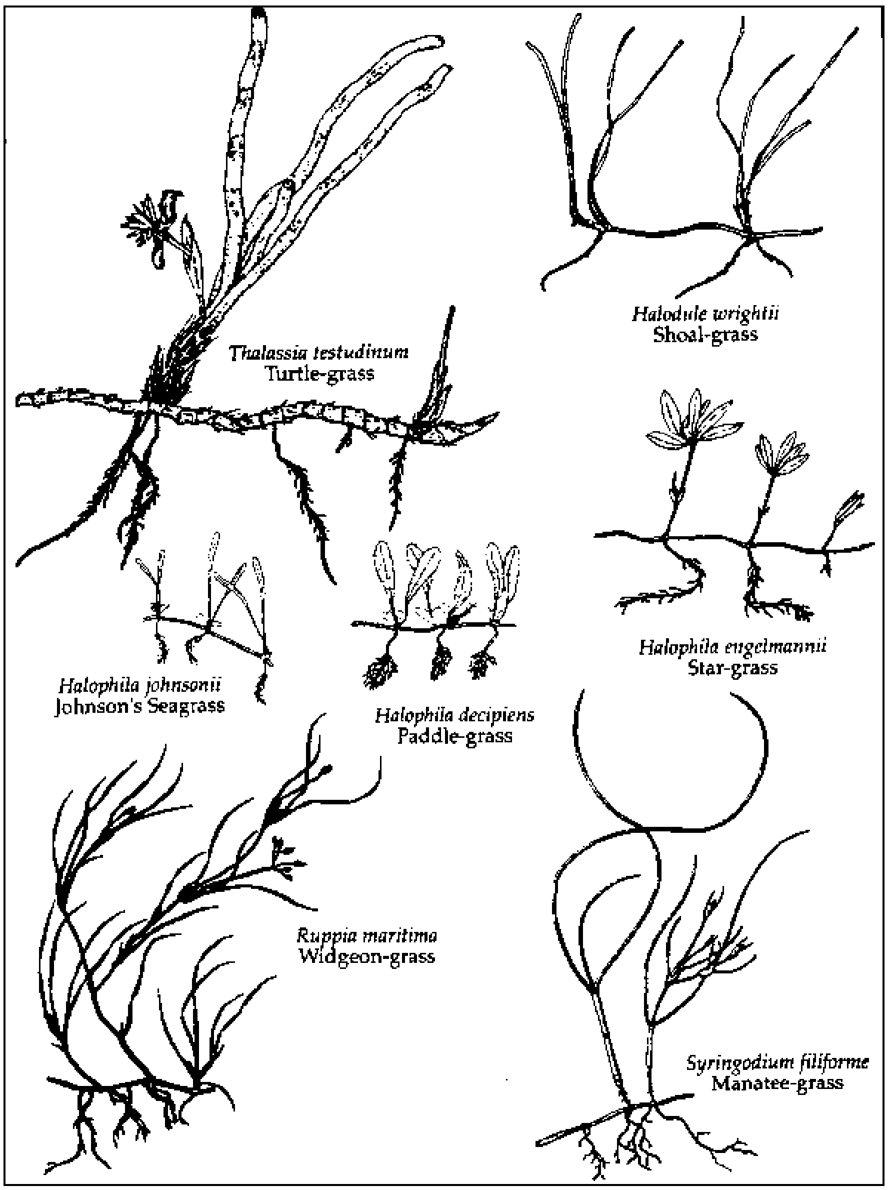


Figure 3.2-4. Illustration of seagrass species in the South Atlantic Region (Source: NMFS, 1997).

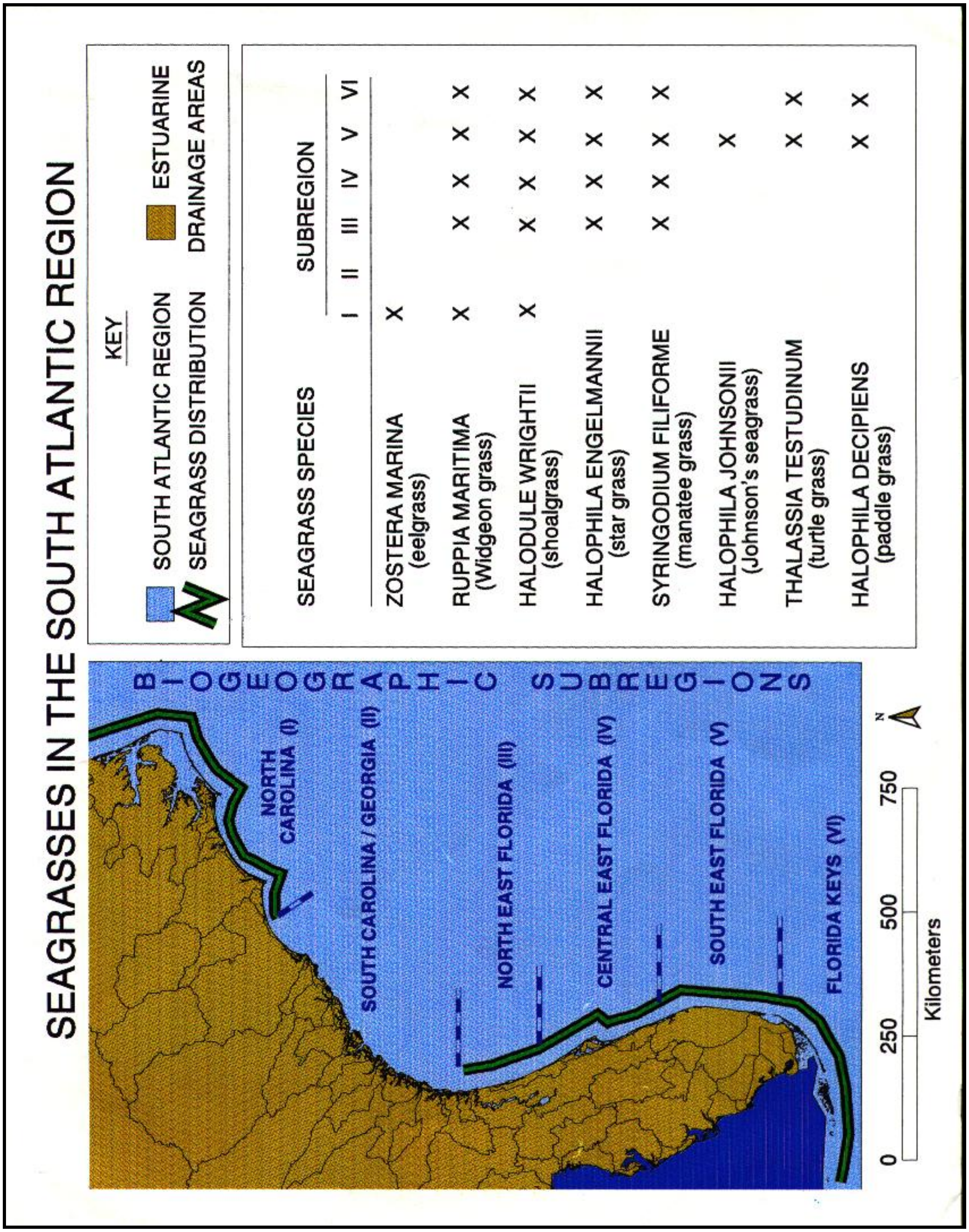


Figure 3.2-5. Illustration and table of the distribution of seagrasses in the South Atlantic Region (Source: NMFS, 1998).

Mapping history in North Carolina

The majority of seagrass habitat in North Carolina was mapped by National Oceanic and Atmospheric Administration (NOAA) using photo-interpretation and groundtruthing of aerial photography taken between 1981 and 1992 (Ferguson and Wood 1994). Bogue Sound was originally mapped in 1981 by Carraway and Priddy (1982), but because of differences in scale and methodology, were not comparable to later mapping. Mapping did not include areas south of Bogue Sound. Most of the oligohaline SAV in Albemarle Sound and western Pamlico Sound tributaries were not mapped during this NOAA project. . However, since then, North Carolina Division of Water Quality (DWQ) and NC Division of Marine Fisheries (DMF) has mapped additional SAV habitat in portions of the Neuse and Pamlico rivers and Pamlico Sound tributaries using field survey techniques, and portions of Albemarle Sound have been mapped by state universities. In 2003, Elizabeth City State University remapped Back Bay, Currituck Sound and Kitty Hawk Bay using aerial photography and specifications recommended by NOAA and Virginia Institute of Marine Science (VIMS) (Finkbeiner et al. 2001; Orth et al. 2001). Although mapping of the coast is not entirely complete, the most recent map of known SAV habitat is shown in Figure 3.2-6. The SAV distribution that is depicted in the figure is a mosaic of multiple projects that used imagery ranging from 1981 to 2003, as well as some mapping conducted completely from field surveys, and includes both seagrasses and oligohaline SAV. Unmapped or inadequately mapped areas should be a high priority for future mapping.

In 2005 a North Carolina SAV Cooperative Habitat Mapping Program was established among 26 state agencies, federal agencies, universities, and non-profit organizations. The purpose of the multi-agency workgroup and 2006 Memorandum of Understanding between organizations is to enhance and accelerate mapping and monitoring efforts by pooling resources and coordinating mapping efforts. The long-term goal of the program is to manage and conserve SAV habitat in North Carolina and southern Virginia in a comprehensive manner through cooperative research, monitoring, restoration, and education (http://www.apnep.org/pages/sav.html). The Albemarle-Pamlico National Estuary Program coordinates the program and is contributing substantial funds for aerial photography so that the entire coast can be mapped in a short time period. However, there is no comprehensive monitoring program yet underway. In 2005, the NC Coastal Habitat Protection Plan (CHPP) was approved by environmental regulatory commissions. The plan summarized the ecological value and status of coastal habitats in North Carolina, including seagrass habitat, and made management recommendations including mapping and monitoring of submerged aquatic vegetation (Street et al. 2005; http://www.ncfisheries.net/habitat/chppdocs/). Through the CHPP and APNEP programs, seagrass management, that includes comprehensive monitoring, should improve over the next few years.

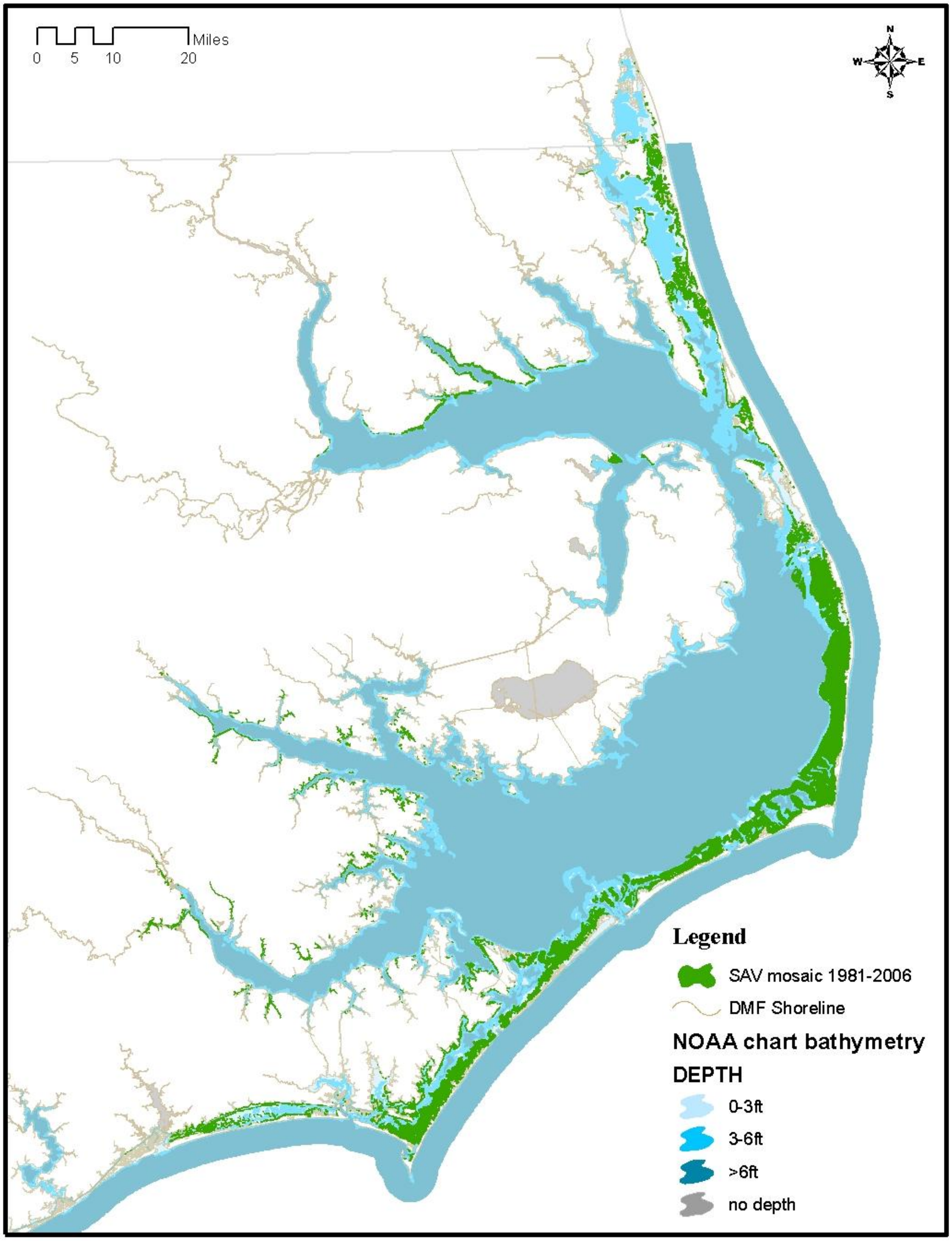


Figure 3.2-6. Distribution of seagrasses and oligohaline SAV in North Carolina (compiled by Scott Chappell, NC DMF, 2007. Published sources include Carroway and Priddy 1983; Ferguson and Wood 1994. Unpublished data sources from NC DWQ; NC DMF bottom mapping program; Elizabeth City State University; North Carolina State University).

Mapping history in Florida

Seagrass cover estimates for Florida have been based on photo-interpretation of aerial photography, mostly at a scale of 1:24,000. Sargent et al. (1995) made the first coast wide effort to summarize statewide seagrass distribution, using photography from 1982-1990. Madley et al. (2003) constructed new statewide seagrass maps using photography from 1987 to 1999 (Figures 3.2-7-3.2-13). Seagrass habitat is regularly mapped every two to three years in the Southwest, St. Johns River, and South Florida Water Management Districts. Other agencies, such as Florida Department of Environmental Protection (DEP), Florida Fish and Wildlife Conservation Commission (FFWCC), National Oceanic and Atmospheric Administration (NOAA), US Army Corps of Engineers (USACOE), US Geological Service (USGS), and US Mineral Management Service (USMMS) have mapped other local areas on a sporadic basis.

Differences in habitat classification schemes and accuracy of methods make overall comparisons difficult. However trend analysis has been done with consistent methodology in several smaller regions of Florida. Overall it appears that seagrass losses have occurred in all regions of Florida, with the largest losses occurring near highly developed areas. Along the Atlantic peninsula, comparison of estimates from recent mapping to estimates in the 1940s found little change had occurred to SAV coverage in the northern Indian River Lagoon and Banana River around the federally protected lands of NASA (FFWCC 2003). Extensive losses have occurred in the southern portion of the Indian River lagoon adjacent to highly developed shorelines. Overall, approximately 59% of what is considered potential SAV habitat (based on SAV presence in 1940 maps) in the Indian River Lagoon is vegetated with seagrass. In South Florida, mapping data has indicated significant declines in SAV coverage in highly developed areas such as northern Biscayne Bay. Seagrass habitat in Dade and Monroe counties has the greatest amount of boat-related propeller damage. Florida Bay has also experienced a large decline in seagrass coverage beginning around 1987. The die-off was attributed to reduced water clarity due to multiple factors including algal blooms, sediment sulfide toxicity, hyper-salinity due to drought, and infection by the slime mold *Labyrinthula*. Although the rate of decline has slowed in recent years, losses continue, which has in turn lead to increased turbidity, further reducing water clarity.

In Florida there are several ongoing regional seagrass management programs, primarily in subtropical portions of the peninsula (e.g., Indian River Lagoon, Florida Bay, Sarasota Bay, and Tampa Bay). To improve coordination of and increase support for seagrass monitoring and management efforts, the Florida Fish and Wildlife Conservation Commission (2003) recommended that the state develop:

- Consensus-based seagrass management strategies at the regional and statewide level;
- a methodologically consistent, statewide seagrass mapping and monitoring program;
- a schedule for reporting regional and statewide status and trends information;
- a schedule for assessing the state’s management strategies and the progress made toward achieving the adopted management goals;
- a management-oriented, statewide seagrass research program; and
- a statewide, public outreach program focused on seagrass management and conservation.

In both North Carolina and Florida, more funding is needed to support comprehensive SAV mapping and management programs. Maps of SAV in Florida can also be viewed on an internet map service at http://ocean.floridamarine.org/mrgis/viewer.htm

Seagrass Distribution along Florida's East Coast- Northern Indian River Lagoon

Figure 3.2-7. Seagrass distribution along the east coast of Florida, Indian River Lagoon. (Source: P. Carlson, FFWCC 2007).

Figure 3.2-8. Seagrass distribution along Florida's east coast – Melbourne to Ft. Pierce. (Source: P. Carlson, FFWCC 2007).

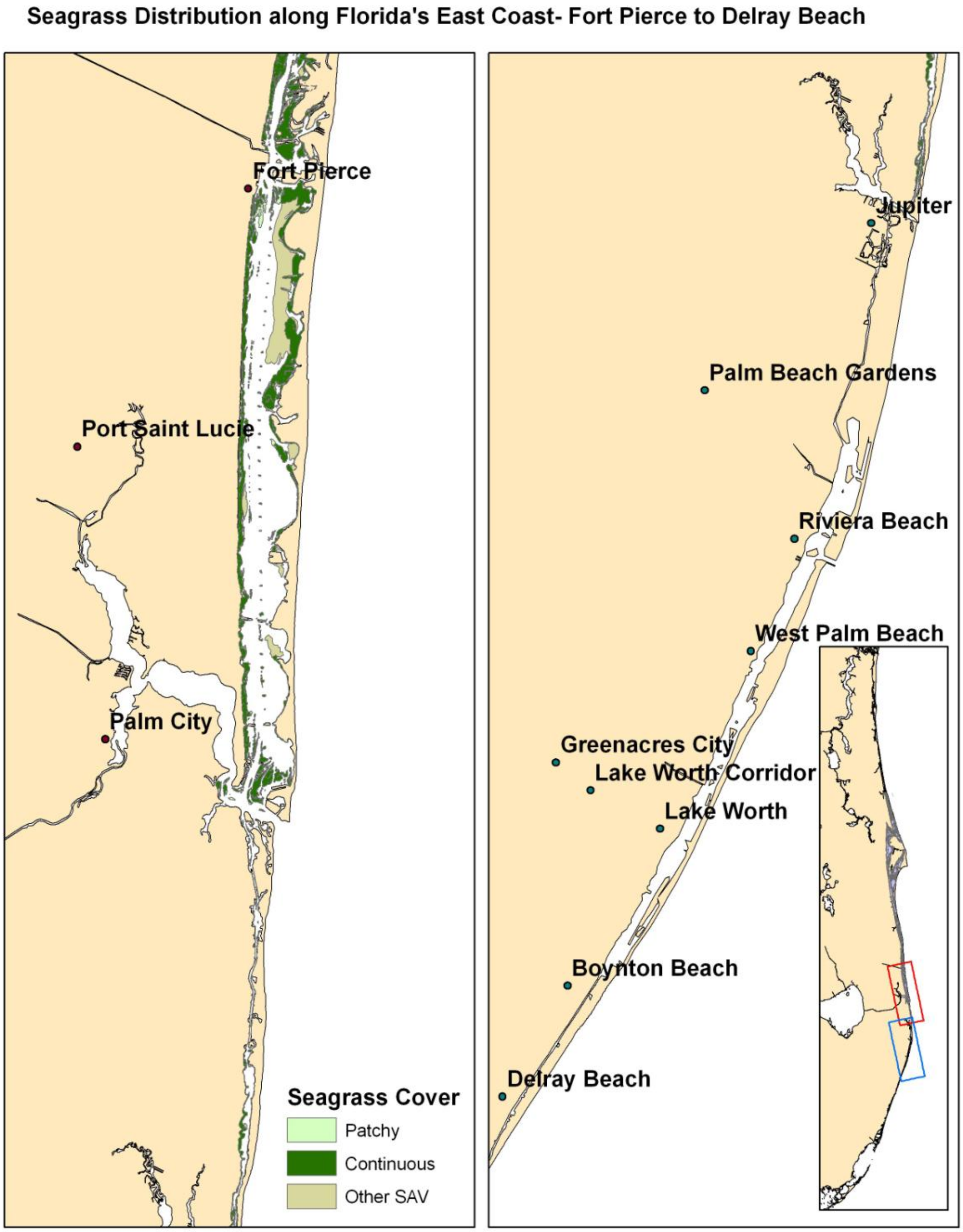


Figure 3.2-9. Seagrass distribution along Florida's east coast – Ft. Pierce to Delray Beach. (Source: P. Carlson, FFWCC 2007).

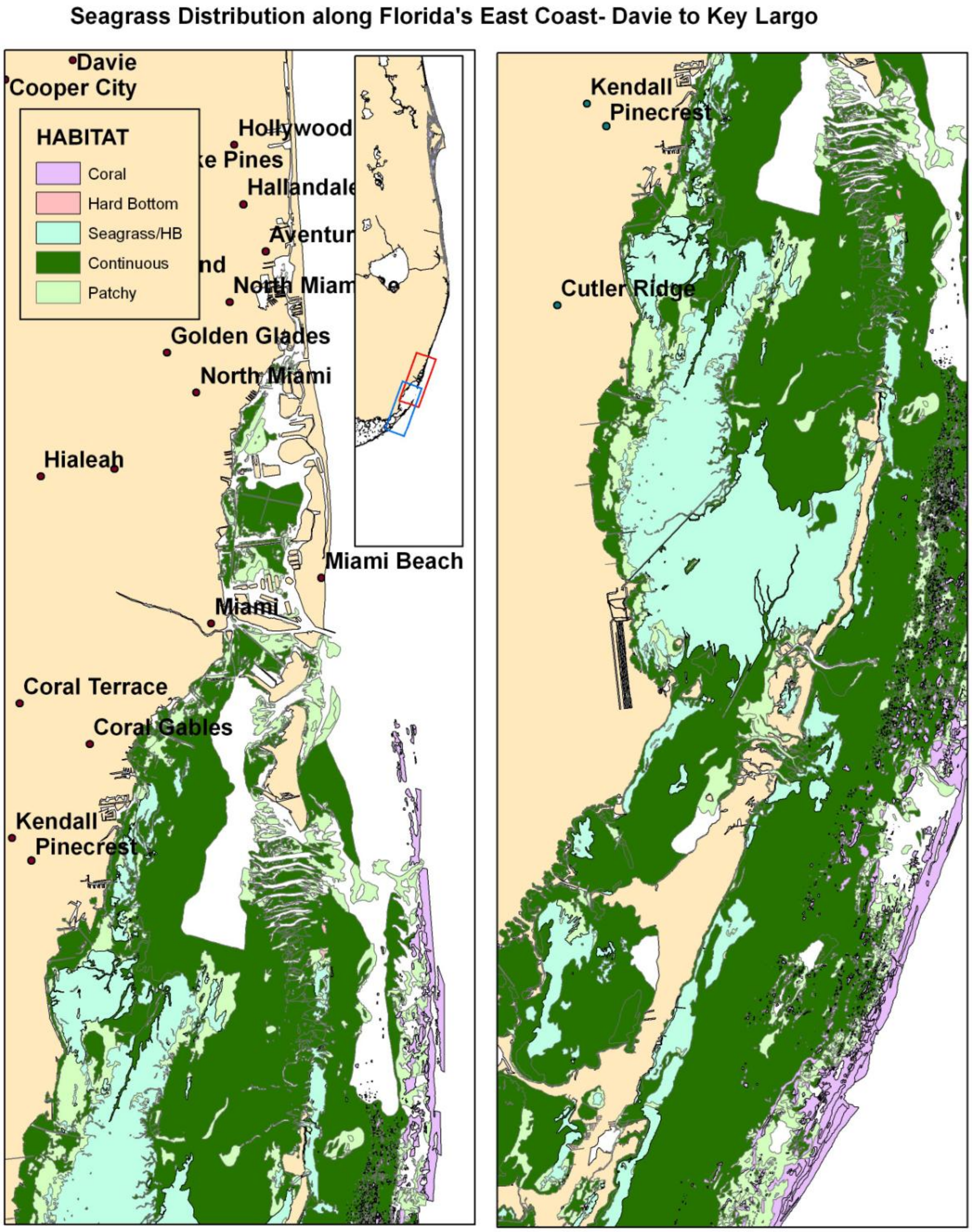


Figure 3.2-10. Seagrass distribution along Florida's southeast coast – Hollywood to Key Largo. (Source: P. Carlson, FFWCC 2007).

Seagrass Distribution along Florida's East Coast- Key Largo to Marathon

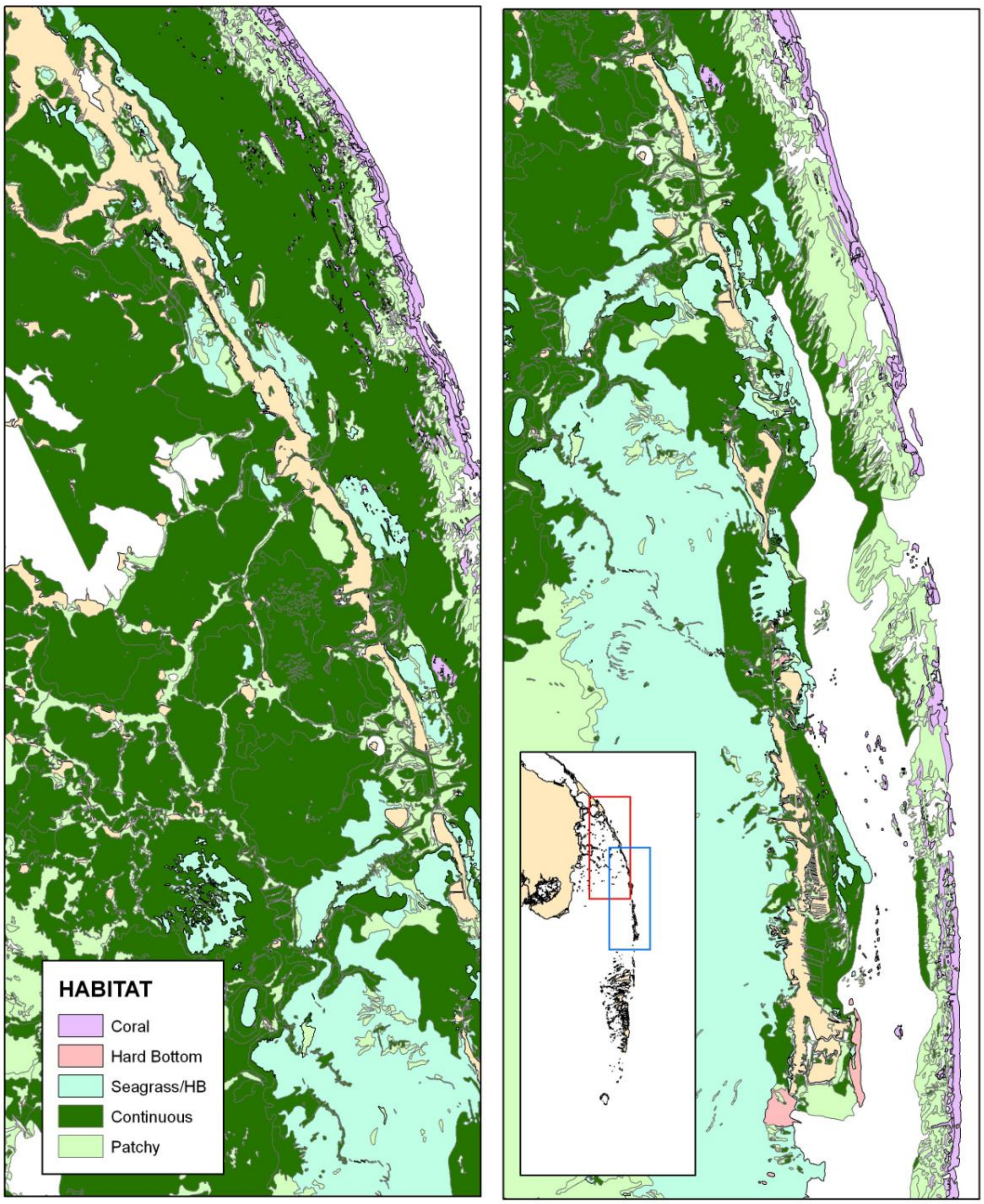


Figure 3.2-11. Seagrass distribution along the upper Florida Keys – Key Largo to Marathon. (Source: P. Carlson, FFWCC 2007).

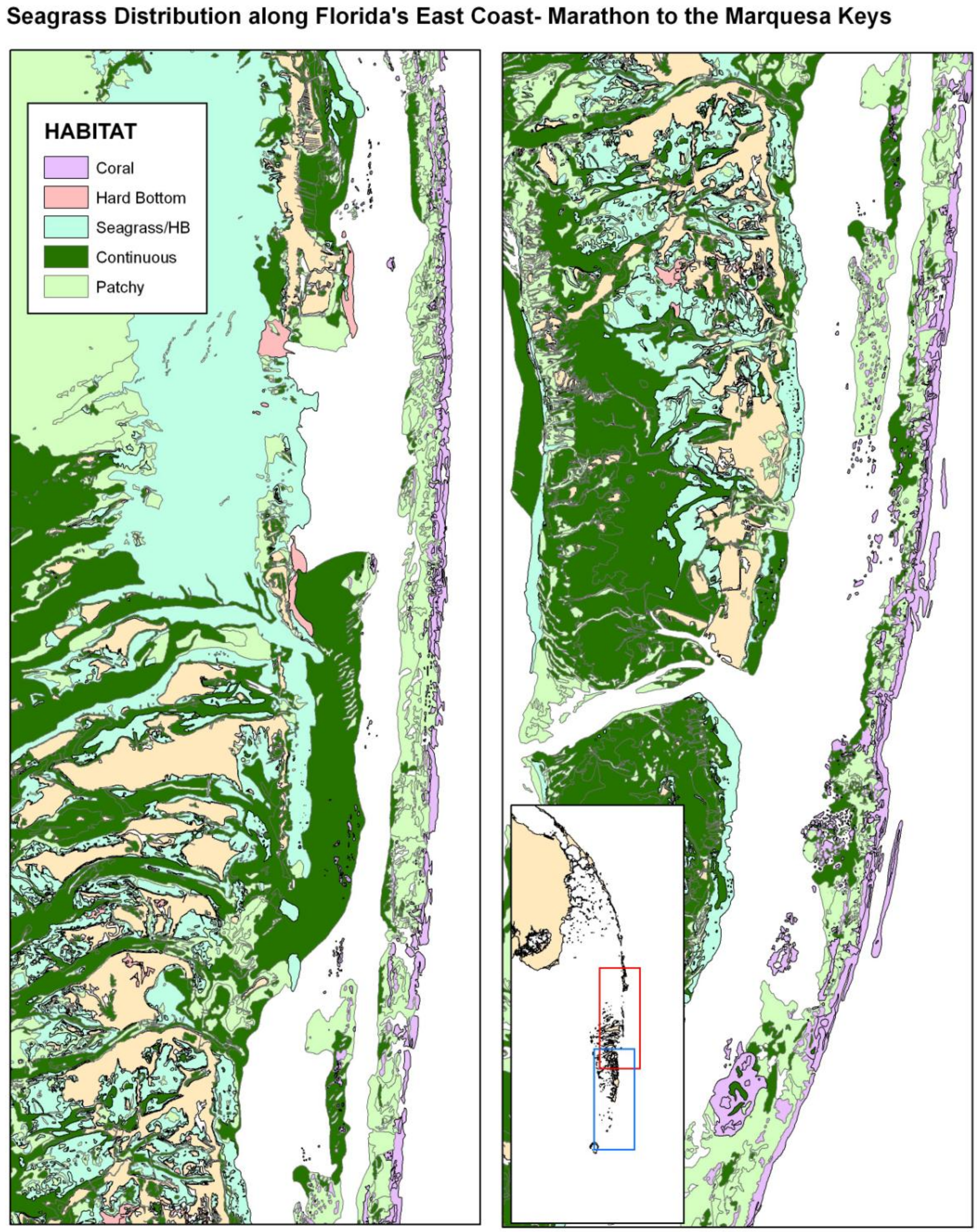


Figure 3.2-12. Seagrass distribution along the lower Florida Keys - Marathon to Marquesas. (Source: P. Carlson, FFWCC 2007)

Seagrass Distribution along Florida's East Coast- Key West to the Dry Tortugas

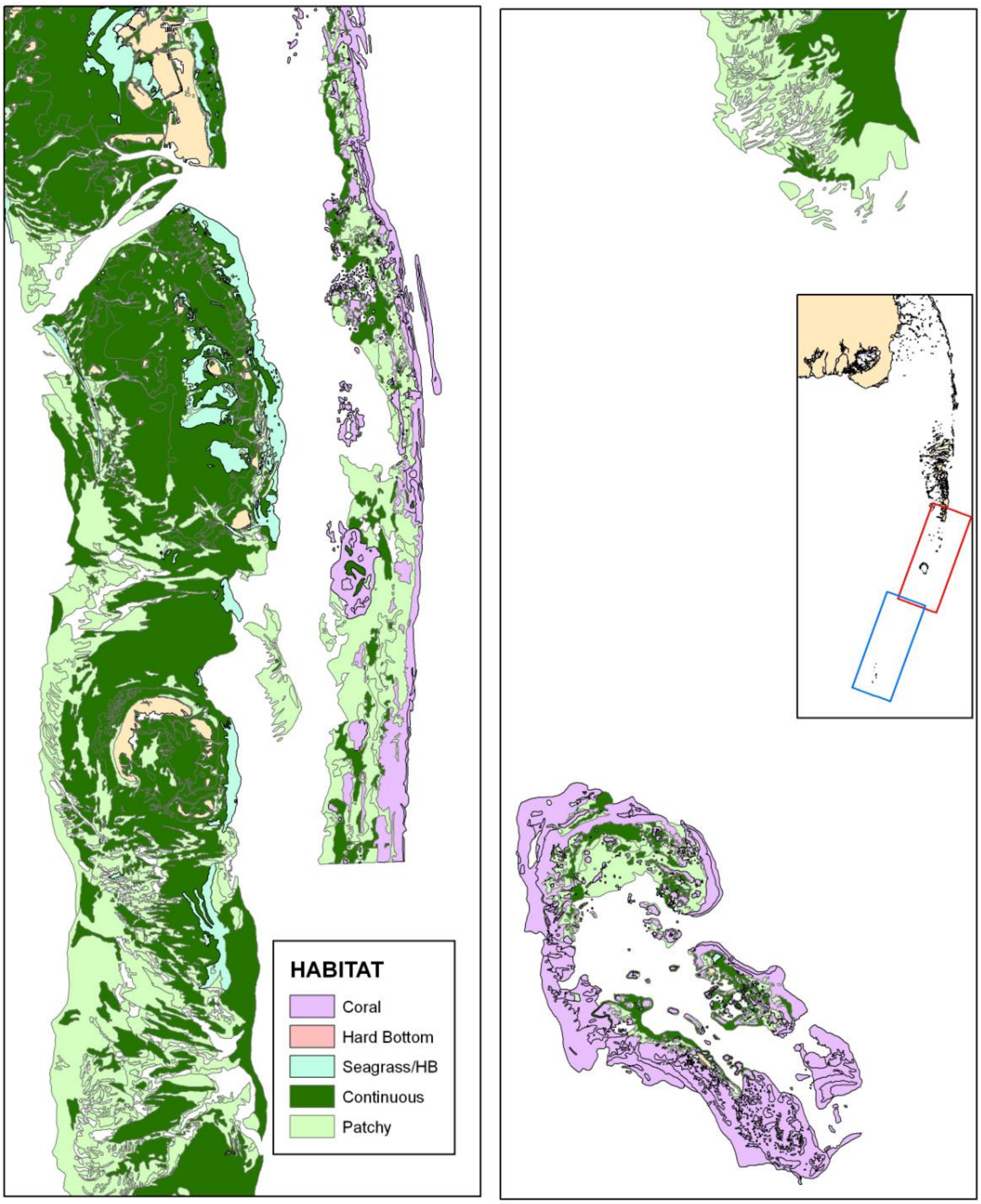


Figure 3.2-13. Seagrass distribution along lower Florida Keys - Key West to the Dry Tortugas. (Source: P. Carlson, FFWCC 2007).

General distribution of seagrass in the south Atlantic

As indicated previously, no seagrasses have been reported to occur in South Carolina and Georgia. Seven of the eight species that occur in the southeastern U.S. are found in Florida. The exception is *Z. marina* whose southern limit is north of Cape Fear, North Carolina (Thayer et al. 1984). In Florida seagrasses are distributed in protected inland waters as well as oceanic environments. In north central (approximately St. Augustine), and southeast Florida most of the seagrasses occur within protected coastal lagoons and in the Intracoastal Waterway (ICW) including; Mosquito Lagoon, Banana River, Indian River Lagoon, Lake Worth, and Biscayne Bay. The most northern distribution of *H. engelmannii* is in the Banana River at Cape Canaveral. The northern limit of *H. decipiens* and *H. johnsonii* is approximately Sebastian Inlet in the Indian River Lagoon. Beginning around the Palm Beach area and continuing south through the Florida Keys, *Halophila decipiens*, while more common inshore in Palm Beach, it is also found on offshore sandy sediments between reefs down to 30m depth. Open water and oceanic meadows of *H. wrightii*, *S. filiforme* and *T. testudinum* begin just south of Virginia Key on the seaward side of Biscayne Bay and continue through the Florida Keys to the Dry Tortugas in water depths up to approximately 30-40 m. (Sargent et al. 1995)

The majority of seagrass biomass is distributed in the subtidal zone; however, all of the species, with the exception of *H. decipiens*, can be found growing in the intertidal zone. The maximum depth limits are determined by optical water quality and transparency and sometimes limited by water velocities associated with inlets, tidal channels and unstable sediments. In North Carolina maximum depths average between 1.5 and 2.5 m and are similar to the maximum depths of seagrasses in the lagoons and Intracoastal Waterway (ICW) along the east coast of Florida. In locations near inlets with clear water and stable sediments seagrasses grow to 3-5 m, while in nearshore and offshore areas of southeastern Florida and the Keys seagrasses grow to depths of 30m.

Salinity is a very important parameter in estuaries because of its potential to control physico-chemical attributes of the system that affect nutrient cycling, water transparency, floral and faunal composition, and productivity. Salinity also undergoes frequent fluctuations and may act as an important stressor. Given the fact that the south Atlantic region has extensive natural and manmade fresh water sources flowing into coastal systems, salinity is a critical parameter controlling seagrass distribution and abundance (Doering and Chamberlain 1999; Estevez 1999). The spatial distribution of seagrasses in coastal systems is controlled locally by salinity, especially the upper reaches of penetration by different seagrass species (Estevez 1999). Seagrass distribution throughout an estuary can also be affected by long-term modification of freshwater inflow such as has occurred in the St. Lucie River in east central Florida.

Of the eight species of seagrass, *R. maritima*, has the widest tolerance to salinity and can grow and thrive from freshwater to hypersaline conditions (Kantrud 1991). When matched with its fecundity, these two characteristics enable *Ruppia* to occur in a wide range of estuarine conditions as well as having the ability to thrive in fluctuating environments. *Ruppia* is a very important species in marginal and transitional environments which are not as suitable for other seagrasses. *H. wrightii* is considered to be the next most tolerant species for relatively lower salinities, and similar to *Z. marina* (McMillan and Moseley 1967; Thayer et al. 1984). Both of these species are considered euryhaline and regularly reported growing at salinities ranging from very low salinities (5-10 ppt) to full strength seawater. *Thalassia* is considered euryhaline and tolerant of salinities as low as 6-10 ppt for brief periods of time; optimum salinities range from 17-36ppt (Doering and Chamberlain 1999).

The salinity tolerances of *Halopila* spp. have not been well studied, however, reports of distribution indicate they are euryhaline and found growing well upstream in estuaries experiencing low salinities and out into the open ocean (Dawes et al. 1989; Toquemada et al. 2005; Kenworthy 2000). The wide range of salinities tolerated by the species of seagrass in the South Atlantic is an important aspect of their function as essential fish habitat. Salinity tolerances enable them to be more widely distributed across the estuarine landscape and are therefore available as habitat to a broader spectrum of fishery species.

As in terrestrial grasslands, seagrass meadows may be seasonal or perennial. The meadows are usually defined by a visible boundary delineating unvegetated and vegetated substrate and vary in size from small, isolated patches of plants less than a meter in diameter to a continuous distribution of grass tens of square kilometers in area. This natural variation in grass bed morphology is related to seagrass dynamics and affects the function of seagrasses as habitat (Fonseca 1996; Murphey and Fonseca 1995; Fonseca and Bell 1998; Fonseca et al. 2002). Seagrass meadows are dynamic spatial and temporal features of the coastal landscape which actually move and can disappear and reappear periodically (den Hartog 1971; Patriquin 1975; Fonseca and Bell 1998; Fonseca et al. 1998; Fonseca et al. 2002). The presence of a seagrasses canopy does not necessarily signify whether or not a location is capable of supporting seagrass habitat. Some species are ephemeral, for example, in North Carolina, shallow *Z. marina* meadows may completely exfoliate in late summer in response to warm temperatures, leaving a signature suggesting there are no seagrasses in the area when, in many instances, the meadows recovers in winter or spring. Because of this, identification of seagrass habitat at certain times of the year can be difficult to determine from visual inspections, which complicates the ability to properly permit water dependent activities such as dredging or marina construction. Environmental characterization of SAV habitat and the better understanding of the processes driving SAV occurrence and temporal changes in distribution are needed to properly identify and protect SAV habitat.

In the South Atlantic region all seagrasses occur on unconsolidated sediments in a wide range of physical settings and different stages of meadow development leading to a variety of cover patterns, ranging from patchy to continuous. Seagrasses patches form and migrate across the sea bottom. In high current environments and areas exposed to wave turbulence, movement is considerable and beds tend to remain in a continuously patchy state. Whereas in low energy embayments and areas protected from large fetch, contiguous perennial beds will tend to form. Seagrass beds developing from seed and mature beds in relatively high energy environments may have similar patchy signatures, but very different physical and chemical characteristics (Kenworthy et al. 1982; Kenworthy 2000).

Depending on the species and the environmental conditions, a meadow may attain full development in a few months (e.g., *Z. marina and Halophila* spp.). Meadows that develop rapidly usually reproduce by seed, forming annual meadows that completely disappear during unfavorable growing conditions. For example, on the east and southeast coasts of Florida between Sebastian Inlet in the Indian River Lagoon (IRL) and North Biscayne Bay, *H. decipiens* forms annual meadows in water generally deeper than 1.5-2.0 m (Dawes et al. 1995; Kenworthy 2000). These depths are where the winter light levels cannot support the larger perennial species such as *R. maritima*, *H. wrightii*, *S. filiforme* and *T. testudinum* (Kenworthy and Fonseca 1996; Kenworthy 2000). In the relatively deeper water the smaller opportunistic *H. decipiens* is capable of germinating seeds in summer months when light levels are adequate. This life history strategy, combined with a thin leaf structure, minimal self shading, and relatively low non-photosynthetic biomass make the genus *Halophila* ideally suited for growth in fluctuating and highly disturbed environments (Kenworthy et al. 1989; Kenworthy 2000).

These dynamic features of seagrass meadows are not just restricted to the genus *Halophila*. In North Carolina annual meadows of a large bodied species, *Z. marina*, are common in shallow, protected embayments where excessively high (> 30^{o} C) summer water temperatures eliminate *Zostera* beds that thrive in winter and spring when water temperatures are optimal (Thayer et al. 1984). These shallow embayments are replenished annually by seed stocks of *Zostera*, whereas in North Carolina during the summer months when water temperatures exceed 25-30°C, *Zostera* thrives only in relatively deeper water or on tidal flats where water movement is nearly continuous so that the plants are insulated from lethal temperatures and desiccation. In general, whether they are found in the warm temperate coastal waters of North Carolina or the subtropical environment in southeastern Florida, seasonal fluctuations in the abundance of seagrass biomass in the subtidal is normal (Dawes et al. 1995). The range of these seasonal fluctuations tends to increase from south Florida to North Carolina. North Carolina is a special case where seasonal fluctuations may be minimized in water bodies and meadows where *Z. marina* and *H. wrightii* co-occur. These two species are at their southern (*Z. marina*) and northern (*H. wrightii*) range limits, and when one species is limited by seasonal thermal extremes the other species may be abundant.

Alternatively, meadows formed by the larger bodied species which have either limited or irregular sexual reproduction may require decades to reach full maturity. For example, the slowest growing species in the south Atlantic region, *T. testudinum*, produces relatively few fruits and seeds at irregular intervals (Tomlinson 1969; Moffler and Durako 1987; Whitfield et al. 2004). When *T. testudinum* is compared to its congeners, *H. wrightii* and *S. filiforme*, it has the slowest rate of vegetative expansion (Fonseca et al., 1987; Kenworthy et al. 2002). Depending on the environmental conditions, rates of vegetative expansion for *H. wrightii* and *S. filiforme* are normally 4 to 10 times faster than *T. testudinum* (Kenworthy et al. 2002). Thus, *T. testudinum* meadows form more slowly than any of the other species, yet if the environmental conditions allow the full development of a *T. testudinum* meadow its biomass and productivity will usually exceed any other seagrass (Zieman 1982).

Regardless of developmental stage or species composition, small seagrass patches and entire meadows can move, the rate of which may also vary on a scale of hours to decades. These dynamic spatial and temporal features of seagrass meadows are important aspects of fishery habitats. Seagrass habitats must be recognized as including not only continuously vegetated perennial beds but also patchy environments with the unvegetated areas between patches as part of the habitat. In fact, available data show that patchy habitats provide many ecological functions similar to continuous meadows (Murphey and Fonseca 1995; Fonseca et al. 1998).

Also, it must be recognized that the absence of seagrasses in a particular location does not necessarily mean that the location is not viable seagrass habitat. It could mean that the present conditions are unfavorable for growth, and the duration of this condition could vary from months to years.

Ecological Role and Function

The ecological role and function of seagrass habitat has been described by Hemminga and Duarte (2000), Larkum et al. (2006) and Duffy (2006). For more specific information of seagrasses in the South Atlantic region we recommend two U.S. Department of Interior Community Profiles: Thayer et al. (1984) and Zieman (1982). A *Symposium on Biodiversity in the Indian River Lagoon* published in Volume 57 of the Bulletin of Marine Science (Swain et al. 1995) is an excellent compendium of the biology, ecology and biodiversity of seagrass communities on the east coast of Florida. Another important source document is the *Symposium on Subtropical-Tropical Seagrasses of the Southeastern United States* (Durako et al. 1987). Additionally, other published books on the general biology and ecology of seagrasses have information pertaining directly to use of seagrass habitat by managed species and their food sources (McRoy and Helfferich 1977; Phillips and McRoy 1980; Larkum et al. 1989; Bortone 1999; Short and Coles 2001). Additionally, *The relationship of submerged aquatic vegetation (SAV) ecological value to species managed by the Atlantic States Marine Fisheries Commission (ASMFC): summary for the ASMFC SAV Subcommittee* by R. Wilson Laney (1997) provides detailed descriptions and literature citations of seagrass use by species managed by the ASMFC and the South Atlantic Fishery Management Council. Following is a brief summarization of the most important aspects of marine seagrasses which pertain directly to their distribution, abundance and function.

Seagrasses are rooted plants that can become nearly permanent, long-term features of coastal marine and estuarine ecosystems either as perennial or annual meadows. Because they are rooted, seagrasses directly link the sediments to the water column. No other marine plants are capable of providing this ecological service. Ecological functions provided by seagrass habitat that enhance conditions for fish species include: 1) primary productivity, 2) structural complexity, 3) modified energy regimes and stabilization of sediment and shorelines, and 4) nutrient cycling.

On a unit area basis seagrasses are among the most productive ecosystems in the world (McRoy and McMillan 1977; Hemminga and Duarte 2000). High rates of primary production lead to the formation of complex, three dimensional physical structures consisting of a canopy of leaves and a dense matt of roots and rhizomes buried in the sediments. The presence of this physical structure provides substrate for attachment of organisms, shelter from predators, frictional surface area for modification of water flow and wave turbulence, sediment and organic matter deposition, and the physical binding of sediments underneath the canopy. Linked together by nutrient absorbing surfaces on the leaves and roots, and a functional vascular system, seagrass organic matter cycles and stores nutrients, and provides both direct and indirect nutritional benefits to hundreds of species of micro-organisms, meiofauna, carnivores, herbivores and detritivores. The most important aspects of these functions are listed below.

Primary productivity

Seagrass meadows provide four important sources of primary organic matter, 1) their own tissues, 2) dissolved organic matter released from their tissues during metabolism, 3) the epiphytic microscopic and macroscopic plants that attach to the surfaces of the seagrass leaves and live among the canopy, 4) the plants that live on the sediments among the seagrass shoots, and 5) the residual organic matter which decomposes in the sediments, on the sediment surface and in the water column. The high rates of primary productivity ensure an abundant supply of organic matter available to be used as an energy source in many different food webs. In some instances a significant portion of the organic matter is exported to adjacent ecosystems (e.g., beach wrack, mangrove forests, open ocean, deep ocean canyons) where it is processed into the food chain. Some fishery organisms consume seagrasses directly (e.g., amphipods and parrot fish), but the majority of the secondary fishery production in the meadows begins with the consumption of epiphyte communities, benthic algae and the utilization of organic detritus. Thus, the food webs supported by seagrass primary production are complex and include many intermediate steps involving microorganisms, meiofauna, small invertebrates such as isopods, and amphipods, as well as the thousands of species of macroinfauna and epifauna in the sediments, on the sediment surface, and in the water column.

Structural complexity

Leaf canopies formed by seagrasses range in size from just a few centimeters (*Halophila* spp.) to more than a meter tall. Where several species co-occur, the three dimensional canopy may take on multiple layers and forms, with long (1.25 m) cylindrical stems and blade surfaces (*S. filiforme*) combined with relatively shorter strap-shaped leaves (*T. testudinum* or *H. wrightii*). No matter what species are present, the existence of leaf surfaces provides structures for attachment of smaller organisms and space between shoots for shelter from predators and adverse environmental conditions. The leaf area in a seagrass meadow may effectively increase the surface area available for colonization by an order of magnitude compared to an unvegetated substrate. While at the same time, the leaves and stems create a large volume of water column sheltered within the canopy and partially obscured by self-shading of the leaves. Within the canopy there is an enormous physico-chemical microenvironment structured and maintained by the seagrasses. This structural influence extends into the sediments where the roots and rhizomes stabilize the substrate and form a large pool of organic biomass and a matrix for meiofauna and macrofauna (Kenworthy and Thayer 1984). The additional structure and productivity, in turn, can support a greater diversity and abundance of species. Several studies have shown significantly greater species richness and abundance in SAV beds compared to unvegetated bottom (Thayer et al. 1975; Heck et al. 1989; Ross and Stevens 1992; Irlandi 1994; ASMFC 1997; Wyda et al. 2002).

Modification of energy regimes and sediment stabilization

The leaf surfaces and the collective structure of the canopy provide frictional drag slows water motion and reduces wave turbulence (Zieman 1982). This process promotes the deposition of particles in the meadows, including but not restricted to inorganic sediments, dead organic matter and living organisms. The addition of all of these materials enhances the productivity, stability, and biodiversity of coastal systems with seagrasses. By promoting sediment deposition and stabilization, coastal habitats coupled to seagrasses meadows by water movement receive both direct and indirect benefits.

<u>Nutrient cycling</u>
The high rates of primary production and particle deposition make seagrass meadows important sources and sinks of nutrients. During active periods of growth the constant and high rate of leaf turnover and epiphyte growth provides nutrients for herbivores and a mechanism for nutrient export and retention. Temporary and permanent retention of nutrients within seagrass meadows is encouraged by particle deposition and burial as well as the formation of organic matter in the sediments by the roots and rhizomes.

Seagrasses are sensitive to the availability and abundance of nutrients in their surrounding environment and often retain nutrient signatures representing environmental conditions they have experienced, both spatially and temporally (Fourqurean et al. 1992). The variation in tissue nutrient composition is an important factor in fishery utilization of seagrass derived organic matter.

Species composition and community structure

Seagrass habitat supports other types of aquatic plants in addition to submerged grasses previously described. Macroalgae (benthic, drift, and floating forms) often co-occur with SAV and provide similar ecological services, but the plant taxa have distinctly different growth forms and contrasting life requirements. Macroalgae grow faster than SAV and do not require unconsolidated substrate for anchoring extensive root systems. Because of this growth pattern, macroalgae do not provide as much sediment stabilization as submerged rooted vascular plants, but do contribute to productivity and biodiversity. Macroalgal genera include salt/brackish (*Ulva*, *Codium*, *Gracilaria*, *Enteromorpha*, *Ectocarpus*, and *Cladomorpha* (Thayer et al. 1984; Mallin et al. 2000). In Florida, calcareous benthic algae, such as *Penicillus* and *Halimeda*, grow among seagrasses and contribute a significant source of calcareous sediment to the system.

Epibiota are another important component of SAV habitat. Epibiota are organisms that attach or grow on the surface of a living plant and may or may not derive nutrition from the plant itself. Micro- and macroalgae (i.e., seaweed) can grow on the leaves of SAV. Invertebrates attached to the SAV leaves include protozoans, nematodes, polychaetes, hydroids, bryozoans, sponges, mollusks, barnacles, shrimps and crabs.

Perhaps seagrass meadows are best known for their source of attachment and/or protection for invertebrates such as bay scallops (*Argopectin irradians*) and hard clams (*Mercenaria mercenaria*). Scientific evidence also indicates that blue crabs (*Callinectes sapidus*), pink and brown shrimp (*Farfantepenaeus duorarum*, *F. aztecus*), and lobster (*Panulirus argus*), just to name a few invertebrates, have a strong reliance on seagrass habitats including seagrass-supported trophic intermediaries.

The three dimensional structure provides protective cover for small resident fish and invertebrates and juvenile fish species. Because of this, the nursery role of SAV is critical for many estuarine dependent fishery species in the South Atlantic region such as gag groupers, flounders, red drum, weakfish, striped mullet, pinfish, pigfish, and silversides, just to list a few of the fish taxa documented to utilize seagrass habitats (Thayer et al. 1984; DMF 1990; ASFMC 1997). Sampling in seagrass beds in North Carolina in the 1980s documented over 150 juvenile fish and invertebrate species, of which 40 were commercially important species. In addition, at least 49 adult fish species were reported from beds in eastern Pamlico Sound (DMF 1990). ASMFC compiled a list of ASMFC managed species that utilize SAV for some portion of their life cycle. Over 30 species were documented potentially using SAV as larvae, juveniles, or adults for various functions (Table 3.2-5).

While there have been few studies dealing with larval fish settlement and use of seagrass habitats, there have been numerous publications listing juvenile and adult fishes collected in seagrass meadows. The same ecological characteristics of seagrass beds that make the habitat favorable for juveniles should also benefit larval fish and invertebrates. Seagrass beds are important for the brooding of eggs (for example, silverstripe halfbeak, *Hyporhamphus unifasciatus*) and for fishes with demersal eggs (e.g., rough silverside, *Membras martinica*). Larvae of spring-summer spawners such as anchovies (*Anchoa* spp.), gobies, (*Gobiosoma* spp.), pipefish (*Syngnathus fuscus*), weakfish (*Cynoscion regalis*), southern kingfish (*Menticirrhus americanus*), red drum (*Sciaenops ocellatus*), silver perch (*Bairdiella chrysoura*), rough silverside, feather blenny (*Hypsoblennius hentzi*), and halfbeaks are present and use seagrass beds.

Table 3.2-5. Ecological functions provided by seagrass habitat for various life stage(s) of ASMFC fishery species (Source: ASFMC 1997).

	Life stage documented to use SAV for function listed [1]			
SPECIES	**REFUGE/ ATTACHMENT**[2]	**SPAWNING**[3]	**FOOD**[4]	**PREY**[5]
Atlantic croaker	L,J,A		J?	J,A
Atlantic menhaden	L,J,A		J,A	
Red drum	L,J	A?		J,A
Spanish mackerel	J?			J?,A?
Spot	L,J,A			J,A
Spotted seatrout	J,A	A		L,J,A
Striped bass	J?			J?,A?
American eel	J			J,A?
Black sea bass	J			J,A?
Scup	L,J,A?	A?		L?,J,A?
Tautog	J, E[2]	E,A		L?,J,A
American lobster	J?		J?,A?	J?,A?
Atlantic herring	L?,J?			L?,J?,A?
Atlantic sturgeon	J?			J?
Bluefin	J			L?,J,A?
Northern shrimp	E?,L?[2],J?,A?	A?	J?,A?	L?,J?,A?
American shad	J?			J?,A?
Hickory shad	J?			J?,A?
Alewife	J?			J?,A?
Blueback herring	J?			J?,A?
Summer flounder	J,A			J,A
Weakfish	L,J,A	A?		L,J,A
Winter flounder	J?,A?			J?,A?
Southern flounder	J,A			J,A?
Striped mullet	J,A		J?,A?	L?,J?,A?
White mullet	L,J,A	A?	J?,A?	L?,J?,A?
Rainbow smelt	J,A?			J?,A?
Black drum	L?,J?,A?	A?	J?,A?	J?,A?
Bay scallop	E?[2],L?,J[2],A	A?	J?,A?	J,A
Brown shrimp	J,A		J,A	J,A
Pink shrimp	J,A		J,A	J,A
White shrimp	J?,A?		J,A	J?,A?
Blue crab	J,A		J,A	J,A

[1] Life stage abbreviations: E = eggs; L = larvae; J = juveniles; A = adults. ? = species overlaps with SAV geographically, but no documentation of use in literature.
[2] The species life stage uses SAV as site of physical attachment
[3] The species deposits eggs in or on SAV beds
[4] The species consumes SAV directly (herbivore) or secondarily (detritivore)
[5] The species feeds on prey that resides in or attached to SAV

In regions of North Carolina where there is often year-round cover of seagrass (either *Zostera* or *Halodule*), larval and early juvenile fishes are present in these beds during much of the year. Lists of these species are presented in referenced literature and policy statements, but it should be pointed out here that larvae and juveniles of important commercial and sportfish such as gag grouper (*Mycteroperca microlepis*), snapper (*Lutjanus griseus*), seatrout or weakfish, bluefish (*Pomatomus saltatrix*), mullet (*Mugil* spp.), spot (*Leiostomus xanthurus*), Atlantic croaker (*Micropogonius undulatus*), flounder (*Paralichthys* spp.), herrings (Clupeidae), and many other species appear in seagrass beds in spring and early summer. Many of these fish reside only temporarily in grass beds to forage, spawn, or escape predation. Some species reside there until the fall when they return to the open coastal shelf waters to spawn. As is noted by the SAFMC's SAV protection policy (See FEP Volume IV, section 7.4.1), economically important species use these habitats for nursery and/or spawning grounds, including spotted seatrout (*Cynoscion nebulosus*), grunts (Haemulids), snook (*Centropomus* spp.), bonefish (*Albula vulpes*), tarpon (*Megalops atlanticus*) and several species of snapper and grouper.

For the most part, the organisms discussed above utilize the grass bed structure and trophic elements associated with the bed, but many species of herbivorous invertebrates (e.g., urchins *Lytechinus variegatus*, *Tripneustes ventricosus*), birds (e.g., black brant *Branta bernicla*), a few fish species (e.g., pinfish *Lagodon rhomboides*, parrotfish *Sparisoma radians*), the green turtle (*Chelonia mydas*) and the manatee (*Trichechus manatus*) feed directly upon coastal and estuarine seagrasses. Work on green turtles in North Carolina has shown a higher incidence of capture in pound nets set in grass beds than by nets set in unvegetated areas. Grazing can have profound effects on the system, but the consequences are neither uniform nor of similar importance in both tropical and temperate seagrasses (Thayer et al. 1984).

Seagrass as Essential Fish Habitat

Seagrasses perform several important functions in coastal ecosystems that facilitate successful spawning, feeding and growth of numerous seasonal and resident fishery species, thus serving as essential fish habitat (Heck et al. 2003; Valentine and Duffy 2006, Heck and Orth, 2006). As ecosystem engineers, SAV presence imparts unique biological, physical and chemical characteristics to water bodies which both directly and indirectly contribute to the necessary attributes of essential fish habitat (ASMFC 1997; Zieman 1982; Thayer et al. 1984). Seagrasses directly attract fish of all life stages, with the three dimensional structure of their leaf canopy offering hiding places that protect juveniles and small adults from predation by larger organisms. As such, seagrass meadows act as nurseries for juvenile fish and their food sources and affect ecological processes which enable fish to grow and mature to different ontogenetic stages, eventually reaching adult forms and emigrating to other habitats (Orth et al. 1984; Heck and Crowder 1991; Koenig and Coleman 1998; Beck et al. 2001). This concept of nursery value is one of the most important aspects of the function of seagrasses as essential fish habitat. Several studies have indicated that juvenile fishes are the most abundant age group in seagrass beds, especially in more temperate waters.

A large proportion of the seasonal residents of seagrass meadows in the south Atlantic region spawn offshore on continental shelves and reefs, enter the estuaries in late winter and early spring and take up residency until fall or until they reach a certain ontogenetic stage when they move to other habitats or offshore to renew this cycle. This process of estuarine dependency is more distinct in the northern most region of the south Atlantic (e.g., North Carolina and north and central Florida). Gag and black sea bass are two estuarine dependent reef species that utilize SAV as nursery areas in North Carolina. Red drum, speckled trout, and weakfish spawn near inlet systems in late summer and fall and use SAV as nursery areas (Street et al. 2005). Further south in the more tropical waters of Biscayne Bay and the Florida Keys the separation in the distribution of reefs and seagrass beds is less distinct. There are also recognizable and predictable interactions where different life stages of fish move between reefs and seagrass beds on a daily basis. The best known examples in Florida are species of grunts which utilize reefs by day and seagrass beds by night. In addition to seasonal and migratory species, there are resident fish species and other fauna that utilize seagrass beds continuously (Sogard et al. 1987).

When seagrass beds are compared to unvegetated substrates, species richness and abundance of animals in seagrass beds is usually greater, implying that there is a preference for seagrass beds by some juvenile and adult species, including fish, decapods and benthic fauna (Thayer et al. 1975; Summerson and Peterson 1984; Heck et al. 1989; Ross and Stevens 1992; Irlandi 1994; ASMFC 1997; Wyda et al. 2002). Many motile species that use seagrass beds can also be found in other habitats, e.g, salt marsh, mangrove, oyster and coral reefs, and macroalgal beds, but use seagrass meadows temporarily for food and for breeding. Thus, seagrasses provide alternative sources of food and shelter and supplement the resources made available by different habitats found throughout the southeastern U.S. Furthermore, since most of the distribution of seagrasses in the southeast Atlantic region is subtidal, where almost all fish reside, seagrasses are a consistently reliable habitat. Compared to intertidal habitats, that are either regularly or irregularly flooded, seagrasses are almost always available to be used by fish. Even though subtidal seagrass beds are regularly available, environmental factors controlling reproduction and dispersal of larvae can affect the abundance of fish in seagrass beds, such that spatial and inter-annual variability is very high. It has been suggested that because most fish spawning is non-local, the abundance and diversity of fish fauna is greatly influenced by processes affecting the fate of planktonic larvae and variable settlement (Bell and Westoby 1986; Hovel et al. 2002).

With the notable exceptions of a few taxa, for example, green turtles, manatees and parrot fish, direct herbivory on seagrasses is uncommon and most of the energy flow is through detritivores, infauna, epifaunal grazers and carnivores (Zieman 1982). In general, the predominant prey items for juvenile fish are small invertebrates, mainly crustaceans, with the most important food categories being amphipods, copepods and shrimps, all of which are very common and abundant in seagrass beds and depend to a large extent on the epiphytes growing in the seagrass canopy for their energy.

Seagrasses also play a less direct but equally important role as essential fish habitat by influencing the environment they grow in as well as adjacent environments. By affecting flow velocity and turbulence within their canopies, they create an environment favorable to settlement of fish and fish food. Organic and inorganic particles settle into the meadows providing nutrients and food, enriching the environment and enhancing secondary production. In turn, the substrate is stabilized, nutrients are temporarily conserved within the meadows and water quality is improved by the presence of seagrass. These ecological services enhance the environmental conditions favoring high rates of primary and secondary production in support of healthy and abundant fish communities. Sediment stabilization by seagrasses plays an important role in protecting adjacent subtidal environments from receiving excessive sediment deposition. This is especially important for coral reefs that are very sensitive to turbidity and sedimentation. The feedback for these indirect effects is the health and secondary production of fish species residing in these adjacent habitats.

Seagrass meadows are sub-systems of larger coastal marine and estuarine ecosystems and as such they are an essential component of ecosystem based fishery management. In tropical ecosystems of the South Atlantic reefs, mangroves, unvegetated bottom and seagrasses are all physically, chemically and biologically connected. Reefs dissipate wave energy and promote physical conditions promoting the growth the seagrasses and mangroves, both of which filter sediments and protect reefs. Similar interconnectivity occurs in temperate South Atlantic estuaries, where the wetlands are represented by salt marsh and the reefs are principally shell bottom. Positive feedbacks in the context of the coastal ecosystem are critical to the diversity and abundance of fish, food and environmental quality supporting fish growth. Thus we can conclude that even though some fish species utilize or depend directly on coral and oyster reefs, mangroves, salt marshes, unvegetated substrates or intertidal flats, there are important direct and indirect dependencies on and connectivity to seagrass habitats (Duffy, 2006).

From the standpoint of essential fish habitat, being submerged most, if not all of the time, seagrasses are available to fishery organisms for extended periods. There has been a growth of research over the past 30 years trying to understand and quantify functional values of seagrass ecosystems. Experiments and observations have shown that juvenile and adult invertebrates and fishes as well as their food sources utilize seagrass beds extensively. In fact, the habitat heterogeneity of seagrass meadows, the plant biomass, and the surface area enhance faunal abundances. Predator-prey relationships in seagrass beds are influenced by canopy structure, shoot density, and surface area. Blade density interferes with the efficiency of foraging predators and the reduction of light within the leafy canopy further conceals small prey that includes young-of-the-year of many ecologically and economically important species. Additionally, some organisms can orient themselves with the seagrass blades and camouflage themselves by changing coloration. The food availability within grass beds for young stages of managed species may be virtually unlimited. These attributes are particularity beneficial to the nursery function of seagrass beds.

The seasonal patterns of reproduction and development of many temperate fishery species coincide with seasonal abundances of seagrasses (ASMFC 1997). It has been concluded in several studies that, although juvenile fish and shellfish can use other types of habitat, many estuarine species rely on seagrasses for either part of their life history or some aspect of their nutrition, and that the loss or reduction of this habitat will produce concomitant declines in juvenile fish settlement. Thus, this habitat type is essential to many species of commercial, recreational and ecologically important shellfish and finfish. In the South Atlantic, SAV was specifically designated as EFH for red drum, the snapper-grouper complex, and shrimp.

It is difficult to put an economic value to ecosystem services provided by seagrass habitat. Fl DEP estimated that each acre of seagrass has an economic value of approximately $20,500/year (equates $55.4 billion statewide) by providing essential fish habitat that supports statewide commercial fishing industry valued at over $124 billion/year, as well as recreational fishing and ecotourism activities (FFWCC 2003).

3.2.4 Oyster Reefs and Shell Banks

Description and Distribution

Reef-forming Species

In the western Atlantic, oysters, mussels, and one genus of gastropod build three-dimensional structures that are commonly called reefs (Figure 3.2-14). Wood (1998, 1999) reviews the term 'reef,' and discusses its origin and those taxa and concepts that relate to reefs. The term derives from a Norse term 'rif,' or hazardous 'rib' of sand, rock, or biologically generated substrate near the surface. Wood (1999) includes the following as extant reef producers: corals, coralline and calcareous algae, sabellariid and serpulid polychaetes, oysters, vermetid gastropods, bryozoans, sponges, and stromatolites (i.e., *Cyanophytes*). Other terms such as "bars" and "beds" also refer to reef structures that are created by the organisms themselves. Holt et al. (1998) define 'biogenic reefs' as:

> *solid, massive structures which are created by accumulations of organisms, usually rising from the seabed, or at least clearly forming a substantial, discrete community or habitat which is very different from the surrounding seabed. The structure of the reef may be composed almost entirely of the reef building organism and its tubes or shells, or it may to some degree be composed of sediments, stones and shells bound together by the organisms.*

The focus here includes many shellfish species (e.g., mussels, dense clam beds) that may be classified somewhere between 'non-reef' and 'reef-forming" biotopes. Holt et al. (1998) try to characterize these biotopes, but this is a difficult task. Furthermore, researchers often refer to the structure that a species generates as a 'habitat,' 'biotope' or 'biogenic reef.' We focus on species that create unique and definable areas that are different from the surrounding unstructured sediments.

Although many species typically occur on shellfish reefs, the main structural component is formed by the attachment of many individual shellfish to each other. At least three species of oysters occur along the Atlantic coast, in addition to several mussel species and other molluscs (e.g., vermetid gastropods) (Abbott 1974). Of these, only the Eastern (or American) oyster (*Crassostrea virginica*), blue mussel (*Mytilus edulis*), and horse mussel (*Modiolus modiolus*) typically form reefs along the Atlantic coast. Currently, in the Chesapeake Bay and elsewhere, there is uncertainty over whether a non-native oyster from the Pacific (*C. ariakensis*) can serve both as a 'reef builder' and suitable fisheries resource substitute for *C. virginica* (NRC 2004; Ruesink et al. 2005).

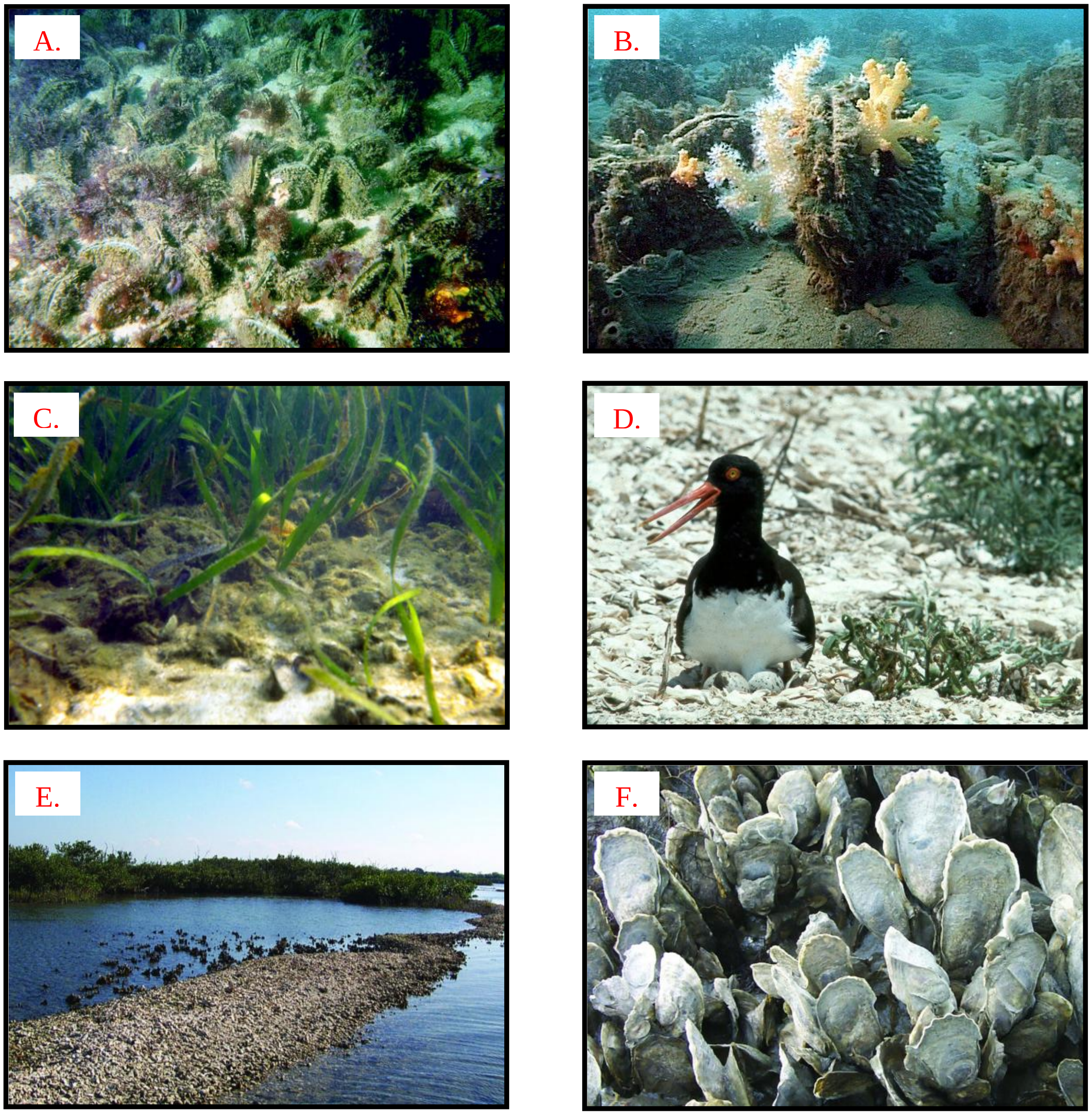


Figure 3.2-14. Examples of intertidal and subtidal shellfish habitats (Source: ASMFC, 2007). A and B: Pen shell, *Atrina zelandica*, aggregations in New Zealand (Source: Simon Thrush, National Institute of Water and Atmospheric Research, New Zealand); C: *Modiolus modiolus* reefs in St. Joe Bay, Florida (Source: Brad Peterson, State University of New York, Stony Brook); D: Nesting oyster catchers on intertidal shell accumulations along the Intracoastal Waterway (Source: Phil Wilkinson, South Carolina Department of Natural Resources); E: Intertidal oyster reefs at Canaveral National Seashore (Source: Loren Coen, South Carolina Department of Natural Resources); F: Close-up of intertidal oysters on South Carolina reefs (Source: Loren Coen, South Carolina Department of Natural Resources).

Estuarine and marine mussels

Reef-forming mussels include the *Mytilus* spp. complex (*M. edulis* and *M. trossulus*) and the horse mussel (*Modiolus modiolus*). *Mytilus* spp. (most widely recognized blue mussels) occur from Labrador to Cape Hatteras, North Carolina, on the western Atlantic coast (Abbott 1974; Suchanek 1978, 1985; Gosling 1992, 2003; Albrecht 1998; Newell 1989; Witman and Sebens 1988; Witman and Dayton 2001; Hellou and Law 2003). In many areas, *M. edulis* and *M. trossulus* are sympatric and hybridize (Riginos and Cunningham 2005). Additionally, the occurrence of *Mytilus galloprovincialis* (originally from the Mediterranean and now cultured throughout Europe and China) and a west coast species, *Mytilus californianus*, further complicate systems as invaders in many areas (McDonald and Koehn 1988; Varvio et al. 1988; Lobel et al. 1990; Seed 1992, 1995; Geller et al. 1994; Suchanek et al. 1997; Riginos and Cunningham 2005).

Gastropods of the family Vermetidae

The only habitat-forming snails on the Atlantic coast are species in the family Vermetidae. Vermetid snails cement themselves together to form dense reefs in intertidal and shallow subtidal waters from southern New England (rarely) to the tropics (Shier 1969; Safriel 1966, 1975; Abbott 1974; Safriel and Ben-Eliahu 1991; Dame et al. 2001). These uniquely cemented gastropods feed using a mucous net (video available at http://www.mbayaq.org/video/video_snailnet_feeding_qt.asp).

Worldwide vermetid snails form an often-conspicuous group of sessile gastropods living in shallow tropical and temperate reefs, commonly constructed on *Crassostrea virginica* shell accumulations. In southwestern Florida they extend intermittently as far north as Sarasota. In addition, some researchers have reported that they consider the species that was found in the Ten Thousand Islands area of southwestern Florida extinct, as the reefs were formed during the last interglacial period that drowned the beach ridges that make up the present-day islands.

There are a number of reef-forming vermetid species in Florida waters. The most common Florida species of vermetid snail, *Dendropoma corrodens*, is a small (10 mm) entrenching and encrusting species that is extremely abundant in the Florida Keys. Vermetid reef formation is restricted to the west coast of Florida, involving gastropods of the genus *Petaloconchus* (e.g., *P. macgintyi*) (less than 35 mm length). This genus is gregarious, and may form large (<1 m height) reef structures in some shallow, intertidal waters (Ortiz-Corps 1985).

In the Ten Thousand Islands area of Florida, longshore currents carry sand and shells to areas suitable for oysters to become established. These oyster reefs then provide stable substrate for mangroves, another important nursery habitat, to take hold (Lodge 1998). In some areas it has been hypothesized that vermetid gastropod reefs provide a similar substrate for mangrove initiation (Davis 1997). Unfortunately, some researchers note that vermetids appear to be in global decline (R. Bieler, Field Museum of Natural History, personal communication).

Aggregations of Living Shellfish

The term "aggregation" is used here to refer to shellfish species that are not attached to one another yet occur at densities sufficient to provide structural habitat for other organisms (Figure 3.2-14, Plate D). The term 'bed' is also sometimes used to refer to the same type of structure.

Three groups of bivalves— scallops, pen shells, and *Rangia* —form habitat in this way (Figure 3.2-14). Although not molluscan, brachiopods also form dense aggregations that function like other molluscan species.

The major habitat-forming scallops that occur along the Atlantic and Gulf coasts are the bay scallop (*Argopecten irradians* with several recognized subspecies), calico scallop (*Argopecten gibbus*), and sea scallop (*Placopecten magellanicus*) (Bourne 1964; Shumway 1991; Blake and Graves 1995).

Pen shells (family Pinnidae) are large bivalves that bury partly into the substrate and are anchored by a substantial byssus (long, fine, silky filament). The upper portion of the shell protrudes above the substrate (often referred to as 'emergent shellfish beds'), which provides habitat for other organisms when they occur in sufficient densities (Figure 3.2-14, Plates A & B). Three species of pen shell occur along the Atlantic coast of the Americas: the saw-toothed pen shell (*Atrina serrata*), the amber pen shell (*Pinna carnea*), and the stiff pen shell (*Atrina rigida*) (Abbott 1974).

The saw-toothed pen shell, *A. serrata,* is typically found in sandy mud at depths of up to 6 m. It ranges from North Carolina to Texas and northern South America, and is relatively common in many areas in North Carolina (Abbott 1974). Several recent studies have shown that pen shells are adept at repairing damage in a short time, pointing to potentially interesting resource allocation issues (e.g., cost of shell repair) with regard to this relatively large infaunal organism (T. Alphin, University of North Carolina at Wilmington, personal communication). Many small shrimp and crab species spend their adult lives in the mantle cavity of this species and other pen shells, where they find refuge and feed on particles brought into the mantle cavity (Abbott 1974).

Although the amber pen shell, *P. carnea,* is generally found in sandy areas with depths up to 4 m, it rarely is found in the intertidal zone. It ranges from southeastern Florida to northern South America. Finally, *A. rigida* is common in sandy muds from low intertidal to 27 m in depth. It ranges from North Carolina to southern Florida and the West Indies (Abbott 1974).

Shell Accumulations

The shells of dead molluscs sometimes accumulate in sufficient quantities to provide important habitat. The term 'shell hash' refers to accumulations consisting mostly of pieces of broken shell (Anderson et al. 1979; Street et al. 2005), although this hash can also be composed of intact small bivalves and gastropod shells (e.g., Sanibel Island, FL).

Shell accumulations can occur from estuaries out to the continental slope, with several species present in each zone (Stanley and Dewitt 1983, Stanley 1985, Newell and Hidu 1986, Rice et al. 1989, MacKenzie and McLaughlin 2000, Kraeuter et al. 2003). For accumulations of smaller molluscs, we know little or nothing about their importance (W. Arnold, Florida Fish and Wildlife Research Institute, personal communication).

Accumulations of eastern oyster shells are a common feature in the intertidal zone of many southern estuaries, particularly along waterways impacted by wind and boat wakes (Figure 3.2-14, Plate D) (Anderson et al. 1979; Bahr and Lanier 1981; Grizzle et al. 2002). The dead shells of blue mussels (*Mytilus* spp.) occur intertidally in some northern estuaries. These accumulations, sometimes extending well above the high tide line, have not been well studied. Subtidal shell accumulations, however, provide habitat for many species of commercially and recreationally important fish (Auster et al. 1991, 1995; Holt et al. 1998).

Ecological Role and Function

The ecological processes that depend on the above characteristics of shellfish habitat can be thought of as "ecosystem services." Hence, in addition to their direct habitat-related value for managed species, shellfish habitats provide important services for the ecosystem as a whole. Three of the most important of these services are discussed in more detail below: refuge, benthic-pelagic coupling, and erosion reduction (or shoreline protection).

Refuge

The term refuge is used here to describe the protective function that shellfish habitat provides for the shellfish themselves, as well as for other organisms that occur in shellfish habitat. This ecosystem service largely results from the increase in structural complexity in shellfish habitat compared to surrounding areas (particularly soft sediments). In other habitats, such as seagrasses or salt marshes, the concept of structural complexity is often associated with the notion of "nursery areas," which refer to places where juvenile invertebrates and fish are protected from predators (Lindberg and Marshall 1984; Heck et al. 1995; Benaka 1999; Halpern et al. 2001; Williams and Heck 2001; Beck et al. 2003; Heck et al. 2003; Minello et al. 2003). Shellfish habitat plays a role similar to seagrasses and other structurally complex habitats in this respect. Most of the research dealing with these topics for shellfish habitat has been done on the reef-forming species, but some information is available for shellfish aggregations and shell accumulations.

Benthic-pelagic coupling

This term refers to the transfer of materials and energy between the bottom community and the water column. It is probably most often used to refer to the overall effect of suspension feeders as they remove suspended particulates from the water column (Dame 1996). The result is a transfer of materials and energy from the water column to the benthos (Frechette et al. 1989; Meyer and Townsend 2000; Cummings et al. 2001; Dame et al. 2001; Ellis et al. 2002).

These feeding activities also typically cause a reduction in turbidity of the water column which has a positive impact on submerged aquatic vegetation (SAV), allowing more light penetration and higher rates of photosynthesis (Meyer and Townsend 2000). The shellfish release ammonia and other metabolites that are nutrients for the SAV. Therefore, SAV (Peterson and Heck 1999, 2001a, 2001b; Williams and Heck 2001; Heck and Orth 2006) and oyster reefs potentially play mutually beneficial roles (Heck 1987; Newell 1988; Dame 1996; Dame et al. 2001; Newell and Koch 2004) (also see Pomeroy et al. 2006 for a different perspective).

Oyster reefs are likely to reduce eutrophication by mediating water column phytoplankton dynamics and denitrification (Dame 1996; Newell et al. 2002; Newell 2004). A decrease in oysters in the Chesapeake Bay has led to increased phytoplankton numbers and reduced competition with zooplankton. An increase in zooplankton leads to a rise in predators, such as ctenophores and jellyfish. An increase in phytoplankton also leads to a microbial shift and anoxic conditions of deeper waters in areas such as the Chesapeake Bay (Ulanowicz and Tuttle 1992; Newell 1988) (also see Pomeroy et al. 2006 for another view). Models have shown that an increase in oyster abundance would reduce phytoplankton primary productivity and secondary gelatinous consumers (e.g., ctenophores) to historically low levels (Ulanowicz and Tuttle 1992).

Erosion reduction

Estuaries in many areas are threatened by increased coastal population growth and associated industrial, residential, and recreational development and utilization (Vernberg et al. 1999). One major area of recreational growth has been in the number of people with Class A (< 16 ft) and Class 1 (16 to 25 feet) motorized boats utilizing these waterways (NMMA 2004). Some problems related to this increase in the number of small boats have been well documented (Crawford et al. 1998; Cyr 1998; Backhurst and Cole 2000; Bauer et al. 2002; Kennish 2002). For example, increases in seagrass scarring from boat propellers and the number of marine mammal collisions are both positively correlated with increased boating activity (R. Virnstein, personal communication; Sargent et al. 1995).

However, little is known about the direct and indirect impacts of boating on other critical estuarine habitats in the landscape, such as intertidal oyster reefs (Grizzle et al. 2002; Coen and Fisher 2002; Coen and Bolton-Warberg 2003, 2005; Piazza et al. 2005; Wall et al. 2005). Those areas dominated by intertidal oyster reefs form a protective breakwater for fringing *Spartina* marshes, retarding shoreline erosion (Coen and Fischer 2002; Coen and Bolton-Warberg 2005).

Additionally, shoreline erosion in tidal channels is an issue in many states (Cyr 1998; Gabet 1998). Undercutting by wind waves and boat impacts can cause slumping (calving) of large masses of sediment embedded with *Spartina* (Gabet 1998; Chose 1999; Piazza et al. 2005). *Spartina* has been documented to be an important habitat for estuarine productivity (e.g., as a feeding ground for juvenile fishes and their prey) and is known to perform many other ecological functions, such as buffering run-off (Weinstein and Kreeger 2000).

Data collected by researchers from the South Carolina Department of Natural Resources noted significant shoreline losses at numerous study sites (n = 11) across South Carolina (Coen and Bolton-Warberg 2005). By reducing erosion, oyster reefs reduce vegetation loss and preserve other habitat types (Meyer and Townsend 2000). They also stabilize creek banks and help to reduce erosion of marshes (Meyer et al. 1997; Chose 1999; Coen and Fischer 2002; Breitburg et al. 2000; Coen and Bolton-Warberg 2003, 2005; Piazza et al. 2005), but may be easily impacted by boat wake or storm damage (Grizzle et al. 2002; Coen and Bolton-Warberg 2005).

Research on recreational boating impacts on estuarine species is surprisingly still in its infancy (Anderson 1976, 2000; Kennish 2002; Bishop 2003, 2004, 2007; Bishop and Chapman 2004). Productivity, diversity, and survival of estuaries in the southeastern United States are threatened by explosive coastal population growth and associated industrial, residential and recreational development and utilization (Vernberg et al. 1999). In spite of the potentially far excursion distances of motorboats, and the large number of boats on the water on any given day, sparse data exist to quantitatively determine the impact of boat wakes on intertidal organisms.

In conclusion, it should be noted that each of the four types of shellfish habitats differ with respect to their major characteristics and the ecosystem services they provide. Shellfish reefs typically provide the most in the way of services because they consist largely of live animals that provide a food source for many fish and invertebrates, and typically have significant vertical structure. Shellfish aggregations consist mainly of live animals but typically do not occur at densities as high, or with vertical structure as extensive, as shellfish reefs. Shellfish accumulations consist only of the dead shell remains, but they provide hard substrate and may have significant vertical structure. There is a rich literature that documents the importance of all four types of shellfish habitat to many species of fish and invertebrates, including most managed species managed.

Habitat utilization

Shell bottom provides critical fisheries habitat not only for oysters, but also for recreationally and commercially important finfish, other mollusks, and crustaceans. The ecological functions of oyster reefs related to oyster production are well known and accepted (Coen et al. 1999). These functions include aggregation of spawning stock, chemical cues for successful spat settlement, and refuge from predators and siltation. Oysters have also been described as "ecosystem engineers that create biogenic reef habitat important to estuarine biodiversity, benthic-pelagic coupling, and fishery production" (Lenihan and Peterson 1998).

Data quantifying fish use of habitats vary from presence/absence and numerical abundance, to actual fish production value. In North Carolina, 18 fishery species have been documented utilizing both natural and restored oyster reefs in Pamlico Sound, including Atlantic croaker, southern flounder, Spanish mackerel, spotted seatrout, weakfish, American eel, and black sea bass (Lenihan et al. 2001). Numerical abundance and production compared to other habitats provides additional information on the importance of habitat for fish. The species found most abundantly on oyster reefs compared to adjacent soft bottom were silver perch, sheepshead, pigfish, pinfish, toadfish, and Atlantic croaker. Southern flounder was collected on both oyster reefs and adjacent soft bottom areas, while bluefish and Atlantic menhaden were not collected near oyster reefs (Lenihan et al. 2001).

Several studies have found higher abundance and diversity of fish on shell bottom than adjacent soft bottom, particularly pinfish, blue crabs, and grass shrimp (Harding and Mann 1999; Posey et al. 1999; Lenihan et al. 2001). A study in Back Sound also found that crabs were more abundant on shell bottom than restored SAV beds (Elis et al. 1996). Breitburg (1998) concluded that the importance of shell bottom to highly mobile species is very likely underestimated, partially due to the difficulty in sampling oyster beds.

Peterson et al. (2003a) estimated the amount of fish production that shell bottom provides in addition to adjacent soft bottom habitats. Using results from numerous studies, they compared the density of fish at different life stages on oyster reefs and adjacent soft bottom habitats. The published growth rates of species were then used to determine the amount of production gained from shell bottom. The species were separated into recruitment-enhanced, growth-enhanced, and not enhanced groups. Recruitment-enhanced species are those having early life stages showing almost exclusive association with shell bottom. For other species with higher abundance in shell bottom, diet and life history studies were used to determine the fraction of their production associated with the consumption of shell bottom-enhanced species. Species consuming relatively more shell bottom-enhanced species were classified as growth-enhanced. Analysis of the studies revealed that every 10m^2 of newly constructed oyster reef in the southeast United States is expected to yield a benefit of an additional 2.6 kg of fish production per year for the lifetime of the reef (Peterson et al. 2003a).

Fish that utilize shell bottom can be classified into three categories: resident, transient, and facultative (Coen et al. 1999; Lowery and Paynter 2002). Resident species live on shell bottom and depend on it as their primary habitat. Transient species are wide-ranging species that use shell bottom for refuge and forage along with other habitats. Facultative species depend on shell bottom for food, but utilize other habitats with vertical relief or shelter sites.

At least seven fish species have been identified as resident species—naked goby, striped blenny, feather blenny, freckled blenny, skilletfish, and oyster toadfish (Coen et al. 1999; Lowery and Paynter 2002). These species were also considered recruitment-enhanced by Peterson et al. (2003a). Resident fish are important prey for transient and facultative predator species (Coen et al. 1999). For example, Breitburg (1998) found high densities of juvenile striped bass (15.4 individuals/m^2 of reef surface) aggregating near the reef surface feeding on naked goby larvae congregated on the down-current side of the reef. Other common predator species sampled on oyster reefs in North Carolina are red and black drum, Atlantic croaker, sheepshead, weakfish, spotted seatrout, summer and southern flounder, blue crab, and oyster toadfish. Of these species, however, only sheepshead, southern flounder, and oyster toadfish were considered shell bottom-enhanced by Peterson et al. (2003a). Production of black drum, Atlantic croaker, blue crab, and summer flounder were classified as not enhanced by shell bottom. Oyster reefs in higher salinity waters are critical habitat for predators such as juvenile gag, snappers (*Lutjanus* spp.) and stone crab (Wenner et al. 1996; Peterson et al. 2003a).

There is some variation in fish use among salinity gradients as well. Oyster reefs in higher salinity waters tend to support a greater number of associated species than reefs in lower salinity waters (Sandifer et al. 1980). Studies summarized by Coen et al. (1999), which included work in North Carolina, identified 72 facultative, resident and transient fish species in close proximity to oyster reefs. The ASMFC-managed species categorized as transient and also important to North Carolina's coastal fisheries are American eel, Atlantic croaker, Atlantic menhaden, black sea bass, bluefish, red drum, spot, striped bass, summer flounder, tautog, and weakfish. Only black sea bass and tautog were considered shell-bottom enhanced by Peterson et al. (2003a).

A partial list of macrofaunal species observed in collections from oyster habitat is provided in Table 3.2-6. Those species that use shell bottom as spawning and/or nursery areas are identified, as are those species that forage on shell bottom habitat and/or use it as a refuge (SAFMC, 1998a; Lenihan et al., 1998; Coen et al., 1999; Grabowski et al., 2000). More than 30 species are listed in Table 2.6, and there are many more not listed, emphasizing the importance of shell bottom as fisheries habitat.

Table 3.2-6. Partial listing of finfish and shellfish species observed in collections from shell bottom in North Carolina, and ecological functions provided by the habitat (Source: Street et al. 2005).

	Shell Bottom Functions [1]						
Species*	Refuge	Spawning	Nursery	Foraging	Corridor	Fishery [2]	Stock Status [3]
ANADROMOUS & CATADROMOUS FISH							
American eel	X		X	X	X	X	U
Striped bass			**X**	**X**		**X**	**V- Albemarle Sound, Atlantic Ocean, O- Central/Southern**
ESTUARINE AND INLET SPAWNING AND NURSERY							
Anchovies (striped, bay)		**X**	**X**	**X**			
Blennies	**X**	**X**	**X**	**X**			
Black drum				**X**		**X**	
Blue crab	**X**	**X**	**X**	**X**	**X**	**X**	**C**
Oyster	**X**	**X**	**X**	**X**		**X**	**C**
Gobies	**X**	**X**	**X**	**X**			
Grass shrimp	**X**	**X**	**X**	**X**			
Hard clam	**X**	**X**	**X**	**X**		**X**	**U**
Mummichog	X	X			X		
Oyster toadfish	**X**	**X**	**X**	**X**		**X**	
Red drum	**X**		**X**	**X**	**X**	**X**	**R**
Sheepshead minnow		**X**		**X**			
Silversides				**X**			
Skilletfish	**X**		**X**	**X**			
Spotted seatrout				**X**		**X**	**V**
Stone crab	**X**		**X**	**X**		**X**	
Weakfish	X		X	X	X	X	V
MARINE SPAWNING , LOW-HIGH SALINITY NURSERY							
Atlantic croaker				X		X	C
Brown shrimp	**X**		**X**	**X**	**X**	**X**	**V**
Southern flounder				**X**		**X**	**O**
Spot	X		X	X	X	X	V
Striped mullet				X		X	C
MARINE SPAWNING , HIGH SALINITY NURSERY							
Atlantic spadefish						X	C [4]
Black sea bass	**X**		**X**	**X**	**X**	**X**	**V- north of Hatteras, O- south of Hatteras**
Gag	**X**		**X**	**X**	**X**	**X**	**V**
Gulf flounder						X	
Pigfish				**X**		**X**	
Pinfish	**X**		**X**	**X**	**X**	**X**	
Pink shrimp	**X**		**X**	**X**	**X**	**X**	**V**
Sheephead	**X**		**X**	**X**	**X**	**X**	**C** [4]
Spanish mackerel						X	V
Summer flounder	X			X	X	X	V

* Scientific names listed in Appendix I. Names in **bold** font are species whose relative abundances have been reported in the literature as being generally higher in shell bottom than in other habitats. Note that lack of bolding does not imply non-selective use of the habitat, just a lack of information.

[1] Sources: Pattilo et al. 1997; SAFMC 1998; Lenihan et al. 1998, 2001; Coen et al. 1999; Grabowski et al. 2000; Peterson et al. 2003

[2] Existing commercial or recreational fishery. Fishery and non-fishery species are also important as prey

[3] V=viable, R=recovering, C=Concern, O=overfished, U=unknown (DMF 2003a).

[4] Status of reef fish complex as a whole. Sheepshead and Atlantic spadefish have not been evaluated in NC.

Resident species, such as gobies (naked and green), Atlantic midshipman, and northern pipefish depend on shell bottom as breeding habitat (Hardy 1978a and b; Johnson 1978; Coen et al. 1999). Other species documented to spawn on shell bottom include the oyster toadfish, mummichog, sheepshead minnow, eastern oyster, grass shrimp, and hard clams (NOAA 2001). Toadfish attach their eggs to the underside of oyster shells, whereas gobies, blennies, and skilletfish place their eggs in recently dead oyster shell (Coen et al. 1999). Well-developed oyster reefs with clean oyster shells in a variety of sizes were shown to accommodate reproduction by the greatest densities of all resident species (Breitburg 1998).

Shell bottom protects oyster spat and other juvenile bivalves, finfish and crustaceans from predators. Juvenile clams, in particular, settle in shell substrate for the protection it provides (Wells 1957; MacKenzie 1977; Peterson 1982; DMF 2001b). The nursery area function of shell bottom was demonstrated by Eggleston et al. (1998) who found that juvenile blue crabs and grass shrimp were equally abundant on shell bottom and SAV in Back Sound, North Carolina. Twelve of the 18 mobile and economically important coastal fisheries species sampled by Lenihan et al. (2001) on natural and restored oyster reefs in Pamlico Sound were juveniles.

In a study where shell structure was added to mud flat reefs, juvenile fish abundance increased on the augmented reefs compared to surrounding soft bottom (Grabowski et al. 2000). The study also found that this initial increase was higher than increases that occurred when SAV and/or salt marsh were added in the same area. The ASMFC considers shell bottom as important nursery habitat for juvenile fish such as sheepshead, gag, snappers, stone and blue crabs, and penaeid shrimps (Lowery and Paynter 2002). An analysis by Peterson et al. (2003a) confirmed that sheepshead, gag, and stone crab were recruitment enhanced, as well as many non-fishery species, including anchovies, blennies, gobies, oyster toadfish, and skilletfish.

While oyster reefs are the most recognized shell bottom habitat, shell hash concentrations on tidal creek bottoms provide important nursery habitat for young fish. For example, the preferred habitat of juvenile drum species in South Carolina is high marsh areas with shell hash and mud bottoms (Daniel 1988). However, the extent of shell hash in North Carolina tidal creeks is currently unknown; known locations of shell hash include concentrations along the Intracoastal Waterway. The nursery value of designated nursery areas could be enhanced by low-density plantings of cultch material. However, the enhancement of fish stocks provided by planting could be negated if recruitment is not limiting the adult population. The recruitment enhancement provided by low-density cultch planting in nursery areas should be evaluated.

A group of important species that are largely understudied throughout their range, but includes important members of intertidal and subtidal oyster reef communities, are the grass (Caridean) shrimp species within the genus *Palaemonetes*. Grass shrimp are found in large numbers in estuarine waters along the Atlantic and Gulf coasts, where they occur from Massachusetts to Texas. They are a very common estuarine species in southeastern marshes and tidal creeks where they are usually associated with beds of submerged or emergent vegetation, oyster reef habitats, or structures such as oyster shell, fouling communities, woody debris (Ruiz et al. 1993), and docks or pilings (Coen et al. 1981). Caridean shrimp are rarely larger than 5 cm; their small size differentiates them from commercial shrimp, such as the penaieds and pendalids.

Grass shrimp are an important species from an ecological perspective because they are instrumental in transporting energy and nutrients between trophic levels in the coastal food web. Grass shrimp are consumed in large quantities by commercially important fishes and forage species, including spotted seatrout, red drum, and mummichogs (*Fundulus heteroclitus*) (Heck and Thoman 1981; Anderson 1985; Wenner et al. 1990; Posey and Hines 1991; Wenner and Archambault 1996).

Although there are no estimates of population sizes of grass shrimp, they are amongst the most widely distributed, abundant, and conspicuous of the shallow water benthic macroinvertebrates in our estuaries, often reaching hundreds to thousands per square meter (Leight et al. 2005; Coen and Luckenbach 2000; Coen et al. 2006a). Grass shrimp can inhabit very shallow areas near the margins of intertidal habitats (e.g., marsh, mudflats, oyster reefs), but have been reported at depths as great as 15 meters. In winter during temperature lows, and in summer when water temperatures approach seasonal highs, daggerblade grass shrimp may move from shallow to relatively deeper water. The extent of the movement of grass shrimp among various depths often coincides with the distribution of oyster shell substrates, which, in some waters, are preferred by both *P. vulgaris* and *P. pugio*. They are abundant in these structured estuarine and marine habitats as shellfish habitats provide abundant food and protection from predators (Thorp 1976; Coen et al. 1981; Heck and Thoman 1981; Heck and Crowder 1991).

Consequently, the association of shellfish habitats with primary producers and consumers may prove quite significant, given the importance of low trophic level species as food for managed species.

Shell bottom provides important foraging area for a variety of aquatic organisms. Fish, shrimp and crabs forage on the worms, algae, crustaceans, mollusks, and other invertebrates present on and in shell bottom habitat. Concentrations of prey organisms among the shell attract both specialized and opportunistic predators. Eggs from oysters and other organisms, and larvae from species belonging to the oyster shell bottom community, are eaten by protozoans, jellyfishes, ctenophores, hydroids, worms, mollusks, adult and larval crustaceans, and fishes (Loosanoff 1965). Blue crabs forage heavily on oyster reefs (Menzel and Hopkins 1955; Krantz and Chamberlin 1978; Mann and Harding 1997). Stomach contents of common finfish predators sampled near shell bottom in Middle Marsh, North Carolina, included fish, shrimp, tanaids, amphipods, isopods, polychaetes, bivalves, gastropods, and tunicates, as well as plant, algal and detrital material (Grabowski et al. 2000).

Grabowski et al. (2000) calculated an index of reef affinity (association) for fish species and analyzed the relative proportion of stomach contents originating from oyster reef versus non-reef habitats. Results showed:

- Pigfish and pinfish foraged more on reefs (amphipods, bivalves, gastropods and polychaetes).
- The ubiquitous spot foraged on both reef and non-reef habitats.
- Gulf and southern flounder foraged on species slightly more common on reefs.
- Blacktip sharks, spotted seatrout, and bluefish exhibited a feeding preference for oyster reef prey (fish, shrimp and crabs).

- Red drum foraged slightly more off reefs.
- Blacknose sharks rarely foraged on reef habitats.

The growth-enhanced species/groups identified in Peterson et al. (2003a) included sheepshead minnow, silversides, pigfish, southern flounder, and black sea bass. These results differ somewhat from those of Grabowski et al. (2000). The discrepancies between Peterson et al. (2003a) and Grabowski et al. (2000) could be due to regional differences in fish habitat use, or other unknown factors. Sheepshead also have an affinity for slow or sessile invertebrates found abundantly on shell bottom (Pattilo et al. 1997).

Oyster reefs are also a foraging ground for many juvenile and adult turtle species. Schmid (1998) found that both the Kemp's ridley and loggerhead sea turtles feed on organisms that inhabit the reef. Kemp's ridley turtles feed on the stone crabs (*Menippe* spp.) and blue crabs (*Callinectes sapidus*) found near the reef's surface. Loggerheads also feed on molluscs. Schmid (1998) also found that Kemp's ridleys will return to the same oyster reef for up to four years.

Another important species that utilizes intertidal and subtidal oyster reefs as foraging grounds is the blue crab, *Callinectes sapidus* (Coen et al. 1999b). Blue crabs forage heavily on oyster reefs (Mann and Harding 1997; Krantz and Chamberlin 1978), including consuming oyster spat as juveniles. A study by Menzel and Hopkins (1955) showed that juvenile blue crabs consumed as many as 19 juvenile oysters (or spat) per day.

Numerous mammals and birds directly and indirectly utilize intertidal oyster reef habitats and washed oyster shell accumulations, particularly along the IWW (Sanders et al. 2004). These include *Procyon lotor* (raccoon), and birds such as *Haematopus palliates* (American oyster catcher), *Egretta tricolor* (Tricolored Heron), *Nyctanassa violacea* (Yellow-crowned Night Heron), *Nycticorax nycticorax* (Black Heron), *Casmerodius albus* (Great Egret), *Egretta thula* (Snowy Egret), *Limosa fedoa* (Marbled Godwit), *Catoptrophorus semipalmatus* (Willet), *Pluvialis squatarola* (Black-bellied Plover), *Calidris pusilla* (Semipalmated Sandpiper), *Calidris mauri* (Western Sandpiper), *Arenaria interpres* (Ruddy Turnstone), *Tringa melanoleuca* (Greater Yellowleg), and *Tringa flavipes* (Lesser Yellowleg).

Some recent observations in SC suggest that a single oystercatcher may be able to consume over 100 adult oysters per day on intertidal reefs (F. Sanders, South Carolina Department of Natural Resources, personal communication).

Corridor and Connectivity

Shell bottom serves as a nearshore corridor to other fish habitats, such as salt marsh and SAV for finfish and crustaceans; therefore, it plays a significant ecological role in landscape-level processes (Coen et al. 1999; Micheli and Peterson 1999). Vicinity (isolation) and connectivity of intertidal oyster reefs to other fish habitats, especially SAV, are two factors that affect fish utilization of shell bottom. For example, connectivity of oyster reefs to SAV enhanced blue crab predation, whereas isolation of oyster reefs enhanced hard clam survivorship (Micheli and Peterson 1999). In Middle Marsh, North Carolina, gag, gray snapper, and spottail pinfish preferred shell bottom habitat adjacent to SAV beds (Grabowski et al. 2000), allowing access to both refuge and prey.

Species composition and community structure

Eastern oyster (*Crassostrea virginica*)

The eastern oyster's range extends from the Gulf of St. Lawrence to Key Biscayne, and south to the West Indies and the Yucatan Peninsula in Mexico (Galtsoff 1964; Burrell 1986; Kennedy 1996; MacKenzie et al. 1997a). The eastern oyster is mainly an estuarine organism, but does occur in some near-shore coastal waters. These oysters grow sub-tidally throughout most of their range, but from southern North Carolina to northeastern Florida they occur predominately in the intertidal zone (Figure 2.14) (Bahr and Lanier 1981; Kennedy 1996; Kennedy and Sanford 1999; Burrell 1986, 1997; Coen and Luckenbach 2000; Luckenbach et al. 2005). Although they occur to a depth of 30 m, the oyster's primary habitat is in shallow water less than 6 m, or intertidal (1 m to 5 m) from North Carolina to Florida. A typical feature of *C. virginica* is their extremely variable shell morphology (Galtsoff 1964; Carriker 1996; Kent 1992). Oysters have indeterminate growth; in historical times, prior to the influence of harvesting and other biological and anthropogenic factors, they often grew to sizes significantly greater than what we see today (20 cm or larger shell height).

The preferred substrate for larval settlement is oyster shell, an adaptation that assures the proximity of other oysters, which is essential for successful future reproduction. Oysters are attached to the substrate or to each other by the left valve, which tends to be thicker and more deeply cupped than the right valve (Galstoff 1964; Kennedy 1996; Soniat et al. 2004). Thus, dense reefs are formed by the setting of successive generations of oysters on the shells of their predecessors (Figure 3.2-14). In some places, oyster shell can be several meters deep or more with live animals only on the surface layer.

Long-term reef development is a complex process that involves interactions among a variety of physical and biotic factors (Bahr and Lanier 1981; Kennedy and Sanford 1999; Coen and Luckenbach 2000). In southern Atlantic waters, a reef-like structure may be achieved in three to five years, but in northern waters the process is apparently much slower. The long-term dynamics of oyster reefs have not been well studied, but some reefs in the Chesapeake Bay have persisted for millennia (Smith et al. 2003). In part because estuaries are geologically ephemeral, oysters must cope with changes in sea level, sediment, and climate. In contrast, within the past 50 years, some intertidal reefs in Florida have been completely destroyed and displaced landward by dredging and/or boat wakes (Figure 3.2-15). Hurricanes have also been implicated in a few instances; for example, in the destruction of the windrows of shell in surf troughs along the Florida coast (Livingston et al. 1999; Grizzle et al. 2002; Walters et al. in press). Elsewhere, hurricanes may have significant impacts on shellfish habitats, particularly in shallow waters (Andrews 1973; Munden 1975; Lowery 1992; Dugas et al. 1998; Livingston et al. 1999; Perret et al. 1999). Bartol and Mann (1997) observed an increase in oyster survival when oysters settled in the interstitial spaces between shells below the reef surface. Additionally, vertically growing oysters in clusters on intertidal reefs provide oysters with a way to cope with siltation, so that they are not smothered (Coen et al. 1999a; Giotta 1999).

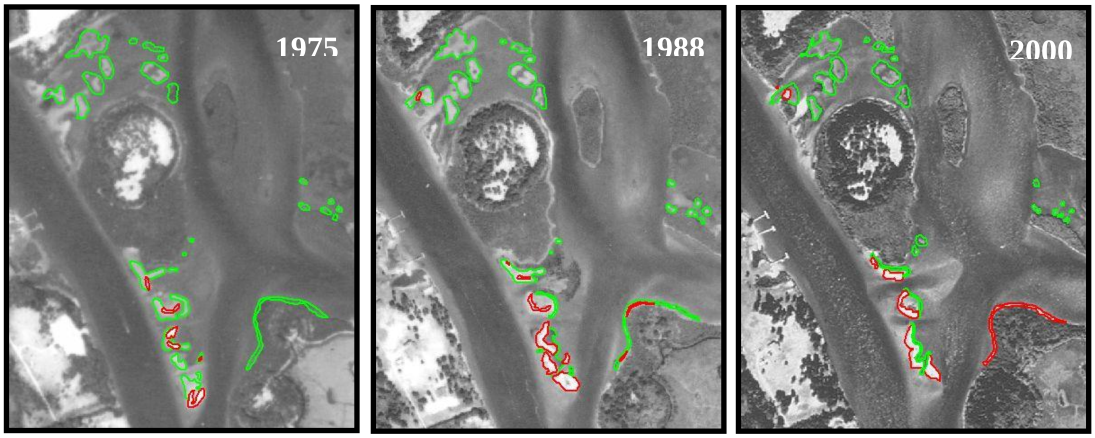


Figure 3.2-15. Time series of intertidal oyster reef changes in east-central Canaveral National Seashore (CANA), Florida (Source: ASMFC 2007). Aerial imagery showing increase in dead reef areas (red) compared to living (green) over time, most probably caused by increased boating activities (Source: Grizzle et al. 2002).

Caribbean mangrove oyster (*Crassostrea rhizophorae*)
The Caribbean mangrove oyster is restricted to the south Atlantic and Gulf coasts (Abbott 1974) and does not typically form reefs. *C. rhizophorae* is well adapted to the warmer tropical and subtropical temperatures in its native range (Bacon et al. 1991). *C. virginica* and *C. rhizophorae* oysters are closely related species (Buroker et al. 1979; Hedgecock and Okazaki 1984). Mangroves are typically the primary 'hard' substrate for attachment of these often common and flat oysters. Numerous other species of 'mangrove oysters' have been described, all in the genus *Crassostrea*. For all these species, information is extremely limited, with even less known on how they may enhance habitat complexity along the southern coast of Florida. *C. rhizophorae* is commercially important, can grow to marketable size (50 -70 mm shell height) in 4 to 8 months (Rodriguez and Frias 1992), and is currently cultivated in aquaculture facilities in the Caribbean (Littlewood 1988; Bacon et al. 1991; Newkirk and Field 1991).

Currently, there is very little information on the Caribbean mangrove oyster's ecology (i.e. densities, filtering, etc.) or potential habitat value for other Florida mangrove-related species. However, it must be noted that the species adds considerable habitat to the recognized three-dimensional mangrove fish nurseries of the Caribbean (L. Stewart, University of Connecticut, personal communication). Presumably Caribbean mangrove oyster reefs are fouled by many different planktonic plant and animal species, thus providing a critically needed substrate for attachment.

In large part resulting from recent work on *Crassostrea ariakensis* in North Carolina (Grabowski et al. 2003, 2004; NRC 2004; Bishop et al. 2006; Carnegie et al. 2006; R. Carnegie, Virginia Institute of Marine Science, personal communication), researchers have begun to examine the dynamics of poorly studied native oyster species, such as the crested oyster (*Ostreola equestris*). Additional attention has been drawn to novel or endemic *Bonamia* spp. (newly described or observed) that may cause diseases in native or non-native species, or act as parasite reservoirs

(Bishop et al. 2006; Carnegie et al. 2006; R. Carnegie, Virginia Institute of Marine Science, personal communication).

Blue mussels *(Mytilus spp.)*
Mytilus spp. occur mainly in shallow coastal waters and estuaries, and are most commonly considered a member of the fouling community because they are often found on rocks, pilings, and other hard substrates (King et al. 1990; Mathieson et al. 1991; Leichter and Witman 1997; Bertness 1999; Witman and Dayton 2001). In many areas mussels play an important role in benthic community structure (Bayne 1976; Witman 1985, 1987; Asmus and Asmus 1991; Lesser et al. 1991; Dame 1993, 1996; Hild and Günther 1999; Norén et al. 1999; Davenport et al. 2000). In some areas mussels also form dense reefs on hardbottom or on soft sediments in the intertidal and subtidal zones (Newell 1989; Nehls and Thiel 1993; Seed and Suchanek 1992; Seed 1996; Côté and Jelnikar 1999; Cranford and Hill 1999).

Blue mussel reef formation and development have not been well studied, but they are recognized as being important food and habitat providers for many species (Tsuchiya and Nishihira 1985, 1986; Witman 1985, 1987; Newell 1989; Asmus and Asmus 1991; Seed 1996; Reusch and Chapman 1997; Ragnarsson and Raffaelli 1999). Mussel consumers include crabs, lobsters, starfish, whelks, fish (e.g., tautog), and birds (e.g., ruddy turnstone, American and European oystercatchers) (Marsh 1986; Meire and Ervynck 1986; Raffaelli et al. 1990; Marsh and Wilkinson 1991; Nol and Humphrey 1994; Nagarajan et al. 2002; Sanders et al. 2004). Mussel reefs perform essentially the same functions as oyster reefs; they provide food, filtration, benthic-pelagic coupling, and physical habitat (Verwey 1952; Suchanek 1978, 1985; Wildish and Kristmanson 1984, 1997; Witman and Suchanek 1984; Dame 1996; Smaal and Hass 1997).

Horse mussel *(Modiolus modiolus)*
The horse mussel has a geographic distribution similar to the blue mussels, but occurs mainly in deeper waters on the continental shelf; however, it can be found in intertidal pools or attached to laminarian holdfasts (Holt et al. 1998). It is a widespread mussel, found throughout the northern hemisphere from the White Sea and Norway, off the Faroes and Iceland to at least as far south as the Bay of Biscay and occasionally North Africa. It is also found from Labrador to North Carolina in the Atlantic and from the Bering Sea south to Japan and California in the Pacific. It most commonly occurs partly buried in soft sediments, or attached by byssal threads to hard substrates where it forms clumps or extensive beds (or reefs) that vary in size, density, thickness, and form (Holt et al. 1998; Wildish et al. 1998).

Horse mussel recruitment is often low and may be variable in some populations (JNCC UK 1999). *M. modiolus* is a long-lived species, with some individuals living for 25 years or more. Juvenile *M. modiolus* are heavily preyed upon, especially by crabs and starfish, until they are 3 to 6 years old, at which point they normally reach a size refuge from most of their native predators.

American horse mussel *(Modiolus americanus)*
The American horse mussel is a common mussel that often forms dense associations within seagrass habitats (Figure 3.2-14, Plate C) (Peterson and Heck 1999, 2001a, 2001b). It ranges from South Carolina to the Gulf of Mexico and south to Brazil; it is also found in Bermuda.

Adults can reach 100 mm shell height and they occur from the intertidal to approximately 6 m water depth. The American horse mussel can be found in densities as high as 2,000 individuals/m^2 with mean densities reaching 625 individuals/m^2 (Valentine and Heck 1993). However, these aggregations of American horse mussels are typically quite patchy (L.D. Coen, personal observation). Little is known about the broader ecological importance of the facultative mutualistic association of seagrass and shellfish, but work in St. Joe Bay, Florida in dense seagrass beds has shown a more complex interaction between these abundant filter-feeders and the *Thalassia* beds within which they reside. Specially, the mussels increase seagrass productivity through their filtering activities, changing nutrient availability through mechanisms such as biodeposition and reducing epiphyte loads on seagrasses (L. Coen, personal observation).

Ribbed mussel (*Geukensia demissa*)
The ribbed mussel is a relatively large mussel, growing to nearly 100 mm shell height. The ribbed mussel is found in coastal waters from the Gulf of St. Lawrence to Texas. It is common on both subtidal and intertidal oyster reef habitats (Van Dolah et al. 1999; Coen et al. 2004b; Luckenbach et al. 2005) and in salt marsh (Bertness 1980, 1984; Lutz and Castagna 1980; Bertness and Grosholz 1985). Unlike oysters, ribbed mussels have the ability to reattach if dislodged, which makes this species better able to adapt following a disturbance event.

The basic biology of the ribbed mussel is well understood, but little is known about its habitat value either alive or as dead articulated shells (Lent 1969; Seed 1980; Brousseau 1984; Kraus and Crow 1985; Hilbish 1987; Lin 1989a, 1989b, 1990, 1991; Wilbur and Hilbish 1989; Kemp et al. 1990; Langdon and Newell 1990; Sarver et al. 1992; Stiven and Gardner 1992; Franz 1993, 1996, 1997, 2001; Nielsen and Franz 1995; Kreeger and Newell 2000). Ribbed mussels attach by byssal threads to any hard substrate (like oyster shells and cordgrass stems) and protrude above the surface. Typically, ribbed mussels occur embedded in and amongst salt marsh sediments attached by byssal threads to each other and/or to *Spartina* spp. stalks.

Ribbed mussels occur throughout the mid- to low-intertidal regions in most southeastern estuaries. Upper intertidal limits are determined by both exposure to high temperatures and limited food availability during longer periods of tidal exposure. Lower intertidal limits are determined by the availability of effective refuge, mainly from crab predators. Although growth rates decline at higher shore levels, this is offset by increased survival (Bertness 1980; Bertness and Grosholz 1985; Stiven and Gardner 1992; Franz 2001).

A large volume of literature exists for ribbed mussels associated with salt marsh habitats on the east coast of the United States; however, much less is known about this mussel's association with oyster reefs. Researchers in South Carolina and Virginia (Coen et al. 1999a; Coen and Luckenbach 2000; Luckenbach et al. 2005) have noted large numbers of ribbed mussels often associated with intertidal and subtidal oyster reef habitats. In South Carolina, there are *G. desmissa* densities of over 500 individuals/m^2, cohabiting areas with one or more smaller (2.5 to 5 cm) mussel species (e.g., scorched mussel (*Brachidontes exustus*) and hooked mussel (*Ischadium recurvum*)). Scorched and hooked mussels can also occur at high densities, often exceeding ribbed mussel densities (L. Coen, personal observation). For example, at some restored South Carolina intertidal oyster sites, *B. exustus* densities exceeded 4,900 individuals/m^2 and *I. recurvum* densities reached 500 individuals/m^2. As a result of these high densities of individuals, mussels can be a significant nuisance species at many Gulf of Mexico oyster reef sites.

Green mussel (*Perna viridis*)
The green mussel is a recent invader to the Caribbean, Florida (Benson et al. 2001; Baker and Benson 2002), and Georgia (Power et al. 2004), reaching lengths up to 171.5 mm (J. Fajans, University of Florida, personal observation). This species should not be confused with two morphologically similar alien species, *P. perna* and *P. canaliculus* (Siddall 1980; Benson et al. 2001; Ingrao et al. 2001). Although the green mussel is overgrowing oyster reefs in Florida (Figure 3.2.16), and becoming a serious fouling problem in Florida and Georgia, it may ultimately generate a complex and important habitat not previously observed in the southeast (J. Fajans and S. Baker, University of Florida, personal communication). Recent (October 2006) collections in Charleston, South Carolina (D. Knott, South Carolina Department of Natural Resources, personal observation), collected *P. viridis*, resulting in a new northern range extension for this non-native fouling mussel species.

Figure 3.2-16. The green mussel, *Perna viridis* (Source: Jon Fajans, Keys Marine Lab, Long Key, Florida) (Source: ASMFC 2007).

Bay scallop (*Argopecten irradians*)
Bay scallops are found on the Atlantic and Gulf coasts from the north shore of Cape Cod, Massachusetts to Laguna Madre, Texas (Waller 1969; Fay et al. 1983). They can reach a maximum size of 60 to 70 mm. Seastars, wading birds, gulls, pinfish, lightning whelks, cow-nosed rays, crabs, starfish, and humans are among the numerous predators of the bay scallop (Peterson et al. 2001a). Scallops are hermaphroditic, with a single individual releasing sperm before eggs (Bricelj et al. 1987). Bay scallops reach sexual maturity within one year, spawning from August through October. The juvenile stage is reached after about 35 days post-fertilization, when they resemble a small adult in shape; their lifespan is less than two years (Peterson et al. 1989).

Bay scallops can migrate *en masse*. In many areas they have declined significantly (e.g., North Carolina). Red tides, often referred to as "harmful algal blooms," can kill millions of adult and larval bay scallops each year. Scallops grow fastest during the warmer months when food is available. They prefer estuaries and bays where salinities are relatively high, waters are 0.3 to 0.6 m deep at low tide, and seagrasses such as eelgrass (*Zostera marina*) or shoal grass (*Halodule wrightii*) are common (Smith et al. 1988; Prescott 1990; Pohle et al. 1991; Garcia-Esquivel and Bricelj 1993; Bologna and Heck 1999, 2002; Bologna et al. 2001). These grass beds offer protection from predators as well as sites for juvenile attachment (Pohle et al. 1991; Bologna and Heck 1999).

Atlantic calico scallop *(Argopecten gibbus)*
The Atlantic calico scallop, a relatively small scallop ranging from 25 to 60 mm shell height, is patchily distributed on the Atlantic coast from Delaware Bay south into the Caribbean Sea to about 20° N latitude. It is most commonly found from just north of Cape Hatteras, North Carolina to the Greater Antilles, and throughout the Gulf of Mexico and Bermuda (Allen and Costello 1972; Blake and Moyer 1991). Genetic and morphological similarities (Waller 1969) between Florida and North Carolina populations and coastal currents support a hypothesis that Florida may be an important larval source for North Carolina stocks (Wells et al. 1964; Krause et al. 1994). Calico scallops can be found in depths of 10 to 400 m, but have been reported from shallower waters in Biscayne Bay (Coleman et al. 1993).

Spawning occurs throughout the year, but peaks in late fall and in the spring (Arnold 1995). As with bay scallops, calicos are simultaneous hermaphrodites that release sperm and eggs. Settling calico scallops require shell or other hard substrate to provide an anchor for byssal attachment. Laboratory studies suggest that after drifting freely for 14–16 days, larvae attach to hard substrates, which are often the disarticulated shells (dead accumulations that are separated or broken) from previous generations (Ambrose and Irlandi 1992; Ambrose et al. 1992). They reach a commercial length of 47 to 53 mm in six to eight months.

The maximum life span of an Atlantic calico scallop appears to be about 24 months. Predation (Wells et al. 1964) is a major factor affecting survival during various phases of the calico scallop life cycle. Aggregations of calico scallops provide habitat for numerous species, including other types of scallops, fish, and invertebrates. Schwartz and Porter (1977) collected 111 species of fish and 60 species of macroinvertebrates, including 25 crustaceans, 12 echinoderms, 4 coelenterates, and 1 annelid. Many of the fish caught used this habitat for feeding purposes (Schwartz and Porter 1977). See section 4.1.9 in this document for more detailed information on this species.

Pen Shells
As with other filter feeders, pinnids can filter large quantities of suspended sediments and plankton out of the water column, thereby affecting phytoplankton levels and water clarity. However, high densities generate both feces and pseudofeces affecting the surrounding sediments and associated organisms (Cummings et al. 2001; Ellis et al. 2002). For example, Ellis et al. (2002) showed that sedimentation can significantly impact *Atrina* spp. populations.

All three species -- the saw-toothed pen shell (*Atrina serrata*), the amber pen shell (*Pinna carnea*), and the stiff pen shell (*Atrina rigida*) -- can occur in large numbers and protrude above the sediment's surface (Figure 3.2-14, Plates A & B). Their shells are typically covered with a diverse assemblage of fouling organisms, including barnacles and slipper shells, which create vertical structure and fish habitat (Kuhlmann 1994, 1996, 1997, 1998; Munguia 2004). Many organisms use the shells as shelter, including crabs (e.g., *Pilumnus sayi*, *Menippe* spp., *Portunus ordwayi*) and benthic fishes such as blennies and gobies) within seagrasses (Kuhlmann 1994). Shells can reach densities of over 13 individuals/m^2 (Kuhlmann 1994, 1996).

Additionally, the Florida blenny (*Chasmodes saburrae*), feather blenny (*Hypsoblennius hentzi*), clingfish (*Gobiesox strumosus*), and Gulf toadfish (*Opsanus beta*) use dead pen shells as nest sites (Kuhlmann 1994). Females lay a single layer of eggs on the inside of the pen shells. Similarly, Joubin's pygmy octopus (*Octopus joubini*) also lays its eggs on the inside of pen shells. Horse conchs (*Pleuroploca gigantea*) are the primary predators of pen shells (Kuhlmann 1994, 1996, 1997, 1998). Dead pen shells provide nesting sites and shelter for many fish species, but are not permanent benthic features. As the shells begin to break apart, the waves and currents sweep them away, thus changing the dynamics of the populations of the species that depend on them (Kuhlmann 1996, 1998).

The most extensive studies of pen shell communities as habitat were completed by researchers in New Zealand (Keough 1984; Cummings et al. 1998, 2001; Nikora et al. 2002; Gibbs et al. 2005). These habitats are also referred to as 'horse mussel' (*Atrina zelandica* and *Atrina novaezelandiae*) beds. Research has included fine scale boundary layer flow studies (Nikora et al. 2002), mesoscale hydrodynamic interactions (Green et al. 1998), community interactions (Keough 1984; Cummings et al. 1998, 2001), and essential fish habitat delineation for juvenile finfish species (Morrison and Carbines 2006).

Estuarine wedge clam (*Rangia cuneata*)

The estuarine wedge clam is found in Atlantic coastal and Gulf of Mexico oligohaline estuaries (Cain 1975; LaSalle and de la Cruz 1985; Abadie and Poirrier 2000), tidal rivers, and backwater bays with regular inputs of fresh water. It occurs from the upper Chesapeake Bay to Mexico, often dominating benthic biomass in low salinity areas of estuaries (Cain 1975). This clam is regarded primarily as a subtidal species found in coastal areas with a large tidal range (Estevez 2005).

The species serves as an important link in the food chain, filtering large volumes of water when at high densities and serving as a food source for fish, crabs, and ducks (LaSalle and de la Cruz 1985). In North Carolina, *Rangia cuneata* are often found within the most critical oyster habitat areas where shells accumulate over long time periods. In these areas, accumulations of estuarine wedge clam shells provide substrate for formation of oyster reefs. In a majority of cases, both living and dead *Rangia cuneata* occur together. Estuarine wedge clams are more abundant in downstream reaches and as intertidal material in upstream reaches. Interestingly, live *Rangia cuneata* in intertidal areas can be larger than those in subtidal beds (Estevez 2005).

In Lake Pontchartrain, Louisiana, individual estuarine wedge clams have an average life span of four to five years. Deposits of wedge clam shells in the lake bottom supported a shell mining industry from 1933 to 1990 (Abadie and Poirrier 2000). As with oyster shells, clam shells used to be so abundant that they were used for construction of roadways, parking lots, levees, and in the production of cement. Large (> 20 mm) *Rangia cuneata* were abundant in Lake Pontchartrain in the early 1950s, but became rare by the 1970s and 1980s. They can dominate the benthos, with densities reaching 1,896 clams/m^2 and dry weight biomass as high as 70 g/m^2. However, clams are absent from areas that are subject to anoxia and hypoxia, or saltwater intrusions (Poirrier and Spalding 2005).

Current *Rangia cuneata* studies are seeking to document similar ecological services to oysters, in order to generate interest in its restoration (M. Poirrier, personal communication). Results indicate that increasing clam abundance by decreasing saltwater intrusion will improve water clarity; this in turn should increase submerged aquatic vegetation and add shell for mud stabilization and erosion reduction. These improvements should reduce eutrophication, improve water quality, and enhance fish habitat (M. Poirrier, personal communication).

Carolina marsh clam (*Polymesoda caroliniana*)
This brackish-water corbiculid clam (often reaching sizes over 50 mm, but typically 25- 40 mm) is often common in low salinity marshes comprised of plants such as *Juncus* sp. and near river mouths (Andrews and Cook 1951; Andrews 1977; Duobinis-Gray and Hackney 1982; Marelli 1990). The geographical range of this species is from Virginia through Florida along the Gulf of Mexico to Texas, with adult densities often exceeding 300 individuals/m^2 (Duobinis-Gray and Hackney 1982) and juvenile (<20 mm) densities at almost 2,000/m^2 (Marelli 1990). The Carolina marsh clam lives primarily in the intertidal zone (Marelli 1990), but may be found subtidally, in mud to fine sediments (Heard 1982). Some researchers have suggested competitive interactions with another common low salinity bivalve, *Rangia cuneata* (more often subtidal, as *Polymesoda* is a poor burrower in intertidal areas) (Duobinis-Gray and Hackney 1982). Early growth can be rapid (>1 mm/month) (Olsen 1973, 1976), and predation, competition, and inundation are often cited as factors controlling the distribution and abundance of this species (Andrews and Cook 1951, Andrews 1977). A related species *P. maritima*, the Florida marsh clam, is common in the Gulf coast region, and southern Florida to the Yucatan (Andrews 1977).

Little is known about the habitat value of shell accumulations or live aggregations of *Polymesoda* spp. for other organisms.

Oyster Reefs and Shell Banks as Essential Fish Habitat

The three major types of shellfish habitat (reefs, aggregations, and accumulations) differ in their combinations of habitat characteristics. However, all shellfish habitats have three major features in common that are the basis for their ecological value for managed species: hard substrate (for settlement/refuge/prey), complex vertical (3-D) structure (for settlement/refuge/prey), and food (feeding sites for larger predators).

Perhaps the most fundamental characteristic of shellfish habitat is hard substrate. The shells provide attachment surfaces for algae and sessile invertebrates, such as polychaetes (e.g., sabellids, serpulids), hydroids, bryozoans, and sponges, which in turn provide substrate for other organisms. Planktonic larvae of some shellfish species, such as oysters, need a hard substrate on which to settle in order to grow into adults (Galtsoff 1964). In many estuarine areas, oyster shell and cultch are the primary settlement material for larval oysters (Kennedy 1996; Powell et al. 2006). All three types of shellfish habitat—reefs, aggregations, and accumulations—provide suitable substrate for other shellfish and many other species that require hard substrate on which to grow.

Sufficient accumulations of hard substrate result in complex habitat structure that provides increased vertical relief and internal complexity of the structure itself. Structural complexity has historically been considered to be an important factor affecting the spatial distribution and diversity of marine and estuarine organisms (Bell et al. 1991). An increase in the physical complexity of an environment is typically correlated with an increase in microhabitat diversity (Sebens 1991). The increase in surface area provides more refuge and feeding sites, which subsequently leads to greater species richness (Bell and Galzin 1984). The interstitial spaces provide recruiting oysters with adequate water flows for growth and refuge from predators, both of which are essential for long-term maintenance of the reef structure (Bartol and Mann 1997; Bartol et al. 1999; Coen et al. 1999b; Powell et al. 2006). Oysters and other reef-forming shellfish can be considered “bioengineers” because they create habitat that allows many additional species to thrive (Jones et al. 1994, 1997).

All four shellfish habitat types provide food for other organisms, whether it is the shellfish themselves or associated organisms. Oysters and mussels are consumed by many species of fish and invertebrates. Many other species of plants and animals also occur on shell accumulations and provide food for a variety of predators. When considered in combination with the hard substrate and complex structure provided by live shellfish, their direct food value results in shellfish reefs and aggregations being uniquely valuable habitat for many managed species.

3.2.5 Intertidal Flats

Description and Distribution

This section is intended to briefly summarize the most important aspects of tidal flats which pertain directly to their function as essential fish habitat. For a more extensive and comprehensive ecological profile of tidal flats in the South Atlantic region we recommend the U.S. Department of Interior Community Profile, Peterson and Peterson (1979).

Intertidal flats are the unvegetated bottoms of estuaries and sounds that lie between the high and low tide lines. These flats occur along mainland or barrier island shorelines or can emerge in areas unconnected to dry land. Intertidal flats are most extensive where tidal range is greatest, such as near inlets and in the southern portion of the coast. Because the influence of lunar tides is minimal in the large sounds (e.g., Pamlico, Albemarle, and Currituck), true intertidal flats are not extensive, except for the area immediately adjacent to inlets (Peterson and Peterson 1979). Sediment composition on intertidal shorelines tends to shift from coarser, sandy sediment on higher portions of the shoreline, with greater wave energy, to finer, muddier sediments in the lower portion of the shoreline, with relatively less wave energy (Peterson and Peterson 1979). Conditions on intertidal flats are physically stressful for associated marine organisms. Drastic fluctuations in salinity, water and air temperature (in addition to air and wind exposure) occur during each tidal cycle. Due to physiological restraints and limited water depth, some mobile organisms are restricted to deeper waters or adjacent habitats to avoid the stressful extremes associated with low tide. However, the sediment provides a buffer from changes in temperature and salinity in the water column for benthic infauna (Peterson and Peterson 1979).

Variability in the tidal regime along the South Atlantic coast results in considerable regional variability in the distribution and character of the estimated 1 million acres (Field et al. 1991) of tidal flat habitat. Geographic patterns in sediment size on tidal flats result primarily from the interaction of tidal currents and wind energy. The coasts of North Carolina and Florida are largely microtidal (0 - 2m tidal range). In these areas wind energy has a strong affect on intertidal flats. The northern North Carolina outer banks have extensive barrier islands and relatively few inlets to extensive sound systems. South of Cape Lookout, flood-tide deltas (remnant and active) are more frequent and tidal inlets and influences on intertidal flat distribution is greater. In contrast, the coasts of South Carolina and Georgia are mesotidal (2 - 3.3m) with short barrier islands and numerous tidal inlets so that tidal currents are the primary force effecting the intertidal. In both types of systems the substrate of the intertidal flats generally becomes finer with distance from inlets due to the progressive damping of tidal currents and wave energy in the upstream direction. Exposure of flats to wave energy, which resuspends fine particles, may cause the development of sand flats in areas where the wind fetch is sufficient for the development of significant wave energy. On the microtidal coast of North Carolina sandy flats tend to develop due to the large size of the sounds and their orientation relative to prevailing winds. In contrast in Georgia and South Carolina most flats are muddy, as the sounds and estuaries are small so that the importance of wave energy is reduced. These different depositional environments result in development of varied physico-chemical environments in and on intertidal flats which in turn cause differences in the animal populations that utilize them.

Ecological Role and Function

Intertidal flats play an important role in the ecological function of South Atlantic estuarine ecosystems, particularly in regard to primary production, secondary production and water quality. Although intertidal flats are usually classified as “unvegetated,” there is actually an extremely productive microalgal community occupying the surface sediments (MacIntrye et al., 1996). The benthic microalgal community of tidal flats consists of benthic diatoms, cyanobacteria, euglenophytes and unicellular algae. Primary production of this community can equal or exceed phytoplankton primary production in the water column, and can represent a significant portion of overall estuarine primary productivity (Pinckney and Zingmark 1993; Buzzelli et al. 1999). Benthic microalgae are resuspended into the water column and transported throughout the estuary, sometimes representing over half of the chlorophyll in the water column (de Jonge and van Beusekom 1995; Tester et al. 1995). Benthic microalgae also stabilize sediments and control fluxes of nutrients (nitrogen and phosphorus) between the sediment and the water column. Autochthonous benthic microalgal and bacterial production and imported primary production in the form of phytoplankton and detritus support diverse and highly productive populations of infaunal and epibenthic animals. The primary factors controlling production by microalgae occupying these sediments include the amount of light they receive, community biomass (chl *a*), and temperature (Pinckney and Zingmark, 1993; Barranguet et al., 1998; Guarini et al., 2000).

Important benthic animals in and on the sediments include ciliates, rotifers, nematodes, copepods, annelids, amphipods, bivalves and gastropods. This resident benthos is preyed upon by mobile predators that move onto the flats with the flood tide. These predators do not always kill their benthic prey and many "nip" appendages of buried animals such as clam siphons and polychaete tentacles that can be regenerated. An important aspect of the function of these systems is the regular ebb and flood of the tide over the flats and the corresponding rhythm that exists among animals and microalgae adapted to life in the intertidal zone. The flooding tide brings food and predators onto the flat while the ebb provides residents a temporal refuge from the mobile predators.

This constantly changing system provides the following ecological functions: 1) nursery grounds for early stages of development of many benthically oriented estuarine dependent species; 2) refuges and feeding grounds for a variety of forage species and juvenile fishes; 3) significant trophic support to fish and shellfish, including oysters and clams (Riera and Richard 1996; Kreeger et al. 1997; Sullivan and Currin 2000; Page and Lastra 2003; Currin et al. 2003); 4) stabilization of sediments via the production of exopolymers (Yallop et al. 1994, 2000) and 5) modulation of sedimentary nutrient fluxes (Miller et al. 1996; Cerco and Seitzinger 1997; Sundback et al. 1991). Although it is recognized that tidal flats provide these important ecological functions, the relative contribution of intertidal flats of different types and in different locations within coastal systems is not well known.

Intertidal flats also provide habitat for a large and diverse community of infauna and epifauna, which in turn may become prey for transient fish species utilizing the intertidal flat. The faunal communities associated with intertidal flats will be described below.

Coastal development and human activities can have direct and dramatic impacts on tidal flats, although subtler impacts may occur from activities that alter current patterns, wave energy or the supply of sediment. Examples of direct impacts include on-site dredging and contaminant spills. Indirect impacts include dredging that significantly alters current patterns, dam construction that traps sediment, beach re-nourishment projects and jetty construction. Although intertidal flats are protected by the same permitting process that regulates activities impacting other estuarine habitats, the perception that flats are of minor importance relative to vegetated habitats increases pressure on intertidal flats. Flats have the same legal protection afforded vegetated intertidal areas, however; the importance of intertidal flats is not generally recognized and the relative value of intertidal flats is not understood. As a consequence permits may be more easily granted for filling/dredging tidal flats than for salt marshes and salt marsh may be planted on a natural intertidal flat when mitigation for marsh destruction is required. Increased recognition of the ecological value of tidal flats by resource managers and permitting agencies is necessary to preserve these valuable habitats, and research on the different types of intertidal flats and their relative value in coastal systems should be encouraged.

Species composition and community structure

Both plankton and benthic feeding herbivorous fish are found in abundance on intertidal flats. Schools of baitfish, small pelagic fish that tend to group together, are common over subtidal soft bottom and very abundant on shallow intertidal flats. These baitfish, such as anchovies, killifish, and menhaden, feed on the abundant supply of phyto- and zooplankton in the water column, but also consume resuspended benthic algae, microfauna, and meiofauna (Peterson and Peterson 1979). Although the majority of detritivores of the soft bottom habitat are invertebrates, striped mullet, white mullet, and pinfish also feed on detritus on subtidal bottom and intertidal flats. Other fish species use detritus as an alternate food source when preferred items are not available.

Most fish that forage on soft bottom are predaceous. Predators of benthic invertebrates include juveniles and adults of the following species (Peterson and Peterson 1979; Bain 1997):

- rays and skates,
- flatfish (southern flounder, summer flounder, hogchoker, tonguefish),
- several species of drum (spot, Atlantic croaker, red drum, kingfishes, silver perch),
- Florida pompano,
- pigfish,
- sea robins,
- lizardfish,
- spadefish,
- gobies, and
- shortnose and Atlantic sturgeons.

The compressed body forms of flatfish, rays, and skates assist in prey acquisition and predator avoidance on shallow intertidal flats (Peterson and Peterson 1979). For example, flounder forage on shallow flats by laying still, by concealing themselves under a thin layer of sediment, or by changing skin color. Small flatfish, including the bay whiff, fringed flounder, hogchoker, and tonguefish, feed mostly on copepods, amphipods, mysids, polychaetes, mollusks, and small fish. By way of comparison, summer and southern flounder primarily consume fish, such as silversides and anchovies, as well as shrimp and crabs, small mollusks, annelids, and amphipods (Peterson and Peterson 1979). Various rays excavate large pits while feeding, creating slightly deeper pockets of water that other fish and invertebrates use as refuge. Mollusks, annelids, crustaceans, and fish comprise the typical diet of rays.

To avoid predation, small fish commonly feed on open, unvegetated bottom at night and hide near structure during the day (Peterson and Peterson 1979). Larger predators that feed on smaller, benthic-feeding fish and invertebrates typically move onto the flats during high water to feed on schools of fish. These predators include sharks (sandbar, dusky, smooth dogfish, spiny dogfish, Atlantic sharpnose, scalloped hammerhead), drum (weakfish, spotted seatrout), striped bass, and estuarine dependent reef fish (black sea bass, gag grouper, sand perch, sheepshead) (Peterson and Peterson 1979; Thorpe et al. 2003).

Due to their size and shape, small baitfish and flat bodied rays, skates, and flounders have a feeding advantage over other fish in that they can forage on intertidal flats for greater amounts of time than larger fish. These fish groups are considered to be most characteristic of intertidal flats and would be most affected by habitat degradation and loss of intertidal flats from dredging, filling, bulkheading, or other anthropogenic causes (Peterson and Peterson 1979).

Fish species and age composition over soft bottom vary seasonally. Baitfish are present on shallow flats throughout the year. In the spring, large schools of baitfish are joined by juvenile fish that were spawned offshore in the winter (spot, Atlantic croaker, menhaden). In the summer, these species remain abundant on shallow unvegetated bottom; flatfish and rays also appear at this time. By fall, fish species diversity is at a maximum since summer residents and fall migrants are both present. Migratory fish feeding on the soft bottom include bluefish, striped mullet, kingfish, spotted seatrout, red drum, and many others (Peterson and Peterson 1979).

Intertidal Flats as Essential Fish Habitat

Benthic Nursery Function

Many species whose larval stages are planktonic but are benthically oriented as juveniles utilize intertidal flats as primary nursery ground. Intertidal flats are particularly suited for animals to make the shift from a pelagic to benthic existence. During this habitat shift these small animals are expected to be particularly vulnerable to adverse physical forces, predation and starvation, and flats may provide a relatively low energy environment where predation pressure is low and small benthic prey abundant. These animals may develop a tidal rhythm of behavior and move off and on the flat with the ebb and flood of the tide. This provides them an area of retention as currents over the flats are reduced, a refuge from a variety of predators due to the shallow water and excellent feeding conditions as the abundant meiofauna emerge to feed with the flooding tide. A wide variety of important fishes and invertebrates utilize intertidal flats as nurseries (Table 3-2.7) including the commercially important paralichthid flounders, many members of the drum family including red drum, and spotted seatrout, the mullets, gray snapper, the blue crab, and penaeid shrimps.

Table 3.2-7. Species' utilization of intertidal flats.

Species	Common name	Function	Life stage(s)
Dastatis sayi	bluntnose stingray	F	A
Rhinoptera bonasus	cownose ray	F	A
Angulla rostrata	American eel		J, A
Conger oceanicus	conger eel		A
Myrophis punctatus	speckled worm eel		J
Brevoortia tyrannus	Atlantic menhaden	R	J
Anchoa hepsetus	striped anchovy	R	J, A
Anchoa mitchilli	bay anchovy	R	J, A
Synodus foetens	inshore lizardfish	F	J, A
Urophycis regius	spotted hake	F	J
Membras martinica	rough silverside	R	J, A
Menidia menidia	Atlantic silverside	R	J, A
Centropristis striata	black seabass	R	J
Diplectrum formosum	sand perch	R	J
Mycteroperca microlepis	gag grouper	R	J
Lujanus griseus	gray snapper	N	J
Eucinostomus argenteus	spotfin mojarra	R, F	J, A
Eucinostomus gula	silver jenny	R, F	J, A
Orthopristis chrysoptera	pigfish	R	J
Archosargus probatocephalus	sheepshead	R, F	J
Lagodon rhombodies	pinfish	N, R, F	J, A
Bairdiella chrysura	silver perch		J, A
Cynocion nebulosus	spotted seatrout	N	PL, J
Cynocion regalis	weakfish		J
Leiostomus xanthurus	spot	N, R, F	PL, J, A
Menticirrhus saxatilus	southern kingfish	R, F	J
Micropogonias undulatus	Atlantic croaker	N, R, F	PL, J, A
Sciaenops ocellatus	red drum	N, R, F	PL, J, A
Mugil cephalus	striped mullet	N, R	J, A
Mugil curema	white mullet	N, R	J
Prionotus carolinus	northern searobin		J, A
Citharichthys spilopterus	bay whiff	N, R, F	PL, J, A
Etropus crossotus	fringed flounder	R, F	J, A
Paralichthys albigutta	gulf flounder	N, R, F	PL, J, A
P. dentatus	summer flounder	N, R, F	PL, J, A
P. lethostigma	southern flounder	N, R, F	PL, J, A
Scopthalmus aquosus	windowpane	F	J, A
Trinetes maculatus	hogchoker	N, R, F	PL, J, A
Symphurus plagiusa	blackcheek tonguefish	N, R, F	PL, J, A
Callinectes sapidus	blue crab	N, R, F	J, A
Penaeus aztecus	brown shrimp	N, R, F	PL, J, A
P. duorarum	pink shrimp	N, R	PL, J
P. setiferus	white shrimp	N, R, F	PL, J, A
Busycon spp.	Welk	F	A
Crassostrea virginica	eastern oyster	F	PL, J, A
Mercenaria mercenaria	hard clam	F	PL, J, A

Letter codes for function use are N=benthic nursery function, R=refuge function, and F=feeding ground function. Life stage codes are PL=post-larval, J=juvenile, and A=adult.

Refuge Function

A variety of pelagic and benthic species utilize the intertidal flats as a refuge from predation and adverse physical conditions (Table 3.2-7). Predation pressure in the subtidal, particularly in the vicinity of inlets may increase during the rising tide due to the influx of coastal predators.

Intertidal flats provide energetic advantages for animals seeking to maintain their position within the system as current velocities are generally low relative to deeper areas. Schools of planktivores including anchovies, silversides and menhaden and schools of benthic feeding juveniles such as the spot and croaker, pinfish and mojarras, move onto flats with the rising tide to take advantage of the favorable conditions flats provide. More solitary species such as black seabass and gag grouper also appear to utilize flats as a refuge during their emigration from structured estuarine nursery habitats to the sea in the fall. Flats also can provide a refuge from low oxygen levels that may develop in deeper areas of estuaries during summer months.

Feeding Ground Function

Several groups of specialized feeders utilize intertidal flats as feeding grounds (Table 3.2-7). The depositional nature of intertidal flats provide a rich feeding ground for detritivores such as mullet and predators of small benthic invertebrates such as spot and mojarra. A variety of invertebrate predators such as whelks and blue crabs feed on tidal flats as do their bivalve prey such as oysters and hard clams, important filter feeding residents of tidal flats. Another group that relies on flats as feeding grounds is predatory fishes such as rays, a wide variety of flatfishes and lizard fish whose form makes them well adapted to feed in shallow water. Other more conventionally shaped fishes whose prey concentrate on flats use these areas as feeding grounds and red drum can be found hunting blue crabs on flats. Because flats are "dry" much of the time activity is concentrated during high water making tidal flats rich feeding grounds for species adapted to shallow waters.

3.2.6 Estuarine Water Column

Description and Distribution

This habitat traditionally comprises four salinity categories: oligohaline (< 8 ppt), mesohaline (8 -18 ppt), and polyhaline waters (18 - 30 ppt) with some euhaline water (>30 ppt) around inlets. Alternatively, a three-tier salinity classification is presented by Schreiber and Gill (1995) in their prototype document developing approaches for identifying and assessing important fish habitats: tidal fresh (0-0.5 ppt), mixing (0.5-25 ppt), and seawater (>25 ppt). Saline environments have moving boundaries, but are generally maintained by sea water transported through inlets by tide and wind mixing with fresh water supplied by land runoff. Particulate materials settle from these mixing waters and accumulate as bottom sediments. Coarser-grained sediments, saline waters, and migrating organisms are introduced from the ocean, while finer grained sediments, nutrients, organic matter, and fresh water are input from rivers and tidal creeks. The sea water component stabilizes the system, with its abundant supply of inorganic chemicals and its relatively conservative temperatures. Closer to the sea, rapid changes in variables such as temperature are moderate compared to shallow upstream waters. Without periodic additions of sea water, seasonal thermal extremes would reduce the biological capacity of the water column as well as reduce the recruitment of fauna from the ocean. While nearby wetlands contain some assimilative capacity abating nutrient enrichment, fresh water inflow and tidal flushing are primarily important for circulation and removal of nutrients and wastes from the estuary.

The water column is composed of horizontal and vertical components. Horizontally, salinity gradients (decreasing landward) strongly influence the distribution of biota, both directly (physiologically) and indirectly (e.g., emergent vegetation distribution). Horizontal gradients of nutrients, decreasing seaward, affect primarily the distribution of phytoplankton and, secondarily, organisms utilizing this primary productivity. Vertically, the water column may be stratified by salinity (fresh water runoff overlaying heavier salt water), oxygen content (lower values at the bottom associated with high biological oxygen demand due to inadequate vertical mixing), and nutrients, pesticides, industrial wastes, and pathogens (build up to abnormal levels near the bottom from lack of vertical mixing).

Typically, parameters of the following variables can be used to chemically, physically, or biologically characterize the water column: total nitrogen, total organic nitrogen, alkaline phosphatase, total organic carbon, NO^{2-}, NO^{3-}, NH^{4+}, turbidity, total phosphorus, chlorophyll a, dissolved oxygen, temperature, and salinity (see Boyer et al. 1997).

Composite signatures by these variables can be used to identify the source of the water column. Components commonly used to describe the water column are organic matter, dissolved inorganic nitrogen, dissolved oxygen, temperature, salinity, and phytoplankton. Additional physical descriptors of the water column include depth, fetch, and adjacent structure (e.g., marshes, channels, shoals). Turbidity is quantified by secchi depth, light attenuation, and NTU. Increases in turbidity, resulting from large river flow runoff or strong wind events, affect the distribution and productivity of submerged aquatic vegetation and phytoplankton through reduction of light levels necessary for photosynthesis and changes in nutrient concentrations.

The quality of our coastal waters affects fish species diversity, production, and distribution but also living fish habitats, such as submerged aquatic vegetation and oyster beds (shell bottom). Water quality in the water column is a key factor that links fish, habitat, and people. That linkage is affected by growing development pressures along our coast as well as far inland, making the protection and enhancement of water quality for fisheries resources a challenging task. Determining the best course of action for enhancing water quality requires detailed knowledge of the water quality characteristics that various species require throughout their life cycle, along with the status, trends, and threats of those characteristics.

Water column habitat is defined in this plan as “the water covering a submerged surface and its physical, chemical, and biological characteristics.” Differences in the chemical and physical properties of the water affect the biological components of the water column, including fish distribution. Water column properties that may affect fisheries resources include temperature, salinity, dissolved oxygen (DO), total suspended solids, nutrients (nitrogen, phosphorus), and chlorophyll a (SAFMC 1998a). Other factors, such as depth, pH, water velocity and movement, and water clarity, also affect the distribution of aquatic organisms.

Water column characteristics in estuaries are a dynamic mix of adjacent riverine and marine systems. Estuaries occupy the transition between freshwater and marine systems, where circulation patterns are determined by prevailing winds, buoyancy-driven flows, and lunar tides. Estuaries are important habitats for many economically important species in the South Atlantic. In North Carolina, for instance, estuarine-dependent species comprise more than 90% of commercial fisheries landings and over 60% of the recreational harvest (by weight) (from DMF annual commercial and recreational fisheries landings data).

Three salinity zones are used for simplicity and consistency with established definitions (Bulger et al. 1993):

- low-salinity (0.5-5 ppt) (also known as oligohaline)
- moderate-salinity (5-18 ppt) (also known as mesohaline)
- high-salinity (18-30 ppt) (also known as polyhaline)

Boundaries between salinity zones change in response to water flow, weather conditions, and tidal fluctuations. Flooding can result in fresh water expanding seaward over denser masses of water in the "mixing zone" (0.5 - 25 ppt). Conversely, dry weather can result in seawater advancing into typically freshwater areas. Less drastic are tidal changes resulting in periodic additions of seawater to the mixing zone. The mixing zone receives coarser-grained sediments, saline water, and migrating organisms from the flood tide, while the ebb tide brings finer-grained sediment, fresh water, nutrients, and organic matter (SAFMC 1998a). This dynamic system is mediated by a series of inlets along a chain of barrier islands separating the ocean from the adjacent estuary. Salinity in estuaries also varies in accordance with the seasonal pattern of river input depicted in Figure 3.2-17. Salinity within estuaries is generally lowest from December to early spring and highest from late spring to early fall (Orlando et al. 1994). Similarly, water temperatures are lowest during mid-winter and highest during the summer. Pilkey et al.'s (1998) analysis of North Carolina's shore and barrier islands revealed much about the variation in salinity and tidal amplitude along North Carolina's coast due to the slope of the coast.

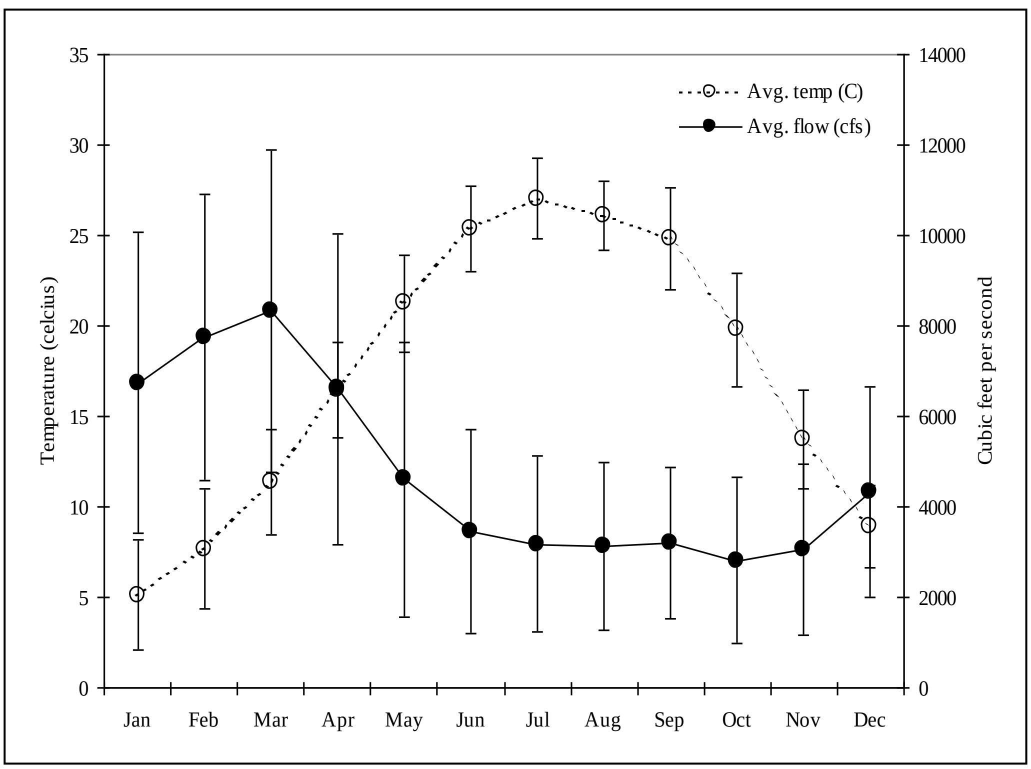


Figure 3.2-17. Average and standard deviation of monthly discharge (time period: 1969 1999, n = 1,464) and water temperature (time period: 1953-2001, data points per month =

52-123). [Source: USGS hydrologic monitoring stations on the lower Roanoke, Tar, Neuse, and Cape Fear rivers, North Carolina.

Steeper slopes with relatively short basin profiles result in less river input and greater tidal amplitude from increasing oceanic influence. In these areas, numerous inlets develop along short barrier islands, protecting narrow, back barrier sounds. Small rivers draining these areas form trunk estuaries (drowned river estuaries perpendicular to the coast) where low volumes of organic-stained fresh water mix with seawater. As a result, small trunk estuaries exhibit a distinct salinity gradient from upstream fresh waters to the ocean, while narrow back barrier sounds maintain high salinities from regular lunar tides.

Other areas have gentler slopes and relatively long basin profiles, with more river input and lower tidal amplitude from reduced seawater intrusion; such areas have few inlets and long barrier islands protecting extensive back barrier sounds with highly variable salinity. Large rivers flowing into the sounds form trunk estuaries with very low salinity.
Strong winds are a major component of water movement in large, irregularly flooded estuarine systems.

At locations relatively isolated from inlets in the Albemarle-Pamlico Sound system, the effects of lunar tides are small (a few inches at most) whereas those of wind tides can be much greater (especially during storms). A strong wind tide often floods the windward shore, exposing bottom along the leeward shore. This situation can also result in colder, nutrient-rich water welling up along the leeward shore. Wind tides also affect salinity in the estuary, by pushing high-salinity water from the ocean toward the estuary. For example, one model of the Albemarle-Pamlico system indicates that southwesterly winds cause the formation of low-salinity plumes from Oregon Inlet seaward while wedge-shaped high-salinity plumes enter Pamlico Sound from Hatteras and Ocracoke inlets (Xie and Pietrafesa 1999). This hydrodynamic model predicted the opposite effect during cold fronts, when northwesterly winds caused a wedge-shaped, high-salinity plume on the sound side of Oregon Inlet.

Circulation, by wind or lunar tide, can increase DO levels in bottom water. But while lunar-driven systems receive regular circulation, wind-driven systems depend on variable weather conditions (Luettich et al. 1999; Borsuk et al. 2001). Irregular mixing can result in stratification of the water column and hypoxia or anoxia during periods of warm, calm weather. Anoxia can also develop with light winds if a strong vertical salinity gradient is present, especially during westerly winds.

Large back barrier sounds and trunk estuaries
In North Carolina, large back barrier sounds occur north of Cape Lookout and include Albemarle, Currituck, Croatan, Roanoke, and Pamlico sounds. Large trunk estuaries flowing into these northern sounds include the Alligator, Pungo, Pamlico, and lower Neuse rivers. The Albemarle-Pamlico sound system (not including Core Sound) connects with nearshore ocean waters through Oregon Inlet in the north, and Hatteras and Ocracoke inlets in the south. These large sounds are of prime importance for North Carolina’s fishery productivity. Small tributary estuaries in west and northwest Pamlico Sound provide important fish nursery habitat.

Outstanding Resource Waters within these northern estuaries include the Alligator River and an area extending offshore from Swan Quarter National Wildlife Refuge. The Alligator River is also classified as Swamp Water. Nutrient Sensitive Waters include the Pamlico, Neuse, and Pungo rivers as well as southwest Pamlico Sound.

The Albemarle-Pamlico system has a long flushing period (about 272 days) relative to the other North Carolina estuarine systems. Since the large trunk estuaries flowing into Pamlico Sound flush more rapidly than Pamlico Sound, the sound acts as a settling basin for sediments and nutrients (Giese et al. 1979). Near inlets in the Albemarle-Pamlico system, lunar tides are the dominant influence on salinity variation and water column mixing (Orlando et al. 1994). Elsewhere, wind mixing is the dominant factor.

Management of river flows can also affect salinity. Releases from Roanoke Rapids Lake and other Roanoke River reservoirs during low-flow periods are generally effective in keeping higher salinity waters out of Albemarle Sound (Giese et al. 1979), except during extreme droughts. Seasonal variation in fresh water has a major effect on salinity. Different salinity layers can occur in estuaries lacking a direct connection to the ocean, such as the Cape Fear and Northeast Cape Fear rivers (Orlando et al. 1994). Different salinity layers can also occur in Albemarle Sound during period of calm or high freshwater inflow (Steel 1991). Although the major factors driving large-scale salinity change are fairly simple in estuaries, the factors underlying smaller-scale horizontal and vertical variation can be very complex, both spatially and temporally.

Small back barrier sounds and trunk estuaries

South of Cape Lookout, back barrier sounds and trunk estuaries begin to narrow as the basin slope becomes steeper. Starting at Core Sound in the north, small back barrier sounds continue south with Bogue Sound and some very narrow sounds located between the small trunk estuaries of the New and White Oak estuaries and the more riverine lower Cape Fear River. Some of these smaller sounds are Stump Sound, Topsail Sound, Masonboro Sound, and Myrtle Grove Sound. Other small trunk estuaries include the Newport and North rivers along Bogue and Back sounds. These small back barrier and trunk estuaries contain numerous designated nursery areas and Outstanding Resource Waters. The only Nutrient Sensitive Water among small back barrier sounds and trunk estuaries is the upper New River (DWQ unpub. data).

In Bogue and Back sounds, lunar tides are the dominant influence on salinity and water column mixing (Orlando et al. 1994) and flushing rates are faster than in the larger sounds. Winds and freshwater inflow are secondary influences on salinity variation, but may cause major seasonal differences in salinity.

During late winter (January-March) and summer (June-August), surface and bottom salinities are only weakly stratified in Bogue Sound. Large seasonal differences in surface salinity occur. The very small back barrier sounds found in the southern estuaries have high salinities year-round. In upper sections of the New River, freshwater inflow is the dominant influence on salinity (Orlando et al. 1994). In the lower New River estuary, lunar tides have the greatest influence on salinity variation.

Cape Fear River estuary
The Cape Fear River is the only major river in North Carolina flowing directly into the ocean, making the Cape Fear River estuary unique among North Carolina estuaries. The lower river is essentially a large trunk estuary, but with a much steeper gradient in salinity than large trunk estuaries in the northern part of the coast. The upper Cape Fear estuary is composed almost entirely of low-moderate salinity fish nursery areas.

In the upper Cape Fear River estuary (north of Wilmington), seasonal patterns of freshwater inflow have the greatest influence on salinity (Orlando et al. 1994). Discharge from the principal rivers in the Cape Fear basin is three times greater during the high-flow period than during the low-flow period. Short-term increases in freshwater discharge also influence salinity in the upper estuary, displacing bottom water downstream and homogenizing the water column (Giese et al. 1979). In the lower and middle estuary, lunar tides have the dominant effect on salinity variation. Due to the relatively high discharge and low volume of the Cape Fear estuary, the flushing rate is approximately 14 days (Table 3.2-8), the most rapid turnover among major estuaries in North Carolina.

Table 3.2-8. Hydrologic and hydrodynamic characteristics of major estuaries in North Carolina. (Note: flushing period = volume / average daily freshwater input; Source: Basta et al. 1990).

Estuary	Drainage area (mi^2)	Surface area (mi^2)	Avg. depth (ft)	Volume (billion ft^3)	Avg. daily freshwater input (100 cfs)	Flushing period (days)
Albemarle-Pamlico sounds*	29,600	2,949	13	1,081	460	272
Pamlico-Pungo River	4,300	166	9	44	46	111
Neuse River	5,600	173	12	55	62	103
Bogue-Core sounds and White Oak River	700	102	5	13	13	116
New River	500	32	6	5	8	72
Cape Fear River	9,100	38	11	12	101	14

* Includes Core Sound

Ecological Role and Function

(excerpted from the NCHPP)
The water column is the lifeblood of aquatic ecosystems. It is the medium through which all other aquatic habitats are connected. As such, the water column provides a basic ecological role and function for organisms within it. The water column also provides other functions, both by itself and due to benthic-pelagic coupling. Benthic-pelagic coupling refers to the influence of the benthic community and sediments on the water column and, in turn, the influence of the water column on them, through integrated events and processes such as resuspension, settlement, and absorption (Warwick 1993).

Productivity
The potential productivity of fish and invertebrates in a system is determined by the assimilation of energy and nutrients by green plants and other life at the base of the food chain. The potential

productivity of a habitat can indicate its relative value in supporting fish populations. Although productivity in the water column is derived mostly from phytoplankton, it can also come from bacterial decomposition of plants (detritus), floating plants, and macroalgae.

Historically, phytoplankton productivity in estuarine systems was thought to be relatively low compared to that of other primary producers (Peterson and Peterson 1979). For instance, Marshall (1970) estimated that phytoplankton contributed only 50 g carbon/m^2/yr to New England's subtidal shoal waters, compared to a contribution of 125 g carbon/m^2/yr for all macrophytes. In the Newport River estuary near Beaufort, North Carolina, Williams and Murdoch (1966) and Thayer (1971) estimated that phytoplankton produce about 110 g carbon/m^2/yr. Subsequent research suggested a higher contribution to overall primary production from phytoplankton (Peterson and Peterson 1979). Sellner and Zingmark (1976) found phytoplankton production as high as 350 g carbon/m^2/yr in shallow tidal creeks and estuaries of South Carolina. Various data sources for North Carolina estimate phytoplankton productivity anywhere from 67 (Beaufort Channel adjacent estuaries) to 500 g carbon/m^2/yr (Pamlico River estuary) during the growing season. Mallin et al. (2000a) found that the highest phytoplankton production is in riverine estuaries where flushing is limited by extensive barrier islands (e.g., Neuse River), whereas areas that are well flushed or unconstrained (e.g., Cape Fear River) support a much lower phytoplankton biomass and productivity. Complex, estuarine creek/salt marsh systems generally have moderate phytoplankton productivity. Lucas et al. (1999) used a depth-averaged numerical model to predict the productivity of phytoplankton in an estuary with shallow shoals, deep channels, and variable turbidity and benthic grazing. The model predicted that phytoplankton growth rate was generally greater in deeper areas when benthic grazing is high and turbidity is low. Conversely, when turbidity was high and benthic grazing was low, phytoplankton growth rate was generally greater in shallow areas.

However, phytoplankton productivity is still generally considered secondary to detritus-based production in salt marsh-dominated estuaries (Peterson and Peterson 1979; Dame et al. 2000). A study conducted on a Georgia salt marsh found a net productivity of 6,850 kcal/m^2/year from emergent vegetation and only 1,600 kcal/m^2/yr from the various algae (Teal 1962). Compared to broad, open water areas, narrow tidal creeks and their associated marsh would likely contribute more detritus than phytoplankton. However, some research suggests that much of the detrital production from emergent vegetation remains in the marsh and that phytoplankton are the major production export (Haines 1979). Planktivorous fish (e.g., menhaden) and detritivores (e.g., shrimp) can also export production from shallow marsh creeks and bays to more open waters (SAFMC 1998a).

Phytoplankton production in shallow estuaries may also be secondary to phytobenthic (microscopic plants that live on the bottom) production. In North Carolina, benthic microalgal biomass frequently exceeds phytoplankton in the nearshore ocean water column by a factor of 10 to 100 (Cahoon and Cooke 1992). Based on relative rates of primary production and nutrient cycling, Webster et al. (2002) found that phytobenthos was the dominant primary producer in a shallow estuary where light was not limiting; however, these results may not be applicable to North Carolina estuaries with higher turbidity. Net productivity for any given estuary depends on the relative proportion of wetlands, shallow soft bottom, and water column in the system.

Salinity
Salinity has a major role in the distribution of aquatic species (Szedlmayer and Able 1996). Some aquatic species are capable of tolerating large variations in salinity (e.g., blue crab), while others are capable of living in only a narrow salinity range (e.g., black sea bass).

Temperature
In general, all estuarine organisms can tolerate a very wide range of temperatures, if given adequate time to acclimate (Nybakken 1993). Organisms cannot readily adapt to a rapid increase or decrease in temperature. Early life stages of many species (e.g., clams, oysters, spot, croaker, flounder, menhaden) have a much narrower temperature tolerance than adults (Kennedy et al. 1974). If water temperature becomes too low, or falls too rapidly, there can be a fish kill of sensitive species like seatrout and red drum. Great variability in annual reported catch is typical for seatrout species and seems related to climatic conditions of the preceding winter and spring. Low catches follow severe winters; winter cold shock of juveniles and adults is cited as a primary factor in local and coast-wide declines in spotted seatrout (<http://www.ncdmf.net/stocks/spectrou.htm>, July 2003).

Dissolved oxygen
All fish and invertebrates require a minimum amount of dissolved oxygen (DO) to survive, and an even greater amount for growth and reproduction. Oxygen tolerance varies by organism type. Not accounting for mobility, fish are generally most sensitive to hypoxia (low dissolved oxygen; DO < 2 mg/l), followed by crustaceans and echinoderms, annelid worms, and mollusks (clams, oysters) (Gray et al. 2002). However, because highly mobile organisms can avoid areas of low DO, they are least affected by hypoxia. Although benthic invertebrates are fairly tolerant of low oxygen (Diaz and Rosenburg 1995), stationary invertebrates are helpless against prolonged anoxia. Therefore, DO is considered a critical factor affecting the survival of stationary benthic invertebrates and sedentary fishes and the distribution of mobile species (Seliger et al. 1985; Jordan et al. 1992; Eby et al. 2000; Buzzelli et al. 2002).

Light and water clarity
Water clarity is determined by the concentration of dissolved and suspended organic and inorganic particles in the water column. Water clarity and the resulting light availability in the water column are important to aquatic organisms for several reasons. The combination of increasing light, water velocity, and temperature during spring is the primary cue for upstream movement and spawning of anadromous fish (Klauda et al. 1991; Orth and White 1993). Extreme turbidity is known to reduce phytoplankton and submerged aquatic vegetation biomass, reduce visibility of pelagic food, reduce availability of benthic food due to smothering or bottom water hypoxia, and clog gill rakers and gill filaments (Bruton 1985). Turbidity also reduces a predator's visual range, which therefore reduces reactive distance (Barrett et al. 1992; Gregory and Northcote 1993), volume of water searched, and feeding efficiency (Moore and Moore 1976; Vingard and O'Brien 1976; Gardner 1981).

The estuarine water column typically has relatively high loading of suspended particles (phytoplankton, detritus, and/or sediment) and reduced water clarity (Nybakken 1993). Some species are adapted to turbid conditions, and the water clarity preference of many estuarine species at various stages of their life cycle is not known (Funderburk et al. 1991). Although excessive turbidity can be problematic, moderate turbidity in estuaries can be beneficial to small or non-visually feeding fish by affording protection from visually feeding predators in shallow, food-rich areas (Ritchie 1972; Blader and Blader 1980; Boehlert and Morgan 1985; Bruton 1985; Miller et al. 1985). Because there is an increased risk of predation in clear waters, some sedentary prey use cryptic coloration, bury under sand, or seek refuge in adjacent habitats to avoid detection. Distinctive aquatic communities can thus be found in turbid and clear water bodies. While water clarity could have an effect on fish species composition, it would be difficult to separate changes in species composition due to water clarity from correlated environmental changes such as salinity, temperature, and depth.

Flow and water movement

Estuaries are mixing zones with complex water movements between fresh and salt water. The four principal factors that affect water movement in North Carolina's estuaries are: (1) rainfall (inflow), (2) wind, (3) lunar tides, and (4) density gradients (salinity and temperature) (DMF 2003b). In some freshwater rivers, flow may also be drastically affected by reservoir releases. Each creek, river, bay, or sound is uniquely different due to these four factors.

Variation in water flow occurs at a broad range of spatial scales in estuarine and marine systems. The interaction of topographic features (e.g., shoals, bays) and tidal or wind-driven circulation patterns creates large-scale (km) spatial variation (Xie and Eggleston 1999; Inoue and Wiseman 2000). At much smaller scales (<1m), topographic changes or the presence of bottom habitat structure (e.g., SAV, oyster reef, pilings, stumps, logs) can create areas of reduced and increased water velocity (Jokiel 1978; Gambi et al. 1990; Komatsu and Murakami 1994; Lenihan 1998). Temporal variation in flow is caused by regular tidal flushing or irregular circulation by the wind.

Each organism in an estuary relies upon certain circulation patterns to provide the conditions that it needs to flourish at a given life stage. Some conditions benefit one species or species' life stage more than others. The conditions needed by a species do not always occur at the same time and location each year due to variations in weather. However, the expansive nature of many South Atlantic estuaries almost assures that proper conditions for a particular species will occur somewhere, but conditions may not be optimal in all locations (NCDMF 2003b).

The aquatic organisms that flourish in estuaries rely on flow and water movement to: (1) deliver the nutrients and physical water conditions for appropriate food and nursery area development at the opportune time; (2) keep eggs and larvae of pelagic spawners in suspension to enhance survival; (3) transport and distribute eggs, larvae, and juveniles to the appropriate nursery area for optimum food availability and protection from predators; and (4) distribute sediment and affect structures that serve as habitats (i.e., shell bottom, SAV, soft bottom) for many fish species (DMF 2003b).

High flows serve as a cue for spawning activity of anadromous fish, whereas low flows correspond to the growth and recruitment period of young fish (Orth and White 1993). Successful spawning of striped bass coincides with optimal water velocities between 3.3 and 6.6 ft/s (100-200 cm/s), while adult American shad prefer water velocities between 2 and 3 ft/s (61-91 cm/s) (Fay et al. 1983d; Mackenzie et al. 1985; Hill et al. 1989). Recruitment of larval river herring in tributaries of the Chowan system is also related to flow conditions (O'Rear 1983). However, water velocity is not the only cue for anadromous fish spawning; increasing light and temperature are also important factors.

Flows have a major effect on biological interactions. Powers and Kittinger (2002) found that blue crab predation on juvenile hard clams and bay scallops decreased with increasing water velocity, while whelk predation on bay scallops increased under the same treatment. Dilution of water-borne chemical cues was likely the reason for reduced blue crab predation (Powers and Kittinger 2002). Tamburri et al. (1996) found that chemical cues successfully induced larval settlement of oysters regardless of flow conditions. In another study, Palmer (1988) showed that higher current velocities increased erosion of small animals from below the sediment surface (meiofauna) into the water column, resulting in increased predation by spot (a more non-visual feeder). Species that rely primarily on visual cues would not be affected by dilution of chemical cues. However, all mobile aquatic organisms (including visual predators) also seek to minimize the energetic cost of movement through the water column while maximizing foraging efficiency.

As fish grow and develop, flow regime requirements or preferences change (Ross and Epperly 1985). Larvae and juveniles generally prefer lower velocities than adults, enabling them to settle out and maintain their positions in the estuary. Consequently, juvenile, estuarine-dependent fish are highly abundant in shallow, side-channel habitats where velocities are low (Ross and Epperly 1985; Noble and Monroe 1991).

There is little information on flow preference of estuarine species. Hydrologic modifications can, in some situations, negatively impact optimum flow conditions for aquatic organisms.

pH

The pH of the water column is a basic chemical characteristic that affects egg development, reproduction, and the ability of fish to absorb DO (Wilbur and Pentony 1999). Among freshwater, estuarine, and marine systems, pH varies naturally, and the organisms of the aquatic community have adapted to that natural variation. However, most fish require pH >5 (Wilbur and Pentony 1999), within a possible range of 0 (extremely acidic) – 14 (extremely basic). The pH of estuaries depends on the dynamic mix of seawater and upstream fresh waters. In high-salinity estuaries with little river input, pH is near that of seawater. Fresh water has the most variable pH, depending on the buffering, or acid controlling, capacity of the water and organic matter input. Freshwater water bodies with low buffering capacity and high organic matter (e.g., swampy creeks) can have very low pH (<5).

The pH of the water is an important requirement for reproduction of estuarine organisms. For example, the optimum pH for normal egg development and larval growth of oysters occurs between 8.25 and 8.5 (Calabrese and Davis 1966; Calabrese 1972). Oysters also have an optimum pH of 7.8 for spawning and >6.75 for successful recruitment. Likewise, hard clam eggs and larvae require pH levels of 7.0-8.75 and 7.5-8.5, respectively, for the same functions (Funderburk et al. 1991). Anadromous fish species can generally tolerate fresh water with lower pH. For example, alewife eggs and larvae require pH between 5.0-8.5 pH and blueback herring eggs and larvae require pH levels between 5.7-8.5 (Funderburk et al. 1991). This pattern of pH requirements between systems also illustrates the adaptation of freshwater and estuarine organisms to their environment.

Species composition and community structure

In many South Atlantic estuaries, during spring and summer, juvenile and adult estuarine species spawned in high-salinity estuarine waters (e.g., blue crab, red drum, weakfish) or the nearshore ocean (e.g., Atlantic menhaden, Atlantic croaker, spot, southern flounder) occupy the low-salinity zone (Table 3.2-9). There are also some resident species that complete their entire life cycle in the low-salinity zone. Residents include estuarine species like bay anchovy but are dominated by freshwater species, such as white perch, yellow perch, catfishes, sunfishes, and minnows (Keefe and Harriss 1981; Copeland et al. 1983; Epperly 1984). Prominent species in this resident group include the spring-spawning white perch and white catfish (Keefe and Harriss 1981). The low-salinity zone is also occupied by the catadromous American eel.

In moderate- and high-salinity estuarine zones, the young of offshore winter and spring spawners, such as Atlantic menhaden, spot, and Atlantic croaker, predominate (Table 3.2-9). See also Essential Fish Habitat section below.

Table 3.2-9. Spawning location/strategy ("spawning guild") and vertical orientation of some prominent coastal fish and invertebrate species. (Street et al. 2005)

Species*	Vertical orientation[1]		Fishery [3]	Stock Status [4]
	Demersal[2]	Pelagic		
ANADROMOUS FISH				
River herring (alewife and blueback herring)	**E**	**A, J, L**	**X**	**O-Albemarle Sound, U-central/southern**
American shad	**E**	**A, J, L**	**X**	**Concern**
Sturgeon (Atlantic and shortnose)	A, J, E		X[5]	Overfished
Hickory shad	**E**	**A, J, L**	**X**	**Unknown**
Striped bass	A, J	E, L	X	V- Albemarle Sound, Atlantic Ocean, O- Central/Southern
CATADROMOUS FISH				
American eel	A, J	E, L	X	
ESTUARINE AND INLET SPAWNING AND NURSERY				
Bay anchovy		**A, J, E, L**		
Bay scallop	A, J, E	L		Concern
Grass shrimps	A, J, E	L		
Hard clam	A J	E, L	X	Unknown
Mummichog	A, J, E	L		
Oyster	A, J	E, L	X	Overfished
Silversides	**E**	**A, J, L**		
Black drum	A, J	E, L	X	
Blue crab	A, J, E	L	X	Concern
Cobia		**A, J, E, L**	**X**	
Red drum	A, J	E, L	X	Recovering
Spotted seatrout	A, J	E, L	X	Viable
Weakfish	A, J	E, L	X	Viable
MARINE SPAWNING, LOW-HIGH SALINITY NURSERY				
Atlantic croaker	A, J	E, L	X	Concern
Atlantic menhaden		**A, J, E, L**	**X**	**Viable**
Shrimp	A, J, E	L	X	Viable
Southern flounder	A, J	E, L	X	Overfished
Spot	A, J	E, L	X	Viable
Striped mullet	**A**	**J, E, L**	**X**	**Concern**
MARINE SPAWNING, HIGH SALINITY NURSERY				
Black sea bass	A, J	E, L	X	O-south of Hatteras, V-north of Hatteras
Bluefish		**A, J, E, L**	**X**	**Recovering**
Florida pompano	A, J	E, L	X	
Gag	A, J	E, L	X	Viable
Gulf flounder	A, J	E, L	X	
King mackerel		**A, J, E, L**	**X**	**Viable**
Kingfish ("sea mullet")	A, J	E, L	X	Unknown
Pinfish	A, J	E, L	X	
Sheepshead	A, J	E, L	X	
Spanish mackerel		**A, J, E, L**	**X**	**Viable**
Summer flounder	A, J	E, L	X	Recovering

[1] Sources include Epperly and Ross (1986), Funderburk et al. (1991), Pattilo et al. (1997), SAFMC (1998a), NOAA (2001), USFWS species profiles (see literature cited: reference titles beginning with Species life histories and Environmental Requirements), and DMF (unpub. data).
[2] Demersal species live primarily in, on, or near the bottom while pelagic species (**bolded**) occur primarily in the water column. A=adult, J=juvenile, L=larvae, and E=egg.
[3] Existing commercial or recreational fishery. Fishery and non-fishery species are also important as prey.
[4] V = Viable, R = Recovering, C = Concern, O = Overfished, U = Unknown (DMF 2003a).
[5] Former fishery, but fishing moratorium since 1991

Estuarine Water Column as Essential Fish Habitat

The large estuaries of the South Atlantic function as settling basins where coastal rivers meet the sea. As such, the flow of water between the rivers and the estuaries, and between the estuary and the ocean, must be maintained so that settlement of transported larvae to the estuary is successful. Many fish and shellfish species occupy the estuarine water column at some point in their life cycle. Meroplankton (organisms that spend only part of their life cycle in the plankton), in particular, rely on the corridor function of the water column to transport them to favorable nursery areas.

Corridor and connectivity

The corridor function is the most basic function of the water column because the various life stages of fish species must move through it to utilize other habitats supporting other functions. The corridor function is particularly important for anadromous species such as river herring, shad, and striped bass, species that must migrate as adults from high-salinity waters, through estuarine waters, and upstream into freshwater systems to spawn in the spring. As a catadromous species, adult American eel must migrate from upstream freshwaters through estuarine waters to their spawning grounds in the Atlantic Ocean.

Spawning

Anadromous fish species such as river herring (alewife and blueback herring), striped bass, and shads (hickory and American shad) use the freshwater water column to broadcast eggs which develop as they float downstream. All of the life stages of these species use the water column as their primary habitat. Environmental conditions such as heavy rainfall, high water flow, and temperature affect anadromous fish life cycle stages and migration patterns in freshwater systems. Sufficient rainfall is needed to provide suitable current velocities for spawning. The strongest currents are required by striped bass and blueback herring. Slower current velocities are needed for American shad and alewife; alewife spawn in slow-moving oxbows and small streams, as well as fast-water sites. Adequate DO levels in slow-moving backwaters are critical to alewife spawning because the eggs require >5 mg/l DO (Funderburk et al. 1991). During their spawning migration, anadromous fish actively avoid waters with low DO and extremely high turbidity (Steel 1991).

The estuarine spawning species are mostly resident forage finfish species that spawn in shallow water during the warmer months (Table 3.2-10). This group also includes some important shellfish species (e.g., oysters, hard clams, bay scallop) and sportfish (e.g., red drum, weakfish, spotted seatrout, cobia) that spawn in deeper, flowing waters (Luczkovich et al. 1999; Powers and Gaskill 2004). Spawning for oysters, clams, and scallops is triggered primarily by increasing water temperatures during spring and/or decreasing water temperatures in fall (Fay et al. 1983c; Burrell 1986; Eversole 1987). Spotted seatrout, weakfish, and cobia spawn from spring to summer, and red drum in late summer (Table 3.2-10).

Table 3.2-10. Spawning seasons for coastal fish and invertebrate species occurring in North Carolina that broadcast planktonic or semidemersal eggs. [Sources: USFWS species profiles (see literature cited: reference titles beginning with Species life histories and Environmental Requirements), DMF fishery management plans, Funderburk et al. (1991), Pattilo et al. (1997), Luczkovich et al. (1999), NOAA (2001), and DMF (2003a)] **Black** squares indicate peak spawning. **Cross-hatched** squares indicate spawning period (Source: Street et al. 2005).

	Winter			Spring			Summer			Fall		
Species	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
ANADROMOUS FISH												
Alewife		■	■	■	■							
American shad			■	■	■	■						
Blueback herring			■	■	■							
Striped bass			■	■	■	■						
ESTUARINE AND INLET SPAWNING AND NURSERY												
Atlantic silversides			▨	▨	▨	▨						
Bay anchovy				▨	▨	▨	▨	▨	▨	▨		
Bay scallop			▨	▨					▨	■	■	▨
Blue crab				■	■	■	▨	■	■			
Black drum				▨								
Cobia					▨	▨	▨	▨				
Hard clam					▨	▨	▨	▨	▨	▨		
Inland silversides			▨	▨	▨	▨	▨	▨	▨			
Oyster					▨	▨	▨	▨	▨	▨		
Red drum								▨	▨			
Spotted seatrout				▨	▨	▨	■	▨	▨			
Weakfish				▨	■	■	▨	▨	▨			
MARINE SPAWNING, LOW-HIGH SALINITY NURSERY												
Atlantic croaker	▨	▨	▨	▨	▨				▨	■	▨	▨
Atlantic menhaden	■	▨	▨								▨	■
Brown shrimp		■	■	▨						▨	▨	
Southern flounder	■	■	▨								▨	▨
Spot	■	▨									▨	■
Striped mullet	▨	▨	▨							■	■	▨
White shrimp					▨	■	▨					
MARINE SPAWNING, HIGH SALINITY NURSERY												
Black sea bass	▨	▨	■	■	■	▨						
Bluefish			▨	▨	▨	▨	▨	▨	▨	▨	▨	
Gag		■	■									
Gulf flounder	▨	▨									▨	▨
King mackerel						▨	▨	▨	▨			
Pinfish	▨	▨	▨							▨	▨	▨
Pink shrimp				▨	▨	▨	▨					
Sheepshead			▨	▨	▨							
Spanish mackerel					▨	▨	▨	▨	▨			
Southern kingfish				▨	▨	▨	▨	▨	▨			
Summer flounder	■	▨	▨								▨	■

Nursery

Open water provides nursery habitat for most planktivorous larvae and many juvenile pelagic species (e.g., bluefish, river herring, menhaden, Spanish mackerel). The value of open water habitat for these species depends on the abundance and timing of planktonic food sources and their coincidence with required environmental conditions needed for growth during this critical time period.

The interactions of spawning locations, physical processes, environmental factors (salinity and temperature), chemical cues, and habitat preferences are determining factors for the time and place of larval settlement in estuaries (Luckenbach 1985; Peterson et al. 2000c; Brown 2002). The total nursery area for larvae of most estuarine-dependent species extends from the spawning locations to juvenile nursery habitat. For species spawned offshore in winter, the larval (primary) nursery habitat extends from the inlet water column, across primarily inshore-flowing channels, to the upper reaches of estuaries. Survival to the juvenile life stage and beyond is then dependent on the estuarine nursery areas providing the biological, physical, and chemical characteristics needed for growth.

Foraging

Within an estuary, menhaden, anchovy, silversides, striped mullet, and other pelagic species use suspended organic matter exported from the adjacent marshes, SAV, and oyster reefs without physically occupying these structured bottom habitats (SAFMC 1998a). The relative contributions of detritus and phytoplankton between the estuarine and nearshore ocean ecosystem are demonstrated by the foraging behavior of Atlantic menhaden. Lewis and Peters (1994) confirmed that the dominant food source for menhaden was detritus in shallow, estuarine systems, but phytoplankton in coastal waters.

Refuge

The water column provides a basic, but relatively minor, function as refuge for adult finfish and invertebrates. However, the water column does provide some indirect protection for forage species that need unobstructed, open water for protective schooling behavior. For example, silversides can create such dense schools that DO concentrations are low enough to repel predators (Fay et al. 1983a). Other areas of low DO can provide refuge for prey species whose predators are less tolerant of low DO. For example, copepods and zooplankton have a high tolerance for low DO, which could impact the food web in areas where the small invertebrates use low DO areas for refuge (Breitburg et al. 1997; Keister et al. 2000). Large expanses of open water can also provide protection for forage species by reducing their encounters with predators. Turbidity in the water column can provide refuge for prey species from visual predation (Bruton 1985). For example, bay anchovy may be attracted to more turbid areas for the refuge it provides (Livingston 1975). Snags from woody debris or overhanging branches extending from the shoreline provide excellent refuge for fish. Deepwater provides an important refuge from birds that feed in shallow water and protection from colder surface temperatures during winter. Deep, open-water habitats also provide refuge for fish and invertebrates during low tide (Ayvasian et al. 1992). Floating aquatic plants in fresh water such as duckweed may provide refuge for some open water fish.

3.2.7 Soft Bottom/Subtidal

Description and Distribution

(Excerpted from NC Coastal Habitat Protection Plan)
Soft bottom habitat is unconsolidated, unvegetated sediment that occurs in freshwater, estuarine, and marine systems. Soft bottom has only one habitat requirement – sediment supply. Environmental characteristics, such as sediment grain size and distribution, salinity, dissolved oxygen, and flow conditions, will affect the condition of the soft bottom habitat and the type of organisms that utilize it. Nevertheless, the habitat itself will persist regardless of its condition unless it becomes starved for sediment or is colonized by other organisms, transforming it into another habitat such as SAV or shell bottom. Refer to FEP Volume IV for more information on ecological impacts of alterations to soft bottom habitat.

Although soft bottom habitat is defined as "unvegetated" and lacks visible structural habitat, the surface sediments support an abundance of microscopic plants; numerous burrowing animals are hidden below the surface (Peterson and Peterson 1979). The characteristic common to all soft bottom types is the mobility of unconsolidated, uncemented soft sediment (Peterson and Peterson 1979). Soft bottom habitat can be characterized by geomorphology (the shape and size of the system), sediment type, water depth, hydrography (riverine, intertidal, or subtidal), and/or salinity regime (DENR 2000a). It is important to understand the physical and chemical properties of soft bottom habitat since these affect the benthic organisms that inhabit these areas and, in turn, their value as fish habitat. The physical and chemical character of all soft bottom is determined by the underlying geology, basin morphology, and associated physical processes (Riggs 1996).

<u>Estuaries and sounds - intertidal flats, unvegetated shoreline and subtidal bottom</u>
Sediment composition of soft bottoms in estuaries and sounds varies with geomorphology and position within the estuary. In North Carolina, the basin morphology of most northern estuaries is similar to a shallow, flat-bottomed dish with a small lip around the perimeter (Pilkey et al. 1998). The estuarine shoreline is a cut bank with a narrow and shallow perimeter platform (the lip) that slopes gradually away from the shoreline to approximately 3-7 ft (1.5-2 m) deep, and then more abruptly to the floor of the central basin. The central basins deepen gradually from the inner estuary to the outer estuary from about 12 – 23 ft deep (4 to 7 m). The central basins become shallow near the mouths of the estuaries due to formation of sandy bars, and behind the barrier islands due to storm overwash and transport of sand from the inlets. Coarse sands are concentrated on the shallow perimeter platforms, shoals, and inlet mouths, while fine sediments such as organic rich mud (ORM) are concentrated in the deeper central basins and downstream channels (Wells 1989; Riggs 1996; Pilkey et al. 1998). The width and thickness of ORM increase as the estuary widens and deepens in the downstream direction, since the fine sediments are easily suspended and transported away from high energy waters (Riggs 1996).

Unvegetated shorelines occur where wave energy prevents colonization by plants and there is a gently sloping area for sand to build upon (Riggs 2001). The shoreline provides an area to absorb the physical energy from waves, tides, and currents, protecting upland areas. Although unvegetated nontidal shorelines are ordinarily exposed from water, and therefore not used by fish, the dynamic processes of erosion and sediment deposition affect the composition and supply of sediment in adjacent shallow water habitats. This in turn affects the type and productivity of the benthic invertebrate community. For example, unvegetated sediment bank shorelines are generally eroding and sandy, providing a source of sand to adjacent waters (Riggs 2001). Sand deposits from inlet flood tide deltas and overwash events on back barrier islands form shallow sand flats behind the islands. In contrast, marsh or swamp forest shorelines are generally not eroding and have a high organic content, thus providing fine organic sediments to adjacent waters. Several shoreline erosion studies have been conducted along North Carolina’s coast that provide information on the character and condition of intertidal, shoreline, and shallow subtidal soft bottom and were compiled and summarized in Riggs (2001).

The inlets separating North Carolina’s barrier islands are part of a sand-sharing system among the islands, estuaries, and nearshore ocean. Intertidal flats or deltas form on the ebb and flood sides of inlets as sediments shift with tides and waves. Sediments in the vicinity of inlets are typically composed of coarse sands and shell fragments (Peterson and Peterson 1979). Ebb-tidal and flood-tidal deltas (i.e., the seaward and estuarine shoals of an inlet, respectively) are formed by waves and currents, and may contain large volumes of sand. Intense wave and current energy cause the flats to continually change, erode, and reform. The high instability of the ebb and flood tide deltas makes colonization by benthic invertebrates difficult (Peterson and Peterson 1979). Inlets are classified as stable, migrating, or ebb-tidal delta breaching (Fitzgerald et al. 1978). Unstable inlets may form extensive spits, tidal deltas, and sand bars, creating bathymetric complexity (or differences in water depth) in nearshore waters that attract certain fish species. The process of channel realignment and abandonment provides a mechanism for large sandbar complexes to move onto the adjacent barrier islands, supporting productive intertidal beach communities (Cleary and Marden 1999).

Ecological Role and Function

(from CHPP)

Soft bottom plays a very important role in the ecology of estuarine ecosystems as a storage reservoir of chemicals and microbes. Intense biogeochemical processing and recycling establish a filter to trap and reprocess watershed-derived natural and human-induced nutrients and toxic substances. These materials may pass through an estuary (Matoura and Woodward 1983), become trapped in the organic rich oligohaline (low salinity) zone (Sigels et al. 1982; Imberger et al. 1983), or migrate within the estuary over seasonal cycles (Uncles et al. 1988). The fate of the materials depends upon salinity gradients, which are driven by freshwater discharges, density stratification, and formation of salt wedges (Matson and Brinson 1985, 1990; Paerl et al. 1998). Density gradients (stratification) hamper mixing and oxygen exchange of sediments and water in bottom waters with overlying oxygenated waters, leading to depletion of dissolved oxygen in bottom water (Malone et al. 1988).

In North Carolina’s slow-moving, expansive estuaries, nutrients and organic matter from the watershed runoff and phytoplankton production are stored in the soft bottoms. Depending upon freshwater discharge and density stratification, these materials are recycled within the sediments via microbial activities and from the sediments into the overlying waters. Increased inflows of nutrients exacerbate the process, leading to more rapid and expanding dissolved oxygen depletion. In organic enriched oligohaline zones (e.g., Pamlico and Neuse River estuaries), nutrient-induced recycling results in higher microbial activity and oxygen depletion (B.J. Copeland, NCSU, pers. com., 2004).

Although soft bottom habitat is composed of unconsolidated shifting sediments, colonization by benthic microalgae reduces the extent to which sediment is resuspended at low velocities, stabilizing bottom sediments and reducing turbidity in the water column (Holland et al. 1974; Underwood and Paterson 1993; Yallop et al. 1994; Miller et al. 1996). In spite of this, microalgae cannot stabilize sediments under intense or prolonged disturbance conditions, such as during large storm events or in the surf zone (Miller 1989). Structure from tube dwelling invertebrates also helps to bind the sediment (Peterson and Peterson 1979), while filtering activity of dense aggregations of suspension feeders (hard clams) clears significant amounts of plankton and sediment from the water column and improves water clarity (Miller et al. 1996). Yet, because of the absence of large, extensive structure, soft bottom provides relatively less stabilization benefits than other estuarine habitats.

Intertidal shorelines, flats, tidal deltas, and sand bars along the ocean shoreline buffer and modify wave energy, reducing shoreline erosion. Alterations to the ebb and flood tide deltas can result in significant changes in the adjacent barrier island shorelines. Flood-tidal deltas are an important source of sand, which allows barrier island migration to respond to sea level rise (Cleary and Marden 1999). The soft bottom associated with inlets has a great influence on overall barrier island dynamics.

Fish utilization

Like the water column, soft bottom is used to some extent by almost all native coastal fish species in North Carolina. However, certain species are better adapted to, characteristic of, or dependent on shallow unvegetated bottom. Flatfish, rays, and skates are well suited for utilization of soft bottom. Juvenile and adult fish species that forage on the rich abundance of microalgae, detritus, and small invertebrates are highly dependent on the condition of soft bottom. Table 3.2-11 summarizes important fishery and nonfishery species that are dependent on subtidal bottom for some portion of their life history and the ecological function of the soft bottom habitat.

Foraging

One of the most important functions of soft bottom habitat is as a foraging area. Members of several trophic levels in the benthic community benefit directly or indirectly from a) the high concentrations of organic matter transported to and produced on soft bottom and b) the numerically abundant, diverse invertebrate fauna associated with soft bottom – including herbivores (e.g., planktonic and benthic algal feeders), detritivores, predators of benthic invertebrates and fish (secondary consumers), and predators of those predators (tertiary consumers) (Peterson and Peterson 1979).

Spawning

Many demersal fish spawn over various areas of soft bottom habitat in North Carolina's coastal waters (Table 3.2-11). In fresh water, resident species such as largemouth bass (*Micropterus* *salmoides*) and bluegill (*Lepomis macrochirus*) spawn on shallow flats where they lay eggs in bowl-shaped nests. Eggs may be dependent on the small structure available on the unvegetated bottom, such as emerging worm tubes or woody debris, to hold them in position. Since all life stages of freshwater resident fish (spawning adults, eggs, larvae, juveniles) remain near the same area of soft bottom habitat, they are relatively more vulnerable to degraded soft bottom habitat conditions than migratory species. Anadromous species, such as Atlantic and shortnose sturgeon (*Acipenser oxyrinchus oxyrinchus* and *A. brevirostrum*, respectively), spawn in upper freshwater portions of coastal rivers (Moser and Ross 1995).

Estuarine spawners include resident fish and invertebrates, as well as migratory fish that are summer estuarine spawners. Estuarine resident species include common invertebrates that occupy the intertidal flats, like hard clams, whelks, snapping shrimp, and hermit crabs. Small schooling baitfish such as mummichogs and striped killifish spawn in the marsh edges near soft bottom (Hildebrand and Schroeder 1972; Manooch 1984). Species of flatfish, including the windowpane, and hogfish have been reported to spawn on estuarine soft bottom (Hildebrand and Schroeder 1972; Manooch 1984).

Summer estuarine spawners include several species of drum. Weakfish and silver perch were documented spawning in deep estuarine channels near Pamlico Sound inlets (Ocracoke and Hatteras inlets) and in deep areas of Pamlico Sound from May to September, peaking in May and June (Luczkovich et al. 1999a). Spotted
seatrout are year-round residents of estuaries along the South Atlantic coast and spawning takes place inshore and in coastal areas (McMichael and Peters, 1989). In North Carolina, spotted sea trout spawn on the east and west sides of Pamlico Sound during a similar time period, with peak activity observed around July. Specific spawning areas for spotted sea trout identified on the west side of Pamlico Sound were Rose Bay, Jones Bay, Fisherman's Bay, and Bay River (Luczkovich et al. 1999a). In South Carolina, spotted seatrout spawn in similar habitats from April through September (Roumillat and Brouwer, 2004). Red drum were documented spawning in the mouth of the Bay River on the west side of Pamlico Sound, and in estuarine channels near Ocracoke Inlet (Luczkovich et al. 1999a). Blue crabs also spawn near inlets in summer (DMF 2000d).

Nursery

Shallow soft bottom habitat, usually adjacent to wetlands, is utilized as a nursery for many species of juvenile fish. The shallow unvegetated bottom provides an abundance of food and is inaccessible to larger predators. Shallow unvegetated flats have been documented as being particularly important nursery habitats for juvenile summer and southern flounder (Burke et al. 1991; Walsh et al. 1999). A partial list of species that use soft bottom habitat as a nursery area is included in Table 3.2-11. Studies and ongoing juvenile fish monitoring conducted by the North Carolina Division of Marine Fisheries have found that shallow unvegetated bottom supports high abundances of juvenile fish, composed of relatively few species but which have similar life histories and feeding patterns (Ross and Epperly 1985).

The dominant juvenile species utilizing shallow soft bottom estuarine nursery areas are estuarine dependent winter spawners. Most of the species spawn offshore during the winter. The larvae are transported through inlets into estuarine waters. For many species, the uppermost area of shallow creek systems corresponds to where larval settlement of winter spawned species occurs – the primary nursery areas (Weinstein 1979; Ross and Epperly 1985). However, in tributaries on the western side of Pamlico Sound, such as Neuse, Pamlico, Bay and Pungo rivers, larval settlement tends to occur in lower portions of the creeks. Unlike larval settlement in areas south of Pamlico Sound, salinity is low in the upper reaches of the Sound's tributaries and this may deter larval settlement in those areas. Abundance of juvenile species in estuarine nursery areas peaks between April and July and is correlated with water temperatures (Ross and Epperly 1985). As fish grow, they move to deeper waters and areas lower in the estuary.

In North Carolina, many areas used as nurseries by estuarine dependent fish have been designated as Primary or Secondary Nursery Areas by the Marine Fisheries Commission. However, there are other areas of soft bottom that function as nurseries but are undesignated. Benthic anadromous fish, such as Atlantic and shortnose sturgeon, use freshwater soft bottom as a nursery.

Refuge

Soft bottom habitat can provide refuge to some organisms in some locations through predator exclusion. Shallow, intertidal flats may be inaccessible to large fish predators and therefore protect small and juvenile fish and invertebrates (Peterson and Peterson 1979; Ross and Epperly 1985). Consequently, juvenile fish recruit into the shallowest portions of the estuary first. Many invertebrates, including hard clams, can avoid predation by burrowing into the sediment (Luettich et al. 1999). Flatfish, such as flounder and rays, and other small cryptic fish, like gobies, can bury slightly into the sediment, camouflaging themselves from predators (Peterson and Peterson 1979). Nonetheless, soft bottom habitat in deepwater is a vulnerable place for small fish and invertebrates that cannot burrow. For example, flounders also camouflage themselves in the sediment to ambush prey (Walsh et al. 1999). Because of this, many fish in subtidal water will venture out to feed on the open bottom only at night (Summerson and Peterson 1984).

Corridor and connectivity

Freshwater and estuarine soft bottom channels are the highways for migrating adult demersal fish species to and from other estuarine habitats and the ocean. Demersal feeding anadromous fish, such as sturgeon and striped bass, require a corridor of soft bottom to reach upstream spawning areas. Inlets act as conduits for exchange of sediment, water, and marine organisms between the estuaries and the ocean. Because large fish are less likely to be consumed as prey, they can travel relatively safely over less turbid sand flats and in channels of the middle and lower estuaries (Walsh et al. 1999). Smaller flatfish tend to be more abundant in the shallower uppermost portion of the estuary, where salinities are low, turbidity high, and sediments muddy with high detritus content (Walsh et al. 1999).

While connectivity among structured habitat patches, such as SAV, wetlands, and shell bottom, facilitates movement of blue crabs and other mobile predators through an estuary, a few meters of unvegetated bottom can act as a barrier to movement (Micheli and Peterson 1999). Such barriers can be beneficial to small invertebrates by potentially obstructing predator dispersal and reducing predation risk. Small crabs, gastropods, and infaunal bivalves, such as hard clams, were more abundant, denser, and had higher survival rates on isolated oyster beds (at least 10-15 m of unvegetated bottom between habitats) than on oyster beds adjacent to salt marsh or SAV (Micheli and Peterson 1999). Blue crab predation on infaunal bivalves was greater along vegetated edges of salt marshes and seagrass beds than in unvegetated intertidal flats (Micheli and Peterson 1999). Although structural habitat separations by unvegetated soft bottom may benefit the survival or viability of infaunal populations, fish and crustacean productivity may be enhanced by connectivity of structured estuarine habitats (Micheli and Peterson 1999). These habitat-mediated predator/prey interactions point out the importance of maintaining the integrity of an entire estuarine system.

Species composition and community structure

Benthic microalgae are a key part of the food chain in estuarine soft bottom habitat. Benthic microalgae are microscopic photosynthetic algae that live in the top few millimeters of the surface of soft bottom (Miller et al. 1996). Because the unvegetated bottom appears barren, but is actually rich in photosynthetic algae, MacIntyre et al. (1996) referred to benthic microalgae as "The Secret Garden." Benthic microalgae on sand, mud flats, and subtidal bottom are composed primarily of benthic diatoms and blue green algae, with benthic dinoflagellates and filamentous green algae also present (Peterson and Peterson 1979). Dense mats of blue green algae sometimes form in protected higher portions of intertidal flats, giving the sediment surface a dark brown or blue-green appearance, which can form a crusty mat when dry at low tides (Peterson and Peterson 1979). Diatom mats are more abundant in the lower intertidal zone (Peterson and Peterson 1979). Benthic microalgae can either be attached to sediment particles or be mobile, migrating vertically through the sediment. Productivity depends on photosynthesis by these microalgae, which can only occur in sediments having adequate light penetration (MacIntyre et al. 1996). Photosynthetically active light generally penetrates only about 2-3 mm into the sediment, but can reach 5-20 mm in sandy, high energy environments.

Most benthic invertebrates inhabiting soft bottom live in the sediment (infauna), as opposed to the bottom's surface (epifauna), because of the high mobility of sediments (Peterson and Peterson 1979). These animals are classified by size and feeding mode. Microfauna are the very small protozoans (< 0.06 mm). Meiofauna are about 0.06 – 0.40 mm in size (the size of a sand grain), and include nematodes and copepods. Both microfauna and meiofauna are important grazers on benthic microalgae and bacteria. Macrofauna (>0.5 mm) contribute the most to infaunal biomass and include organisms such as amphipods, polychaetes, mollusks, echinoderms, and crustaceans (Peterson and Peterson 1979). These macrofauna may be deposit feeders or suspension feeders (Peterson and Peterson 1979; Miller et al. 1996). Deposit feeders ingest sediment and detrital deposits and assimilate bacteria, fungi, and microalgae from them. Compared to detritus and larger plants, microalgae may be a nutritionally richer food source for benthic invertebrates (Miller et al. 1996). Deposit feeders include mud snails, many polychaete worms, and certain bivalve clams and crustaceans.

Table 3.2-11. Partial list of common or important fish species occurring on soft bottom habitat in riverine, estuarine, and ocean waters, and ecological functions provided to hose species. Bolded species indicate relatively higher association on soft bottom habitat (Source: Street et al. 2005).

Species*	Soft bottom functions [1]					Fishery [2]	Stock status [3]
	Spawning	Nursery	Foraging	Refuge	Corridor		
ANADROMOUS SPAWNING							
Atlantic sturgeon	**X**	**X**	**X**		**X**	**X**[4]	**O**
Shortnose sturgeon	**X**	**X**	**X**		**X**	**X**[4]	**O**
ESTUARINE AND INLET SPAWNING AND NURSERY							
Blue crab	X	X	X	X		X	C
Hard clam	**X**	**X**	**X**	**X**		**X**	**U**
Hermit crab spp.	**X**	**X**	**X**				
Horseshoe crab	**X**	**X**	**X**			**X**	
Mud crab spp.	**X**	**X**	**X**				
Mummichug	**X**	**X**	**X**				
Naked goby	X	X	X				
Red drum	**X**	**X**	**X**			**X**	**R**
Sheepshead minnow	**X**	**X**	**X**				
Silver perch	X	X	X			X	
Striped killifish	X	X	X				
Whelks	X	X	X			X	
MARINE SPAWNING, LOW-HIGH SALINITY NURSERY							
Atlantic croaker		**X**	**X**			**X**	**C**
Bay whiff		**X**	**X**	**X**	**X**		
Blackcheek tonguefish	**X**	**X**	**X**	**X**	**X**		
Hogchoker	**X**	**X**	**X**	**X**	**X**		
Penaeid shrimp (brown, white, pink)		**X**	**X**	**X**	**X**	**X**	**V**
Southern flounder		**X**	**X**	**X**	**X**	**X**	**O**
Spot		**X**	**X**			**X**	**V**
Striped mullet		**X**	**X**			**X**	**C**
MARINE SPAWNING, HIGH SALINITY NURSERY							
Atlantic stingray	**X**	**X**	**X**	**X**	**X**	**X**	
Coastal sharks [5]	**X**	**X**	**X**			**X**	**O**
Cownose ray	**X**	**X**	**X**	**X**	**X**	**X**	
Florida pompano		**X**[6]	**X**			**X**	
Fringed flounder		**X**	**X**	**X**	**X**		
Gulf flounder		**X**	**X**	**X**	**X**	**X**	
Gulf kingfish		**X**[6]	**X**			**X**	**U**
Smooth dogfish	X	X	X			X	U
Spiny dogfish		X	X			X	O
Striped anchovy		**X**[6]	**X**				
Summer flounder	**X**	**X**	**X**	**X**	**X**	**X**	**V**

* Scientific names listed in Appendix I. Names in **bold** font are species whose relative abundances have been reported in the literature as being generally higher in soft bottom than in other habitats. Note that lack of bolding does not imply non-selective use of the habitat, just a lack of information.

[1] Sources: Peterson and Peterson (1979); Thorpe et al. (2003); Manooch (1984); Hildebrand and Schroeder (1972); Lippson and Moran (1974); Wang and Kernehan (1979)

[2] Existing commercial or recreational fishery. Other species important to the system as prey items.

[3] V = viable, R = recovering, C = concern, O = overfished, U = unknown (DMF 2003a)

[4] Former fishery, but fishing moratorium since 1991

[5] Incl. Atlantic sharpnose, blacknose, blacktip, bonnethead, dusky, sandbar, scalloped hammerhead, and spinner sharks

[6] Uses surf zone almost exclusively as nursery area

Suspension feeders capture particles suspended in the water column. Common suspension feeders are bivalves such as the hard clam (*Mercenaria mercenaria*) and razor clam (*Tagelus plebeius*), and some polychaete worms (Miller et al. 1996). When sediment is resuspended, the benthic microalgae become available to the suspension feeders (Miller et al. 1996). A large proportion of intertidal bivalves' diet has been shown to consist of suspended benthic microalgae, particularly when chlorophyll concentrations in the water column are low (Page and Lastra 2003). While resuspended benthic microalgae can be beneficial to the invertebrate community as an additional food source, excessive suspended sediment and associated algae have been found to reduce growth rates and survival of macrofauna, such as hard clams (Bock and Miller 1995). Although the abundance of food sources affects invertebrate populations, benthic predators (such as spot and pinfish) were found to have a larger influence on soft bottom community composition and biomass relative to that of nutrient availability (Posey et al. 1995).

On submerged flats and shallow bottom, blue crab (*Callinectes sapidus*) is an important predator. Other mobile invertebrates include horseshoe crab (*Limulus polyphemus*), whelks (*Busycon* spp.), tulip snails (*Fasciolaria* spp.), moon snails (*Polinices duplicatus*), penaeid shrimp (*Farfantepenaeus* spp. and *Litopenaeus* spp.), hermit crabs (*Pagurus* spp., *Petrochirus* spp., and *Clibanarius vittatus*), sand dollars (*Mellita quinquiesperforata*), and spider crabs (*Libinia* spp.). Overall, estuarine soft bottom supports a high diversity of benthic invertebrates, with over 300 species documented in the southern portion of North Carolina (Hackney et al. 1996).

Soft Bottom/Subtidal as Essential Fish Habitat

3.3 Marine/offshore systems

3.3.1 Coral, Coral Reefs and Live/Hardbottom Habitat

3.3.1.1 Coral Reefs and Coral Communities

Description and distribution

Shallow water coral reefs and coral communities exist within the southern geographical areas under Council authority. In this document these habitats are defined as occurring in depths generally less than 40 meters. Depending upon many variables, stony corals may dominate a habitat, be a significant component, or be individual colonies within a community characterized by other fauna (e.g., sponges or macroalgae). In some areas stony corals have grown in such profusion that their old skeletons accumulate and form reef structure (e.g., coral reefs). In other areas, corals grow as a less dominant component of benthic communities on geologically derived hard substrates (e.g., coral communities). This section focuses on those ecosystems under Council authority having Scleractinians as an important member of the community. Hardbottom communities that have little or no Scleractinians are treated in the Live/Hardbottom Habitat section of this document (Section 3.3.1.2 below).

Reefs have been defined or characterized in numerous ways on the basis of rigidity, location, framework elements, sediments, and biotic diversity. To that end, Fagerstrom (1987) listed several definitive characteristics of reefs that apply to shallow coral reefs in the southeast U.S.:

- A rigid framework is present;
- Calcareous skeletons or other calcareous micro-structures are abundant;
- Structures have positive topographic relief;
- Framework organisms have rapid growth rates; and
- Taxonomic diversity is high, with several ecological functional groups.

Shallow warm water coral reef and coral communities are typically, though not always, built upon coralline rock and support a wide array of corals, finfish, invertebrates, plants, and microorganisms. Hardbottoms and hard banks, found on a wider bathymetric and geographic scale, often possess high species diversity but may lack reef building corals, the supporting coralline structure, or some of the associated biota. In deeper waters, large elongate mounds called deepwater banks, hundreds of meters in length, often support a rich fauna compared to adjacent areas. Lastly are communities that may include solitary corals. This category often lacks a topographic relief as its substrate, but instead may use a sandy bottom, for example.

This section discusses coral reefs and coral communities which are habitats with corals as important contributors, and includes outer bank coral reefs, coral communities, and patch reefs (defined below). Although attempts have been made to generalize the discussion into definable types, it must be noted that the continuum of habitats includes many more than these varieties discussed below.

The following definitions of selected terminology are used throughout this Section.

Stony Corals: Stony corals are marine invertebrates that secrete a calcium carbonate skeleton. For the purpose of this plan, includes species belonging to the Class Hydrozoa, Family Milleporidae (fire corals) and Class Anthozoa, Order Scleractinia. The scleractinians can be hermatypic (significant contributors to the reef-building process) or ahermatypic, and may or may not contain endosymbiotic algae (zooxanthellae) (Schumacher and Zibrowius 1985). Zooxanthellate corals, host symbiotic algae from the Genus *Symbiodinium*, which provide a phototrophic contribution to the coral’s energy budget, enhance calcification, and give the coral most of its color.

Octocorals: For the purpose of this plan, includes species belonging to the Class Anthozoa, subclass Octocorallia (soft corals and gorgonians).

Reef Habitat Types

Outer Bank Reefs

Outer bank reefs represent perhaps the geologically and ecologically oldest, most structurally complex and diverse type of coral habitat. They are located in the Florida reef tract primarily shoreward of the 18 m (60 ft) isobath. Shinn et al. (1977) and Shinn (1979) concluded that the linearity of these reefs approximately parallel to the Keys is due to underlying bedrock topography, rather than biological or water quality causes. The Florida reef tract includes approximately 96 km (52 nm) of outer bank reefs located between Fowey Rocks and the Dry Tortugas, a distance of about 270 km (146 nm) along the 20 m (66 ft.) isobath. A large portion of the reef tract is in the EEZ just beyond Florida's three-mile territorial sea.

In some areas, outer bank reefs display some characteristics of classical Caribbean reef structure and zonation such as high-relief spur and groove structures in the shallow fore-reef, a very shallow or emergent reef crest, and a rubble habitat in the leeward shadow of the reef crest. Spurs are extensions of coral reef growth seaward up to 30 m (100 ft) or more; grooves occur between adjacent spurs. Spurs and grooves are best developed in the upper and lower Keys. The middle Keys area exhibits some spur and groove formation but the orientation and development is variable (Marszalek et al. 1977). Shinn et al. (1981) found that spurs at Looe Key were constructed of *Acropora palmata* and had formed over five meters of carbonate sand. Spurs at Looe Key are no longer accreting due to the extensive die-off of *A. palmata*.

Generally, Florida reefs are smaller in area, less biologically diverse, and lack the vertical relief of most coral reefs of the Bahamas or Caribbean Sea (Marszalek et al. 1977). However, coral species diversity is still comparable to or greater than reefs bordering nearby countries.

Some areas of the outer bank reef are underdeveloped, occurring as coral reefs with sparse coral growth and no *Acropora palmata* zone. These reefs may represent relict limestone ridges in the spur and groove arrangement or relatively young reefs with immature biological zonation patterns (Marszalek et al. 1977). Long Reef in the upper Keys is an example of the relic reef case (see, for example, Shinn et al. 1977). Small stands of immature coral reef biota often bridge the gaps between more well-developed reefs.

Other areas of the outer bank reef are more developed (Marszalek et al. 1977) characterized by their "reef-flat formed of *in situ* dead encrusted elkhorn coral, *Acropora palmata*, skeletons and rubble." Colonies of *Acropora*, finger coral *Porites*, and starlet coral *Siderastrea* plus encrusting fire coral *Millepora* and dozens of benthic species form most of the live reef structure. The typical zonation pattern shows *A. palmata* colonies on the seaward face of the reef to a depth of about 4 m, with *M. complanata* and the colonial zooanthid *Palythoa* in the turbulent shallow zone and a diverse coral assemblage dominated by small star coral, *Montastraea annularis*, heads in the deeper sections (Shinn 1963). Within the Florida reef tract, Carysfort Reef and Key Largo Dry Rocks (Grecian Rocks) are examples of well developed coral reefs.

Coral Communities

Coral communities constitute a group of communities characterized by a thin veneer of live corals and other biota overlying assorted sediment types. They are usually of low relief and on the continental shelf (Bright et al. 1981); many are associated with relic reefs where the coral veneer is supported by dead corals. This grouping of coral habitat encompasses a large portion of the management area containing stony corals (Southeast Florida), especially north of the Florida Keys and south of central Florida.

Ecologically and geologically, coral communities are a diverse category. Most have a diverse assemblage of stony corals but lack the clear ecological zonation and density of frame builders typical of other coral reefs throughout the Caribbean. Diverse biotic zonation patterns vary between many of these communities because of their geologic structure and geographic location. For example the shallow water (<5m) coral communities located nearshore differ from the coral communities in deep water (>20m) in stony coral species, size distribution, and density. Coral communities are common on rocky ledges, overlying relic reefs, or on a variety of sediment types. In each case, species compositions may vary dependent upon water depth and associated parameters (light, temperature, etc.).

Coral communities in different geographical areas support different coral assemblages. Near the Florida Keys, they co-exist as underdeveloped reefs nearshore and seaward of the outer bank reef tract. North of Fowey Rocks off southeastern Florida, coral communities include all types of corals, though hermatypic species are near their northern limit (Martin County).

In the Florida Keys, coral communities of nearshore areas have been characterized by Chiappone and Sullivan (1994) and off the mainland by Nelson (1989) and Nelson and Demetriades (1992). Nearshore coral communities' characteristics differ substantially between the mainland coast of east Florida and the Florida Keys. These differences include higher wave energies, fewer corals and grasses, and coarser sediments in nearshore coral communities of mainland areas (Lindeman 1997). Additional factors complicate Keys and mainland comparisons of coral communities. Nearshore coral communities in the Keys are distributed across more physiographically variable cross-shelf gradients with a greater potential for structural heterogeneity than on the mainland. The presence of over 6000 patch reefs in Hawk Channel (Marszalek et al. 1977), many near shallow coral communities, introduces additional inter-habitat relationships rarely found in nearshore coral communities of mainland areas.

In southeast Florida (north of the Keys), coral communities have been described by Goldberg 1973a, Moyer et al. 2003, Gilliam et al. 2007a and b, and Banks et al. 2007, and mapped using GIS and remote sensing techniques by Walker et al. *In press*. These communities have developed on relict reef tracts parallel to the shoreline in different depths separated by large expanses of sand (Banks et al 2007). The deepest community, the Outer Reef, still has many evident features of the relict reef zonation. For example, spur and groove formations dominate the eastern sides of these reefs, yet they reside in >25m depth. Even though they appear as spur and groove, they no longer function as such and do not contain an abundant population of fast-growing, frame-building corals. This is in contrast to some nearshore coral communities in the same area. Some nearshore coral communities (especially in Broward County) have a significant number of fast-growing, large, frame-building corals, yet they lack distinct zonation. There is no emergent reef crest, spur and groove fore reef, or lagoon. This community may be considered the beginnings of a new reef, however without the advantage of the Caribbean's fastest growing, frame-building coral, *Acropora palmata*, and its proximity to significant coastal development, it is unlikely to continue.

Communities containing corals from Florida north (Martin County) to North Carolina, have distinctly different assemblages than those further south. There are deep water communities dominated by a single species (*Oculina*), and shallow-water sponge or macroalgae dominated hardbottom communities where very few species of stony corals exist at low densities. These communities are covered in other sections of this document.

Patch Reefs

Patch reefs are irregularly distributed clusters of corals and associated biota located in the management area generally along the seaward (southeast) coast of the Florida Keys. Most patch reefs occur 3 to 7 km (1.6 to 3.8 nm) offshore between Miami and the Dry Tortugas on the inner shelf (less than about 15 m depth). Vertical relief ranges from less than 1 m to over 10 m. Patch reefs occur as either dome-type patches on the leeward side of outer bank coral reefs or as linear-type patches that parallel bank reefs in arcuate patterns. More than 6,000 patch reefs occur in the Florida reef tract between Miami and the Marquesas Keys, (Marszalek et al. 1977), mostly between Hawk Channel and the outer bank reefs. From above, dome patch reefs tend to be clustered. Linear-type patch reefs support flora and fauna, including elkhorn coral (*Acropora palmata*), which more nearly resemble the bank reefs. Most dome patch reefs have less than 5 m of topographic relief, but some as high as 9 m do occur. Linear-type reefs are usually situated seaward of dome-type patch reefs parallel to the outer bank reefs. In top view, linear patch reefs appear arcuate to linear, much like the outer bank coral reefs of the Florida reef tract. Hence, instead of forming clusters, these patch reefs often occur end-to-end. These linear offshore reefs are also referred to as inner line reefs and probably represent an ecologic transition form between dome patch reefs and outer bank reefs (Marszalek et al. 1977).

Patch reefs also exhibit ecological variability. Dome-type assemblages support a diverse array of stony corals and octocorals, plus numerous benthic invertebrates, algae, and fish (Marszalek et al. 1977). Except for the noticeable absence of elkhorn coral, *Acropora palmata*, the biota of dome patches resembles that of consolidated outer bank reefs, but with less coral zonation. Octocorals dominate the top interior zones whereas *M. annularis, Diploria* spp., and *Colpophyllia natans* dominate western margins. The dominant coral in this type of patch reef is the small star coral, *Montastraea annularis*, which is often present in single enormous colonies, (see also Shinn 1963). Linear-type patch reefs support corals and other marine life much like dome-types with the possible addition of *A. palmata*.

Other Habitats

Throughout much, if not all, of the management area, other bottom communities exist which include corals as a minor component of biotic diversity and abundance [for example Cairns (1979) in the Atlantic]. Although these corals contribute benthic relief and habitat to communities throughout the Council authority, they apparently comprise a minor percentage of the total coral stocks in the management area.

Ecological role and function

Coral reefs and communities serve a number of functional roles in subtropical and tropical environments of the western Atlantic, including, but not limited to: primary production, recycling of nutrients in relatively oligotrophic waters, calcium carbonate deposition yielding reef construction, refuge and foraging base for other organisms, and modification of near-field or local water circulation patterns (De Freese 1991). Coral reefs also protect shorelines, serving to buffer inshore subtidal (e.g., seagrass) and intertidal (e.g., mangroves) communities from otherwise high wave energy conditions in certain localities.

Coral reefs and communities, including associated sediments, afford organisms an incredible array of refuges (Jaap 1984). Epifauna are organisms living on the reef surface, and include mobile animals (crustaceans, echinoderms, mollusks, and fishes) and sessile animals (e.g., ascidians, sponges, corals, and bryozoans). Infauna include those animals which burrow into reef substrate, such as polychaete worms and mollusks. Meiofauna include animals associated with reef sediments. Holes and crevices in the reef structure provide shelter for echinoderms, mollusks, polychaetes, crustaceans, and fishes. In a single coral colony, for example, Grassle (1973) counted 1,441 polychaetes representing 103 species. In several coral colonies, McClosky (1970) counted 1,517 individuals representing 37 different invertebrate species. Gastropods, crustaceans, echinoderms, and fishes consume benthic algae associated with the reef structure (i.e., coral-produced substrate); these herbivores, in turn, fuel the production of higher trophic levels such as invertivores and piscivores.

Coral reefs and communities occurring in the management area, and indeed throughout the world, are markedly affected by patterns of water circulation. The most highly developed reefs in the management area are the Florida Keys reefs, generally confined to the windward or southeastern margins of the land masses (Glynn 1973; Shinn 1976). An important characteristic of coral reefs is their ability to modify the surrounding physical-chemical environment (Ginsburg and Lowenstam 1958). The reef framework controls the accumulation of sediments on and adjacent to the reef, as well as local circulation patterns (Jaap 1984). Coral reefs are an example of the ability of biological communities to affect physical circulation mechanisms, which in turn influence benthic community distribution and sedimentation. Bank reefs provide shelter for the back reef lagoon, allowing for benthic communities adapted to low-wave energy conditions, such as seagrass beds, to persist and flourish. Several studies have noted the differences in sediment and habitat characteristics between inshore and offshore environments (Enos 1977; Szmant and Forrester 1996) and associated differences in sediment nutrient characteristics. Sediments in the back reef (inner shelf margin) consist of finer grain particles with greater nutrient pools relative to sediments directly associated with reefs, such as large skeletal fragments. Benthic community distribution also differs considerably between nearshore and offshore. Seagrasses and other soft-sediment communities dominate the inner shelf margin, while reefs and bare sand slope areas dominate the outer shelf margin.

The protection offered by land from cross-platform currents (Ginsburg and Shinn 1964) is mirrored by the buffer provided to the islands by relic and/or live coral reefs. Offshore reefs help dissipate storm energies and serve to minimize impacts of storms, wave action, and other physical stresses.

Protection offered by coral reefs is crucial to the existence of other shallow-water, continental shelf communities in South Florida. Sea grass beds, mangroves, and back reef coral communities are protected from high wave energy by coral reefs in the Florida Keys. Without the buffer of coral reefs, these three important components of the coastal ecosystem would be exposed to unusually destructive forces. A loss of one of these habitats would affect the other communities as they are dependent on one another. Mangroves and beds of turtle grass

(*Thalassia testudinum*), manatee grass (*Syringodium filiforme*), and shoal grass (*Halodule wrightii*) represent highly productive communities (Helfrich and Townsley 1965), on which numerous species such as spiny lobster (Herrnkind 1979; Davis 1979) and commercial finfish (Weinstein and Heck 1979), depend for development, recruitment, and foraging grounds. These habitats are also crucial to nutrient flows in the coastal environment and without grass beds and mangroves to assist in filtering sediments, coastal waters would deposit particulates on corals and other bottom dwellers. Therefore protection of all of these habitats is essential.

Species composition and community structure

Central Florida to North Carolina

Coral assemblages from central Florida (Stuart Inlet) north to North Carolina, are dominated by ahermatypic stony coral species and gorgonians, although some hermatypic species do occur off North Carolina (MacIntyre and Pilkey 1969) and Georgia (Hunt 1974). The very limited coral assemblages within this area are found on shallow-water hardbottom habitats ((Johnston 1976); off Georgia and South Carolina (Stetson et al. 1962; Porter 1978 personal communication; Thomas 1978 personal communication); and North Carolina (Huntsman 1984; MacIntyre and Pilkey 1969)) and deep-water banks (*Oculina* spp.). These are further described in Section 4.1.6 of this document.

Southeast Florida

This extensive coral reef and coral community system is a northward continuation of the Florida reef tract extending over 150 kilometers from northern Monroe County, through Miami-Dade, and Broward Counties, and northern Palm Beach and southern Martin County. The percent coverage of scleractinian corals decrease as you move north, but the reefs are still lush with octocorals and provide habitat. From northern Miami-Dade County into Palm Beach County, there are generally three reef lines, parallel to the shore and separated by sand deposits, – one that nominally crests in 3 to 4 m of water depth (Inner Reef), another in 6 to 8 m (Middle Reef), and one in 15 to 21 m depth (Outer Reef). On the shoreward side of the Inner Reef, a series of nearshore hardbottom ridges often occur (Moyer et al. 2003, Banks et al. 2007, Walker et al. *In press*).

This reef system includes over 30 species of stony corals with an average coverage of 2-3% (maximum of nearly 15%) and includes a diverse assemblage of gorgonians and sponges (Gilliam et al. 2007a and b). Nearshore, however, there are a number of *Acropora cervicornis* patches with cover approaching 30% (Gilliam et al. 2007a and b). The common stony coral species include: *Montastrea cavernosa*, *Siderastrea siderea*, *S. radians*, *Porites astreoides*, *Solenastrea bournoni*, *Meandrina meandrites*, and *Dichocoenia stokesii*.

Octocorals (gorgonians) and sponges dominate most of the communities in the system with a density of 8-10 colonies/m^2 and 11-14 colonies/m^2 and a cover of 7-20% and 2-8%, respectively (Gilliam et al. 2007a and b). Some of the common octocoral genera include: *Eunicea* spp., *Pseudopterogorgia* spp., *Muricea* spp., *Plexaurella* spp., and *Pterogorgia* spp.

The coral communities in northern Palm Beach and southern Martin Counties are a reasonable northern limit for the subtropical coral reefs on the east coast of Florida. These communities exist on hardbottom habitats with diverse assemblage of reef biota. Fewer stony coral species are present in these northern areas but several of the species common throughout the coral reef habitats south are also common and include: *Montastrea cavernosa*, *Diploria clivosa*, *Siderastrea siderea*, *Isophyllia sinuosa*, *Solenastrea bournoni*, and *Oculina diffusa*.

Nearshore Coral Communities

The nearshore coral communities extend from Key Biscayne in Central Miami-Dade County to Hillsboro Inlet in northern Broward County (Shallow Colonized Pavement and Ridges in Walker et al. *In press*). This habitat is defined as flat, low relief, solid carbonate rock with coverage of macralgae, stony coral, gorgonians, and other sessile invertebrates that are dense enough to partially obscure the underlying carbonate rock (Walker et al. *In press* adapted from Kendall et al. 2001). This habitat can have variable sand cover, which shifts according to wave-energy in response to weather. Thus, some of the colonized pavement will always be covered by shifting sand and colonization will be highly variable (Walker et al *In press*). There are nearshore hardbottom communities north of Broward County but they have a different community structure. They can, however, support scleractinian corals

Portions of the nearshore coral communities contain areas of the highest stony coral cover in the region (Gilliam et al. 2007a and b). Larger stony corals in this area are abundant with 15% or higher coral coverage (compared to the more typical 1-3% coral coverage). *Montastrea cavernosa* dominates this assemblage.

This habitat also contains perhaps the most abundant population of staghorn coral, *Acropora cervicornis* in the Council management area. Cover with *A. cervicornis* patches exceeds 20% (Gilliam et. al 2007a and b) and coral spawning activity has been documented (Vargas-Angel et. al 2006).

The largest corals in the Southeast Florida have been documented on this habitat as well. Although a formal study has not been performed, an analysis of bathymetric data and subsequent field verification has identified many very large, living *Montastrea faveolata* and *M. annularis* colonies. These colonies range in size from 1 to 4 meters in diameter/height and shelter many large fishes and invertebrates. One area in particular contains over 20 *M. faveolata* colonies over 1m diameter including several >2m. Several of these large colonies throughout Broward County have been cored to identify the age of the coral and recent past living conditions. The largest known colony located off Hollywood, FL is a 2.5 m tall, 4.2m wide *M. faveolata* which was estimated at ~310 years of age in 2005 when it was cored (Helmle pers. comm.).

Inner Reef

The Inner Reef extends from central Miami-Dade County (Key Biscayne) to northern Broward County (Hillsboro Inlet). It is composed mainly of *A. palmata* framework (Banks et al. 2007) and has many breaks and sediment pockets within and along its linear, shore-parallel morphology. The Inner Reef is not a mature reef with distinct zonation and the present lack of fast growing, reef building corals on this feature (especially *A. palmata*) suggests it is no longer aggrading (Banks et al. 2007, Walker et al. *In press*).

The Inner Reef is however a valuable coral reef community colonized by many ecologically important species. Typical sessile organisms are sponges, octocorals, and stony corals. The stony coral assemblage is quite diverse including but not limited to the following species: *M. cavernosa*, *S. siderea*, *S. radians*, *P. astreoides*, *S. bournoni*, *M. meandrites*, *D. stokesii*, and *A. cervicornis*. Some coral species, especially those with flat growth forms (*Diploria clivosa*, *Meandrina meandrites*) reach over 1m in diameter. Other ecologically important species include a diverse, abundant assemblage of octocorals and sponges, as well as colonial zoanthids (*Palythoa caribaeorum*).

The Inner Reef, and the nearshore community, appears to be an important nursery area for fishes. A recent survey recorded 169 species of fishes in this area of which recently settled juveniles (≤ 5 cm) were the dominant component (>84%), consisting primarily (>90%) of grunts (Haemulidae) (Baron et al. 2004).

<u>Middle Reef</u>

The Middle Reef extends from Northern Miami-Dade County (Haulover Inlet) to Southern Palm Beach County (Boca Inlet). This feature has more structural relief and is more continuous than the Inner Reef; however its composition is quite different. The Middle Reef is thought to be an ancient cemented shoreline ridge that was submerged during the latest sea level transgression (Banks et al. 2007, Walker et al. *In press*). The reef structure mostly contains a cap of mostly massive coral framework. There does appear to be some increased reef development in the northern extent of this feature, where some *A. palmata* framework has been found (Banks et al. 2007).

The present benthic coral community growing on this reef is dominated by large patches of octocorals with some areas containing 30 per m^2 (Gilliam et al 2007b). The octocoral assemblage is dominated by the following genera: *Eunicea* spp., *Pseudopterogorgia* spp., *Muricea* spp., *Plexaurella* spp., and *Pterogorgia* spp. An abundant and diverse stony coral assemblage also exists. This is dominated by *M. cavernosa*, *S. siderea*, and *P. astreoides*. Although coral densities can be high, coral coverage averages approximately 2-3% (Gilliam et al 2007b). Very large (>1m wide) barrel sponges, *Xestospongia muta*, are conspicuous on the Middle Reef and are quite abundant in certain areas.

<u>Outer Reef</u>

The Outer Reef is the most conspicuous underwater feature in Southeast Florida. It extends 128 km from southern Miami-Dade County to Central Palm Beach County. This linear, shore-parallel feature is broken by gaps of varying size caused by paleo-river drainage (Banks et al. 2007). It is composed of *A. palmata* and *A. cervicornis* framework and classic Caribbean reef morphology is evident. This believed to be a relict reef system, having "drowned" about 8000 years ago (Lighty et al. 1978; Toscano and Macintyre 2003). This means that although the reef morphology has not changed it no longer functions the same.

Presently, the Outer Reef is capped by a coral community (Walker et al. *In press*). It has the strongest vertical relief of any of the local reef systems and exhibits a high diversity, abundance, and coverage of sessile reef organisms. Its benthic assemblages are very similar to those found on the Middle Reef. Octocorals and large barrel sponges (*Xestospongia muta*) are conspicuous and abundant. Moderate-sized stony coral colonies are also common. Coral coverage averages approximately 2-3% (Gilliam et al. 2007a and b). For fishes, there is significantly greater species richness and fish abundance on the Outer Reef and Middle Reefs than the Inner Reef and nearshore hardbottom (Walker 2007 from Ferro et al. 2005).

Florida Keys/Florida Reef Tract

Within the management area, the Florida Reef Tract is perhaps the best-known coral reef area. This region has coral reef characteristics similar to many areas in the Bahamas and Caribbean Basin. The types of coral reef habitats described previously are found in the Florida Keys, the most extensive are coral communities. This is colonized by calcifying algae (e.g., *Halimeda*), sponges, octocorals, and a few species of stony corals. This habitat has very wide bathymetric distribution, from the intertidal to great depths. Local environmental conditions dictate what species colonize the substrate.

The patch reef habitat is constructed by a few species of massive stony corals; most often the principal species is *Montastraea annularis*, bolder star coral. Other common foundation building species include *Colpophyllia natans* and *Siderastrea siderea*. Patch reefs are concentrated in the area off Elliott Key (Biscayne National Park), north Key Largo (John Pennekamp Coral Reef State Park, Florida Keys National Marine Sanctuary, FKNMS), and in the Hawk Channel area from Marathon to Key West (FKNMS). Stony coral species diversity and richness is highest in the patch reef habitat (Jaap et al. 2003).

The outer bank reefs are the seaward most reefs in the Florida Keys coastal ecosystem. They are the reefs most commonly visited by the diving and snorkeling charters. Their principal, unique feature is the spur and groove system (Shinn 1963). The system is a series of ridges and channels facilitating water transport from seaward to inshore. The coral most responsible for building the spurs is *Acropora palmata*, elkhorn coral (Shinn 1963). The spur and groove systems are in depths that range from a few centimeters to 10 meters. Beyond 10 meters, the spur and groove formation may or may not continue seaward as very low relief structures. Often, this habitat subunit is referred to as the fore-reef and may continue to about 30 m depth. Seaward there are sediment beds that separate the fore-reef from deeper reef formations in 40 m depth.

The Tortugas Banks are variation of the deeper reefs found in Dry Tortugas National Park. The depths are greater than 20 m and extend to 40 m. The foundation is Pleistocene karst limestone. The banks are extensive and a major grouper and snapper fishery is focused there. The most conspicuous coral is *Montastraea cavernosa*. Its growth is similar to a large toadstool: a column, capped with a hemisphere. The banks have abundant coral of a few species. Black coral (Antipatharia) are common on the outer edge of the bank.

Coral Reefs as Essential Fish Habitat

As a vital first step in understanding and managing coral reef resources, it is necessary to recognize that corals are not spread evenly over the management area. Rather, dense clusters of certain species concentrate at specific geographic locations to form coral reefs or coral communities, etc. Precise understanding of the geographic distribution of major coral habitats has been largely ignored, until recent mapping efforts (Walker et al. *In press*, Reigl et al. 2007). As these and other mapping projects are completed, expanded, and refined, they will become an important source of Essential Fish Habitat information.

Coral's most valuable contribution to the marine environment is as habitat for numerous associated organisms. As described by Jones and Endean (1973, 1976), Antonius et al. (1978), Starck (1968) Jaap (1984) Bohnsack et al. (1987) and Chiappone and Sluka (1996) and many other researchers, a coral assemblage within the management area may support rich populations of invertebrates (corals, sponges, tunicates, echinoderms, crabs, lobsters, gastropods, etc.), vertebrates (primarily fish, turtles, birds, and marine mammals), and plants (coralline algae, fleshy algae, eelgrass, turtle grass, etc.). Wells (1957) emphasized this habitat value in defining a coral reef as "... fauna and flora ... (that) ... provide the ecological niches essential to the existence of all other reef dwelling animals and plants." Undoubtedly coral is a primary provider of high quality refuge habitat for a multitude of attached and mobile organisms.

While no comprehensive quantitative inventories have been made of all of the flora and fauna associated with coral reefs, probably the best information illustrating the diversity of fauna associated with these structures is for fishes. In western Atlantic reef environments, the number of fish species directly or indirectly associated with the reef system can easily exceed 400 species (Starck 1968; Jones and Thompson 1978, Bohnsack et al. 1987; Ferro et al. 2005). The high taxonomic diversity of reef fishes indicates that many species are highly evolved, with several families generally restricted to the reef environment, among them: Chaetodontidae (butterflyfishes), Scaridae (parrotfishes), Acanthuridae (surgeonfishes), Labridae (wrasses), Holocentridae (squirrelfishes), and Pomacentridae (damselfishes) (Sale 1977; Longhurst and Pauly 1987). Many reef fishes are highly sedentary, with some species (e.g., damselfishes) actively defending territories. Even the spatial distribution of larger predatory species tends to be very reef-specific, with individuals rarely traveling more than 5 km from a home site after post-settlement, except for spawning purposes (Longhurst and Pauly 1987).

Assessments of reef fish abundances and diversity have been conducted in the Caribbean and Florida over the last four to five decades. Invariably, these studies have quantified fish populations relative to geomorphic strata or reef zonation (Ehrlich 1975; McGehee 1994; Lindeman 1997; Kendall et al. 2003; Ferro et al. 2005, Walker 2007), to substrate characteristics such as rugosity (Luckhurst and Luckhurst 1978, Walker 2007), complexity (Nunez Lara and Arias Gonzalez 1998), spatial isolation (Jordan et al. 2005), or refuge (hole) size (Hixon and Beets 1989, 1993; Sherman et al. 2001). Studies have also investigated temporal variation of juvenile fish populations (Gilliam 1999; Baron et al. 2004). Numerous reef studies have described the relationship between increased habitat complexity, and increased species richness, abundance and diversity of fishes (Walker 2007). Habitat selection is seen as a trade-off between refuge from predation and access to feeding resources (Werner and Gilliam 1984, Jordan et al. 2005). Settlement to juvenile habitats is thought to reduce exposure to predators (Shulman 1984) as a way to maximize survival. Hixon and Beets (1989, 1993) showed that appropriately sized refuges could moderate predation effects and thus alter reef fish distribution patterns. At a larger scale, complete absence of particular habitats has been shown to affect fish assemblage composition if species are not able to use alternate habitats (Nagelkerken et al. 2000).

All demersal fish species under SAFMC management which can associate with coral habitats are contained within the snapper-grouper FMP. Seventy-three managed species within ten diverse families are under this plan (Section 4.1.2). Several of these families are among the most commercially and recreationally valuable fishes of the south Atlantic coast of the United States (e.g., snappers and groupers). All of these species can show some association with coral reef or community habitats during their life history. Among species, these associations differ as some coral habitat use patterns are obligate while some are facultative. In addition, temporal variations in habitat use operate at broad scales ranging from interannual to seasonal to daily (nocturnal feeding migrations). The value of coral habitats can vary accordingly. Within snapper grouper species, ontogenetic changes in habitat use lead to further variation in coral habitat use. However, the coral reef ecosystem is fundamental to the occurrence and survival of all of these species by providing direct food or shelter resources to at least some life stages of all snapper-grouper species, or providing food or shelter to their prey resources (SAFMC 1983).

Of the ten families within the snapper-grouper plan, the three most diverse and valuable are the groupers, snappers, and grunts, with 21, 14, and 11 managed species, respectively. In groupers, the demersal life history of almost all *Epinephelus* species, several *Mycteroperca* species, and all *Centropristis* species, takes place in direct or peripheral association with coral habitats. In contrast, several species of *Mycteroperca* (gag, scamp), utilize nearshore, vegetated habitats before offshore migrations to hard structures with maturation. This latter pattern (primary use of coral structures during later ontogenetic stages) is also seen in many species of snappers and grunts. However, some species, particularly those preferring deeper water, utilize coral structures throughout their life cycle while others utilize both vegetated and hard structures opportunistically.

Similar variations in use of coral habitats are present within most of the other snapper-grouper families. For example, some managed species of triggerfish and porgy utilize coral habitats during their demersal life history, while spadefish and hogfish typically settle in vegetated, nearshore areas and use coral habitats only during later ontogenetic stages. Other patterns are also present. Most notably, jacks, although not demersal, are commonly associated with coral/ habitats as free-swimming transients. Coral habitats are primary aggregators of prey species for many species of jacks, providing habitat of essential value for the maintenance of food resources.

Due to state and Federal laws prohibiting the removal of coral much of the current economic value derived from corals in the management area comes from the non-consumptive recreational uses of coral habitats or collection of other reef resources. Throughout the management area perhaps especially in southeast Florida and the Florida Keys, dive shops, glass bottom boats, reef fishing tours, snorkel trips, boat ramps, and/or tropical specimen collecting companies, emphasize the importance of corals to many local economies. Recent studies have gone into detail describing the economic important of reef resources (Johns et al. 2001). Coastal regions depend on viable coral ecosystems therefore; extreme care must be taken to protect the long-term viability of the reef and the closely related economics of coastal counties, particularly southeast Florida and the Florida Keys.

Preservation of existing fisheries that are related to coral habitats should be of vital economic concern. Increasing fishery effort has resulted in substantial reductions in stocks of many fishery species. An analysis of fishery-independent data from 1979 to 1996 indicted that 23 analyzed reef fish species in the Florida Keys d were considered overfished with Spawning Potential Ratios below 30% Ault et al. 1998). Offshore Broward County (southeast Florida), during 667 stationary fish surveys only 2 legal-sized groupers and 219 legal-sized snappers were recorded (Ferro et al. 2005).

Complex coral reef systems usually provide greater types and quantities of habitat than more unidimensional hardbottoms. The living and nonliving components of the ecosystem are also of considerable significance in assessing value as habitat. Corals and associated benthos, such as sponges, tunicates, and algae, contribute most of the living habitat. Dead corals, perhaps parts of relic reefs, coral limestone, or lithified coral rock contribute refuge habitat and areas where the larvae of corals and sponges can settle. Regardless of the type of substrate or source of protection, the coral community offers space for organisms ranging from microscopic invertebrates to large fish. Those animals in turn contribute to the food webs of the entire ecosystem.

3.3.1.2 Live/Hardbottom Habitat

Description and distribution

Natural hardbottom consists of rock outcrops that vary in topographic relief from relatively flat and smooth to a scarped ledge with up to 10 m of vertical, sloped or stepped relief. The exposed areas of rock outcrop or relic reef are colonized to varying extent by algae, sponges, soft coral, hard coral, bryozoans, other invertebrates. Due to substantial biological, climatic, and geological differences between the temperate and tropical components of the managed area, the following summary is geographically segregated into two sections: Cape Hatteras to Cape Canaveral, and Cape Canaveral to the Dry Tortugas. Broadly, these regions represent temperate, wide-shelf systems and tropical, narrow-shelf systems, respectively, with concomitant distinctions in fish fauna (Lindeman et al., 2000). The zoogeographic break between these regions typically occurs between Cape Canaveral and Jupiter Inlet (approximately 230 km to the south). Distributions and areal amounts of hardbottom from the Florida/Georgia border to Jupiter Inlet (encompassing portions of both of the regions collated below) have been estimated from the comprehensive GIS assembly of almost all available data records (SAFMC-SA, 2001). The depth ranges covered extend from intertidal to almost 1000 m, depending on information for the varying shelf attributes of the South Atlantic Bight.

Cape Hatteras to Cape Canaveral

Major fisheries habitats on the continental shelf along the southeastern United States from Cape Hatteras to Cape Canaveral (South Atlantic Bight) can be stratified into at least five general categories: coastal, open shelf, live/hardbottom, shelf edge, and /upper slope and Blake Plateau (Figure 3.3-1) based on type of bottom and water temperature. While Figure 3.3-1 does not indicate the presence of live/hardbottom in the shallowest zone, subsequent surveys have documented extensive hardbottom habitat in this zone (SAFMC-SA 2001). Each of these habitats harbors a distinct association of demersal fishes (Struhsaker 1969) and invertebrates.

Most of the bight substrate is covered by a vast plain of sand and mud (Newton et al. 1971) underlain at depths of less than a meter by carbonate sandstone (Riggs et al. 1996; Riggs et al. 1998). The productivity of this sand- and mud-covered plain is relatively low. Scattered irregularly over the shelf, however, are zones of highly concentrated invertebrate and algal growth, usually in association with marked deviations in relief that support substantial fish assemblages (Struhsaker 1969; Huntsman and Mcintyre 1971; Wenner et al. 1983; Chester et al. 1984; Sedberry and Van Dolah 1984; Sedberry et al. 1998; Sedberry et al. 2001). Commonly called "live bottom" areas, they are usually found near outcropping shelves of sedimentary rock in the zone from 15 to 35 fathoms. High-relief rock outcrops are especially evident at the shelf break, a zone from about 55-200m where the continental shelf adjoins the deep ocean basin and is often characterized by steep cliffs and ledges (Huntsman and Manooch 1978).

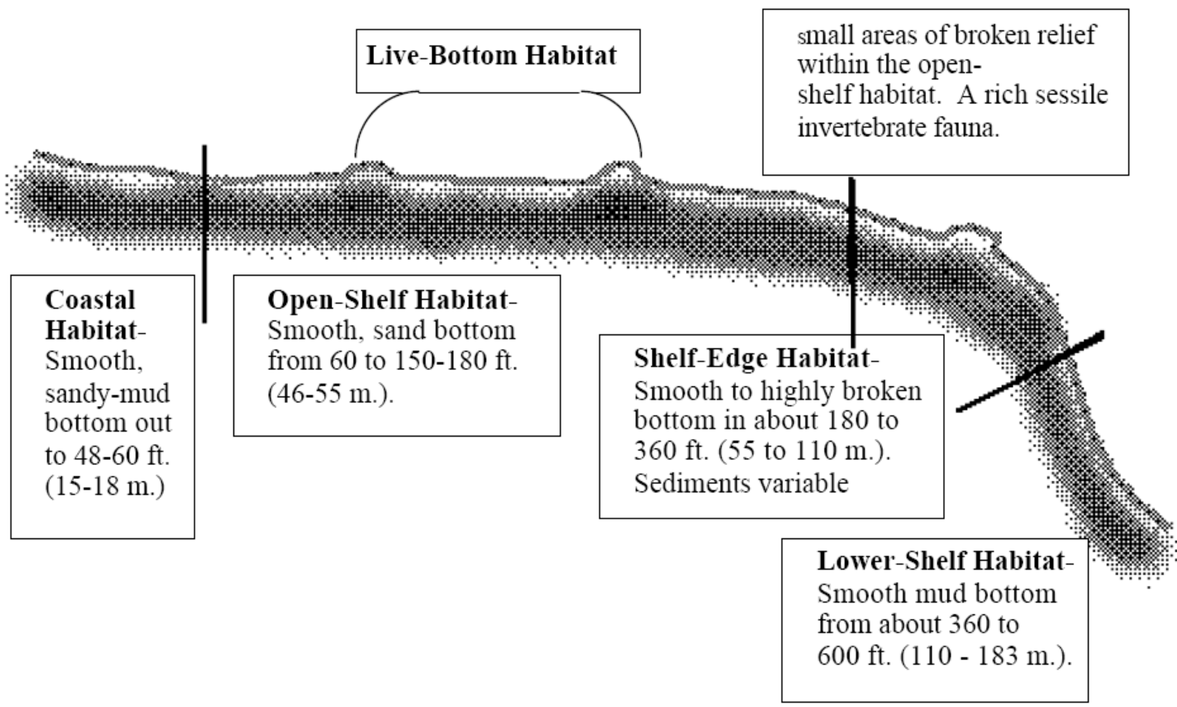


Figure 3.3-1. Selected Habitat Types on the Continental Shelf of the Southeastern United States North of Cape Canaveral (Original source: Struhsaker, 1969). Note that extensive shallow hardbottom has been revealed by recent surveys (SAFMC – SA, 2001), the term "upper slope" is now often used in place of "lower-shelf", and additional fisheries habitat exists beyond the shelf break, on the Blake Plateau at 400-650 m depth (Sedberry et al., 2001).

The temperature regimes of the offshore shelf habitats mentioned above are strongly influenced by the Gulf Stream. The Gulf Stream plays an important role in global-scale heat, momentum, and mass flux, as well as circulation patterns throughout its length. Physical, chemical, and biological processes are influenced by the presence of the Gulf Stream. It flows generally northeastward and, with its associated pressure gradient, is responsible for transporting water along the seaward flank of the Sea Slope gyre. The conditions and flow of the Gulf Stream are highly variable on time scales ranging from two days to entire seasons. The Gulf Stream flows toward the northeast with a mean speed of 1 m/s (2 kt). The location of the Gulf Stream's western boundary is variable because of meanders, attributable to atmospheric conditions, bottom topography, and eddies. These boundary features move to the south-southwest, and transport momentum, mass, heat, and nutrients to the vicinity of the shelf break.

All of the snapper and grouper offshore shelf habitats referred to above contain hard or live bottom areas, which provide surfaces for the growth of invertebrate organisms and the development of an ecosystem capable of supporting fishes important to commercial and recreational fisheries.

In general, the shelf demonstrates a ridge-and-swale (hill-and-valley) topography on the inner shelf and part of the outer shelf, with ridges having coarser surficial sediments than swales. At the shelf break, the topography is a discontinuous series of terraces before sloping or dropping off into steep slopes with submarine canyons, the relatively flat Blake Plateau, or deep Straits of Florida, depending on latitude.

On the shelf, the live-bottom habitats are often small, isolated areas of broken relief consisting of rock outcroppings that are heavily encrusted with sessile invertebrates such as ascidians, hydroids, bryozoans, sponges, octocorals, and hard corals. These outcrops are the ridges referred to above and are scattered over the continental shelf north of Cape Canaveral, although they are most numerous off northeastern Florida.

A study of live bottom areas from North Carolina to northern Florida (Continental Shelf Associates, 1979; Wenner et al., 1983) revealed three hardbottom habitat types: 1) emergent hardbottom dominated by sponges and gorgonian corals; 2) sand bottom underlain by hard substrate dominated by anthozoans, sponges and polychaetes, with hydroids, bryozoans, and ascidians frequently observed; and 3) softer bottom areas not underlain with hardbottom. Along the southeastern United States, most hard/live bottom habitats occur at depths greater than 27 m (90 ft), but many also are found at depths of from 16 to 27 m (54 to 90 ft), especially off the coasts of North Carolina and South Carolina, and within Gray's Reef National Marine Sanctuary off Georgia. Portions of the coastal zone off South Carolina also support extensive hardbottom habitat in depths less than 50 ft (SAFMC-SA 2001; Ojeda et al. 2004). Bottom water temperatures range from approximately 11° to 27°C (52° to 80°F). Temperatures less than 12°C may result in the death of some of the more tropical species of invertebrates and fishes.

Generally, snappers (Lutjanidae), groupers (Serranidae), porgies (Sparidae), and grunts (Haemulidae) inhabit hardbottom habitats off northeastern Florida and the offshore areas of Georgia, South Carolina, and North Carolina. The live bottom areas inshore (at depths of about 18 m; 60 ft) have cooler temperatures, less diverse populations of invertebrates, and are inhabited primarily by black sea bass, scup and associated temperate species (Sedberry and Van Dolah 1984).

The shelf edge habitat extends more or less continuously along the edge of the continental shelf at depths of 55 to 110 m (180 to 360 ft). The sediment types in this essential fish habitat zone vary from smooth mud to areas that are characterized by great relief and heavy encrustations of coral, sponge, and other predominately tropical invertebrate fauna. Some of these broken bottom areas (e.g., in Onslow Bay, North Carolina) may represent the remnants of ancient reefs that existed when the sea level was lowered during the last glacial period.

Struhsaker (1969) reported that, as a result of the proximity of the Gulf Stream, average bottom temperatures at the shelf edge are higher for a longer duration than those further inshore at other hardbottom areas. Bottom temperatures at the shelf edge habitat range from approximately 12° to 26°C (55° to 78°F). However, Miller and Richards (1980) and Sedberry et al. (2005) noted that there is a stable temperature area between 26 and 51 m (85 to 167 ft) where the temperature does not drop below 15°C (59° F). Cold water intrusions may cause the outer shelf bottom temperatures to drop (Avent et al. 1977; Mathews and Pashuk 1977; Leming 1979). Fishes that generally inhabit the shelf edge zone are more tropical, such as snappers, groupers, and porgies. Fish distribution is often diffuse in this zone, with fishes aggregating over broken bottom relief in associations similar to those formed at inshore live bottom sites. Shelf-edge reefs are important spawning grounds for many species of managed reef fish (Sedberry et al. in press).

The lower shelf habitat has a predominately smooth mud bottom, but is interspersed with rocky and very coarse gravel substrates where snowy and yellowedge groupers (*Epinephelus niveatus*, *E. flavolimbatum*) and tilefishes (Malacanthidae) are found. This habitat and its association of fishes roughly marks the transition between the fauna of the continental shelf and the fauna of the continental slope. Depths represented by this habitat zone range from 110 to 183 m (360 to 600 ft), where bottom water temperatures vary from approximately 11° to 14°C (51° to 57°F). Some species inhabiting the deeper live or hardbottom areas may be particularly susceptible to heavy fishing pressure due to limited habitat.

The continental slope off North Carolina, Georgia and Northern Florida is interrupted by the relatively flat Blake Plateau, which divides the slope into the Florida-Hatteras Slope and the Blake Escarpment. On the northern Blake Plateau are important fish habitats, including coral mounds and the Charleston Bump.

Between the 360-500 m depth contour on the Blake Plateau, and starting to the north off central North Carolina, discontinuous large mounds of deep sea coral reefs occur. While this deep coral habitat was previously described (Squires 1959; Stetson et al. 1962; Rowe and Menzies 1968), recent submersible dives have documented more information on their location and species composition (Ross 2004; See Section 3.3.1.3). The mounds consist primarily of dense thickets of the branching ahermatypic coral *Lophelia pertusa*, although other coral species have also been identified. As coral colonies die, others form on top of the mound, and extensive coral rubble accumulates to the sides of the mound. In North Carolina, two mounds have been documented off Cape Lookout and one mound off Cape Fear. The vertical height of the mounds was estimated to range from 50 to 80 m over 0.4 to 1.0 km distance. Over 43 benthic or benthopelagic fish species have been identified on these coral mounds (Ross et al. 2004).

The Charleston Bump is a deepwater rocky bottom feature on the Blake Plateau southeast of Charleston, South Carolina. It includes a shoaling ramp and ridge/trough features on which the seafloor rises from 700 m to shallower than 400 m within a relatively short distance and at a transverse angle to both the general isobath pattern of the upper slope, and to Gulf Stream currents (Brooks and Bane, 1978). The Charleston Bump includes areas of nearly vertical, 100-200-m high rocky scarps with carbonate outcrops and overhangs; other complex bottom such as coral mounds; and flat hardbottom consisting of phosphorite-manganese pavement (Popenoe and Manheim 2001; Sedberry et al. 2001). The bottom relief is important to deep reef species and supports the wreckfish (*Polyprion americanus*) fishery (Sedberry et al. 1999). It is also an important pelagic longlining area (Cramer 1996; Sedberry et al. 2001).

The feature was first described by Brooks and Bane (1978), who noted that it deflected the Gulf Stream offshore. This deflection and the subsequent downstream eddies, gyres and upwellings may increase productivity and concentrate fishes and other organisms along thermal fronts downstream from the Charleston Bump (McGowan and Richards 1985; Dewar and Bane 1985; Haney 1986; Collins and Stender 1987; Lee et al. 1991). Similar increases in productivity may occur around other deepwater bottom features. The restriction of Gulf Stream flow between the shoaling bottom and the Florida-Hatteras Slope causes swift and variable flows in the Gulf Stream, and subsequent wide-ranging and unpredictable variation in bottom temperatures (Sedberry et al. 1999; Sedberry et al. 2004). These variable oceanographic conditions and swift currents undoubtedly make life a challenge for benthic organisms, particularly sessile species. Complex bottom features, however, might provide shelter from the current for many of these, and such features could harbor a number of unique species.

Populations of economically valuable reef fishes have been in decline for at least two decades in the SAB. Such declines of top-level predators have an effect down through the food chain (Sedberry et al. 1999), and there is evidence for ecosystem overfishing on SAB reefs (McGovern et al. 1998). As a result of this overfishing and the inability of traditional methods to reverse this trend, the SAFMC has developed a series of Deepwater Marine Protected Areas (MPAs) (SAFMC, 2007). The process of siting these MPAs included obtaining input from user groups, interested parties, and the general public, along with review of existing biological and habitat data (SAFMC 2004). Of prime concern is protecting those habitats and locations that are essential to completing the life cycles of overfished species, particularly deepwater snappers and grouper populations that do not respond well to traditional management.

Proposed MPAs include eight shelf-edge (50-100 m depth) reef sites (SAFMC 2007). This SAFMC siting process highlighted some significant problems with gaps in knowledge of distribution of habitat, species and spawning locations (see also Sale et al. 2005). These gaps include knowledge of community structure, benthic food webs, oceanographic processes that affect recruitment to and from reefs, and placement of MPA networks to maximize resource protection and production of surplus fish biomass that might spill over into adjacent fished areas. High fish biomass is known to be associated with hardbottom vs. sand bottom habitat (Wenner 1983), but additional study of distribution of individual reef fish species and spawning sites in relation to bottom habitats and faunas, and the relationship of bottom features to hydrographic features and proposed MPA sites, is needed. Oceanographic conditions, circulation patterns, chlorophyll-a concentrations, and locations of upwelling need to be mapped in relation to spawning locations and areas of juvenile recruitment. These data are needed to maximize the effectiveness of management measures such as no-take reserves. By strategic placement of MPAs in networks based on biological and oceanographic data, it is hoped that the maximum positive effect can be achieved with minimal impact on fishermen. It is imperative to collect and summarize such biological and oceanographic data, particularly data on spawning locations and recruitment pathways.

The exact extent and distribution of productive live bottom habitat on the continental shelf north of Cape Canaveral is unknown. Although a number of attempts have been made, estimations of the total area of hardbottom are confounded due to the discontinuous or patchy nature of this habitat type. Henry and Giles (1979) estimated about 4.3 percent of the Georgia Bight to be hardbottom, but this is considered an underestimate. Miller and Richards (1980) reported that live bottom reef habitat comprises a larger area of the South Atlantic Bight. The method used to determine areas of live bottom involved the review of vessel station sheets from exploratory research cruises to locate sites where reef fishes were collected. Parker et al. (1983) suggested that rock-coral-sponge (live bottom) habitat accounts for about 14 percent, or 2,040 km^2, of the substratum between the 27 m and 101 m isobaths from Cape Hatteras to Cape Fear. Live bottom constitutes a much larger percentage of the substratum at the above depths from Cape Fear to Cape Canaveral. Parker et al. (1983) estimate that approximately 30 percent, or 7,403 km^2, of the bottom in this area was composed of rock-coral-sponge substrate.

In 1992, the SEAMAP-South Atlantic Bottom Mapping Work Group of the Atlantic States Marine Fisheries Commission began an extensive effort to establish a regional database for hardbottom resources throughout the South Atlantic Bight (Van Dolah et al. 1994). The primary objectives of the effort are to identify hardbottom habitats from the beach out to a depth of 200 meters, and to summarize the information into an easily-accessible database for researchers and managers. These data are available on the Council's Internet mapping Server at www.safmc.net. In addition, the Council brought together state partners to extend the acquisition and interpretation of bottom data from 200 to 2000 meters. This project was completed in August 2007 and data will also be available to the public via the IMS at www.safmc.net.

Moser and Taylor (1995) conducted a study on hardbottom distribution in nearshore (state-territorial) waters of North Carolina using information from local researchers, dive professionals, and fishermen. Additional sites were identified, primarily in the southern portion of Onslow Bay and northern part of Long Bay -- 20 of which were more than two meters in vertical relief. Hardbottom habitat may be concentrated seaward of inlets. Large areas of low relief hardbottom, intermittently covered with a thin layer of sand, occurs extensively off of Onslow and Brunswick Counties

In addition to the natural hard or live bottom reef habitats, wrecks and other manmade structures (e.g. artificial reefs) also provide suitable substrate for the proliferation of live bottom. However, the combined area of artificial substrates will always be dwarfed compared with the total area of natural, exposed live/hardbottom. The faunal species composition on artificial reefs is similar to that identified on natural hardbottom habitat at the same depth and in the same general area (Stone et al. 1979; Stephan and Lindquist 1989; Potts and Hulbert 1994). In 1997, an assessment of the effectiveness of differently constructed artificial reefs in North Carolina (DMF 1998) found species composition to be similar on reefs constructed of different materials. However, CPUE of natural reefs was 71-85% greater than on nearby artificial reefs (DMF 1998).

Cape Canaveral to Dry Tortugas

The term hardbottom is applied in two relatively different areas of southeast Florida: the mainland and associated sedimentary barrier islands, and the coral islands and reef tract of the Florida Keys (Hoffmeister 1974). Therefore, this summary is collated by two subregions: a) mainland southeast Florida; and b) the Florida Keys. The benthic habitat characteristics of the shelf bordering the mainland are not as complex as in the Florida Reef Tract. Within both subregions, non-coralline, hardbottom habitats are present in both nearshore (<4 m) and mid- and outer-shelf areas (>4 m).

Mainland Southeast Florida

Nearshore Hardbottom

Nearshore hardbottom habitats are the primary natural reef structures at depths of 0-4 m of this subregion. These habitats are derived from large accretionary ridges of coquina mollusks, sand, and shell marl which lithified parallel to ancient shorelines during Pleistocene interglacial periods (Duane and Meisburger 1969). Currently, the majority of nearshore hardbottom reefs are within 200 m of the shore. However, they are often separated by kilometers of flat nearshore sand expanses. Nearshore hardbottom habitats on the mainland are patchily distributed among large expanses of barren, coarse sediments, commonly possess worm reefs, and show reduced coral diversities. Nelson (1990) recorded 325 species of invertebrates and plants from nearshore hardbottom habitats at Sebastian Inlet. In some areas, the hardbottom reaches heights of 2 m above the bottom and is highly convoluted. Hard corals are rare due to high turbidities and wave energy. However, hard corals that are encountered are *Siderastrea radians, Oculina diffusa* and *Oculina varicosa* (McCarthy, pers. com.). The habitat complexity of nearshore hardbottom is expanded by colonies of tube-building polychaete worms (Kirtley and Tanner 1968; McCarthy 2001) other invertebrates and macroalgae (Goldberg 1973; Nelson and Demetriades 1992). A large array of literature and many new species records are summarized for algae (277 species total), invertebrates (523 species), fishes (257) and sea turtles from nearshore hardbottom of mainland east Florida in CSA (2009).

A keystone contributor to the biological diversity of hardbottom habitats along the east Florida coast is the polychaete *Phragmatopoma lapidosa*, also known as *P. caudata* (Kirtley 1994; Drake et al. in review) and/or *P. lapidosa* (Pawlik 1988). Worms of this species (Family Sabellariidae) extract and glue sand together to make sand tubes, forming vast reefs in intertidal and shallow (<5 m) subtidal hardbottoms from Cape Canaveral to Key Biscayne in Florida. Their distribution continues southward to Santa Catarina, Brazil (Kirtley 1994). In Florida, the structure provided by these “worm reefs” supports a higher diversity and abundance of marine species than that of neighboring sand or hardbottom habitats. There are 8 federally and 15 State-listed species that are associated with nearshore reefs off east Florida (USFWS 1999). In particular, worm reefs are considered important sources of food and shelter for juvenile green turtles (*Chelonia mydas*) (Ehrhart et al. 1996; Wershoven and Wershoven 1988; Holloway-Adkins 2001). The reefs also provide shelter for over 325 invertebrate species (Gore et al. 1982; Nelson 1988, 1989; Nelson and Demetriades 1992) and 192 fish species (Gilmore 1977; Gilmore et al. 1981; Lindeman 1997a; Lindeman and Snyder 1999). Substantial geological evidence suggests that worm reefs are important in the maintenance and persistence of beaches and barrier islands by retention of sediment and the progradation of beaches (Kirtley 1966; Kirtley 1967; Multer and Milliman 1967; Kirtley and Tanner 1968; Gram 1968; Mehta 1973; Kirtley 1974).

Offshore Hardbottom
Several lines of offshore hardbottom reefs, derived from Pleistocene and Holocene reefs, begin in depths usually exceeding 8 m, and in bands that roughly parallel the shore (Goldberg 1973; Lighty 1977). The geologic origins and biotic characteristics of these deeper reef systems are different from the nearshore hardbottom reefs (Lighty 1977), although reefs of both depth strata are lower in relief than reefs of the Florida Reef tract.

Florida Keys and Reef Tract

Nearshore Hardbottom
Nearshore hardbottom habitats of the Florida Keys can differ both geologically and biologically from mainland areas. Florida Keys nearshore hardbottom is semi-continuously distributed among areas with high organic sediments, increased seagrasses, more corals, and reduced wave conditions. Emergent upland components of the Florida Keys are derived from ancient reefs of the Florida Reef Tract and typically do not have sizeable beaches nor a nearshore current regime for delivery of beach-quality sediments. In contrast to the Keys, beach systems associated with sedimentary barrier islands are common in mainland areas.

Within the Keys, nearshore hardbottom is widely distributed and shows compositional differences based on proximity to tidal passes (Chiappone and Sullivan 1994). Near tidal passes, these habitats are dominated by algae, gorgonians and sponges. In the absences of strong circulation, such habitats are characterized by fleshy algae, such as *Laurencia* (Chiappone and Sullivan 1994). Hard corals are relatively uncommon in nearshore areas, presumably due to greater environmental variability in key parameters (temperature, turbidity, salinity).

Midshelf and Offshore Hardbottom
Due to the warmer water and immediate downstream positioning to the Florida Keys, these areas support a higher diversity and abundance of hard coral species. The section on Corals in the FEP document should be consulted for significant information.

Ecological role and function

The vertical relief and irregularity of hardbottom structure provides protective cover for numerous fish species and increases the surface area available for colonization by invertebrates and plants. Because of this, natural reefs can sustain greater fish stocks (270 to 5,279 kg/ha) compared to non-reef open shelf bottom (6.3 to 46.3 kg/ha) (Huntsman 1979). The abundance of fish on hardbottom and artificial reefs is related to the amount and type of structural complexity of the reef (Carr and Hixon 1997). Rocky structures with high complexity consistently supported a more abundant and diverse resident fish community than less complex structures. In addition, areas with small patches of hardbottom surrounded by sand bottom supported greater fish abundance and diversity than one large area of equal material, suggesting the importance of habitat edge and diversity to ecosystem productivity (Bohnsack et al. 1994; Auster and Langton 1999).

Most reef fish spawn in aggregations in the water column above the reef, and the eggs remain planktonic during development (Jaap 1984). Species known to spawn on nearshore hardbottom include black sea bass (*Centropristis striata*) and sand perch (*Diplectrum formosum*) between January and June (Powell and Robins 1998). Sheepshead (*Archosargus probatocephalus*), Atlantic spadefish (*Chaetodipterus faber*), and other non-fishery reef species are also thought to spawn on inshore hardbottom in North Carolina (F. Rohde, DMF, pers. com., 2001).

Nearshore and inner shelf hardbottom areas serve as important settlement and nursery habitat for immigrating larvae of many important fisheries species. Powell and Robbins (1998) collected larvae from 22 reef-associated families adjacent to hardbottom habitat in Onslow Bay. Planehead filefish, *Monacanthus hispidus*; the blenny, *Parablennius marmoreus*; the goby, *Ioglossus calliurus*; tomtate, *Haemulon aurolineatum*; white grunt, *H. plumieri*; snappers including vermilion snapper, *Rhomboplites aurorubens*; black sea bass; bank sea bass; sand perch; spottail pinfish; and whitebone porgy were commonly collected. These species are thought to have been spawned in Onslow Bay in somewhat deeper water and recruited locally to nearshore hardbottom (Powell and Robins 1998). Nearshore hardbottom also serves as intermediate nursery habitat for late juveniles emigrating out of the estuaries (Lindeman and Snyder 1999). In North Carolina, this group of fishes includes black sea bass, gag, red grouper, sheepshead, Atlantic spadefish, bank sea bass, and gray snapper, which are estuarine-dependent as early juveniles, moving offshore to hardbottom habitat as older juveniles.

In addition to providing essential functions for numerous fishery species, bio-erosion of hardbottom provides a source of new sand on the continental shelf (Riggs et al. 1985). Boring and burrowing shrimp and bivalves excavate holes chemically or mechanically, eventually weakening the rock. This process also enhances the structural complexity of hardbottom outcrops, promoting diversity of reef habitat structure.

Off Florida McCarthy (2001) suggests that worm (*Phragmatopoma lapidosa*) reefs go through predictable patterns of annual change which include high recruitment in early autumn through winter, rapid reef growth (~0.5 cm/day) resulting in maximum structure in spring and summer, and decay by early autumn (McCarthy 2001; McCarthy 2003). As recruits grow, the structure of their reef changes and these changes are important in determining the resiliency of the reefs when disturbed. Juveniles form low-lying mounds and reefs that often survive winter wave and sand disturbance (McCarthy 2001). As individuals continue to grow and accrete sand, they form large reefs that reach maximum size during the summer. Many of the intertidal colonies grow into somewhat unstable mushroom-shaped mounds whereas subtidal *Phragmatopoma lapidosa* mounds generally remain carpet-like in shape (McCarthy 2001).

Mortality of *P. lapidosa* colonies. a significant component of nearshore hardbottom in some areas of east-central Florida, increases during the summer as a result of the effects of several disturbance agents (McCarthy 2001). In the early summer, some individuals at the tops of intertidal mounds perish, leaving the tops susceptible to decay. It is likely that this mortality is caused by desiccation and/or heat stress from extreme summer temperatures. By the late summer and early autumn, wave activity from hurricanes results in maximum physical disturbance to sabellariid reefs. A large percentage of both intertidal and subtidal reefs are severely damaged at this time. Intertidal worms are more susceptible to physical destruction of their colonies, whereas subtidal worms get smothered by sand but the sand reef remains intact.

Almost simultaneously with peaks in lethal disturbance, however, larvae of *P. lapidosa* arrive in large numbers to renew the colonies by massive recruitment in cracks or atop mounds of adults (McCarthy, 2001). This process results in low lying reefs that are highly resilient and will eventually restore the structure of the reefs. Consequently, as disturbance lowers adult abundance and creates new settlement space, new individuals arrive in sufficient numbers to restore the populations. Therefore, local metapopulations may remain at fairly high abundances year after year while experiencing moderately high mortality from various agents of disturbance. When these seasonal data are integrated with those of other researchers (Gilmore 1977; Gilmore et al. 1981; Lindeman and Snyder 1999), they reveal important links between the seasonal cycle of sabellariid reef expansion and degradation, and the occupation of those reefs by juvenile and adult organisms.

Species composition and community structure

The character and extent of colonization on temperate nearshore hardbottom differs from that occurring on subtropical reefs off Florida, and varies with topography, environmental conditions and distance offshore. Studies that have documented the composition and diversity of the communities on hardbottom in North Carolina include MacIntyre and Pilkey (1969), Schneider (1976), Crowson (1980), Peckol and Searles (1984), and Kirby-Smith (1989). The dominant colonizing organisms on hardbottom in North Carolina are macroalgae (Peckol and Searles 1984), ranging from 10 to 70% of the biotic cover, and varying among seasons and years. Perennial and crustose brown and red algae were the dominant algal forms, including *Lobophora variegata*, *Lithophyllum subtenellum*, *Zonaria tournefortii*, and *Gracilaria mammillaris*. Roughly 150 species of macroalgae were identified on hardbottom in North Carolina; the majority was red algae (Rhodophyta) (Schneider 1976).

Non-mobile, attached invertebrates accounted for 10% or less of the biotic cover on hardbottom off North Carolina (Peckol and Searles 1984). The most abundant non-mobile invertebrates were the soft corals, *Titandeum frauenfeldii* and *Telesto fructiculosa*, and the hard coral, *Oculina arbuscula*. Sea urchins (*Arbacia punctulata* and *Lytechinus variegatus*) were the most common mobile invertebrates. Species composition of invertebrates occurring at hardbottom sites in South Carolina and Georgia were studied by Wenner et al. (1984). Study results using dredge and trawl samples showed that sponges, bryozoans, corals, and anemones dominated the large macroinvertebrate collection in terms of numbers and species diversity during all seasons. Sponges were the most important invertebrate group overall on the inner shelf, comprising 60–78% of the total biomass (Wenner et al. 1984). Species characteristic of the inner shelf sites included the sponges, *Homaxinella waltonsmithi*, *Spheciospongia vesparium*, *Cliona caribbaea*, and *Halichondria bowerbanki*; the echinoderms, variegated urchin (*Lytechinus variegatus*), purple sea urchin (*Arbacia punctuata*), *Encope michelini*, and *Ocnus pygmaeus*; the bryozoan, *Membranipora tenuis*; and the decapod crustacean, *Synalpheus minus*. Grab samples of small invertebrates showed that polychaetes were the most diverse and abundant group, followed by mollusks, and amphipods (Wenner et al. 1984).

Cooler and more fluctuating water temperatures limit the extent of coral colonization on hardbottom (Kirby-Smith 1989). Two species of reef building corals that have been documented on North Carolina hardbottom are *Solenastrea hyades* and *Siderastrea siderea*. These species occurred on rock outcrops at depths of 20 to 26 m in Onslow Bay approximately 32 km offshore (MacIntyre and Pilkey 1969). Other species of coral reported for North and South Carolina include the hard corals, ivory bush coral (*Oculina arbuscula*), *Oculina varicosa*, *Astrangia danae*, *Phyllangia americana*, *Balanophyllia floridana*, and the soft corals, sea whip (*Leptogorgia virgulata*), *Telesto* spp., *Lophogorgia* spp., *Titanideum frauenfeldii*, and *Muricea pendula* (Wenner et al. 1984; Hay and Sutherland 1988).

Studies that have examined fish assemblages on natural and artificial reef habitats in North Carolina include Huntsman and Manooch (1978), Miller and Richards (1980), Grimes et al. (1982), Lindquist et al. (1989), Potts and Hulbert (1994), and Parker and Dixon (1998). Water temperature and topography are the most important factors in determining use of habitat by warm-temperate and tropical hardbottom species (Wenner et al. 1984). Lindquist et al. (1989) reported 32 species at inner shelf hardbottom sites in North Carolina, approximately five miles from shore. Commonly occurring and numerically abundant species for both natural and artificial reefs were, in order of decreasing abundance round scad (*Decapterus punctatus*), tomtate (*Haemulon aurolineatum*), spottail pinfish (*Diplodus holbrookii*), black sea bass (*Centropristis striata*), and slippery dick (*Halichoeres bivittatus*). Other common species included scup (*Stenotomus chrysops*), juvenile grunts, pigfish (*Orthopristis chrysoptera*), cubbyu (*Equetus umbrosus*), and belted sandfish (*Serranus sublgiarius*). Fish composition varied due to seasonal inshore migrations of tropical and subtropical species, fishing pressure, and microhabitat differences.

Off Florida, adult populations of the polychaete *Phragmatopoma lapidosa* dominate both intertidal and shallow subtidal habitats that can be very harsh physically in part because *P. lapidosa* can tolerate physical disturbances better than most other species (Kirtley 1966; Main and Nelson 1992; McCarthy 2001). In most areas, no other invertebrate encrusting species is as abundant as *P. lapidosa* in these habitats (McCarthy pers. com.). *P. lapidosa* can tolerate sand burial for up to three days before a significant percentage of individuals begin to die (Main and Nelson 1992). While large numbers of larvae of other encrusting species, including sponges, cnidarians, bryozoans, ascidians, bivalves and polychaetes, settle in the same intertidal and subtidal hardbottom habitats, only *P. lapidosa* settles and ultimately thrives in these habitats (McCarthy et al. 2002; McCarthy and Young, In prep).

Few quantitative characterizations of nearshore hardbottom fish assemblages are available. Based on visual censusing of three mainland southeast Florida sites over two years, 86 species from 36 families were recorded (Lindeman and Snyder 1999). Grunts (Haemulidae) were the most diverse family with 11 species recorded, more than double the species of any other family except the wrasses (Labridae) and parrotfishes (Scaridae) with seven and six species, respectively. The most abundant species were the sailor's choice, silver porgy, and cocoa damselfish. Use of hardbottom habitats was recorded for newly settled stages of over 20 species (Lindeman and Snyder 1999). Pooled early life stages (newly settled, early juvenile, and juvenile) represented over 80% of the individuals at all sites. Nearshore hardbottom fish assemblages of this subregion are characterized by diverse, tropical faunas which are dominated by early life stages.

Three studies have included sections on nearshore hardbottom fishes as part of larger project goals. Gilmore (1977) listed 105 species in association with “surf zone reefs” at depths less than two meters. Two additional species were added in later papers (Gilmore et al., 1983; Gilmore, 1992). Using visual surveys, Vare (1991) recorded 118 species from nearshore hardbottom sites in Palm Beach County. Futch and Dwinell (1977) included a list of 34 species obtained from several ichthyocide collections on “nearshore reefs.” In addition to the species censused in Lindeman and Snyder (1999), 19 species were qualitatively recorded at the Jupiter and Ocean Ridge sites. Including the prior studies, over 190 species within 62 families have now been recorded in association with nearshore hardbottom habitats of mainland southeast Florida (Table 3.3-1). At least 90 species are utilized in recreational, commercial, bait, or aquaria fisheries. Nearshore hardbottom habitats typically had over thirty times the individuals per transect as natural sand habitats (Lindeman and Snyder 1999) and newly settled individuals were not recorded during any surveys of natural sand habitats.

Surveys in the Ft. Lauderdale area revealed similarly high numbers of fishes in association with nearshore hardbottom (Baron et al. 2004). This study also found a predominance of early life stages for many taxa, with species of Haemulon to be the most abundant taxon at the generic level. During 34 visual transects over sand sites in southeast Florida, Vare (1991) recorded seven species (primarily clupeids and carangids). Approximately 15 months of sampling by seine hauls at a nearshore sand site in east-central Florida yielded a total of 22 species (Peters and Nelson 1987). One species each of engraulid and carangid comprised 70% of the total catch.

During a 4-year period, 1998 to 2002, the fishes of the three coral reef/hardbottom reef tracts count off Broward County, FL were censused (Ferro et al. 2005). A total of 86,463 fishes belonging to 208 species (52 families) was recorded. Significant differences ($p<0.05$) in total abundance, species richness and biomass were noted among the three reef tracts. In general, greater species richness and fish abundance was found on the offshore reef tract than on the middle or inshore reef tracts. The juvenile grunts, an important forage base, were significantly higher on the inshore and middle reefs, which did not differ significantly from each other, than on the offshore reef. Of management interest, the results of this census highlight a scarcity of legal size groupers (2) and snappers (198) over the entire survey.

Ault et al. (2001) describe the habitats and fish community structure within of Biscayne National Park (BNP) off Miami-Dade County, FL. Habitats were described in terms of bottom substrates, bathymetry, and seasonal salinity patterns. Analysis of community fish structure in BNP from visual census, creel census, and trawl survey databases provided spatial and temporal relationships between fishery resources and habitats.

Table 3.3-1. Species of fishes recorded from natural nearshore hardbottom habitats of mainland southeast Florida (Lindeman, 1997a), Gilmore (1977) and Vare (1991). Depths surveyed: Lindeman 1-4m; Gilmore 0-2m; Vare 4m.

Species	Lindeman	Gilmore	Vare
Rhincodontidae - Carpet Sharks			
Ginglymostoma cirratum	X	X	X
Carcharhinidae - Requiem Sharks			
Carcharhinus brevipinna	X[1]		X
Carcharhinus leucas		X	
Carcharhinus limbatus		X	
Carcharhinus plumbeus		X	
Rhinobatidae - Guitarfishes			
Rhinobatos lentiginosus			X
Dasyatidae - Stingrays			
Dasyatis americana			X
Urolophidae - Round Stingrays			
Urolophus jamaicensis			X
Muraenidae - Moray Eels			
Echidna catenata	X		
Enchelycore carychroa			X
Enchelycore nigricans[2]			
Gymnothorax funebris		X	X
Gymnothorax miliaris	X		
Gymnothorax moringa	X	X	X
Ophichthidae - Snake Eels			
Ahlia egmontis[2]			
Myrichthys breviceps	X		X
Elopidae - Tarpons			
Megalops atlanticus	X[1]		X
Clupeidae - Herrings			
Harengula clupeola	X[1]	X	
Harengula humeralis		X	
Harengula jaguana	X	X	
Opisthonema oglinum		X	X
Sardinella aurita	X[1]	X	
Clupeid sp.	X		
Engraulidae - Anchovies			
Anchoa cubana		X	
Anchoa hepsetus	X		
Anchoa lyolepis		X	
Gobiesocidae - Clingfishes			
Gobiesox strumosus		X	
Mugilidae - Mullets			
Mugil cephalus	X[1]		X
Mugil curema	X[1]		
Exocoetidae - Halfbeaks			
Hemiramphus brasiliensis	X[1]		
Hyporhamphus unifasciatus		X	
Hyporhamphus sp.		X	
Belonidae - Needlefishes			
Strongylura marina			X
Atherinidae - Silversides			
Membras martinica		X	
Menidia peninsulae		X	
Scorpaenidae - Scorpionfishes			
Scorpaena plumieri	X	X	X
Holocentridae - Squirrelfishes			
Holocentrus adscensionis			X
Holocentrus rufus	X		
Pomacentridae - Damselfishes			
Abudefduf saxatilis	X	X	X
Abudefduf taurus	X		
Microspathodon chrysurus			X
Pomacentrus fuscus	X		X

Table 3.3-1. continued.

Pomacentrus leucostictus		X		X		X
Pomacentrus partitus		X				X
Pomacentrus planifrons						X
Pomacentrus variabilis	X		X		X	
Serranidae - Sea Basses & Groupers						
Centropristis striata				X		X
Diplectrum formosum					X	
Epinephelus adscensionis						X
Epinephelus itajara				X		
Epinephelus morio		X				
Mycteroperca bonaci		X[1]				X
Mycteroperca microlepis				X		
Serranus subligarius				X		
Grammistidae - Soapfishes						
Rypticus maculatus		X		X		
Rypticus saponaceus						X
Lutjanidae - Snappers						
Lutjanus analis			X		X	
Lutjanus apodus		X		X		X
Lutjanus chrysurus		X		X		X
Lutjanus griseus		X		X		X
Lutjanus jocu				X		X
Lutjanus mahogoni				X		
Lutjanus synagris		X		X		X
Haemulidae - Grunts						
Anisotremus surinamensis		X		X		X
Anisotremus virginicus	X		X		X	
Haemulon album				?		
Haemulon aurolineatum		X		X		X
Haemulon carbonarium		X		X		X
Haemulon chrysargyreum		X		X		X
Haemulon flavolineatum		X		X		X
Haemulon macrostomum		X				X
Haemulon melanurum	X		X		X	
Haemulon parra		X		X		X
Haemulon plumieri		X		X		X
Haemulon sciurus		X				X
Haemulon striatum						?
Orthopristis chrysoptera						?
Inermiidae - Bogas						
Inermia vittata					?	
Apogonidae - Cardinalfishes						
Apogon binotatus		X				
Apogon maculatus		X		X		X
Apogon pseudomaculatus				X		
Astrapogon stellatus[2]						
Phaeoptyx conklini[2]						
Pomatomidae - Bluefishes						
Pomatomus saltatrix				X		
Carangidae - Jacks and Pompanos						
Caranx bartholomaei		X		X		X
Caranx crysos	X		X		X	
Caranx hippos	X[1]		X		X	
Caranx latus				X		X
Caranx ruber		X		X		X
Chloroscombrus chrysurus		X[1]		X		
Decapterus punctatus		X				
Oligoplites saurus		X[1]		X		X
Selar crumenopthalmus	X[1]					
Selene setapinnis		X				
Selene vomer				X		
Seriola dumerili				X		
Trachinotus carolinus	X[1]					
Trachinotus falcatus		X[1]				
Trachinotus goodei						X

Table 3.3-1. continued.

Mullidae - Goatfishes						
Mulloidichthys martinicus		X				X
Pseudupeneus maculatus		X		X		X
Centropomidae - Snooks						
Centropomus undecimalis		X[1]				X
Sparidae - Porgies						
Archosargus probatocephalus	X		X		X	
Calamus bajonado		X		X		
Diplodus argenteus		X		X		
Diplodus holbrooki				X		X
Coryphaenidae - Dolphins						
Coryphaena equiselis				X		
Sciaenidae - Drums						
Bairdiella sanctelucaie			X[3]			
Equetus acuminatus		X		X		X
Equetus lanceolatus						X
Equetus umbrosus		X				
Odontoscion dentex		X		X		X
Umbrina coroides		X		X		
Gerreidae - Mojarras						
Eucinostomus argenteus		X?		X		X
Eucinostomus gula		X?		X		
Eucinostomus sp.		X				
Gerres cinereus		X		X		X
Echeneidae - Remoras						
Echeneis naucrates						X
Priacanthidae - Bigeyes						
Priacanthus arenatus						X
Pempheridae - Sweepers						
Pempherus schomburgki		X		X		X
Aulostomidae - Trumpetfishes						
Aulostomus maculatus			X[4]			
Fistularidae - Cornetfishes						
Fistularia tabacaria						X
Ephippidae - Spadefishes						
Chaetodipterus faber				X		X
Chaetodontidae - Butterflyfishes						
Chaetodon capistratus					X	
Chaetodon ocellatus		X				X
Chaetodon sedentarius					X	
Chaetodon striatus				X		
Pomacanthidae - Angelfishes						
Holacanthus bermudensis		X				X
Holacanthus ciliarus				X		
Pomacanthus arcuatus	X		X		X	
Pomacanthus paru		X				X
Labridae - Wrasses						
Bodianus rufus	X				X	
Doratonotus megalepis			X			
Halichoeres bivittatus	X		X		X	
Halichoeres garnoti						X
Halichoeres maculipinna		X		X		X
Halichoeres poeyi		X		X		
Halichoeres radiatus		X		X		X
Hemipteronotus splendens						X
Hemipteronotus sp.		X[1]				
Lachnolaimus maximus		X				X
Thalassoma bifasciatum		X		X		X
Scaridae - Parrotfishes						
Scarus coelestinus		X				
Scarus guacamaia		X				
Scarus taeniopterus						X
Scarus vetula		X				
Sparisoma atomarium			X			
Sparisoma aurofrenatum		X				

Table 3.3-1. continued.

Sparisoma chrysopterum		X				X
Sparisoma radians				X		
Sparisoma rubripinne	X		X		X	
Sparisoma viride		X				X
Scarid sp.		X				
Synodontidae - Lizardfishes						
Synodus intermedius						X
Sphyraenidae - Barracudas						
Sphyraena barracuda		X		X		X
Sphyraena guachancho			X			
Kyphosidae - Sea Chubs						
Kyphosus incisor		X?		X		
Kyphosus sectatrix		X?		X		X
Kyphosus sp.		X				
Scombridae - Mackerels						
Scomberomorus regalis	X[1]				X	
Opistognathidae - Jawfishes						
Opistognathus macro.			X			
Dactyloscopidae - Sand Stargazers						
Dactyloscopus crossotus				X		
Platygillellus rubrocinctus[2]						
Uranoscopidae - Stargazers						
Astroscopus y-graecum			X			
Ogcocephalidae - Batfishes						
Ogcocephalus radiatus					X	
Labrisomidae - Clinids						
Labrisomus bucciferus	X					
Labrisomus gobio		X				
Labrisomus nuchipinnis		X		X		X
Malacoctenus macropus		X		X		
Malacoctenus triangulatus		X		X		
Paraclinus nigripinnis			X			
Starksia ocellata		X				
Blenniidae - Combtooth Blennies						
Entomacrodus nigricans				X		
Parablennius marmoreus		X				X
Scartella cristata		X		X		
Gobiidae - Gobies						
Coryphopterus glaucofrenum	X					
Gobiosoma oceanops		X[1]				X
Nes longus		X				
Eleotridae - Sleepers						
Erotelis smaragdus				X		
Triglidae - Searobins						
Prionotus ophryas				X		
Acanthuridae - Surgeonfishes						
Acanthurus bahianus		X		X		X
Acanthurus chirurgus	X		X		X	
Acanthurus coeruleus	X		X		X	
Bothidae - Lefteye Flounders						
Bothus lunatus					X	
Balistidae - Triggerfishes						
Balistes capriscus				X		
Balistes vetula					X	
Canthidermis sufflamen						X
Monacanthidae - Filefishes						
Aluterus scriptus		X				X
Cantherhines pullus		X				X
Monacanthus hispidus			X			
Ostraciidae - Boxfishes						
Lactophrys triqueter		X		X		X
Lactophyrs quadricornis		X				X
Tetraodontidae - Pufferfishes						
Canthigaster rostrata		X				X
Sphoeroides spengleri					X	

Table 3.3-1. continued.

Diodontidae - Porcupinefishes			
Diodon holocanthus			X
Diodon hystrix	X	X	

[1] - Observed, but not censused in Lindeman (1997a).
[2] - Reported only by Futch and Dwinell (1977).
[3] - Reported in Gilmore (1992).
[4] - Reported in Gilmore et al. (1983).
? - Reported, but identification questionable.

The tropical invertebrate fauna of several of the mid-shelf reefs off east Florida are described by Goldberg (1973) and Blair and Flynn (1989). No quantitative examinations of the fish assemblages of these habitats are published. Qualitative characterizations exist in Herrema (1974) and Courtenay et al. (1974, 1980). Using various collecting gears and literature reviews, Herrema (1974) recognized the occurrence of 206 "primary reef" fishes off the mainland southeast coast of Florida. Emphasis was placed on the similarities between this fauna and the reef fish fauna characterized at Alligator Reef in the Florida Keys (Starck 1968). Lutjanids, haemulids and many other families were represented in both subregions on almost a species by species basis (Herrema 1974). This information was not contradicted by the faunal characterizations in Courtenay et al. (1974, 1980). Based primarily on offshore records, Perkins et al. (1997) identified 264 fish taxa from the shelf of mainland Florida as hardbottom obligate taxa.

Chiappone and Sluka (1996) identified only one study that had quantitatively focused on fishes of nearshore hardbottom areas in the Florida Keys. This work was based on strip transect surveys at two sites in the middle Keys and recorded a total of 30 species within 18 families. In Jaap's (1984) review of Keys reefs, Tilmant compiled a list of 47 fish species occurring on nearshore hardbottom. In contrast, 192 species have been compiled for mainland areas (Lindeman 1997). The paucity of fish studies on nearshore hardbottom habitats of both the mainland and the Florida Keys render definitive comparisons premature at this stage. Several additional factors further complicate Keys and mainland comparisons. First, nearshore hardbottom in the Keys is distributed across more physiographically variable cross-shelf strata with a greater potential for structural heterogeneity than on the mainland. Second, the presence of over 6000 patch reefs in Hawk Channel (Marszalek et al. 1977), many near shallow hardbottom habitats, introduces additional inter-habitat relationships rarely found in nearshore hardbottom of mainland areas. Characterizing the fish assemblages of the heterogenous nearshore areas of the Keys may be more problematic than for the relatively homogeneous nearshore hardbottom areas of mainland Florida. In both regions, some ecotones and attributes of vertical relief (e.g., sand-hardbottom interfaces and ledges) appear to aggregate some taxa. However, the microhabitat-scale distributions of fishes within nearshore hardbottom habitats remain unquantified.

In Chiappone and Sluka (1996), no studies of fishes from hardbottom areas of the outer reef tract or the intermediate Hawk Channel area were identified. Most studies of offshore fish faunas in the Florida Keys have focused on reef formations derived primarily from hermatypic corals. Such areas may contain bedrock outcroppings properly termed hardbottom, however, this is typically not discriminated in the literature. Therefore, characterizations of offshore hardbottom ichthyofauna are not available and literature focused on coral reef fish assemblages of Hawk Channel and the Florida Reef Tract must be consulted. This document does not attempt to summarize the literature on offshore hardbottom of the Florida Keys. Significant recent references on carbonate bank geology include Mallinson et al. (2003).

Bohnsack et al. (1999) provide a summary of a 20 year historical data base that will form the baseline for assessing future changes in reef fish communities in the Florida Keys National Marine Sanctuary. A total of 263 fish taxa from 54 families were observed from 118 coral reef/hardbottom sites in the Florida Keys from 6,673 visual stationary samples from 1979 through 1998. The ten most abundant species accounted for 59% of all individuals observed. Ten species had a frequency-of-occurrence in samples greater than 50% and only ten species accounted for 55% of the total observed biomass.

Live/hardbottom as Essential Fish Habitat

The live bottom areas constitute essential habitat for warm-temperate and tropical species of snappers, groupers, and associated fishes. Exploratory surveys for reef fishes has yielded 119 species representing 47 families of predominately tropical and subtropical fishes off the coasts of North Carolina and South Carolina (Grimes et al., 1982; Lindquist et al 1989; Table 3.3-2). Recently, Parker and Dixon (1998, 2002) identified 119 species of reef fish representing 46 families during underwater surveys 44 km off Beaufort, North Carolina (Table 2.18). Twenty-nine tropical fishes and a basket sponge were new to the study area. Distinct faunal assemblages were associated with two habitats: live/hardbottom on the open shelf; and at the shelf edge.

Table 3.3-2. List of fishes occurring at reef and rock outcropping habitats on the outer continental shelf of North Carolina and South Carolina (Source: Grimes et al. 1982; Lindquist et al. 1989).

Species	Common name	Collection	Habitat type
Carcharhinidae			
Carcharhinus falciformis	Silky shark	HL	SE, ILB
Sphyrnidae			
Sphyrna lewini	Scalloped harmmerhead	GN	SE
Rajidae			
Raja sp.	Skate	TWL	SE
Dasyatidae			
Dasyatis sp.	Stingray	TWL	SE
Muraenidae			
Gymnothorax nigromarginatus	Blackedge moray	HL	SE, ILB
Muraena retifera	Reticulate moray	HL	SE
Ophichthidae			
Ophictus ocellatus	Palespotted eel	HL, SC	SE, ILB
Congridae			
Conger oceanicus	Conger eel	HL, T	SE
Paraconger caudilimbatus	Margintail conger	HL	SE
Engraulidae			
Anchoa sp.	Anchovy	SC	ILB
Synodontidae			
Synodus foetens	Inshore lizardfish	HL	ILB
S. synodus	Red lizardfish	TWL	SE
Trachinocephalus myops	Snakefish	HL, TWL	SE, ILB
Batrachoididae			
Opsanus pardus	Leopard toadfish	T	ILB
Antennaridae			
Antennarius ocellatus	Ocellated frogfish	T	ILB
Ogcocephalidae			
Halieutichthys aculeatus	Pancake batfish	TWL	SE
Ogcocephalus sp.	Batfish	TWL, SC	SE
Gadidae			
Urophycis earlii	Carolina hake	HL	ILB
Ophidiidae			
Rissola marginata	Striped cusk-eel	SC, TWL	ILB
Holocentridae			
Holocentrus ascensionis	Squirrelfish	HL	ILB
H. rufus	Longspine squirrelfish	HL	SE
Fistulariidae			
Fistularia villosa	Red cornetfish	HL	SE
Sygnathidae			
Hippocampus erectus	Lined seahorse	SC	SE, ILB
Sygnathus sp.	Pipefish	SC	SE, ILB
Serranidae			

Centropristis ocyurus	Bank sea bass	HL, TWL	ILB
C. striata	Black sea bass	HL, T, SC	ILB
Dermatolepis inermis	Marbled grouper	HL	ILB
Diplectrum formosum	Sand perch	HL, SC, TWL	ILB
Epinephelus adscensionis	Rock hind	HL	ILB
E. drummondhayi	Speckled hind	HL	ILB
E. flavolimbatus	Yellowedge grouper	HL	SE
E. fulva	Coney	HL	ILB
E. guttatus	Red hind	HL	ILB
E. morio	Red grouper	HL	SE
E. mystacinus	Misty grouper	HL	SE
E. nigritus	Warsaw grouper	HL	SE
E. niveatus	Snowy grouper	HL	SE
Mycteroperca microlepis	Gag	HL	SE, ILB
M. phenax	Scamp	HL	SE, ILB
M. venenosa	Yellowfin grouper	HL	ILB
Ocyanthias martinicensis	Roughtongue bass	TWL	SE
Petrometopon cruentatum	Graysby	HL	ILB
Paranthias furcifer	Creolefish	HL	SE
Serranus phoebe	Tattler	AC	SE
S. subligarius	Belted sandfish	D	ILB
Grammistidae			
Rypticus saponaceous	Greater soapfish	T	ILB
Priacanthidae			
Pristigenys alta	Short bigeye	TWL	ILB
Priacanthus cruentatus	Glasseye snapper	TRP	ILB
Apogonidae			
Apogon pseudomaculatus	Twospot cardinalfish	TWL	ILB
Branchiostegidae			
Caulolatilus microps	Gray tilefish	HL	SE
C. chrysops	Atlantic golden tilefish	HL	SE
Malacanthidae			
Malacanthus plumieri	Sand tilefish	HL	SE
Rachycentridae			
Rachycentron canadum	Cobia	HL	SE
Carangidae			
Alectis crinitus	African pompano	T	ILB
Caranx ruber	Bar jack	D	ILB
Decapterus punctatus	Round scad	SC, TWL	ILB
Seriola dumerili	Greater amberjack	HL	SE, ILB
S. rivoliana	Almaco jack	HL	SE, ILB
Ephippidae			
Chaetodipterus faber	Atlantic spadefish	D	ILB
Lutjanidae			
Lutjanus cyanopterus	Cubera snapper	HL	SE
L. buccanella	Blackfin snapper	HL	SE
L. campechanus	Red snapper	HL	SE, ILB
L. synagris	Lane snapper	TWL	ILB
L. vivanus	Silk snapper	HL	SE

Ocyurus chrysurus	Yellowtail snapper	HL	ILB
Rhomboplites aurorubens	Vermilion snapper	HL	SE, ILB
Pomadasyidae			
Haemulon aurolineatum	Tomtate	SC, HL, TWL	SE, ILB
H. melanurum	Cottonwick grunt	HL	ILB
H. plumieri	White grunt	HL, TWL	ILB
Orthopristis chrysoptera	Pigfish	D	ILB
Balistidae			
Aluterus schoepfi	Orange filefish	SC	ILB
Balistes capriscus	Gray triggerfish	HL	SE, ILB
B. vetula	Fringed filefish	TWL	ILB
Monacanthus hispidus	Planehead filefish	TWL	ILB
Tetraodontidae			
Sphoeroides dorsalis	++Marbled puffer	TWL	ILB
S. spengleri	++Bandtail puffer		
Sparidae			
Diplodus holbrookii	Spottail pinfish	D	ILB
Archosargus probatocephalus	Sheepshead	D	ILB
Calamus leucosteus	Whitebone porgy	D	ILB
Stenotomus chrysops	Scup	D	ILB
Sciaenidae			
Equetus umbrosus	Cubbyu	D	ILB
Labridae			
Haliachoeres bivittatus	Slippery dick	D	ILB

HL=hook and line, T= trap, TWL=trawl, GN=gill net, SC=stomach contents, D=observed by divers, AC= ???
SE=shelf edge, ILB=inshore live bottom
++ indicated species not recorded by Struhsaker (1969)

Table 3.3-3. Number of dives during which fishes and sponges were observed from October 1975 through March 1980[1,2] and April 1990 through August 1993[1] (of a total of 48 and 31 dives, respectively) on the "210 Rock" off Beaufort, North Carolina (Parker and Dixon (1998; 2002).

Species	1975-1980	%	1990-1993	%
Rhincodontidae				
Ginglyostoma cirratum, nurse shark[3]	2	4.2		
Odontaspididae				
Odontaspis taurus, sand tiger			1	2.1
Carcharhinidae				
Carcharhinus leucas, bull shark			1	2.1
C. obscurus, dusky shark			1	3.2
Galeocerdo cuvier, tiger shark			1	2.1
Rhizoprionodon terraenovae, Atlantic sharpnose shark	5	10.4		
Sphyrnidae				
Sphyrna sp., hammerhead			1	2.1
Dasyatidae				
Dasyatis sp., stingray	3	6.3	2	6.5
Muraenidae				
Gymnothorax moringa, spotted moray (S)	5	10.4	5	16.1
G. saxicola, blackedge moray (S)			1	2.1
Muraena retifera, reticulate moray (S)			3	6.3
Ophichthidae				
Myrichthys breviceps, sharptail eel (S)			4	12.9
Congriidae				
Conger sp. or *Paraconger caudilimbatus*, conger (S)	3	6.3		
Clupeidae				
Sardinella aurita, Spanish sardine			2	4.2
Synodontidae				
Synodus foetens, inshore lizardfish (S)			6	19.4
Gadidae				
Urophycis earlli, Carolina hake (S)	9	18.8	2	6.5
Batrachoididae				
Opsanus sp., toadfish[4] (S)			1	3.2
Lophiidae				
Lophius americanus, goosefish (N)			1	2.1
Holocentridae				
Holocentrus ascensionis, longjaw squirrelfish (S)			10	32.3
Aulostomidae				
Aulostomus maculatus, trumpetfish (S)			7	22.6
Fistulariidae				
Fistularia petimba, red cornetfish (S)			2	6.5
Scorpaenidae				
Scorpaena dispar, hunchback scorpionfish (S)	1	2.1		
Serranidae				
**Centropristis striata*, black sea bass (N)	44	91.7	21	67.7
**C. ocyurus*, bank sea bass (S)	44	91.7	30	96.8

Diplectrum formosum, sand perch (S)	1	2.1	6	19.4
**Epinephelus morio*, red grouper (S)	3	6.3	10	32.3
**E. adscensionis*, rock hind (S)			13	41.9
**E. guttatus*, red hind (S)	2	6.5		
**E. cruentatus*, graysby (S)			5	16.1
Hypoplectrus unicolor, butter hamlet (S)			20	64.5
Liopropoma eukrines, wrasse bass (S)	9	18.8	20	64.5
**Mycteroperca microlepis*, gag (S)	48	100.0	30	96.8
**M. phenax*, scamp (S)	20	41.7	30	96.8
**M. interstitialis*, yellowmouth grouper (S)			8	25.8
Rypticus maculatus, whitespotted soapfish (S)	29	60.4	21	67.7
Serranus subligarius, belted sandfish (S)	41	85.4	23	74.2
S. tigrinus, harlequin bass (S)	3	6.3	17	54.8
S. phoebe, tattler (S)	3	9.7		
Priacanthidae				
Priacanthus arenatus, bigeye (S)			18	58.1
P. cruentatus, glasseye snapper (S)			3	9.7
Apogonidae				
Apogon pseudomaculatus, twospot cardinalfish (S)	4	50.0	15	48.4
Rachycentridae				
Rachycentron canadum, cobia			2	6.5
Echeneidae				
Remora remora, remora			1	3.2
Carangidae				
Caranx crysos, blue runner			4	8.3
C. ruber, bar jack	2	4.2	11	35.5
C. bartholomaei, yellow jack			5	16.1
Decapterus punctatus, round scad	26	54.2	5	16.1
**Seriola dumerili*, greater amberjack	41	85.4	28	90.3
**S. rivoliana*, almaco jack	7	14.6	11	35.5
S. zonata, banded rudderfish			4	12.9
Coryphaenidae				
Coryphaena hippurus, dolphin			2	6.5
Lutjanidae				
**Lutjanus campechanus*, red snapper (S)	17	35.4	1	3.2
**L. apodus*, schoolmaster (S)			2	6.5
**Rhomboplites aurorubens*, vermilion snapper (S)			7	14.6
Gerreidae (mojarra)			1	3.2
Haemulidae				
**Haemulon plumieri*, white grunt (S)	45	93.8	30	96.8
**H. aurolineatum*, tomtate (S)	31	64.6	26	83.9
Sparidae				
**Archosargus probatocephalus*, sheepshead (N)		2	4.2	
**Calamus leucosteus*, whitebone porgy (S)	25	52.1	18	58.1
**C. nodosus*, knobbed porgy (S)	12	25.0	30	96.8
**Diplodus holbrooki*, spottail pinfish (S)	34	70.8	14	45.2
**Pagrus pagrus*, red porgy (S)	29	60.4	14	45.2
Stenotomus caprinus, longspine porgy (S)			8	16.7

Sciaenidae				
Equetus umbrosus, cubbyu (S)	39	81.3	27	87.1
E. lanceolatus, jacknife-fish (S)	5	10.4	11	35.5
E. punctatus, spotted drum (S)			2	4.2
Mullidae				
Mulloidichthys martinicus, yellow goatfish (S)	1	2.1	9	29.0
Pseudupeneus maculatus, spotted goatfish (S)	1	2.1	17	54.8
Kyphosidae				
Kyphosus sp., chub (S)			2	4.2
Ephippidae				
Chaetodipterus faber, Atlantic spadefish	6	12.5	9	29.0
Chaetodontidae				
Chaetodon ocellatus, spotfin butterflyfish (S)	9	18.8	22	71.0
C. sedentarius, reef butterflyfish (S)	2	4.2	13	41.9
C. striatus, banded butterflyfish (S)			6	19.4
Pomacanthidae				
Holacanthus bermudensis, blue angelfish (S)	16	33.3	30	96.8
H. ciliaris, queen angelfish (S)	2	4.2	21	67.7
H. tricolor, rock beauty (S)			2	6.5
Pomacanthus paru, French angelfish (S)			4	12.9
Pomacentridae				
Abudefduf tauras, night sergeant (S)			9	29.0
Chromis multilineata, brown chromis (S)	1	2.1	1	3.2
C. insolata, sunshinefish (S)	1	2.1	14	45.2
C. scotti, purple reeffish (S)	45	93.8	29	93.5
C. cyaneus, blue chromis (S)	3	6.3	7	22.6
C. enchrysurus, yellowtail reeffish (S)	36	75.0	25	80.6
Microspathodon chrysurus, yellowtail damselfish (S)	1	2.1		
Poacentrus partitus, bicolor damselfish (S)	18	37.5	24	77.4
P. variabilis, cocoa damselfish (S)	20	41.7	27	87.1
P. fuscus, dusky damselfish (S)	3	6.3	11	35.5
Sphyraenidae				
Sphyraena barracuda, great barracuda	11	21.6	11	32.4
Labridae				
Bodianus pulchellus, spotfin hogfish (S)	8	16.7	29	93.5
B. rufus, Spanish hogfish (S)	15	31.3	26	83.9
Clepticus parrae, creole wrasse (S)			3	9.7
Halichoeres bivittatus, slippery dick (S)	39	81.3	27	87.1
H. garnoti, yellowhead wrasse (S)	10	20.8	13	41.9
**Lachnolaimus maximus,* hogfish (S)	24	77.4		
**Tautoga onitis,* tautog (N)	17	35.4	13	41.9
Thalassoma bifasciatum, bluehead (S)	9	18.8	21	67.7
Scaridae				
Scarus sp. (S)	11	35.5		
Sparisoma viride, stoplight parrotfish (S)	2	6.5		
Sparisoma sp. (S)			11	35.5
Blenniidae				
Hypleurochilus geminatus, crested blenny (S)			2	4.2

Parablennius marmoreus, seaweed blenny (S)	19	47.1	7	2.4
Gobiidae				
Coryphopterus puntipectophorus, spotted goby (S)	14	29.2	5	16.1
G. oceanops, neon goby (S)	2	4.2	2	6.5
Gobiosoma sp. (S)			2	6.5
Ioglossus calliurus, blue goby (S)	9	18.8	11	35.5
Acanthuridae				
Acanthurus bahianus, ocean surgeon (S)	4	8.3	9	29.0
A. coeruleus, blue tang (S)	2	4.2	17	54.8
A. chirurgus, doctorfish (S)			21	67.7
Scombridae				
**Euthynnus alletteratus,* little tunny			3	6.3
**Scomberomorus cavalla,* king mackerel	10	20.8	1	3.2
Balistidae				
Aluterus scriptus, scrawled filefish (S)	1	3.2		
**Balistes capriscus,* gray triggerfish (S)	18	37.5	13	41.9
Monacanthus hispidus, planehead filefish (S)	28	58.3	29	93.5
Ostraciidae,				
Lactophrys sp., boxfish (S)			1	3.2
Tetraodontidae				
Canthigaster rostrata, sharpnose puffer (S)	1	2.1	3	9.7
Diodon sp., porcupinefish (S)			1	2.1
Sphoeroides spengleri, bandtail puffer (S)	3	6.3	22	71.0
**S. maculatus,* northern puffer (N)	2	4.2	1	3.2
Molidae				
Mola mola, ocean sunfish			2	4.2
Nepheliospongiidae				
Xestospongia muta, basket sponge				X[5]
TOTAL				
SPECIES	119		85	96
FAMILIES	46		34	38

[1] Sampling effort was extended beyond the 3-year study periods in an effort to obtain more winter data.
[2] Some totals differ from the published study because three stations were eliminated for locality comparison, and counting errors were corrected.[3] Nondesignated species were not the main concern of this study (e.g., sharks, jacks, and mackerels).
[4] *Opsanus sp*. is likely an undescribed offshore form.
[5] Although invertebrates usually were not recorded, the first observation of basket sponges was noted during our initial resurvey of the "210 Rock", and basket sponges were the subject of many underwater pictures and notations on cleaning stations throughout the second survey period.
* Target species (important in the recreational and commercial fisheries).
S Tropical species.
N Temperate species.

A total of 181 fish species has been reported from Gray's Reef National Marine Sanctuary, an inner-shelf (18-20 m) live bottom reef off Georgia (Hare et al., in prep). A study of South Atlantic Bight reef fish communities by Chester et al. (1984) confirmed that specific reef fish communities could be identified based on the type of habitat. Bottom topography and bottom water temperatures are the two most important factors which create habitats suitable for warm-temperate and tropical species.

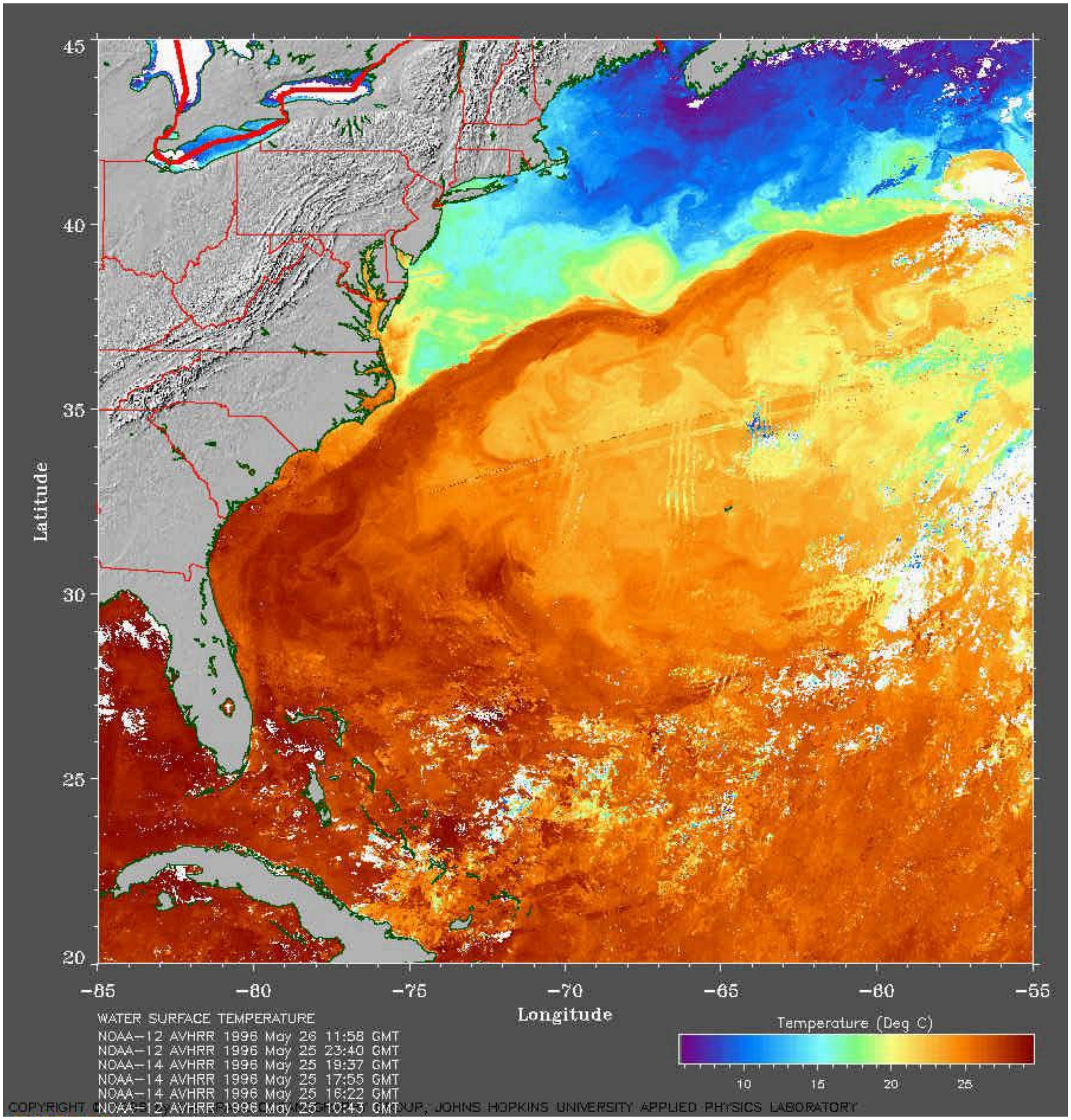
Hardbottom habitats off mainland southeast Florida and areas off the Carolinas are often centrally placed between mid-shelf reefs to the east and estuarine habitats within inlets to the west. Therefore, they may serve as settlement habitats for immigrating larvae or as intermediate nursery habitats for juveniles emigrating out of inlets (Vare 1991; Lindeman and Snyder 1999). This cross-shelf positioning, coupled with their role as the only natural structures in these areas, suggests nearshore hardbottom may represent important Essential Fish Habitat.

Section 600.815 (a) (9) of the final rule on essential fish habitat determinations recognizes that subunits of EFH may be of particular concern. Such areas, termed Essential Fish Habitat-Habitat Areas of Particular Concern (EFH-HAPCs), can be identified using four criteria from the rule: a) importance of ecological functions; b) sensitivity to human degradation; c) probability and extent of effects from development activities; and d) rarity of the habitat. Applications of EFH and EFH-HAPCs in the management of the SAFMC snapper-grouper complex was examined in Lindeman et al (2000), with a focus on developmental variation and MPAs. Hardbottom habitat types which ranked high in terms of the four criteria above are summarized below.

Charleston Bump and Gyre

The topographic irregularity southeast of Charleston, South Carolina known as the Charleston Bump is an area of productive seafloor, which rising abruptly from 700 to 300 meters over 20 km. The Charleston Bump is located approximately at 32° 44' N. Latitude and 78° 06' W. Longitude and at an angle which is approximately transverse to both the general isobath pattern and the Gulf Stream currents. Those areas that contain the highest relief are the only known spawning locations for wreckfish. This species is fished intensively within the relatively small area of high relief, and is one of the few species within the snapper-grouper fisheries complex that has been successfully managed as a sustained fishery (Sedberry et al. 2001).

The Charleston Gyre (Figure 3.3-2) is considered an essential nursery habitat for some offshore fish species with pelagic stages, such as reef fishes (Govoni and Hare 2001; Sedberry et al. 2001). The cyclonic Charleston Gyre is a permanent oceanographic feature of the South Atlantic Bight induced by the deflection of rapidly moving Gulf Stream waters by the Charleston Bump. The gyre produces a large area of upwelling of nutrients, which contributes significantly to primary and secondary production within the SAB region. It is also important in retention and cross-shelf transport of larvae of reef fishes that spawn at the shelf edge (Sedberry et al. 2001). The size of the deflection and physical response in terms of replacement of surface waters with nutrient rich bottom waters from depths of 450 meters to near surface (less than 50 meters) vary with seasonal position and velocity of the Gulf Stream currents (Bane et al. 2001). The nutritional contribution of the large upwelling area to productivity of the relatively nutrient poor SAB is significant. While a lot of emphasis has been placed on shallow habitats, the South Atlantic Fishery Management Council (SAFMC 1998) designated the Charleston Gyre as an essential nursery habitat for some offshore fish species with pelagic stages, such as reef fishes, because of increased productivity that is important to ichthyoplankton.



Approximate Corner Points of - Area Encompassing Charleston Gyre Occurrence

NW 79° 30' W 32° 30' N NE 77° W 34°20' N

SW 78° 45' W 31° 20' N SE 75° 30' W 33° N

Figure 3.3-2. Composite sea surface temperature image (3 day image, ending May 26, 2002). Deflection of the Gulf Stream offshore and downstream of the Charleston Bump creates the "The Charleston Gyre". The Gyre is visible at 32°N latitude (Source: Johns Hopkins University / Applied Physics Laboratory, Ocean Remote Sensing Group recording Advanced High Resolution Radiometer (AVHRR) on the NOAA polar-orbiting satellite).

The South Atlantic Bight, the Charleston Bump and Gyre are described in greater detail in several research and review papers (e.g., Bane et al. 2001; Sedberry et al. 2001; Govoni and Hare 2001 and papers cited therein). The following synopsis is based on the review by Sedberry et al. (2001) and O. Pashuk (pers. comm).

The continental shelf off the southeastern United States, commonly called the South Atlantic Bight (SAB), extends from Cape Hatteras, North Carolina, to Cape Canaveral, Florida (or according to some researchers, to West Palm Beach, Florida). The northern part of the SAB is known as the Carolina Capes Region, while the middle and southern areas are called the Georgia Embayment, or Georgia Bight. The Carolina Capes Region is characterized by complex topography, and their prominent shoals extending to the shelf break are effective in trapping Gulf Stream eddies, whereas the shelf to the south is smoother.

Shelf widths vary from just a few kilometers off West Palm Beach, FL, to a maximum of 120 km off Brunswick and Savannah, Georgia. Gently sloping shelf (about 1m/km) can be divided into the following zones: 1) **Inner shelf (0-20 m)** which is dominated by tidal currents, river runoff, local wind forcing and seasonal atmospheric changes; 2) **Midshelf zone (21-40 m)** where waters are dominated by winds but influenced by the Gulf Stream. Stratification of water column changes seasonally: mixed conditions, in general, characterize fall and winter while vertical stratification prevail during spring and summer. Strong stratification allows the upwelled waters to advect farther onshore near the bottom and, at the same time, it facilitates offshore spreading of lower salinity water in surface layer. 3) **Outer shelf (41-75 m)** is dominated by the Gulf Stream. The shelf break, generally, occurs at about 75-m depth, but is shallower southward.

Oceanographic regime on the continental shelf in the South Atlantic Bight is mainly conditioned by 1) proximity of the Gulf Stream with its frequent meanders and eddies; 2) river runoff; 3) seasonal heating and cooling; and 4) bottom topography. Winds and tides can also modify circulation patterns, especially nearshore, or where density gradients are weak. Temperature and salinity of shelf waters widely fluctuate seasonally (from 10° C to 29° C and from 33.0 ppt to 36.5 ppt), whereas warm and salty surface Gulf Stream waters have much less variable properties.

The warming influence of the Gulf Stream is especially notable in the winter near the shelf break where tropical species of fish, corals and other animals are found. A warm band of relatively constant temperature (18-22° C) and salinity (36.0 ppt - 36.2 ppt) water is observed near bottom year-round just inshore of the shelf break, bounded by seasonally variable inshore waters on one side, and by fluctuating offshore waters on the other side, which are subject to cold eddy/upwelling events and warm Gulf Stream intrusions.

Fresh water nearshore is supplied mainly by the Cape Fear, Pee Dee, Santee, Savannah, and Altamaha rivers. River runoff is the highest during late winter-early spring, with maximum in March. The affect of runoff on coastal and shelf waters is most pronounced by April. Seasonal heating and cooling of coastal and shelf waters follow a trend in air temperature's increase and decrease, with a lag of approximately one month also.

Geostrophic southward flow develops on the continental shelf and appears to be seasonal, reflecting river runoff and heating-cooling effects. This counter-current is maximum during summer. In late fall-winter, in general, it is no longer a broad continuous flow, and is restricted to narrow patches mainly in nearshore areas in the vicinity of river mouths.

Fluctuations in the Icelandic Low, the Bermuda-Azores High, and the Ohio Valley High largely govern the mean wind patterns in the SAB. Winds, in general, are from Northeast in fall-winter, and from Southwest in spring-summer, but they can be of different directions during a passage of atmospheric fronts.

Semidiurnal (M2) tides dominate the SAB. Tidal range varies considerately in the SAB because of varying shelf widths. The maximum coastal tides of 2.2 m occur at Savannah, Georgia, where the shelf is widest, and decrease to 1.3 m at Cape Fear and 1.1 m at Cape Canaveral.

Small frontal eddies and meanders propagate northward along the western edge of the Gulf Stream every 1-2 weeks. They provide small-scale upwellings of nutrients along the shelf break in the SAB. In contrast to transit upwellings, there are two areas in the SAB where upwelling of nutrient-rich deepwater is more permanent. One such upwelling is located just to the north of Cape Canaveral which is caused by diverging isobaths. The other, much larger and stronger upwelling occurs mainly between 32° N. Latitude and 33° N. Latitude, and it results from a deflection of the Gulf Stream offshore by the topographic irregularity known as the Charleston Bump.

In general, the Gulf Stream flows along the shelf break, with very little meandering, from Florida to about 32° N latitude where it encounters the Charleston Bump and is deflected seaward forming a large offshore meander. The cyclonic Charleston Gyre is formed, with a large upwelling of nutrient-rich deepwater in its cold core. The Charleston Bump is the underwater ridge/trough feature located southeast of Charleston, South Carolina, where seafloor rises from 700 to 300 m within a relatively short distance and at a transverse angle to both the general isobaths pattern of the upper slope, and to Gulf Stream currents. Downstream of the Charleston Bump, enlarged wavelike meanders can displace the Gulf Stream front up to 150 km from the shelf break. These meanders can be easily seen in satellite images.

Although 2-3 large meanders and eddies can form downstream of the Bump, the Charleston Gyre is the largest and the most prominent feature. The consistent upwelling of nutrient-rich deepwaters from the depths over 450 m to the near-surface layer (less than 50 m) is the main steady source of nutrients near the shelf break within the entire South Atlantic Bight, and it contributes significantly to primary and secondary production in the region. The Charleston Gyre is considered an essential nursery habitat for some offshore fish species with pelagic stages. It is also implicated in retention of fish eggs and larvae and their transport onshore.

The Charleston Bump and the Gyre can also create suitable habitats for adult fish. For example, the highest relief of the Bump is the only known spawning location of the wreckfish. The Charleston Gyre may be also beneficial to other demersal species of the Snapper-Grouper complex, as well as to pelagic migratory fishes, due to food availability and unique patterns of the currents in this area.

Ten Fathom Ledge and Big Rock
The Ten Fathom Ledge and Big Rock areas are located south of Cape Lookout, North Carolina. The Ten Fathom Ledge is located at 34° 11' N. Latitude 76° 07' W. Longitude in 95 to 120 meter depth on the Continental Shelf in Onslow Bay, North Carolina, beginning along the southern edge of Cape Lookout Shoals. This area encompasses numerous patch reefs of coral-algal-sponge growth on rock outcroppings distributed over 136 square miles of ocean floor. The substrate consists of oolithic calcarenites and coquina forming a thin veneer over the underlying Yorktown formation of silty sands, clays, and calcareous quartz sandstones.

The Big Rock area encompasses 36 square miles of deep drowned reef around the 50-100 meter isobath on the outer shelf and upper slope approximately 36 miles south of Cape Lookout. Hard substrates at the Big Rock area are predominately algal limestone and calcareous sandstone. Unique bottom topography at both sites produces oases of productive bottom relief with diverse and productive epifaunal and algal communities surrounded by a generally monotonous and relatively unproductive sand bottom. Approximately 150 species of reef-associated species have been documented from the two sites (R. Parker, pers. comm.).

Shelf Break Area from Florida to North Carolina
Although the area of bottom between 100 and 300 meters depths from Cape Hatteras to Cape Canaveral is small relative to the more inshore live bottom shelf habitat as a whole, it constitutes essential fish habitat for deepwater reef fish. A series of troughs and terraces are composed of bioeroded limestone and carconate sandstone (Newton et al. 1971), and exhibit vertical relief ranging from less than half a meter to more than 10 meters. Ledge systems formed by rock outcrops and piles of irregularly sized boulders are common.

Overall, the deepwater reef fish community probably consists of fewer than 50 species. Parker and Ross (1986) observed 34 species of deepwater reef fishes representing 17 families from submersible operations off North Carolina in waters 98 to 152 meters deep. In another submersible operation in the Charleston Bump area off South Carolina, Gutherz et al. (1995) describe sightings of 27 species of deepwater reef fish in waters 185 to 220 meters in depth.

Gray's Reef National Marine Sanctuary
Gray's Reef National Marine Sanctuary (GRNMS) is located 17.5 nautical miles east of Sapelo Island, Georgia, and 35 nautical miles northeast of Brunswick, Georgia. Gray's Reef encompasses nearly 32 km^2 at a depth of about 22 meters (Parker et al. 1994). The Sanctuary contains extensive, but patchy hardbottoms of moderate relief (up to 2 meters). Rock outcrops, in the form of ledges, are often separated by wide expanses of sand, and are subject to weathering, shifting sediments, and slumping, which create a complex habitat including caves, burrows, troughs, and overhangs (Hunt 1974). Parker et al. (1994) described the habitat preference of 66 species of reef fish distributed over five different habitat types. Numbers of species and fish densities were highest on the ledge habitat, intermediate on live bottom, and lowest over sand.

Nearshore Hardbottom of Mainland East Florida
Extending semi-continuously from at least St. Augustine Cape Canaveral to the Florida Keys, nearshore hardbottom was evaluated in terms of the four HAPC criteria in Section 600.815 of the

final EFH interim rule. In terms of ecological function, several lines of evidence suggest that nearshore hardbottom reefs may serve as nursery habitat. The most recent summary information on NHB in mainland east Florida is within CSA (2009). The following is based on the quantitative information available for the southeast Florida mainland (Lindeman 1997a and b; Lindeman and Snyder 1999; Baron et al. 2004), which also included life stage-specific abundance data. First, pooled early life stages consistently represented over 80% of the total individuals at all sites censused. Second, eight of the top ten most abundant species were consistently represented by early stages. Third, use of hardbottom habitats was recorded for newly settled stages of more than 20 species.

Although suggestive of nursery value, these lines of evidence need to be viewed in the appropriate context. The presence of more juvenile stages than adults does not guarantee a habitat is a valuable nursery. Rapid decays in the benthic or planktonic survival of early stages of marine fishes are common demographic patterns (Shulman and Ogden 1987; Richards and Lindeman 1987), ensuring that if distributions are homogeneous, all habitats will have more early stages than adults. Are early stages equally distributed among differing habitats or consistently skewed towards particular cross-shelf habitats? The high numbers of early stages on nearshore reefs appear to reflect more than just larger initial numbers of young individuals. Newly settled stages of most species of grunts and eight of nine species of snappers of the southeast mainland Florida shelf have been recorded primarily in depths less than five meters, despite substantial sampling efforts in deeper waters. Adults are infrequent or absent from the same shallow habitats. There is habitat segregation among life stages, with the earliest stages using the most shallow habitats in many species of grunts and snappers (Starck 1970; Dennis 1992; Lindeman et al. 1998). Similar ontogenetic differences in both distribution and abundance exist for many other taxa which utilize nearshore hardbottom habitats. Based on this and other evidence, Lindeman and Snyder (1999) concluded that at least 35 species utilize nearshore hardbottom as a primary or secondary nursery area. At least ten of these species are managed under the Snapper/Grouper FMP.

Because nearshore areas are relatively featureless expanses of sand in the absence of hardbottom, such structures may also have substantial value as reference points for spawning activities of inshore fishes. Many fishes require three-dimensional structure as a reference point for coarse-scale aggregation and fine-scale behavior during spawning (Thresher 1984). Using information from the literature, personal observations, and discussions with commercial fishermen, 15 species were estimated to spawn on nearshore reefs (Lindeman 1997a). An additional 20 species may also spawn on or near these reefs. Some are of substantial economic value; these include snook, pompano, and several herring species. At least 90 species known to associate with nearshore hardbottom structures are utilized in South Florida fisheries. The majority of these species are represented primarily by early life stages. Approximately 51 species are of recreational value and thirty species are of commercial value. Twenty-two species are utilized for bait and 21 species are marketed within the aquaria industry. Based on the demonstrated or potential value of these areas as nurseries and spawning sites for many economically valuable species, nearshore hardbottom habitats were estimated to support highly important ecological functions, the first HAPC criterion.

The second and third HAPC criteria, sensitivity and probability of anthropogenic stressors, are interrelated in terms of nearshore hardbottom. They are treated collectively here. Various stretches of nearshore hardbottom have been completely buried by dredging projects associated with beach management activities in this subregion (Section 7.4.2.2). They may also be subjected to indirect stressors over both short and long time scales from such projects. For example, between 1995 and 1998, up to 19 acres of nearshore hardbottom reefs were buried by beach dredging projects at two sites in Palm Beach County. Such activities occur within other counties of this subregion as well. The 50-year planning document for beach management in southeast mainland Florida (ACOE 1996), includes beach dredge-fill projects for over fifteen areas, with renourishment intervals averaging 6-8 years. Given the past and projected future, it is concluded that both the sensitivity of these habitats and the probability of anthropogenic stressors is high.

In terms of the final EFH-HAPC criterion, rarity, nearshore hardbottom also ranks high. In southeast mainland Florida, most shorelines between Dade and Broward Counties (25°30'-26°20' N) lack natural nearshore hardbottom with substantial three-dimensional structure (ACOE 1996). Although substantial stretches of nearshore hardbottom exist in portions of Palm Beach, Martin, St. Lucie, and Indian River Counties (Perkins et al. 1997) (26°20'-27°15' N) these reefs are often separated by kilometers of barren stretches of sand. Offshore, most mid-shelf areas (5-20 m) are also dominated by expanses of sand despite the variable occurrence of several mid-shelf reef lines. Therefore, there are no natural habitats in the same or adjacent nearshore areas that can support equivalent abundances of early life stages. Absences of nursery structure can logically result in increased predation and lowered growth. In newly settled and juvenile stages, such conditions could create demographic bottlenecks that ultimately result in lowered local population sizes.

Nursery usage of nearshore hardbottom reefs may be a bi-directional phenomenon. Many species utilize these habitats during both newly settled and older juvenile life stages. This suggests that nearshore hardbottom can facilitate both inshore and offshore migrations during differing ontogenetic stages of some species. Their limited availability does not necessarily decrease their value. When present, they may serve a primary nursery role as shelter for incoming early life stages which would undergo increased predation mortality without substantial habitat structure. In addition, some species use these structures as resident nurseries; settling, growing-out, and maturing sexually as permanent residents (e. g., pomacentrids, labrisomids). A secondary nursery role may result from increased growth because of higher food availabilities in structure-rich environments. Nearshore hardbottom may also serve as secondary nursery habitat for juveniles that emigrate out of inlets towards offshore reefs. This pattern is seen in gray snapper and bluestriped grunt which typically settle inside inlets and primarily use nearshore hardbottom as older juveniles (Lindeman et al. 1998).

In summary, nearshore hardbottom habitats of southeast Florida ranked high in terms of ecological function, sensitivity, probability of stressor introduction, and rarity. Based on the criteria in Section 600.815 (a) (9), it is concluded that they represent Essential Fish Habitat-Habitat Areas of Particular Concern for species managed under the Snapper/Grouper Fishery Management Plan and dozens of other species which co-occur with many species in this management unit. Many of these other species, not currently managed under the SAFMC are important prey items (Randall, 1968) for those species under management.

3.3.1.3 Deepwater coral habitat

Description and distribution

(excerpted from Chapter 6 (Ross and Nizinski) of the 2007 Status of Deep Coral Ecosystems) The southeast U.S. slope area, including the slope off the Florida Keys, appears to have a unique assemblage of deepwater Scleractinia (Cairns and Chapman 2001). The warm temperate assemblage identified by Cairns and Chapman (2001) contained about 62 species, four endemic to the region. This group was characterized by many free living species, few species living deeper than 1000 m, and many species with amphi-Atlantic distributions. For the southeastern U.S., in areas deeper than 200 m, we report a similar assemblage, consisting of 57 species of scleractinians (including 47 solitary and ten colonial structure-forming corals), four antipatharians, one zoanthid, 44 octocorals, one pannatulid, and seven stylasterids. Thus the region contains at least 114 species of deep corals (classes Hydrozoa and Anthozoa). This list is conservative, however; we expect that more species will be discovered in the region as exploration and sampling increase. Below we discuss the major structure-forming corals that most contribute to reef-like habitats in the southeastern U.S.

Stony Corals (Class Anthozoa, Order Scleractinia)

The dominant structure-forming coral on the southeastern U.S. outer shelf (<200 m) is *Oculina varicosa* (ivory tree coral). Although it occurs from Bermuda and North Carolina south through the Gulf of Mexico and the Caribbean in 2-152 m depths, this coral only forms large reefs off east-central Florida, 27° 32’ N to 28° 59’ N, in 70-100 m (Figure 3.3-3; Reed 2002b). The shallow water form of *Oculina* may have symbiotic zooxanthellae, but the deeper form does not.

The deeper reefs are almost monotypic mounds and ridges which exhibit a vertical profile of 3-35 m (Avent et al. 1977; Reed 2002b). Superficially, these structures resemble the deep reefs formed by *Lophelia pertusa*. Despite cool temperatures, the shelf edge *Oculina* exhibit rapid growth, probably facilitated by regular upwellings of nutrient rich water (Reed 1983).

Lophelia pertusa, the major structure building coral in the deep sea, is the dominant scleractining off the southeastern U.S. This species has a cosmopolitan distribution, occurring on the southeastern U.S. slope, in the Gulf of Mexico, off Nova Scotia, in the northeastern Atlantic, the South Atlantic, the Mediterranean, Indian Ocean and in parts of the Pacific Ocean over a depth range of 50 to 2170 m (Cairns 1979; Rogers 1999). The 3380m depth record off New York for *L. pertusa* reported by Squires (1959) was based on a misidentified specimen (Cairns 1979). Coral habitats dominated by *Lophelia pertusa* are common throughout the southeast U.S. in depths of about 370 to at least 800 m.

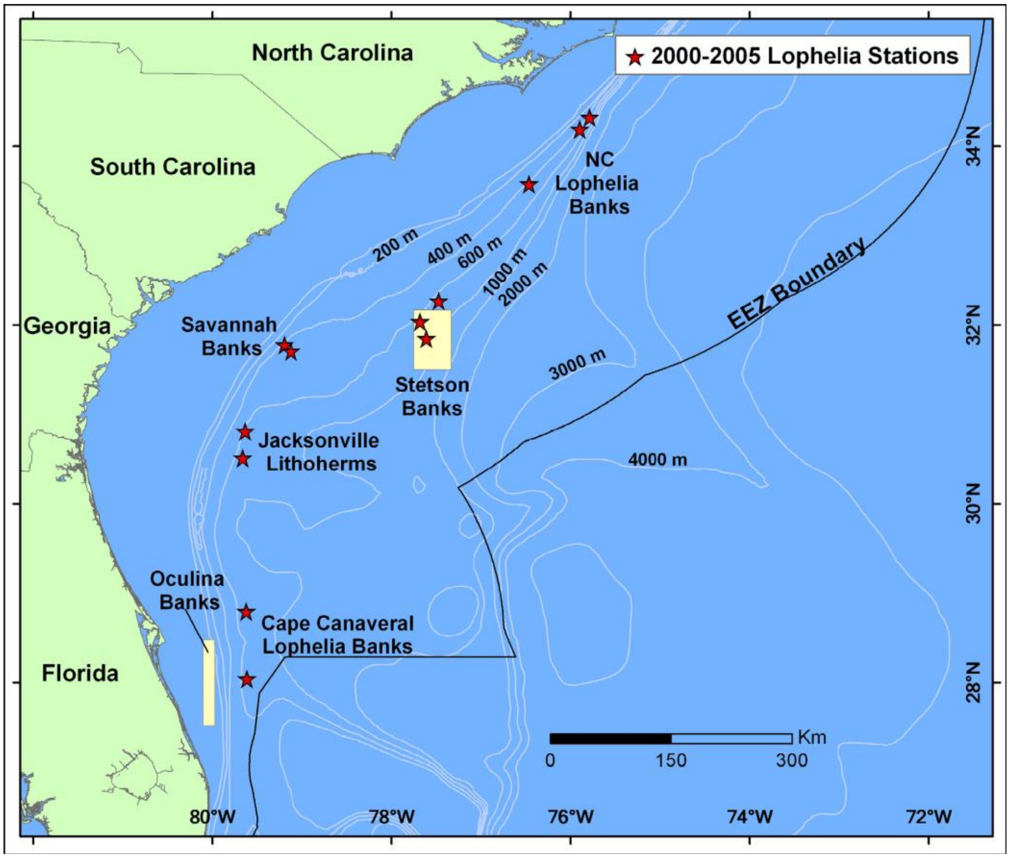


Figure 3.3-3. Southeastern United States regional report area, indicating general areas of *Oculina varicosa* reefs and the deeper coral (*Lophelia* mostly) habitats sampled by Ross et al. from 2000-2005 (red stars). The Stetson Bank (white box) is described in the text. Note that these areas do not represent all sites where deep (> 200 m) corals occur nor all sites visited by other researchers. See Reed et al. (2005, 2006) and Partyka et al. (in press) for additional deep coral sites in this region.

Although *Lophelia* may occur in small scattered colonies attached to various hard substrata, it also forms complex, high profile features. For instance, off North Carolina, *Lophelia* forms what may be considered classic mounds that appear to be a sediment/coral rubble matrix topped with almost monotypic stands of *L. pertusa*. Along the sides and around the bases of these banks are rubble zones of dead, gray coral pieces which may extend large distances away from the mounds. To the south sediment/coral mounds vary in size, and *L. pertusa* and other hard and soft corals populate the abundant hard substrata of the Blake Plateau in great numbers

Data are lacking on how *Lophelia* coral banks in the southeastern U.S. are formed. Hypotheses for coral mound formation in the northeastern Atlantic were proposed (Hovland et al. 1998; Hovland and Risk 2003; Masson et al. 2003), but it is unclear how relevant these are off the southeastern U.S. The mounds off North Carolina and those in other locations off the southeastern U.S. (particularly east of south-central Florida) appear to be formed by successive coral growth, collapse, and sediment entrapment (Wilson 1979; Ayers and Pilkey 1981; Paull et al. 2000; Popenoe and Manheim 2001). Other coral formations in the area (especially on the

Blake Plateau) seem to form by coral colonization of appropriate hard substrates, without mound formation by the corals. If bottom currents are too strong, mound formation may be prevented (Popenoe and Manheim 2001) because sediments cannot be trapped. Ayers and Pilkey (1981) suggested that Gulf Stream currents may erode coral mounds, and that present coral bank sizes may be related to historical displacements of that current. Assuming currents also carry appropriate foods, it may be that currents with variable speeds or at least currents of moderate speeds (fast enough to facilitate filter feeding but not too fast to prevent sediment entrapment) coupled with a supply of sediment are the conditions necessary to facilitate coral mound formation (Rogers 1999). Regardless of how coral formations are created, we agree with Masson et al. (2003) that elevated topography appears to be an important attribute for well developed coral communities.

Deep-coral reefs are fragile and susceptible to physical destruction (Fossa et al. 2002). It is estimated that these deep reefs may be hundreds to thousands of years old (Neumann et al. 1977; Wilson 1979; Ayers and Pilkey 1981; Mikkelsen et al. 1982; Mortensen and Rapp 1998); however, aging data are so limited (especially in the western Atlantic) that age of coral mounds in the western Atlantic is unclear. Recent drilling on coral mounds off Ireland indicated that these structures started forming over two million years ago and that formation was not related to hydrocarbon seeps (Williams T et al. 2006). While the genetic structure (gene flow, population relationships, taxonomic relationships) of *Lophelia* in the northeastern Atlantic is being described (Le Goff-Vitry et al. 2004), such studies are just beginning in the western Atlantic (C. Morrison et al. unpublished data). Preliminary genetic results from the southeast region suggest that the population structure of *L. pertusa* is more diverse than expected (C. Morrison et al. unpublished data). Understanding the population genetics and gene flow will provide insights into coral biology, dispersal and distribution of deep corals off the southeastern U.S. Although *Lophelia* is the dominant hard coral off North Carolina, other scleractinians contribute to the overall complexity of the habitat (Table 2.18). Overall, species diversity of scleractinians increases south of Cape Fear, NC, but *L. pertusa* is still dominant. For example, the colonial corals *Madrepora oculata* and *Enallopsammia profunda*, rare off Cape Lookout, NC, are relatively common south of Cape Fear, NC. These hard corals tend not to occur singly or as species-specific mounds, but rather live on or adjacent to the *Lophelia* mounds. A variety of solitary corals are also found off the southeastern U.S. Individuals are often attached to coral rubble or underlying hard substrata. Most species appear to be either uncommon or rare. But, in some instances, particularly in the central portion of the region, local abundance can be high. For example, aggregations of *Thecopsammia socialis* and *Bathypsammia fallosocialis* carpet the bottom adjacent to reef habitat at study sites off South Carolina and northern Florida (Ross et al. unpublished data).

Black corals (Class Anthozoa, Order Antipatharia)
Black corals (Families Leiopathidae and Schizopathidae, ca. four species) are important structure-forming corals on the southeastern U.S. slope (Table 3.3-4). These corals occur locally in moderate abundances, but their distributions seem to be limited to the region south of Cape Fear, NC. Colonies may reach heights of 1-2 m. Black coral colonies, occurring singly or in small aggregations, may be observed either in association with hard coral colonies or as separate entities. Some of these living components of the deep reefs attain ages of hundreds to thousands of years (Williams B et al. 2006; Williams et al. in press; C. Holmes and S.W. Ross, unpublished

data), and thus, along with gold corals, are among the oldest known animals on Earth. Black corals form annual or regular bands, and these bands contain important chemical records on past climates, ocean physics, ocean productivity, pollution, and data relevant to global geochemical cycles. An effort to investigate these geochemical data is underway by U.S. Geological Survey (C. Holmes and S.W. Ross).

Table 3.3-4. Attributes of structure-forming deep-sea corals of the southeastern United States.

Taxa	Reef-building	Abundance	Max colony size	Morphology	Associations with other structure-forming invertebrates	Colony spatial dispersion	Overall structural importance
Lophelia pertusa	Yes	High	Large	Branching	Many	Clumped	High
Solenosmillia variabilis	No	Low	Small	Branching	Many	Clumped	Low
Enallopsammia profunda	No	Low-Medium	Small-Medium	Branching	Many	Clumped	Low-Medium
Madrepora oculata	No	Low	Small	Branching	Many	Clumped	Low
Oculina varicosa	Yes	High	Large	Branching	Many	Clumped	High
Madracis myriaster	No	Low	Small-Medium	Branching	Many	Clumped	Low
Leiopathes glaberrima	No	Medium	Medium - Large	Branching	Many	Solitary	Medium
Bathypathes alternata	No	Low	Medium - Large	Branching	Many	Solitary	Low
Keratoisis spp.	No	Medium	Medium - Large	Branching	Many	Solitary	Medium

Table Key	
Attribute	**Measure**
Reef-Building	Yes/No
Relative Abundance	Low/ Medium/ High
Size (width or height)	Small (< 30cm)/ Medium (30cm-1m)/ Large (>1m)
Morphology	Branching/ Non-branching
Associations	None/ Few (1-2)/ Many (>2)
Spatial Dispersion	Solitary/ Clumped
Overall Rating	Low/ Medium/ High

Gold corals (Class Anthozoa, Order Zoanthidae)

Gerardia spp. colonies are found most often singly away from other coral structure, but these corals are also found associated with colonies of other structure-forming corals such as *Lophelia* *pertusa*, *Keratoisis* spp., or antipatharians (*Leiopathes* spp.). Very little is known about this group of organisms. They apparently exhibit slow growth, reaching ages of at least 1800 years old (Griffin and Druffel 1989; Druffel et al. 1995) and may be valuable in paleoecology studies.

Gorgonians (Class Anthozoa, Order Gorgonacea)
The gorgonians are by far the most diverse taxon on the southeastern U.S. slope represented by seven families, 17 genera, and 32 species. The diversity of gorgonians increases dramatically south of Cape Fear, NC. Additional sampling is likely to increase the numbers of known species in this group for this region. To date, material we collected off Jacksonville, FL represented a newly described species (*Thourella bipinnata* Cairns 2006); the specimen of *Chrysogorgia squamata* also collected off Jacksonville represented the fifth known specimen of this species and increased our knowledge of its geographic range (previously known only from the Caribbean).

Bamboo corals (Family Isididae, four species), possibly the best known members of this group because of their larger size and distinctive morphology, are also important structure-forming corals off the southeast region (Table 3.3-4). They occur locally in moderate abundances, and their distributions also seem to be limited to the region south of Cape Fear, NC. Colonies may reach heights of 1-2 m. Bamboo coral colonies occur either singly or in small aggregations and may be observed either in association with hard coral colonies or as separate entities.

True soft corals (Class Anthozoa, Order Alcyonacea)
Three families, Alcyoniidae, Nephtheidae, and Nidaliidae, comprise the Alcyonacea off the southeastern U.S. No family is speciose; total known diversity for this group is only six species. The most abundant species observed in the region is *Anthomastus agassizi*, which is relatively abundant at sites off Florida. It is usually attached to dead *Lophelia*, but some individuals have also been observed on dermosponges and coral rubble. The majority of the alcyonacean species are smaller in size, both in vertical extent and diameter, than the gorgonians. Thus, these corals add to the overall structural complexity of the habitat by attaching to hard substrata such as dead scleractinian skeletons and coral rubble.

Stoloniferans, a suborder (Stolonifera) within the Alcyonacea, are represented by one family (Clavulariidae) off the southeast region. Six species from four genera have been reported from the region. One species, *Clavularia modesta*, is widespread throughout the western Atlantic; the other five species are known from North Carolina southward to the Caribbean.

Pennatulaceans (Class Anthozoa, Order Pennatulacea)
Little is known about pennatulids (sea pens) off the southeastern U.S. It is unlikely that this group contributes significantly to the overall complexity and diversity of the system. No sea pens have been observed during recent surveys (Ross et al., unpublished data) and based on museum records, only one species (*Kophobelemnon sertum*) is known in the region.

Stylasterids (Class Hydrozoa, Order Anthoathecatae)
Although not found in great abundances, stylasterids (lace corals) commonly occur off the southeastern U.S. Seven species representing four genera have been reported from the region.

Individuals observed in situ are often attached to dead scleractinian corals or coral rubble. Abundance and diversity of stylasterids increase southward from the Carolinas.

The following detailed descriptions of deepwater coral areas included in the SAFMC's proposal for HAPC designation were extracted from reports developed by S. Ross and J. Reed for the SAFMC in 2006 and 2004, respectively.

North Carolina Deep Coral Banks (from Ross' report to the SAFMC 2006)
Off North Carolina, *Lophelia* forms what may be considered classic mounds (three areas surveyed so far) that appear to be a sediment/coral rubble matrix topped with almost monotypic stands of *L. pertusa*. Although *Lophelia* is the dominant hard coral off North Carolina, other scleractinians contribute to the overall complexity of the habitat. These include the colonial corals *Madrepora oculata* and *Enallopsammia* spp. as well as a variety of solitary corals. These hard corals tend to live on or within the *Lophelia* matrix. The three North Carolina *Lophelia* mounds are the northernmost coral banks in the southeast U.S. Because these banks seem to be a northern terminus for a significant zoogeographic region, they may be unique in biotic resources as well as habitat expression. The three NC banks are generally similar in physical attributes and faunal composition. Some observed differences, however, are being investigated, and more detailed results will be presented in several peer reviewed publications in preparation (Ross et al.). For convenience these three areas have been designated as Cape Lookout *Lophelia* Bank A, Cape Lookout *Lophelia* Bank B, and Cape Fear *Lophelia* Bank. These names are to facilitate research and may eventually be changed. General descriptions of the NC coral mounds and associated fauna follows. Since there are almost no data published for the NC deep coral banks and because they are different than those to the south, they are discussed in more detail below. Between summer 2000 and fall 2005 Ross et al. (unpubl. data) sampled these areas extensively using a variety of methods throughout the water column. Their major method for collecting bottom data on the reef proper was the *Johnson-Sea-Link* (JSL) research submersible.

<u>Cape Lookout Lophelia Bank A</u>
Preliminary observations suggest that this area contains the most extensive coral mounds off North Carolina; however, it must be emphasized that data are lacking to adequately judge overall sizes and areal coverage. Ross et al. JSL submersible dives in this area ranged from 370-447 m. Mean bottom temperatures ranged from 6.3 to 10.9°C, while mean bottom salinities were always around 35 ppt. There appear to be several prominences capping a ridge system, thus, presenting a very rugged and diverse bathymetry, but there are also other mounds away from the main ridge sampled (Figure 3.3-4). The main mound system rises vertically nearly 80 m over a distance of about 1 km, and in places exhibits slopes in excess of 50-60 degrees. Sides and tops of these mounds are covered with extensive colonies of living *Lophelia pertusa*, with few other corals being observed. Dead colonies and coral rubble interspersed with sandy channels are also abundant. Extensive coral rubble zones surround the mounds for a large, but unknown, distance (exact area not yet surveyed), especially at the bases of the mounds/ridges, and in places seem to be quite thick. These mounds appear to be formed by successive coral growth, collapse, and sediment entrapment (Wilson 1979; Popenoe and Manheim 2001). These topographic highs accelerate bottom currents, which favor attached filter feeders; very strong bottom currents have also been observed.

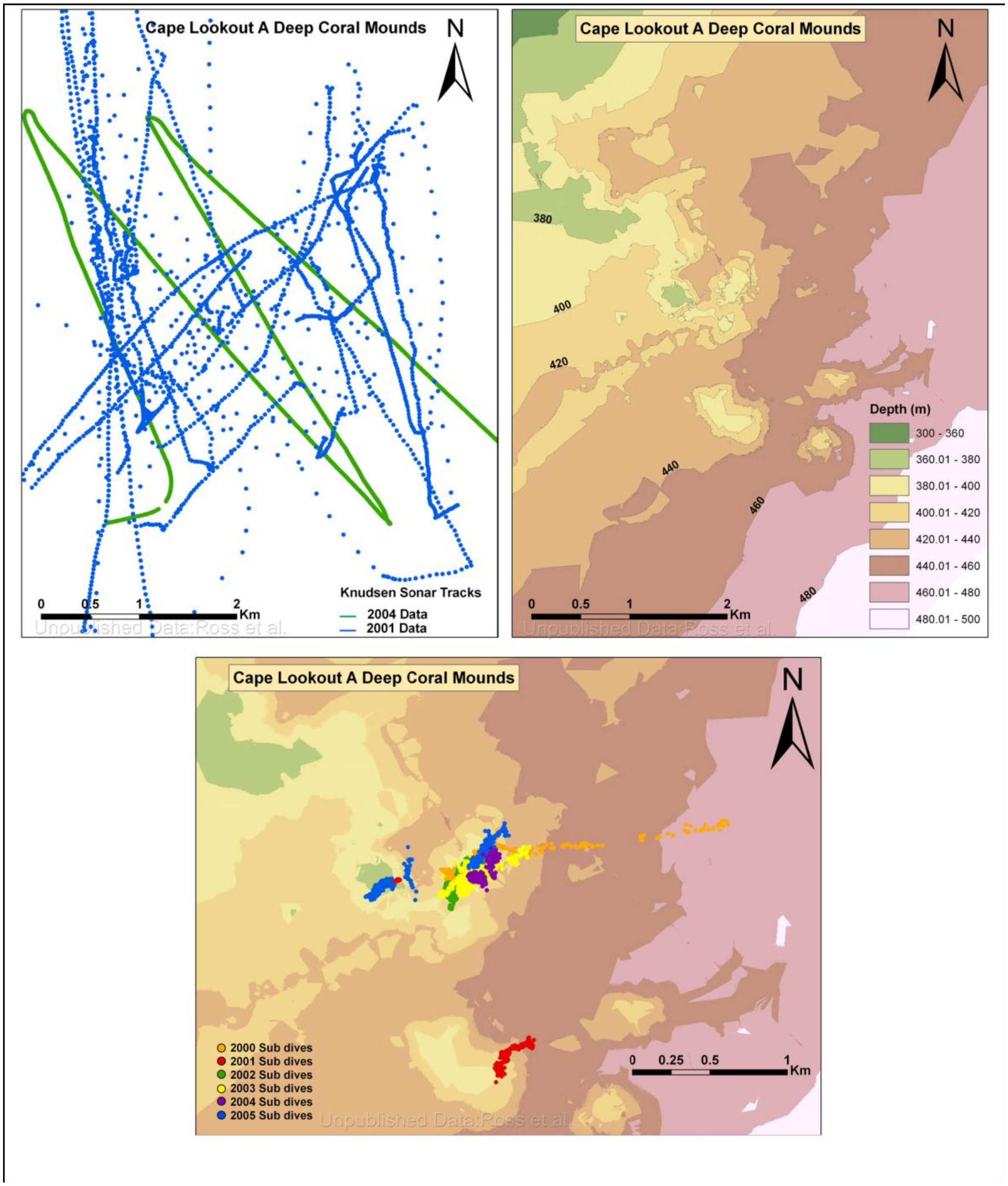


Figure 3.3-4. Ship collected sonar tracks (top left) and resulting bathymetry maps (top right) from the deep coral area off Cape Lookout, NC (A). In this area additional data from our files were added for the bathymetry map. Bottom panel shows JSL submersible dive tracks in this area from 2000- 2005. All data are from Ross et al. (unpublished). See Fig. 3.3-3 to locate this area.

Cape Lookout Lophelia Bank B

The least amount of data are available for this area. Mounds appear to cover a smaller area than those described above, but here again better mapping data are needed. Ross et al. JSL dives in this area ranged from 396-449 m. Mean bottom temperatures ranged from 5.8 to 10.4°C, and as above mean bottom salinities were always around 35 ppt. These mounds rise at least 53 m over a distance of about 0.4 km. There is a small mound away from the main system (Figure 3.3-5), and in general these mounds were less dramatic than those described above. They appeared to be of the same general construction as Bank A, appearing to be built of coral rubble matrix that had trapped sediments. Extensive fields of coral rubble surrounded the area. Both living and dead corals were common on this bank, with some living bushes being quite large.

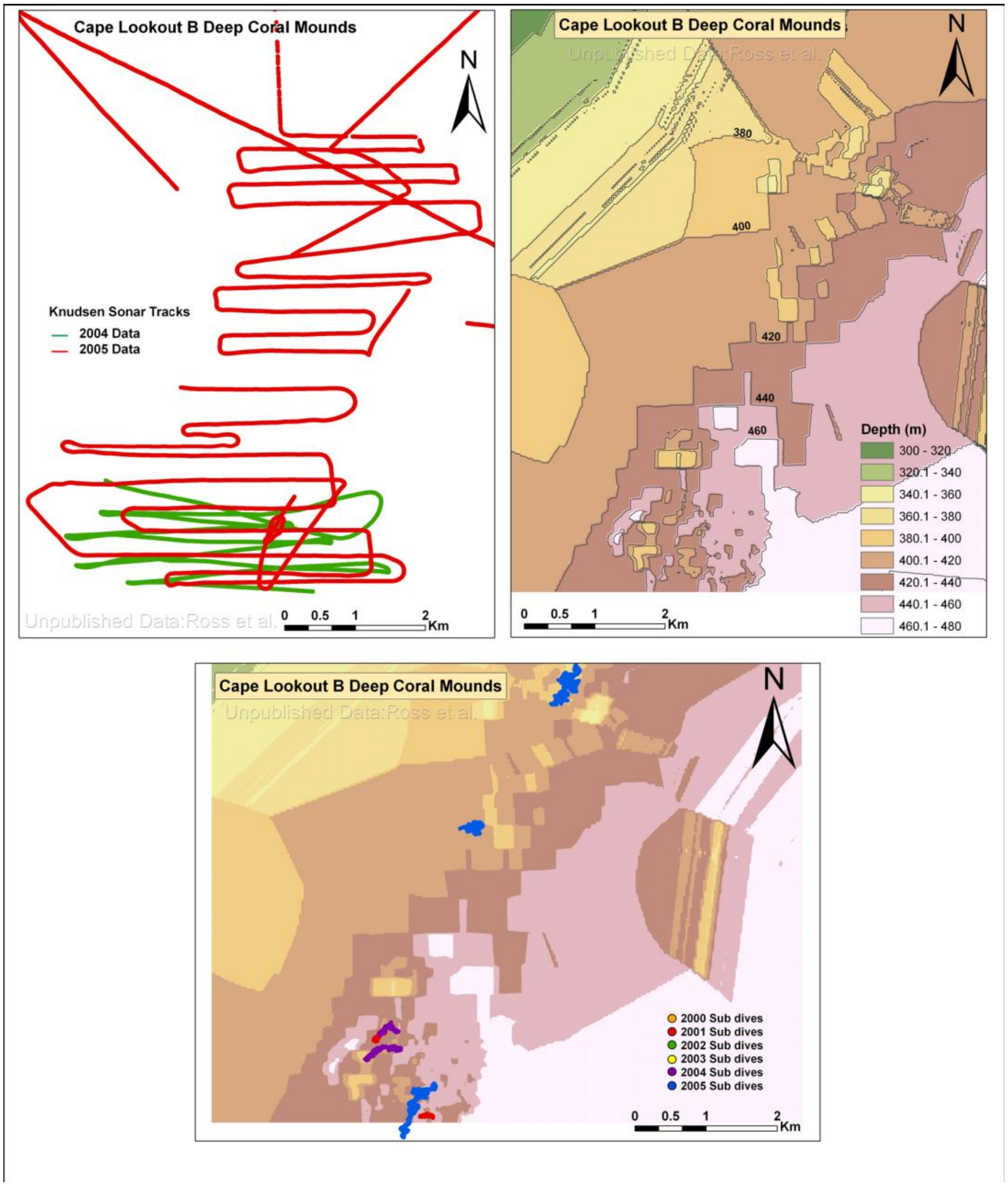


Figure 3.3-5. Ship collected sonar tracks (top left) and resulting bathymetry maps (top right) from the deep coral area off Cape Lookout, NC (B). Bottom panel shows JSL submersible dive tracks in this area from 2000-2005. All data are from Ross et al. (unpublished). See Fig. 3.3-3 to locate this area.

Cape Fear Lophelia Bank

Aside from the map in EEZ-SCAN 87 Scientific Staff (1991) there are no published data from this coral mound and no indication that it was sampled before the studies initiated by Ross et al. (unpubl. data) between summer 2002 and fall 2005. Ross et al. located this bank based on estimated coordinates from the USGS survey (EEZ-SCAN 87 Scientific Staff 1991). As above, the JSL submersible was the major method for collecting bottom data on the reef proper. Sampling in this area was focused on a relatively small area (Figure 3.3-6), but data are lacking to accurately estimate the size and area covered by coral mounds or rubble zones.

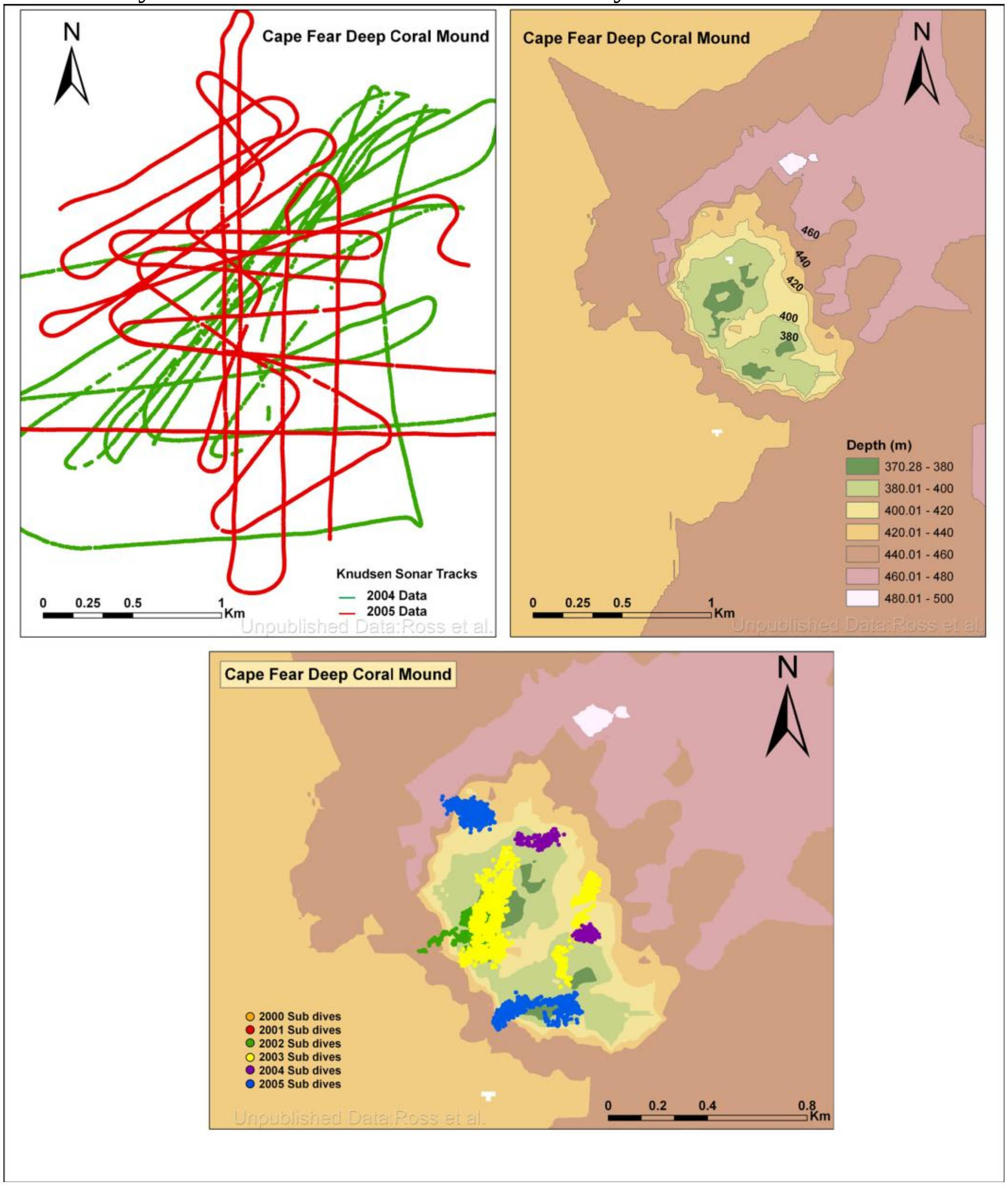


Figure 3.3-6. Ship collected sonar tracks (top left) and resulting bathymetry maps (top right) from the deep coral area off Cape Fear, NC. Bottom panel shows JSL submersible dive tracks in this area from 2000-2005. All data are from Ross et al. (unpublished). See Fig. 3.3-3 to locate this area.

Ross et al. JSL dives in this area ranged from 371-449 m. Mean bottom temperatures ranged from 8.7 to 11.7°C, and as above mean bottom salinities were always near 35 ppt. These mounds rise nearly 80 m over a distance of about 0.4 km, and exhibit some of the most rugged habitat and vertical excursion of any area sampled. This mound system also appears to be of the same general construction as Banks A and B, being built of coral rubble matrix with trapped sediments. Fields of coral rubble are common around the area. Both living and dead corals were common on this bank.

Potential NC Coral Mounds

Several potential deep coral banks (Figure 3.3-3) were identified in the USGS survey of the EEZ off of North Carolina (EEZ-SCAN 87 Scientific Staff 1991). During surveys with the NR-1 submarine (Sulak and Ross unpubl. data, 1993) and again during a cruise of the R/V *Cape Hatteras* (S.W. Ross, Chief Scientist, 2001), attempts were made to locate the bank between Cape Lookout Bank A and Bank B (Figure 3.3-3). However, no coral mounds were observed in this area. It is possible that there are coral mounds in this area but the small search pattern and potential navigation issues prevented finding them. Other banks may exist on the slope south of 33°N (Figure 3.3-3). As far as known these have not been accurately located or confirmed as coral banks, although the location referenced by George (2002) is near one of these areas. These banks would be important to confirm as they would occur in what may be a transition area between a region of coral/sediment built mounds composed almost entirely of *Lophelia pertusa* and the area to the south where coral development is generally quite different.

Coral Banks of the Blake Plateau

South of Cape Fear sediment/coral mounds are smaller and scattered; however, *L. pertusa* and other hard and soft corals populate the abundant hard substrates of the Blake Plateau in great numbers. Overall, species diversity of anthozoans and other associated sessile invertebrates (e.g., sponges, hydrozoans) increases south of Cape Fear, NC. For convenience, some deep coral study areas in this region have been named, giving the impression of isolated areas of coral habitat. It appears, however, that Blake Plateau coral habitats are larger and more continuous than these names imply. Future detailed mapping of the area combined with ground-truthing will clarify coral habitat distributions and the extent to which areas may require discrete names.

There are existing research data for this area, but historically most of it was geological. Most deepwater coral expeditions south of North Carolina concentrated around the area described by Stetson et al. (1962), referred to as "Stetson Banks" (Figure 3.3-7), an area off Georgia ("Savannah Banks"), the Charleston Bump (Sedberry 2001), a large area straddling the Georgia/Florida border ("Jacksonville Lithoherms") and numerous coral sites along the FL East coast. General properties of these study areas were described in several papers by Reed and colleagues (Reed 2002, Reed unpubl. rept. to SAFMC 2004, Reed and Ross 2005, Reed et al. 2005, 2006). Because it is unclear that these coral study areas are physically separate, they are not discussed individually.

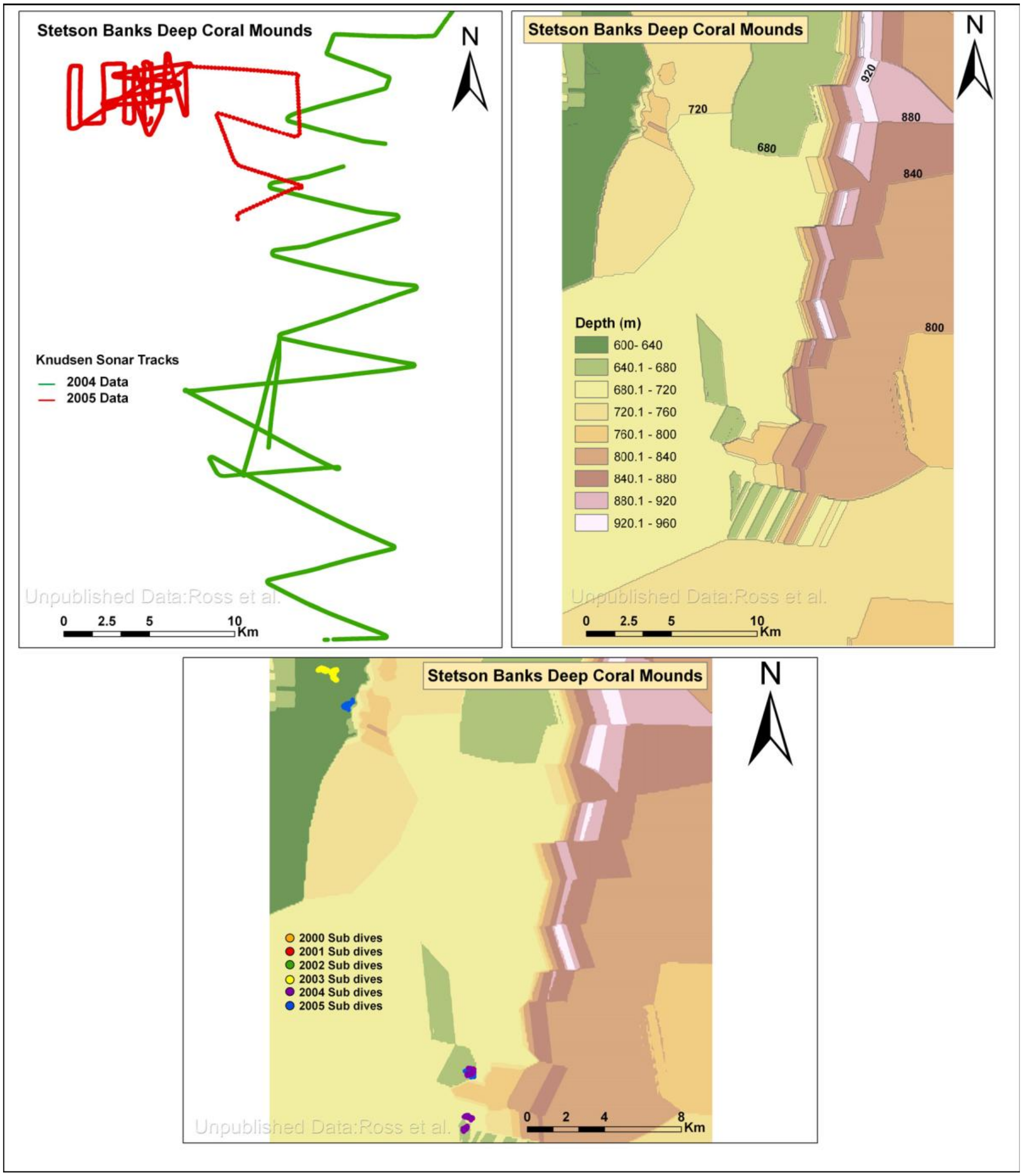


Figure 3.3-7. Ship collected sonar tracks (top left) and resulting bathymetry maps (top right) from the Stetson deep coral area off of SC. Bottom panel shows JSL submersible dive tracks in this area from 2000-2005. All data are from Ross et al. (unpublished). See Fig. 3.3-3 to locate this area.

The Stetson Bank is a very large region of extremely diverse, rugged topography and bottom types. There is a deep canyon on the eastern side of this system with abundant corals on its western rim. While the surface waters of Stetson Bank are often outside the main Gulf Stream path, bottom currents can be quite strong. This is one of the deeper and more interesting of the

Blake Plateau coral areas and warrants further exploration. The Savannah Bank system appears to have a heavier sediment load, perhaps because it is closest to the continental shelf. Deepwater corals occur there in scattered patches and are often less well developed than at other sites. Many sites in the "Jacksonville area" were composed of rocky ledges to which corals were attached, especially on the northern end. Bottom types in this area are diverse as is the fauna. Topographic highs, most having corals, are very abundant from the "Jacksonville area" to just south of Cape Canaveral (see also Reed et al. 2005, 2006). Faunal diversity is quite high in this region.

<u>Stetson Reefs, Eastern Blake Plateau</u> (from Reed, 2002a; Reed et al., 2004b)
This site is on the outer eastern edge of the Blake Plateau, approximately 120 nm SE of Charleston, South Carolina, at depths of 640-869 m (Figures 3.3-8 and 3.3-9). Over 200 coral mounds up to 146 m in height occur over this 6174 km^2 area that was first described by Thomas Stetson from echo soundings and bottom dredges (Stetson et al. 1962; Uchupi 1968). These were described as steep-sloped structures with active growth on top of the banks. Live coral colonies up to 50 cm in diameter were observed with a camera sled. *Enallopsammia profunda* (=*D. profunda*) was the dominant species in all areas although *L. pertusa* was concentrated on top of the mounds. Densest coral growth occurred along an escarpment at Region D1. Stetson et al. (1962) reported an abundance of hydroids, alcyonaceans, echinoderms, actiniaria, and ophiuroids, but a rarity of large mollusks. The flabelliform gorgonians were also current-oriented. Popenoe and Manheim (2001) have made detailed geological maps of this Charleston Bump region which also indicate numerous coral mounds.

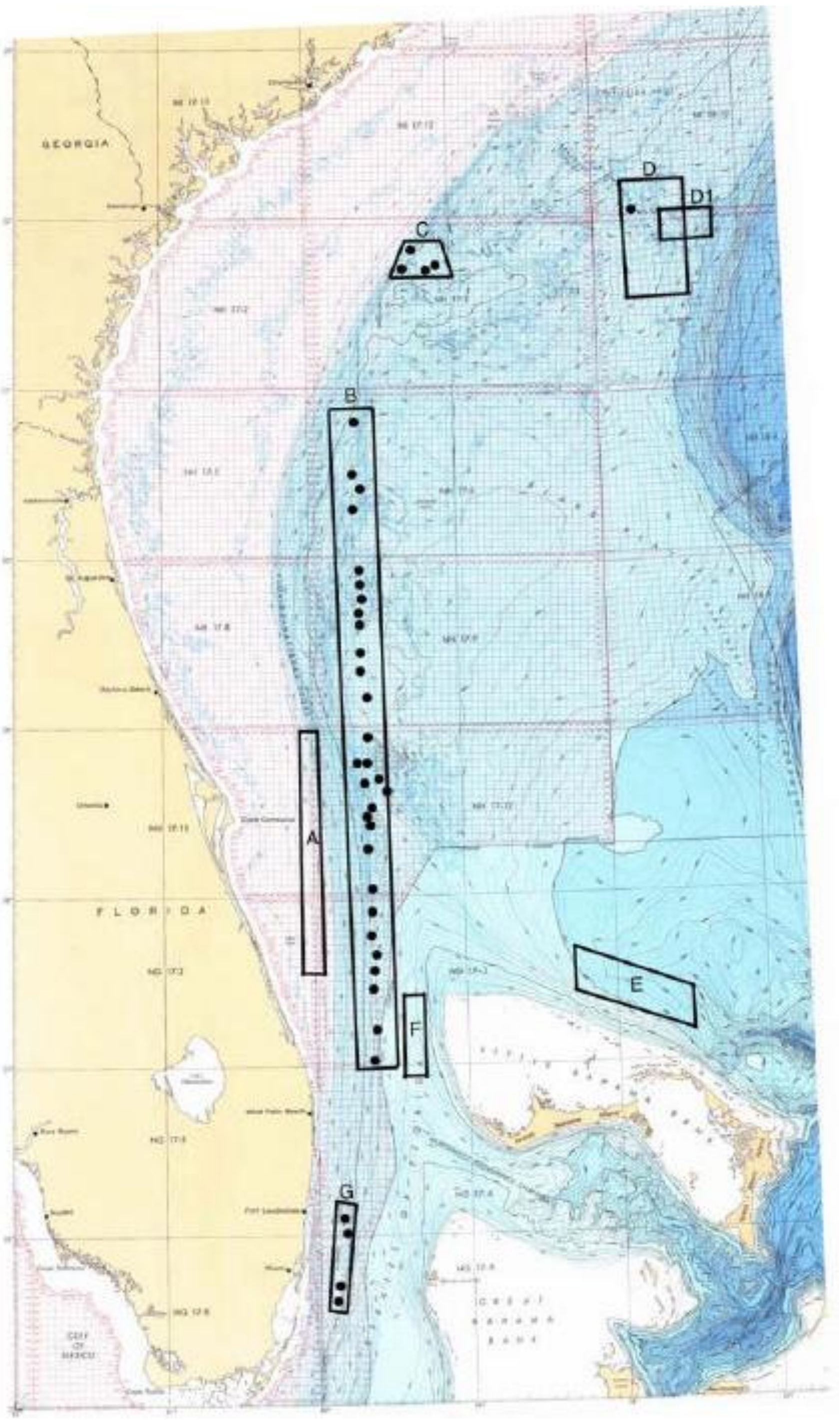


Figure 3.3-8. Deep-water coral reef regions off southeastern U.S.A. ?= *Johnson-Sea-Link* I and II submersible dive sites and echosounder sites of high-relief reefs; Regions: A=*Oculina* Coral Reefs, B= East Florida *Lophelia* Reefs, C= Savannah Lophelia Lithoherms, D= Stetson's Reefs (D1= region of dense pinnacles), E= *Enallopsammia* Reefs (Mullins et al., 1981), F= Bahama Lithoherms (Neumann et al., 1977), G= Miami Terrace Escarpment. (from Reed et al. 2004b; chart from NOAA NOS 1986).

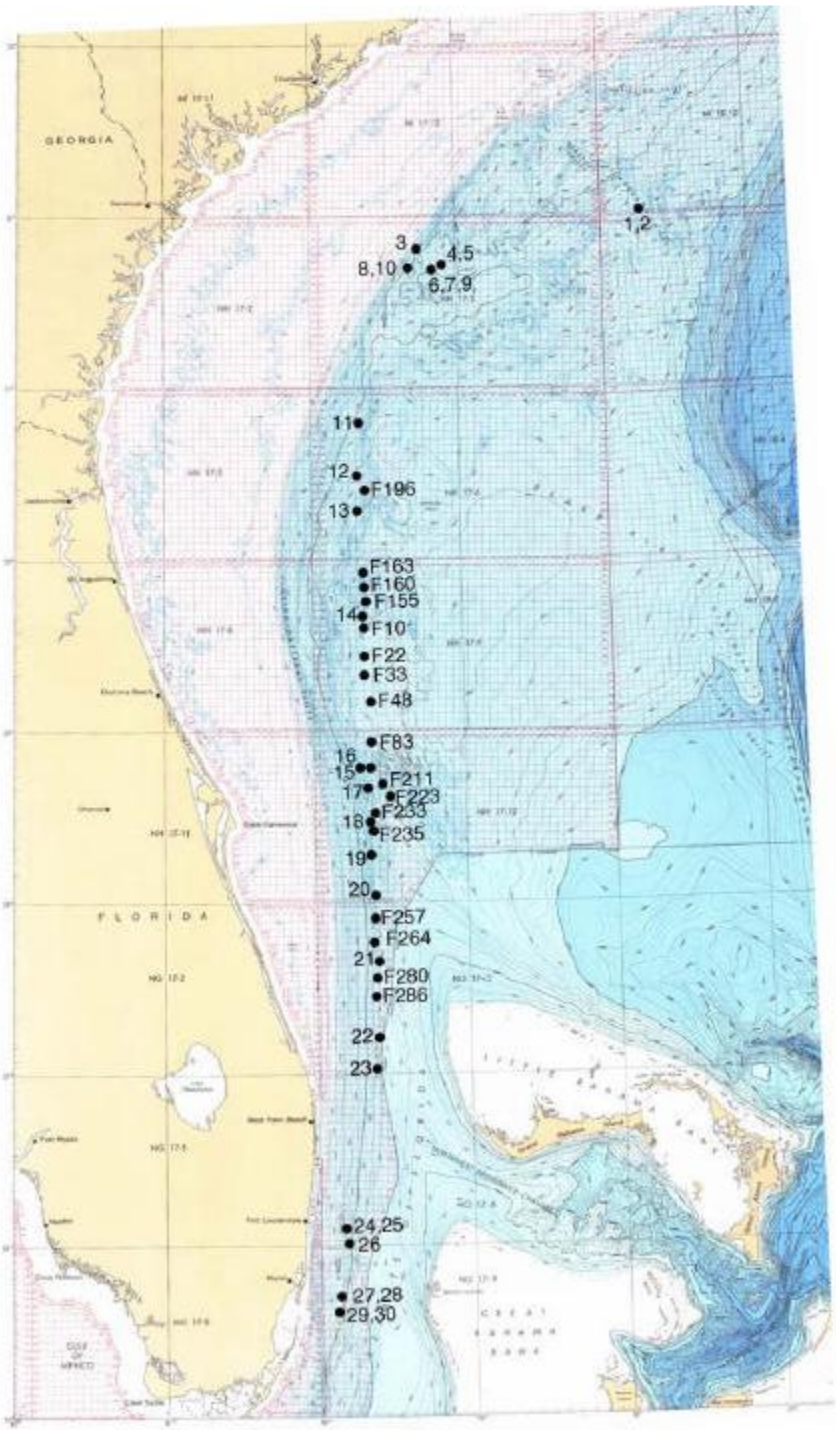


Figure 3.3-9. Bathymetry and submersible dive sites on Pourtalès Terrace at Region H. = *Johnson-Sea-Link* and *Clelia* submersible dive sites; JS= Jordan Sinkhole, MS= Marathon Sinkhole, TB1= Tennessee Humps Bioherm #1, TB2= Tennessee Humps Bioherm #2, AB3= Alligator Humps Bioherm #3, AB4= Alligator Humps Bioherm #4 (from Reed et al. 2004b; chart from Malloy and Hurley 1970; Geol. Soc. Amer. Bull. 81: 1947-1972).

Fathometer transects by J. Reed indicated dozens and possibly hundreds of individual pinnacles and mounds within the small region that we surveyed which is only a fraction of the Stetson Bank area (Reed and Pomponi 2002b; Reed et al. 2002; Reed et al. 2004b). Two pinnacle regions were selected from fathometer transects. Three submersible dives were made on “Pinnacle 3” and four dives on “Stetson’s Peak” which is described below. A small subset of the Stetson Bank area was first mapped by six fathometer transects covering approximately 28 nm^2, in which six major peaks or pinnacles and four major scarps were plotted. The base depth of these pinnacles ranged from 689 m to 643 m, with relief of 46 to 102 m. A subset of this was further mapped with 70 fathometer transects spaced 250 m apart (recording depth, latitude and longitude ~ every 3 seconds), covering an area of 1 x 1.5 nm, resulting in a 3-D bathymetric GIS Arcview map of a major feature, which was named named Stetson’s Pinnacle (Figure 3.3-10).

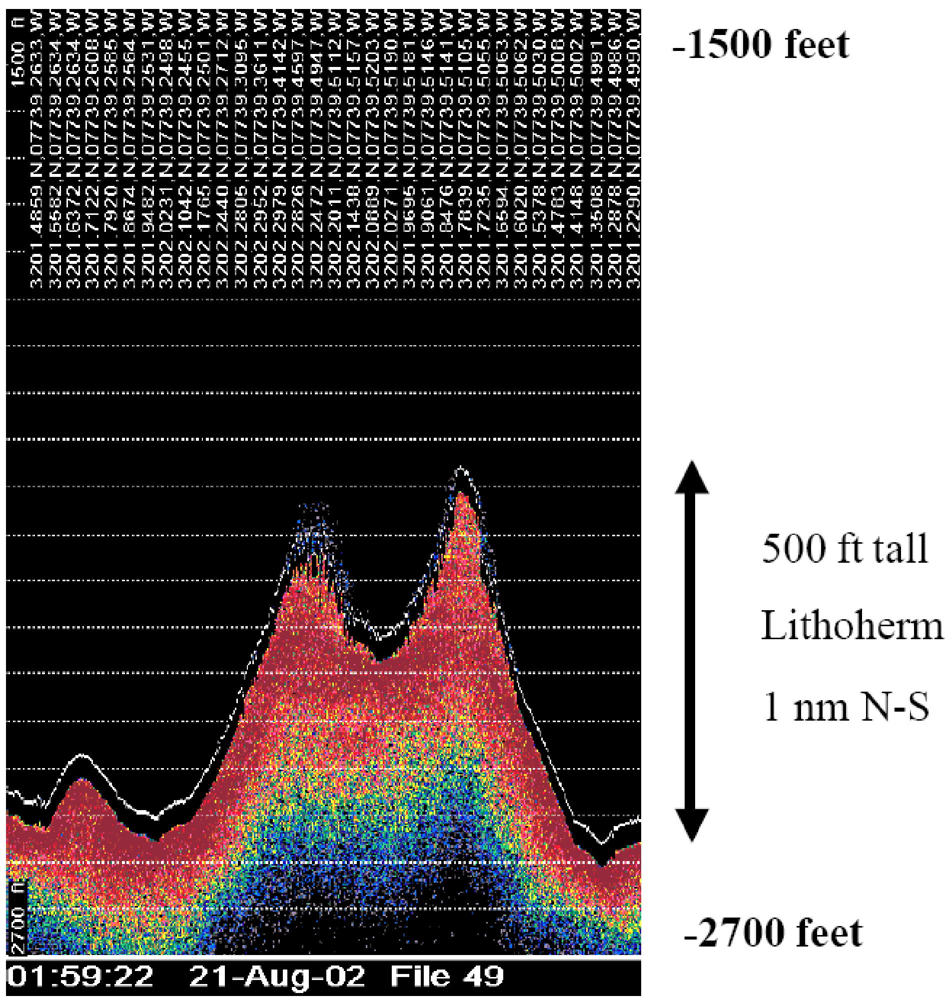


Figure 3.3-10. Echosounder profile of Stetson’s Pinnacle (depth 780 m, relief 153 m) (from Reed et al., 2004b).

Stetson's Pinnacle was 780 m at the south base and the peak was 627 m. This represents one of the tallest *Lophelia* coral lithoherms known, nearly 153 m in relief. The linear distance from the south base to the peak was approximately 0.5 nm. The lower flank of the pinnacle from ~762 m to 701 m on the south face was a gentle slope of 10-30° with a series of 3-4 m high ridges and terraces that were generally aligned 60-240° across the slope face. These ridges were covered with nearly 100% *Lophelia* coral rubble, 15-30 cm colonies of live *Lophelia*, and standing dead colonies of *Lophelia*, 30-60 cm tall. Very little rock was exposed, except on the steeper exposed, eroded faces of the ridges. Some rock slabs, ~30 cm thick, have slumped from these faces. From 701 m to 677 m the slope increased from ~45° to 60 °. From 671 m to the peak, the geomorphology was very complex and rugged, consisting of 60-90° rock walls and 3-9 m tall rock outcrops. Colonies of *Lophelia*, 30-60 cm tall, were more common, and some rock ledges had nearly 100% cover of live *Lophelia* thickets. The top edge of the pinnacle was a 30 cm thick rock crust which was undercut from erosion; below this was a 90° escarpment of 3-6 m. The peak was a flat rock plateau at 625- 628 m and was approximately 0.1 nm across on a S-N submersible transect. The north face was not explored in detail but is a vertical rock wall from the peak to ~654 m then grades to a 45° slope with boulders and rock outcrops.

Dominant sessile macrofauna consisted of scleractinia, stylasterine hydrocorals, gorgonacea and sponges. The colonial scleractinia were dominated by colonies of *Lophelia pertusa* (30-60 cm tall) and *Enallopsammia profunda*, and *Solenosmilia variabilis* were present. Small stylasterine corals (15 cm tall) were common and numerous species of solitary cup corals were abundant. Dominant octocorallia consisted of colonies of Primnoidae (15-30 cm tall), paramuriceids (60-90 cm), Isididae bamboo coral (15-60 cm), stolonifera, and stalked Nephtheidae (5-10 cm). Dominant sponges consisted of Pachastrellidae (25 cm fingers and 25- 50 cm plates), Corallistidae (10 cm cups), Hexactinellida glass sponges (30 cm vase), *Geodia sp*. (15-50 cm spherical), and *Leiodermatium sp*. (50 cm frilly plates). Although motile fauna were not targeted, some dominant groups were noted. No large decapods crustaceans were common although some red portunids were observed. Two species of echinoids were common, one white urchin and one stylocidaroid. No holothurians or asteroids were noted. Dense populations of Ophiuroidea were visible in close-up video of coral clusters and sponges. No large Mollusca were noted except for some squid. Fish consisted mostly of benthic gadids and rattails. On the steeper upper flank, from 671 to 625 m the density, diversity, and size of sponges increased; 15-50 cm macro sponges were more abundant. Massive *Spongosorites sp*. were common, Pachastrellidae tube sponges were abundant, and Hexactinellida glass sponges were also common. On the peak plateau the dominant macrofauna were colonies of *Lophelia pertusa* (30-60 cm tall), coral rubble, *Phakellia sp*. fan sponges (30-50 cm), and numerous other demosponges were abundant. No large fish were seen on top.

<u>Savannah Lithoherms, Blake Plateau</u> (from Reed 2002a; Reed et al. 2004b)
A number of high-relief lithoherms occur within this region of the Blake Plateau, approximately 90nm east of Savannah, Georgia (Figures 3.3-8 and 3.3-9). This region is at the base of the Florida-Hatteras Slope, near the western edge of the Blake Plateau, and occurs in a region of phosphoritic sand, gravel and rock pavement on the Charleston Bump (Sedberry 2001). Wenner and Barans (2001) described 15-23 m tall coral mounds in this region that were thinly veneered with fine sediment, dead coral fragments and thickets of *Lophelia* and *Enallopsammia*. They found that blackbellied rosefish and wreckfish were frequent associates of this habitat. In

general, the high-relief *Lophelia* mounds occur in this region at depths of 490-550 m and have maximum relief of 61 m. JSL-II dives 1690, 1697 and 1698 reported a coral rubble slope with <5% cover of 30 cm, live coral colonies (Reed, 2002a). On the reef crest were 30-50 cm diameter coral colonies covering approximately 10% of the bottom.

Some areas consisted of a rock pavement with a thin veneer of sand, coral rubble, and 5-25 cm phosphoritic rocks. At *Alvin* dive sites 200 and 203, Milliman et al. (1967) reported elongate coral mounds, approximately 10 m wide and 1 km long, that were oriented NNE-SSW. The mounds had 25-37° slopes and 54 m relief. Live colonies (10-20 cm diameter) of *E. profunda* (=*D. profunda*) dominated and *L. pertusa* (=*L. prolifera*) was common. No rock outcrops were observed. These submersible dives found that these lithoherms provided habitat for large populations of massive sponges and gorgonians in addition to the smaller macroinvertebrates which have not been studied in detail. Dominant macrofauna included large plate-shaped sponges (*Pachastrella monilifera*) and stalked, fan-shaped sponges (*Phakellia ventilabrum*), up to 90 cm in diameter and height.

At certain sites (JSL-II dive 1697), these species were estimated at 1 colony/10 m^2. Densities of small stalked spherical sponges (*Stylocordyla sp*., Hadromerida) were estimated in some areas at 167 colonies/10 m^2. Hexactinellid (glass) sponges such as *Farrea*? sp. were also common. Dominant gorgonacea included *Eunicella* sp. (Plexauridae) and *Plumarella pourtalessi* (Primnoidae).

Recent fathometer transects by J. Reed at Savannah Lithoherm Site #1 (JSL II-3327) extended 2.36 nm S-N revealed a massive lithoherm feature that consisted of five major pinnacles with a base depth of 549 m, minimum depth of 465 m, and maximum relief of 83 m (Reed and Pomponi 2002b; Reed et al. 2002; Reed et al. 2004b). The individual pinnacles ranged from 9 to 61 m in height. A single submersible transect, south to north, on Pinnacle #4 showed a minimum depth of 499 m. The south flank of the pinnacle was a gentle 10-20° slope, with ~90% cover of coarse sand, coral rubble and some 15 cm rock ledges. The peak was a sharp ridge oriented NW-SE, perpendicular to the prevailing 1 kn current. The north side face of the ridge was a 45° rock escarpment of about 3 m which dropped onto a flatter terrace. From a depth of 499 to 527 m, the north slope formed a series of terraces or shallow depressions, ~9-15 m wide, that were separated by 3 m high escarpments of 30-45°. Exposed rock surfaces showed a black phosphoritic rock pavement. The dominant sessile macrofauna occurred on the exposed pavement of the terraces and in particular at the edges of the rock outcrops and the crest of the pinnacle.

The estimated cover of sponges and gorgonians was 10% on the exposed rock areas. Colonies of *Lophelia pertusa* (15-30 cm diameter) were common but not abundant with ~1% coverage. Dominant Cnidaria included several species of gorgonacea (15-20 cm tall), Primnoidae, Plexauridae (several spp.), *Antipathes* sp. (1 m tall), and *Lophelia pertusa*. Dominant sponges included large *Phakellia ventilabrum* (fan sponges, 30-90 cm diameter), Pachastrellidae plate sponges (30 cm), *Choristida* plate sponges (30 cm), and Hexactinellid glass sponges. Motile fauna consisted of decapod crustaceans (*Chaceon fenneri*, 25 cm; and Galatheidae, 15 cm) and mollusks. Few large fish were observed but a 1.5 m swordfish, several 1 m sharks, and numerous blackbelly rosefish were noted.

A fathometer transect by J. Reed at Savannah Lithoherm Site 2 (Figure 3.3-11) extended 4.6 nm, SW to NE, mapped 8 pinnacles with maximum depth of 549 m and relief of 15-50 m.

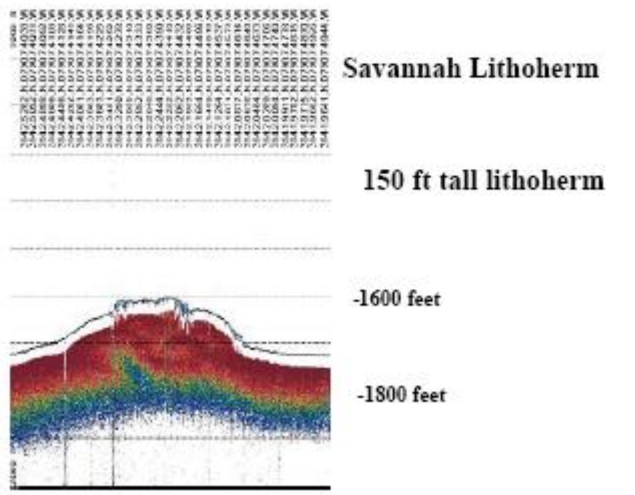


Figure 3.3-11. Echosounder profile of Savannah Lithoherm, Site 2, Pinnacle #1 (depth 537 m, relief 50 m) (from Reed et al., 2004b).

Submersible dives were made on Pinnacles 1, 5 and 6 of this group. Pinnacle 1 was the largest feature of this group; the base was 537 m and the top was 487 m. The south face, from a depth of 518 to 510 m, was a gentle 10° slope, covered with coarse brown sand and *Lophelia* coral rubble. A 3-m high ridge of phosphoritic rock, extended NE-SW, cropped out at a depth of 510 m. This was covered with nearly 100% cover of 15 cm thick standing dead *Lophelia* coral and dense live colonies of *Lophelia pertusa* (15-40 cm). From depths of 500 m to 495 m were a series of exposed rock ridges and terraces that were 3-9 m tall with 45° slopes.

Some of the terraces were ~30 m wide. Each ridge and terrace had thick layers of standing dead *Lophelia*, and dense live coral. These had nearly 100% cover of sponges (*Phakellia* sp., *Geodia* sp., Pachastrellidae, and Hexactinellida), scleractinia (*Lophelia pertusa*, *Madrepora oculata*), stylasterine hydrocorals, numerous species of gorgonacea (Ifalukellidae, Isididae, Primnoidae), and 1 m bushes of black coral (*Antipathes* sp.). Deep deposits of sand and coral rubble occurred in the depressions between the ridges. The north face, from 500 m to 524 m was a gentle slope of 10° that had deep deposits of coarse brown foraminiferal sand and coral rubble. Exposed rock pavement was sparse on the north slope, but a few low rises with live bottom habitat occurred at 524 m. Dominant mobile fauna included decapod crustaceans (*Chaceon fenneri*, 15 cm Galatheidae), rattail fish, and 60 cm sharks were common.

Florida

Deepwater coral ecosystems in U.S. EEZ waters also exist along the eastern and southwest Florida shelf slope (in addition to the Oculina HAPC and deep shelf-edge reefs with hermatypic coral). These include a variety of high-relief, hardbottom, live-bottom habitats at numerous sites along the base of the Florida-Hatteras Slope off northeastern and central eastern Florida, the Straits of Florida, the Miami Terrace and Pourtales Terrace off southeastern Florida, and the southwestern Florida shelf slope. The predominate corals on these reefs are the azooxanthellate, colonial scleractinian corals, *Lophelia pertusa*, *Madrepora oculata*, and *Enallopsammia profunda*; various species of hydrocorals of the family Stylasteridae, and species of the bamboo octocoral of the family Isididae. Various types of high- relief, live-bottom habitat have been discovered in the area: *Lophelia* mud mounds, lithoherms, sinkholes, ancient Miocene escarpments and karst topographic features (Reed 2002b; Reed et al. 2004a, b). These all provide hardbottom substrate and habitat for sessile macrofauna including deepwater corals, octocorals (gorgonians), black coral, and sponges, which in turn provide habitat and living space for a relatively unknown but biologically rich and diverse community of associated fish, crustaceans, mollusks, echinoderms, polychaete and sipunculan worms, and other macrofauna, many of which are undoubtedly undescribed species. Preliminary studies by Reed et al. (2004a, b) have found new species of octocorals and sponges from some these sites.

Florida Lophelia Pinnacles (from Reed 2002a; Reed et al. 2004b)
Numerous high-relief *Lophelia* reefs and lithoherms occur in this region at the base of the Florida- Hatteras Slope and at depths of 670-866 m. The reefs in the southern portion of this region form along the western edge of the Straits of Florida and are 15-25 nm east of the *Oculina* HAPC. Along a 222-km stretch off northeastern and central Florida (from Jacksonville to Jupiter), nearly 300 mounds from 8 to 168 m in height (25- 550 ft) were recently mapped by J. Reed using a single beam echosounder (Figure 3.3-12; Reed et al. 2004b). Between 1982 and 2004, dives with the *Johnson-Sea-Link* (JSL) submersibles and ROVs by J. Reed confirmed the presence of *Lophelia* mounds and lithoherms in this region (Reed 2002a; Reed et al. 2002; Reed and Wright 2004; Reed et al. 2004b). The northern sites off Jacksonville and southern Georgia appeared to be primarily lithoherms which are pinnacles capped with exposed rock (described in part by Paull et al. 2000), whereas the features from south of St. Augustine to Jupiter were predominately *Lophelia* coral pinnacles or mud mounds capped with dense 1m-tall thickets of *Lophelia pertusa* and *Enallopsammia profunda* with varying amounts of coral debris and live coral. Dominant habitat-forming coral species were *Lophelia pertusa*, *Madrepora oculata*, *Enallopsammia profunda*, bamboo coral (Isididae), black coral (Antipatharia), and diverse populations of octocorals and sponges (Reed et al. 2004b).

Paull et al. (2000) estimated that over 40,000 coral lithoherms may be present in this region of the Straits of Florida and the Blake Plateau. Their dives with the *Johnson-Sea-Link* submersible and the U.S. Navy's submarine NR-1 described a region off northern Florida and southern Georgia of dense lithoherms forming pinnacles 5 to 150 m in height with 30-60° slopes that had thickets of live ahermatypic coral (unidentified species, but photos suggest *Lophelia* and/or *Enallopsammia*). The depths range from 440 to 900+ m but most mounds were within 500-750 m. Each lithoherm was ~100-1000 m long and the ridge crest was generally oriented perpendicular to the northerly flowing Gulf Stream current (25-50 cm/s on flat bottom, 50-100 cm/s on southern slopes and crests).
Thickets of live coral up to 1 m were mostly found on the southern facing slopes and crests whereas the northern slopes were mostly dead coral rubble. These were termed lithoherms since the mounds were partially consolidated by a carbonate crust, 20-30 cm thick, consisting of micritic wackestone with embedded planktonic foraminifera, pteropods, and coral debris (Paull et al. 2000).

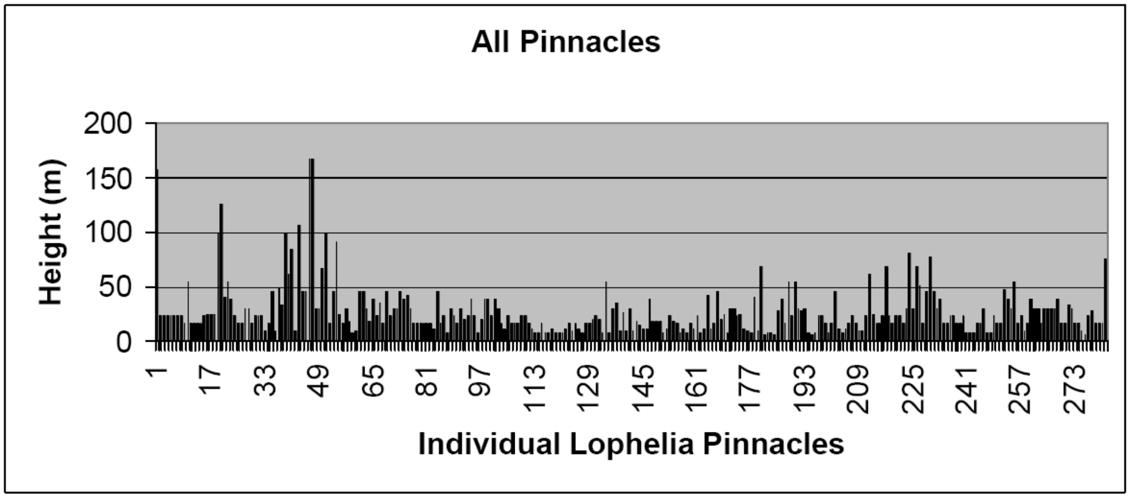


Figure 3.3-12. Height of *Lophelia* pinnacles and lithoherms on echosounder transects from Jacksonville to Jupiter, Florida at depths of 600 to 800 m. (from Reed et al. 2004b).

A recent echosounder transect by J. Reed revealed a massive lithoherm, 3.08 nm long (N-S) that consisted of at least 7 individual peaks with heights of 30-60 m (Figure 3.3-13; Reed and Wright 2004; Reed et al. 2004b). The maximum depth was 701 m with total relief of 157 m. Three submersible dives (JSL II-3333, 3334; I-4658) were made on Peak 6 of pinnacle #204B which was the tallest individual feature of the lithoherm with maximum relief of 107 m and a minimum depth at the peak of 544 m (Reed et al. 2004b). The east face was a 20-30° slope and steeper (50°) near the top. The west face was a 25-30° slope which steepened to 80° from 561 m to the top ridge. The slopes consisted of sand and mud, rock pavement and rubble. A transect up the south slope reported a 30-40° slope with a series of terraces and dense thickets of 30-60 cm tall dead and live *Lophelia* coral that were mostly found on top of mounds, ridges and terrace edges. One peak at 565 m had dense thickets of live and dead standing *Lophelia* coral (~20% live) and outcrops of thick coral rubble. Dominant sessile fauna consisted of *Lophelia pertusa*, abundant Isididae bamboo coral (30-60 cm) on the lower flanks of the mound, Antipatharia black coral, and abundant small octocorals including the gorgonacea (*Placogorgia* sp., *Chrysogorgia* sp, and Plexauridae) and Nephtheidae soft corals (*Anthomastus* sp., *Nephthya* sp.). Dominant sponges consisted of *Geodia* sp., *Phakellia* sp., *Spongosorites* sp., Petrosiidae, Pachastrellidae and Hexactinellida.

Further south off Cape Canaveral, echosounder transects by J. Reed on *Lophelia* Pinnacle #113 revealed a 61 m tall pinnacle with maximum depth of 777 m (Figure 3.3-14). The width (NW-SE) was 0.9 nm and consisted of at least 3 individual peaks or ridges on top, each with 15-19 m relief. One submersible dive (JSL II-3335) reported 30-60° slopes, with sand, coral rubble, and up to 10% cover of live coral. No exposed rock was observed. This appeared to be a classic *Lophelia* mud mound.

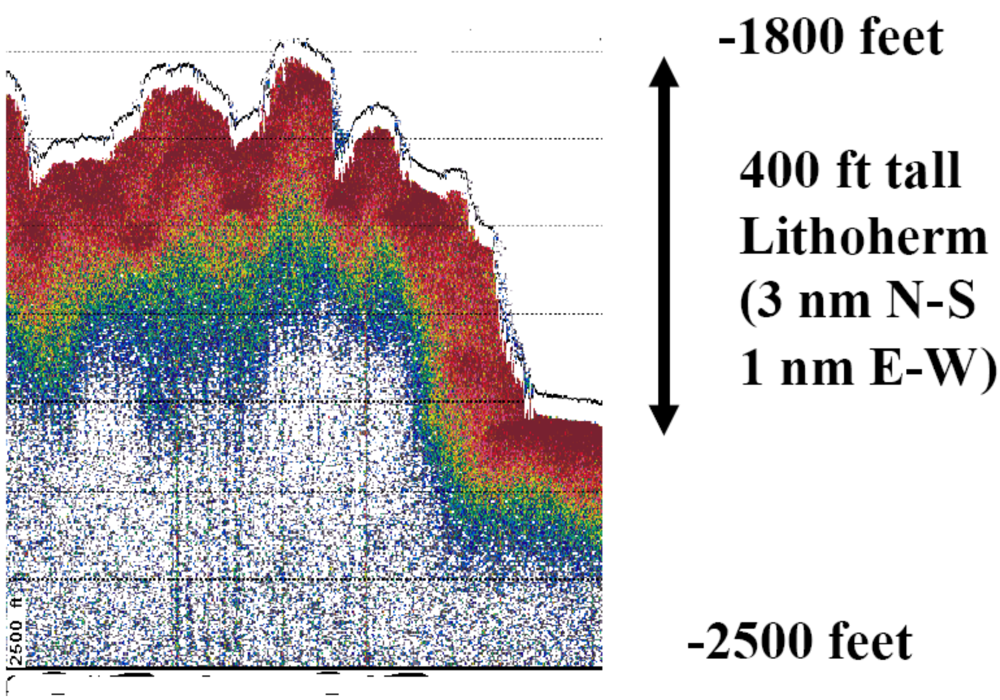


Figure 3.3-13. Echosounder profile of Jacksonville Lithoherm, Pinnacle #204B (depth 701 m, relief 157 m) (from Reed et al., 2004b).

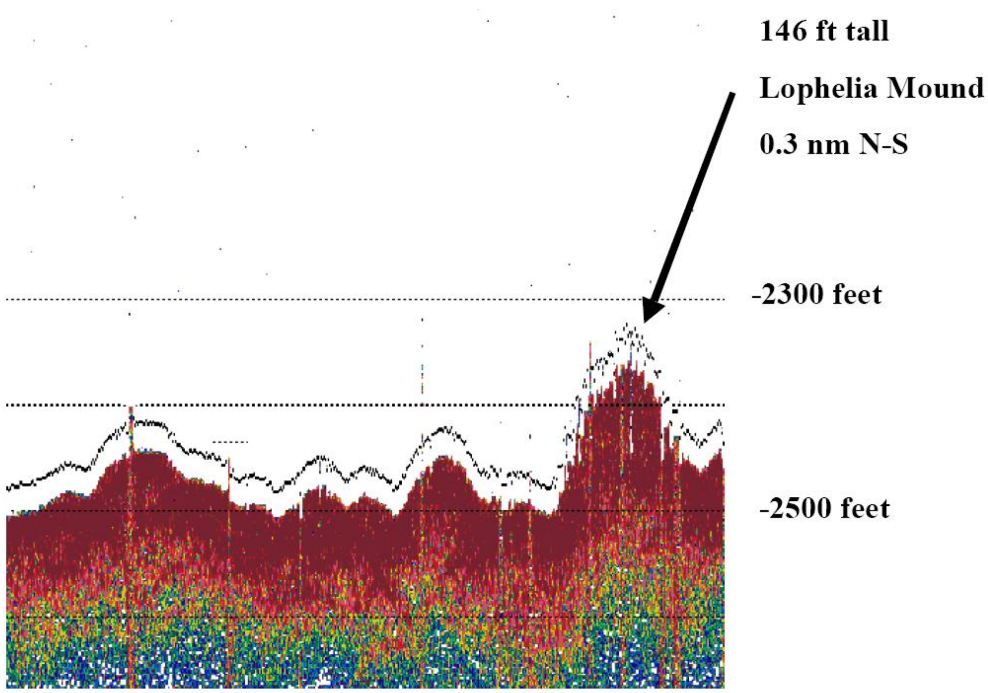


Figure 3.3-14. Echosounder profile of Cape Canaveral Lophelia Reef, Pinnacle #113 (depth 777 m, relief 61 m) (from Reed et al., 2004b).

The second dive site (JSL II-3336) at Pinnacle #151 was also a deepwater *Lophelia* coral reef comprised entirely of coral and sediment. Maximum depth was 758 m, with 44 m relief, and ~0.3 nm wide (N-S). The top was a series of ridged peaks from 713 to 722 m in depth. The lower flanks of the south face was a 10-20° slope of fine light colored sand with a series of 1-3 m high sand dunes or ridges that were linear NW-SE. The ridges had ~50% cover of thickets of *Lophelia pertusa* coral. The thickets consisted of 1 m tall dead, standing and intact, *Lophelia pertusa* colonies. Approximately 1-10% was alive on the outer parts (15-30 cm) on top of the standing dead bases. There was very little broken dead coral rubble in the sand and there was no evidence of trawl or mechanical damage. Most of the coral was intact, and the dead coral was brown. The sand between the ridges was fine and light colored, with 7-15 cm sand waves. The upper slope steepened to 45° and 70-80° slope near the upper 10 m from the top. The top of the pinnacle had up to 100% cover of 1-1.5 m tall coral thickets, on a narrow ridge that was 5-10 m wide. The coral consisted of both *Lophelia pertusa* and *Enallopsammia profunda*. Approximately 10-20% cover was live coral of 30-90 cm. The north slope was nearly vertical (70-80°) for the upper 10 m then consisted of a series of coral thickets on terraces or ridges. No exposed rock was visible and the entire pinnacle appeared to be a classic *Lophelia* mud mound.

No discernable zonation of macrobenthic fauna was apparent from the base to the top. Corals consisted of *Lophelia pertusa*, *Enallopsammia profunda*, *Madrepora oculata*, and some stylasterine hydrocorals. Dominant octocoral gorgonacea included Primnoidae (2 spp.), Isididae bamboo coral (*Isidella* sp. and *Keratoisis flexibilis*), and the alcyonaceans *Anthomastus* sp. and *Nephthya* sp. Dominant sponges consisted of several species of Hexactinellida glass sponges, large yellow demosponges (60-90 cm diameter), Pachastrellidae, and *Phakellia* sp. fan sponges. Echinoderms included urchins (cidaroid and *Hydrosoma*? sp.) and comatulid crinoids, but no stalked crinoids. Some large decapod crustaceans included *Chaceon fenneri* and large galatheids. No mollusks were observed but were likely within the coral habitat that was not collected. Common fish were 2 m sharks, 25 cm eels, 25 cm skates, chimaera and blackbelly rosefish.

<u>Miami Terrace Escarpment</u> (from Reed et al. 2004b)
The Miami Terrace is a 65-km long carbonate platform that lies between Boca Raton and South Miami at depths of 200-400 m in the northern Straits of Florida. It consists of high-relief Tertiary limestone ridges, scarps and slabs that provide extensive hardbottom habitat (Uchupi 1966, 1969; Kofoed and Malloy 1965; Uchupi and Emery 1967; Malloy and Hurley 1970; Ballard and Uchupi 1971; Neumann and Ball 1970). At the eastern edge of the Terrace, a high-relief, phosphoritic limestone escarpment of Miocene age with relief of up to 90 m at depths of 365 m is capped with *Lophelia pertusa* coral, stylasterine hydrocoral (Stylasteridae), bamboo coral (Isididae), and various sponges and octocorals (Reed et al. 2004b; Reed and Wright 2004). Dense aggregations of 50-100 wreckfish were observed here by J. Reed during JSL submersible dives in May 2004 (Reed et al. 2004b). Previous studies in this region include geological studies on the Miami Terrace (Neumann and Ball 1970; Ballard and Uchupi 1971) and dredge- and trawl-based faunal surveys in the 1970s primarily by the University of Miami (e.g., Halpern 1970; Holthuis 1971, 1974; Cairns 1979). *Lophelia* mounds are also present at the base of the escarpment (~670 m) within the axis of the Straits of Florida, but little is known of their distribution, abundance or associated fauna. Using the *Aluminaut* submersible, Neumann and

Ball (1970) found thickets of *Lophelia*, *Enallopsammia* (=*Dendrophyllia*), and *Madepora* growing on elongate depressions, sand ridges and mounds. Large quantities of *L. pertusa* and *E. profunda* have also been dredged from 738-761 m at 26°22' to 24'N and 79°35' to 37'W (Cairns 1979).

Recent JSL submersible dives and fathometer transects by J. Reed at four sites (Reed Site #BU4, 6, 2, and 1b) indicated the outer rim of the Miami Terrace to consist of a double ridge with steep rocky escarpments Reed and Wright 2004; Reed et al. 2004b). At Miami Terrace Site #BU4, the narrow N-S trending east ridge was 279 m at the top and had a steep 95 m escarpment on the west face. The east and west faces of the ridges were 30-40° slopes with some near vertical sections consisting of dark brown phosphoritic rock pavement, boulders and outcrops. The crest of the east ridge was a narrow plateau approximately 10 m wide. At Site #BU6, the crest of the west ridge was 310 m and the base of the valley between the west and east ridges was 420 m. At Site #BU2, the echosounder transect showed a 13 m tall rounded mound at a depth of 636 m near the base of the terrace within the axis of the Straits of Florida. The profile indicated that it is likely a *Lophelia* mound. West of this feature the east face of the east ridge was a steep escarpment from 567 m to 412 m at the crest. The west ridge crested at 321 m. Total distance from the deep mound to the west ridge was 2.9 nm. Site #BU1b was the most southerly transect on the Miami Terrace. An E-W echosounder profile at this site indicated a double peaked east ridge cresting at 521 m, then a valley at 549 m, and the west ridge at 322 m. The east face of the west ridge consisted of a 155 m tall escarpment (Figure 3.3-15).

There were considerable differences among the sites in habitat and fauna; however, in general, the lower slopes of the ridges and the flat pavement on top of the terrace were relatively barren. However, the steep escarpments especially near the top of the ridges were rich in corals, octocorals, and sponges. Dominant sessile fauna consisted of the following Cnidaria: small (15-30 cm) and large (60-90 cm) tall octocoral gorgonacea (*Paramuricea* spp., *Placogorgia* spp., Isididae bamboo coral); colonial scleractinia included scattered thickets of 30-60 cm tall *Lophelia pertusa* (varying from nearly 100% live to 100% dead), *Madrepora oculata* (40 cm), and *Enallopsammia profunda*; stylasterine hydrocorals (15-25 cm); and Antipatharia (30-60 cm tall). Diverse sponge populations of Hexactinellida and Demospongiae included: *Heterotella* sp., *Spongosorites* sp., *Geodia* sp., *Vetulina* sp., *Leiodermatium* sp., *Petrosia* sp., Raspailiidae, Choristida, Pachastrellidae, and Corallistidae. Other motile invertebrates included *Asteroporpa* sp. ophiuroids, *Stylocidaris* sp. urchins, Mollusca, Actiniaria, and Decapoda crustaceans (*Chaceon fenneri* and Galatheidae). Schools of ~50-100 wreckfish (*Polyprion americanus*), ~60-90 cm in length, were observed on several submersible dives along with blackbelly rosefish, skates, sharks and dense schools of jacks.

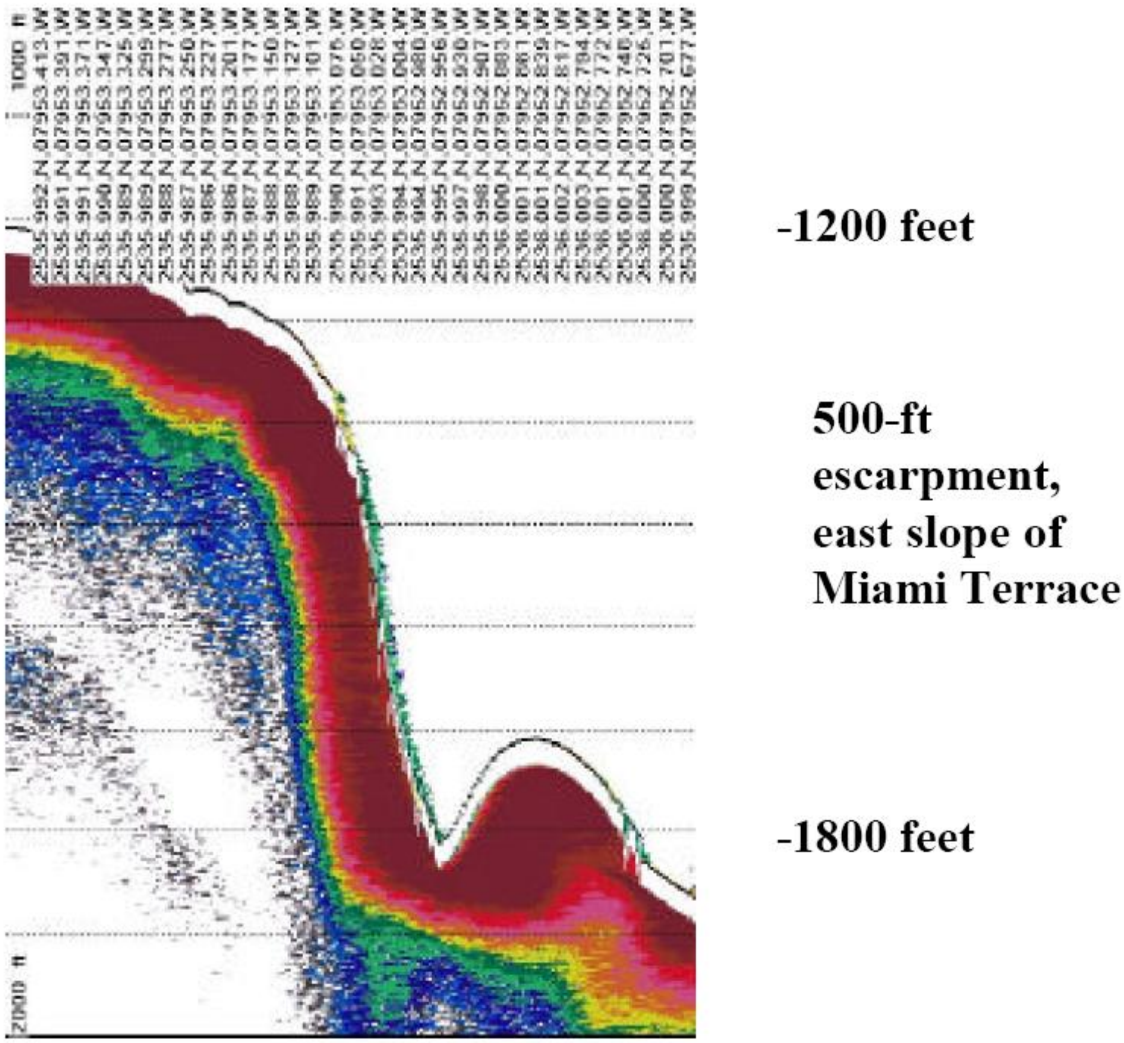


Figure 3.3-15. Echosounder profile of Miami Terrace Escarpment, Site #BU1b, west ridge (depth 549 m at base, relief 155 m) (from Reed et al., 2004b).

Pourtalès Terrace Lithoherms (from Reed et al., 2004a)
The Pourtalès Terrace provides extensive, high-relief, hardbottom habitat, covering 3,429 km^2 (1,000 nm^2) at depths of 200-450 m. The Terrace parallels the Florida Keys for 213 km and has a maximum width of 32 km (Jordan 1954; Jordan and Stewart 1961; Jordan et al. 1964; Gomberg 1976; Land and Paull 2000). Reed et al. (2004a) surveyed several deepwater, high-relief, hardbottom sites including the Jordan and Marathon deepwater sinkholes on the outer edge of the Terrace, and five high-relief bioherms on its central eastern portion. The JSL and *Clelia* submersibles were used to characterize coral habitat and describe the fish and associated macrobenthic communities. These submersible dives were the first to enter and explore any of these features. The upper sinkhole rims range from 175 to 461 m in depth and have a maximum relief of 180 m. The Jordan Sinkhole may be one of the deepest and largest sinkholes known.

The high-relief area of the middle and eastern portion of the Pourtalès Terrace is a 55 km-long, northeasterly trending band of what appears to be karst topography that consists of depressions flanked by well defined knolls and ridges with maximum elevation of 91 m above the terrace (Jordan et al. 1964; Land and Paull 2000). Further to the northeast of this knoll-depression zone is another zone of 40-m high topographic relief that lacks any regular pattern (Gomberg 1976). The high-relief bioherms (the proposed HAPC sites within this region) lie in 198 to 319 m, with a maximum height of 120 m. A total of 26 fish taxa were identified from the sinkhole and bioherm sites. Species of potential commercial importance included tilefish, sharks, speckled hind, yellow-edge grouper, warsaw grouper, snowy grouper, blackbelly rosefish, red porgy, drum, scorpion fish, amberjack, and phycid hakes. Many different species of Cnidaria were recorded, including Antipatharia black corals, stylasterine hydrocorals, octocorals, and one colonial scleractinian (*Solenosmilia variabilis*).

Tennessee and Alligator Humps, Bioherms #1-4- Pourtalès Terrace (from Reed et al. 2004a)
The Tennessee and Alligator Humps are among dozens of lithoherms that lie in a region called "The Humps" by local fishers, ~14 nm south of the Florida Keys and south of Tennessee and Alligator Reefs . Three dives were made by J. Reed on Bioherm #3 (Clelia 597, 598, 600; Aug. 2001), approximately 8.5 nm NE of Bioherm #2 (Figure 3.3-16). Bioherm #3 consisted of two peaks 1.05 nm apart with a maximum relief of 62 m. The North Peak's minimum depth was 155 m and was 653 m wide at the base, which was 217 m deep at the east base and 183 m at the west side. The minimum depth of South Peak was 160 m and was about 678 m in width E to W at the base. The surrounding habitat adjacent to the mounds was flat sand with about 10% cover of rock pavement. From 213 m to the top, generally on the east flank of the mound, were a series of flat rock pavement terraces at depths of 210, 203, 198, 194, 183, and 171 m and the top plateau was at 165 m. Between each terrace a 30-45° slope consisted of either rock pavement or coarse sand and rubble. Below each terrace was a vertical scarp of 1-2 m where the sediment was eroded away leaving the edge of the terrace exposed as a horizontal, thin rock crust overhang of <1 m and 15-30 cm thick. The top of the bioherm was a broad plateau of rock pavement with 50-100% exposed rock, few ledges or outcrops, and coarse brown sand. Less time was spent on the western side, which was more exposed to the strong bottom currents. The west side of South Peak sloped more gradually than the eastern side, had more sediment, and no ledges were observed.

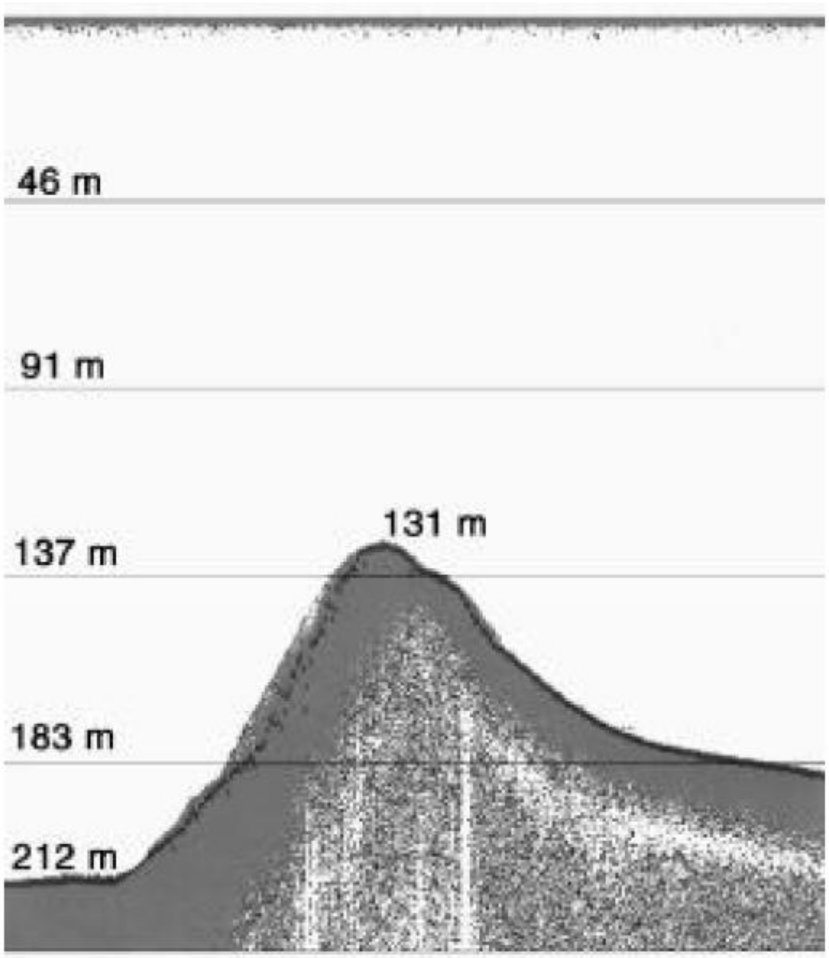


Figure 3.3-16. Echosounder profile of Pourtalès Terrace, Tennessee Bioherm #2 (depth 212 m at base, relief 85 m) (from Reed et al., 2004a)

Ecological role and function

(excerpted from Chapter 1 of the 2007 State of Deep Coral Ecosystems)
As the understanding of deep coral communities and ecosystems has increased, so has appreciation of their value. Deep coral communities can be hot-spots of biodiversity in the deeper ocean, making them of particular conservation interest. Stony coral "reefs" as well as thickets of gorgonian corals, black corals, and hydrocorals are often associated with a large number of other species. Through quantitative surveys of the macroinvertebrate fauna, Reed (2002b) found over 20,000 individual invertebrates from more than 300 species living among the branches of ivory tree coral (Oculina varicosa) off the coast of Florida. Over 1,300 species of invertebrates have been recorded in an ongoing census of numerous Lophelia reefs in the northeast Atlantic (Freiwald et al. 2004), and Mortensen and Fosså (2006) reported 361 species in 24 samples from Lophelia reefs off Norway. Gorgonian corals in the northwest Atlantic have been shown to host more than 100 species of invertebrates (Buhl-Mortensen and Mortensen 2005). An investigation by Richer de Forges et al. (2000) reported over 850 macro- and megafaunal species associated with seamounts in the Tasman and south Coral Seas with many of

these species associated with the deep coral Solenosmilia variabilis (Rogers 2004). The three-dimensional structure of deep corals may function in very similar ways to their tropical counterparts, providing enhanced feeding opportunities for aggregating species, a hiding place from predators, a nursery area for juveniles, fish spawning aggregation sites, and attachment substrate for sedentary invertebrates (Fosså et al. 2002; Mortensen 2000; Reed 2002b).

The high biodiversity associated with deep coral communities is intrinsically valuable, and may provide numerous targets for chemical and biological research on marine organisms. For example, several deep-water sponges have been shown to contain bioactive compounds of pharmaceutical interest; sponges are often associated with deep coral communities. Bamboo corals (family Isididae) are being investigated for their medical potential as bone grafts and for the properties of their collagen-like gorgonin (Ehrlich et al. 2006). A number of deep corals are also of commercial importance, especially black corals (order Antipatharia) and pink and red corals (Corallium spp.), which are the basis of a large jewelry industry. Black coral is Hawaii's "State Gem."

Deep coral communities have also been identified as habitat for certain commercially-important fishes. For example, commercially valuable species of rockfish, shrimp, and crabs are known to use coral branches for suspension feeding or protection from predators in Alaskan waters (Krieger and Wing 2002). Husebø et al. (2002) documented a higher abundance and larger size of commercially valuable redfish, ling, and tusk in Norwegian waters in coral habitats compared to non-coral habitats. Costello et al. (2005), working at several sites in the Northeast Atlantic, report that 92% of fish species, and 80% of individual fish were associated with Lophelia reef habitats rather than on the surrounding seabed. Koenig (2001) found a relationship between the abundance of economically valuable fish (e.g., grouper, snapper, sea bass, and amberjack) and the condition (dead, sparse and intact) of Oculina colonies. Oculina reefs off Florida have been identified as essential fish habitat for federally-managed species, as have gorgonian-dominated deep coral communities off Alaska and the West Coast of the United States. In other cases, however, the linkages between commercial fisheries species and deep corals remain unclear (Auster 2005; Tissot et al. 2006) and may be indirect.

Due to their worldwide distribution and the fact that some gorgonian and stony coral species can live for centuries, deep corals may serve as a proxy for reconstructing past changes in global climate and oceanographic conditions (Risk et al. 2002; Williams et al. 2007). The calcium carbonate skeletons of corals incorporate trace elements and isotopes that reflect the physical and chemical conditions in which they grew. Analysis of the coral's microchemistry has allowed researchers to reconstruct past oceanic conditions.

Species composition and community structure

(Excerpted from Chapter 6 of the 2007 Status of Deep Coral Ecosystems)

Oculina Banks (<150 m)

The fish community on the Florida shelf edge *Oculina* banks is typical of the southeastern U.S. shelf edge reef fauna (see review in Quattrini and Ross 2006). At least 73 species of fishes are known from the *Oculina* reefs (GOMFMC and SAFMC 1982; Koenig et al. 2005; Reed et al.

2006), and like the invertebrate community, this is a sub-tropically derived fauna. In recent years, commercial fishing on these reefs has significantly depleted members of the snapper-grouper complex and caused habitat destruction (Koenig et al. 2000, 2005). Some groupers, *Mycteroperca microlepis* (gag) and *M. phenax* (scamp), use the reefs as spawning aggregation sites (Gilmore and Jones 1992); however, these have also been negatively impacted by habitat destruction (Koenig et al. 2000).

The Florida *Oculina* reefs support a diverse invertebrate fauna with mostly sub-tropical affinities (Figure 6.2). Densities of associated invertebrates rival those of shallow coral reef systems (see review in Reed 2002b). Avent et al. (1977) presented a preliminary list of benthic invertebrates dredged from some *Oculina* mounds. Analysis of 42 small *Oculina* colonies yielded about 350 invertebrate species, including 262 mollusc species (Reed and Mikkelson 1987), 50 decapod crustacean species (Reed et al. 1982), 47 amphipod species, 21 echinoderm species, 15 pycnogoid species, and 23 families of polychaetes (Reed 2002b). The invertebrate community has been reduced by habitat destruction (Koenig et al. 2000). Although *Oculina* habitats appear to have more associated mobile macroinvertebrates than deeper coral areas, large sponges and soft/horny corals are less abundant (Reed et al. 2006).

Deep-sea slope coral areas (>150 m, but most >300 m)
Deep coral habitat may be more important to western Atlantic slope species than previously known. Some commercially valuable deep-water species congregate around deep-coral habitat (Table 2.19). Various crabs, especially galatheoids, are abundant on the deep reefs, playing a role of both predator on and food for the fishes. Other invertebrates, particularly ophiuroids, populate the coral matrix in high numbers. On the relatively barren Blake Plateau, reefs (coral and hardgrounds) and surrounding coral rubble habitat seem to offer abundant shelter and food.

There are few deep-coral ecosystem references for the southeast region related to fishes, and those are generally qualitative (fishes neither collected nor counted) or fishes were not a specific target of the research (Popenoe and Manheim 2001; Weaver and Sedberry 2001; Reed et al. 2005, 2006). In the most detailed study of fishes to date, Ross and Quattrini (2007) identified 99 benthic or benthopelagic fish species on and around southeastern U.S. deep-coral banks, 19% of which yielded new distributional data for the region. Additional publications resulting from their fish database documented the anglerfish fauna (Caruso et al. 2007), midwater fish interactions with the reefs (Gartner et al. in review), a new species of eel (McCosker and Ross in press), and a new species of hagfish (Fernholm and Quattrini in press). Although some variability in fish fauna was observed over this region, most of the deep-coral habitat was dominated by relatively few fish species (Table 3.3-5).

Table 3.3-5. Dominant benthic fish species (in phylogenetic order) observed and/or collected during submersible dives (2000-2005) on or near southeastern U.S. *Lophelia* habitat based on Ross and Quattrini (2007). Asterisk (*) indicate commercially important species.

Scientific name	**Common name (if known)**
Myxinidae (mixed Myxine glutinosa and Eptatretus spp.)	hagfishes
Scyliorhinus retifer	chain dogfish
Scyliorhinus meadi	
Cirrhigaleus asper	roughskin dogfish
Dysommina rugosa	
Synaphobranchus spp.	cutthroat eels
*Conger oceanicus**	conger eel
Netenchelys exoria	
Nezumia sclerorhynchus	
Laemonema barbatulum	shortbeard codling
Laemonema melanurum	reef codling
Physiculus karrerae	
Lophiodes beroe	
Hoplostethus occidentalis	western roughy
*Beryx decadactylus**	red bream
*Helicolenus dactylopterus**	blackbelly rosefish
Idiastion kyphos	
Trachyscorpia cristulata	Atlantic thornyhead
*Polyprion americanus**	wreckfish

Many of these species are cryptic, being well hidden within the corals (e.g., *Hoplostethus occidentalis*, *Netenchelys exoria*, *Conger oceanicus*). Various reef habitats were characterized by *Laemonema melanurum*, *L. barbatulum*, *Nezumia sclerorhynchus*, *Beryx decadactylus*, and *Helicolenus dactylopterus* (Ross and Quattrini 2007). Nearby off reef areas were dominated by *Fenestraja plutonia*, *Laemonema barbatulum*, *Myxine glutinosa*, and *Chlorophthalmus agassizi*. *Beryx decadactylus* usually occurs in large aggregations moving over the reef, while most other major species occur as single individuals. The morid, *Laemonema melanurum*, is one of the larger fishes abundant at most sites with corals. This fish seems to rarely leave the prime reef area, while its congener *L. barbatulum* roams over a broader range of habitats. Although *Helicolenus dactylopterus* can be common in all habitats, it occurs most often around structures. It is intimately associated with the coral substrate, and it is abundant around deep-reef habitat. Results (Ross and Quattrini 2007) suggested that some of the fishes observed around the deep-coral habitats may be primary (obligate) reef fishes.

One of the most impressive biological aspects of these coral habitats (aside from the corals themselves) is the diverse and abundant invertebrate fauna (Table 3.3-6 and Reed et al. 2006). *Eumunida picta* (galatheoid crab; squat lobster) and *Novodinia antillensis* (brisingid seastar) were particularly obvious, perched high on coral bushes to catch passing animals or filter food from the currents. One very different aspect of the North Carolina deep-coral habitat compared to the rest of the southeast region is the massive numbers of the brittle star, *Ophiacantha bidentata*, covering dead coral colonies, coral rubble, and to a lesser extent, living Lophelia colonies. It is perhaps the most abundant macroinvertebrate on these banks and may constitute a major food source for fishes (Brooks et al. 2007). In places the bottom is covered with huge numbers of several species of anemones. The hydroid fauna is also rich with many species being newly reported to the area and some species being new to science (Henry et al. in press). The abundance of filter feeders suggests a food rich habitat. Various species of sponges, echinoderms, cnidarians (Messing et al. 1990) and crustaceans (Wenner and Barans 2001) also have been reported from deep-coral reefs off Florida, the northeastern Straits of Florida and the Charleston Bump region (Reed et al. 2006). Reed et al. (2006) provided a preliminary list of invertebrates, mostly sponges and corals, from some deep-coral habitats on the Blake Plateau and Straits of Florida; however, most taxa were not identified to species. Lack of data on the invertebrate fauna associated with deep corals is a major deficiency.

Although the invertebrate assemblage associated with northeastern Atlantic *Lophelia* reefs has been described as being as diverse as shallow water tropical coral reefs (e.g., Jensen and Frederickson 1992), data analysis of invertebrates associated with western Atlantic deep corals is too preliminary to speculate on the degree of species richness. Preliminary data on the invertebrate fauna (Nizinski et al. unpublished data) seem to indicate a faunal and habitat transition with latitude. In addition to changes in reef structure and morphology (see above), relative abundance within a single species decreases, overall species diversity increases, and numerical dominance between species decreases with decreasing latitude. In contrast to some fishes, the reef associated invertebrate assemblage appears to use deep reefs more opportunistically.

Table 3.3-6. Preliminary list of dominant benthic megainvertebrates observed or collected on or near southeastern U.S. deep coral habitats. References are 1= Nizinski et al. unpublished data, 2= Reed et al. 2006, 3 = Henry et al. in review.

Dominant Non-Coralline Invertebrate Taxa	
Phylum Porifera (Sponges) Class Demospongiae multiple species[1,2] Class Hexactinellida (glass sponges) multiple species[1,2] including *Aphrocallistes beatrix*[1]	Phylum Cnidaria Class Hydrozoa (Hydroids) multiple species (≥ 37 species)[3] Class Anthozoa Order Actinaria (anemones) multiple species including *Actinaugi rugosa* (Venus flytrap anemone)[1] Order Zoanthidea (zoanthids) multiple species[1,2]
Phylum Mollusca Class Cephalopoda Squids, *Ilex* sp.[1] Octopus, multiple species[1] Class Gastropoda *Coralliophila* (?) sp.[1]	Phylum Annelida Class Polychaeta (polychaetes) multiple species including *Eunice* sp.[1]
Phylum Arthopoda Subphylum Crustacea Class Malacostraca Order Decapoda Infraorder Anomura Family Chirostylidae (squat lobster) *Eumunida picta* [1,2] *Gastroptychus salvadori*[1] *Uroptychus* spp.[1] Family Galatheidae (squat lobster) *Munida* spp.[1] *Munidopsis* spp.[1] Superfamily Paguroidea (hermit crabs and their relatives) multiple species[1] Infraorder Brachyura Family Pisidae *Rochinia crassa* (inflated spiny crab)[1] Family Geryonidae *Chaceon fenneri* (golden deepsea crab)[1,2] Family Portunidae *Bathynectes longispina* (bathyal swimming crab)[1,2] Other taxa Shrimps, multiple species[1]	Phylum Echinodermata Class Crinoidea (crinoids) multiple species[1] Class Asteroidea (sea stars) multiple species[1,2] Order Brisingida (brisingid sea star) Family Brisingidae *Novodinia antillensis*[1] Class Ophiuroidea (brittle stars) multiple species[1], including *Ophiacantha bidentata*[1] Class Echinoidea (sea urchins) Order Echinoida Family Echinidae *Echinus gracilis*[1] *E. tylodes*[1] Order Echinothurioida Family Echinothuriidae *Hygrosoma* spp.[2] Order Cidaroida Family Cidaridae *Cidaris rugosa*[1] *Stylocidaris* spp.[2]

3.3.2 Artificial reefs

Description and distribution

Artificial reefs, sometimes called man-made reefs, are broadly defined as any structure placed on the seabed, either deliberately or accidentally (i.e. shipwrecks), that acts similar to natural hardbottom or reefs. Artificial reefs may be composed of a wide variety of materials ranging from natural rock or discarded materials, such as concrete rubble, to entirely manufactured materials. Natural reefs artificially enhanced or rehabilitated by transporting and attaching living corals are usually not considered artificial reefs.

Artificial reefs are constructed for a variety of purposes, but are particularly popular sites for fishing and diving. Here we focus on the use of artificial reefs in an ecosystem approach to fisheries. The fishery focus is on fish and invertebrate fisheries, with the recognition that other biota are important ecological factors that influence fisheries as sources of food, habitat, and mortality for exploited species. Manmade reefs can be considered fishery management tools. Although manmade reefs are not identical to naturally occurring hardbottom areas or coral reefs, they share similar biota and ecological processes.

Artificial reef programs in the southeastern U.S. are overseen by individual states (Florida, Georgia, South Carolina, North Carolina) and require construction permits by the Army Corp of Engineers with review and approval by the U.S. Coast Guard and the Environmental Protection Agency.

While manmade reefs have been in use along the U.S. South Atlantic since the 1800s, their development in this region was somewhat limited through the mid-1960s. From the late 1960s to the present, reef development off the South Atlantic states (as measured by the number of permitted construction sites) has increased nearly five-fold, with approximately 250 sites now permitted in the coastal and offshore waters of these four states. Roughly half of these sites are in waters off the east coast of Florida alone. Artificial reef locations are considered live/hardbottom habitat and are available on the Council's Internet Mapping System accessible at www.safmc.net.

The total area of ocean and estuarine bottom along the South Atlantic states which has been permitted for the development of manmade reefs at present is approximately 130,000 acres (or 155 nm^2) which is a small % area of the shelf bottom and of the natural hardbottom managed by the SAFMC. Due to the practical limitations of all artificial reef programs, it is very likely that only a very small percentage of any of these permitted reef sites has actually been developed through the addition of suitable hard substrate. However, since in most cases construction activities may continue indefinitely on these sites, the percentage of hardbottom habitat developed will continue to rise as new materials are added.

Recreational anglers are the chief users of manmade reefs in this region. Financial resources made available directly or indirectly through many saltwater sportfishing interests have been a prominent factor in most reef development projects. Due to favorable environmental conditions throughout most of the year along the South Atlantic states, recreational divers have also been a driving force in establishing manmade reefs in recent years. This relatively new user group will likely continue to grow as diving becomes more popular. Finally, commercial fishing interests use some manmade reefs, but are less common users compared to recreational fishing and diving users.

State marine resources management agencies in all four South Atlantic states are actively involved in various aspects of manmade reef planning, development and management in their own waters as well as contiguous federal waters. All four states have, or are in the process of developing, their own state artificial reef management plans. North Carolina, South Carolina and Georgia control all manmade reef development through programs within their respective natural resource management agencies, and hold all active permits for reef development. Florida's reef development efforts are carried out by individual county or municipal programs with a limited degree of oversight conducted by the Florida Fish and Wildlife Conservation Commission. Reef construction permits in Florida are held by state, county and municipal government agencies or programs.

North Carolina

The North Carolina Division of Marine Fisheries (DMF) has been involved in artificial reef construction since the early 1970s. Responding to interest generated by local fishing club reef projects, the DMF began a reef construction program using bundled automobile tires. Hundreds of thousands of tires were deployed on several reefs from Cape Lookout to Brunswick County.

In 1974, three 440-foot Liberty Class ships were cleaned and sunk on reef sites off Oregon Inlet, Beaufort Inlet and Masonboro Inlet. Another Liberty ship was added to the Oregon Inlet site in 1978. These surplus vessels were obtained from the federal government under Public Law 92-402, also known as the Liberty Ship Act. Artificial reef construction continued using tires and smaller surplus vessels until 1986 when the reef program was reorganized.

During 1986 and 1987, twenty-one new reef sites were permitted by the DMF and 210 train cars were deployed on these sites. Use of tires was eliminated in the early 1980s due to stability problems. Reef construction permits which were held by various counties and clubs were transferred to the DMF under a general permit issued by the U.S. Army Corps of Engineers (USACOE).

At present, the DMF maintains 47 artificial reef sites. These sites are located from one to 38 miles from shore and are strategically located near every maintained inlet and one unmaintained inlet along the coast. In recent years, most of the oceanic and some of the estuarine reefs have received new construction. Materials deployed since 1986 include 39 vessels, 10,000 pieces of large diameter concrete pipe, 210 train cars and over 40,000 tons of concrete pipe, bridge spans, railings and rubble.

In addition to USACOE construction permits, aids to navigation permits are also maintained for the buoys marking the center point of each artificial reef site requiring a buoy. The reef program uses a 130-foot landing craft for deploying and maintaining buoys, as well as for small construction projects.

Prior to 1990, emphasis was placed on artificial reef construction. With funding provided by the Federal Aid in Sportfish Restoration Program, the reef program has maintained a monitoring program to evaluate the effectiveness of reef materials, to test designed materials and to monitor fish assemblages on the reef. Past work also includes aerial surveys conducted to assess artificial reef usage along the coast and surveys of king mackerel tournament entrants are used to measure reef use, awareness and catch rates.

The DMF maintains one of the most active artificial reef programs in the nation. State and Sportfish Restoration funding, and enthusiastic support from many civic and fishing clubs along the coast continues to ensure the success of North Carolina's artificial reef program.

South Carolina
The use of manmade structures to enhance fishing activities in South Carolina's coastal waters was first documented during the mid-1800s. During the mid-1960s the construction of offshore and coastal artificial reefs for the benefit of saltwater recreational anglers was carried out by numerous private organizations. In 1967 the state provided funding for its first manmade reef construction project, and in 1973 an on-going state-sponsored marine artificial reef program was established. This program is currently maintained by the Marine Resources Division of the South Carolina Department of Natural Resources (SCDNR) within the Division's Office of Fisheries Management. Funding for the program consists of state support through the South Carolina Marine Recreational Fisheries License, federal support through grants from the U.S. Fish and Wildlife Service-managed Sport Fish Restoration Program and donations from private fishing and diving clubs and other civic organizations.

The primary focus of the South Carolina Marine Artificial Reef Program (SCMARP) is the coordination and oversight of all activities within the state of South Carolina concerning the management of a viable system of marine artificial reefs in both state and contiguous federal waters. The primary goal of these manmade reefs is the enhancement of hardbottom marine habitats, associated fish stocks and resulting recreational fishing activities that take place on and around them. The SCMARP's responsibilities include reef planning, design, permitting, construction, monitoring, evaluation, research and marking. The program also plays a key role in interfacing with the public in areas related to general fisheries management issues as well as in providing specific reef-related information to user groups.

All manmade reef development and management in South Carolina is guided by the South Carolina Marine Artificial Reef Management Plan, adopted in 1991. As of June 2006, the state's system of marine artificial reefs consisted of 48 permitted sites (13 inside state waters) along approximately 160 miles of coastline. These sites range in location from estuarine creeks to as far as 50 miles offshore. Each manmade reef site consists of a permitted area ranging from several thousand square yards to as much as 24 square miles. Approximately 37.5 square miles of coastal and open ocean bottom has been permitted, of which only about one percent has actually been developed through the addition of manmade reef substrate.

Saltwater recreational anglers are the primary group associated with marine artificial reef utilization in South Carolina. Their annual fishing activities on manmade reef sites alone account for tens of thousands of angler-days, which result in an estimated total economic benefit to the state of over 20 million dollars each year. While some use of permitted artificial reefs by commercial fishing interests has been reported over the past three decades, this activity has been difficult to quantify since these practices do not have popular support with the majority of the fishing public, or may in some cases be illegal. Recreational divers comprise the second most common user group relying on the presence of marine artificial reefs. While sport divers have traditionally not been as large a user group as the saltwater recreational fishing community, significant expansion of the recreational diving industry in the state has resulted in a noticeable increase in this type of usage over the past two decades.

In an attempt to better manage the use of permitted manmade reefs in offshore waters and to ensure their long-term viability, the SCDNR has, through the South Atlantic Fishery Management Council, obtained Special Management Zone (SMZ) status for 29 of the 35 permitted reef sites located in federal waters. Fishing on those reef sites granted SMZ status is restricted to hand-held hook and line gear and spearfishing (without powerheads). In addition, the SCDNR has established experimental artificial reefs in order to examine the feasibility and possible benefits of establishing no-take manmade reefs in nearshore and offshore waters solely for the purpose of stock and habitat enhancement. For additional information visit: www.dnr.sc.gov/marine/pub/seascience/artreef.html.

Georgia

The continental shelf off Georgia slopes gradually eastward for over 80 miles before reaching the Gulf Stream and the continental slope. This broad, shallow shelf consists largely of dynamic sand/shell expanses that do not provide the firm foundation or structure needed for the development of reef communities, which include popular gamefish such as groupers, snappers, sea bass, and amberjack. It is estimated that only about 5% of the adjacent shelf features natural reefs or “live bottoms” anchored to rock outcrops, with most of these found well offshore. Large areas of Georgia’s estuaries similarly feature broad mud and sand flats lacking the firm substrate needed for the growth of oyster reefs, which provide prey and shelter for seatrout, sheepshead, drum, and other popular sportfish in an otherwise highly energetic environment. Ditching, pollution, and coastal development have also impacted water quality and further restricted use of inshore areas by not only fish, but also fishermen, resulting in even greater demands on the remaining estuarine habitat.

Sporadic attempts to develop manmade or “artificial” reefs in Georgia were begun in earnest in the late 1950s by sport fishermen, who knew that good angling opportunities existed on scattered shipwrecks and other manmade structures found in estuarine and offshore waters. Only short-term benefits were realized through these limited initiatives when deployed materials rapidly silted in, deteriorated, or were lost. Working with coastal sport fishing clubs, the Georgia State Game and Fish Commission began experimenting with artificial reef construction in the 1960s, focusing initially on estuarine areas and expanding later to offshore waters in the 1970s. Today, the program is housed within the Coastal Resources Division of the Georgia Department of Natural Resources (GADNR) and is funded through State fishing license revenues, the Federal Aid in Sport Fish Restoration (SFR) program, and private donations, including the support of fishing and conservation organizations, tournaments, businesses, individuals, military services, and other branches of State and federal government.

Goals of Georgia’s artificial reef program are to 1) create and enhance fisheries habitat and associated marine communities; 2) develop increased, more accessible recreational fishing opportunities; 3) facilitate and support fisheries management; and 4) generate economic benefits for coastal communities and the State.

To date, GADNR has initiated reef construction at 22 sites 2½ to 70 nautical miles (nm) offshore and at 15 estuarine locations along Georgia's 90-mile coast. Georgia's inshore artificial reef sites are typically small and largely inter-tidal in order to promote oyster reef development. Offshore, with the exception of three 400-yard diameter, experimental "beach reefs" sited in the State's territorial sea, the majority of the artificial reefs off Georgia are located in adjacent EEZ waters 6 to 23 nm in 30 to70 feet of water and east of coastal trawling grounds. Development of two experimental "deepwater" reefs in 120 to 160 feet of water 50 to 70 nm offshore has also been initiated to address a growing recreational component targeting tunas, wahoo, and other "bluewater" gamefish. A third, yet undeveloped deepwater reef site 65 nm east of Brunswick, Georgia, was permitted in 2005.

All artificial reefs constructed in inshore and nearshore waters within Georgia's 3-nm territorial sea require individual U.S. Army Corps of Engineers (USACOE) and State permits. In the adjacent EEZ, the State conducts artificial reef development under the authority of a USACOE Regional Permit that encompasses 20 specific reef locations. While the permitted estuarine and coastal "beach reef" sites are limited in size, the offshore EEZ sites typically average 4 nm^2. These larger areas allow for the development of multiple "patch reefs," a design that improves material performance and helps disperse fishing pressure.

Artificial reef development in Georgia has largely relied on stable and durable secondary use materials or "materials of opportunity" to create fisheries habitat. Complexity and surface area are other important factors. Similar to other early U.S. artificial reef development efforts, the Georgia program also initially utilized tires, which were bound into compressed 8-tire units using rebar and anchored with concrete. While many tire units remain intact at Georgia's offshore reefs, several have also deteriorated; however, due to early concerns expressed by the trawler fleet in coastal waters, most units were also placed well offshore and many have sunken into the soft sand bottoms at the reef sites closest to shore.

Perhaps the best known and most popular materials of opportunity used for artificial reef development are metal vessels, which have been employed as materials off Georgia for over fifty years or more. Prior to sinking, all vessels are cleaned, cut down to satisfy required water depth clearances, and modified to promote sunlight and water flow. As vessels age and collapse, they often become more complex, improving the overall growth and development of associated reef communities. Ranging from 34 to 447 feet in length, almost 70 vessels are found on Georgia's offshore reefs, including tugs, barges, landing craft, sailboats, steel trawlers, a dredge, a USCG buoy tender, a former Japanese research vessel, and two Liberty ships -- the *Edwin S. Nettleton* and the *Addie Bagley Daniels*.

Emulating the rock outcroppings underlying temperate natural reef communities, marine grade concrete is another preferred material of opportunity used for reef development in Georgia's estuarine and adjacent offshore waters. To date, almost 200,000 tons of concrete pipe, pilings, and bridge/wharf rubble generated through coastal construction projects have been deployed on Georgia's artificial reefs. Other notable materials of opportunity also utilized for offshore artificial reef development in Georgia include 55 U.S. Army battle tanks and 50 New York City Transit System subway cars.

Designed for stability, complexity, and long-term service, several thousand concrete fisheries enhancement units have been deployed by the program since the mid-1990s on Georgia's inshore and offshore artificial reefs. Commercially available, the final unit design selected is dictated by project goals, site characteristics, cost per-unit-deployed, and the availability of comparable reef materials.

Normally occurring during the warmer months, SCUBA diving at Georgia's artificial reefs primarily takes place on the reef sites 15 nm and further offshore due to poor water visibilities and strong tidal influences found closer to shore. The larger wrecks popular with divers are also found on the artificial reefs located further offshore deeper water depths. However, Georgia's artificial reefs are constructed to first provide fisheries habitat and angling opportunities and are not designed for diving. Entanglement and entrapment are diving hazards unavoidably associated with artificial reef structures, especially as the materials age, deteriorate, and collapse.

The artificial reefs located in Georgia's adjacent EEZ waters have been established as Special Management Zones (SMZs) under the SAFMC's Snapper-Grouper Fishery Management Plan. In conjunction with this designation, allowable gears the reefs are restricted to handheld hook-and-line and spearfishing gear, including powerheads or "bangsticks." Powerheads may only be used to harvest a recreational bag limit and any powerheaded catches in excess of the bag limits aboard a vessel at a SMZ is considered *prima facie* evidence of a violation.

Further information on Georgia's marine artificial reefs may be obtained through Coastal Resources Division, One Conservation Way, Suite 300, Brunswick, GA 31520; phone # (912) 264-7218, or by going to http://crd.dnr.state.ga.us.

Florida (East Coast)

Encompassing 34 of 35 different coastal counties spread along 2,184 kilometers (1,357 miles) of ocean fronting coastline (1,362 kilometers fronting the Gulf of Mexico and 822 kilometers fronting the Atlantic Ocean), Florida manages one of the most diverse, and most active artificial reef programs in the United States. Florida leads the nation in the number of public manmade fishing reefs developed. The first permitted artificial reef off Florida was constructed in 1918. Manmade reefs are found in waters ranging from eight feet to over 400 feet with an average depth of 65 feet. As of September 2006, no fewer than 790 deployments of manmade reef materials off the Florida East Coast are on record with the Florida Fish and Wildlife Conservation Commission (FWC). Over the last 40 years the state artificial reef program has experienced a gradual transition in construction materials use, funding sources, and recognition of the importance of measuring effectiveness.

The State's involvement in funding manmade reef construction began in the mid-1960s when the Florida Board of Conservation awarded a limited number of grants to local governments to fund reef development projects. In 1971 a Florida Recreational Development Assistance Program grant was awarded to a local government by the DNR Division of Recreation and Parks for reef construction. Between 1976 and 1980 the DNR Division of Marine Resources received, and oversaw the preparation and placement of five Liberty ships, secured as a result of passage of the

Liberty Ship Act, which facilitated the release of obsolete troop and cargo ships for use as artificial reefs.

In 1978 a systematic state artificial reef program was begun. The Division of Marine Resources received a large grant from the Coastal Plains Regional Commission for artificial reef development. Rules for disbursing these funds were developed, defining a grants-in-aid program with projects selected through a competitive evaluation of local government proposals. In 1979 the State Legislature appropriated general revenue funds for reef construction which continued on an annual basis, with the exception of one year, through 1990. In 1982, in addition to receiving general revenue funds, the program was officially established as a grants-in-aid program by law (s. 370.25, Florida Statutes). One staff position was assigned responsibility for program administration.

The rapid proliferation of publicly funded artificial reefs in Florida beginning in the mid- 1980s is the result of increased levels of federal, state and local government funding for artificial reef development. Prior to that, other state funding sources intermittently provided reef development assistance. In 1966 there were seven permitted artificial reef sites off Florida in the Atlantic Ocean. By 1987, this number had grown to 112. Consistent federal funding for Florida's reef program became available in 1986 as a result of the Wallop-Breaux amendment to the 1950 Federal Aid in Sport Fish Restoration Act (Dingle-Johnson). During the decade of reef-building activity from 1986 to 1996, Sport Fish Restoration Funds provided almost three million dollars to complete 164 Florida reef projects.

In January 1990, Florida instituted a saltwater fishing license program. About 5% of the revenue from the sale of over 850,000 fishing licenses annually became available for additional artificial reef projects. Two additional personnel were hired into the state artificial reef program to assist with coordination, information sharing, grant monitoring/compliance and diving assessment of artificial reefs. Funding in Florida was steady from 1996 through 2005, with $300,000 coming from the Federal Aid to Sport Fish Restoration Program matched with $100,000 in state saltwater license funds and another $200,000 state saltwater license funds for a total of $600,000 annual appropriation. In 2006 the total annual appropriation was increased to $700,000 with $400,000 coming from the Federal Aid in Sport Fish Restoration Program and $300,000 from state saltwater license funds.

Florida is the only southeastern Atlantic coastal state active in artificial reef development which does not have a direct state-managed artificial reef program. For the last 20 years, Florida's artificial reef program has been a cooperative local and state government effort, with additional input provided by non-governmental fishing and diving interests. The state program's primary objective has been to provide grants-in-aid to local coastal governments for the purpose of developing artificial fishing reefs in state and adjacent federal waters off both coasts in order to locally increase sport fishing resources and enhance sport fishing opportunities. All but three active permitted reef sites are held by individual coastal counties or cities.

Reef management expertise at the local government level is variable. Reef programs are found in solid waste management, public works, natural resources, recreation and parks, administrative, and planning departments. Local government reef coordinators range from biologists and marine engineers to city clerks, grants coordinators, planners, and even unpaid volunteers. Reef management and coordination are generally collateral duties for most local government reef coordinators.

In response to long-range planning initiatives, in 2003 the FWC completed a long-range Artificial Reef Strategic Plan (Florida Fish and Wildlife Commission, 2003) to serve as a blueprint for both the FWC and the local coastal government reef programs. Representing the broad range of public interests in artificial reefs throughout Florida, the plan is comprised of guiding principles, goals, and objectives that optimize biological and economic benefits, provide policy guidance, support research and data collection, pursue additional funding opportunities, provide a framework for public education and outreach, and provide guidance for operational planning at the state, regional, and local levels of artificial reef construction and monitoring. The Strategic Plan is available at http://myfwc.com/marine/ar/FLARStrategicPlan2.pdf

Due to its long coastline, ideal conditions, and large number of academic and research-oriented institutions, a significant quantity of the existing body of field research dealing with manmade reefs has been conducted in waters off Florida. Artificial reef research projects undertaken with over $3.6 million dollars in state funding since 1990 have included studies on reef spacing and design, material stability and storm impact studies, long term studies of reef community succession, residency of gag grouper on patch reefs through tagging and radio telemetry, juvenile recruitment to reefs, impacts of directed fishing, remote biological monitoring techniques, and the effects of unpublished manmade reefs.

As with most other artificial reef programs in the U.S., there has been a shift in the types of materials used in the construction of manmade reefs in Florida waters over the past 40 years. Through experience, reef builders have learned which materials work best in providing effective long-lived manmade reefs. Modern construction practices have evolved to a point where reef programs are much more selective in the types of materials they use.

Concrete materials, chiefly culverts and other prefabricated steel reinforced concrete, were the primary reef material in nearly 67% of the 2,349 public reef deployments in waters off Florida as of September 2006. Engineered artificial reef units have been a growing component of the state’s manmade reef development efforts since the early 1990s and now represent 24% of the manmade reefs off Florida. Most, but not all, units designed specifically for use as artificial reefs have proven to be durable and stable in major storm events. Prefabricated units designed specifically for use as manmade reefs have focused on improving upon habitat complexity, stability and durability, as well as providing a standard design for research and monitoring projects.

Secondary use materials such as obsolete oil platforms and steel vessels have also been used off Florida in the development of manmade reefs. Twenty-eight percent of Florida’s manmade reef structures are metal structures, including 460 sunken vessels and barges. These vessel reefs have catered to fishermen fishing for pelagic species, and a rapidly expanding resident and tourist diving population. The majority of vessels sunk as manmade reefs are concentrated off Miami-Dade, Palm Beach, and Broward Counties. On May 18, 2006, in partnership with the U.S. Navy, Florida’s artificial reef program and Escambia County successfully deployed the *Oriskany,* an

888 foot-long aircraft carrier, 23 miles southeast of Pensacola, FL. The *Oriskany* is presently the largest vessel in the world intentionally deployed as a manmade reef.

Ecological role and function

Manmade reefs have the effect of changing habitats from a soft substrate to a hard substrate system or to add vertical profile to low profile (< 1m) hard substrate systems. When manmade reefs are constructed, they provide new primary hard substrate similar in function to newly exposed hardbottom (Goren 1985). Aside from the often obvious differences in the physical characteristics and nature of the materials involved in creating a manmade reef, the ecological succession and processes involved in the establishment of the epibenthic assemblages occur in a similar fashion on natural hard substrates and man-placed hard substrates (Wendt et al. 1989). Demersal reef-dwelling finfish, pelagic planktivores and pelagic predators use natural and manmade hard substrates in very similar ways and often interchangeably (Sedberry 1988). The changes in species composition and local abundance of important species in a specific area are often seen as the primary benefits of reef deployment activities.

Hardbottom habitats can be formed when overlying soft sediments are transported away from an area by storms, currents or other forces. The underlying rock or hard-packed sediment which is exposed provides new primary hard substrate for the attachment and development of epibenthic assemblages (Sheer 1945; Goldberg 1973a; Jackson 1976; Osmand 1977). This substrate is colonized when marine algae and larvae of epibenthic animals successfully settle and thrive. Species composition and abundance of individuals increase quickly until all suitable primary space is used by the epibenthos. At some point, a dynamic equilibrium may be reached with the number of species and number of new recruits leveling off. Competition for space and grazing pressure become significant ecological processes in determining which epibenthic species may persist (Kirby-Smith and Ustach 1986; Paine 1974; Sutherland and Karlson 1977). The reef community itself should remain intact as long as the supporting hard substrate remains and is not buried under too great an overburden of sediment.

Concurrent with the development of the epibenthic assemblage, demersal reef-dwelling finfish recruit to the new hardbottom habitat. Juvenile life stages will use this habitat for protection from predators, orientation in the water column or on the reef itself and as a feeding area. Adult life stages of demersal reef-dwelling finfish can use the habitat for protection from predation, feeding opportunities, orientation in the water column and on the reef and as spawning sites.

Pelagic planktivores can occur on hardbottom habitats in high densities and use these habitats for orientation in the water column and feeding opportunities. These species provide important food resources to demersal reef-dwelling and pelagic piscivores. The pelagic piscivores use the hardbottom habitats for feeding opportunistically. Most of these species do not take up residence on individual hardbottom outcrops, but will transit through hardbottom areas and feed for varying periods of time (Sedberry and Van Dolah 1984).

As noted by researchers the physical characteristics of manmade reef habitat may result in differences in the observed behavior of fish species on or around such structures in contrast to behavior observed on equivalent areas of natural hardbottoms (Bohnsack 1989). Some reef structures, particularly those of higher profile, seem to yield generally higher densities of managed and non-managed pelagic and demersal species than a more widely spread lower profile, natural hardbottom or reef (Rountree 1989). The fishery management implications of these differences must be recognized and taken into consideration when planning, developing, and managing manmade reefs as essential fish habitat.

Other manmade hard substrates in marine and estuarine systems provide habitat of varying value to fisheries resources. Coastal engineering structures such as bridges, jetties, breakwaters and shipwrecks provide significant hard substrate for epibenthic colonization and development of an associated finfish assemblage (Van Dolah 1987). Some of these structures also provide habitat in the water column and intertidal zone which differs significantly from typical benthic reefs. The result of the different ecotones provided by these coastal structures is often higher species diversity than was present before the structure was placed on site. These structures also may provide refuge from predation as well as feeding opportunities and orientation points for juvenile and adult life stages of important finfish species in the South Atlantic region. They differ from manmade reefs as defined above, in that there is generally no direct intention in their design or placement to achieve specific fishery management objectives. However, their impacts should be considered just as any other activity which modifies habitats in the marine environment.

Fisheries Enhancement

The proper placement of manmade materials in the marine environment can provide for the development of a healthy reef ecosystem, including intensive invertebrate communities and fish assemblages of value to both recreational and commercial fishermen. The effectiveness of a manmade reef in the enhancement of fishing varies and is dictated by geographical location, species targeted, stock health, and design and construction of the reef (Bohnsack 1989). An examination of both the historical and present use of manmade reefs along each of the South Atlantic states reveals that fisheries enhancement was the primary reason for establishing these sites. Manmade reefs have developed an impressive track-record of providing beneficial results, as measured by fishing success for a wide range of finfish species. To date, manmade reefs have been chiefly employed to create specific, reliable and more accessible opportunities for recreational anglers. They have been used to a lesser extent to enhance commercial fishing probably because manmade reef total area is small compared to much larger, traditionally relied-upon, natural commercial fishing grounds.

In their present scale and typical design, most manmade reefs, while well-suited for use by recreational anglers, would be unable to withstand intensive commercial fishing pressure, especially for many of the popularly sought-after demersal finfish species, for more than a short period of time. Currently, most manmade reef programs receive the majority of their funding through sources tied directly to recreational fishing interests.

Special Management Zones

Conceptualized by the South Atlantic Fishery Management Council within the Snapper/Grouper Management Plan, several “Special Management Zones” or “SMZs” have been established in the South Atlantic off South Carolina, Georgia, and Florida to provide gear and harvest regulations for defined locations. The basic premise of this concept is to reduce user conflicts through gear and landings regulations at locations that feature limited resources, managed for specific user groups. Generally, manmade reefs have been developed for recreational use utilizing recreational resources. The ability to regulate gear types utilized over the relatively limited area of a manmade reef enables fisheries managers to prevent rapid depletion of these sites and promote a more even allocation of reef resources and opportunities.

Present SMZ regulations apply to about 30 manmade reef sites off South Atlantic States, with several more proposed. Since regulations concerning the management of SMZs are tied to specific gear restrictions, it is possible that the use of SMZs in the future could be expanded to a point where any possible type of fishing gear could be restricted for a set period of time or indefinitely. This could provide fishery managers with the ability to turn individual manmade reef sites "on or off" as the specific needs of the fishery in question dictate. The ability to have some degree of control over fishing activities on these sites would give managers more power to use artificial reefs as a true fishery management tool.

Hardbottom Habitat Enhancement

Habitat enhancement through the construction of manmade reefs can be achieved by converting some other type bottom habitat into a hardbottom community. Mud, sand, shell or other relatively soft bottom habitat can be altered by the addition of hard structure with low to high profile to add to the total amount of hardbottom reef environment in a given area. While it would be difficult and particularly costly to construct manmade reefs with an equivalent area of most typical hardbottom found off the southeastern U.S., substantial areas of ocean bottom can be effectively converted to hardbottom over time given sufficient planning, proper design and adequate resources.

In areas where existing hardbottom habitat is limited spatially, temporally, or structurally, manmade structures may be used to augment what is already in place. Hardbottom with or without a thin veneer of sediment constitutes a preferred substrate for this type of manmade reef development, as opposed to sand and mud bottoms; however, deployment of structures in already productive areas carries a certain degree of risk. Existing hardbottom may be directly damaged or impacted by modified current regimes, movement of materials and potentially increased user pressure. Although sparse, the hardbottom may constitute valuable juvenile habitat and refugia that may be severely compromised by creating additional habitat conducive to predators. On the other hand, a properly planned manmade reef could be constructed without impact to existing resources by utilizing stable materials that are designed to enhance juvenile habitat and survival.

In cases where critical hardbottom habitat is damaged or lost due to natural forces such as severe storms or burial, the addition of manmade reef material could be used to compensate for this loss on site or in adjacent areas. Manmade reef structures can also be used to repair damaged habitat or mitigate for its loss in cases where stable, hard substrate placed on the bottom would provide the closest in-kind replacement as possible, or at least provide the long-term base for the eventual re-establishment of the hardbottom reef community that was originally impacted.

Manmade Marine Reserves

Marine reserves and sanctuaries are a proven management technique that has been implemented successfully worldwide to protect essential fisheries habitat and sustain fisheries stocks and genetic variability. Although the concept of marine reserves has gained some support in the southeastern United States, the actual application of this management measure has generated resistance among user groups who feel that the establishment of such reserves will adversely impact fishing opportunities by limiting access to existing habitat. For areas with little fisheries habitat, these impacts are viewed as significant.

The potential role that manmade reefs could play in implementing marine reserves and similar management measures remains largely unexplored at present. It is conceivable that effective marine reserves consisting of manmade structures could be developed in habitat-limited areas to assist specifically in such roles as habitat and stock enhancement. Detailed research needed to measure their effectiveness in these roles is needed. Substantial resources and funds would also be required to develop the large reserve areas proposed, although smaller sanctuaries are entirely feasible. Manmade structures could be utilized to enhance existing marine reserve areas by improving existing habitat or providing additional hardbottom substrate. Manmade reef reserves could also be used as test platforms to demonstrate to the public the potential effectiveness of such areas, without impacting existing fisheries practices on sites in a given area.

At this time, perhaps the most important contribution that manmade reef technology can provide for fisheries management efforts employing marine reserves would be to create additional habitat and fisheries to “compensate” user groups for perceived “losses.” Coupled with positive effects of adjacent marine reserves, properly sited, more accessible artificial reefs would increase benefits to user groups. Another potential function could be to enhance areas that are not being fished and create reserves; that way, fishers would not be giving up “fishable” area and could benefit from spillover.

Enhancement of Eco-Tourism Activities

Along with other eco-tourism activities, recreational diving is one of the fastest growing sports in the United States. Properly planned, manmade reefs can be designed to encourage diving and to reduce spatial conflicts with other user groups, including fishermen. Specific SMZ or other regulations established for a manmade reef could conceivably allow non-extractive uses only, including diving, underwater photography, snorkeling, and other eco-tourism activities. Materials selected could be designed and deployed to create specific fisheries habitat for tropical, cryptic, and other species valued by tourists, conservationists, naturalists, photographers and other non-extractive users.

The establishment of additional hardbottom reef communities in areas with thriving dive-related industries could be used to reduce diving-related pressures on existing natural reefs, especially in the case of sensitive coral reefs in the Florida Keys (Leeworthy et al. 2006). Finally, a non-extractive, conservation reef would essentially constitute a sanctuary, providing fisheries and the associated habitat with *de facto* protection.

Manmade reef construction practices

Manmade reefs have been built from a wide variety of materials over the years. Throughout the present century, most construction materials relied upon in the South Atlantic states have been forms of scrap or surplus; some more suitable for this purpose than others. In an effort to decrease dependency of successful reef development on the availability of scrap or surplus materials, and to improve the overall effectiveness and safety of manmade reefs, most artificial reef programs have, in recent years, designed, manufactured and/or evaluated a number of specifically engineered reef habitat structures which may become a more viable option for future reef development projects. Due primarily to improved financial support for most artificial reef programs in the South Atlantic states and a willingness within private industry to develop new and affordable designed reef structures, the use of such reef construction material is now much more feasible.

Whether specifically designed or secondary-use materials are utilized to construct manmade reefs, individual state resource management agencies should be able to define particular materials that are deemed acceptable for use as reef structures in their coastal and adjacent offshore waters. The decision to allow or disallow the use of certain materials should be based on existing state and federal regulations and guidelines, as well as any soundly based policies established by a particular state. Materials should only be considered for use if they possess characteristics which allow them to safely meet the established objectives for the manmade reef project under consideration, and present no real risk to the environment in which they are being placed. The document entitled *Guidelines for Marine Artificial Reef Materials* (Gulf States Marine Fisheries Commission, 1997) provides detailed information of the experiences, benefits, and drawbacks of past uses of a variety of materials by state resource management agencies. This, as well as other related documents (e.g National Artificial Reef Plan), and the collective experiences of individual artificial reef programs, may be relied upon as the best available data in making decisions regarding the use of certain types of materials in manmade reef development.

Secondary Use Materials

Although past artificial reef development in most states has been directly tied to the availability of surplus or “secondary use” materials due to budgetary constraints, this may not be the most desirable situation for continued planning and development of reef construction efforts in the future. While a total dependency on scrap and surplus materials is not the most effective means of managing reef development activities, some secondary use materials, when available in the proper condition, are very desirable in carrying out manmade reef construction projects and should continue to be utilized to enhance fisheries habitat.

In some cases naturally occurring materials such as quarry rock, limestone, or even shell have been utilized to construct manmade reefs. While these are not by definition scrap materials, their availability is sometimes dictated by a desire to move them from an existing site where for some reason they may no longer be desired. In these cases, they could be classified as a “material of opportunity.” In other cases, as in the intent to build a reef to provide a rocky bottom substrate, material such as quarry rock or limestone may be the most suitable material available to create the intended habitat, and may be specifically sought after.

In the South Atlantic states individual state artificial reef programs, resource management agencies, or other approved reef programs serve as the central contact and coordination point for evaluating, approving, distributing and deploying secondary use materials on a given state’s system of artificial reefs. Before agreeing to approve any materials for use in reef construction, the managing or oversight agency must carefully inspect the items and ensure that they are environmentally safe, structurally and physically stable, needed, practical, and can be deployed in a cost-effective and safe manner. A detailed discussion of the benefits, limitations and problems encountered in using the almost limitless list of secondary use materials that have been employed over the years in the construction of manmade reefs is well beyond the scope of this document. However, the Atlantic and Gulf State Marine Fisheries Commission's, as well as other individual artificial reef programs have produced publications which cover in great detail, many of the strengths and weaknesses of secondary use materials which have been employed in reef development.

Designed Habitat Structures
If an artificial reef program is to function in a manner that is conducive to effective long-term planning and the pursuit of realistic (fishery management driven) reef development goals, it cannot continue to base reef construction solely on the unpredictable availability and diminished quantity of acceptable scrap or surplus materials. The only practical solution is to consider the incorporation of manufactured reef structures into planned reef development activities.

Manufactured manmade reef structures can be developed which possess the characteristics desired of a reef substrate for a specific environment, application, or end result. Although the initial costs in procuring these reef materials may be higher than those involved in obtaining many secondary use materials, the transportation, handling and deployment costs are typically about the same, and the lack of expense in having to clean or otherwise prepare these structures can often balance out this difference. Being able to engineer into a reef material design specific qualities of stability, durability, structural integrity, transportability and biological effectiveness also gives manufactured reef structures a great advantage over most secondary use materials which are often severely limited in how they can be modified or deployed.

Manufactured reef units can be deployed in any quantity, profile and pattern required, allowing them to provide for maximum efficiency of the materials used in achieving the desired results. Secondary use materials such as ships must be deployed in a single unit, often with a great deal of the total material volume being taken up in vertical profile. The same volume of designed reef materials that would be found in a vessel can be spread over a much larger area of ocean bottom with much less relief, allowing for better access to a larger number of reef users and a "more natural" appearance in the layout of the reef.
One of the most significant advantages offered by the use of designed reef structures is the ability to procure them in any quantity any time they are needed. This allows reef managers to plan ahead and make the best possible use of available funding, as well as predict exact costs needed to accomplish specific reef construction objectives from month to month or year to year. When depending on secondary use materials for reef development, this type of short and long-term planning is rarely available.

Standards for Manmade Reef Construction
The National Fishing Enhancement Act of 1984 (Title II of P.L.98-623) provides broad standards for the development of manmade reefs in the United States. The purpose of the Act was to "promote and facilitate responsible and effective efforts to establish artificial reefs in the navigable waters of the US and waters superjacent to the outer continental shelf (as defined in 43 USC, Section 1331) to the extent such waters exist in or are adjacent to any State." In Section 203, the Act establishes the following standards for artificial reef development. "Based on the

best scientific information available, artificial reefs in waters covered under the Act...shall be sited and constructed, and subsequently monitored and managed in a manner which will:

(1) enhance fishery resources to the maximum extent practicable;
(2) facilitate access and utilization by U.S. recreational and commercial fishermen;
(3) minimize conflicts among competing uses of waters covered under this title and the resources in such waters;
(4) minimize environmental risks and risks to personal health and property; and
(5) be consistent with generally accepted principles of international law (e.g MARPOL) and shall not create any unreasonable obstruction to navigation."

Section 204 of the Act also calls for the development of a National Artificial Reef Plan consistent with these standards. This plan was first published by the National Marine Fisheries Service in 1985 and includes discussions of criteria for siting and constructing manmade reefs, as well as mechanisms and methodologies for monitoring and managing such reefs. While the Plan itself lacked any degree of regulatory authority, adopted regulations subsequently developed by the U.S. Army Corps of Engineers for dealing with the issuance of artificial reef construction permits were based on the standards set forth in the Act as well as wording taken from the Plan. The plan, National Artificial Reef Plan (as Amended): Guidelines for Siting, Construction, Development, and Assessment of Artificial Reefs (NOAA, 2007) was approved in 2007 and is available at http://www.nmfs.noaa.gov/sfa/PartnershipsCommunications/NARPwCover3.pdf

Each state artificial reef program has its own set of standards for the development and management of artificial reefs. In most cases these state standards were developed with the federal standards from the National Fisheries Enhancement Act and the National Artificial Reef Plan in mind. While specific state programs may differ in matters involving technical operation or specific management issues, they are all very similar in their adoption of the national standards that exist.

Human use and environmental concerns

Different artificial reef uses can potentially conflict. Fishing, for example, may conflict with research, education, non-extractive diving, or conservation. Conflicts can occur between commercial and recreational fishing and between spearfishers and hook-and-line anglers. Large ships used as artificial reefs can entrap divers who get disoriented or lost or acts as an attractive nuisance by luring divers to attempt diving at unsafe depths or under other unsafe conditions. With some exceptions (i.e. Johns et al. 2001), the costs and benefits of artificial reef construction from social and economic perspectives have rarely been evaluated. Illegally constructed artificial reefs, such as casitas used to attract spiny lobster, for example, are a public concern in terms of causing environmental damage and social and economic imbalance in terms of resource allocation.

Poorly designed or positioned manmade reefs can damage or alter natural habitat, create hazards to navigation, disrupt some fishing operations (e.g. shrimp trawling), become sources of pollution or contamination, and can contribute to overfishing or aesthetic pollution. Because the southeastern U.S. is vulnerable to storm, wave, and hurricane damage, durability and stability become especially important design considerations to avoid damaging surrounding habitat from structural failures and reef movement.

Cumulative impacts of artificial reefs are poorly understood. Despite the existence of extensive construction programs, it remains unclear whether artificial reefs provide significant long-term biological benefits to primary or secondary productivity, in part because all artificial reefs usually are only a small portion of existing natural hardbottom. Replacing natural habitats with artificial reefs may lead to environmental concerns about altering food webs, behavior, and settlement patterns, as well as possible detrimental impacts to adjacent habitats.

Public pressure to build artificial reefs often develops in response to signs of fishery depletion. In these cases other management actions may be needed in addition to or instead of constructing artificial reefs for rebuilding stocks. In these cases enthusiasm for building artificial reefs may divert limited resources away from more effective measures, such as improving habitat protection or strengthening fishing effort controls. Aggregation of fish by artificial reefs may increase fishing success at least in the short-term, but over the long-term, aggregation or increased total fishing activity at artificial reefs may overwhelm production and aggravate overfishing problems.

Artificial reefs as Essential Fish Habitat

Earlier sections have discussed the ways in which manmade reefs are specifically used by both invertebrate and finfish species. Since manmade reefs are established by marine resource managers throughout the entire South Atlantic Bight, the diversity of species present on and around such structures is extremely wide. Manmade reefs are used in almost every possible marine environment, from shallow-water estuarine creeks to offshore sites up to several hundred feet in depth. Due to the broad distribution of reef sites along the South Atlantic states, many different species may interact with manmade reefs at different life-stages and at different times. For species which may be to some degree habitat-limited, the establishment of additional suitable habitat targeted to specific life-history stages may improve survival (Herrnkind et al., 1997). Additional manmade habitat designed specifically to promote survival of targeted species in "protected" areas could potentially enhance existing ecosystems or create new ones to fill in gaps where essential fish habitat had been damaged, lost, or severely overfished. Man-made structures also may provide essential habitat while simultaneously acting as a deterrent to illegal fishing practices in specially managed areas (e.g. Oculina HAPC).

Since the majority of the manmade reefs constructed along the southeastern U.S. are in coastal and offshore waters, the species most often present on these sites are predominantly the adult and/or sub-adult stages of virtually all species within the South Atlantic Snapper Grouper Complex, as well as all species managed within the Coastal Migratory Pelagics Fishery Management Plan. Depending on environmental conditions on a specific reef site, and the behavior patterns of certain fish, species within the Snapper Grouper Complex tend to be long to short-term reef residents, while those among the Coastal Pelagics tend to be more transient visitors to the reefs as they migrate up and down the coast. Red drum and spiny lobster, as well as some of the managed shrimp species, may be found on and around specific reef sites at different times of the year, depending on the exact location and design of the reef. While some species of managed corals may occur on reef structures as far north as the Carolinas, the waters off South Florida are the predominant site where such species are found attached to manmade substrate.

Artificial reefs are constructed from a wide range of materials, and used for a variety of purposes. They function by altering natural habitat and are especially popular sites for fishing and diving. Considerable evidence exists that artificial reefs attract and concentrate certain exploited species and can lead to short-term increases in catch rates. Artificial reefs constitute a habitat-based tool that ideally should be incorporated into an integrated holistic approach to fishery management.

3.3.3 Sargassum Habitat

Description and distribution

Within warm waters of the western North Atlantic, pelagic brown algae *Sargassum natans* and *S. fluitans* (Phaeophyta: Phaeophyceae: Fucales: Sargassaceae) form a dynamic structural habitat. These holopelagic species are believed to have evolved from benthic ancestors at least 40 million years ago. Evidence supporting this contention include: 1) lack of sexual reproduction characteristic of benthic species, 2) absence of a basal holdfast, 3) endemic faunal elements (10 invertebrates and 2 vertebrates), 4) greater buoyancy than benthic forms, and 5) late Eocene to early Miocene fossil remains from the Carpathian basin of the Tethys Sea (Winge 1923; Parr 1939; Friedrich 1969; Butler et al. 1983; Stoner and Greening 1984, Luning 1990). *Sargassum natans* is much more abundant than *S. fluitans*, comprising up to 90% of the total drift macroalgae in the Sargasso Sea. Limited quantities of several benthic species, including *S. filipendula, S. hystrix, S. polycertium, S. platycarpum* and *S. pteropleuron*, detached from coastal areas during storms, are also frequently encountered adrift. However, the drifting fragments of these benthic species soon perish (Hoyt 1918; Winge 1923; Parr 1939; Butler et al. 1983).

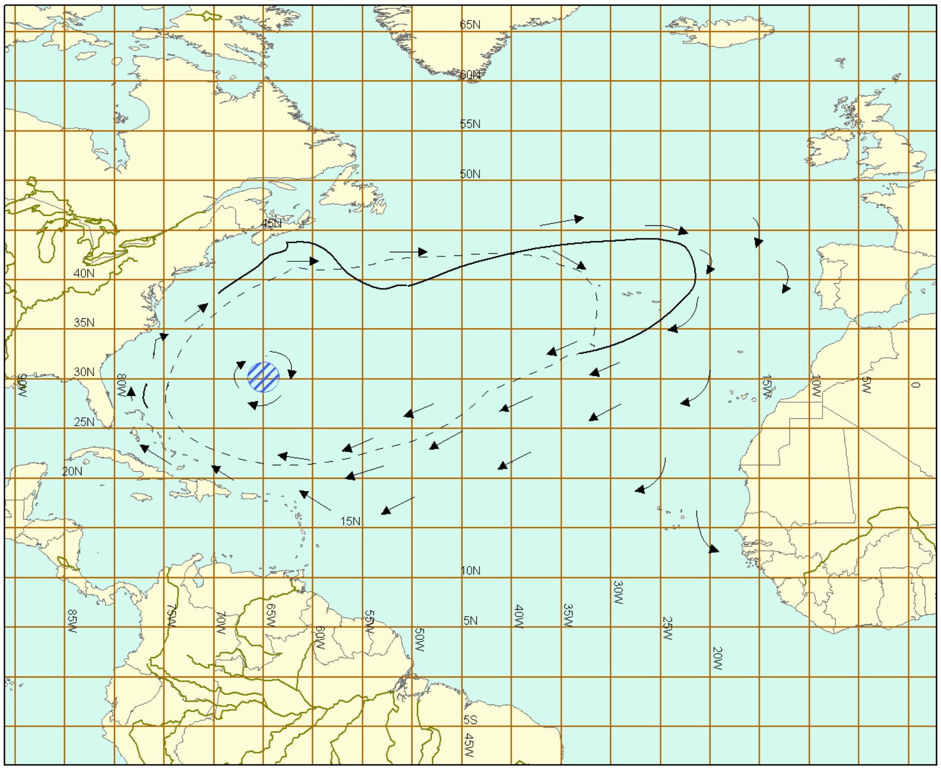
The pelagic species are golden to brownish in color and typically 20 to 80 cm in diameter. Both species are sterile and propagation is by vegetative fragmentation. The plants exhibit complex branching of the thallus, lush foliage of lancolate to linear serrate phylloids and numerous berry-like pneumatocysts. Perhaps the most conspicuous features are the pneumatocysts. These small vesicles function as floats and keep the plants positively buoyant. Gas within these bladders is predominately oxygen with limited amounts of nitrogen and carbon dioxide. The volume of oxygen within the pneumatocysts fluctuates diurnally in response, not to diurnal cycles of photosynthesis, but to changes in the partial pressure of oxygen in the surrounding medium (Woodcock 1950; Hurka 1971). There are generally a large number of pneumatocysts on a healthy plant: up to 80% of the bladders can be removed and the plants will remain positively buoyant (Zaitsev 1971). Under calm sea states the algae are at the surface with less than 0.3% of their total mass exposed above the air-water interface. Experiments indicate that an exposure to dry air of 7 to 10 minutes will kill phylloids, whereas pneumatocysts and thallomes can tolerate exposures of 20 to 30 minutes and 40 minutes, respectively. Wetting of exposed parts with seawater at 1 minute intervals, however, is enough to prevent tissue damage (Zaitsev 1971). In nature, such stress is likely encountered only during the calmest seas or when the alga is cast ashore. Illustrations and descriptions of *S. natans* and *S. fluitans* are given in Hoyt (1918), Winge (1923), Parr (1939), Taylor (1960), Prescott (1968), Humm (1979), Littler et al. (1989) and Schneider and Searles (1991).

Most pelagic *Sargassum* circulates between 20°N and 40°N latitudes and 30°W longitude and the western edge of the Florida Current/Gulf Stream (Figure 3.3-17). The greatest concentrations are found within the North Atlantic Central Gyre in the Sargasso Sea (Winge 1923; Parr 1939; Ryther 1956; Dooley 1972; Butler et al. 1983; Butler and Stoner 1984; Nierman et al. 1986). Total biomass is unknown, but, estimates obtained from net tows range from 800 to 2000 kg wet weight/km^2. Within the Sargasso Sea, this translates into a standing crop of 4 to 11 million metric tons (Parr 1939; Zaitzev 1971; Peres 1982; Butler et al. 1983; Butler and Stoner 1984; Nierman et al. 1986; Luning 1990). Stoner (1983) suggested that there had been a significant decline in biomass this century, but later recanted (Butler and Stoner 1984). Nierman et al. (1986) also calculated that no apparent decline had occurred.

Pelagic *Sargassum* contributes a small fraction to total primary production in the North Atlantic. However, within the oligotrophic waters of the Sargasso Sea it may constitute as much as 60% of total production in the upper meter of the water column (Howard and Menzies 1969; Carpenter and Cox 1974; Hanson 1977; Peres 1982). Estimates of production are typically around 1 mg C/m^2/d with slightly higher values reported from more nutrient rich shelf waters. Production has been shown to double under conditions of nitrogen and phosphorus enrichment (LaPointe 1986, 1995). Hanisak and Samuel (1984) found *Sargassum* to have low nitrogen and phosphorus requirements, and optimal growth at water temperatures of 24 to 30°C and salinity of 36 ppt. Nitrogen fixation by epiphytic cyanobacteria of the genera *Dichothrix*, *Trichodesmium*, and *Synechococcus* may enhance production (Carpenter 1972; Carpenter and Cox 1974; Phlips and Zeman 1990; Spiller and Shanmugam 1987). Photosynthesis in both *Sargassum* and the blue-green epiphytes is not inhibited at high light intensities (Hanisak and Samuel 1984; Phlips et al. 1986): not surprising in view of the neustonic niche they occupy.

Large quantities of *Sargassum* frequently occur on the continental shelf off the southeastern United States. Depending on prevailing surface currents, this material may remain on the shelf for extended periods, be entrained into the Gulf Stream, or be cast ashore (Hoyt 1918; Humm 1951; Howard and Menzies 1969; Carr and Meylen 1980; Winston 1982; Haney 1986; Baugh 1991). During calm conditions *Sargassum* may form large irregular mats or simply be scattered in small clumps. Langmuir circulations, internal waves, and convergence zones along fronts aggregate the algae along with other flotsam into long linear or meandering rows collectively termed “windrows” (Winge 1923; Langmuir 1938; Ewing 1950; Faller and Woodcock 1964; Stommel 1965; Barstow, 1983; Shanks 1988; Kingsford 1990). The algae sink in these convergence zones when downwelling velocities exceed 4.5 cm/sec. Buoyancy is not lost unless the algae sink below about 100 m or are held under at lesser depths for extended periods (Woodcock 1950). A time-at-depth relationship exists which affects the critical depth at which bladder failure ensues (Johnson and Richardson 1977). If buoyancy is lost, plants slowly sink to the sea floor. Schoener and Rowe (1970) indicate that sinking algae can reach 5000 m in about 2 days. Such sinking events contribute to the flux of carbon and other nutrients from the surface to the benthos (Schoener and Rowe 1970; Pestana 1985; Fabry and Deuser 1991). However, the flux of *Sargassum* to the sea floor has not been quantified and there is no information on the fate of this surface export.

Distribution of Pelagic Sargassum in Northwest Atlantic, Adapted from Dooley, 1972.



Solid line refers to the outer boundary of regular occurrence; dashed line refers to the area in which there is a> 5% probability of encounter within 1° square; hatched circle represents possible center of distribution.

Figure 3.3-17. Distribution of pelagic Sargassum in the Northwest Atlantic (Source: Dolphin Wahoo FMP, Adapted from Dooley 1972).

Current understanding of the seasonal distribution and areal abundance (i.e., biomass per unit area) of pelagic *Sargassum* within the EEZ is poor. Gross estimates of the standing stock for the North Atlantic obtained from towed net samples are highly variable and range between 4 and 11 million metric tons. There is a clear need to improve the understanding of the distribution and abundance of this important habitat. Remote technology could aid to that end. Satellite-based Synthetic Aperture Radar (SAR) offers potential for assessing the distribution of large aggregations over broad swaths of the ocean surface. Coincident ship-based ground-truthing would permit an evaluation of the applicability of routine remote measurements of *Sargassum* distribution and abundance.

Ecological role and function

Pelagic *Sargassum* supports a diverse assemblage of marine organisms including fungi (Winge 1923; Kohlmeyer 1971), micro-and macro-epiphytes (Carpenter 1970; Carpenter and Cox 1974; Mogelberg et al. 1983), at least 145 species of invertebrates (Winge 1923; Parr 1939; Adams

1960; Yeatman 1962; Weis 1968; Friedrich 1969; Fine 1970; Dooley 1972; Morris and Mogelberg 1973; Ryland 1974; Teal and Teal 1975; Peres 1982; Butler et al. 1983; Deason 1983; Andres and John 1984; Stoner and Greening 1984; Morgan et al. 1985; Nierman 1986; see Table 1 in Coston-Clements et al. 1991), over 100 species of fishes (Adams 1960; Parin 1970; Zaitzev 1971; Dooley 1972; Bortone et al. 1977; Fedoryako 1980, 1989; Gorelova and Fedoryako 1986; Settle 1993; Moser et al., in press), four species of sea turtles (Smith 1968; Fletemeyer 1978; Carr and Meylan 1980; Redfoot et al. 1985; Ross 1989; Carr 1986, 1987a, 1987b; Schwartz 1988; 1989; Witham, 1988; Manzella and Williams, 1991; Richardson and McGillivary, 1991), and numerous marine birds (Haney 1986). Many of the organisms most closely associated with *Sargassum* have evolved adaptive coloration or mimic the algae in appearance (Crawford and Powers 1953; Adams 1960; Teal and Teal 1975; Gorelova and Fedoryako 1986; Hacker and Madin 1991).

The following points noted in Manooch et al. (1984) and Table 3.3-7 developed from information presented in Manooch et al. (1984), further emphasizes the complexity of the *Sargassum* community and the importance of pelagic *Sargassum* habitat to pelagic fishes especially dolphin (*Coryphaena hippurus*).

"One major contribution of this paper is that we have documented the importance of the Sargassum community to dolphin, and therefore to anglers that fish for the species. Traditionally, fishermen seek weed-lines to land dolphin and other pelagic fishes. Seasonal angling success has been associated with the distribution of Sargassum along the southeastern United States. For instance, Rose and Hassler (1974) suggested that diminished landings of dolphin off North Carolina were probably caused by lack of tide-lines (usually caused by floating rows of Sargassum) rather than overfishing in previous years as some believed."

"Much of the material indicated that dolphin frequently feed at the surface and ingest fishes, crustaceans, insects, plants, and inorganic items that are associated with floating Sargassum."

"Sargassum which occurred in 48.6% of the stomachs was considered to be consumed incidental to normal foods."

"The relative contribution of the Sargassum community to the diet may be indicative of physiological constraints on the foraging behavior of these pelagic predators. The pursuit and capture of free-swimming prey in the open ocean is energetically expensive, while grazing on relatively sessile animals associated with Sargassum can be accomplished without great energy expenditure. The tunas consume a greater proportion of pelagic, adult fishes and take less prey from the Sargassum community than do dolphin. Although both tunas and dolphin are capable of high speed pursuit, tunas have highly vascularized locomotion muscles enabling sustained aerobic metabolism. Dolphin, with a much smaller portion of red muscle, must rely primarily on anaerobic metabolic pathways (mainly glycolosis), and therefore are limited to short bursts of acceleration. Thus, the energetic strategy for dolphin seems to be forage primarily on smaller prey from the Sargassum community, but also to capture larger prey with short bursts of high speed pursuit if the opportunity arises."

Table 3.3-7. Percentages occurrence of *Sargassum* in the stomachs of dolphin, *Coryphaena hippurus* and yellowfin tuna (Data Source: Manooch et al. 1984; Rose and Hassler 1974; and Manooch and Mason 1983).

	Species	Number	Season or Size (FL) stomach	% Occurrence of Sargassum in
Rose and Hassler (1974)	Dolphin	396	All	28%
Manooch et al. (1984)	Dolphin	2,219	All	48.6%
Manooch et al. (1984)	Dolphin	158	Spring	55.1%
Manooch et al. (1984)	Dolphin	845	Summer	50.9%
Manooch et al. (1984)	Dolphin	61	Fall	29.5%
Manooch et al. (1984)	Dolphin	14	Winter	41.2%
Manooch et al. (1984)	Dolphin	13	≥300 mm	23%
Manooch et al. (1984)	Dolphin	987	≥300-500 mm	49%
Manooch et al. (1984)	Dolphin	686	≥500-700 mm	55%
Manooch et al. (1984)	Dolphin	192	≥700-900 mm	43.8%
Manooch et al. (1984)	Dolphin	189	≥900-1,100 mm	43%
Manooch et al. (1984)	Dolphin	71	≥1,100 mm	38%
Manooch and Mason (1983)	Yellowfin tuna			26.5%
Manooch and Mason (1983)	Blackfin tuna			12.4%

Species composition and community structure

Fishes

The fishes associated with pelagic *Sargassum* in the western North Atlantic have been studied by a number of investigators (Adams 1960; Parin 1970; Zaitzev 1971; Dooley 1972; Bortone et al. 1977; Fedoryako 1980, 1989; Gorelova and Fedoryako 1986; Settle 1993; Moser et al., in press). Similar research has also addressed the ichthyofauna of drift algae in the Pacific (Uchida and Shojima 1958; Besednov 1960; Hirosaki 1960b; Shojima and Ueki 1964; Anraku and Azeta 1965; Kingsford and Choat 1985; Kingsford and Milicich 1987; Nakata et al. 1988). In all cases, juvenile fishes were numerically dominant. Sampling designs and gear avoidance have no doubt contributed to the poorly described adult fish fauna. However, studies by Gibbs and Collette (1959), Beardsley (1967), Parin (1970), Manooch and Hogarth (1983), Manooch and Mason (1983), Manooch et al. (1984, 1985), and Fedoryako (1989) clearly indicate that large, pelagic, adult fishes utilize *Sargassum* resources. This becomes even more evident when one observes the efforts of fishermen targeting “weedlines.”

Many of the fishes found in association with *Sargassum* are not restricted to that habitat and are known to frequent various types of drift material and fish aggregating devices (Besednov 1960; Mansueti 1963; Hunter and Mitchell 1967; Kojima 1966; Kulczycki et al. 1981; Lenanton et al. 1982; Robertson 1982; Nakata et al. 1988; Fedoryako 1989; Rountree 1989, 1990). Protection, feeding opportunity, cleaning, shade, structural affinity, visual reference, tactile stimulation, historical accident, passive drift, and use as a spawning substrate have all been postulated as reasons for such associations (Hirosaki 1960a; Hunter and Mitchell 1968; Senta 1966a, 1966b, 1966c; Dooley 1972; Helfman 1981).

Species composition and abundance of fishes associated with *Sargassum* are affected by surface residence time, season, and geographic location. Most of the young fishes that associate with the algae are surface forms (Fahay 1975; Powles and Stender 1976) and it is not known if they remain near the *Sargassum* when it is submerged. Recruitment of fishes to drift algae and flotsam is initially rapid and continues to increase over time (Senta 1966a; Hunter and Mitchell 1968; Kingsford and Choat 1985; Kingsford 1992). The abundance of larval and juvenile fishes varies seasonally and regionally, both in terms of numbers of fish and fish biomass (Dooley 1972; Settle 1993).

Regional trends in the mean abundance and biomass of young fish show a decrease in abundance across the continental shelf and into the Gulf Stream and Sargasso Sea, and a decrease from spring through winter (Settle 1993). Species richness is generally highest on the outer shelf during spring and summer and further offshore during the fall and winter (Settle, 1993). Overall, diversity is greatest in offshore waters (Bortone et al. 1977; Fedoryako 1980, 1989; Settle 1993).

Fish abundance has been found to be positively correlated with *Sargassum* biomass. Correlations were significant over the middle shelf throughout the year. Fish biomass was also positively correlated over the outer shelf during the fall (Settle, 1993). No correlation was observed in the Gulf Stream or Sargasso Sea (Dooley, 1972; Fedoryako, 1980; Settle, 1993).

The types of *Sargassum* habitats (e.g., individual clumps, small patches, large rafts, and weedlines) and the "age" (i.e., growth stage and degree of epibiont colonization) also affect the distribution and abundance of associated fishes. Ida et al. (1967a, b), Fedoryako (1980), Gorelova and Fedoryako (1986) and Moser et al. (in press) described the spatial distribution of fishes in and around clumps and rafts of *Sargassum*. Juvenile *Diodon*, *Coryphaena*, *Lobotes*, and the exocoetids occupy the outer periphery, whereas *Canthidermis*, *Balistes*, *Kyphosus*, *Abudefduf*, *Caranx*, and *Seriola* are distributed below the algae. Other genera such as *Histrio* and *Syngnathus* are typically hidden within the foliage. Larger juveniles and adults occupy nearby waters out to several tens of meters from the patches. With regard to algal age, Conover and Sieburth (1964) and Sieburth and Conover (1965) suggest that the community could be significantly controlled by the effects of exogenous metabolites on algal epibionts. These substances, which are released during periods of new algal growth, inhibit epibiotic colonization, and could alter the trophic resources available to associated macrofauna, including fish (Gorelova and Fedoryako 1986). Stoner and Greening (1984) concluded that algal age did affect the macrofaunal composition, but the abundance of carnivores remained stable. However, since their study dealt primarily with the invertebrate fauna, the effects of these substances on other trophic links remains unknown although similar compounds are known to deter some herbivores (Paul 1987; Hay and Fenical 1988; Hay et al. 1988; Steinberg 1988).

There have been well over 100 species of fishes collected or observed associated with the *Sargassum* habitat (Table 3.3-8). The carangids and balistids are the most conspicuous, being represented by 21 and 15 species respectively. The planehead filefish, *Monacanthus hispidus*, is clearly the most abundant species in shelf waters off the southeastern U.S. and in the Gulf of Mexico (Dooley 1972; Bortone et al. 1977; Settle 1993; Moser et al., in press).

A number of species have direct fisheries value although not all of them are common. However, the seasonal abundances of *Caranx* spp., *Elagatis bipinnulata*, *Seriola* spp., *Coryphaena hippurus*, *Pagrus pagrus*, *Mugil* spp., *Peprilus triacanthus*, and *Balistes capriscus* illustrate the importance of the habitat to the early life stages of these species.

Table 3.3-8. List of fishes collected or observed in association with pelagic *Sargassum* in the North Atlantic Ocean including the Gulf of Mexico and Caribbean Sea. Life-stages are E=egg, L=larva, J=juvenile, and A=adult. Nomenclature follows Robins et al. (1991) (Source: Larry Settle NMFS SEFSC pers. comm. 1997).

Family Genus and species	Common name	Life-stage(s)
Carcharhinidae	requiem sharks	
Carcharhinus falciformis	silky shark	A
C. limbatus	blacktip shark	A
C. longimanus	oceanic whitetip shark	A
Muraenidae	morays	
Unidentified	moray	L
Clupeidae	herrings	
Sardinella aurita	Spanish sardine	J
Gonostomatidae	lightfishes	
Unidentified	lightfish	L
Myctophidae	lanternfishes	
Unidentified	lanternfish	L
Gadidae	cods	
Urophycis chuss	red hake	L, J
U. earlli	Carolina hake	L, J
U. floridana	southern hake	L, J
U. regia	spotted hake	L, J
Antennariidae	frogfishes	
Histrio histrio	*Sargassum*fish	L, J, A
Exocoetidae	flyingfishes	
Cypselurus furcatus	spotfin flyingfish	E, L, J, A
C. melanurus	Atlantic flyingfish	E, L, J, A
Exocoetus obtusirostris	oceanic two-wing flyingfish	J
Hemirhamphus balao	balao	J
H. brasiliensis	ballyhoo	J
Hirundichthys affinis	fourwing flyingfish	E, L, J, A
Hyporhamphus unifasciatus	silverstripe halfbeak	L, J
Paraexocoetus brachypterus	sailfin flyingfish	E, L, J, A
Prognichthys gibbifrons	bluntnose flyingfish	E, L, J, A
Belonidae	needlefishes	
Tylosurus acus	agujon	L, J
Fistulariidae	cornetfishes	
Fistularia tabacaria	bluespotted cornetfish	J
Centriscidae	snipefishes	
Macroramphosus scolopax	longspine snipefish	J
Syngnathidae	pipefishes	
Hippocampus erectus	lined seahorse	J
H. reidi	longsnout seahorse	J
Microphis brachurus	opossum pipefish	J
Syngnathus caribbaeus	Caribbean pipefish	J
S. floridae	dusky pipefish	J
S. fuscus	northern pipefish	J
S. louisianae	chain pipefish	J
S. pelagicus	*Sargassum* pipefish	E, L, J, A
S. scovelli	gulf pipefish	J

S. springeri	bull pipefish	J
Dactylopteridae	flying gurnards	
Dactylopterus volitans	flying gurnard	L, J
Scorpaenidae	scorpionfishes	
Unidentified	scorpionfish	L
Serranidae	sea basses	
Epinephelus inermis	marbled grouper	J
Priacanthidae	bigeyes	
Priacanthus arenatus	bigeye	J
Pristigenys alta	short bigeye	L, J
Apogonidae	cardinalfishes	
Apogon maculatus	flamefish	L
Pomatomidae	bluefish	
Pomatomus saltatrix	bluefish	L
Rachycentridae	cobias	
Rachycentron canadum	cobia	E, L, J, A
Echeneidae	remoras	
Phtheirichthys lineatus	slender suckerfish	J
Carangidae	jacks	
Caranx bartholomaei	yellow jack	L, J
C. crysos	blue runner	L, J
C. dentex	white trevally	J
C. hippos	crevalle jack	J
C. latus	horse-eye jack	J
C. ruber	bar jack	L, J
Chloroscombrus chrysurus	Atlantic bumper	L, J
Decapterus macerellus	mackerel scad	J
D. punctatus	round scad	J
D. tabl	redtail scad	J
Elagatis bipinnulata	rainbow runner	L, J, A
Naucrates ductor	pilotfish	J
Selar crumenophthalmus	bigeye scad	L, J
Selene vomer	lookdown	J
Seriola dumerili	greater amberjack	L, J
S. fasciata	lesser amberjack	J
S. rivoliana	almaco jack	L, J, A
S. zonata	banded rudderfish	J
Trachinotus falcatus	permit	L, J
T. goodei	palometa	J
Trachurus lathami	rough scad	L, J
Coryphaenidae	dolphins	
Coryphaena equisetis	pompano dolphin	L, J, A
C. hippurus	dolphin	L, J, A
Lutjanidae	snappers	
Lutjanus sp.	snapper	L
Rhomboplites aurorubens	vermilion snapper	L, J
Lobotidae	tripletails	
Lobotes surinamensis	tripletail	L, J, A
Gerreidae	mojarras	
Eucinostomus sp.	mojarra	L
Sparidae	porgies	
Pagrus pagrus	red porgy	L, J

Mullidae	goatfishes	
Mullus auratus	red goatfish	L, J
Unidentified	goatfish	L
Kyphosidae	sea chubs	
Kyphosus incisor	yellow chub	L, J
K. sectatrix	Bermuda chub	L, J
Chaetodontidae	butterflyfishes	
Chaetodon ocellatus	spotfin butterflyfish	J
C. striatus	banded butterflyfish	J
Pomacentridae	damselfishes	
Abudefduf saxatilis	sergeant major	L, J
Mugilidae	mullets	
Mugil cephalus	striped mullet	L
M. curema	white mullet	L
Sphyraenidae	barracudas	
Sphyraena barracuda	great barracuda	A
S. borealis	northern sennet	L, J
Polynemidae	threadfins	
Polydactylus virginicus	barbu	J
Labridae	wrasses	
Bodianus pulchellus	spotfin hogfish	J
Thalassoma bifasciatum	bluehead	J
Scaridae	parrotfishes	
Unidentified	parrotfish	L
Uranoscopidae	stargazers	
Unidentified	stargazer	L
Blenniidae	combtooth blennies	
Hypsoblennius hentzi	feather blenny	L
Parablennius marmoreus	seaweed blenny	L
Gobiidae	gobies	
Microgobius sp.	goby	L
Acanthuridae	surgeonfishes	
Acanthurus randalli	gulf surgeonfish	J
Acanthurus sp.	surgeonfish	L
Trichiuridae	snake mackerels	
Unidentified	snake mackerel	L
Scombridae	mackerels	
Acanthocybium solandri	wahoo	J, A
Auxis thazard	frigate mackerel	J, A
Euthynnus alletteratus	little tunny	A
Katsuwonus pelamis	skipjack tuna	A
Scomber japonicus	chub mackerel	J
Scomberomorus cavalla	king mackerel	A
Thunnus albacares	yellowfin tuna	J, A
T. atlanticus	blackfin tuna	A
Xiphiidae	swordfishes	
Xiphius gladius	swordfish	L, J
Istiophorus platypterus	sailfish	L, J
Makaira nigricans	blue marlin	L, J, A
Tetrapturus albidus	white marlin	L, J, A
Stromateidae	butterfishes	
Ariomma sp.	driftfish	L

Centrolophus sp.	ruff	J
Cubiceps pauciradiatus	bigeye cigarfish	J
Hyperoglyphe bythites	black driftfish	J
H. perciformis	barrelfish	J
Peprilus triacanthus	butterfish	L, J
Psenes cyanophrys	freckled driftfish	J
Bothidae	lefteye flounders	
Bothus sp.	flounder	L
Cyclopsetta fimbriata	spotfin flounder	L
Balistidae	leatherjackets	
Aluterus heudeloti	dotterel filefish	L, J
A. monoceros	unicorn filefish	L, J
A. schoepfi	orange filefish	L, J
A. scriptus	scrawled filefish	L, J
Balistes capriscus	gray triggerfish	J, A
B. vetula	queen triggerfish	J
Cantherhines macrocerus	whitespotted filefish	J
C. pullus	orangespotted filefish	J, A
Canthidermis maculata	rough triggerfish	J
C. sufflamen	ocean triggerfish	J
Monacanthus ciliatus	fringed filefish	J
M. hispidus	planehead filefish	J
M. setifer	pygmy filefish	J
M. tuckeri	slender filefish	J
Xanthichthys ringens	*Sargassum* triggerfish	J
Ostraciidae	boxfishes	
Lactophrys sp.	cowfish	L
Tetraodontidae	puffers	
Chilomycterus antennatus	bridled burrfish	J
C. schoepfi	striped burrfish	J
Diodon holocanthus	ballonfish	J
D. hystrix	porcupinefish	J
Sphoeroides maculatus	northern puffer	L
S. spengleri	bandtail puffer	L
Unidentified	puffer	L
Molidae	molas	
Mola sp.	mola	J

Turtles

There are five species of sea turtles that associate with *Sargassum* and all are highly migratory. The offshore waters of the Western Atlantic may be used by these species as post-hatchling developmental habitat, foraging habitat, or migratory pathways. No individual members of any of the species are likely to be year-round residents of *Sargassum*. Individual animals will make migrations into nearshore waters as well as other areas of the North Atlantic Ocean, Caribbean Sea, and the Gulf of Mexico.

Sargassum as Essential Fish Habitat

The SAFMC has designated *Sargassum* as EFH for species in the snapper grouper complex and for species under the Coastal Migratory Pelagics Fishery Management Plan, including dolphin.

3.3.4 Marine Water Column

Description and distribution

Specific habitats in the water column can best be defined in terms of gradients and discontinuities physical and biological characteristics, such as temperature, salinity, density, nutrients, light and depth. These “structural” components of the water column environment (sensu Peters and Cross 1992) are not static but change both in time and space. Therefore, there are numerous potentially distinct water column habitats for a broad array of species and life-stages within species.

Winds are important in all layers of the marine water column. Wind stress can alter or reverse the generally southern pattern of flow in the coastal frontal zone, CFZ (Blanton et al. 1999). Winds can also mix and move water masses inshore. In the mid-Atlantic, waters from Gulf Stream intrusions move across the shelf at a rate of approximately 2-3 mi/day (3-5 km/day), and parallel to the coast at a rate of approximately 3-9 mi/day (5-15 km/day) (Hare et al. 1999). Georgian shelf waters flow into the North Carolina Capes region during periods of persistent southwesterly winds, while Virginian coastal waters flow south across Diamond, and occasionally Lookout, shoals during periods of persistent northerly winds (Pietrafesa 1989). Current and wind patterns will have a strong effect on the recruitment and retention of various fish larvae from different offshore areas.

The continental shelf off the southeastern U.S., extending from the Dry Tortugas to Cape Hatteras, encompasses an area in excess of 100,000 km^2 (Menzel 1993). Based on physical oceanography and geomorphology, this environment can be divided into two regions: Dry Tortugas to Cape Canaveral and Cape Canaveral to Cape Hatteras. The break between these two regions is not precise and ranges from West Palm Beach to the Florida-Georgia border depending on the specific data considered. The shelf from the Dry Tortugas to Miami is ~25 km wide and narrows to approximately 5 km off Palm Beach. The shelf then broadens to approximately 120 km off of Georgia and South Carolina before narrowing to 30 km off Cape Hatteras. The Florida Current/Gulf Stream flows along the shelf edge throughout the region. In the southern region, this boundary current dominates the physics of the entire shelf (Lee et al. 1992, 1994). In the northern region, additional physical processes are important and the shelf environment can be subdivided into three oceanographic zones (Atkinson et al. 1985; Menzel 1993). The outer shelf (40-75 m) is influenced primarily by the Gulf Stream and secondarily by winds and tides. On the mid-shelf (20-40 m), the Gulf Stream, winds, and tides almost equally affect the water column. Freshwater runoff, winds, tides and bottom friction influence inner shelf waters (0-20 m).

Several water masses are present in the region. From the Dry Tortugas to Cape Canaveral, the three water types are: Florida Current Water (FCW), waters originating in Florida Bay, and shelf water. Shelf waters off the Florida Keys are an admixture of FCW and waters from Florida Bay (Lee et al. 1992, 1994). From Cape Canaveral to Cape Hatteras, four water masses are found: Gulf Stream Water (GSW), Carolina Capes Water (CCW), Georgia Water (GW) and Virginia Coastal Water (VCW). Virginia Coastal Water enters the region from north of Cape Hatteras.

Carolina Capes Water and GW are admixtures of freshwater runoff and GSW (Pietrafesa et al. 1985, 1994).

Spatial and temporal variation in the position of the western boundary current has dramatic affects on water column habitats. Variation in the path of the Florida Current near the Dry Tortugas induces formation of the Tortugas Gyre (Lee et al. 1992, 1994). This cyclonic eddy has horizontal dimensions on the order of 100 km and may persist in the vicinity of the Florida Keys for several months. The Pourtales Gyre, which has been found to the east, is formed when the Tortugas Gyres moves eastward along the shelf. Upwelling occurs in the center of these gyres, thereby adding nutrients to the near surface (<100 m) water column. Wind and input of Florida Bay water also influence the water column structure on the shelf off the Florida Keys (Smith 1994; Wang et al. 1994).

Similarly, further downstream, the Gulf Stream encounters the Charleston Bump, a topographic rise on the upper Blake Ridge. Here the current is often deflected offshore, again resulting in the formation a cold, quasi-permanent cyclonic gyre, and associated upwelling (Brooks and Bane 1978). Along the entire length of the Florida Current and Gulf Stream, cold cyclonic eddies are imbedded in meanders along the western front. Three areas of eddy amplification are known: Downstream of Dry Tortugas, downstream of Jupiter Inlet (27°N to 30°N latitude) ("The Point" or "Amberjack Hole"), and downstream of the Charleston Bump (32°N to 34°N latitude) ("The Charleston Gyre"). Meanders propagate northward (i.e., downstream) as waves. The crests and troughs represent the onshore and offshore positions of the Gulf Stream front. Cross-shelf amplitudes of these waves are on the order 10 to 100 km. Upwelling within meander troughs is the dominant source of "new" nutrients to the southeastern U.S. shelf and supports primary, secondary, and ultimately fisheries production (Yoder 1985; Menzel 1993). Off Cape Hatteras the Gulf Stream turns offshore to the northeast. Here, the confluence of the Gulf Stream, the Western Boundary Under-Current (WBUC), Mid-Atlantic Shelf Water (MASW), Slope Sea Water (SSW), CCW, and VCW create a dynamic and highly productive environment, known as the "Hatteras Corner" or "The Point" (Figure 3.3-18).

On the continental shelf, offshore projecting shoals at Cape Fear, Cape Lookout and Cape Hatteras affect longshore coastal currents and interact with Gulf Stream intrusions to produce local upwelling (Blanton et al. 1981; Janowitz and Pietrafesa 1982). Shoreward of the Gulf Stream, seasonal horizontal temperature and salinity gradients define the mid-shelf and inner-shelf fronts. In coastal waters, river discharge and estuarine tidal plumes contribute to the water column structure.

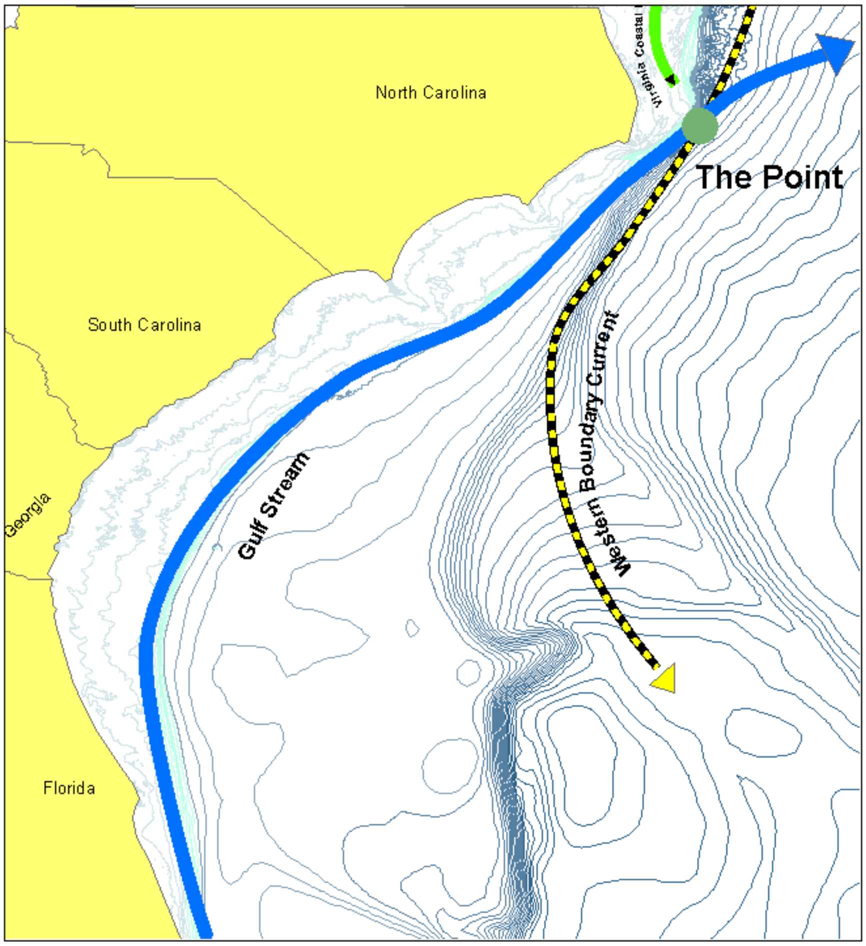


Figure 3.3-18. Water Masses off North Carolina (Source: Dolphin Wahoo FMP, Adapted from Shepard and Hulbert 1994).

Ecological role and function

Coastal waters off the southeastern U.S. are split into two zoogeographic provinces based on shore fishes and continental shelf invertebrate species. The Caribbean Province includes the Florida Keys and extends northward to approximately the Florida-Georgia border, but its northern boundary is not sharp. The Carolinian Province extends from this border, northwards to Cape Hatteras (Briggs 1974). A similar faunal break is evident in mesopelagic fish fauna. The boundary between the North Sargasso Sea Province and the South Sargasso Sea Province occurs approximately parallel with Jupiter Inlet, Florida (Backus et al. 1977).

The water column from Dry Tortugas to Cape Hatteras serves as habitat for a variety of marine fish and shellfish. Most marine fish and shellfish broadcast spawn pelagic eggs and thus, most fishery-targeted species utilize the water column during some portion of their early life history (e.g., egg, larvae, and juvenile stages). Larvae of shrimp, lobsters, crabs, and larvae of reef, demersal and pelagic fishes are found in the water column (e.g., Fahay 1975; Powels and Stender 1976; Leis 1991; Yeung and McGowan 1991; Criales and McGowan 1994). Challenges with species-level identifications impede an exact accounting of the number of fishes whose larvae inhabit the water column, but the number of families represented in ichthyoplankton collections ranges from 40 to 91 depending on location, season, and sampling method.

In nearshore ocean waters, the depth that light penetrates to allow photosynthesis (euphotic zone) may be quite shallow because of high turbidity and wind mixing. Proceeding offshore there is generally a sharp decrease in chlorophyll a where the water column becomes more stratified. Menzel (1993) reported that primary production rates decreased significantly from the inner shelf to the outer shelf of the South Atlantic Bight. Production levels may increase by a factor of three to ten with warm core intrusions from the Gulf Stream. Because these intrusions occur irregularly on the inner shelf zone, this nearshore area depends more on nutrients recycled or resuspended by wind or tidal forces (Menzel 1993). Zooplankton distribution is directly related to location of phytoplankton blooms. Cahoon et al. (1990) found that on the inner shelf in Onslow Bay, NC, 80% of the chlorophyll a was associated with the sediment. Benthic microalgal biomass (average density =36.4 mg chlorophyll a/m^2) always exceeded phytoplankton biomass (average density =8.2 mg chlorophyll a/m^2) (Cahoon and Cooke 1992). Hackney et al. (1996) reported that, because of circulation patterns, inorganic nutrients could be resuspended and retained in sufficient amounts to allow localized phytoplankton blooms within the surf zone. Primary production within the water column can also come from macroalgae detached from hard substrate (e.g., *Enteromorpha*) or floating on the surface (e.g., *Sargassum*).

The surf zone and shallow intertidal waters are important corridors for seasonal fish migrations and for larval transport in and out of estuarine waters. Several studies have focused on surf zone fishes in North Carolina (Francesconi 1994; Hackney et al. 1996; Ross and Lancaster 1996). These studies reported 47 species in North Carolina's surf zone. About 130 species of fishes have been reported from North Carolina through Georgia (Tagatz and Dudley 1961).

The surf zone is an important migratory path for larval and juvenile fish moving toward the estuaries in the winter and spring. Adult fish are thought to migrate close to shore in the surf zone during the fall migration offshore (Hackney et al. 1996). Adult fish abundance in the surf zone is highly seasonal with lowest abundance and diversity in the winter and maximum abundance and diversity in the late summer (Hackney et al. 1996). When including all life stages, maximum biomass occurs in the fall when juveniles are at peak sizes, and large schools of fish migrate from the estuaries along the beaches.

Larval fish are an important component of zooplankton in the coastal ocean water column. In Onslow Bay, NC, Powell and Robbins (1998) documented a total of 110 families from ichthyoplankton samples. Estuarine-dependent species such as menhaden, spot, and Atlantic croaker are an important component of the ichthyoplankton during late fall and winter. These species spawn offshore and must be transported into estuaries through the water column. Ichthyoplankton from estuarine-dependent species that spawn in the sounds, inlets, and nearshore ocean waters during spring and early summer (e.g., pigfish, silver perch, weakfish) were also found in the ocean water column shortly afterward. Reef fish larvae were most abundant during spring, summer, and early fall. The frequent occurrence of larvae from deepwater oceanic species indicates that Gulf Stream waters transported those larvae to shelf waters off North Carolina.

Inlets are important corridors (or bottlenecks) through which many fish must successfully pass to complete their life cycles. Larval fish diversity in North Carolina's inlets is very high. Sixty-one larval species have been found in Oregon Inlet; Atlantic croaker and summer flounder were particularly abundant (Hettler and Barker 1993). Some of the other species included bluefish, black sea bass, gray snapper, several flounder species, pigfish, pinfish, spotted seatrout, weakfish, spot, kingfish, red drum, mullet, and butterfish. In North Carolina, Beaufort, Ocracoke, and Oregon inlets also support significant larval fish passage, although Oregon Inlet may be especially important due to the great distance between it and adjacent inlets, its orientation along the shoreline, and the direction of prevailing winds. Oregon Inlet provides the only opening into Pamlico Sound north of Cape Hatteras for larvae spawned and transported from the Mid-Atlantic Bight.

Research projects conducted under the South Atlantic Bight Recruitment Experiment (SABRE) studied transport of winter-spawned fish larvae into the estuaries. Larvae concentrate on the shelf in a narrow "withdrawal zone" upwind of an inlet within the 23-foot (7 m) deep isobath. Upon the appropriate conditions of ocean currents, the larvae pass through the inlets. Even during best wind and tidal conditions, only about 10% of the available larvae are successfully drawn into the inlet (Blanton et al. 1999). Larvae passing downwind and outside the narrow withdrawal zone pass seaward of the inlet shoals and, given the right conditions, will be transported into the next available inlet downstream. Churchill et al. (1999) noted that transport dynamics in the immediate vicinity of inlets are complex, and that larvae may also remain near an inlet or move in and out repeatedly before actually immigrating. However, since the along-shore flow component of the coast is four to five times greater than the cross-shelf component, larvae are highly dependent on being transported along the shore in a narrow zone and then injected through the inlet (Hare et al. 1999). Offshore-spawning, estuarine-dependent species include many of the region's most important commercial and recreational fish species, such as menhaden, spot, Atlantic croaker, pinfish, flounders, shrimp, black sea bass, and gag. Red drum and blue crabs, which spawn in and near the inlets, also require transport of larvae through inlet systems. Consequently, successful movement of larvae through the inlets is of great importance to regional fisheries, particularly where inlets are limited.

The marine spawning species generally spawn in locations where prevailing currents will carry their eggs and larvae to nursery areas within estuaries and nearshore ocean waters. Spot, Atlantic croaker, southern flounder, Atlantic menhaden, and striped mullet spawn offshore where they produce planktonic eggs and larvae from fall to late winter (Anderson 1958; Epperly and Ross 1986). Their larvae are transported into the estuaries where they settle in nursery areas with low to moderate-salinity. The spawning function of pelagic waters for demersal species is therefore limited to egg dispersal. The specific time of spawning is determined by coincidence of environmental conditions in the water column. The other group of marine spawners reproduces at various times, but their nursery habitat consists of higher salinity areas.

Bluefish, Florida pompano and Gulf kingfish use the surf zone and nearshore ocean waters as a nursery (Hackney et al. 1996). Juveniles of these species tend to stay in one area and use the surf zone for an extended time (>25 days during the summer months) (Ross and Lancaster 1996). Some fish, such as anchovies and king mackerel, rely on the nearshore boundaries of ocean water masses as nursery habitats (SAFMC 1998a). Juveniles of other estuarine species, such as red drum, Spanish mackerel, bluefish, and black sea bass, use the surf zone and nearshore waters seasonally while migrating between estuarine and ocean waters (Godcharles and Murphy 1986; DMF 2000a). Pelagic species that use nearshore ocean waters as a nursery to some extent include butterfish, pinfish, striped anchovy, striped mullet, and Atlantic thread herring (F. Rohde, DMF, pers. com. 2001). The major recruitment period for juvenile fish to surf zone nurseries is late spring through early summer.

A large number of fish inhabits the marine water column as adults. Coastal pelagics, highly migratory species, and anadromous fish species are dependent on the water column for adequate foraging (Manooch and Hogarth 1983). The boundaries of water masses (coastal fronts) in the nearshore ocean are favorite foraging areas for mackerel and dolphin (SAFMC 1998a). King and Spanish mackerel feed on baitfish that congregate seasonally on shoals and natural and artificial reefs. The SAFMC (1998a) has designated the cape shoals of North Carolina as Habitat Areas of Particular Concern (HAPC) for both mackerels. Anadromous species such as shad, river herring, and striped bass utilize the cape shoals as a staging area for migration along the coast. Large aggregations of striped bass have been documented, in the northern, nearshore coastal area of the state during winter months, feeding and resting prior to initiation of an extensive northward spawning migration (Holland and Yelverton 1973; Laney et al. 1999). This wintering ground is shared by the Chesapeake, Hudson, and Roanoke/Albemarle striped bass stocks, and is therefore important to the entire Atlantic coast population (Benton 1992). The water column off the Outer Banks during winter supports an abundance of anchovies and menhaden, weakfish and other sciaenids, on which the striped bass feed. Laney et al. (1999) considered the existence of an area with such abundant food sources to be critical for building energy reserves for successful migration and reproduction of striped bass.

The value of floating plants has been evaluated in marine systems, where *Sargassum* floating in the water column supports a diverse assemblage of marine organisms, including at least 145 species of invertebrates, 100 species of fish, four species of marine turtles, and numerous marine birds (see section 3.3.2). *Sargassum* is concentrated as small patches, large rafts, or weedlines at the convergence of water masses in the coastal ocean, such as those found along “tide lines” near coastal inlets. The greatest concentrations of *Sargassum* patches are found in the Sargasso Sea and on the outer continental shelf of the South Atlantic, although they can be pushed into nearshore waters by winds and currents. Large pelagic adult fish such as dolphin and sailfish feed on the small prey in and around *Sargassum*. This behavior prompts sport fishermen to target *Sargassum* patches.

Species composition and community structure

Temperature varies least in the marine system (Peterson and Peterson 1979; Nybakken 1993) and marine species tend to be less tolerant of temperature extremes and rapid changes in temperature. Water temperature is one of the most important factors in determining use of coastal ocean habitat by warm temperate and tropical species (SAFMC 1998a). Tropical species occur off the North Carolina coast where offshore bottom water temperatures range from approximately 52-81°F (11–27°C) (SAFMC 1998a). Temperatures less than 54°F (12°C) may result in the death of some tropical fish and invertebrates (Wenner et al. 1984; SAFMC 1998a). Estuarine-dependent species in the nearshore ocean, such as black sea bass and southern flounder, have a broader temperature tolerance (Reagan and Wingo 1985; Steimle et al. 1999). Research in North Carolina marine waters has found that fish species composition over hardbottom shifted during a 15-year period, with an increase in tropical species and decrease in temperate species (Parker and Dixon 1998). The change in species composition was associated with global warming trends.

Species- and life-stage-specific patterns of water column habitat utilization are not well known for most fishes. Some utilize nearshore fronts as feeding or nursery habitats (e.g., *Anchoa*, *Scomberomorus*); others utilize offshore fronts (e.g., *Coryphaena*, *Xiphius*). Important spawning locations include estuarine fronts (e.g., *Cynoscion*, *Sciaenops*), the mid-shelf front (e.g., *Micropogonias, Leiostomus, Paralichthys*), and the Gulf Stream front (e.g., *Coryphaena*, *Xiphius*). Studies have shown an accumulation of fish larvae in these shelf fronts (Govoni 1993). Movement of the Gulf Stream front also affects the distribution of adult fishes (Magnuson et al. 1981) and hook and line fishermen and longliners target much of their effort for pelagic species in these frontal zones. In addition, the quasi-permanent gyres which impinge upon the shelf near the Florida Keys and downstream from the Charleston Bump probably serve as important spawning/larval retention habitat for a variety of fishes including (Collins and Stender 1987; Lee et al.1994). The region known as "The Point" off Cape Hatteras supports an unusually high biomass of dolphin and wahoo and other upper trophic level predators, including many important pelagic fishes. It has been suggested that the area is the most productive sport fishery on the east coast targeting dolphin, wahoo, and other pelagic species including billfish (Ross 1989).

Common, year-round residents of the nearshore marine zone include bottom fish such as black sea bass, gag, kingfishes, dogfish sharks, and summer flounder, along with more pelagic species like Spanish mackerel, king mackerel, cobia, silversides, and bluefish. Juveniles and adults of these species are also common in the high-salinity estuarine zone (NOAA 2001). Many high-salinity estuarine species are also found in the nearshore ocean (e.g., red drum, spotted seatrout, weakfish, black drum). During late fall and winter, the nearshore marine zone is flooded with adult offshore spawning estuarine species like southern flounder, Atlantic croaker, spot, shrimp, striped mullet, and Atlantic menhaden. Florida pompano and Gulf kingfish are common species in the nearshore marine zone (primarily during the summer).

Marine water column as Essential Fish Habitat

Due to their important ecological function, areas of the offshore pelagic environments discussed above and the associated benthic habitats have been designated essential fish habitat-habitat areas of particular concern (EFH-HAPC) (SAFMC 1998b). These include The Point, The Ten-Fathom Ledge, and Big Rock (North Carolina); The Charleston Bump and the Georgetown Hole (South Carolina); for species in the Snapper Grouper complex, Coastal Migratory Pelagic species including dolphin and Coral and Live/Hardbottom Habitat. Additional EFH-HAPCs were designated for Coastal Migratory Pelagics including: Amberjack Hole (The Point) off Jupiter Inlet (Florida); The Hump off Islamorada, Florida; The Marathon Hump off Marathon, Florida; and The "Wall" off of the Florida Keys. These areas are productive and highly dynamic oceanic areas. A quasi-permanent cyclonic eddy with, attendant upwelling of nutrient-rich deepwater, sets up in the wake of the Charleston Bump. Upwelling results in persistent primary and secondary production that may well result in an important, if not essential feeding environment for the larvae of fishes that congregate to spawn there. The hydrodynamics of the eddy may serve in the retention of fish propagules that are lost from local populations elsewhere through entrainment into the Gulf Stream. "The Point" off Cape Hatteras is also highly productive due to the confluence of as many as four water masses. Adults of highly migratory species congregate in this area, while the diversity of larval fishes found there is truly astounding (SAFMC, 1998b). Other water column habitats with high production or dynamic bottom habitats include "Big Rock" and "The Ten Fathom Ledge." Other areas where water flow is affected by bottom habitat concentrating bait and increasing availability of pelagic habitat like *Sargassum*, include "The Georgetown Hole" off South Carolina.

3.3.5 Marine Soft Bottom

Description and distribution

(from NC CHPP)

Ocean intertidal beaches and subtidal bottom

The seafloor off the North Carolina coast is part of the Atlantic continental shelf, which slopes gradually from the coastline before dropping off steeply at approximately the 160–250 ft (50–75 m) isobath where the continental slope begins. In North Carolina, the continental shelf is relatively narrow, approximately 16 mi (30 km) off Cape Hatteras, 32 mi (60 km) off Cape Lookout, and about 49 mi (90 km) off Cape Fear. Water depth at the seaward limit of state territorial waters ranges from 50–70 ft (15–21 m). Because North Carolina is located at a transition between two major physiographic and zoogeographic zones, the marine subtidal bottom supports a high diversity of invertebrates.

North of Cape Hatteras, the shoreline and adjacent shoals tend to be linear, the shelf is relatively steep, and the bottom consists of a regional depositional basin known as the Albemarle Embayment, resulting in few exposed rock outcrops. Several prominent shoals, such as Wimble, Kinnekeet, and Platt shoals, also occur in this region, as well as a series of prominent ridges and swales that are spaced about 1,300–2,000 ft (400–600 m) apart, with mean relief of 3–23 ft (1–7 m), averaging 6–10 ft (2–3 m) in height (Inman and Dolan 1989; Rice et al. 1998). Shoals closest to shore, such as Wimble and Kinnekeet shoals, tend to be oriented at a 20–30 degree angle from the coastline, while those farther offshore run more parallel to the coast (MMS 1993).

The coastline south of Cape Hatteras consists of a series of arcs, dominated by three major capes (Hatteras, Lookout, and Fear) and three associated bays (Raleigh, Onslow, and Long). Long Bay continues into South Carolina to Cape Romain. Large shoals extend across the shelf from each cape (Diamond, Lookout, and Frying Pan shoals) for more than 11 mi (20 km). South of Cape Hatteras, the continental shelf has a greater amount of exposed rock outcroppings and is intersected with younger sediments originating from filled ancient river valleys (Riggs et al. 1995).

The continental shelf off North Carolina has a relatively low supply of incoming sand, due to low direct river input, entrapment of most river-borne sediment in the upper estuaries and sounds, and minimal sediment exchange between adjacent shelf embayments (Riggs et al. 1998). The shoreface is the generally concave, upward surface extending from the surf zone to the point where the slope matches that of the continental shelf (Thieler et al. 1995). The base of the shoreface off North Carolina occurs at approximately 33–40 ft (10–12 m) water depth. The shoreface represents the area of active beach sand movement. Six classes of shoreface systems were recognized by Riggs et al. (1995) based on differences in the underlying geology. The nature of these shorefaces affects the geologic composition of the surface and underlying substrate of the subtidal bottom and shoreline and partially explains the patterns of localized erosion or deposition.

The intertidal zone of oceanfront barrier island beaches is the area periodically exposed and submerged by waves, varying with frequency and with lunar tide cycles. In this high energy area, waves continually rework and sort sediment by grain size. The uprush of water carries sediment onto the beach, with larger sediments deposited first and finer-grained sediment carried farther landward. The backwash carries some sediment back into the water. Because of this regular high wave energy, as well as occasional storm events associated with extreme wave action, the intertidal beach and surf zone typically have rapid scour and fill events. The sediments are generally much coarser, more highly sorted, and contain less organic matter than in protected estuarine intertidal flats (Donoghue 1999).

The surf zone is the shallow subtidal area of breaking waves seaward of the intertidal beach. Within the surf zone, longshore sandbars frequently develop and shift seasonally in response to wave energy. Seaward of the surf zone, the subtidal bottom consists of a series of minor ridges and swales. Ripple scour depressions, ranging from 130–330 ft (40–100 m) in width and up to 3 ft (1 m) in depth, occur along the southern portion of the coast and are perpendicularly oriented to the beach, extending to the base of the shoreface (Thieler et al. 1995; Reed and Wells 2000). These features are located adjacent to areas experiencing chronic severe beach erosion, and may be indicative of rapid offshore transport of sand during storms (Thieler et al. 1995).

Three major shoals extend perpendicular to Cape Hatteras, Cape Lookout, and Cape Fear: Diamond Shoals, Cape Lookout Shoals, and Frying Pan Shoals, respectively. Water depth on the shoals ranges from 2–18 ft (0.6–5.5 m), in contrast to adjacent waters that are 20–40 ft (6–12 m) deep. Due to an interest in beach nourishment projects for Dare County, Boss and Hoffman (2000) collected detailed information on the sand resources of North Carolina's Outer Banks, including specific data about Diamond Shoals. Diamond Shoals extend approximately 11 nautical miles (nm) (20 km) and are about 5.5 nm (11 km) wide. The estimated total volume of sand on the shoal was at least 1.66 billion cubic yards, with approximately 256 million cubic yards within state waters (Boss and Hoffman 2000). As such, cape shoals are major sand resources for coastal processes. Detailed mapping of the bottom has been done in other areas of the coast to varying extent with different techniques. The results of these studies need to be compiled in a comprehensive and comparable manner to evaluate changes and trends in substrate character, as well as the feasibility of beach nourishment projects.

Ecological role and function

(from CHPP)

Several species of sharks pup in North Carolina's nearshore ocean waters. North of Cape Hatteras, pupping of spiny dogfish over subtidal bottom has been documented in winter months

(W. Laney, USFWS, pers. com. 2003). Subtidal bottom in the southern portion of North Carolina state waters serves as pupping grounds for the Atlantic sharpnose shark (*Rhizoprionodon terraenovae*), bonnethead shark (*Sphyrna tiburo*), blacknose shark (*Carcharhinus acronotus*), spinner shark (*C. brevipinna*), dusky shark (*C. obscurus*), and, to a lesser extent, blacktip shark (*C. limbatus*), sandbar shark (*C. plumbeus*), and scalloped hammerhead shark (*S. lewini*). Most neonate (newborn) sharks were found in June and July (Beresoff and Thorpe 1997; Thorpe et al. 2003).

Most ocean spawning activity by estuarine dependent species occurs beyond state waters during the winter months. However, eggs and larvae are carried in the water column by currents through nearshore state waters and inlets to estuarine nursery areas. Important spawning aggregations of summer flounder occur on Wimble, Platt, and Kinnekeet shoals off the Outer Banks, in state and federal waters from November to March, peaking near January in North Carolina (MAFMC 1998). Locations of summer flounder spawning aggregations are linked to environmental conditions, such as water temperature and wind direction, and are generally concentrated north of Cape Hatteras, but extend to Cape Lookout.

Nearshore ocean subtidal bottom is also a nursery area for summer flounder and shark species. The primary nursery grounds for coastal shark species is in the vicinity of where pupping occurs. Small coastal sharks that use this habitat for a nursery area include spinner (*C. brevipinna*), blacknose (*C. acronotus*), and dusky (*C. obscurus*) sharks (Beresoff and Thorpe 1997; Thorpe et al. 2003). Juvenile Atlantic sturgeon and spiny dogfish, both demersal feeders with overfished fishery status, have been documented over nearshore subtidal bottom between Oregon Inlet and Kitty Hawk during winter months (Cooperative Striped Bass Tagging Program, unpub. data). Subtidal bottom, particularly the surf zone, is also a nursery area for Florida pompano, southern and gulf kingfish (Hackney et al. 1996).

Species composition and community structure

On oceanfront beaches, most benthic animals in the intertidal zone consist of infaunal burrowing forms. A diverse assemblage of meiofauna (0.06 – 0.4 mm in size) occurs in the lower beach community and acts as an important food source for many juvenile fish (Levinton 1982; Hackney et al. 1996). A relatively low diversity of macrofauna (>0.5 mm in size) (~ 20 – 50 species) exists in the intertidal beach compared to estuarine intertidal flats (~ 300 – 400 species) (Hackney et al. 1996). The dominant macrofauna by biomass in North Carolina's oceanfront intertidal beaches are mole crabs (*Emerita talpoida*) and coquina clams (*Donax variablis*, *D. parvula*) (Hackney et al. 1996; Donoghue 1999). Several species of amphipods and the spionid polychaete (*Scolelepis squamata*) have been reported as highly abundant on some beaches as well (Lindquist and Manning 2001).

Polychaete worms, isopods, mollusks, echinoderms, amphipods, and other crustaceans occur in sediments in the oceanfront intertidal beaches, cape and ebb tide shoals, surf zone and other subtidal bottom (Jutte 1999; Peterson et al. 1999). Three general groups of polychaetes occur in intertidal beaches (Hackney et al. 1996): 1) burrowing deposit feeders, including thread worms (*Lumbrineris* sp., *Scolelepsis* sp.), and red-lined worms (*Nepthys* sp.); 2) suspension feeders; and 3) tube building burrow dwellers, such as plumed worms (*Diopatra* sp.) and lugworms

(*Arenicola* sp.). Offshore sand bottom communities along the North Carolina coast are relatively diverse habitats containing over a hundred polychaete taxa (Lindquist et al. 1994; Posey and Ambrose 1994). Tube dwellers and permanent burrow dwellers are important benthic prey for fish and epibenthic invertebrates. These species are also most susceptible to sediment deposition, turbidity, erosion, or changes in sediment structure associated with sand mining activities, compared to other more mobile polychaetes (Hackney et al. 1996). In South Carolina, 243 species of benthic invertebrates were documented in the nearshore subtidal bottom (Van Dolah et al. 1994). Polychaetes and amphipods were the most abundant, although oligochaetes, bivalves, and crabs were also highly represented (Van Dolah et al. 1994). On ebb tide deltas, polychaetes, crustaceans (primarily amphipods), and mollusks (primarily bivalves) were the most abundant infauna, while decapod crustaceans and echinoderms (sand dollars) dominated the epifauna. Because periodic storms can affect benthic communities along the Atlantic coast to a depth of about 115 ft (35 m), the soft bottom community tends to be dominated by opportunistic taxa that are adapted to recover relatively quickly from disturbance (Posey and Alphin 2001). Many faunal species documented on the ebb tide delta are important food sources for demersal predatory fishes and mobile crustaceans, including spot, croaker, weakfish, red drum, and penaeid shrimp. These fish species congregate in and around inlets during various times of the year (Peterson and Peterson 1979), presumably to enhance successful prey acquisition and reproduction.

Ocean subtidal bottom serves as important foraging grounds for numerous fish species, particularly for Florida pompano, red drum, kingfish, spot, and Atlantic croaker, weakfish, and striped bass. Many commercially or recreationally important fish and invertebrate species, such as red drum, striped bass, shrimp, and summer flounder, are caught while they aggregate and feed over subtidal bottom in nearshore ocean waters. These species appear to be strongly associated with distinct topographic features of the subtidal bottom, such as the cape shoals, channel bottoms, sandbars, and sloughs. The natural processes that create these features need to be maintained.

The food resources present in and on soft bottom are needed to support hardbottom fish species. Demersal zooplankton and infaunal macroinvertebrates from sand substrate have been found to be a quantitatively important component of many species' diets and an important link to reef fish production (Cahoon and Cooke 1992; Thomas and Cahoon 1993; Lindquist et al. 1994). Reef species documented foraging over sand bottom away from the reef include tomtate (*Haemulon aurolineatum*), whitebone porgy (*Calamus leucosteus*), cubbyu (*Equetus umbrosus*), black sea bass (*Centropristis striata*), and scup (*Stenotomus chrysops*) (Lindquist et al. 1994). Therefore, benthic microalgal production on the subtidal bottom of Onslow Bay, as well as other similar shelf habitats, is an important component to the continental shelf productivity and is an important link to the ecology of hardbottom habitats.

4.0 Species' Biology, Distribution and Status

4.1 Species under management by the South Atlantic Council

4.1.1 Penaeid and Deepwater Shrimp

4.1.1.1 Penaeid Shrimp

Description and distribution

The shrimp fishery in the South Atlantic includes six species: brown shrimp (*Farfantepeneaus aztecus*), pink shrimp (*Farfantepenaeus duorarum*), white shrimp (*Litopenaeus setiferus*), seabob shrimp (*Xiphopenaeus kroyeri*), rock shrimp (*Sicyonia brevirostris*), and royal red shrimp (*Pleoticus robustus*). The shrimp species of the southeastern U.S. occupy similar habitats with the greatest differences being in optimal substrate and salinity.

White shrimp

Common names for the white shrimp (Figure 4.1-1) include gray shrimp, lake shrimp, green shrimp, green-tailed shrimp, blue tailed shrimp, rainbow shrimp, Daytona shrimp, common shrimp, and southern shrimp.

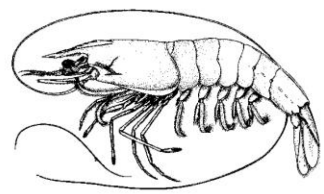


Figure 4.1-1. White shrimp, *Litopenaeus setiferus* (Williams 1984).

White shrimp range from Fire Island, New York to St. Lucie Inlet on the Atlantic Coast of Florida. Along the Atlantic Coast of the U.S., the white shrimp has centers of abundance in South Carolina, Georgia, and northeast Florida. White shrimp are generally concentrated in waters of 27 m (89 ft) or less, although occasionally found much deeper (up to 270 ft).

Brown shrimp

The **brown shrimp** (Figure 4.1-2) is also known as brownie, green lake shrimp, red shrimp, redtail shrimp, golden shrimp, native shrimp, and also the summer shrimp in North Carolina.

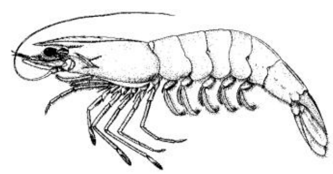


Figure 4.1-2. Brown shrimp, *Farfantepenaeus aztecus* (Williams 1984).

On the Atlantic Coast, brown shrimp occur from Martha's Vineyard, Massachusetts to the Florida Keys. While it may occur seasonally along the Mid-Atlantic states, breeding populations apparently do not range north of North Carolina. The species may occur in commercial quantities in waters as deep as 110 m (361 ft), but they are most abundant in water less than 55 m (180 ft).

Pink shrimp

Other names for the **pink shrimp** (Figure 4.1-3) include spotted shrimp, hopper, pink spotted shrimp, brown spotted shrimp, grooved shrimp, green shrimp, pink night shrimp, red shrimp, skipper, and pushed shrimp.

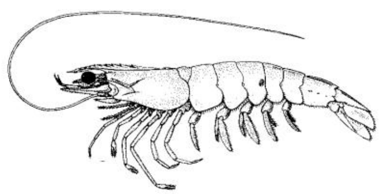


Figure 4.1-3. Pink shrimp, *Farfantepenaeus duorarum* (Williams 1984).

Along the Atlantic, pink shrimp occur from southern Chesapeake Bay to the Florida Keys. Maximum abundance is reached off southwestern Florida. Pink shrimp are most abundant in waters of 11-37 m (36-121 ft) although in some areas they may be abundant as deep as 65 m (213 ft). Pink shrimp are common in the estuaries and shallow marine waters surrounding southern Florida and into deepwater (approximately 100 meters) southeast of the Keys, and are the dominant species within the Dry Tortugas shrimping grounds and Florida Bay (Solamon 1968).

Seabob shrimp

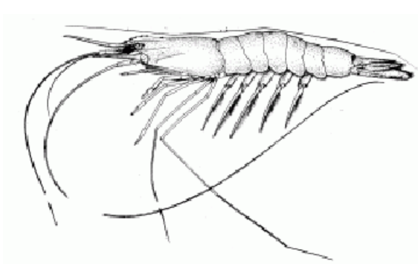


Figure 4.1-4. Seabob shrimp, *Xiphopenaeus kroyeri* (FAO FIGIS Species Factsheet 2007. Available online at http://www.fao.org/fi/website/FIRetrieveAction.do?dom=species&fid=2600)

Seabob shrimp (Figure 4.1-4) range from North Carolina to Estado de Santa Catarina (Brazil). Seabobs inhabit waters from 1 to 70 m, usually less than 27 m over mud or sand bottom. They are found in marine, brackish and exceptionally fresh waters and are most plentiful in areas near river estuaries. This species is of limited commercial importance off the southeast Atlantic coast (see William, 1984 for review). Burkenroad (1949) found ripe or nearly ripe females off North Carolina in May. Information on the biology of seabob shrimp is scant so the discussion in following sections pertains only to the other three penaeid species in the management unit.

Reproduction

White Shrimp

White shrimp attain sexual maturity at about 35-140 mm (5.3-5.5 in) total length (TL). Fecundity for all penaeid species ranges from 500,000 to 1,000,000 ova. Eggs are demersal (sink to the bottom) and measure 0.28 mm in diameter (SAFMC 1996b).

Off Georgia and northern Florida, some white shrimp spawning may occur inshore, although most spawning occurs more than 1.2 miles from the coastline. Off Florida, spawning occasionally takes place inshore, at or near inlets, but most occurs offshore in depths of 6.1 to 24.4 m (20-80 ft). In South Carolina, most spawning occurs within about four miles of the coast. Spawning is correlated with bottom water temperatures of 17° to 29°C (62.6 to 84.2° F) although spawning generally occurs between 22° and 29°C (71.6 and 84.2° F). White shrimp begin spawning during April off Florida and Georgia, and late April or May off South Carolina (Lindner and Anderson 1956). Spawning may continue into September or October (SAFMC 1996b).

Brown shrimp

Similar to white shrimp, brown shrimp reach sexual maturity at about 140 mm TL (5.5 in). Eggs are demersal and measure 0.26 mm in diameter (SAFMC 1996b).

Brown shrimp spawn in relatively deep water. In the Gulf of Mexico, it was concluded that brown shrimp did not spawn in water less than 13.7 m (45 ft) deep and the greatest percentage of ripe females were at 45.7 m (150 ft) (Renfro and Brusher 1982). Spawning season for brown shrimp is uncertain, although there is an influx of postlarvae into the estuaries during February and March (Bearden 1961; DeLancey et al. 1994). Mature males and females have been found off South Carolina during October and November (SAFMC 1996b).

Pink Shrimp

Pink shrimp reach sexual maturity at about 85 mm TL (3.3 in). Eggs are demersal measuring 0.31-0.33 mm in diameter (SAFMC 1996b).

Pink shrimp apparently spawn at depths of 3.7 to 15.8 m (12 to 52 ft). Off eastern Florida, peak spawning activity probably occurs during the summer. In North Carolina, roe-bearing females are found as early as May, and by June, most pink shrimp are sexually mature (Williams 1955).

Development, growth and movement patterns

All three penaeid species have 11 larval stages before developing into postlarvae. Duration of the larval period is dependent on temperature, food and habitat. Records suggest larval periods of 10 to12 days for white shrimp, 11 to 17 days for brown shrimp and 15 to 25 days for pink shrimp. Brown shrimp postlarvae appear to overwinter in offshore bottom sediments. Postlarval sizes are similar for white and pink shrimp ranging from approximately 2.9 to 12 mm TL (0.1-0.5 in); brown shrimp are usually larger (SAFMC 1996b).

The mechanisms that transport penaeid shrimp postlarvae from distant spawning areas to inside estuaries are not well known. Shoreward countercurrents north of Cape Canaveral have been suggested as a mechanism for transport of pink shrimp postlarvae from spawning areas to nursery areas along the northeast Florida coast (Kennedy and Barber 1981). Favorable winds may enhance movement of postlarvae toward oceanic inlets (Wenner et al. 1998).

White shrimp
Movement of white shrimp postlarvae into the estuary is most likely a result of nearshore tidal currents as white shrimp spawn relatively close to shore. In the South Atlantic, white shrimp enter the estuaries at about the same time as pink shrimp, usually beginning in April and early May in the southern part of their range and in June and July in North Carolina sounds where white shrimp are relatively less abundant than in more southern states.

Smaller (juvenile and subadult) individuals may overwinter inside estuaries forming part of the overwintering stock (SAFMC 1996b). Harsh winter conditions such as cold water temperatures and rainfall can affect the survival of overwintering stocks and subsequent year-class strength.

Large white shrimp begin emigrating out of the estuary to the commercial fishing areas in mid-summer. In North Carolina, white shrimp begin entering the commercial fishery in July and continue to be caught through December (Williams 1955). In Florida, white shrimp leave inshore waters at about 120 mm TL (4.7 in). This movement to offshore waters may be caused by cold weather, storms, high tides and/or large influxes of fresh water, but size is the principal determinant (SAFMC, 1996b). The migrating white shrimp, called roe shrimp, make up the spring fishery and also produce the summer and fall crops of shrimp. When a majority of white shrimp do not survive the winter, the North Carolina and South Carolina fisheries are believed to be dependent on a northward spring migration of white shrimp from more southerly areas to form the spawning stock. However, tagging data are inconclusive on the extent of this northward movement, and recruitment of postlarvae from southern spawning stocks may account for much of the replenishment of the populations.

White shrimp grow from 1.0 to 2.3 mm (0.04 to 0.09 in) per day (SAFMC 1993). Salinity is a factor determining growth rate in white shrimp. Although field studies indicate that juvenile white shrimp prefer low salinities, laboratory studies have revealed that they tolerate a wide range of salinities; they have been successfully reared at salinities of 18 to 34 ppt (Perez-Farfante 1969). Nevertheless, McKenzie and Whitaker (1981) cited several studies in which fast growth was reported for white shrimp at lower salinities of 7 to 15 ppt. The lowest salinity in which white shrimp were recorded in the northern Gulf of Mexico was 0.42 ppt (Perez-Farfante 1969). High salinities appear to inhibit growth in white shrimp, but for brown shrimp, salinities in excess of 10 ppt seem to enhance growth rate. Relatedly, during years of low densities, the average size of white shrimp is generally larger.

Water temperature directly or indirectly influences white shrimp spawning, growth, habitat selection, osmoregulation, movement, migration and mortality (Muncy 1984). Spring water temperature increases trigger spawning, and rapid water temperature declines in fall portend the end of spawning (Lindner and Anderson 1956). Ingress of white shrimp postlarvae has also been linked to temperature (Wenner et al. 2002). Growth is fastest in summer and slowest or negligible in winter. Water temperatures below 20°C (68°F) inhibit growth of juvenile shrimp (Etzold and Christmas 1977) and growth is virtually nil at 16°C (61°F) (St. Amant and Lindner 1966). Growth rates increase rapidly as temperatures increases above 20°C (68°F). Temperature and food supply limited the growth of white shrimp postlarvae more than did salinity differences between 2 and 35 ppt (Zein-Eldin 1964). Freshwater inflow may affect coastal water temperatures, which in turn affect the growth rates (White and Boudreaux 1977) and migration of white shrimp (Shipman 1983b). Increased water temperatures also affect molting rate (Perez-Farfante 1969)

Brown shrimp

Movement of brown shrimp appears to take place primarily at night with peak movement at, or shortly after dusk. In the South Atlantic, juvenile and adult brown shrimp are rarely affected by severe winter weather because most surviving shrimp have moved offshore prior to the onset of cold weather (SAFMC 1996b). Brown shrimp first enter the commercial fishery in North Carolina in June at about 100 mm TL (4 in).

Brown shrimp grow 0.5 to 2.5 mm (0.02 – 0.1 in) per day (SAFMC 1993). Salinity is a factor determining growth rate in brown shrimp. Temperature also affects brown (and pink) shrimp growth rates, with rates as high as 3.3 mm (0.13 in) per day recorded when temperature exceeded 25°C (77° F) but less than 1.0 mm (0.04 in) per day when water temperature was below 20°C (68° F). Gaidry and White (1973) stated that years of low commercial landings of brown shrimp were associated with prolonged estuarine temperatures of less than 20°C (68°F) at the time of postlarval immigration into the estuary. Aldrich et al. (1968) demonstrated in laboratory experiments that brown shrimp postlarvae burrowed in the sediment when water temperature was reduced to 12°-16.5°C (54°-62°F). Brown shrimp postlarvae may overwinter in offshore waters and migrate into estuaries the following spring (Aldrich et al., 1968).

Pink shrimp

Pink shrimp leave Florida estuaries two to six months after having arrived as postlarvae. In North Carolina, young pink shrimp enter the commercial catch in August. Recruitment to the area offshore of Cape Canaveral begins in April and May and again during October and November (SAFMC 1996b). In North Carolina, pink shrimp begin entering the estuaries in June and July. In Florida, larvae can take two routes to the estuarine nursery areas where they spend most of their life cycle. One route is directly to the shallow-water estuaries of 10,000 Island, Whitewater Bay, and Florida Bay. On the other route, larvae are swept southwesterly into the Florida Current by way of the Loop Current, and are carried northeasterly along the outer edge of the Florida Reef Tract or east coast of Florida (Ingle et al. 1959).

Pink shrimp that overwinter inside estuaries are susceptible to mortality induced by cold weather. However, pink shrimp bury deeply in the substrate with the onset of cold weather and are protected to some extent from winter mortalities (Purvis and McCoy 1972). Pink and white shrimp that survive the winter grow rapidly in late winter and early spring before migrating to the ocean. Pink shrimp that overwinter in estuaries migrate to sea in May and June, at which time spawning takes place. Recruitment to the area offshore of Cape Canaveral begins in April and May and again during October and November (SAFMC 1996b).

Pink shrimp grow 0.25 to 1.7 mm (0.01 – 0.07 in) per day (SAFMC 1993). In Florida Bay, pink shrimp were found to grow 3.5 mm Carapace Length (CL) (0.14 in) in winter and only 1.9 mm CL (0.07 in) in spring (SAFMC 1993). In North Carolina, maximum pink shrimp growth rates were recorded in summer (SAFMC 1993).

Ecological relationships

The inshore phase of the penaeid life cycle is perhaps the most critical because this is a period of rapid growth. Estuarine nursery areas, dominated by the marsh grass, *Spartina alterniflora*, provide abundant food, suitable substrate, and shelter from predators for postlarval shrimp.

Juvenile shrimp appear to be most abundant at the *Spartina* grass-water interface. This "estuarine edge" is the most productive zone in many estuaries. Because there is a minimum of wind generated turbulence and stabilization of sediments, rich bands of organic material are found along the edges of marshes (Odum 1970). Furthermore, Odum (1970) found the percentages of organic detritus in sediments along the shore in the Everglades estuary are several times greater than a few meters offshore. Mock (1967) examined two estuarine habitats, one natural and one altered by bulkheading. He found a 0.6 m (2 ft) band of rich organic material along the natural shore and very little organic material along the bulkheaded shore. White shrimp were 12.5 times and brown shrimp 2.5 times more numerous in the natural area as in the altered area. Loesch (1965) found that juvenile white shrimp in Mobile Bay were most abundant nearshore in water less than 0.6 m (2 ft) deep containing large amounts of organic detritus. Brown shrimp were congregated in water 0.6 to 0.9 m (2-3 ft) deep where there was attached vegetation.

White shrimp appear to prefer muddy or peaty bottoms rich in organic matter and decaying vegetation when in inshore waters. Offshore they are most abundant on soft muddy bottoms (Lindner and Cook, 1970). Brown shrimp appear to prefer a similar bottom type and as adults may also be found in areas where the bottom consists of mud, sand, and shell. Pink shrimp are found most commonly on hard sand and calcareous shell bottom (Williams 1955, 1984). Both brown and pink shrimp generally bury in the substrate during daylight, being active at night. White shrimp do not bury with the regularity of pink or brown shrimp.

Juvenile and adult penaeids are omnivorous (eating both plants and animals) bottom feeders, with most feeding activity occurring at night, although daytime feeding may occur in turbid waters (Darnell 1958; Broad 1965). Food items may consist of polychaetes, amphipods, nematodes, caridean shrimps, mysids, copepods, isopods, amphipods, ostracods, mollusks, foraminiferans, chironomid larvae, and various types of organic debris. In addition, aggregations of shrimp have been shown to increase community metabolism and inorganic nitrogen available to phytoplankton (Vetter and Hopkinson 1985).

Shrimp are preyed on by a wide variety of species at virtually all stages in their life history (Gunter 1957). Predation on postlarvae has been observed by sheepshead minnows, water boatmen, and insect larvae. Grass shrimp, killifishes, and blue crabs prey on young penaeid shrimp, and a wide variety of finfish are known to prey heavily on juvenile and adult penaeid shrimp (Minello and Zimmerman 1983).

Abundance and status of stocks

Population sizes of brown, pink, and white shrimp are believed to be primarily regulated by environmental conditions and available habitat. Penaeid (brown, pink and white) shrimp have an annual life cycle, where adults spawn offshore and the larvae are transported to coastal estuaries. Recruitment to the estuaries and eventually to the fishing grounds is extremely dependent on fluctuations of environmental conditions within estuaries. Poor recruitment to the fishery may occur because of excessively cold winters or heavy rains that reduce salinities and cause high mortality of post-larvae. Conversely, high recruitment to the fishery may occur when environmental conditions are favorable for postlarval development. Effort in the penaeid fishery has been relatively stable over the last 20 years; therefore, catches in any given year may show large fluctuations depending on the magnitude of successful recruitment of young shrimp as they emigrate from the estuaries to offshore waters.

Although shrimp trawling certainly reduces population size over the course of a season, the impact of fishing on subsequent year-class strength is unknown. Natural mortality rates are very high, and coupled with fishing mortality, most of the year class may be removed by the end of a season. Because annual variation in catch is presumed to be due to a combination of prevailing environmental conditions, fishing effort, price and relative abundance of shrimp (SAFMC 1996b), fishing is not believed to have any impact on subsequent year class strength unless the spawning stock has been reduced below a minimum threshold level by environmental conditions. Nevertheless, due to high fecundity and migratory behavior, the three penaeid species are capable of rebounding from very low population sizes in one year to large population sizes in the next, provided environmental conditions are favorable (SAFMC 1996b).

Fluctuations in abundance resulting from changes in environmental conditions will continue to occur. Perhaps the most serious potential threat to the stocks is loss of habitat due to pollution or physical alteration. For white and brown shrimp, salt marsh habitat is especially important as juvenile nursery areas. Inshore seagrass beds are important nursery areas for juvenile pink shrimp. The quality and availability of these habitat areas to the juvenile penaeid shrimp species is critical to overall shrimp production (SAFMC 1996b).

During years when inshore overwintering white shrimp stocks are greatly reduced due to cold water temperature or heavy rain, management action may accelerate recovery of the stocks and increase fall production by protecting the few remaining spawners that survive a freeze. Also, elimination of winter and spring fishing mortality off southern Georgia and Florida may enable a greater quantity of potential spawners to move north, possibly resulting in larger regional white shrimp stocks the following fall. An offshore or deep estuarine water reserve of overwintering white shrimp may also contribute significantly to the spawning stock. In either case, while fishing does not by itself appear to be a factor in determining subsequent year class strength for white shrimp, in years when the overwintering adult population is significantly reduced due to severe winter weather, the additional mortality caused by fishing can result in a further reduction in subsequent fall production (SAFMC 1996b).

(from Shrimp Amendment 6)
For the South Atlantic shrimp fishery, only historical catch records and limited effort information is available. Current data gaps preclude the estimation of B_{MSY}. Furthermore, because of high fluctuations in annual recruitment and landings, F_{MSY}, or even F_{CURR}, cannot be estimated. This limited information makes it difficult to use standard procedures to establish an overfishing threshold based on F_{MSY}. Nevertheless, the Council has stated, that although estimates of population size are not available, effort in the fishery is known to be high and the fishery may be fishing at near-maximum levels. Therefore, it can be assumed to be operating at or near B_{MSY} and F_{MSY}. Based on that assumption, the Council has established targets and thresholds using annual landings as an indication of relative abundance (health) of the parent stock.

The limitation to this approach, especially for annual species such as shrimp, is its total dependence on catch, without accounting for external factors such as economic or social conditions that might influence the overall annual landings of a particular species. It is possible that the fishery might not target a species to the extent possible during a given year, and low landings could result from a lack of effort instead of a reduced stock size. Similarly, a stock might undergo a poor recruitment year, but still be relatively healthy, but reduced catch rates combined with economic or social factors might inhibit fishery effort on that stock, and annual landings would decline. Conversely, because of good prices or exceptionally good recruitment, landings might be exceptionally high during a given year, or two-year period. In either situation, the Council would want to further evaluate all the conditions before making a determination regarding the status of the stock, which could delay effective remedial action.

The National Standard Guidelines (50 CFR 600.310[c][2][i]) identify alternatives for establishing MSY to include removal of a constant catch each year that allows the stock size to remain above an identified lower level, or to allow a constant level of parent stock escapement each year. For penaeid shrimp stocks, it is appropriate to establish an MSY control rule based on maintaining a constant level of escapement each year that will produce sufficient recruits to maintain harvest at historical levels. This approach would relate MSY in terms of catch to a quantifiable level of escapement in each stock, where a proxy for B_{MSY} is established as the minimum parent stock size known to have produced MSY the following year. MFMT, as a fishing mortality that drives the stock below B_{MSY} in a given year when exceeded, would define overfishing. MSST, or the overfished level, would represent a biomass level lower than $0.5*B_{MSY}$ (i.e., one-half the parent stock size or other proxy). In other words, this would be an MSY control rule that relied on constant escapement of B_{MSY}.

In accordance with the Technical Guidelines (Restrepo et al., 1998), CPUE data can be used as a proxy for biomass-based parameters including B_{MSY} and current biomass. Until those data become available from the fishery, CPUE-based abundance estimates from fishery-independent Southeast Area Monitoring and Assessment Program - South Atlantic (SEAMAP-SA) data can serve as a proxy to indicate parent stock (escapement).

The SEAMAP-SA Shallow Water Trawl Survey is funded by NOAA Fisheries and conducted by the South Carolina Department of Natural Resources - Marine Resources Division (SCDNR-MRD). This survey provides long-term, fishery-independent data on seasonal abundance and biomass of all finfish, elasmobranchs, decapod and stomatopod crustaceans, sea turtles, horseshoe crabs and cephalopods that are accessible by high-rise trawls. Samples are taken by trawl from Cape Hatteras, North Carolina to Cape Canaveral, Florida. Cruises are conducted in spring (early April - mid-May), summer (mid-July - early August) and fall (October - mid-November). Stations are randomly selected from a pool of stations within each stratum. Strata are delineated by the 4 m depth contour inshore and the 10 m depth contour offshore.

SEAMAP data for the period 1990-1992 indicate that the average escapement results in annual abundance estimates ranging from 1.975 to 10.277 shrimp per hectare for brown shrimp, 0.211 to 1.728 shrimp per hectare for pink shrimp and 5.665 to 34.799 shrimp per hectare for white shrimp (Table 4.1-1).

Table 4.1-1. Annual shrimp CPUE (nos/ha) estimates derived from the SEAMAP Shallow water Trawl Survey.

Year	Brown Shrimp	Pink Shrimp	White Shrimp
1990	4.022	0.568	9.028
1991	2.469	0.873	12.880
1992	2.000	0.511	5.868
1993	5.899	0.673	5.665
1994	5.568	0.594	10.606
1995	3.104	1.728	17.535
1996	10.277	0.461	12.913
1997	2.275	0.948	7.447
1998	1.975	0.853	18.256
1999	2.972	0.450	34.799
2000	7.697	0.211	13.060
2001	8.637	0.502	10.454
2002	3.347	0.867	9.186
2003	9.640	0.418	7.372

Because of their high sensitivity to certain environmental factors, South Atlantic shrimp show extreme fluctuations in population size. Annual sampling of shrimp from the southeast region indicate that density per hectare have varied by a factor of 5 to 10 and can more than double from one year to the next (Table 4.1-1).

The current stock status determination criteria for white, brown and pink shrimp were calculated from landings information. The data used to generate these parameters are presented in Table 4.1-2. These landings statistics were compiled in the original plan and Amendment 2 to the South Atlantic Shrimp Plan (SAFMC 1993; SAFMC 1996b).

Table 4.1-2. Landings data used to calculate the current MSY values for the penaeid species in the South Atlantic. (SAFMC 1996b).

Year	White Shrimp	Brown Shrimp	Pink Shrimp
1957	14,712,461	9,740,164	2,157,243
1958	11,092,893	9,189,603	823,467
1959	12,823,217	9,434,893	2,061,216
1960	18,788,016	9,038,236	1,226,496
1961	14,033,378	2,495,614	1,747,822
1962	12,133,840	11,532,694	2,246,510
1963	7,268,926	7,646,291	554,339
1964	8,119,217	7,089,616	1,948,048
1965	16,304,005	8,126,345	1,687,237
1966	9,162,164	11,604,450	531,230
1967	10,902,104	7,978,838	1,579,998
1968	16,945,887	5,919,510	1,337,930
1969	16,914,732	8,570,168	1,698,021
1970	12,491,819	7,133,124	860,584
1971	18,810,304	9,764,458	1,914,656
1972	16,635,560	7,725,422	788,277
1973	18,241,500	4,502,900	1,518,395
1974	13,375,345	11,088,656	2,118,261
1975	15,910,990	6,713,349	2,015,874
1976	14,370,316	9,651,432	1,815,048
1977	4,961,115	10,605,268	801,227
1978	8,913,478	6,601,646	561,297
1979	17,014,249	6,643,381	1,775,764
1980	14,255,717	13,368,442	1,573,926
1981	8,367,526	4,372,667	871,121
1982	10,517,276	8,915,451	1,749,785
1983	12,404,793	6,711,871	2,699,625
1984	4,088,105	7,209,256	1,391,292
1985	7,727,811	16,318,704	1,438,953
1986	10,968,861	8,702,924	2,101,628
1987	13,086,952	3,024,169	3,139,447
1988	10,909,691	8,143,448	2,929,585
1989	13,851,605	9,231,743	3,393,081
1990	12,613,723	8,734,294	1,651,188
1991	18,272,539	10,680,481	2,699,144

White shrimp

Maximum Sustainable Yield

The existing definition of MSY established by the original Shrimp Plan was calculated as mean total landings for the South Atlantic during 1957 to 1991 adjusted for recreational landings. In calculating total landings, an additional ten percent (an estimate made by state shrimp biologists) was added to the commercial catch to account for recreational landings that were unreported. There were other adjustments based on more accurate recreational landings information when the shrimp baiting permit went into effect in South Carolina. Using this methodology, MSY is estimated to be 14.5 million pounds for white shrimp (SAFMC 1993).

Optimum Yield
OY for the white shrimp fishery is defined as the amount of harvest that can be taken by U.S. fishermen without reducing the spawning stock below the level necessary to ensure adequate reproduction. This level has been estimated only for the central coastal area of South Carolina, and only in terms of subsequent fall production (assumed to represent recruitment). Therefore, in actual application, OY for the white shrimp fishery is the amount of harvest that can be taken by the U.S. fishery during the fishing season which may vary from year to year based on both state regulations and regulations promulgated pursuant to the Shrimp FMP (i.e., closures due to cold kills) (SAFMC 1993).

Overfished Definition
The Council has not established an overfished definition for white shrimp. Nevertheless, the overfishing definition, indicating when population sizes have declined below a minimum threshold would also represent an overfished definition.

Overfishing Definition
Overfishing is indicated when the overwintering white shrimp population within a state's waters declines by 80% or more following severe winter weather resulting in prolonged cold water temperatures. Continued fishing following such a decline may reduce the reproductive capacity of the stock affecting subsequent recruitment and would be considered overfishing. Relative population abundance will be determined by catch per unit effort (CPUE) during standardized assessment sampling (SAFMC 1993).

Brown shrimp
Maximum Sustainable Yield
The existing definition of MSY established by the original Shrimp Plan was calculated as the mean total landings for the South Atlantic during 1957 to 1991 adjusted for recreational landings. In calculating total landings, an additional ten percent (an estimate provided by state shrimp biologists) was added to the commercial catch to account for recreational landings that are unreported. Using this methodology, MSY was estimated to be 9.2 million pounds for brown shrimp (SAFMC 1993).

Optimum Yield
OY for brown shrimp was defined in Amendment 2 to the Shrimp Plan as the amount of harvest that can be taken by U.S. fishermen without annual landings falling two standard deviations below the mean landings during 1957 through 1993 for three consecutive years (SAFMC 1996b). This value is 2,946,157 pounds (heads on).

Overfished Definition
The South Atlantic brown shrimp resource is considered to be overfished when annual landings fall below two standard deviations below mean landings for the period 1957 to 1993 for three consecutive years (2,946,157 pounds (heads on)). The brown shrimp stocks in the South Atlantic are not considered overfished. Annual production appears to be most influenced by late winter

and early spring environmental conditions as has been observed in the Gulf of Mexico (SAFMC 1996b).

Overfishing Definition
The Council has not established an overfishing definition for brown shrimp. If landings fall below the overfished threshold, it can be assumed that overfishing is also occurring.

Pink shrimp
Maximum Sustainable Yield
The existing definition of MSY established by the original Shrimp Plan was calculated as mean total landings for the South Atlantic during 1957 to 1991 adjusted for recreational landings. In calculating total landings, an additional ten percent (an estimate provided by state shrimp biologists) was added to the commercial catch to account for recreational landings that are unreported. Using this methodology, MSY was estimated to be 1.8 million pounds for pink shrimp (SAFMC 1993).

Optimum Yield
OY for pink shrimp was defined as the amount of harvest that can be taken by U.S. fishermen without annual landings falling two standard deviations below the mean landings during 1957 through 1993 for three consecutive years. This value is 286,293 pounds (heads on) for pink shrimp (SAFMC 1996b).

Overfished Definition
The South Atlantic pink shrimp resource is overfished when annual landings fall below two standard deviations below mean landings during 1957 to 1993 for three consecutive years (286,293 pounds (heads on)). There are indications that pink shrimp abundance may be reduced by prolonged cold water conditions. However, unlike with white shrimp, there does not appear to be a biological justification for closing the fishery following cold kills. It is believed that overwintering shrimp that are not harvested before reaching the ocean may simply be lost to the fishery. Further, being at the northern end of their range, larvae produced by overwintering North Carolina pink shrimp may be carried north by prevailing currents and lost to the system (SAFMC 1993).

Overfishing Definition
The Council has not established an overfishing definition for pink shrimp. If landings fall below the overfished threshold, it can be assumed that overfishing is also occurring.

4.1.1.2 Deepwater Shrimp

Description and distribution

Rock Shrimp
Rock shrimp, *Sicyonia brevirostris*, (Figure 4.1-5) are very different in appearance from the three penaeid species. Rock shrimp can be easily separated from penaeid species by their thick, rigid, stony exoskeleton. The body of the rock shrimp is covered with short hair and the abdomen has deep transverse grooves and numerous tubercles.

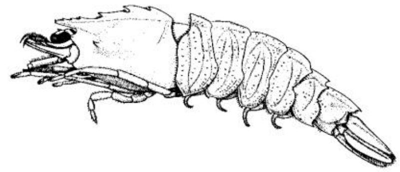


Figure 4.1-5. Rock shrimp, *Sicyonia brevirostris*.

Recruitment to the area offshore of Cape Canaveral occurs between April and August with two or more influxes of recruits entering within one season (Kennedy et al. 1977).
Keiser (1976) described the distribution of rock shrimp in coastal waters of the southeastern United States. Whitaker (1982) presented a summary of information on rock shrimp off South Carolina. The only comprehensive research to date on rock shrimp off the east coast of Florida was by Kennedy et al. (1977). This section presents some of the more significant findings by Kennedy et al. (1977) regarding the biology of rock shrimp on the east coast of Florida.

Rock shrimp are found in the Gulf of Mexico, Cuba, the Bahamas, and the Atlantic Coast of the U.S. up to Virginia (SAFMC, 1993). The center of abundance and the concentrated commercial fishery for rock shrimp in the south Atlantic region occurs off northeast Florida south to Jupiter Inlet. Rock shrimp live mainly on sand bottom from a few meters to 183 m (600 ft), occasionally deeper (SAFMC 1993). The largest concentrations are found between 25 and 65 m (82 and 213 ft).

Although rock shrimp are also found off North Carolina, South Carolina, and Georgia and are occasionally landed in these states, no sustainable commercially harvestable quantities of rock shrimp comparable to the fishery prosecuted in the EEZ off Florida are being exploited.

Royal Red Shrimp
Royal red shrimp, *Pleoticus robustus*, (Figure 4.1-6) are members of the family Solenoceridae, and are characterized by a body covered with short hair and a rostrum with the ventral margin toothless. Color can range from orange to milky white. Royal red shrimp are found on the continental slope throughout the Gulf of Mexico and South Atlantic area from Cape Cod to French Guiana. In the South Atlantic they are found in large concentrations primarily off northeast Florida. They inhabit the upper regions of the continental slope from 180 m (590 ft) to about 730 m (2,395 ft), but concentrations are usually found at depths of between 250 m (820 ft) and 475 m (1,558 ft) over blue/black mud, sand, muddy sand, or white calcareous mud. Royal red shrimp are not burrowers but dig grooves in the substrate in search of small benthic organisms (Carpenter 2002). They have been commercially harvested in a relatively limited capacity.

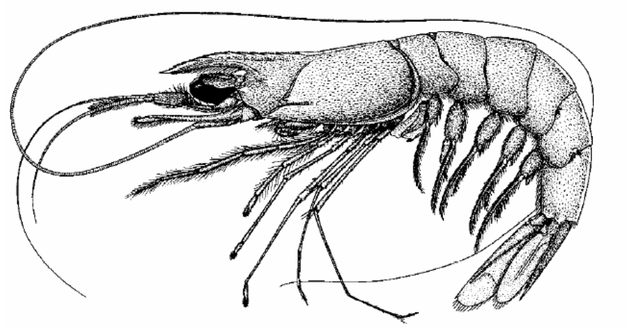


Figure 4.1-6. Royal red shrimp, *Pleoticus robustus* (Perez-Farfante and Kenlsey 1997)

Reproduction

Rock Shrimp

Rock shrimp are dioecious (separate sexes). Female rock shrimp attain sexual maturity at about 17 mm carapace length (CL), and all males are mature by 24 mm CL. Seasonal temperature initiates maturation. Rock shrimp have ovaries that extend from the anterior end of the cephalothorax to the posterior end of the abdomen.

Female rock shrimp attain sexual maturity at about 0.7 in (17 mm) carapace length (CL), and all males are mature by 0.9 in (24 mm) CL. Rock shrimp, as with most shrimp species, are highly fecund. Fecundity most probably, as with penaeids, increases with size. In rock shrimp, copulation is believed to take place between hard-shelled individuals. During copulation, similar to penaeid shrimp, the male anchors the spermatophore to the female's thelycum by the petasma and other structures and a glutinous material. Fertilization is believed to take place as ova and spermatozoa are simultaneously expulsed from the female. The spawning season for rock shrimp is variable with peak spawning beginning between November and January and lasting 3 months (Kennedy et al. 1977). Individual females may spawn three or more times in one season. Peak spawning activity seems to occur monthly and coincides with the full moon (Kennedy et al. 1977).

Kennedy et al. (1977) found rock shrimp larvae to be present year round with no trend relative to depth, temperature, salinity, and length or moon phase. The development from egg to postlarvae takes approximately one month. Subsequently the development from postlarvae to the smallest mode of recruits takes two to three months.

Development, growth and movement patterns

Rock Shrimp

For rock shrimp the development from egg to postlarvae takes approximately one month. Subsequently, the development from postlarvae to the smallest mode of recruits takes two to three months. The major transport mechanism affecting planktonic larval rock shrimp is the shelf current systems near Cape Canaveral, Florida (Bumpus 1973). These currents keep larvae on the Florida Shelf and may transport them inshore during spring. Recruitment to the area offshore of Cape Canaveral occurs between April and August with two or more influxes of recruits entering within one season (Kennedy et al. 1977).

Rates of growth in rock shrimp are variable and depend on factors such as season, water temperature, shrimp density, size, and sex. Rock shrimp grow about 2 to 3 mm CL (0.08 – 0.1 in) per month as juveniles and 0.5 - 0.6 mm CL (0.02 in) per month as adults (Kennedy et al. 1977).

Density is thought to also affect growth of rock shrimp. In 1993, the industry indicated that rock shrimp were abundant but never grew significantly over 36/40 count that was the predominant size class harvested during July and August of that year. During years of low densities, the average size appears to be generally larger.

Since rock shrimp live between 20 and 22 months, natural mortality rates are very high, and with fishing, virtually the entire year class will be dead at the end of the season. The intense fishing effort that exists in today's fishery, harvests exclusively the incoming year class. Three year classes were present in sampling conducted between 1973 and 1974 by Kennedy et al. (1977). Fishing mortality in combination with high natural mortality and possibly poor environmental conditions may be high enough to prevent any significant escapement of adults to constitute a harvestable segment of the population. The better than average rock shrimp production in the 1996 season possibly resulted from better environmental conditions more conducive to rock shrimp reproduction and spawning.

Ecological relationships

Rock Shrimp

Along the Florida Atlantic coast, the predominant substrate inside of 200 m depth is fine to medium sand with small patches of silt and clay (Milliman 1972). Juvenile and adult rock shrimp are bottom feeders. Rock shrimp are most active at night (Carpenter 2003). Stomach contents analyses indicated that rock shrimp primarily feed on small bivalve mollusks and decapod crustaceans (Cobb et al. 1973). Kennedy et al. (1977) found the relative abundance of particular crustaceans and mollusks in stomach contents of rock shrimp corresponding to their availability in the surrounding benthic habitat. The diet of *Sicyonia brevirostris* consists primarily of mollusks, crustaceans and polychaete worms. Also included are nematodes, and foraminiferans. Ostracods, amphipods and decapods made up the bulk of the diet, with lesser amounts of tanaidaceans, isopods, cumaceans, gastropods, and other bivalves also present (Kennedy et al. 1977).

Kennedy et al. (1977) characterized rock shrimp habitat and compiled a list of crustacean and molluscan taxa associated with rock shrimp benthic habitat. The bottom habitat on which rock shrimp thrive is limited and thus limits the depth distribution of these shrimp. Cobb et al. (1973) found the inshore distribution of rock shrimp to be associated with terrigenous and biogenic sand substrates and only sporadically on mud. Rock shrimp also utilize hardbottom and coral, more specifically *Oculina*, habitat areas. This was confirmed with research trawls capturing large amounts of rock shrimp in and around the Oculina Bank HAPC prior to its designation.

Abundance and status of stocks

Rock Shrimp

(from Shrimp Amendment 6)
For stocks such as rock shrimp information from which to establish stock status determination criteria are limited to measures of catch. Nevertheless, with the development of a permitting system and reporting requirements associated with the permit, better information will be collected on the effort and catch in this fishery. Data should be reviewed periodically to determine if better inferences can be drawn to address $B_{MSY.}$ Additionally, any time that annual catch levels trigger one of the selected thresholds, new effort should be made to infer B_{MSY} or a reasonable proxy.

The current stock status determination criteria for rock shrimp were calculated from catch estimates as reported in Amendment 1 of the Shrimp Plan (SAFMC 1996a) during the period 1984-1996 (Table 4.1-3).

Table 4.1-3. Landings data used to calculate the current MSY value for rock shrimp in the South Atlantic.

Year	Landings
1986	2,514,895
1987	3,223,692
1988	1,933,097
1989	3,964,942
1990	3,507,955
1991	1,330,919
1992	2,572,727
1993	5,297,197
1994	6,714,761

Note: Data for the period 1986 to 1994 are taken from Shrimp Amendment 1 (SAFMC 1996a).

Maximum Sustainable Yield
Because rock shrimp live only 20 to 22 months, landings fluctuate considerably from year to year depending primarily on environmental factors. Although there is a good historical time series of catch data, the associated effort data were not considered adequate to calculate a biologically realistic value for MSY. Nevertheless, two standard deviations above the mean total landings was considered to be a reasonable proxy for MSY (SAFMC 1996a). The MSY proxy for rock shrimp, based on the state data from 1986 to 1994, is 6,829,449 pounds heads on (SAFMC 1996a).

Optimum Yield
OY is equal to MSY. The intent is to allow the amount of harvest that can be taken by U.S. fishermen without reducing the spawning stock below the level necessary to ensure adequate reproduction. This is appropriate for an annual crop like rock shrimp when recruitment is dependent on environmental conditions rather than female biomass. A relatively small number of mature shrimp can provide sufficient recruits for the subsequent year's production (SAFMC 1996a).

Overfished Definition

The South Atlantic rock shrimp resource is overfished when annual landings exceed a value two standard deviations above mean landings during 1986 to 1994 (mean=3,451,132 lb., s.d. =1,689,159), or 6,829,449 pounds heads on (SAFMC 1996a). In other words, the stock would be overfished if landings exceeded MSY. The status of rock shrimp stocks in the South Atlantic are not considered overfished at this time. High fecundity enables rock shrimp to rebound from a very low population size in one year to a high population size in the next when environmental conditions are favorable (SAFMC 1996a).

Overfishing Definition

There is no designation of overfishing for rock shrimp. The overfished definition, which is based on landings (and fishing effort) in excess of average catch is, in essence, an overfishing definition.

4.1.2 Snapper Grouper Complex

4.1.2.1 Species Descriptions

Sea basses and Groupers (Serranidae)

(all species' descriptions updated from the Snapper Grouper SAFE Report Nov. 2005)
All serranids described in this document are reported to be protogynous hermaphrodites meaning that all individuals change sex from female to male at a certain size and/or age. This size and age at sex transition is species-dependent and can vary considerably within species.

Gag

Gag, *Mycteroperca microlepis*, occur in the Western Atlantic from North Carolina to the Yucatan Peninsula, and throughout the Gulf of Mexico. Juveniles are sometimes observed as far north as Massachusetts (Heemstra and Randall 1993). Gag commonly occurs at depths of 39-152 m (131-498 ft) (Heemstra and Randall 1993) and prefers inshore-reef and shelf-break habitats (Hood and Schlieder 1992). Bullock and Smith (1991) indicated that gag probably do not move seasonally between reefs in the Gulf of Mexico, but show a gradual shift toward deeper water with age. McGovern et al. (2005) reported extensive movement of gag along the Southeast United States. In a tagging study, 23% of the 435 recaptured gag moved distances greater that 185 km. Most of these individuals were tagged off South Carolina and were recaptured off Georgia, Florida, and in the Gulf of Mexico (McGovern et al. 2005).

Gag are considered estuarine dependent (Keener et al. 1988; Ross and Moser 1995; Koenig and Coleman 1998; Strelcheck et al. 2003). Juveniles (age 0) occur in shallow grass beds along Florida's east coast during the late spring and summer (Bullock and Smith 1991). Sea grass is also an important nursery habitat for juvenile gag in North Carolina (Ross and Moser 1995). Post-larval gag enter South Carolina estuaries when they are 13 mm TL and 40 days old during April and May each year (Keener et al. 1988), and utilize oyster shell rubble as nursery habitat. Juveniles remain in estuarine waters throughout the summer and move offshore as water temperatures cool during September and October. Adults are often seen in shallow water 5-15 m (16-49 ft) above the reef (Bullock and Smith 1991) and as far as 40-70 km (25-44 ft) offshore.

Huntsman et al. (1999) indicated that gag are vulnerable to overfishing since they are long-lived, late to mature, change sex, and aggregate to spawn. The estimated natural mortality rate is 0.15 (Potts et al. 1998a). Maximum reported size for gag is 145 cm (57.5 in) TL and 36.5 kg (81 lbs) (Heemstra and Randall 1993), and maximum reported age is 26 years (Harris and Collins 2000). Almost all individuals less than 87.5 cm (34.7 in) TL are females. At 105.0 cm (41.6 in) TL, 50% of fishes are males, while almost all gag are males at sizes greater than 120.0 cm (47.5 in) TL (McGovern et al. 1998).

Along the southeastern United States (1994-1995), size at first maturity is 50.8 cm (20.2 in) TL, and 50% of gag females are sexually mature at 62.2 cm (24.7 in) (McGovern et al. 1998). According to Harris and Collins (2000), age-at-first-maturity is 2 years, and 50% of gag are mature at 3 years. For data that were collected during 1978-1982 off the southeastern United States, McGovern et al. (1998) reported that the smallest mature females were 58.0 cm (22.9 in) TL and 3 years old. Hood and Schlieder (1992) indicated that most females reach sexual maturity at ages 5-7 in the Gulf of Mexico. Off the southeastern United States, gag spawn from December through May, with a peak in March and April (McGovern et al., 1998). Duration of planktonic larvae is about 42 days (Keener et al. 1988; Koenig and Coleman 1998; Lindeman et al. 2000). McGovern et al. (1998) reported that the percentage of male gag landed by commercial fishermen decreased from 20% during 1979-1981 to 6% during 1995-1996. This coincided with a decrease in the mean length of fish landed. A similar decrease in the percentage of males was reported in the Gulf of Mexico (Hood and Schleider 1992; Coleman et al. 1996).

Adults are sometimes solitary, or can occur in groups of 5 to 50 individuals, especially during the spawning season. They feed primarily on fishes, but also prey on crabs, shrimps, and cephalopods (Heemstra and Randall 1993), and often forage in small groups far from the reef ledge (Bullock and Smith 1991). Juveniles feed primarily on crustaceans, and begin to consume fishes when they reach about 25 mm (1 in) in length (Bullock and Smith 1991; Mullaney 1994).

Red grouper

Red grouper, *Epinephelus morio*, is primarily a continental species, mostly found in broad shelf areas (Jory and Iversen 1989). Distributed in the Western Atlantic, from North Carolina to southeastern Brazil, including the eastern Gulf of Mexico and Bermuda, but can occasionally be found as far north as Massachusetts (Heemstra and Randall 1993). The red grouper is uncommon around coral reefs; it generally occurs over flat rock perforated with solution holes (Bullock and Smith 1991), and is commonly found in the caverns and crevices of limestone reef in the Gulf of Mexico (Moe 1969). It also occurs over rocky reef bottoms (Moe 1969).

Adult red grouper are sedentary fish that are usually found at depths of 5-300 m (16-984 ft). Fishermen off North Carolina commonly catch red grouper at depths of 27-76 m (88-249 ft) for an average of 34 m (111 ft). Fishermen off southeastern Florida also catch red grouper in depths ranging from 27-76 m (88-249 ft) with an average depth of 45 m (148 ft) (Burgos, 2001; McGovern et al., 2002a). Moe (1969) reported that juveniles live in shallow water nearshore reefs until they are 40.0 cm (16 in) and 5 years of age, when they become sexually mature and move offshore. Spawning occurs during February-June, with a peak in April (Burgos 2001). In the eastern Gulf of Mexico, ripe females are found December through June, with a peak during April and May (Moe 1969). Based on the presence of ripe adults (Moe 1996) and larval red grouper (Johnson and Keener 1984) spawning probably occurs offshore. Coleman et al. (1996) found groups of spawning red grouper at depths between 21-110 m (70-360 feet). Red grouper do not appear to form spawning aggregation or spawn at specific sites (Coleman et al. 1996). They are reported to spawn in depths of 30-90 m (98-295 ft) off the Southeast Atlantic coast (Burgos 2001; McGovern et al. 2002a).

Off North Carolina, red grouper first become males at 50.9 cm (20.1 in) TL and males dominate size classes greater than 70.0 cm (27.8 in) TL. Most females transform to males between ages 7 and 14. Burgos (2001) reported that 50% of the females caught off North Carolina are undergoing sexual transition at age 8. Maximum age reported by Heemstra and Randall (1993) was 25 years. Burgos (2001) and McGovern et al. (2002a) indicated that red grouper live for at least 20 years in the Southeast Atlantic and a maximum age of 26 years has been reported for red grouper in the Gulf of Mexico (L. Lombardi, NMFS Panama City, personal communication). Natural mortality rate is estimated to be 0.20 (Potts and Brennan 2001). Maximum reported size is 125.0 cm (49.2 in) TL (male) and 23.0 kg (51.1 lb). For fish collected off North Carolina during the late 1990s, age at 50% maturity of females is 2.4 years and size at 50% maturity is 48.7 cm (19.3 in) TL. Off southeastern Florida, age at 50% maturity was 2.1 years and size at 50% maturity was 52.9 cm (21.0 in) TL (Burgos 2001; McGovern et al. 2002a). These fish eat a wide variety of fishes, octopuses, and crustaceans, including shrimp, lobsters, and stomatopods (Bullock and Smith 1991; Heemstra and Randall 1993).

Scamp

Scamp, *Mycteroperca phenax*, occurs in the Western Atlantic, from North Carolina to Key West, in the Gulf of Mexico, and in the southern portion of the Caribbean Sea. Juveniles are sometimes encountered as far north as Massachusetts (Heemstra and Randall 1993). Its reported depth range is 30-100 m (98-328 ft) (Heemstra and Randall 1993). Juveniles are found in estuarine and shallow coastal waters (Bullock and Smith 1991; Heemstra and Randall 1993).

Scamp are protogynous, with females dominating sizes less than 70.0 cm (27.8 in) (Harris et al. 2002). Scamp live for at least 30 years (Harris et al. 2002), and attain sizes as great as 107.0 cm (42.4 in) TL and 14.2 kg (31.3 lbs) (Heemstra and Randall 1993). Natural mortality rate is estimated to be 0.15 (Potts and Brennan 2001). Harris et al. (2002) report that the length and age at first spawning of females off North Carolina to southeast Florida was 30.0-35.0 cm (11.9-13.8 in) TL and age 1. Length and age at 50% maturity was 35.3 cm (13.9 in) TL and 1.28 years, respectively (Harris et al. 2002). In a study conducted in the eastern Gulf of Mexico, all fish larger than 35.0 cm TL were sexually mature (M. Godcharles and L. Bullock unpublished data).

Spawning occurs from February through July in the South Atlantic Bight and in the Gulf of Mexico, with a peak in March to mid-May (Harris et al., 2002). Hydration of eggs occurs primarily during the morning and late afternoon, which indicates that scamp spawn during late afternoon and evening. Spawning individuals have been captured off South Carolina and St. Augustine, Florida at depths of 33 to 93 m. Scamp aggregate to spawn. Spawning locations and time of spawning overlap with those of gag (Gilmore and Jones 1992). Fish are the primary prey of this species (Matheson et al. 1986).

Black grouper

The black grouper, *Mycteroperca bonaci*, occurs in the Western Atlantic, from North Carolina to Florida, Bermuda, the Gulf of Mexico, West Indies, and from Central America to Southern Brazil (Crabtree and Bullock 1998). Adults are found over hard bottom such as coral reefs and rocky ledges. Black grouper occur at depths of 9 to 30 m (30 to 98 ft). Juveniles sometimes occur in estuarine seagrass and oyster rubble habitat in North Carolina and South Carolina (Keener et al. 1988; Ross and Moser 1995). In the Florida Keys, juveniles settle on patch reefs (Sluka et al. 1994). Commercial landings of black grouper exceed landings of any other grouper in the Florida Keys.

Natural mortality (M) is estimated to be 0.15 (Potts and Brennan 2001). Crabtree and Bullock (1998) found that black grouper live for at least 33 years and attain sizes as great as 151.8 cm (60.1 in) TL. Females ranged in length from 15.5 to 131.0 cm (6.1-51.9 in) TL and males range in length from 94.7 to 151.8 cm (38.3-60.1 in) TL. Black grouper are protogynous. Approximately 50% of females are sexually mature by 82.6 cm (32.7 in) TL and 5.2 years of age. At a length of 121.4 cm (48.1 in) TL and an age of 15.5 years, approximately 50% of the females have become males. Black grouper probably spawn throughout the year. However, peak spawning of females occurs from January to March.

Off Belize, black grouper are believed to spawn in aggregations at the same sites used by Nassau grouper (Carter and Perrine 1994). Eklund et al. (2000) describe a black grouper spawning aggregation discovered during winter 1997-1998, less than 100 m outside a newly designated marine reserve. Adults feed primarily on fishes.

Rock hind

Rock hind, *Epinephelus adcensionis*, are found in the western Atlantic from Massachusetts to southern Brazil, Bermuda, the Gulf of Mexico, and the Caribbean, (Smith 1997). They also occur in the eastern Atlantic from Ascension Island and St. Helena Island (Smith 1997). The rock hind is a demersal species, inhabiting rocky reef habitat to depths of 120 m (394 ft). It is usually solitary.

Maximum reported size is 61.0 cm (24.2 in) TL (male) and 4.1 kg (9.1 lbs) (Heemstra and Randall 1993). Size at maturity and age at first maturity are estimated as 28.0 cm (11.1 in) TL and 6.1 years, respectively. Maximum reported age is 12 years (Potts and Manooch 1995). The natural mortality rate is estimated as 0.25 (Ault et al. 1998).

Rock hind has been observed to spawn in aggregations near the shelf edge off the southwest coast of Puerto Rico in January at depths of 20-30 m (66 – 98 ft) (Rielinger 1999). Off Cuba, rock hind spawn during January through March (García-Cagide et al. 1994). Off South Carolina, females in spawning condition (hydrated oocytes or postovulatory follicles) have been collected during May through August (Unpublished MARMAP data). Crabs comprise the majority of their diet, but rock hind have also been observed to feed on fishes and young sea turtles (Heemstra and Randall 1993).

Red hind

Red hind, *Epinephelus guttatus*, is found in the Western Atlantic from North Carolina to Venezuela and is the most common species of *Epinephelus* in Bermuda and the West Indies

(Smith 1997). The red hind is found in shallow reefs and rocky bottoms, at depths of 2-100 m (7 – 328 ft) (Heemstra and Randall 1993). It is usually solitary and territorial.

Maximum reported size is 76.0 cm (30.0 in) TL (male) and 25.0 kg (55.5 lbs) (Heemstra and Randall 1993). Natural mortality rate is estimated to be 0.18 (Ault et al. 1998). Potts and Manooch (1995) examined 146 otoliths of red hind that were collected from North Carolina to the Dry Tortugas during 1980-1992 and report a maximum age of 11 years and maximum sizes of 49.0 cm (19.4 in) TL. Sadovy et al. (1992) conducted an age and growth study of red hind from Puerto Rico (n = 624) and St. Thomas, USVI (n = 162) and report a maximum age of 18 and a maximum size of 47.5 cm (18.8 in) TL. Luckhurst et al. (1992) captured a red hind off Bermuda that was 72.0 cm (28.5 in) TL and 22 years old.

Females (n = 390) off Puerto Rico become sexually mature at 21.5 cm (9.7 in) TL, the size at 50% maturity is 28.5 cm (11.3 in) TL, and they range in size from 11.0 to 48.0 cm (4.4 to 19.0 in) TL Sadovy et al. (1994). Males (n = 120) range in size from 27.3 to 51.0 cm (10.8 to 20.2) TL and transitional individuals (n = 7) were from 27.5 to 34.5 cm (10.9 to 13.7 in) TL. Annual spawning aggregations occur during the full moon in January and February off the southwest coast of Puerto Rico and during the summer in Bermuda with no relation to lunar periodicity (Shapiro et al. 1993; Sadovy et al. 1994). Spawning off Jamaica, Puerto Rico, and USVI occurs from December to February (Thompson and Munro 1978; Colin et al. 1987; Sadovy et al. 1992; Sadovy et al. 1994). Burnett-Herkes (1975) reports that red hind spawn from April to July off Bermuda. Red hind spawn during the summer off the southeastern United States (MARMAP unpublished data).

This species aggregates in large numbers during the spawning season (Coleman et al. 2000; Sadovy et al. 1994). A number of spawning aggregation sites have been documented in the Caribbean. The timing of aggregations is somewhat variable. Aggregations off Puerto Rico generally occur from January through March in association with the full moon, while those off the USVI generally occur from December through March in association with the full moon (Rielinger 1999). The red hind feeds mainly on crabs and other crustaceans, fishes, such as labrids and haemulids, and octopus (Randall, 1967, Heemstra and Randall 1993).

Graysby

Graysby, *Cephalopholis cruentata*, occur from North Carolina to south Florida and in the Gulf of Mexico, Caribbean and Bermuda. The graysby inhabits seagrass (*Thalassia*) beds and coral reefs, and is found as deep as 170 m (557 ft). It is sedentary, solitary, and secretive, usually hiding during the day, and feeding at night. This small grouper is rare in landings off the southeast United States, and is more commonly seen in the Caribbean (Potts and Manooch 1999). Graysby are probably most often landed as unclassified grouper by commercial fishermen off the southeastern United States.

Maximum reported size is 42.6 cm (16.9 in) TL (male) and 1.1 kg (2.4 lbs). In the northeastern Caribbean, individuals in spawning condition have been observed in March, and from May to July (Erdman 1976). Nagelkerken (1979) determined that graysby collected in the Caribbean spawn from July through October. Graysby spawn during summer off the Southeastern United States (MARMAP unpublished data). Size at maturity and age at first maturity are estimated as

14.0 cm (5.5 in) TL and 3.5 years (Nagelkerken 1979). Sexual transition occurs at sizes ranging from 14.0 to 26.0 cm (5.5-10.3 in) TL with most transitional individuals occurring between the sizes of 20.0-23.0 cm (7.9-9.1 in) TL and ages 4-5 (Nagelkerken 1979).

Potts and Manooch (1999) examined otoliths from 118 graysby that were collected from 1979 to 1997. Maximum reported age is 13 years and maximum size is 40.5 cm (16.0 in) TL. Juveniles feed on shrimp, while adults eat primarily fishes. Natural mortality rate is estimated as 0.20 (Ault et al. 1998). Adult graysby eat bony fish, shrimp, stomatopods, crabs, and gastropods (Randall 1967).

Yellowfin grouper

Yellowfin grouper, *Mycteroperca venenosa*, occur in the Western Atlantic, ranging from Bermuda to Brazil and the Guianas, including the Gulf of Mexico and Caribbean Sea at depths of 2-137 m (7-449 ft). Juveniles are commonly found in shallow sea grass beds, while adults occur over rocky areas and coral reefs.

Maximum reported size is 100.0 cm (39.6 in) TL (male) and 18.5 kg (41.1 lbs) (Heemstra and Randall 1993). Thompson and Munro (1978) reported that yellowfin grouper off Jamaica are 4 years old between 46.0-57.0 cm (18.1-22.4 in) TL, and by 80.0 cm (31.5 in) TL, they are 10 years of age. Manooch (1987) reported a maximum age of 15 years for yellowfin grouper. Natural mortality rate is estimated to be 0.18 (Ault et al. 1998). Yellowfin grouper aggregate at some of the same sites utilized by tiger grouper, Nassau grouper, and black grouper (Sadovy et al. 1994). Spawning occurs during March in the Florida Keys (Taylor and McMichael 1983), and from March and May to August in the Gulf of Mexico (Bullock and Smith, 1991). Most spawning occurs in Jamaican waters between February and April (Thompson and Munro 1978), and during July off Bermuda (Smith 1958). Yellowfin grouper feed mainly on fishes (especially coral reef species) and squids (Heemstra and Randall 1993).

Coney

Coney, *Cephalopholis fulva*, is a small grouper that occurs in the Western Atlantic, ranging from South Carolina (USA) and Bermuda to southern Brazil, including Atol das Rocas. The coney is a sedentary species. It prefers coral reefs and clear water, and can be found to depths as great as 150 m (492 ft). Coney are most commonly taken in the Caribbean, where they are found associated with patch reefs. Most commercial landings of coney are off southeast Florida and are often labeled as unclassified grouper.
Maximum reported length is 41.0 cm (16.2 in) TL (male). This species is protogynous (Heemstra and Randall 1993). Size at 50% maturity for females sampled off the west coast of Puerto Rico was 13.0 cm (5.1 in) FL (Figuerola and Torrez Ruiz 2000). Heemstra and Randall (1993) report that females mature at 16.0 (6.3 in) cm TL and transform to males at about 20.0 (7.9 in) cm TL.

Potts and Manooch (1999) examined the otoliths from 55 coney that were collected during 1979-1997 from North Carolina to the Dry Tortugas, Florida. The maximum reported age is 11 years and maximum size is 39.7 cm (15.7 in) TL. Natural mortality rate is estimated as 0.18 (Ault et al. 1998).

Spawning occurs in small groups composed of one male and multiple females. Although ripe ovaries are found from November to March off the west coast of Puerto Rico, spawning activity appears to be limited to several days around the last quarter and new moon phases during January and February (Figuerola et al. 1997). The diet is composed primarily of small fishes and crustaceans (Randall 1967).

Yellowmouth grouper

Yellowmouth grouper, *Mycteroperca interstitialis,* occur along the eastern U.S. coast, Bermuda, Bahamas, Gulf of Mexico, and in the Caribbean south to Brazil (Smith 1971). Adults are found over rocky hard bottom and coral reefs near the shoreline as deep as 55 m (100 ft). Individuals have been found as deep as 150 m (275 ft). Young commonly occur in mangrove lined lagoons.

The maximum reported size of yellowmouth grouper is 84.0 cm (33.2 in) TL (male) and 10.2 kg (22.6 lbs) (IGFA data base, 2001 http://www.igfa.org in FISHBASE www.fishbase.org). In the Gulf of Mexico, maximum reported age for yellowmouth grouper is 28 years (Bullock and Murphy 1994), while in Trinidat and Tobago the maximum reported age was 41 years (Maninckhand-Heilman and Phillip 2000). Males (2-28 years) are generally older than females (2-17 years). Females become sexually mature between 40.0-45.0 cm (15.8-17.7 in) TL and ages 2-4 years. Fifty percent are males at 60.0-64.9 cm (23.6-25.6 in) TL. Fish undergo sexual transition from female to male at lengths from 50.3 to 64.3 cm (19.8-25.3 in) TL, between the ages of 5 and 14 years. Yellowmouth grouper may spawn all year, but peak spawning of females in the Gulf of Mexico occurs during March to May (Bullock and Murphy 1994). Finfish constitute a large part of the diet of yellowmouth grouper (Randall 1967).

Tiger grouper

Tiger grouper, *Mycteroperca tigris*, occur in the Western Atlantic, ranging from Bermuda and south Florida to Venezuela and, possibly Brazil, including the Gulf of Mexico and the Caribbean Sea. It inhabits coral reefs and rocky areas at depths of 10 to 40 m (33-131 ft).

Maximum reported size is 101.0 cm (40.0 in) TL (male) and 10 kg (22.2 lbs) (Heemstra and Randall 1993). Approximate life span is 26 years, and M is estimated at 0.12 (Ault et al. 1998).

The size-sex ratios described in a study conducted off Bermuda indicate this fish is probably protogynous (Heemstra and Randall 1993). It forms aggregations at specific times and locations each year, but only during the spawning season (Coleman et al. 2000; White et al. 2002). White et al. (2002) reported that spawning aggregations of tiger grouper occurred one week after the full moon during January through April off Puerto Rico. Tiger grouper spawn from December through April off southwest Cuba (García-Cagide et al. 1999). The tiger grouper preys on a variety of fishes, and frequents cleaning stations (Heemstra and Randall 1993).

Goliath grouper

Goliath grouper, *Epinephelus itajara* -- formerly known as the "jewfish," occurs in the Western and Eastern Atlantic, and in the Eastern Pacific Ocean. In the Western Atlantic, its range extends from Florida to southern Brazil, including the Gulf of Mexico and the Caribbean Sea. A solitary species, goliath grouper inhabits rock, coral, and mud bottom habitats in both shallow, inshore areas and as deep as 100 m (328 ft) (Heemstra and Randall 1993). Juveniles are generally found in mangrove areas and brackish estuaries. Large adults also may be found in estuaries. They appear to occupy limited home ranges with little movement (Heemstra and Randall 1993).

The goliath grouper is the largest grouper in the Western North Atlantic. Maximum reported size is 250 cm (99 in) TL (male) and 455 kg (1,003 lbs) (Heemstra and Randall 1993). Bullock et al. (1992) indicated that fish taken from exploited populations have a maximum age of 37 years. However, it is likely that this species could live much longer if left unexploited. Froese and Pauly (2003) estimate M to be 0.13. Porch et al. (2003) use M between 0.04 and 0.19.

There is some evidence that males may transform from immature females (Bullock et al. 1992). Males exhibit a similar testicular structure to those of other serranids that are protogynous, however, mature males are observed at smaller lengths than those of mature females. Bullock et al. (1992) found that males become mature at slightly smaller sizes and at younger ages than females. They first become mature at 110.0 cm (43.6 in) TL and age 4. All males are mature by 115.2 cm (45.6 in) and age 7. Females first become mature at 120.0 cm (47.0 in) TL and age 6, and all are mature by 135.0 cm (53.1 in) TL and age 8.

Goliath grouper form consistent aggregations (always containing the largest, oldest individuals in the population), but only during the spawning season (Sadovy and Eklund 1999; Coleman et al. 2000). Aggregations off Florida declined in the 1980s from 50 to 100 fish per site to less than 10 fish per site. Since the harvest prohibition, aggregations have rebounded somewhat to 20-40 fish per site. Spawning off Florida occurs July through September during the full moon. Fish may move distances as great as 100 km from inshore reefs to the offshore spawning aggregations in numbers of up to 100 or more on shipwrecks, rock ledges, and isolated patch reefs along the southwest coast. In the northeastern Caribbean, individuals in spawning condition have been observed in July and August (Erdman 1976). Bullock et al. (1992) reported that goliath grouper spawn during June through December with a peak in July to September in the eastern Gulf of Mexico.

Goliath grouper feed primarily on crustaceans, particularly spiny lobsters, as well as turtles and fishes, including stingrays. It is a territorial species, and larger individuals have reportedly stalked and attempted to eat human divers (Heemstra and Randall 1993).

Nassau grouper

The Nassau grouper, *Epinephelus striatus*, occurs in the tropical Western Atlantic, ranging from Bermuda, the Bahamas, and Florida to southern Brazil. It has not been found in the Gulf of Mexico, except at the Campeche Bank off the coast of Yucatan, at Tortugas, and off Key West. The Nassau grouper occurs from the shoreline to depths of at least 90 m (295 ft). It is a sedentary, reef-associated species and usually encountered close to caves, although juveniles are common in seagrass beds (Heemstra and Randall 1993). Adults lead solitary lives, except when they aggregate to spawn (Sadovy and Eklund 1999).

Maximum reported size is 122 cm (48.3 in) TL (male) and 23-27 kg (51.1-29.9 lbs), and maximum reported age is 29 years (Sadovy and Eklund 1999). M has been estimated at 0.18 (Ault et al. 1998).

Unlike most other serranids where males are derived from females (protogyny), Sadovy and Colin (1995) indicated that Nassau grouper is primarily a gonochoristic species (separate sexes) with a potential for sex change. Male and female Nassau grouper mature between 40.0-50.0 cm (15.8-19.8 in) SL and 4-8 years of age. Most individuals attain maturity by 50.0 cm (19.8 in) SL and 7 years.

This species aggregates to spawn at specific times and locations each year (Coleman et al. 2000; Sadovy et al. 1994), reportedly at some of the same sites utilized by the tiger grouper, yellowfin grouper, and black grouper (Sadovy et al. 1994). Concentrated aggregations of from a few dozen to 30,000 Nassau grouper have been reported off the Bahamas, Jamaica, Cayman Islands, Belize, and the Virgin Islands (Heemstra and Randall 1993). Spawning aggregations composed of about 2,000 individuals have been documented north and south of St. Thomas, USVI at depths of 10-40 m, from December through February, around the time of the full moon (Rielinger 1999).

The spawning season is brief and associated with water temperature and the moon phase. At lower latitudes, reproductive activity lasts for about one week per month during December-February. In more northern latitudes (e.g. Bermuda), reproduction occurs between May and August, with a peak in July. Spawning aggregations in the Caribbean occurs at depths of 20-40 m on the outer reef shelf edge, in December and January around the time of the full moon in waters 25-26° C (Sadovy and Eklund 1999).

Juveniles feed primarily on crustaceans (Eggleston et al. 1998), while adults forage on fishes, bivalves, lobsters, and gastropods (Sadovy and Eklund 1999).

Snowy grouper

Snowy grouper, *Epinephelus niveatus*, occur in the Eastern Pacific and the Western Atlantic from Massachusetts to southeastern Brazil, including the northern Gulf of Mexico (Robins and Ray 1986 in Froese and Pauly 2003). It is found at depths of 30-525 m (98-1,722 ft). Adults occur offshore over rocky bottom habitat. Juveniles are often observed inshore and occasionally in estuaries (Heemstra and Randall 1993).

The snowy grouper is a protogynous species. The smallest, youngest male examined by Wyanski et al. (2000) was 72.7 cm (28.8 in) TL and age 8. The median size and age of snowy grouper was 91.9 cm (34.5 in) and age 16. The largest specimen observed was 122 cm (48 in) TL and 30 kg (66 lbs), and 27 years old (Heemstra and Randall 1993). The maximum age reported by Wyanski et al. (2000) is 29 years for fish collected off of North Carolina and South Carolina. Radiocarbon techniques indicate that snow grouper may live for as long as 40 years (Harris, South Carolina Department of Natural Resources, personal communication). Wyanski et al. (2000) reported that 50% of the females are mature at 54.1 cm (21.3 in) TL and 5 years of age. The smallest mature female was 46.9 cm (18.5 in) TL, and the largest immature female was 57.5 cm (22.6 in) TL.

Females in spawning condition have been captured off western Florida during May, June, and August (Bullock and Smith 1991). In the Florida Keys, ripe individuals have been observed from April to July (Moore and Labinsky 1984). Spawning seasons reported by other researchers are as follows: South Atlantic (north of Cape Canaveral), April through September (Wyanski et al. 2000) and April through July (Parker and Mays 1998); and South Atlantic (south of Cape Canaveral), May through July (Manooch 1984). Wyanski et al. (2000) reported that snowy grouper spawn at depths from 176 to 232 m (577 to 761 ft) off South Carolina. Adults feed on fishes, gastropods, cephalopods, and crustaceans (Heemstra and Randall 1993).

Yellowedge grouper

Yellowedge grouper, *Epinephelus flavolimbatus*, occur in the Western Atlantic from North Carolina to southern Brazil, including the Gulf of Mexico. A solitary, demersal, deepwater species, the yellowedge grouper occurs in rocky areas and on sand mud bottom, at depths ranging from 64 to 275 m (210 to 902 ft). On soft bottom habitats, this fish is often seen in or near trenches or burrow-like excavations (Heemstra and Randall 1993).

Maximum reported size is 114 cm (45.3 in) TL (male) and 18.6 kg (41 lbs). Manickchand-Heileman and Phillip (2000) reported a maximum age for yellowedge grouper of 35 years in Trinidad and Tobage, but Cass-Calay and Bahnick (2002) observed a maximum age of 85 years that was validated by the use of radiocarbon dating. M is estimated to be 0.05 (Cass-Calay and Bahnick 2002).

Bullock et al. (1996) in the Gulf of Mexico reported that 50% of fishes are mature at 22.4 in, and that 50% of females transform into males by 81 cm (32.2 in) TL. Spawning occurs from April through October in the South Atlantic (Keener 1984; Manooch 1984; Parker and Mays 1998). Ripe females were found in the eastern Gulf of Mexico from May through September (Bullock et al. 1996). Yellowedge grouper eat a wide variety of invertebrates (mainly brachyuran crabs) and fishes (Bullock and Smith 1991; Heemstra and Randall 1993).

Warsaw grouper

Warsaw grouper, *Epinephelus nigritus*, occur in the Western Atlantic from Massachusetts to southeastern Brazil (Robins and Ray 1986), and in the Gulf of Mexico (Smith 1971). The Warsaw grouper is a solitary species (Heemstra and Randall 1993), usually found on rocky ledges and seamounts (Robins and Ray 1986), at depths from 55 to 525 m (180-1,722 ft) (Heemstra and Randall 1993). Juveniles are sometimes observed in inshore waters (Robins and Ray 1986), on jetties and shallow reefs (Heemstra and Randall 1993).

Maximum reported size is 230 cm (91 in) TL (Heemstra and Randall 1993) and 263 kg (580 lbs) (Robins and Ray 1986). The oldest specimen was 41 years old (Manooch and Mason 1987). M was estimated by the SEDAR group during November 2003 to range from 0.05 to 0.12 (SEDAR 4 2004). The Warsaw grouper spawns during August, September, and October in the Gulf of Mexico (Peter Hood, NOAA Fisheries, personal communication), and during April and May off Cuba (Naranjo 1956). Adults feed on benthic invertebrates and on fishes (Heemstra and Randall 1993).

Speckled hind

Speckled hind, *Epinephelus drummondhayi*, occur along the southeast coast of United States from North Carolina to Florida, around Bermuda and in the northern and eastern Gulf of Mexico (Heemstra and Randall, 1993. Speckled hind are found at depths from 25 m to 400 m but most commonly occur at depths of 60 to 120 m (Heemstra and Randall, 1993). They have been caught at depths of 28 to 165 m (Roe, 1976; Sedberry, et al., 2006). Bullock and Smith (1991) reported that most commercial catches are taken from depths of 50 m or more. Juveniles occur in the shallower portions of the depth range.

The largest speckled hind on record is 110 cm total length and 30 kg (Matheson and Huntsman, 1984; Heemstra and Randall, 1993). Matheson and Huntsman (1984) observed a recruitment age of 3.3 years and a maximum age of at least 25 years. The von Bertalanffy equation calculated by Matheson and Huntsmen (1984) indicate that this species reaches maximum size slowly (L_t=967{1-exp[-0.13(t+1.01]}).

Histological examination of gonads collected from speckled hind revealed that it is a protogynous hermaphrodite (Brule et al., 2000). The estimated age at maturity for females is 4 to 5 years and the estimated size at maturity is 45 to 60 cm. The estimated age at transition from female to male is 8 to 12 years. It is thought that although speckled hind is a solitary species, they do form spawning aggregations (G. Gilmore, ECOS, personal communication). Spawning reportedly occurs between April and September (Brule et al., 2000; Heemstra and Randall, 1993).

Prey items include fishes, crustaceans, and squids (Bullock and Smith, 1991).

Prior to 1976, commercial landings of speckled hind were infrequent but increased in the late 70s and early 80s (Matheson and Huntsmen, 1984). Commercial landings of speckled hind reached a maximum of 14.8 metric tons in 1984. Landings of speckled hind steadily decreased until 1994 when a one fish per vessel limit was put into place. Commercial landings of speckled hind have averaged less than 1 metric ton annually from 1995 to 2004. Huntsmen *et al*. (1999) reported that in 1990 the population size was 10% and biomass was 5% of what they were in 1973 off North Carolina and South Carolina. The South Atlantic Fishery Management Council considers the speckled hind population in the South Atlantic to be overfished and currently experiencing overfishing (SAFMC, 1991).

Misty grouper

Misty grouper, *Epinephelus mystacinus*, occur in the Western and Eastern Atlantic Ocean (Heemstra and Randall 1993 in Froese and Pauly 2003). In the Western Atlantic, it ranges from Bermuda and the Bahamas to Brazil (Robins and Ray 1986). The misty grouper is a solitary, bathydemersal species. Adults generally occur at depths from about 100 to 550 m (327 to 1,803 ft) (Robins 1967). Juveniles occur in shallower waters (e.g., 30 m (98 ft)).

Little is known about the age, growth, and reproduction of this species. Maximum reported size is 160 cm (63 in) TL and 100 cm (39 in) TL for males and females, respectively. Maximum reported weight is 107 kg (236 lbs) (Heemstra and Randall 1993). The estimated size at maturity is 81.1 cm (31.9 in), and M is 0.14 (Froese and Pauly 2003). This species feeds primarily on fishes, crustaceans, and squids (Heemstra and Randall 1993).

Black sea bass

Black sea bass, *Centropristis striata*, occur in the Western Atlantic, from Maine to northeastern Florida, and in the eastern Gulf of Mexico. It can be found in extreme south Florida during cold winters (Robins and Ray 1986). Separate populations were reported to exist to the north and south of Cape Hatteras, North Carolina (Wenner et al. 1986). However, genetic similarities suggest that this is one stock (McGovern et al. 2002b). This species is common around rock jetties and on rocky bottoms in shallow water (Robins and Ray 1986) at depths from 2-120 m (7-394 ft). Most adults occur at depths from 20-60 m (66-197 ft) (Vaughan et al. 1995).

Maximum reported size is 66.0 cm (26.1 in) TL and 3.6 kg (7.9 lbs) (McGovern et al. 2002b). Maximum reported age is 10 years (SEDAR 2 2003a). Natural mortality is estimated to be 0.30 (SEDAR 2-SAR1 2003). The minimum size and age of maturity for females studied off the southeastern U.S. coast is 10.0 cm (3.6 in) SL and age 0. All females are mature by 18.0 cm (7.1 in) SL and age 3 (McGovern et al. 2002). Wenner et al. (1986) reported that spawning occurs from March through May in the South Atlantic Bight. McGovern et al. (2002) indicated that black sea bass females are in spawning condition during March-July, with a peak during March through May (McGovern et al., 2002). Some spawning also occurs during September and November. Spawning takes place in the evening (McGovern et al. 2002). Black sea bass change sex from female to male (protogyny). McGovern et al. (2002b) noted that the size at maturity and the size at transition of black sea bass was smaller in the 1990s than during the early 1980s. Black sea bass appear to compensate for the loss of larger males by changing sex at smaller sizes and younger ages.

In the eastern Gulf of Mexico and off North Carolina, females dominate the first 5-year classes. Individuals over the age of 5 are more commonly males. Black sea bass live for at least 10 years. The diet of this species is generally composed of shrimp, crab, and fish (Sedberry 1988). Sedberry (1988) indicated that black sea bass consume primarily amphipods, decapods, and fishes off the Southeastern United States. Smaller black sea bass ate more small crustaceans and larger individuals fed more on decapods and fishes.

Bank sea bass

The bank sea bass, *Centropristis ocyurus*, is a small demersal serrarid occuring in reefs or rocky offshore habitats from Cape Lookout, North Carolina, to the Yucatan banks of the southern Gulf of Mexico (Miller 1957). In the South Atlantic Bight it is more common in shelf edge habitats than the black sea bass, which is found more on inner- and mid-shelf reefs (Wyanski et al. 1992). Bank sea bass ranked between fifth and eight in abundance in chevron trap catches of the 1990-2005 MARMAP reef fish surveys in sponge-coral hard bottom habitat (Wyanski et al. 1992; MARMAP unpublished data). Unlike the larger and more abundant black sea bass (*C. striata*), it is of limited direct economic interest and is captured incidentally by anglers and commercial fishermen (Wyanski et al. 1992).

Little is known about the life history of ban sea bass. Most information comes from unpublished documents by Link (1980, unpubl. dissertation) and Wyanski et al (1992, unpubl. analytical MARMAP report). Maximum reported age is 7 (Link 1980) or 8 years (Wyanski et al. 1992). Maximum reported length in the off the SE coast of the US is 39 cm (15.4in) and 778 g (unpubl. data MARMAP). Sexual transition occurs over a wide range of sizes and ages, but most frequently between 12.5 and 17.4 cm TL (Wyanski et al. 1992). Peak spawning occurs in

February, March, and April, but ripe females were collected in January through April and in October and November (Wyanski et al. 1992).

Link (1980) reported that food off the bank sea bass of North Carolina consisted of crustaceans (frequency of occurrence 63%), mollusks (42%), fishes (12%) and echinoderms (8%).

Rock sea bass

Rock sea bass, *Centropristis philadelphica*, occurs in the Western Atlantic from North Carolina to Palm Beach, Florida as well as the northern Gulf of Mexico (Froese and Pauly 2003). It prefers hard bottom, rocks, jetties, and ledges. Maximum reported size is 30.0 cm (11.9 in).

Link (1980) reported that food of the rock sea bass off North Carolina consisted of crustaceans (frequency of occurrence 75%), fishes (46%), and mollusks (35%).

Wreckfish (Polyprionidae)

The wreckfish, *Polyprion americanus*, is a large grouper-like fish that has a global anti-tropical distribution, but it was rarely captured in the western North Atlantic until the late 1980s, when a bottom hook-and-line fishery that targets wreckfish developed on the Blake Plateau (Vaughan et al. 2001). Wreckfish occur in the Eastern and Western Atlantic Ocean, on the Mid-Atlantic Ridge, on Atlantic islands and seamounts, and in the Mediterranean Sea, southern Indian Ocean, and southwestern Pacific Ocean (Heemstra 1986; Sedberry et al. 1994; Sedberry 1995). In the western Atlantic, they occur from Grand Banks (44°50' N) off Newfoundland (Scott and Scott 1988) to the Valdes Peninsula (43°30' S) in Argentina (Menni et al. 1981). Genetic evidence suggests that the stock encompasses the entire North Atlantic (Sedberry et al. 1996). Active adult migration is also possible as the frequent occurrence of European fishhooks in western North Atlantic wreckfish suggests migration across great distances (Sedberry et al. 2001).

Wreckfish have supported substantial fisheries in the eastern North Atlantic, Mediterranean, Bermuda, and the western South Atlantic, but concentrations of wreckfish adequate to support a fishery off the southeastern United States were not discovered until 1987. The fishery off the southeastern United States occurs over a complex bottom feature that has over 100 m of topographic relief, known as the Charleston Bump, that is located 130-160 km southeast of Charleston, South Carolina, at 31°30'N and 79°00'W on the Blake Plateau (Sedberry et al. 2001). Fishing occurs at water depths of 450-600 m. Primary fishing grounds comprise an area of approximately 175-260 km^2, characterized by a rocky ridge and trough feature with a slope greater than 15° (Sedberry et al. 1994; Sedberry et al. 1999; Sedberry et al. 2001).

Adults are demersal and attain lengths of 200 cm TL (79 in; Heemstra 1986) and 100 kg (221 lbs; Roberts 1986). Wreckfish landed in the southeastern United States average 15 kg (33 lbs) and 100 cm TL (39 inches TL) (Sedberry et al. 1994). Juvenile wreckfish (< 60 cm TL) are pelagic, and often associate with floating debris, which accounts for their common name. The absence of small pelagic and demersal wreckfish on the Blake Plateau has led to speculation that young wreckfish drift for an extended period, up to four years, in surface currents until reaching the eastern Atlantic, or perhaps that they make a complete circuit of the North Atlantic (Sedberry et al. 2001).

Vaughan et al. (2001) reported maximum ages of 35 years, however, off Brazil ages as great as 76 years have been reported for wreckfish (Peres and Haimovici 2004). In a recent MARMAP report, mature gonads were present in 60% of females at 751-800 mm, 57% at 801-850 mm, and 100% at larger sizes. The smallest mature female was 692 mm, and immature females were 576-831 mm. The estimate of length at 50% maturity was 790 mm (Gomperz model; 95% CI = 733-820). Mature gonads were present in 40% of males at 651-800 mm and 100% at larger sizes. The smallest mature male was 661 mm, and immature males were 518-883 mm. L50 was not estimated because transition to maturity was abrupt.

Wreckfish spawn from December through May, with a peak during February and March. The highest percentages of ripe males occurred during December through May, which corresponded with the female spawning season; however, males in spawning condition were collected throughout the year. The male spawning peak was also during February and March.

Snappers (Lutjanidae)

Queen snapper

The queen snapper, *Etelis oculatus*, occurs in the Western Atlantic, ranging from Bermuda and North Carolina to Brazil, including the Gulf of Mexico and Caribbean Sea. It is commonly found near oceanic islands, and is particularly abundant in the Bahamas and the Antilles. This species is bathydemersal species (Allen 1985) and moves offshore to deepwater reefs and rocky ledges as it grows and matures (SAFMC 1999). Allen (1985) indicated it is primarily found over rocky bottom habitat, in depths of 100 to 450 m (327 to 1,475 ft). Thompson and Munro (1974a) report it was caught on mud slopes of the south Jamaica shelf at a depth of 460 m (1,508 ft). Maximum reported size is 100 cm TL (39 inches, male). Maximum reported weight is 5,300 g (11.7 lbs) (Allen 1985). Size at maturity and age at first maturity are estimated as 53.6 cm TL (21 inches) and 1 year, respectively. Spawning is reported to occur during April and May off St. Lucia (Murray et al. 1998). Approximate life span is 4.7 years; natural mortality rate, 0.76 (Froese and Pauly 2003). Primary prey items include small fishes and squids (Allen 1985).

Yellowtail snapper

Yellowtail snapper, *Ocyurus chrysurus*, occurs in the Western Atlantic, ranging from Massachusetts to southeastern Brazil, including the Gulf of Mexico and Caribbean Sea, but is most common in the Bahamas, off south Florida, and throughout the Caribbean. Most U.S. landings are from the Florida Keys and southeastern Florida. The yellowtail snapper inhabits waters as deep as 180 m (590 ft), and usually is found well above the bottom (Allen 1985). Muller et al. (2003) state that adults typically inhabit sandy areas near offshore reefs at depths ranging from 10 to 70 m (33-230 ft). Thompson and Munro (1974a) indicate that this species is most abundant at depths of 20-40 m (66-131 ft) near the edges of shelves and banks off Jamaica. Juveniles are usually found over back reefs and seagrass beds (Thompson and Munro 1974a; Muller et al. 2003). Yellowtail snapper exhibits schooling behavior (Thompson and Munro 1974a).

Maximum reported size is 86.3 cm (34.2 in) TL (male) and 4.1 kg (9.1 lbs) (Allen 1985). Maximum age is 17 years (Manooch and Drennon 1987). M is estimated at 0.20 with a range of

0.15-0.25 (Muller et al. 2003). There is a truncation in the size and age structure of yellowtail snapper near human population centers.
Yellowtail snapper have separate sexes throughout their lifetime (i.e., they are gonochoristic). Figuerola et al. (1997) estimated size at 50% maturity as 22.4 cm (8.9 in) FL (males) and 24.8 cm (9.8 in) FL (females), based on fishery independent and dependent data collected off Puerto Rico.

Spawning occurs over a protracted period and peaks at different times in different areas. In southeast Florida, spawning occurs during spring and summer, while it may occur year-round in the Bahamas and Caribbean (Grimes 1987). Figuerola et al. (1997) reported that, in the U.S. Caribbean, spawning occurs during February to October, with a peak from April to July. Erdman (1976) reported that 80% of adult yellowtail snapper captured off San Juan spawn during March through May. Spawning occurs in offshore waters (Figuerola et al. 1997; Thompson and Munro 1974a) and during the new moon (Figuerola et al. 1997). Large spawning aggregations are reported to occur seasonally off Cuba, the Turks and Caicos, and USVI. A large spawning aggregation occurs during May-July at Riley's Hump near the Dry Tortugas off Key West, Florida (Muller et al. 2003).

Yellowtail snapper are nocturnal predators. Juveniles feed primarily on plankton (Allen 1985; Thompson and Munro 1974a). Adults eat a combination of planktonic (Allen 1985), pelagic (Thompson and Munro 1974a), and benthic organisms, including fishes, crustaceans, worms, gastropods, and cephalopods (Allen 1985). Bortone and Williams (1986) stated that both juveniles and adults feed on fish, shrimp, and crabs.

Gray (mangrove) snapper

Gray snapper, *Lutjanus griseus*, occur in the Western Atlantic from Massachusetts to Brazil, including the Gulf of Mexico and Caribbean Sea. Most gray snapper landed in the U.S. South Atlantic are caught in Florida. This species occupies a variety of habitats during its life history (Burton 2001). It occurs at depths of 5-180 m (16-591 ft), in coral reefs, rocky areas, estuaries, mangrove areas, and in the lower reaches of rivers (especially the young). Gray snapper often forms large aggregations (Allen 1985).

Maximum reported size is 89.0 cm (35.2 in) TL (male) and 20.0 kg (44.4 lbs) (Allen 1985). Burton (2001) reported a maximum age of 24 year for gray snapper. M is estimated at 0.30 (Ault et al. 1998).

Gray snapper are gonochorists. Length and age at first maturity is estimated as 23.0 cm (9.1 in) FL and 2 years for females (Stark, 1971) and 22.0 cm (8.7 in) for males. Allen (1985) indicates that spawning occurs during summer near the time of the full moon. This species spawns during July and August in the Florida Keys (Thompson and Munro 1974a). In the northeastern Caribbean, individuals in spawning condition have been observed in May, August, and September (Erdman 1976). Off Cuba, gray snapper spawn during June through October with a peak in July (García-Cagide et al. 1994). In Key West, FL, female gray snapper spawn from June to September with a peak in July (Domeier et al. 1996).

The gray snapper feeds mainly at night on small fishes, shrimps, crabs, gastropods, cephalopods, and some planktonic items (Allen 1985). The stomachs of 18 juveniles collected off the south coast of Jamaica contained 60% by volume of larval fish and 40% crabs and shrimp (Thompson and Munro 1974a). Sierra et al. (1994) indicated that gray snapper feed on fish, mollusks, and benthic crustaceans.

Mutton snapper

Mutton snapper, *Lutjanus analis*, are found in the Western Atlantic from Massachusetts to southeastern Brazil, including the Caribbean Sea and the Gulf of Mexico. It is most abundant around the Antilles, the Bahamas, and off southern Florida. According to Allen (1985), mutton snapper can be found in both brackish and marine waters at depths of 25-95 m (82-312 ft). This species is captured on mud slopes off the southeast coast of Jamaica at depths of 100-120 m (328-656 ft) (Thompson and Munro 1974a). Juveniles generally occur closer to shore, over sandy, vegetated (usually *Thalassia*) bottom habitats, while large adults are commonly found offshore among rocks and coral habitat (Allen 1985).

Allen (1985), reported a maximum size of 94.0 cm (37.2 in) TL (male) and 15.6 kg (34.6 lbs). The largest male and female observed in a study conducted in Puerto Rico between February 2000 and May 2001 measured 70.0 cm (27.8 in) FL and 69 cm (27.3 in) FL, respectively (Figuerola et al. 1997). Burton (2002) reported a maximum age of 29 years for mutton snapper. M is estimated as 0.21 (Ault et al. 1998).

Mutton snapper are gonochorists (separate sexes). Size at 50% maturity is 33.0 cm (13.1 in) FL and 41.4 cm (16.4 in) FL for males and females, respectively, off Puerto Rico (Figuerola and Torrez Ruiz 2001). All males and females are probably mature by 43.1 cm (17.1 in) FL and 45.0 cm (17.8 in) FL, respectively. Spawning occurs in aggregations (Figuerola et al. 1997). Individuals have been observed in spawning condition in the U.S. Caribbean from February through July (Erdman 1976). Some spawning occurs during February to June off Puerto Rico, but spawning peaks during the week following the full moon in April and May. Spawning aggregations are known to occur north of St. Thomas, USVI, and south of St. Croix, USVI, in March, April, and May (Rielinger 1999). This species feeds on fishes, shrimps, crabs, cephalopods, and gastropods (Allen 1985).

Lane snapper

Lane snapper, *Lutjanus synagris*, occur in the Western Atlantic, ranging from North Carolina and Bermuda to southeastern Brazil, including the Gulf of Mexico and Caribbean Sea. It is most common near the Antilles, on the Campeche Bank, off Panama, and off the northern coast of South America. This species occurs over all bottom types, but is usually encountered near coral reefs and on vegetated sandy areas, in turbid as well as clear water, at depths of 10-400 m (33-1,311 ft) (Allen 1985). Larvae and juveniles can be found in sea grass beds and bays in the eastern Gulf of Mexico (Froese and Pauly 2003).

Maximum reported size is 60.0 cm (23.8 in) TL (male) and 3.5 kg (7.8 lbs) (Allen 1985). The world record is 8.3 lbs from Mississippi (Andy Strelcheck, Pers. Com.). Luckhurst et al. (2000) a maximum age of 19 years for lane snapper caught off Bermuda. In the northern Gulf of

Mexico, the maximum reported age of lane snapper is 17 years (Johnson et al. 1995). Estimates of M ranged from 0.11 to 0.24 (Johnson et al. 1995).

Figuerola et al. (1997) estimated size at 50% maturity as 14.7 cm (5.8 in) FL (males) and 18.5 cm (7.3 in) FL (females) in the U.S. Caribbean. Mean size at maturity of lane snapper collected off Jamaica was 26.8 cm (10.6 in) and 22.1 cm (8.8 in) in males and females respectively. Lane snapper first become sexually mature at age 1 (Luckhurst et al. 2000).

This fish often forms large aggregations, especially during the spawning season (Allen 1985). Reproduction occurs over a protracted period, with some degree of reproductive activity occurring all year (Figuerola et al. 1997). Most spawning occurs from March to September in the U.S. Caribbean (Erdman 1976; Figuerola et al. 1997) with peak spawning during April to July. Spawning is believed to peak in June and July around the full moon off Jamaica (Figuerola et al. 1997). This species feeds at night on small fishes, benthic crabs, shrimps, worms, gastropods, and cephalopods (Allen 1985).

Cubera snapper

Cubera snapper, *Lutjanus cyanopterus*, occur in the Western Atlantic from Nova Scotia and Bermuda to Brazil. It also occurs throughout the Bahamas and Caribbean, including Antilles. It is rare north of Florida and in the Gulf of Mexico (Froese and Pauly 2003). Adults are found mainly around ledges over rocky bottoms or around reefs, at depths of 18-55 m (59-180 ft). Juveniles are reef-associated but also occur in brackish marine waters, and sometimes inhabit mangrove areas. Maximum reported sizes for cubera snapper are 160.0 cm (63.4 in) TL (male/unsexed) and 57.0 kg (126.5 lbs) (Froese and Pauly 2003). Appeldoorn et al. (1987) estimated the maximum length as 102.0 cm (40.4 in) TL. Cubera snapper spawn during July-August off Cuba (García-Cagide et al. 1994). Cubera snapper feed on fishes, crabs, and shrimp (Froese and Pauly 2003).

Dog snapper

Dog snapper, *Lutjanus jocu*, occur in the Western and Eastern Atlantic. In the Western Atlantic, it occurs from Massachusetts to northern Brazil, including the Gulf of Mexico and Caribbean. The dog snapper is found at depths of 5-30 m (16-98 ft). Adults are common around rocky or coral reefs. Young are found in estuaries, and occasionally enter rivers (Allen 1985).

Maximum reported size is 128.0 cm (50.7 in) TL (male) and 28.6 kg (63.4 lbs) (Allen, 1985). Approximate life span is 29 years, and M is estimated at 0.33 (Ault et al. 1998). Dog snapper are gonochorists. The mean length at sexual maturity off Cuba is 43.0 cm (17.0 in) for females and 48.0 cm (19.0 in) FL for males (García-Cagide et al. 1994). Dog snapper are reported to spawn throughout the year off Cuba (García-Cagide et al. 1999). In the Caribbean, females in spawning condition have been collected during February-March, and in November (Thompson and Munro 1974a). In the northeastern Caribbean, individuals in spawning condition have been observed in March (Erdman 1976). Spawning aggregations have been observed on the outer fore reef of a promontory along the central province of the Belize barrier reef (Carter and Perrine 1994).

The dog snapper feeds mainly on fishes and benthic invertebrates, including shrimps, crabs, gastropods, and cephalopods (Allen 1985). Sierra et al. (1994) indicate that 92% of the diet is fishes, 4% mollusks, and 4% benthic crustaceans.

Schoolmaster

Schoolmaster, *Lutjanus apodus*, are found in the Western and Eastern Atlantic Ocean. In the Western Atlantic, it is found from Massachusetts to Trinidad and northern Brazil, including the Gulf of Mexico and Caribbean Sea. The schoolmaster snapper is found in shallow, clear, warm, coastal waters over coral reefs, from 2 to 63 m (7-207 ft) deep. Adults often seek shelter near elkhorn corals and gorgonians. Juveniles are encountered over sand bottoms with or without seagrass (*Thalassia*), and over muddy bottoms of lagoons or mangrove areas. Young sometimes enter brackish waters (Allen 1985).

Allen (1985) reported maximum sizes as 67.2 cm (26.6 in) TL and 75.0 cm (29.7 in) FL for males and females, respectively. The maximum reported weight is 10.8 kg (24.0 lbs) (Allen 1985). Estimated M is 0.25 (Ault et al. 1998). Off Jamaica, the smallest mature female was 25.0 cm (9.9 in) long (García-Cagide et al. 1994).

The schoolmaster is a gonochorist. Ripe and/or recently spent fishes have been collected in nearshore and oceanic habitats off Jamaica in February-June and August-November (Thompson and Munro, 1974a). Erdman (1976) reports the occurrence of ripe males and females in September. Schoolmaster is reported to spawn during April-June off Cuba (García-Cagide et al. 1994).

Schoolmaster sometimes form resting aggregations during the day (Allen 1985). Schools of this species observed over reefs off Florida dispersed at dusk in search of food (Thompson and Munro 1974a). Prey items include fishes, shrimps, crabs, worms, gastropods, and cephalopods (Allen 1985).

Mahogany snapper

Mahogany snapper, *Lutjanus mahogoni*, occur in the Western Atlantic from North Carolina to Venezuela, including the Gulf of Mexico and Caribbean Sea. This species is common in the Caribbean but is rare in US waters (Froese and Pauly 2003). The mahogany snapper occurs in nearshore water as deep as 100 m (328 ft). It is usually found in clear, shallow water over rocky bottoms near coral reefs but occurs less frequently in sandy areas or seagrass. It often forms large aggregations during the day (Allen 1985) and has been observed to school with white grunt, *Haemulon plumieri*, at Grand Cayman (Thompson and Munro 1974a).

Maximum reported size is 48.0 cm (19.0 in) TL (male) and 1.3 kg (2.9 lbs) (Allen 1985). M is estimated at 0.30 (Ault et al. 1998). Ripe females have been observed during August in the northeastern Caribbean (Erdman 1976). This fish feeds at night mainly on small fish, shrimps, crabs, and cephalopods (Allen 1985).

Vermilion snapper

Vermilion snapper, *Rhomboplites aurorubens*, occur in the Western Atlantic, from North Carolina to Rio de Janeiro. It is most abundant off the southeastern United States and in the Gulf of Campeche (Hood and Johnson 1999). The vermilion snapper is demersal, commonly found over rock, gravel, or sand bottoms near the edge of the continental and island shelves (Allen 1985). It occurs at depths from 18 to 122 m (59 to 400 ft), but is most abundant at depths less than 76 m (250 ft). Individuals often form large schools. This fish is not believed to exhibit extensive long range or local movement (SEDAR 2 2003b).

The maximum size of a male vermilion snapper, reported by Allen (1985), was 60.0 cm (23.8 in) TL and 3.2 kg (7.1 lbs). Maximum reported age in the South Atlantic Bight was 14 years (Zhao et al. 1997; Potts et al. 1998b). SEDAR 2-SAR2 (2003) recommends that M be defined as 0.25/yr, with a range of 0.2-0.3/yr.

This species spawns in aggregations (Lindeman et al. 2000) from April through late September in the southeastern United States (Cuellar et al. 1996). Zhao et al. (1997) indicated that most spawning in the South Atlantic Bight occurs from June through August. Eggs and larvae are pelagic.

Vermilion snapper are gonochorists. All vermilion snapper are mature at 2 years of age and 20.0 cm (7.9 in) (SEDAR 2 2003b). Cuellar et al. (1996) collected vermilion snapper off the southeastern United States and found that all were mature. The smallest female was 16.5 cm (6.5 in) FL and the smallest male was 17.9 cm (7.1 in) FL (Cuellar et al. 1996). Zhao and McGovern (1997) reported that 100% of males that were collected after 1982 along the southeastern United States were mature at 14.0 cm (5.6 in) TL and age 1. All females collected after 1988 were mature at 18.0 cm (7.1 in) TL and age 1.
This species preys on fishes, shrimps, crabs, polychaetes, and other benthic invertebrates, as well as cephalopods and planktonic organisms (Allen 1985). Sedberry and Cuellar (1993) reported that small crustaceans (especially copepods), sergestid decapods, barnacle larvae, stomatopods, and decapods dominated the diets of small (< 50 mm (2 in) SL) vermilion snapper off the Southeastern United States. Larger decapods, fishes, and cephalopods are more important in the diet of larger vermilion snapper.

Red snapper

The red snapper, *Lutjanus campechanus*, is found from North Carolina to the Florida Keys, and throughout the Gulf of Mexico to the Yucatan (Robins and Ray 1986). It can be found at depths from 10 to 190 m (33-623 ft). Adults usually occur over rocky bottoms. Juveniles inhabit shallow waters and are common over sandy or muddy bottom habitat (Allen 1985).

The maximum size reported for this species is 100 cm (39.7 in) TL (Allen 1985 and Robins and Ray 1986) and 22.8 kg (50 lbs) (Allen 1985). Maximum reported age in the Gulf of Mexico is 53 years (Goodyear 1995). For samples collected from North Carolina to eastern Florida, maximum reported age is 45 years (White and Palmer 2004). Potts and Brennan (2001) estimated M at 0.25.

Red snapper are gonochorists. In the U.S. South Atlantic Bight and in the Gulf of Mexico, Grimes (1987) reported that size at first maturity is 23.7 cm (9.3 in) FL. For red snapper collected along the Southeastern United States, White and Palmer (2004) found that the smallest mature male was 20.0 cm (7.9 in) TL, and the largest immature male was 37.8 cm (15 in) TL.

50% of males are mature at 22.3 cm (8.8 in) TL, while 50% of females are mature at 37.8 cm (15 in) TL. Males are present in 86% of age 1, 91% of age 2, 100% of age 3, 98% of age 4, and 100% of older age fish. Mature females are present in 0% of age 1, 53% of age 2, 92% of age 3, 96% of age 4, and 100% of older age individuals. Grimes (1987) found that the spawning season of this species varies with location, but in most cases occurs nearly year round. White and Palmer (2004) reported that the spawning season for female red snapper off the southeastern United States extends from May to October, peaking in July through September. Red snapper eat fishes, shrimps, crabs, worms, cephalopods, and some planktonic items (Szedlemayr and Lee 2004).

Silk snapper

Silk snapper, *Lutjanus vivanus*, occur in the Western Atlantic, from North Carolina to Brazil, including the Bahamas and the northern Gulf of Mexico. It is commonly found along rocky ledges, in depths of 91-242 m (299-794 ft) (Robins and Ray 1986). Adults are generally found further offshore than juveniles (SAFMC, 1999), and usually ascend to shallow water at night (Allen 1985). However, juveniles are sometimes observed on deep reefs (Robins and Ray 1986). Silk snapper form moving aggregations of similar-sized individuals (Boardman and Weiler 1980).

Maximum reported size is 83.0 cm (32.9 in) TL and 8.3 kg (18.3 lb) (Allen 1985). Size at maturity and age at first maturity are estimated at 43.4 cm (17.2 in) TL and 6.3 years, respectively (Froese and Pauly 2003). Silk snapper do not change sex. Spawning occurs in June, July, and August in waters off North and South Carolina (Grimes 1987).

Silk snapper eat primarily fishes, shrimps, crabs, gastropods, cephalopods, tunicates, and some pelagic items, including urochordates (Allen 1985).

Blackfin snapper

Blackfin snapper, *Lutjanus buccanella*, occur in the Western Atlantic, generally ranging from North Carolina, south throughout the Bahamas, and the northern Gulf of Mexico, to southeast Brazil (Robins and Ray 1986). This is a demersal species. Adults occur in deep waters over sandy or rocky bottoms, and near drop-offs and ledges (Allen 1985), ranging from 50-91 m (164-300 ft) depth (Robins and Ray 1986). Juveniles occur in shallower waters, often associated with reefs in depths of 35-50 m (115-164 ft) (Allen 1985).

Male blackfin snapper can reach sizes of 75.0 cm (29.8 in) and 14 kg (30.9 lbs). Blackfin snapper are gonochorists. Off Jamaica, the length at first maturity for males is 25.0-27.0 cm (9.9-10.7 in) FL and the mean length of females is 23.0-25.0 cm (9.1-9.9 in) FL (Thompson and Munro 1983). Allen (1985) identified fishes as the primary prey item of blackfin snapper.

Black snapper

Black snapper, *Apsilus dentatus*, occur in the Western Central Atlantic, off the Florida Keys, and in the western Gulf of Mexico and Caribbean Sea. A demersal species, the black snapper is primarily found over rocky bottom habitat, although juveniles are sometimes found near the surface (Allen 1985 in Froese and Pauly 2003). It moves offshore to deep-water reefs and rocky ledges as it matures (SAFMC 1999). Allen (1985) reported the depth range as 100-300 m (328-

984 ft). Off Jamaica, it is most abundant at depths of 60-100 m (197-328 ft) (Thompson and Munro 1974a).

Maximum reported size is 65.0 cm (25.7 in) TL (male) and 3.2 kg (7.1 lbs) (Allen 1985). Observed maximum fork lengths are 56.0 cm (22.2 in) FL and 54.0 cm (21.4 in) FL for males and females, respectively (Thompson and Munro 1974a).

Black snapper have separate sexes throughout their lifetime. Size and age at maturity estimated in Froese and Pauly (2003) is 34.9 cm (13.8 in) TL and 1 year, respectively. Estimated mean size at maturity for fish collected off Jamaica is 43.0-45.0 cm (17.0-17.8 in) FL and 39.0-41.0 (15.4-16.2 in) cm FL for males and females, respectively (Thompson and Munro 1974a). Off Cuba the mean size at maturity is 44.0 cm (17.4 in) FL for males and 40.0 cm (15.8 in) FL for females (García-Cagide et al. 1994).
In the northeastern Caribbean, individuals in spawning condition have been observed from February through April and in September (Erdman 1976). Off Jamaica, the greatest proportions of ripe fishes were found from January to April and from September to November (Thompson and Munro 1974a).

Large catches occasionally obtained over a short period suggest a schooling habit for this species (Thompson and Munro 1974a). Prey includes fishes and benthic organisms, including cephalopods, tunicates (Allen 1985), and crustaceans (Thompson and Munro 1974a).

Porgies (Sparidae)

Red porgy

The red porgy, *Pagrus pagrus*, occurs in both the Eastern and Western Atlantic Oceans. In the Western Atlantic, it ranges from New York to Argentina, including the northern Gulf of Mexico. Adults are found in deepwater near the continental shelf, over rock, rubble or sand bottoms, to depths as great as 280 m (918 ft). Red porgy are most commonly captured at depths of 25-90 m (82-295 ft). Young occur in water as shallow as 18 m (59 ft) (Robins and Ray 1986), and are sometimes observed over seagrass beds (Bauchot and Hureau 1990).
Maximum reported size is 91.0 cm (36.0 in) (Robins and Ray 1986) and 7.7 kg (17.1 lbs) (Bauchot and Hureau 1990). Maximum reported age of red porgy in the South Atlantic is 18 years (Potts and Manooch 2002).

Maximum reported length is 73.3 cm (28.9 in) in the South Atlantic (Potts and Manooch 2002). Based on histological examination of reproductive tissue, it has been determined that red porgy spawn from December through May off the southeastern United States, with a peak in January and February (Harris and McGovern 1997; Daniel 2003). Manooch (1976) examined red porgy ovaries macroscopically and stated that peak spawning of red porgy was during March-April.

Based on data collected off the southeast United States from 1995-2000, females first mature at 20.1-22.4 cm (8.0-8.9 in) TL, and at age 0. Size and age at 50% maturity is 28.9 cm (11.5 in) TL and 1.5 years, respectively. Red porgy are protogynous. At 35.1-40.0 cm (13.9-15.9 in) TL, 72% of all individuals collected during 1995-2000 were male; by age 9, 100% of all individuals were males. Researchers observed a much greater percentage of males in smaller size classes during recent years, than during the early 1980s (Daniel 2003). This species feeds on crustaceans, fishes, and mollusks (Bauchot and Hureau 1990).

Sheepshead

The sheepshead, *Archosargus probatocephalus*, is a reef-associated species that occurs to depths as great as 15 m (49 ft) from Nova Scotia, Canada and northern Gulf of Mexico to Brazil. Sheepshead have been observed to depths as great as 24 m (80 ft) in the Gulf of Mexico (Andy Strelcheck, pers.com.). It is absent in the Bahamas, West Indies, Bermuda, and Grenada (Froese and Pauly 2003). Sheepshead inhabits bays and estuaries. It freely enters brackish waters and is sometimes found in freshwater. Sheepshead are commonly found around pilings. Maximum reported size is 91.0 cm (36.0 in) TL (male/unsexed) and 9.6 kg (21.3 lbs) and maximum reported age is 20 years (Schwartz 1990). Sheepshead feeds on crabs, other benthic crustaceans, and mollusks (Lieske and Myers 1994).

Knobbed porgy

Knobbed porgy, *Calamus nodosus*, occur in the Western Atlantic Ocean from North Carolina to Southern Florida, and throughout the Gulf of Mexico (Robins and Ray 1986). This fish is a demersal species, and typically occurs over hard bottom habitat at depths from 7-90 m (23-295 ft) (Robins and Ray 1986). Maximum reported size is 54.4 cm (21.4 in) TL (male/unsexed) (Horvath et al. 1990) and 2.63 kg (5.8 lb) (Froese and Pauly 2003).

Maximum reported age is 21 years off the southeastern United States (Sharp 2001). Few immature fish were sampled by Sharp (2001). Length and age at which 100% of sampled fish are mature is 6 years and 29.8 cm (11.8 in) FL, respectively. Male to female sex ratios increased with increasing length and age, and histological evidence of protogyny was found. Females changed sex at 26.5-37.7 cm (10.5-15.0 in) FL and 5-20 years, during any time of year. Females spawned during March-July with a peak during April and May, with an estimated spawning frequency of 1.46 days.

Jolthead porgy

Jolthead porgy, *Calamus bajonado*, occur in the Western Atlantic from Rhode Island and Bermuda, southward to Brazil, including the northern Gulf of Mexico (Robins and Ray 1986). This species inhabits coastal waters from 3 to more than 200 m (10–656 ft) in depth. It can be found on vegetated sand bottoms, but occurs more frequently on coral and hard bottom. Large adults are usually solitary. Maximum reported size is 76.0 cm (30.1 in) FL (male) and 10.6 kg (23.4 lbs) (Robins and Ray 1986). Crabs and mollusks constitute its primary prey items (Robins and Ray 1986).

Scup

Scup, *Stenotomus chrysops*, occur in the Western Atlantic from Nova Scotia in Canada to Florida. Maximum reported size is 46.0 cm (18.2 in) TL (male/unsexed) and 2.1 kg (4.6 lbs). Length at 50% maturity is 15.5 cm (6.1 in) TL (O'Brien et al. 1993). Spawning is reported to occur during June off North Carolina. Scup feeds on squid, polychaetes, amphipods, and other benthic invertebrates.

Whitebone porgy

Whitebone porgy, *Calamus leucosteus*, are found in the Western Atlantic from North Carolina to southern Florida in the USA and the entire Gulf of Mexico (Waltz et al. 1982). They are most frequently encountered in or near sponge-coral habitats at depths of 10-100 m (33-328 ft). Off the Southeastern United States, maximum reported size is 41.0 cm (16.2 in) and maximum reported age is12 years (Waltz et al. 1982).

Whitebone porgy are protogynous and approximately 60% of the females undergo sex reversal (Waltz et al. 1982). Spawning occurs during April-August off the Southeastern United States with peak during May (Waltz et al. 1982). Off the Southeastern United States, whitebone porgy feed mainly on small hard-shelled species of gastropods, pagurid decapods, and sipunculids (Sedberry 1989). Polychaetes, pelecypods, barnacles, and fishes are also eaten. Larger individuals consume fishes and echinoderms.

Saucereye porgy

Saucereye porgy, *Calamus calamus*, are a reef-associated species that occurs from North Carolina and Bermuda to Brazil at depths of 1-75 m (3-246 ft). Adults are frequently found in coral areas, while the young prefer seagrass (e.g. *Thalassia*) and sandy bottoms. Maximum reported size is 56.0 cm (22.2 in) TL (male/unsexed) and 0.68 kg (1.5 lbs). The diet of saucereye porgy includes polychaetes, echinoderms, mollusks, crabs, gastropods, and other benthic crustaceans (Randall 1967).

Grass porgy

Grass porgy, *Calamus arctifrons*, occur in the Western Central Atlantic from southern Florida to Louisiana. It is also found in the eastern Gulf of Mexico. Grass porgy occurs in sea grass beds from near shore to depths of at least 22 m (72 ft). Small individuals have been known to form small aggregations. Maximum reported size is 25.0 cm (9.9 in) TL. Diet includes benthic invertebrates.

Longspine porgy

The longspine porgy, *Stenotomus caprinus*, is found on mud bottom from North Carolina to Georgia in the USA and in the Gulf of Mexico from northern Florida to Yucatan, Mexico at depths of 5-185 m (16-607 ft) (Froese and Pauly 2003). Maximum reported size is 30.0 cm (11.9 in) TL. Maximum age is reported to be 3 years. Their diet includes polychaetes, crabs, other benthic invertebrates, shrimps, prawns, fishes, stomatopods, and amphipods (Sheridan and Trimm 1983).

Grunts (Haemulidae)

White grunt

The white grunt, *Haemulon plumieri*, is a demersal fish distributed in coastal waters of the Atlantic Ocean from the Chesapeake Bay to southeastern Brazil, including the Bahamas, West Indies, eastern Gulf of Mexico, and the Central American coast (Potts and Manooch 2001). It has also been introduced in Bermuda (Fischer 1978; Darcy 1983; Sadovy and Severin 1992; Bohlke and Chaplin 1993). The white grunt is found in tropical and subtropical waters (Johnson

1978; Miller and Richards 1979; Darcy 1983). It inhabits nearshore sponge-coral ("live-bottom") habitats or offshore rocky outcrop habitats on the continental shelf along the southeastern coast of the United States and the Gulf of Mexico (Powles and Barans 1980; Darcy 1983) in depths ranging from 18-55 m (59-180 ft) (Huntsman 1976).

Maximum reported size is 53.0 cm (21.0 in) TL (male/unsexed) and 4.4 kg (9.8 lbs). White grunt occurring off North and South Carolina live for at least 27 years (Padgett 1997). Potts and Brennan (2001) estimate natural mortality for white grunt at 0.25.

Males are significantly larger than females. In fishery-independent samples, mature females are present in 50% of age 1 females, 88% of age 2 females, 99% of age 3 females, and 100% of older age females. Mature males from fishery-independent samples were present in 0% of age 1 males, 73% of age 2 males, 95% of age 3 males, and 100% of older age males. Females mature at 16.9-24.1 cm (6.7-9.5 in) TL (L50 = 16.7 cm (6.6 in) TL) and males mature at 17.3-27.7 cm (6.9-11.0) TL (L50 of 18.6 cm (7.4 in) TL). Off the southeastern United States, females are in spawning condition from March-September with a peak during May and June (Padgett 1997). Males are in spawning condition throughout the year with most activity occurring from March-June. Padgett (1997) indicated that the sex ratio of white grunt taken with fishery-dependent and fishery-independent gear was skewed towards females. White grunt feed on mollusks, polychaetes, fishes, benthic crustaceans, stomatopods, echinoderms, and amphipods (Bowman et al. 2000).

Black margate

Black margate, *Anistotremus surinamensis*, is found in the Western Atlantic from Florida, Bahamas, Gulf of Mexico Caribbean, and south American coast (Froese and Pauly 2003). It inhabits larger patch reefs and sloping rocky bottoms at depths of 3-20 m (10-66 ft). It attains sizes as large as 76.0 cm (30.1 in) TL and 5.8 kg (12.8 lbs). Spawning occurs May-July off Cuba (García-Cagide et al. 1994). Black margate feeds on echinoderms, gastropods, crabs, shrimp, prawns, fishes, and benthic invertebrates.

Margate

Margate, *Haemulon album,* occurs in the Western Atlantic from the Florida Keys to Brazil, including the Caribbean Sea. Margate are found in pairs or larger schools, over seagrass beds, sand flats, coral reefs, and wrecks in depths of 20-60 m (66-197 ft). Maximum reported size is 79.0 cm (31.3 in) TL (male) and 7.1 kg (2.1 lbs) (Cervigón 1993). Estimated natural mortality rate is 0.37 (Ault et al. 1998). García-Cagide et al. (1994) indicate that the mean size at maturity off Jamaica is 24.0 cm (9.5 in) FL. Peak spawning occurs during January and April off Jamaica, with a minor peak in September-November. In the northeastern Caribbean, individuals in spawning condition have been observed in February, March, April, and September (Erdman 1976). Margate off Cuba are in spawning condition throughout the year with a peak during March and April (García-Cagide et al. 1994). This fish feeds on benthic invertebrates, and has been observed to eat subsurface invertebrates such as peanut worms and heart urchins (Cervigón 1993).

Tomtate

The tomtate, *Haemulon aurolineatum*, occurs in the Western Atlantic from Massachusetts to Brazil, including the Gulf of Mexico and Caribbean Sea (Courtney, 1961). The tomtate inhabits seagrass beds, sand flats, patch reefs, rocky outcrops, and even muddy bottom habitat, to depths of 55 m (180 ft) (Manooch and Barans 1982; unpublished MARMAP data). Along the Southeastern United States, maximum reported length is 261.0 mm FL, female and the maximum reported age is 17 years (Mikell et al. 2007). Maximum reported age is 9 years along the Southeastern United States Estimated natural mortality rate is 0.33 (Ault et al. 1998).

Peak spawning occurs during January and April off Jamaica (Munro et al. 1973; Gaut and Munro 1983). In the northeastern Caribbean, individuals in spawning condition have been observed from January through May, and in July and August (Erdman 1976). Along the southeastern United States, female tomtate are in spawning condition from March through July, with peak spawning occurring in April through June. Nearly all females (99.4%) were mature within the 150-159 mm FL category and by age 2 (MARMAP unpublished data Mikell et al. 2007).

Prey items include small crustaceans, mollusks, other benthic invertebrates, plankton, and algae (Carpenter 2002). In the Southeast Atlantic, polychaetes and amphipods are the most important component of the diet (Sedberry 1985). Decapods are also frequently consumed, but make up a small percentage of the volume or number of prey items. Pelecypods are the most abundant prey and cephalochordates make up a large portion of the food volume.

Sailor’s choice

The Sailor’s choice, *Haemulon parra*, is a reef-associated species that occurs in the Western Atlantic including the Bahamas, Florida, northern Gulf of Mexico, throughout the Caribbean Sea, and Central and South American coasts (Froese and Pauly 2003). They inhabit shallow coastal reefs, with young occurring on seagrass beds at depths of 3-30 m (10-98 ft). Adults occur in schools in relatively open areas and the species is rare around oceanic islands. It attains a maximum size of 41.2 cm (16.3 in) TL. Sailor’s choice feeds on annelids, benthic crustaceans, and echinoderms (Sierra et al. 1994).

Porkfish

The porkfish, *Anisotremus virginicus*, occurs in the Western Atlantic from Florida to Brazil, including the Gulf of Mexico and Caribbean Sea. It inhabits reef and rocky bottom habitats at depths of 2-20 m (7-65 ft). Maximum reported size is 40.6 cm (16.1 in) TL (male) and 0.93 kg (2.1 lbs) (Robins and Ray 1986). Estimated natural mortality rate is 0.43 (Ault et al. 1998). Peak spawning occurs during January and April offshore of Jamaica (Munro et al. 1973; Gaut and Munro 1983). In the northeastern Caribbean, individuals in spawning condition have been collected during April, July, October, and December (Erdman 1976). This species feeds at night on mollusks, echinoderms, annelids, and crustaceans. Juveniles pick parasites from the bodies of larger fishes (Robins and Ray 1986).

Bluestriped grunt

The bluestriped grunt, *Haemulon sciurus*, occurs in the Western Atlantic from Florida to Brazil, including the Gulf of Mexico and Caribbean. It is found in small groups over coral and rocky reefs to depth of 30 m (98.4 ft). Juveniles are abundant in seagrass (*Thalassia*) beds. Maximum reported size is 46.0 cm (18.2 in) TL (male) and 0.75 kg (1.7 lbs) (Froese and Pauly 2003).

Few fish are mature at sizes 18.0 cm (7.1 in) FL and that full maturity is probably at about 22.0 cm (8.7 in) FL (Munro et al. 1973; Gaut and Munro 1983). Peak spawning off Jamaica occurs during January-April, with a minor peak in September-November. In the northeastern Caribbean, individuals in spawning condition have been observed during January and March (Erdman 1976). Off Cuba, bluestriped grunt are reported to be in spawning condition during October through April with a peak during December and January (García-Cagide et al. 1994). The bluestriped grunt feeds on crustaceans, bivalves and, occasionally, on small fishes (Froese and Pauly 2003).

French grunt

The French grunt, *Haemulon flavolineatum*, occurs in the Western Atlantic from Bermuda, South Carolina, northern Gulf of Mexico, Caribbean, and Brazil. It occurs in large schools on rocky and coral reefs to depths of 60 m (197 ft). Juveniles are abundant in nearshore seagrass beds. Maximum reported size is 30.0 cm (11.9 in) TL (male) (Robins and Ray 1986).

French grunt become sexually mature at lengths of 12.0 cm (4.8 in) FL or less (Munro et al. 1973; Gaut and Munro 1983). Spawning probably occurs throughout the year off Jamaica. In the northeastern Caribbean, individuals in spawning condition have been observed in March and September (Erdman 1976). Small crustaceans are the primary prey (Robins and Ray 1986).

Cottonwick

Cottonwick, *Haemulon melanurum,* is found in the Western Atlantic from Bermuda, southeastern Florida, and the Bahamas to Brazil. It is also reported from Yucatan, Mexico (Froese and Pauly 2003). This reef-associated species occurs at depths ranging from 3-50 m (10-164 ft). Maximum reported size is 33.0 cm (13.1 in) TL (male/unsexed) and 0.55 kg (1.2 lbs). The length at 50% maturity is 19.0 cm (7.5 in) FL off Jamaica (Billings and Munro 1974). Cottonwick feeds on benthic crustaceans and other benthic invertebrates.

Spanish grunt

Spanish grunt, *Haemulon macrostomum*, is found in the Western Atlantic from southern Florida and the Antilles to Brazil. This reef-associated species occurs in dense schools at depths of 5-25 m (16-82 ft) (Froese and Pauly 2003). The maximum size reported is 43.0 cm (17.0 in) TL (male/unsexed) and 0.85 kg (1.9 lbs). Spawning occurs during May and June off Cuba (García-Cagide et al. 1994). Spanish grunt feeds on benthic crustaceans and echinoderms (Froese and Pauly 2003).

Smallmouth grunt

The smallmouth grunt, *Haemulon chrysargeryum*, is a reef-associated species that occurs in the Western Atlantic in southern Florida, Bahamas, and Yucatan, Mexico to Brazil at depths of 0 - 25 m. They are of minor commercial importance and are more commonly used as bait and in aquariums. It inhabits exposed rocky areas and coral reefs often near elkhorn and staghorn corals. Smallmouth grunt commonly found in schools and juveniles are encountered in *Thalassia* beds. Adults are observed in coral reefs during the day but enter open waters at night to feed primarily on mainly on plankton, but also on small crustaceans and mollusks (Froese and Pauly 2003).

Jacks (Carangidae)

Greater amberjack

The greater amberjack, *Seriola dumerili*, is a pelagic and epibenthic member of the family Carangidae (Manooch and Potts 1997a). This species occurs in the Indo-West Pacific, and in the Western and Eastern Atlantic Oceans. In the Western Atlantic, it occurs as far north as Nova Scotia, Canada, southward to Brazil, including the Gulf of Mexico (Carpenter 2002; Manooch and Potts 1997a; Manooch and Potts 1997b). The greater amberjack is found at depths of 18-360 m (60-1,181 ft). It inhabits deep reefs, rocky outcrops or wrecks and, occasionally, coastal bays. Juveniles and adults occur singly or in schools in association with floating plants or debris in oceanic and offshore waters.

This species is the largest jack and the maximum reported size is 190 cm (75 in) and 80.6 kg (177.7 lbs) (Paxton et al. 1989). Sexual dimorphism was evident in greater amberjack, with females being larger at age than males, although females were significantly larger than males only for ages 3, 4, 7 and 9 (Harris et al. In press). Maximum reported age is 17 years (Manooch and Potts 1997a). The natural mortality rate is estimated to be 0.25 (Legault and Turner 1999).

Greater amberjack are gonochorists (separate sexes). The smallest mature female was 514 mm FL and the youngest was age 1, whereas the largest immature female was 826 mm FL and the oldest was age 5; the size at 50% maturity was 733 mm FL (95% CI = 719-745). Age at 50% maturity for females was 1.3 yr (95% CI = 0.7-1.7). All females were mature by 851-900 mm FL and age 6 (Harris et al. In press). The smallest mature male was 464 mm FL and the youngest was age 1, whereas the largest immature male was 755 mm FL and the oldest was age 5; the size at 50% maturity was 644 mm FL (95% CI = 610-666). All males were mature at 751-800 mm FL and age 6.

Based on the occurrence of migratory nucleus oocytes and postovulatory follicles (POFs), spawning occurs from January through June, with peak spawning in April and May. Although fish in spawning condition were captured from North Carolina through the Florida Keys, spawning appears to occur primarily off south Florida and the Florida Keys (Harris et al. In press). Greater amberjack in spawning condition were sampled from a range of depths, although the bulk of samples were from the shelf break. Given that annual fecundity in greater amberjack is indeterminate, estimates of spawning frequency and batch fecundity are necessary to estimate annual fecundity. Multiplying the estimated number of spawning events (n = 14) per year by batch fecundity (BF) estimates (BF = 7.955*FL – 6,093,049) for specimens 930-1296 mm FL produced estimates of potential annual fecundity that ranged from 18,271,400 to 59,032,800 oocytes (Harris et al. In press). Relative to age, estimates of potential annual fecundity ranged from 25,472,100 to 47,194,300 oocytes for ages 3-7.

Tagging data indicated that greater amberjack are capable of extensive movement that might be related to spawning activity. Greater amberjack tagged off South Carolina have been recaptured off Georgia, east Florida, Florida Keys, west Florida, Cancun Mexico, Cuba, and the Bahamas

(MARMAP, unpublished data). Primary food items include fishes, such as bigeye scad, and invertebrates (Paxton et al. 1989 in Froese and Pauly 2003)

Crevalle jack

The crevalle jack, *Caranx hippos*, occurs in the Western Atlantic Ocean, ranging as far north as Nova Scotia, southward to Uruguay, including the northern Gulf of Mexico (Robins and Ray 1986).

This is a pelagic species, which is generally found over the continental shelf, although young are often found in brackish estuaries. The depth range is 1-350 m (3-1,148 ft) (Smith-Vaniz et al. 1990 in Froese and Pauly 2003). The crevalle jack forms schools, although large individuals may be solitary (Smith-Vaniz et al. 1990 in Froese and Pauly 2003). Maximum reported size is 150.0 cm (59.4 in) TL and 9.0 kg (20.0 lbs) (Robins and Ray 1986 in Froese and Pauly 2003).

Maximum reported age from Florida is 19 years (Snelson 1992). Males become sexually mature by age 4 or 5 and females are sexually mature when they are 5-6 years old. Its diet is composed of smaller fish, shrimp and other invertebrates (Saloman and Naughton 1984; Smith-Vaniz et al. 1990 in Froese and Pauly 2003).

Blue runner

The blue runner, *Caranx crysos*, occurs in the Eastern and Western Atlantic. In the Western Atlantic, it is found from Nova Scotia, Canada to Brazil, including the Gulf of Mexico and Caribbean. Blue runner is a pelagic species that occurs in water as deep as 100 m (328 ft), but generally stays close to the coast. Juveniles often occur in association with floating *Sargassum*. Maximum reported size is 70.0 cm (27.7 in) TL (male) and 5.1 kg (11.3 lbs) (Smith-Vaniz et al. 1990). Maximum reported age is 11 years (Smith-Vaniz et al. 1990). This species is believed to form spawning aggregations (Thompson and Munro 1974b). Thomas and Munro (1974b) indicate that blue runner spawn from February to September. Erdman (1976) indicate that off La Parguera, spawning occurs mainly during March through May. Prey items include fishes, shrimps, and other invertebrates (Smith-Vaniz et al. 1990).

Almaco jack

The almaco jack, *Seriola rivoliana*, occurs in the Indo-West Pacific, in the Eastern Pacific, and in the Western Atlantic, where it occurs from Massachusetts to northern Argentina. This species is thought to occur in the Eastern Atlantic as well, but the extent of its distribution there is not well established (Myers 1991). A benthopelagic species, the almaco jack inhabits outer reef slopes and offshore banks, generally at depths from 15-160 m (49-525 ft). It has been observed to occur in small groups. Juveniles are often seen around floating objects (Myers 1991).

Maximum reported size is 160.0 cm (63.4 in) FL (male) and 59.9 kg (132.1 lbs) (Myers 1991 in Froese and Pauly 2003). Size at maturity is estimated as 81.1 cm (32 in) FL (Froese and Pauly 2003). Fishes serve as its primary prey but invertebrates also make up a portion of its diet (Myers 1991).

Banded rudderfish

Banded rudderfish, *Seriola zonanta*, are found in the Western Atlantic from Nova Scotia, Canada to Santos, Brazil, including the Gulf of Mexico and the Caribbean Sea. They are absent from Bahamas and most islands (Froese and Pauly 2003). Adults are pelagic or epibenthic and confined to coastal waters over the continental shelf. Maximum reported size is 75.0 cm (29.7 in) TL (male/unsexed) and 5.2 kg (11.5 lbs). Banded rudderfish feed on shrimp and fishes.

Bar jack

The bar jack, *Caranx ruber*, occurs in the Western Atlantic from New Jersey to southern Brazil, including the Gulf of Mexico and throughout the Caribbean Sea. It is commonly found in clear insular areas or coral reef habitats off mainland coasts, from depths of 3-35 m (10-115 ft). Juveniles frequent areas with *Sargassum* (Berry and Smith-Vaniz 1978) and appear to be common in shallow water (0-15 m; 0-49 ft) reef habitats, but probably move to the outer margins of the shelf at or before maturity (Thompson and Munro 1974b). Bar jacks are sometimes solitary, but usually forms schools, possibly associated with spawning events (Berry and Smith-Vaniz 1978).

Maximum reported size is 69.0 cm (27.3 in) TL and 8.2 kg (18.2 lbs) (Berry and Smith-Vaniz 1978). The minimum size of maturity for both males and females off Jamaica is 22.0-23.9 cm (8.7-9.5 in) FL (Thompson and Munro 1974b). The mean length at maturity is 24.0 cm (9.5 in) TL for both sexes, and most fish are probably mature by 26.0-27.0 cm (10.3-10.7 in) FL. Spawning occurs during all year with peak spawning during April and October (Thompson and Munro 1974b). Peak spawning off Cuba occurs during April and July (García-Cagide et al. 1994). Prey items include fishes, shrimps, and other invertebrates (Berry and Smith-Vaniz 1978).

Lesser amberjack

The lesser amberjack, *Seriola fasciata*, occurs in the Eastern and Western Atlantic Oceans. In the Western Atlantic, it is found from Massachusetts to Brazil (Robins and Ray 1986). This is a benthopelagic species, primarily found in depths of 55-130 m (180-427 ft) (Smith-Vaniz et al. 1990). Maximum reported size is 68 cm (27 in) FL (Claro 1994). It feeds on squids and fishes (Smith-Vaniz et al. 1990).

Yellow jack

The yellow jack, *Caranx bartholomaei*, occurs in both the Western and Eastern Atlantic Oceans. In the Western Atlantic, its range extends from Massachusetts to Brazil, including the Gulf of Mexico and Caribbean Sea. It is usually found in offshore reef and open marine water habitat to depths of 50 m (164 ft). Yellow jack is solitary, but also has been observed to occur in small groups. Juveniles are often found near the shore on seagrass beds (Cervigón 1993), and probably move to the outer margins of the shelf at or before maturity (Thompson and Munro 1974b). They often occur in association with jellyfish or floating *Sargassum* (Cervigón 1993).

Maximum reported size is 100.0 cm (39.6 in) TL (male) and 14 kg (31.1 lbs) (Cervigón 1993). According to Cervigón (1993), yellow jack spawns offshore during February to October. Thompson and Munro (1974b) reported that fish in spawning condition have been collected in November off Jamaica. This species feeds on small fishes (Cervigón 1993).

Tilefishes (Malacanthidae)

Golden tilefish

Tilefish, *Lopholatilus chamaeleonticeps*, is distributed throughout the Western Atlantic, occurring as far north as Nova Scotia, to southern Florida, and in the eastern Gulf of Mexico (Robins and Ray 1986). According to Dooley (1978), the tilefish occurs at depths of 80-540 m (263-1,772 ft). Robins and Ray (1986) report the depth range of this fish as 82-275 m (270-900 ft). It is most commonly found at about 200 m (656 ft), usually over mud or sand bottom but, occasionally, over rough bottom (Dooley 1978).

Maximum reported size is 125 cm (50 in) TL and 30 kg (66 lbs) (Dooley 1978).. Maximum reported age is 40 years (Palmer et al. 2004). Radiocarbon aging indicates that tilefish may live for at least 50 years (Harris South Carolina Department of Natural Resources, personal communication). A recent SEDAR assessment estimated M at 0.07 (SEDAR 4 2004). Palmer et al. (2004) reported that this species spawns off the southeast coast of the United States from March through late July, with a peak in April. Grimes et al. (1988) indicated that peak spawning occurs from May through September in waters north of Cape Canaveral. Tilefish primarily prey upon shrimp and crabs, but also eat fishes, squid, bivalves, and holothurians (Dooley 1978).

Blueline tilefish

Blueline tilefish, *Caulolatilus microps*, occurs in the Western Atlantic Ocean, North Carolina to southern Florida and Mexico, including the northern (and probably eastern) Gulf of Mexico (Dooley 1978). Blueline tilefish are found along the outer continental shelf, shelf break, and upper slope on irregular bottom with ledges or crevices, and around boulders or rubble piles in depths of 30-236 m (98-774 ft) and temperatures ranging from 15 to 23°C (59-73.4° F) (Ross 1978; Ross and Huntsman 1982; Parker and Mays 1998).

Maximum reported size is 90 cm (35.7 in) TL and 7 kg (15 lbs) (Dooley 1978). Maximum reported age is 42 years. The SEDAR group estimated M is between 0.04 and 0.17 (SEDAR 4 2004). Spawning occurs at night, from February to October, with a peak in May at depths of 48-232 m (157-761 ft) (Harris et al. 2004). This species feeds primarily on benthic invertebrates and fishes (Dooley 1978).

Sand tilefish

Sand tilefish, *Malacanthus plumieri*, occur in the Western and Southeast Atlantic. In the Western Atlantic, the species ranges from North Carolina and Bermuda to Venezuela, Brazil, and to Rio de la Plata in Uruguay, including the Gulf of Mexico and Caribbean Sea. The sand tilefish occurs at depths of 10-153 m (33-502 ft), but is described as primarily a shallow-water benthic species. It generally occurs on sand and rubble bottoms, and is known to build mounds of rubble and shell fragments near reefs and grass beds. Maximum reported size is 70.0 cm (27.7 in) SL (male) and 1.1 kg (2.4 lbs) (Dooley 1978). There is little information on the life history of this species. Since blueline tilefish and other tilefish species are not hermaphroditic (Harris et al. 2004; Palmer et al. 2004), it is likely that sand tilefish is also a gonochorist. Prey items include stomatopods, fishes, polychaete worms, chitons, sea urchins, sea stars, amphipods, and shrimps (Dooley 1978).

Triggerfishes (Balistidae)

Gray triggerfish

Gray triggerfish, *Balistes capriscus,* are found in the Eastern Atlantic from the Mediterranean to Moçamedes, Angola and in the Western Atlantic from Nova Scotia to Bermuda, the northern Gulf of Mexico, and to Argentina. The gray triggerfish is associated with live bottom and rocky outcrops from nearshore areas to depths of 100 m (328 ft). It also inhabits bays, harbors, and lagoons, and juveniles drift at the surface with *Sargassum*.

Maximum reported size is 60 cm (23.76 in) TL (male/unsexed) and 6.2 kg (13.8 lbs; Froese and Pauly 2003). Males are significantly larger than females (Moore 2001). The maximum age of gray triggerfish collected from North Carolina to eastern Florida was 10 years (Moore 2001). The maximum age of gray triggerfish collected from the Northeastern Gulf of Mexico was 13 years (Johnson and Saloman 1984). Potts and Brennan (2001) estimated the natural mortality of gray triggerfish to be 0.30.
Gray triggerfish are gonochorists that exhibit nest-building and territorial reproductive behavior. Mature females from fishery-independent samples are found in 0% of age-0, 98 % of age-1 and age-2 fish, and 100% of fish older than age-3. Mature males from fishery-independent samples are present in 63% of age-1, 91% of age-2, 98% of age-3, 99% of age-4 and age-5, and 100% of older age fish. Females reach first maturity at 14.2 cm (5.6 in) FL, with an L50 of 15.8 cm (6.3 in) FL. Males first mature at 17.0 cm (6.7 in) FL, with a L50 of 18.0 cm (7.1 in) FL (Moore 2001).

Along the southeast United States, Moore (2001) determined that gray triggerfish spawn every 37 days, or 3-4 times per season. In contrast, Ingram (2001) estimated that gray triggerfish spawn every 3.7 days in the Gulf of Mexico. Off the southeast United States, female gray triggerfish are in spawning condition from April-August, with a peak of activity during June-July. Male gray triggerfish are found in spawning condition throughout the year; however, there was a peak in activity during May-September (Moore 2001).

Ocean triggerfish

The ocean triggerfish, *Canthidermis sufflamen*, occurs in both the Western and Eastern Atlantic. In the Western Atlantic, it ranges from Massachusetts to South America, including the Gulf of Mexico and Caribbean. The ocean triggerfish is found at depths of 5-60 m (16-197 ft) (Robins and Ray 1986 in Froese and Pauly 2003), in mid-water or at the surface associated with *Sargassum* (Aiken 1983), near drop-offs of seaward reefs, and occasionally in shallow waters (Robins and Ray 1986 in Froese and Pauly 2003). This species is sometimes solitary, but also is known to form small groups in open water (Aiken 1983; Robins and Ray 1986 in Froese and Pauly 2003) of over 50 individuals. It is sometimes seen in association with the black durgon (Aiken 1983).

Maximum reported size is 65.0 cm (25.7 in) TL (male) and 6.1 kg (13.5 lbs) (Robins and Ray 1986). Off Jamaica, spawning occurs during January, May, August, September, and December, with a peak in September (Aiken 1983). In the northeastern Caribbean, individuals in spawning condition have been observed in April (Erdman 1976).

This species feeds primarily on large zooplankton (Robins and Ray 1986), but also has been observed to consume benthic invertebrates (Aiken 1983).

Queen triggerfish

The queen triggerfish, *Balistes vetula*, occurs in both the Eastern and Western Atlantic. In the Western Atlantic, its range extends from Massachusetts to southeastern Brazil, including the Gulf of Mexico and Caribbean (Robins and Ray 1986). It is generally found over rocky or coral areas at depths of 2-275 m (7-902 ft). It also has been observed over sand and grassy areas (Robins and Ray 1986). Juveniles tend to inhabit shallower waters, and then move into deeper water as they mature (Aiken 1983). This fish may school, but also has been observed alone and in small groups (Aiken 1983).

Maximum reported size is 60.0 cm (23.8 in) TL (male) and 5.4 kg (11.9 lbs) (Robins and Ray 1986). Aiken (1983) estimated mean size at maturity as 26.5 cm (10.5 in) fork length (FL) and 23.5 cm (9.3 in) for males and females, respectively, collected in a Jamaican study. Aiken (1983) reported that peak spawning occurs during January to February and from August to October. In the northeastern Caribbean, spawning reportedly occurs during February through June (Erdman 1976). Froese and Pauly (2003) estimate that queen triggerfish live for 12.5 years. The queen triggerfish feeds primarily on benthic invertebrates, such as sea urchins (Robins and Ray 1986).

Wrasses (Labridae)

Hogfish

Hogfish, *Lachnolaimus maximus*, occur in the Western Atlantic from Nova Scotia (Canada) to northern South America, including the Gulf of Mexico and Caribbean Sea (Robins and Ray 1986). Hogfish are primarily found in warm subtropical and tropical waters (SEDAR 6-SAR2 2004). Froese and Pauly (2003) reported that hogfish is found at depths of 3-30 m (10-98 ft) over open bottom or coral reef. However, hogfish have occasionally been captured by the MARMAP program at depths ranging from 23 to 53 m (75 to 174 ft) and have been observed during submersible dives off South Carolina at depths of 52 m (171 ft) (McGovern, Pers. Com.). Hogfish exhibit sexual dimorphism. Large males have an elongate pig-like snout that is lacking in females and small males. Males also exhibit dark markings on top of the head and along the base of the medial fins, as well as a dark spot behind the pectoral fin.

Maximum reported size is 91.0 cm (36.0 in) TL (male) and 10.0 kg (22.2 lbs) (Robins and Ray 1986). M is estimated as 0.13 (SEDAR6 - SAR2 2004). Maximum reported age in the eastern Gulf of Mexico is 23 years (McBride et al. 2001) and 13 years in the Florida Keys (McBride 2001). Ault et al. (2003) and McBride and Murphy (2003) indicated hogfish were experiencing overfishing, and increasing the minimum size could increase yield.

Hogfish are protogynous (McBride et al. 2001). Spawning aggregations have been documented to occur in water deeper than 16 m (52 ft) off La Parguera, Puerto Rico from December through April (Rielinger 1999). García-Cagide et al. (1994) reported that hogfish spawn off Cuba during May through July. Colin (1982) found that peak spawning of hogfish off Puerto Rico is during

December through April. Off the Florida Keys, Davis (1976) reports that spawning occurs from September to April with a February and March peak. Hogfish primarily eat mollusks, but also feed on crabs and sea urchins (Robins and Ray 1986).

Puddingwife

Puddingwife, *Halichoeres radiatus*, occur in the Western and Eastern Central Atlantic. In the Western Atlantic, they are found from North Carolina and Bermuda to Brazil, including the Gulf of Mexico and Caribbean (Carpenter 2002). Adults are found on shallow patch or seaward reefs as deep as 55 m. Juveniles usually occur in shallower coral reefs.

Maximum reported size in the Atlantic is about 45cm (17.7 in) (Carpenter 2002). In the northeastern Caribbean, individuals in spawning condition have been observed in March, April, and December (Erdman 1976). Prey items include polychaetes, mollusks, sea urchins, crustaceans, and brittle stars (Carpenter 2002).

Spadefishes (Eppiphidae)

Atlantic spadefish

The Atlantic spadefish, *Chaetodipterus faber*, occurs in the Western Atlantic, from Massachusetts to southeastern Brazil, including the Gulf of Mexico and Caribbean (Robins and Ray 1986, Carpenter 2002). It has also been introduced to waters surrounding Bermuda (Hayse 1987). Atlantic spadefish is found in depths of 3-35 m (10-115 ft), and is abundant in shallow coastal waters, from mangroves and sandy beaches, to wrecks and harbors. Juveniles are common in estuaries. Adults often occur in large schools of up to 500 individuals (Carpenter 2002). Maximum reported size is 100 cm (39 in) TL (Carpenter 2002). Hayse (1987) reported that Atlantic spadefish live for at least 8 years off South Carolina.

Atlantic spadefish are gonochorists (Hayse 1987). Histological examination of gonads indicates that 64% of age 0 males are sexually mature and all males age 1 and older are mature. All age 0 females are immature, while all females age 1 and older are mature (Hayse 1987). Atlantic spadefish are in spawning condition off South Carolina during May-September with peak spawning occurring during May (Hayse 1987). In the northeastern Caribbean, individuals in spawning condition have been observed in May and September (Erdman 1976).

Atlantic spadefish feed on benthic invertebrates like crustaceans, mollusks, annelids, cnidarians, as well as on plankton (Robins and Ray 1986). Hayse (1987) reported that cannonball jellyfish is the dominant food item in Atlantic spadefish collected off South Carolina. Hydroids, epifaunal amphipods, and sea anemones are observed in considerably lower volumes.

4.1.2.2 Habitat

Inshore/estuarine habitat

Snapper grouper species utilize both pelagic (open ocean) and benthic (bottom) habitats during their life cycle. Free-swimming larval stages live in the water column and feed on zooplankton. Juveniles and adults are typically bottom dwellers and usually associate with hard structures on the continental shelf that have moderate to high relief; i.e., coral reefs, artificial reefs, rocky hard-bottom substrates, ledges and caves, sloping soft-bottom areas, and limestone outcroppings. More detail on these habitat types is found in Section 3.0 of this document. However, juveniles of some species, such as mutton snapper, gray snapper, dog snapper, lane snapper, yellowtail snapper, goliath grouper, red grouper, gag, snowy grouper, yellowfin grouper, black sea bass, Atlantic spadefish, and hogfish may occur in inshore seagrass beds, mangrove estuaries, lagoons, oyster reefs, and bay systems. In many species, various combinations of these habitats may be utilized during daily feeding migrations or seasonal shifts in cross-shelf distributions.

Offshore habitat

The principal snapper grouper fishing areas are located in live bottom and shelf-edge habitats; depths range from 54 to 90 feet or greater for live-bottom habitats, 180 to 360 feet for the shelf-edge habitat, and 360 to 600 feet for the lower-shelf habitat. Temperatures range from 11° to 27°C over the continental shelf and shelf-edge due to the proximity of the Gulf Stream, with lower shelf habitat temperatures varying from 11° to 14°C. The SEAMAP Bottom Mapping Project using a variety of data sources has mapped the extent and distribution of productive snapper grouper habitat on the continental shelf north of Cape Canaveral. Current data suggest that from 3% to 30% of the shelf is suitable bottom. These hard, live-bottom habitats may be low relief areas supporting sparse to moderate growth of immobile invertebrates, moderate relief reefs from 1.6 to 6.6 feet, or high relief ridges at or near the shelf break consisting of outcrops of rock that are heavily encrusted with immobile invertebrates such as sponges and sea fans. Live-bottom habitat is scattered irregularly over most of the shelf north of Cape Canaveral, but is most abundant off northeastern Florida. South of Cape Canaveral, the continental shelf narrows from 35 to 10 miles and less off the southeast coast of Florida and the Florida Keys. The lack of a large shelf area, presence of extensive, rugged living fossil coral reefs, and dominance of a tropical Caribbean fauna are distinctive characteristics.

Rock outcroppings occur throughout the continental shelf from Cape Hatteras, NC to Key West, FL. Generally, the outcroppings are composed of eroded limestone and carbonate sandstone and exhibit vertical relief ranging from less than ½ meter to over 10 meters. Ledge systems formed by rock outcrops and piles of irregularly sized boulders are common. It has been estimated that 24% (9,443 square kilometers) of the area between the 27 and 101 meter depth contours from Cape Hatteras to Cape Canaveral is reef habitat. Although the area of bottom between 100 and 300 meter depths from Cape Hatteras to Key West is small relative to the shelf as a whole, it constitutes prime reef fish habitat according to fishermen and probably contributes significantly to the total amount of reef habitat.

Man-made artificial reefs are also utilized to attract fish and increase fish harvests. Research on manmade reefs is limited and opinions differ as to whether or not artificial structures actually promote an increase of biomass or merely concentrate fishes by attracting them from nearby natural areas.

The distribution of coral and live hardbottom habitat as presented in the SEAMAP Bottom Mapping Project can be used as a proxy for the distribution of the species in the snapper grouper complex. These maps are available over the Council's Internet Mapping System under "Mapping/GIS" on the Habitat/Ecosystem section (www.safmc.net).

Additional information on use of offshore fish habitat by snapper grouper species has been obtained through the Marine Resources Monitoring, Assessment, and Prediction Program (MARMAP). This fishery-independent survey program has been collecting data in the South Atlantic Bight region since 1973. The program began as a larval fish and groundfish survey of shelf and upper slope waters from Cape Fear to Cape Canaveral. However, since 1978, efforts of the South Carolina MARMAP program have concentrated on fishery-independent assessments of reef fish abundance and life history. The spatial distribution of sampling effort has varied considerably by gear type. Maps portraying the distribution of offshore species were created with this temporal and spatial variability in fishing effort in mind (see the Council's Habitat Plan). Maps of the distribution of snapper grouper species by gear type based on MARMAP data can be generated through the Council's Internet Mapping System under "Mapping/GIS" on the Habitat/Ecosystem section (www.safmc.net).

Spawning habitat

Along with habitat settlement patterns, spawning locations are a key demographic attribute of reef fish species. Protection of spawning habitats is an unquestionably logical component of managing essential fish habitat. Specific information on the spawning sites and component habitats for many snapper grouper species has been provided by the MARMAP Program (Sedberry et al. 2006). Several seasonal patterns are present: a) spawning is concentrated over one or two winter months (as in many groupers); b) spawning occurs at low levels year-round with one or two peaks in warmer months; and c) spawning occurs year-round with more than two significant peaks. In addition, spawning can occur in pairs or in various types of aggregations. Many species of groupers and snappers can form sizeable spawning aggregations. However, this may not be the case among all species in the snapper grouper management unit. In fact, some species that spawn in aggregations may also pair-spawn under certain conditions.

Species in the snapper grouper complex may form spawning aggregations in the same spawning locales for decades. One explanation for the choice of spawning sites has to do with the avoidance of egg predation. This assumes that the upward rush culminating the spawning act takes place at structural features positioned in such a manner that eggs will be immediately carried offshore and away from predators on the reef. However, this hypothesis suffers from limited and sometimes contradictory experimental evaluation.
Spawning sites within Council's jurisdiction have been identified for many grouper and snapper species (Sedberry et al. 2006) and available information for other species suggests that shelf edge environments of moderate to high structural relief are sites of spawning for many species, perhaps throughout the entire South Atlantic region. In addition, shallow areas may also be spawning sites for some snapper grouper species such as goliath grouper. As new information becomes available, maps of all documented spawning areas will be created. In addition to pinpointing existing spawning information, this approach will allow the assessment of the spawning value of similar habitat types within Council's jurisdiction

4.1.2.3 Abundance and status of stocks

The Southeast, Data, Assessment, and Review process (SEDAR) process was initiated in 2002. Stocks in the Snapper Grouper Fishery Management Unit (FMU) that have gone through the SEDAR process include red porgy, black sea bass, vermilion snapper, yellowtail snapper, hogfish, goliath grouper, snowy grouper, and tilefish. Brief summaries of these assessments are provided below as well as links to the assessments.

Red porgy

Red porgy was the subject of the first SEDAR assessment that updated previous assessments conducted by Vaughan et al. (1991), Huntsman et al. (1994), Vaughan (1999), and Vaughan and Prager (2002). Data for the assessment were assembled and reviewed at a data workshop during the week of March 11, 2002, in Charleston, SC. The assessment utilized commercial and recreational landings, as well as abundance indices and life history information from fishery-independent and fishery-dependent sources. Four abundance indices were developed: two indices derived from CPUE in the NMFS headboat survey (1976-1991; 1992-1998), and two derived from CPUE observed by the South Carolina MARMAP fishery-independent monitoring program ("Florida" trap index, 1983-1987; and chevron trap index, 1990-2001) (SEDAR 1 2002).

At the assessment workshop (AW), age-structured and production models were applied to available data. Although the AW determined that the age-structured model provided the most definitive view of the population, both models provide a similar picture of the status of red porgy. SEDAR 1 (2002) indicated that, given the different assumptions used by each type of model and the lack of age structure in the production models, this degree of agreement increased confidence in the assessment results. It was concluded that the stock was overfished, but overfishing was not occurring (Table 4.1-4).

Table 4.1-4. Stock assessment parameters for red porgy.
Values are those recommended by SARC and SEFSC staff (SEDAR 1 2002).

Parameter	**Value**	**Notes**	**Status**
M	0.225		
F_{MSY}	0.19		
SSB_{MSY}	3,050	Metric Tons	
MSST	2,364	$(1-M)*B_{MSY}$; Metric Tons	
MSY	375	Metric Tons	
F_{2001}/F_{MSY}	0.45		Not Overfishing
SSB_{2001}/SSB_{MSY}	0.44		

SSB_{2001}/MSST	0.57		Overfished

The South Atlantic Council defined the rebuilding schedule for red porgy in Amendment 12 to the Snapper Grouper FMP. That schedule is 18 years, which is the maximum allowable rebuilding time frame based on the formula: TMIN (10 years) + one generation time (8 years) (SAFMC 2000). The schedule began with the implementation of a no harvest emergency rule in September of 1999 (64 FR 48324), and ends December 31, 2017.

Black Sea Bass

2003 Assessment

At the second SEDAR (SEDAR 2 2003a), assessments were conducted on black sea bass and vermilion snapper, which updated a black sea bass assessment conducted by Vaughan et al. (1996) and a vermilion snapper assessment conducted by Manooch et al. (1998). Data for the SEDAR assessment were assembled and reviewed at a data workshop held during the week of October 7, 2002 in Charleston, SC. The assessment utilized commercial and recreational landings, as well as abundance indices and life history information from fishery-independent and fishery-dependent sources. Six abundance indices were developed by the data workshop. Two CPUE indices were used from the NMFS headboat survey (1978-2001) and the MRFSS recreational survey (1992-1998). Four indices were derived from CPUE observed by the South Carolina MARMAP fishery-independent monitoring program ("Florida" trap index, 1981-1987; blackfish trap index, 1981-1987; hook and line index, 1981-1987; and chevron trap index, 1990-2001) (SEDAR 2 2003a).

Age-structured and age-aggregated production models were applied to available data at the assessment workshop. The age-structured model was considered the primary model, as recommended by participants in the data workshop. The stock assessment indicated that black sea bass was overfished and overfishing was occurring (Table 4.1-5).

Previously, the rebuilding clock for black sea bass was restarted with the effective date of the regulations implementing the Sustainable Fisheries Act (SFA) Comprehensive Amendment on December 2, 1999. Black sea bass rebuilt to Bmsy within 10 years (December 2, 2009). The stock assessment indicated that black sea bass could not be rebuilt to SSBmsy in 10 years in the absence of fishing mortality (SEDAR 2 2003a). The maximum rebuilding time is 18 years based on the formula: TMIN (11 years) + one generation time (7 years).

Table 4.1-5. Stock assessment parameters for black sea bass.
Note: M=0.3 and steep=free (SEDAR 2 2003a).

Parameter (Table 6-2	**Value**	**Notes**	**Status**
F_{2001}	1.04		
SSB_{2002}	1,755	As of January 1, 2002; Metric Tons	

Parameter (Table 6-2	**Value**	**Notes**	**Status**
F_{MSY}	0.2		
$F_{0.1}$	0.29		
F_{MAX}	0.83		
SSB_{MSY}	13,500	Metric Tons	
MSY	1,730	Metric Tons	
MSST	9,460	Metric Tons	
F_{2001}/F_{MSY}	5.22		Overfishing
SSB_{2002}/SSB_{MSY}	0.13		
SSB_{2002}/MSST	0.19		Overfished
Reduction Needed to End Overfishing	50-90%		
Rebuilding in Absence of Fishing	11 years	If F=0	

<u>2005 Update</u>

At the request of the SAFMC, the SEDAR panel convened to update the 2003 black sea bass stock assessment, using data through 2003, and to conduct stock projections based on possible management scenarios (SEDAR Update 1, 2005). The assessment indicated that the stock was overfished and overfishing was occurring (Table 4.1-6). However, the stock could be rebuilt to BMSY in 5 years when F = 0.

Table 4.1-6. Stock assessment parameters from black sea bass update 1 (SEDAR Update 1, 2005).

Parameter	**Value**	**Notes**	**Status**
F_{2003}	2.641		
SSB_{2004}	1,858	Metric Tons	
F_{MSY}	0.429	Fully selected fishing mortality rate	
E_{MSY}	0.100	Ages 1+	

Parameter	Value	Notes	Status
SSB_{MSY}	6,812	Metric Tons	
MSY	1,260	Metric Tons	
MSST	4,768	Metric Tons	
F_{2003}/F_{MSY}	6.151		Overfishing
E_{2003}/E_{MSY}	1.617		
SSB_{2004}/ SSB_{MSY}	0.273		Overfished
$SSB_{2004}/ MSST$	0.390		
Reduction Needed to End Overfishing	62%		
Rebuilding in Absence of Fishing	5 years	F = 0	

Vermilion snapper
The vermilion snapper assessment utilized commercial and recreational landings, as well as abundance indices and life history information from fishery-independent and fishery-dependent sources. Four abundance indices were developed by the data workshop. One CPUE index was developed from the NMFS headboat survey, 1973-2001. Three indices were derived from CPUE observed by the South Carolina MARMAP fishery-independent monitoring program ("Florida" trap index, 1983-1987; hook and line index, 1983-1987; and chevron trap index, 1990-2001) (SEDAR 2 2003b).

A forward-projecting model of catch at length was formulated for this stock. Two other models (forward-projecting catch at age and age-aggregated production model) were applied but neither could provide estimates. The assessment was based on the catch-at-length model, which was applied in a base run and eight sensitivity runs. The assessment indicated that the stock was undergoing overfishing but that there was a high level of uncertainty in the overfished condition as the stock recruitment relationship was poorly defined (Table 4.1-7).

Table 4.1-7. Stock assessment parameters for vermilion snapper (SEDAR 2, 2003b).

Parameter	Value	Notes	Status
$F_{PROJECTED}$	0.60	Averaged over the last 3 years	
F_{2001}	0.64		

F_{MSY}	0.36		
F_{MAX}	0.375		
$F_{40\%}$	0.33		
E_{MSY}	5.06×10^{11}	Eggs; E=Egg Production (Analogous to spawner biomass)	
MSST	3.8×10^{11}		
MFMT	0.36/year	= F_{MSY}	
E_{2002}/E_{MSY}	0.66	Eggs; E=Egg Production (Analogous to spawner biomass)	
F_{2001}/F_{MSY}	1.78		Overfishing

Yellowtail snapper
The stock assessment on yellowtail snapper was conducted by the State of Florida but went through the SEDAR review process (Muller et al. 2003). Abundance indices were developed from MRFSS data and from commercial CPUE data. Two age-structured models (Fleet-Specific and Integrated Catch at Age) were formulated for the stock. The results from both models were very similar and neither model was recommended to represent the status of the stock. It was concluded that yellowtail snapper was not overfished and was not experiencing overfishing (Table 4.1-8).

Table 4.1-8. Stock assessment parameters for yellowtail snapper (Muller et al., 2003).

Parameter	**ICA Model**	**Fleet-Specific Model**	**Notes**	**Status**
F_{2001}	0.19	0.24		
F_{MSY}	0.33	0.33		
F_{OY}	0.21	0.21		
MSY	946	1,388	Metric Tons	
MSST	2,947	4,288	(1-M)*(B_{MSY}); Metric Tons	
MFMT	0.33	0.33	F_{MSY}	
F_{2001}/MFMT	0.6	0.7		Not Overfishing

SSB_{2001}/B_{MSST}	1.5	1.2		Not Overfished

Goliath Grouper
The summary below is from NMFS. 2006. Status report on the continental United States distinct population segment of the goliath grouper (*Epinephelus itajara*). January 12, 2006. 49 pp.

This status report provides a summary of information gathered for the continental United States distinct population segment (DPS) of the goliath grouper (*Epinephelus itajara*), which was formerly on the 1999 Endangered Species Act (ESA) candidate species list and currently is considered a species of concern. The purpose of this status report is to investigate the current status of goliath grouper relative to the criteria for including a species on the species of concern list, in light of updated information about the status of and threats to the continental U.S. DPS of the goliath grouper.

Goliath grouper is a long-lived and late-maturing serranid. The species depends on mangrove habitat during its early development, and recovery of the species may be impacted by habitat loss and degraded water quality along the coast. Because goliath grouper readily strike at a baited hook or a struggling fish and are easily approached by divers (i.e., spearfishermen), large juvenile goliath grouper and adults are susceptible to harvest. Additionally, goliath grouper aggregate to spawn and are particularly vulnerable to fishing during this period.

Historically, the distribution of the species within the continental U.S. stretched from North Carolina through Texas, with the center of abundance extending from the central east coast of Florida through the Gulf of Mexico to the Florida Panhandle. The population showed a decline in abundance and a truncation of range during the late 1970s and 1980s, primarily due to overutilization by the recreational and commercial fisheries.
Because of goliath grouper population declines, fishery regulations and eventual prohibitions were enacted to conserve and manage the population. Both the Gulf of Mexico Fishery Management Council (GMFMC) and the South Atlantic Fishery Management Council (SAFMC) prohibited the harvest and possession of goliath grouper in 1990. Likewise, the state of Florida prohibited the harvest and possession of goliath grouper from state waters in 1990, followed by all other coastal states from North Carolina through Texas.

The declines in abundance and occurrence of goliath grouper also prompted several organizations to recognize the species' uncertain status in an effort to provide additional consideration related to its management. NMFS identified the species as a candidate for possible listing as threatened or endangered under the ESA in 1991 for the entire range of the species within continental U.S. waters (56 FR 26797). In 1996, the World Conservation Union (IUCN) recognized the species as "critically endangered" throughout its range and distribution based on the conclusion that the species has been "observed, estimated, inferred, or suspected" of a reduction in abundance of at least 80 percent over the last 10 years or three generations (IUCN, 2005). The IUCN considers a species "critically endangered" if it appears to be at an “extremely high risk of extinction in the wild in the immediate future.” Furthermore, in reports submitted to Congress under the Magnuson Stevens Fishery Conservation and Management Act (MSFCMA) on the status of fisheries in U.S. waters between 1999 and 2005, NMFS identified goliath grouper as “overfished,” meaning the level of fishing mortality has jeopardized the capacity of the fishery to produce the maximum sustainable yield on a continuing basis (i.e., the population is below a level considered healthy, requiring management action to achieve an appropriate level and rate of rebuilding). However, in 2000, the American Fisheries Society identified goliath grouper as being conservation dependent, which is a category that recognizes the species is reduced but stabilized or recovering under a continuing conservation plan (Musick et al. 2000).

In 2004, a Southeast Data, Assessment, and Review (SEDAR) assessment indicated that the goliath grouper stock in south Florida waters was recovering, but that full recovery to the MSFCMA management target might not occur until 2020 or later (SEDAR 2004). Based on the results of the assessment and due to inquiries from numerous stakeholders, NMFS proceeded to evaluate whether the continental U.S. population of goliath grouper still warranted species of concern status.

After evaluating the most up-to-date data, the NMFS assessment team concludes that the continental U.S. DPS of goliath grouper has undergone significant increases in abundance since its identification in 1991 as a candidate species under the ESA. The species has also become re-established throughout its historical range. Due to management actions implemented via the MSFCMA, extraction of goliath grouper by commercial and recreational fisheries is currently not a threat to the species. While the team is concerned about the rate of habitat loss and modification, in particular the loss of mangrove habitat, we do not feel the current habitat loss is a factor affecting the species’ status at this time. Therefore, the team believes inclusion of goliath grouper on the NMFS’ species of concern list is no longer warranted due to the fact that it no longer meets the definition of a species of concern.

Hogfish

The hogfish assessment was conducted under contract to the State of Florida (SEDAR 6-SAR2 2004). It was reviewed by SEDAR because the Gulf of Mexico Fishery Management Council and the South Atlantic Fishery Management Council manage hogfish. The SEDAR Review Panel did not find a solid basis for accepting the quantitative assessment and had further reservations that, even if the problems with the assessment were corrected, the model was still limited in its geographic application to the Florida Keys.

Snowy Grouper

The data workshop convened in Charleston, SC during the week of November 3, 2003 to examine data from eight deep-water species for assessment purposes. The group determined that data were adequate to conduct assessments on snowy grouper and tilefish. Four indices were available for snowy grouper including a logbook index, headboat index, MARMAP trap index, and MARMAP short longline index. The assessment workshop chose not to use the logbook index for snowy grouper due to reasons listed below. Commercial and recreation landings as well as life history information from fishery-independent and fishery-dependent sources were used in the assessment.

A statistical catch-at-age model and a production model were used to assess the snowy grouper population (SEDAR 4 2004). The population was determined to be overfished and experiencing overfishing (Table 4.1-9). In the absence of fishing it was determined that it would take 13 years to rebuild the stock to SSBmsy. The maximum rebuilding time is 34 years based on the formula: TMIN (13 years) + one generation time (21 years).

Table 4.1-9. Stock assessment parameters for snowy grouper (SEDAR 4, 2004).

Parameter	Value	Notes	Status
E_{MSY}	0.037	Median estimate under current gear pattern $_M$. E=exploitation rate, the fraction of fish by number taking during one year of fishing. E=C/N, where C=catch in a fishing year and N=number of fish at beginning of year.	
$E_{30\%}$	0.046		
$E_{40\%}$	0.035		
B_{MSY}	2,481	Median value in metric tons	
SSB_{MSY}	2,116	Median value in metric tons	
MSST	1,587	$0.75*SSB_{MSY}$ (metric tons)	
SSB_{2002}/ SSB_{virgin}	0.05		Overfished
E_{2002}/E_{MSY}	3.11		Overfishing
SSB_{2002}/ SSB_{MSY}	0.18	Median value	
Reduction Needed	68%	Reduction in fishing pressure needed to end overfishing	Reduction Needed
Rebuilding Projection	13 years	If no fishing, population will recover to SSB_{MSY} in 13 years based on 2002 data.	

Tilefish

There were two indices of abundance available for the tilefish stock assessment (SEDAR 4 2004). A fishery-independent index was developed from MARMAP horizontal longlines. A fishery-dependent index was developed from commercial logbook data during the data workshop. Commercial and recreation landings as well as life history information from fishery-independent and fishery-dependent sources were used in the assessment.

A statistical catch-at-age model and a production model were used to assess the tilefish population (SEDAR 4 2004). It was determined that this population was not overfished but overfishing was occurring (Table 4.1-10).

Table 4.1-10. Stock assessment parameters for tilefish (golden) (SEDAR 4 2004).

Parameter	**Value**	**Notes**	**Status**
E_{MSY}	0.035 per year	Median estimate using average E among three% fisheries for 1999-2002 and their respective selectivity patterns. E=exploitation rate, the fraction of fish by number taking during one year of fishing. E=C/N, where C=catch in a fishing year	
$E_{30\%}$	0.047	Based on ages 1+ Y %	
$E_{40\%}$	0.035	Based on ages 1+ Y %	
B_{MSY}	2,611.4	Median value in metric tons	
SSB_{MSY}	879.4	Median value in metric tons	
$MSST_{MSY}$	659.6	0.75*SSB_{MSY} (metric tons) Based on ages 1+	
E_{2002}/E_{MSY}	1.55	Median value	Overfishing
SSB_{2002}/SSB_{MSY}	0.95	Median value	
SSB_{2002}/ MSST	1.27		Not Overfished
Reduction Needed	35%	Reduction in fishing pressure needed to end overfishing.	Reduction Needed
Rebuilding Projection	1 year	If no fishing, population will recover to SSB_{MSY} in 1 year based on 2002 data.	

Gag

The SEDAR assessment for gag was completed in 2006 (Table 4.1-11) and based a statistical catch-at-age (primary model) and an age-aggregated production model. Data sources were fishery dependent indices.

Table 4.1-11. Stock assessment parameters for gag (SEDAR 10 2006).

Parameter	**Value**	**Notes**	**Status**
E_{MSY}	0.035 per year	Median estimate using average E among three% fisheries for 1999-2002 and their respective selectivity patterns. E=exploitation rate, the fraction of fish by number taking during one year of fishing. E=C/N, where C=catch in a fishing year	
$E_{30\%}$	0.047	Based on ages 1+ Y %	
$E_{40\%}$	0.035	Based on ages 1+ Y %	
B_{MSY}	2,611.4	Median value in metric tons	
SSB_{MSY}	879.4	Median value in metric tons	
$MSST_{MSY}$	659.6	0.75*SSB_{MSY} (metric tons) Based on ages 1+	
E_{2002}/E_{MSY}	1.55	Median value	Overfishing

Parameter	Value	Notes	Status
SSB_{2002}/SSB_{MSY}	0.95	Median value	
SSB_{2002}/ MSST	1.27		Not Overfished
Reduction Needed	35%	Reduction in fishing pressure needed to end overfishing.	Reduction Needed
Rebuilding Projection	1 year	If no fishing, population will recover to SSB_{MSY} in 1 year based on 2002 data.	

4.1.3 Coastal Migratory Pelagics

Description and Distribution

(from CMP Am 15)
The coastal migratory pelagics management unit includes cero (*Scomberomous regalis*), cobia (*Rachycentron canadum*), king mackerel (*Scomberomous cavalla*), Spanish mackerel (*Scomberomorus maculatus*) and little tunny (*Euthynnus alleterattus*). The mackerels and tuna in this management unit are often referred to as "scombrids." The family Scombridae includes tunas, mackerels and bonitos. They are among the most important commercial and sport fishes. The habitat of adults in the coastal pelagic management unit is the coastal waters out to the edge of the continental shelf in the Atlantic Ocean. Within the area, the occurrence of coastal migratory pelagic species is governed by temperature and salinity. All species are seldom found in water temperatures less than 20°C. Salinity preference varies, but these species generally prefer high salinity. The scombrids prefer high salinities, but less than 36 ppt. Salinity preference of little tunny and cobia is not well defined. The larval habitat of all species in the coastal pelagic management unit is the water column. Within the spawning area, eggs and larvae are concentrated in the surface waters.

(from PH draft Mackerel Am. 18)
King Mackerel
King mackerel is a marine pelagic species that is found throughout the Gulf of Mexico and Caribbean Sea and along the western Atlantic from the Gulf of Maine to Brazil and from the shore to 200 meter depths. Adults are known to spawn in areas of low turbidity, with salinity and temperatures of approximately 30 ppt and 27°C, respectively. There are major spawning areas off Louisiana and Texas in the Gulf (McEachran and Finucane 1979); and off the Carolinas, Cape Canaveral, and Miami in the western Atlantic (Wollam 1970; Schekter 1971; Mayo 1973).

(from PH draft Mackerel Am 18)
Spanish Mackerel
Spanish mackerel is also a pelagic species, occurring over depths to 75 meters throughout the coastal zones of the western Atlantic from southern New England to the Florida Keys and throughout the Gulf of Mexico (Collette and Russo 1979). Adults usually are found in neritic waters (area of ocean from the low-tide line to the edge of the continental shelf) and along coastal areas. They inhabit estuarine areas, especially the higher salinity areas, during seasonal migrations, but are considered rare and infrequent in many Gulf estuaries.

Cero Mackerel
(from the Florida Museum of Natural History website – see link below)
The elongate, streamlined body of the cero mackerel is well-adapted for swimming at speeds up to 30 mph (48 kph). The body is covered with small scales, with the lateral line sloping downwards toward the caudal peduncle. Another similar fish, the king mackerel, can be distinguished from the cero mackerel as it has a lateral line that curves downward below the second dorsal fin. The caudal fin is lunate and the pelvic fins are relatively long. Scales extend out onto the pectoral fins. This characteristic distinguishes it from the king mackerel and the Spanish mackerel, two scombrids lacking scales on the pectoral fins.

The range of the cero mackerel is limited to the western Atlantic Ocean, from Massachusetts south to Brazil, including the Bahamas and West Indies. It is common in the Caribbean, Bahamas, and Florida. Usually solitary, the cero mackerel occasionally forms schools over coral reefs, wrecks, and along ledges at depths ranging from 3.3 to 66 feet (1-20 m). It is usually seen in mid-water and near the water's surface.

Little Tunny
(from the Florida Museum of Natural History website – see link below)
The little tunny, *Euthynnus alletteratus,* is a member of the family Scombridae. It is steel blue with 3-5 broken, dark wavy lines, not extending below the lateral line. The belly is white and lacks stripes. There are 3-7 dark spots between the pelvic and pectoral fins. Spots below the pectoral fin are dusky. The little tunny has a robust, torpedo-shaped body built for powerful swimming. The mouth is large, slightly curved, and terminal with rigid jaws with the lower jaw slightly protruding past the upper jaw. Scales are lacking on the body except for the corselet and the lateral line. The corselet is a band of large, thick scales forming a circle around the body behind the head, extending backwards along the lateral line. The lateral line is slightly undulate with a slight arch below the front of the dorsal fin, then straight to the caudal keel. The caudal fin is deeply lunate, with a slender caudal peduncle including one short keel on each side.

The little tunny is found worldwide in tropical to temperate waters, between 56°N-30°S. In the western Atlantic Ocean, it ranges from Massachusetts south to Brazil, including the Gulf of Mexico, Caribbean Sea, and Bermuda. It is the most common scombrid in the western north Atlantic. This fish is typically found in nearshore waters, inshore over the continental shelf in turbid, brackish waters. Adult little tunny school according to size with other scombrid species at depths ranging from 1-150 m (3-490 feet). However, during certain times of the year the schools break apart with individuals scattering throughout the habitat. Juveniles form compact schools offshore.

Cobia
(from the FL Mus. of Natural History)
The cobia, *Rachycentron canadum*, is a member of the family Rachycentridae. It is managed under the Coastal Migratory Pelagics FMU because of its migratory behavior. The cobia is distributed worldwide in tropical, subtropical and warm-temperate waters. In the western Atlantic Ocean this pelagic fish occurs from Nova Scotia (Canada), south to Argentina, including the Caribbean Sea. It is abundant in warm waters off the coast of the U.S. from the Chesapeake

Bay south and throughout the Gulf of Mexico. Cobia prefer water temperatures between 68°-86°F. Seeking shelter in harbors and around wrecks and reefs, the cobia is often found off south Florida and the Florida Keys. As a pelagic fish, cobia are found over the continental shelf as well as around offshore reefs. It prefers to reside near any structure that interrupts the open water such as pilings, buoys, platforms, anchored boats, and flotsam. The cobia is also found inshore inhabiting bays, inlets, and mangroves. Remoras are often seen swimming with cobia.

The body is dark brown to silver, paler on the sides and grayish white to silvery below, with two narrow dark bands extending from the snout to base of caudal fin. These dark bands are bordered above and below by paler bands. Young cobia have pronounced dark lateral bands, which tend to become obscured in the adult fish. Most fins are deep brown, with gray markings on the anal and pelvic fins. The body is elongate and torpedo-shaped with a long, depressed head. The eyes are small and the snout is broad. The lower jaw projects past the upper jaw. The skin looks smooth with very small embedded scales.

Reproduction

(from PH draft Mackerel Amendment 18)

King Mackerel

Spawning occurs generally from May through October with peak spawning in September (McEachran and Finucane 1979). Eggs are believed to be released and fertilized continuously during these months, with a peak between late May and early July with another between late July and early August. Maturity may first occur when the females are 450 to 499 mm (17.7 to 19.6 in) in length and usually occurs by the time they are 800 mm (35.4 in) in length. Stage five ovaries, which are the most mature, are found in females by about age 4 years. Males are usually sexually mature at age 3, at a length of 718 mm (28.3 in). Females in U.S. waters, between the sizes of 446-1,489 mm (17.6 to 58.6 in) released 69,000-12,200,000 eggs. Because both the Atlantic and Gulf populations spawn while in the northernmost parts of their ranges, there is some thought that they are reproductively isolated groups.

Larvae of the king mackerel have been found in waters with temperatures between 26-31°C (79-88°F). This stage of development does not last very long. Larva of the king mackerel can grow up to 0.02 to 0.05 inches (0.54-1.33 mm) per day. This shortened larval stage decreases the vulnerability of the larva, and is related to the increased metabolism of this fast-swimming species.

Spanish Mackerel

Spawning occurs along the inner continental shelf from April to September (Powell 1975). Eggs and larvae occur most frequently offshore over the inner continental shelf at temperatures between 20°C to 32°C and salinities between 28 ppt and 37 ppt. They are also most frequently found in water depths from 9 to about 84 meters, but are most common in < 50 meters.

Cero Mackerel

Spawning occurs offshore during April through October off Jamaica, and year round off the coast of Florida, Puerto Rico, and Venezuela. Females between 15-31 inches (38-80 cm) release from 160,000 to 2.23 million eggs each. This species has oviparous, buoyant eggs and pelagic larva. The eggs are usually 0.046-.048 inches (1.16-1.22 mm) in diameter and hatch at 0.013-0.014 inches (0.34-0.36 mm) (FL Museum of Nat. History website: http://www.flmnh.ufl.edu/fish/Gallery/Descript/CeroMackerel/CeroMackerel.html)

Little Tunny

(from the Fl Mus. of Nat. History)

Spawning occurs in April through November in the eastern and western Atlantic Ocean while in the Mediterranean Sea spawning takes place from late spring through summer. Little tunny spawn outside the continental shelf region in water of at least 25°C (77°F), where females release as many as 1,750,000 eggs in multiple batches. The males release sperm, fertilizing the eggs in the water column. These fertilized eggs are pelagic, spherical, and transparent, with a diameter of 0.8-1.1 mm.

Cobia

(from the FL Mus. of Nat. Hist.)

Cobia form large aggregations, spawning during daylight hours between June and August in the Atlantic Ocean near the Chesapeake Bay, off North Carolina in May and June, and in the Gulf of Mexico during April through September. Spawning frequency is once every 9-12 days, spawning 15-20 times during the season. During spawning, cobia undergo changes in body coloration from brown to a light horizontal-striped pattern, releasing eggs and sperm into offshore open water. Cobia have also been observed to spawn in estuaries and shallow bays with the young heading offshore soon after hatching. Cobia eggs are spherical, averaging 1.24mm in diameter. Larvae are released approximately 24-36 hours after fertilization.

Development, growth and movement patterns

(from PH draft Mackerel Amendment 18)

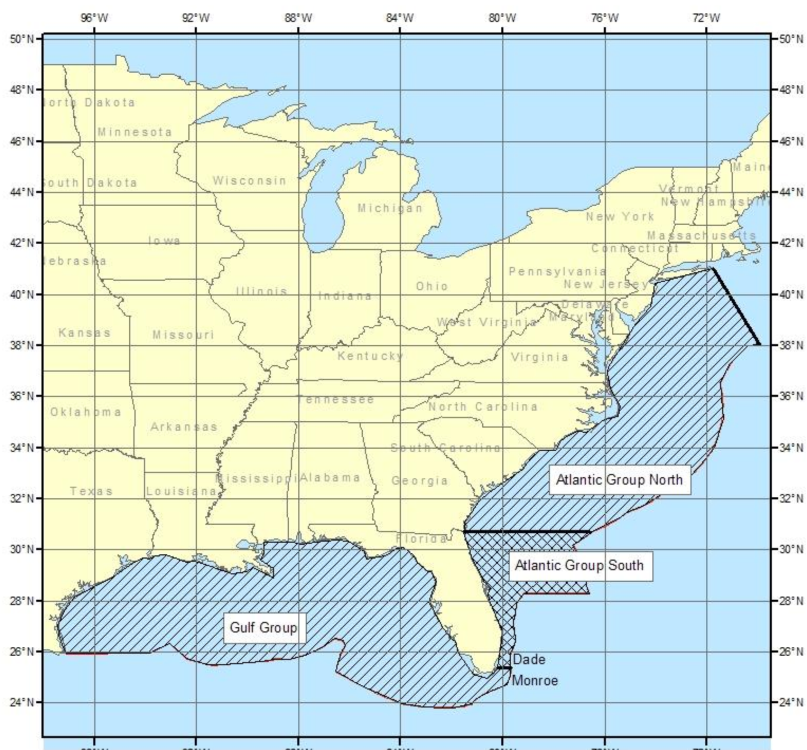
King Mackerel

Juveniles are generally found closer to shore at inshore to mid-shelf depths (to < 9 m) and occasionally in estuaries. Adults are migratory, and the CMP FMP recognizes two migratory groups (Gulf and Atlantic) that are shown in Figure 4.1-7. Typically, adult king mackerel are found in the southern climates (south Florida and extreme south Texas/Mexico) in the winter and in the northern Gulf in the summer. Food availability and water temperature are likely causes of these migratory patterns. King mackerel mature at approximately age 2 to 3 and have longevities of 24 to 26 years for females and 23 years for males (GMFMC/SAFMC 1985; MSAP 1996; Brooks and Ortiz 2004).

Spanish Mackerel

Juveniles are most often found in coastal and estuarine habitats and at temperatures >25°C and salinities >10 ppt. Although they occur in waters of varying salinity, juveniles appear to prefer marine salinity levels and generally are not considered estuarine dependent. Like king mackerel, adult Spanish mackerel are migratory, generally moving from wintering areas of south Florida and Mexico to more northern latitudes in spring and summer. Spanish mackerel generally mature at age 1 to 2 and have a maximum age of approximately 11 years (Powell 1975).

Figure 4.1-7. Gulf and Atlantic migratory groups.



Cero Mackerel

(from the FL Mus. of Nat. Hist.)

The cero mackerel grows to a maximum size of 72 inches (183 cm) in length and 17 pounds (7.76 kg) in weight. The record in Florida waters is 15.5 pounds (7 kg), although the fish commonly weighs up to 8 pounds (3.6 kg). Males reach maturity at lengths between 12.8-13.4 inches (32.5-34 cm), and females at lengths of approximately 15 inches (38 cm).

Little Tunny

The average size of the little tunny is up to 81 cm (32 in) in length, weighing up to 9.1 kg (20 lbs). The maximum recorded size is 122 cm (48 in) and 16 kg (35.3 lbs). The little tunny may live to 10 years of age. Females reach maturity at 27-37 cm (10.6-14.6 in) in length while males mature at approximately 40 cm (15.7 in).

Cobia
(from the FL Mus. of Natural History)
Newly hatched larvae are 2.5 mm long and lack pigmentation. Five days after hatching, the mouth and eyes develop, allowing for active feeding. A pale yellow streak is visible, extending the length of the body. By day 30, the juvenile takes on the appearance of the adult cobia with two color bands running from the head to the posterior end of the juvenile.

Weighing up to a record 61 kg (135 lbs), cobia are more common at weights of up to 23 kg (50 lbs). They reach lengths of 50-120 cm (20-47 in), with a maximum of 200 cm (79 in). Cobia grow quickly and have a moderately long life span. Maximum ages observed for cobia in the Gulf of Mexico were 9 and 11 years for males and females respectively while off the North Carolina coast maximum ages were 14 and 13 years. Females reach sexual maturity at 3 years of age and males at 2 years in the Chesapeake Bay region.

During autumn and winter months, cobia migrate south and offshore to warmer waters. In early spring, migration occurs northward along the Atlantic coast.

Ecological relationships

King Mackerel (Source: Florida Museum of Nat. History website).
Like other members of this genus, king mackerel feed primarily on fishes. They prefer to feed on schooling fish, but also eat crustaceans and occasionally mollusks. Some of the fish they eat include jack mackerels, snappers, grunts, and halfbeaks. They also eat penaeid shrimp and squid at all life stages (larvae to adult). Adult king mackerels mainly eat fish between the sizes of 3.9-5.9 inches (100-150 mm). Juveniles eat small fish and invertebrates, especially anchovies. The Atlantic and Gulf of Mexico populations differ significantly in their feeding habits. The Atlantic stock consumed 58% engraulids, 1% clupeids, and 3.1% squid, the Gulf stock consumed 21.4% engraulids, 4.3% clupeids, and 7.1% squid. The Gulf population also showed more diversity in its feeding habits. In south Florida, the king mackerel's food of choice is the ballyhoo. On the east coast of Florida, the king mackerel prefers Spanish sardines, anchovies, mullet, flying fish, drums, and jacks. Larval and juvenile king mackerel fall prey to little tunny and dolphins. Adult king mackerel are consumed by pelagic sharks, little tunny, and dolphins. Bottlenosed dolphins have been known to steal king mackerel from commercial fishing nets.

The king mackerel is a host to 23 parasitic species. The copepods *Caligus bonito*, *Caligus mutabilis*, and *Caligus productus* are found on the body surface and on the wall of the branchial cavities. Other copepods including *Brachiella thynni*, located on the fins, and *Pseudocycnoides buccata*, found on the gill filaments, are also parasites of the king mackerel.

Other parasites include digenea (flukes), monogenea (gillworms), cestoda (tapeworms), nematoda (roundworms), acanthocephala (spiny-headed worms), copepods, and isopods. Sea lampreys (*Petromyzon marinus*) is an ectoparasite associated with the king mackerel

Spanish Mackerel

Like Gulf group king mackerel, Spanish mackerel primarily eat other fish species (herring, sardines, and menhaden) and to a lesser extent crustaceans and squid at all life stages (larvae to adult). They are eaten primarily by larger pelagic predators like sharks, tunas, and bottlenose dolphin.

Cero Mackerel

(from the FL Mus. of Nat. Hist.)

This swift, shallow water predator feeds primarily on clupeioid fish including herrings as well as silversides of the genus *Allanetta*. The diet of the cero mackerel also includes squid and shrimp. Predators of the cero mackerel include wahoo (*Acanthocybium solandri*), sharks, dolphins, and diving sea birds.

The cero mackerel hosts 21 documented parasites. Among these parasites is the copepod *Brachiella thynni*, which is found on the fins of this fish. Other parasitic copepods are *Caligus bonito* and *Caligus productus* which occur on the body surface and on the wall of the branchial cavities, as well as *Pseudocycnoides buccata* which occurs as a parasite on the gill filaments. Other parasites include protozoans, digenea (flukes), didymozoidea (tissue flukes), monogenea (gillworms), cestoda (tapeworms), nematoda (roundworms), and isopods.

Little Tunny

(from the FL Mus. of Nat. History)

Little tunny is an opportunistic predator, feeding on crustaceans, clupeid fishes, squids, and tunicates. It often feeds on herring and sardines at the surface of the water. Predators of little tunny inlcude other tunas, including conspecifics and yellowfin tuna (*Thynnus albacares*). Fishes such as dolphin fish (*Coryphaena hippurus*), wahoo (*Acanthocybium solandri*), Atlantic sailfish (*Istiophorus albicans*), swordfish (*Xiphias gladius*), and various sharks as well as other large carnivorous fish all prey on the little tunny. Seabirds also prey on small little tunny.

Parasites of the little tunny include the copepods *Caligus bonito*, *Caligus coryphaenae*, and *Caligus productus*, all found on the body surface as well as on the wall of the branchial cavities. Another copepod, *Pseudocycnoides appendiculatus*, has been documented as parasitic on the gill filaments. Other parasites include digenea (flukes), monogenea (gillworms), cestoda (tapeworms), and isopods.

Cobia

(from the FL Mus. of Nat. History)

Cobia are voracious feeders often engulfing their prey whole. Their diet includes crustaceans, cephalopods, and small fishes such as mullet, eels, jacks, snappers, pinfish, croakers, grunts, and herring. A favorite food is crabs, hence the common name of "crabeater." Cobia often cruise in packs of 3-100 fish, hunting for food during migrations in shallow water along the shoreline.

They are also known to feed in a manner similar to remoras. Cobia will follow rays, turtles, and sharks; sneaking in to scavenge whatever is left behind. Little is known about the feeding habits of larvae and juvenile cobia.

Not much is known regarding the predators of cobia, however they are presumably eaten by larger pelagic fishes. Dolphin (*Coryphaena hippurus*) have been reported to feed on small cobia.

The majority of parasites found on cobia are host-specific, suggesting this fish is not closely related to any other fishes. Parasites include a variety of trematodes, cestodes, nematodes, acanthocephalans, and copepods as well as barnacles. Thirty individuals of a single trematode species, *Stephanostomum pseudoditrematis*, were found in the intestine of a single cobia taken from the Indian Ocean. Infestations of the nematode *Iheringascaris inquies* are quite common in the stomachs of cobia.

Abundance and status of stocks

(from Habitat Plan)
NOAA's Estuarine Living Marine Resource Program (ELMR), through a joint effort of National Ocean Service and NMFS, conducts regional compilations of information on the use of estuarine habitat by select marine fish and invertebrates. A report prepared through the ELMR program (NOAA 1991b) and revised information (NOAA 1998), provided the Council during the Habitat Plan development process, present known spatial and temporal distribution and relative abundance of fish and invertebrates using southeast estuarine habitats. Twenty southeast estuaries selected from the National Estuarine Inventory (NOAA 1985) are included in the analysis which resulted from a review of published and unpublished literature and personal consultations. The resulting information emphasizes the importance and essential nature of estuarine habitat to all life stages of Spanish mackerel.

Regional salinity and relative abundance maps for use in determining EFH for two estuarine dependent coastal migratory pelagic species included in the data, Spanish mackerel and cobia. Maps are included in Appendix F of the Council's Habitat Plan (SAFMC 1998a). Figures 43-46 in the Habitat Plan present a representative sample of the distribution maps for juvenile Spanish mackerel.

King Mackerel
In 2003, the first SEDAR assessment of Atlantic and Gulf of Mexico king mackerel was conducted using data from 1981 to 2002. The SEDAR 5 Advisory Report (April 2004) concluded that the Atlantic king mackerel stock was not overfished and overfishing was not occurring in 2002/2003. Current estimates indicate the fishing mortality rate of Atlantic king mackerel in fishing year 2002/2003 was well below MFMT and spawning biomass was well above MSST at the beginning of fishing year 2003/2004. The Base model resulted in only a 2% probability that B2003 was less than MSST, and there was only a 1% probability that F2002/2003 was greater than MFMT (FMSY). Combined mean landings of king mackerel were 7.37 million pounds between 1981/1982 and 2001/2002, with a range of 5.66 million pounds (1999/2000) to 9.62 million pounds (1985/1986) (Table 4.1-12). Estimated Atlantic king

mackerel stock size has increased since the mid-1990s but not to the higher levels seen in the early 1980s. Recently, recruitment has been highly variable with a low and highly uncertain value in the most recent data year (2001/2002).

Table 4.1-12. Atlantic migratory group king mackerel management regulations and harvest. Pounds are in millions.

Fishing Year	ABC Range (M lbs)	TAC (M lbs)	Rec. Allocation (lbs. / numbers)	Rec. Bag Limit	Commercial Quota	Annual Com.	Harvest Rec.	Levels Total
1986/87	6.9 -15.4	9.68		3	3.59 (PS=0.40)	2.837	5.980	8.817
1987/88	6.9 -15.4	9.68	6.09	3	3.59 (PS=0.40)	3.448	3.905	7.353
1988/89	5.5 -10.7	7.00	4.40	2 in FL, 3 GA-NC	2.60 (PS=0.40)	3.091	4.881	7.972
1989/90	6.9 -15.4	9.00	5.66 / 666,000	2 in FL, 3 GA-NC	3.34	2.619	3.400	6.019
1990/91	6.5 -15.7	8.30	5.22 / 601,000	2 in FL, 3 GA-NY	3.08	2.675	3.718	6.393
1991/92	9.6 -15.5	10.50	6.60 / 735,000	5 in FL-NY	3.90	2.515	5.822	8.337
1992/93	8.6 -12.0	10.50	6.60 / 834,000	2 in FL, 5 GA-NY	3.90	2.254	6.251	8.505
1993/94	9.9 -14.6	10.50	6.60 / 854,000	2 in FL, 5 GA-NY	3.90	2.018	4.438	6.456
1994/95	7.6 -10.3	10.00	6.29 / 709,000	2 in FL, 5 GA-NY	3.71	2.182	3.728	5.910
1995/96	7.3 -15.5	7.30	4.60 / 454,000	2 in FL, 3 GA-NY	2.70	1.866	4.153	6.019
1996/97	4.1 - 6.8	6.80	4.28 / 438,525	2 in FL, 3 GA-NY	2.52	2.703	3.990	6.693
1997/98	4.1 - 6.8	6.80	4.28 / 438,525	2 in FL, 3 GA-NY	2.52	2.683	5.158	7.841
1998/99	8.4 - 11.9	8.40	5.28 / 504,780	2 in FL, 3 GA-NY	3.12	2.549	4.268	6.817
1999/00	8.9 - 13.3	10.0	6.29 / 601,338	2 in FL, 3 GA-NY	3.71	2.236	3.424	5.660
2000/01	8.9 - 13.3	10.0	6.29 / 601,338	2 in FL, 3 GA-NY	3.71	2.107	5.338	7.445
2001/02	8.9 - 13.3	10.0	6.29 / 601,338	2 in FL, 3 GA-NY	3.71	2.022	3.240	5.263
2002/03	8.9 - 13.3	10.0	6.29 / 601,338	2 in FL, 3 GA-NY	3.71	1.745	2.672	4.417
2003/04	8.9 - 13.3	10.0	6.29 / 601,338	2 in FL, 3 GA-NY	3.71	1.730	4.100	5.831
2004/05	8.9 - 13.3	10.0	6.29 / 601,338	2 in FL, 3 GA-NY	3.71	2.820	3.287	6.107
2005/06	8.9 - 13.3	10.0	6.29 / 601,338	2 in FL, 3 GA-NY	3.71	2.424	3.954	6.378

Notes: 1) The range has been defined in terms of acceptable risk of achieving the FMP's fishing mortality rate target; the Panel's best estimate of ABC has been intermediate to the end-points of this range; 2) Recreational allocation in numbers is the allocation divided by an estimate of annual average weight; 3) Sums within rows may not appear to equal the total value shown due to rounding of numbers before printing; 4) Bag limit not reduced to zero when allocation reached, beginning fishing year 1992; 5) Bag limit reduced from 5 to 3 effective 1/1/96; and 6) Season is April through March for 2001/02 through 2004/05 and March through the end of February for 2005/06.
Source: ALS data, August 9, 2006; Data provided by the Southeast Fisheries Science Center, October 2006.

The SAMFC's stated objective is to select a TAC for Atlantic king mackerel that has a median probability of achieving its management target, Optimum Yield (OY), defined as the yield associated with a fishing mortality rate of F40%SPR. The SEDAR 5 Advisory Report (April 2004) only provided a point estimate of ABC for Atlantic king mackerel and not a range as was done for Gulf king mackerel. The point estimate provided in the Advisory Report was 5.6 million pounds. The Advisory Report did provide information on a range of yields at F40%SPR. The median estimate of yield at F40%SPR is 5.8 million pounds (20th - 80th percentile range = 4.5 – 7.9 million pounds). Catches above 5.8 million pounds would exceed 50% probability of future F> F40%SPR, conditional on projection assumptions. F40%SPR is the SAFMC's target mortality rate while the actual fishing mortality threshold (MFMT) is F30%SPR (FMSY). [Note: These recommendations are based on assuming 100% of the fish in the mixing zone are Gulf king mackerel. The alternatives included here are based on a 50/50 mixing rate.]

Spanish Mackerel

The Mackerel Stock Assessment Panel (MSAP 1996) conducted a full stock assessment for Atlantic Group Spanish mackerel in 2003, which included data through the 2001/2002 fishing year; projected landings through 2002/2003 also were included. Estimated fishing mortality for Atlantic Group Spanish mackerel has been below FMSY and FOY since 1995. Estimated stock abundance has increased steadily since 1995 and is now at a high for the analysis period. Stock biomass has increased from about 19 million to 24 million fish (Figure 4.1-8). Probabilities that Spanish mackerel is overfished are less than 1% and that overfishing has occurred in the most recent fishing year of the assessment are 3%; therefore the MSAP concluded that Atlantic Group Spanish mackerel were not overfished and overfishing did not occur in 2002/2003. Although all measures of stock status are well within desirable ranges, the median estimate of MSY dropped from 6.4 million pounds in the last full assessment in 1998 to 5.2 million pounds in the 2003 assessment. Much of the decline is believed to be due to the lower estimates of recruitment between the 2003 and the 1998 assessments. The MSAP recommended ABC as the median estimate of catch at F 40% SPR, which is 6.7 million pounds (20th –80th percentile range = 5.2 - 8.4 million pounds).

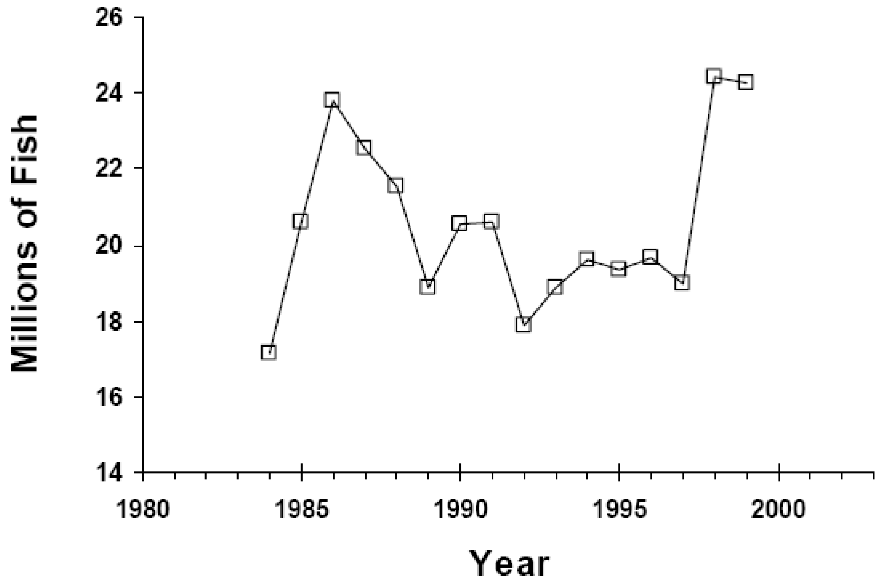


Figure 4.1-8. Estimated Atlantic Spanish mackerel stock abundance from the 2003 base model (MSAP 2003).

The Council staff presented the 2003 MSAP stock assessment and a variety of management options to the South Atlantic Council. The Council voted to defer framework action on Spanish mackerel until after the SEDAR stock assessment. Therefore the existing regulation of a TAC of 7.04 million pounds remained in effect for the 2005/2006 and 2006/07 fishing years. The estimate of landings for the 2000/2001 fishing year was 5.08 million pounds (Table 4.1-13), well below the TAC of 7.04 million pounds. If the fishery developed greater capacity and TAC was realized at a level of 7.04 million pounds for several years, fishing mortality rates would increase and eventually may exceed F 30% SPR. Consequently, fishing at this level over time would eventually reduce spawning stock biomass to a level below that which is capable of producing MSY on a continuing basis.

Table 4.1-13. Spanish mackerel estimated landings by fishing year (1987-2006).

Fishing Year	ABC Range (M lbs)	TAC (M lbs)	Rec. Allocation (lbs. / numbers)	Rec. Bag Limit	Commercial Quota	Annual Com.	Harvest Rec.	Levels Total
1987/88	1.7 - 3.1	3.1	0.74	4 in FL, 10 GA-NC	2.36	3.475	1.474	4.949
1988/89	1.3 - 5.5	4.0	0.96	4 in FL, 10 GA-NC	3.04	3.521	2.740	6.261
1989/90	4.1 - 7.4	6.0	2.76 / 1,725,000	4 in FL, 10 GA-NC	3.24	3.941	1.569	5.51
1990/91	4.2 - 6.6	5.0	1.86 / 1,216,000	4 in FL, 10 GA-NC	3.14	3.535	2.075	5.61

1991/92	5.5 - 13.5	7.0	3.50 / 2,778,000	5 in FL, 10 GA-NC	3.50	4.707	2.287	6.994
1992/93	4.9 - 7.9	7.0	3.50 / 2,536,000	10 FL - NY	3.50	3.727	1.995	5.722
1993/94	7.3 - 13.0	9.0	4.50 / 3,214,000	10 FL - NY	4.50	4.811	1.493	6.304
1994/95	4.1 - 9.2	9.2	4.60 / 3,262,000	10 FL - NY	4.60	5.254	1.378	6.632
1995/96	4.9 - 14.7	9.4	4.70 / 3,113,000	10 FL - NY	4.70	1.834	1.089	2.923
1996/97	5.0 - 7.0	7.0	3.50 / 2,713,000	10 FL - NY	3.50	3.098	0.849	3.947
1997/98	5.8 - 9.4	8.0	4.00 / 2,564,000	10 FL - NY	4.00	3.057	1.660	4.717
1998/99	5.4 - 8.2	8.0	4.00 / 2,564,000	10 FL - NY	4.00	3.272	0.817	4.089
1999/00	5.7 - 9.0	7.04	3.17 /	10 FL - NY	3.52	2.370	1.505	3.875
2000/01	5.7 - 9.0	7.04	3.17 / 2,032,000	15 FL - NY	3.87	2.794	2.699	5.493
2001/02	5.7 - 9.0	7.04	3.17 / 2,032,000	15 FL - NY	3.87	3.036	2.008	5.044
2002/03	5.7 - 9.0	7.04	3.17 / 2,032,000	15 FL - NY	3.87	3.207	2.072	5.279
2003/04	5.7 - 9.0	7.04	3.17 / 2,032,000	15 FL - NY	3.87	3.741	1.994	5.735
2004/05	5.7 - 9.0	7.04	3.17 / 2,032,000	15 FL - NY	3.87	3.678	1.371	5.049
2005/06	5.7 - 9.0	7.04	3.17 / 2,032,000	15 FL - NY	3.87	3.579	1.985	5.564

Notes: 1) The range has been defined in terms of acceptable risk of achieving the FMP's fishing mortality rate target; the Panel's best estimate of ABC has been intermediate to the end-points of this range; 2) Recreational allocation in numbers is the allocation divided by an estimate of annual average weight (not used prior to fishing year 1989); 3) Sums within rows may not appear to equal the total value shown due to rounding of numbers before printing; 4) Allocations and rec. quota are as revised October 14, 1989; 5) Bag limit not be reduced to zero when allocation reached, beginning fishing year 1992; and 6) Season is April through March for 2001/02 through 2004/05 and March through the end of February for 2005/06.
Source: ALS data, August 9, 2006; Data provided by the Southeast Fisheries Science Center, October 2006.

The Atlantic States Marine Fisheries Commission Plan Review Team (PRT) believes harvest reductions are due to management measures in state and federal waters as well as the recreational fishery targeting other species. The low level of harvest in relation to the stock size is encouraging for stock rebuilding, which is reflected in the increase in transitional SPR. Cooperative State/Federal management has achieved a successful stock recovery.

TAC is currently 7.04 million pounds, and based on the most recent assessment, the Stock Assessment Panel recommended an ABC range of 5.2 to 8.4 million pounds, with a median value of 6.7 million pounds. This yield would be in excess of the best point estimate of maximum sustainable yield (5.2 million pounds); however, the Atlantic migratory group Spanish mackerel fishery is not overfishing the available stock, and the stock is not overfished. This is because the current biomass is estimated to be above the biomass at MSY. Therefore, the difference in the current stock size and the MSY stock size could be harvested, reducing the stock size to the MSY level.

4.1.4 Golden Crab

Description and Distribution

The golden crab, *Chaceon fenneri,* is a large gold or buff colored species whose diagnostic characters include an hexagonal carapace; five anterolateral teeth on each side of carapace; well-developed, large frontal teeth; shallow, rounded orbits; chelipeds unequal; and the dactyli of the walking legs laterally compressed (Manning and Holthuis 1984, 1989). Golden crab inhabit the continental slope of Bermuda (Luckhurst 1986; Manning and Holthuis 1986) and the southeastern United States from off Chesapeake Bay (Schroeder 1959), south through the Straits of Florida and into the eastern Gulf of Mexico (Manning and Holthuis 1984, 1986; Otwell et al. 1984; Wenner et al. 1987, Erdman 1990).

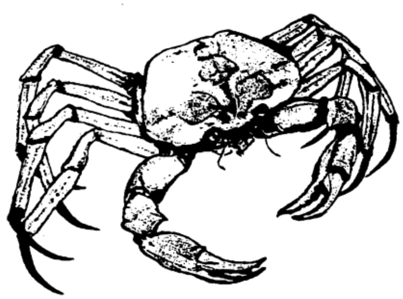


Figure 4.1-9. Golden Crab, *Chaceon fenneri*.

Reported depth distributions of *C. fenneri* range from 205 m off the Dry Tortugas (Manning and Holthuis 1984) to 1007 m off Bermuda (Manning and Holthuis 1986). Size of males examined range from 34 to 139 mm carapace length (CL) and females range from 39 to 118 mm CL. Ovigerous females have been reported during September, October and November, and range in size from 91 to 118 mm CL (Manning and Holthuis 1984, 1986).

The following text is from Lockhart et al. (1990):
"The distribution patterns of *Chaceon fenneri* and possibly *C. quinquedens* in the eastern Gulf of Mexico suggest a causal role for the Loop Current System (Maul 1977) in basic life history adaptations. Female distribution within these species' geographic ranges and the timing of larval release supports this hypothesis. Ours was the first study to discover female golden crabs in any significant numbers and was also the first to find a major population of female red crabs in the Gulf of Mexico. Both of these concentrations of females were seemingly shifted counter-current to the Loop Current circulation. We hypothesize that this counter-current shift is linked to larval release and transport, and serves to maximize recruitment into the parent population by minimizing risk of larval flushing.

Similar counter-current shifts of other female decapods have been reported or hypothesized. In the Gulf of Mexico, spawning female blue crabs (*Callinectes sapidus*) have been hypothesized to undergo a late summer spawning migration in the northeastern Gulf of Mexico that is counter to the Loop Current system (Oesterling and Adams 1979). Female western rock lobsters (*Panulirus cygnus*) are hypothesized to undergo migration to favor recruitment back into the parent population (Phillips et al. 1979). Kelly et al. (1982) proposed that only those red crab larvae (*Chaceon quinquedens*) released up-current in the species' range will recruit back into the parent population. Melville-Smith (1987a, 1987b, 1987c) in a tagging study of red crabs (*C. maritae*) off the coast of southwest Africa, showed that the only segment of the population exhibiting significant directional movement were adult females: 32% of recaptures had moved greater than 100 km and the greatest distance traveled was 380 km over 5 yr. This directional movement was later shown to be counter to the prevailing surface currents (Melville-Smith 1990).

Thus, within decapods in general, and the genus in particular, adult females are capable of, and appear to undergo, long-distance directional movement in their lifetimes.
A similar migration of adult female golden crabs, counter-current to Loop Current circulation in the Gulf of Mexico, would produce the geographic population structure observed off the southeastern United States. Females would be most common farthest up-current whereas males would be most common intermediate in the species geographic range. Wenner et al. (1987) reported a 15:1 (M:F) sex ratio in the South Atlantic Bight and in this study, we had an overall sex ratio of 1:4 — both consistent with hypothesized net female movements to accommodate larval retention and offset the risk of larval flushing.

In fact, given this, two female strategies could maximize recruitment in a prevailing current. The first is for females to position themselves far enough up current so that entrainment would return larvae to the parent population (Sastry 1983). The second is to avoid larval entrainment altogether and thus avoid flushing of the larvae out of the system. Female *Chaceon fenneri*, and perhaps *C. quinquedens*, appear to use both strategies but rely mainly on the latter.

Female golden crabs release larvae offshore in depths usually shallower than 500 m. If larvae were released directly into the Loop Current-Gulf Stream System, they would be entrained for their entire developmental period. Given a developmental time of 33-40 d at 18°C (K. Stuck, Gulf Coast Research Laboratories, Ocean Springs, Mississippi, pers. comm.) and current speeds of 10-20 cm/sec (Sturges and Evans 1983), transport of the larvae would be 285 km to 690 km downstream. Thus, larvae released on the Atlantic side of Florida are in danger of being flushed out of the species' range before recruiting to the benthic stock. Likewise, larvae released directly into the current in the southeastern Gulf of Mexico would be flushed from the Gulf.

Female golden crabs release larvae from February to March (Erdman and Blake 1988; Erdman et al., 1989) and the greatest concentration of female golden crabs to date found in this study was in the northeastern Gulf of Mexico off central Florida. Only during this period and in this region (Maul, 1977), can female golden crabs avoid complete entrainment and possible flushing of larvae out of the system. Partial entrainment of larvae might still occur, but its duration should be much reduced, and the risk of larval flushing minimal. This hypothesis predicts that most larvae should be found near the concentrations of females we found in the northeastern Gulf of Mexico with decreasing settlement further downstream. The abundance of juveniles should show a similar pattern.

One need not invoke similar counter-current movements for male geryonid crabs. In particular, males moving perpendicular to adult females (i.e. males moving up and down the continental slope) would have a greater encounter rate with females than males moving along the slope with females. Given low female reproductive frequency (Erdman et al. 1989), intense male-female competition (Lindberg and Lockhart 1988), and probability of multiple broods (Hinsch 1988) from a single protracted copulation (H. M. Perry, pers. obs.), the male strategy should be to intercept relatively rare receptive females all along the species' range, not to aggregate with presumably inseminated females. This hypothesis would predict a relatively uniform abundance of males along their geographic range. In addition, the incidence of inseminated females should be high farthest upstream with an ever decreasing percentage down-stream. Our study supports the former hypothesis but we cannot address the latter.

The distributional patterns of geryonid crabs we observed are consistent with those reported from elsewhere. Furthermore, these patterns lead us to suggest that the Loop Current System has had a causal role in life history adaptations of *Chaceon fenneri* and perhaps *C. quinquedens*. In general, females are expected to release larvae during a time and in a region where risk of larval flushing is minimal (Sinclair 1988), whereas males are expected to compete intensely for rare, receptive mates."

The coastal physical oceanography in the Florida Keys was described by Yeung (1991) in a study of lobster recruitment:
"The strong, northward-flowing Florida Current is the part of the Gulf Stream system confined within the Straits of Florida. It continues from the Loop Current in the Gulf of Mexico, and proceeds beyond Cape Hatteras as the North Atlantic Gulf Stream.

The mean axis of the Florida Current is approximately 80 km offshore of Key West and 25 km off Miami (Lee et al. 1991). Mean annual cross-stream surface current speed in the Straits of Florida is approximately 100 cm/s (U.S. Naval Oceanographic Office 1965).

Brooks and Niller (1975) observed a persistent countercurrent near Key West extending from surface to the bottom, and from nearshore to approximately 20 km seaward. They believed that it was part of the cyclonic recalculation of the Florida Current between the Lower and Middle Keys.

The presence of a cold, cyclonic gyre was confirmed by physical oceanographic data collected in the SEFCAR cruises. It was named the Pourtales Gyre since it occurs over the Pourtales Terrace -- that area of the continental shelf off the Lower and Middle Keys (Lee et al. 1991). When the Florida Current moves offshore, the Pourtales Gyre forms over the Pourtales Terrace, and can last for a period of 1-4 weeks.

The Pourtales Gyre could entrain and retain locally spawned planktonic larvae for a short period. The combination of the cyclonic circulation and enhanced surface Ekman transport could also advect foreign arrivals into, and concentrate them at, the coastal boundary (Lee et al. 1991).

Vertical distribution of the larvae within the 3-dimensional circulation will subject them to complicated hydrographic gradients, which might influence their development time, and hence their dispersal potential (Kelly et al. 1982; Sulkin and McKeen 1989). Thus, variability in the circulation features and water mass properties can lead to variability in larval transport and recruitment."

The Pourtales Gyre may provide a mechanism for entrainment of golden crab larvae spawned on the Florida east coast, and also as a mechanism to entrain and advect larvae from the Gulf and Caribbean (e.g., Cuba). This possibility is supported by the conclusion of Yeung (1991) suggesting that larvae of a foreign origin supply recruits to the Florida spiny lobster population: "The foreign supply of pre-recruits arriving with the Florida Current might easily meet the same fate as the locally spawned larvae, that is, passing on with the Florida Current. The Pourtales Gyre may play a significant role in recruitment by providing a physical mechanism to entrain and advect larvae into the coastal boundary.

The Pourtales Gyre, even if linked with the Dry Tortugas gyre or the Florida Bay circulation, may not be able to provide a pathway much more than 2 months in period. For locally spawned Panulirus larvae to be retained for their entire development would require several circuits -- not impossible, but unlikely."

The timing of the Pourtales Gyre provides a mechanism for local recruitment of *Scyllarus* larvae (Yeung 1991) and may also provide a similar mechanism for golden crab larvae. Golden crab larvae from the Gulf of Mexico, Cuba, and possibly other areas of the Caribbean, probably provide larvae to the South Atlantic population. The proportion of local recruitment is unknown but could be significant.

Wenner et al. (1987) note: "Other studies have described an association of *G. quinquedens* with soft substrates. Wigley et al. (1975) noted that bottom sediments throughout the area surveyed for red crab from offshore Maryland to Corsair Canyon (Georges Bank) consisted of a soft, olive-green, silt-clay mixture. If golden crabs preferentially inhabit soft substrates, then their zone of maximum abundance may be limited within the South Atlantic Bight. Surveys by Bullis and Rathjen (1959) indicated that green mud occurred consistently at 270-450 m between St. Augustine and Cape Canaveral, FL (30°N and 28°N). This same depth range from Savannah, GA to St. Augustine was generally characterized by Bullis and Rathjen (1959) as extremely irregular bottom with some smooth limestone or "slab" rock present. Our study indicates, however, that the bottom due east between Savannah and St. Catherines Island, GA at 270-540 m consists of mud and biogenic ooze. Further north from Cape Fear, NC to Savannah, bottom topography between 270 and 450 m is highly variable with rocky outcrops, sand and mud ooze present (Low and Ulrich 1983)."

In a subsequent study using a submersible, Wenner and Barans (1990) found the greatest abundance in rock outcrops:
"Observations on density and a characterization of essential habitat for golden crab, *Chaceon fenneri*, were made from a submersible along 85 transects in depths of 389-567 m approximately 122 km southeast of Charleston, South Carolina. Additional observations on habitat were made on 16 transects that crossed isobaths between 293-517 m.

Seven essential habitat types can be identified for golden crab from observations:

- A flat foraminiferon ooze habitat (405-567 m) was the most frequently encountered habitat. This habitat type is characterized by pteropod-foraminiferan debris mixed with larger shell fragments, a sediment surface mostly covered with a black phosphorite precipitate;

- Distinct mounds, primarily of dead coral at depths of 503 to 555 meters, constituted 20% of the bottom surveyed on dives to count crabs. Coral mounds rose approximately 15 to 23 meters in height above the surrounding sea floor and included several that were thinly veneered with a fine sediment and dead coral fragments, as well as a number that were thickly encrusted with live branching ahermatypic corals (*Lophelia prolifera* and *Enallopsammia profunda*). Fan-shaped sponges, pennatulids and crinoids were oriented into the northerly 1.4-1.9 km- h-1 current. The decapod crustaceans *Bathynectes longispina*, *Eugonatonotus crassus* and *Eumunida pita*, the black-bellied rosefish, *Helicolenus dactylopterus*, and the wreckfish, *Polyprion americanus*, were frequently sighted along transects in the coral mound habitat.

- Ripple habitat (320-539 m); dunes (389-472 m); black pebble habitat (446-564 m); low outcrop (466-512 m); and soft-bioturbated habitat (293-475 m). A total of 109 *C. fenneri* were sighted within the 583,480 m^2 of bottom surveyed. Density (mean no. per 1,000 m^2) was significantly different among habitats, with highest values (0.7 per 1,000 m^2) noted among low rock outcrops. Lowest densities were observed in the dune habitat (<0.1 per 1,000 m^2), while densities for other habitats were similar (0.15-0.22 per 1,000 m^2)."

A similar submersible study in the eastern Gulf of Mexico (Lindberg and Lockhart, 1993) found similar results with higher abundance on hardbottom: "Within the bathymetric range of golden crabs, crab abundance may be related more to habitat type than to depth. The greatest density (36.5 crabs/ha) occurred on or near hardbottom canyon features."

Golden crabs occupy offshore oceanic waters along the Atlantic and Gulf of Mexico coasts as adults. Offshore areas used by adults are probably the least affected by habitat alterations and water quality degradation. Currently, the primary threat comes from oil and gas development and production, offshore dumping of dredged material, disposal of chemical and other wastes, and the discharge of contaminants by river systems.

Reproduction

Reproduction and anatomy of the reproductive tracts of males and females of the golden crab *Geryon fenneri* were studied by Hinsch (1988) in specimens collected from deep water of the eastern Gulf of Mexico.

"The male crab is larger than female. Their reproductive tracts are typical of brachyurans. Light and electron microscopic studies of the testes and vasa deferentia at various times during the year indicate that *G. fenneri* has a single reproductive season. Spermatogenesis begins in the fall. By January, many acini of the testes are filled with mature sperm and spermatophores and seminal fluids accumulate in the anterior and middle vasa deferentia. In March all portions of the vasa deferentia are swollen with seminal products. Mating occurs during March and April. The reproductive organs of males are reduced in size from May through September.

The fully developed ovary of golden crabs is purple in color. Females oviposit in September and October. Females undergo vitellogenesis at the same time that they carry eggs undergoing embryonic development. Females with broods have ovaries which vary in color and size. They release their larvae during February and March. Females may be reproductive for several seasons and appear to be capable of mating while in the hardened condition"

Also see Erdman, R.B., N.J. Blake, F.D. Lockhart, W.J. Lindberg, H.M. Perry, and R.S. Waller. 1991. Comparative reproduction of the deep-sea crabs *Chaceon fenneri* and *C. quenquedens* (Brachyura: Geryonidae) from the northeastern Gulf of Mexico. Journal of Invertebrate Reproduction and Development 19:175-184.

Development, growth and movement patterns

Wenner et al. (1987) found in the South Atlantic Bight that:
"Size-related distribution of *C. fenneri* with depth, similar to that reported for red crab, may occur in the South Atlantic Bight. We found the largest crabs in the shallowest (274-366 m) and deepest (733-823 m) strata. A clear trend of size-related up-slope migrations such as Wigley et al. (1975) reported for *C. quinquedens* is not apparent, however, because of trap bias for capture of larger crabs of both sexes. Otwell et al. (1984) also noted no pattern in size of golden crab by depth for either sex. Tagging studies of red crab off southern New England provided no evidence for migration patterns and indicated instead that tagged crabs seldom moved more than 20 km from their site of release (Lux et al. 1982)."

Lindberg and Lockhart (1993) found in the Gulf of Mexico:
"The golden crab *Chaceon fenneri* in the eastern Gulf of Mexico exhibits a typical bathymetric pattern of partial sex zonation and an inverse size-depth relationship, as first reported for red crabs (*C. quinquedens*: Wigley et al. 1975; *C. maritae*: Beyers and Wilke 1980). Sex segregation, with females shallower than most males, was more evident in our results than in those of Wenner et al. (1987) from the South Atlantic Bight, primarily because our trap catch had a higher proportion of females (25.9% compared to 5.2%)." Also see above section on distribution for details on movement patterns.

Ecological relationships

Feeding habits are very poorly known. Golden crabs are often categorized as scavengers that feed opportunistically on dead carcasses deposited on the bottom from overlying waters (Hines 1990).

Abundance and status of stocks

Golden crab abundance studies are limited. Data from the South Atlantic Bight (Wenner et al. 1987) estimated abundance from visual assessment was 1.9 crabs per hectare while traps caught between 2 and 10 kg per trap. Wenner and Barans (1990) estimated the golden crab population in small areas of 26-29 square km between 300-500 m off Charleston to be 5,000-6,000 adult crabs. In the eastern Gulf of Mexico adult standing stock was estimated to be 7.8 million golden crabs and the biomass was estimated to be 6.16 million kg (13.6 million pounds) (Lindberg et al. 1989). Experimental trapping off Georgia yielded an average catch of 7 kg per trap (Kendall 1990).

Based on exploratory trapping, golden crab maximum abundance occurs between 367 and 549 meters in the South Atlantic Bight. Information on sediment composition suggests that golden crab abundance is influenced by sediment type with highest catches on substrates containing a mixture of silt-clay and foraminiferan shell (Wenner et al. 1987).

Participation in the Fishery (Source: Golden Crab SAFE 2004)
Thirty-four permits were issued in permit year 1996, but during that year only three vessels landed golden crab (Table 4.1-14). More vessels landed golden crab in permit years 1997 and 1998 (13 and 11, respectively) (Table 4.1-14). There was then a decline to five or less vessels reporting landings during each of permit years 2001-2003. Although at least 10 permits have been issued annually since 1996, at most 50% of permit holders actually fished for golden crab in a given year from 2001 to 2003 (Table 4.1-14). By 2003 there were three permits issued for the Northern Zone (after the addition of two permits in Amendment 3), but no fishermen have reported landing golden crab there since the beginning of the permit process in 1996 (Table 4.1-14). Of the five companies processing golden crab in 1995, only one was still processing in 2002 (Antozzi 2002; NMFS 2004, Appendix 4). Antozzi (2002, Appendix 4) thought that implementation of Amendment 3 may encourage permit holders to re-enter the fishery, but the number of fishermen participating in the fishery has been fairly stable from 2001 through 2003.

Table 4.1-14. Number of permitted golden crab vessels and the number that reported landings, 1996-2003. Permit year begins November 1 of the previous year. Source: Sadler 2004 and NMFS Logbook Database.

Permit Year	Number Issued Northern Zone	Number Fished Northern Zone	Number Issued Middle Zone	Number Fished Middle Zone	Number Issued Southern Zone	Number Fished Southern Zone	Total Number Issued	Total Number Fished
1996	2	0	6	3	26	0	34	3
1997	1	0	5	4	20	9	26	13
1998	0	0	3	4	8	7	11	11
1999	0	0	3	4	7	2	10	6
2000	0	0	3	3	7	5	10	8
2001	0	0	3	3	7	1	10	4
2002	1	0	3	4	7	1	10	5
2003	3	0	3	4	0	0	13	4

Landings and Effort

Middle Zone

Eighty-seven months of landings and effort data were added (from May 1996 to August 2003), reflecting 426 additional trips (NMFS 2004, Appendix 1). Overall, catches continued to occur primarily in the Middle Zone (Figure 4.1-10). Landings fell by 40% from 2000 to 2003, from 587,330 lbs to 351,987 lbs (Figure 4.1-10). Monthly catches generally decreased from January to July, then increased beginning in August (Figure 4.1-11a). This trend did not hold in 2001, when landings started out very high but decreased consistently over most of the year.

Annual CPUE has been fairly consistent from 1995 to 2003, ranging from 39 to 59 lbs per trap (Figure 4.1-12). CPUE in 2003 was the highest since records began in 1995 (Figure 4.1-12). Monthly CPUE has been relatively consistent during the last five years (Figure 4.1-13). Record high CPUE in 2001 was primarily due to unusually high CPUE from January through May. CPUE in 2003 was higher than in most other years measured, during the months for which data were available (Figure 4.1-13).

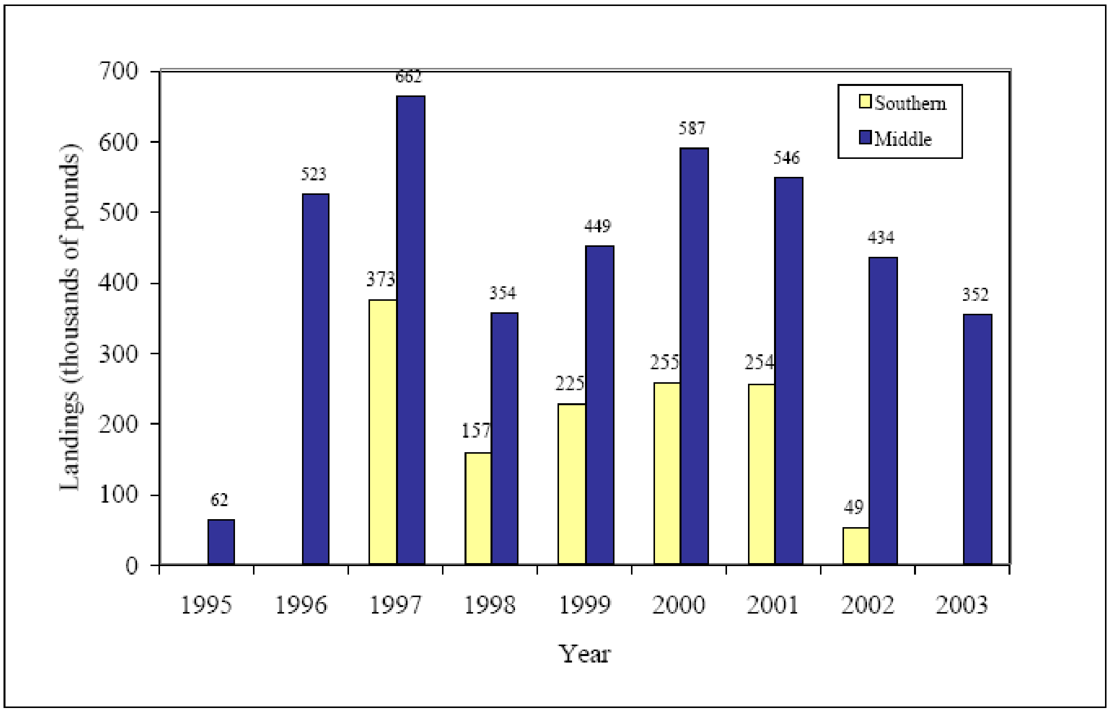


Figure 4.1-10. Total golden crab landings by year, Middle and Southern Zones.

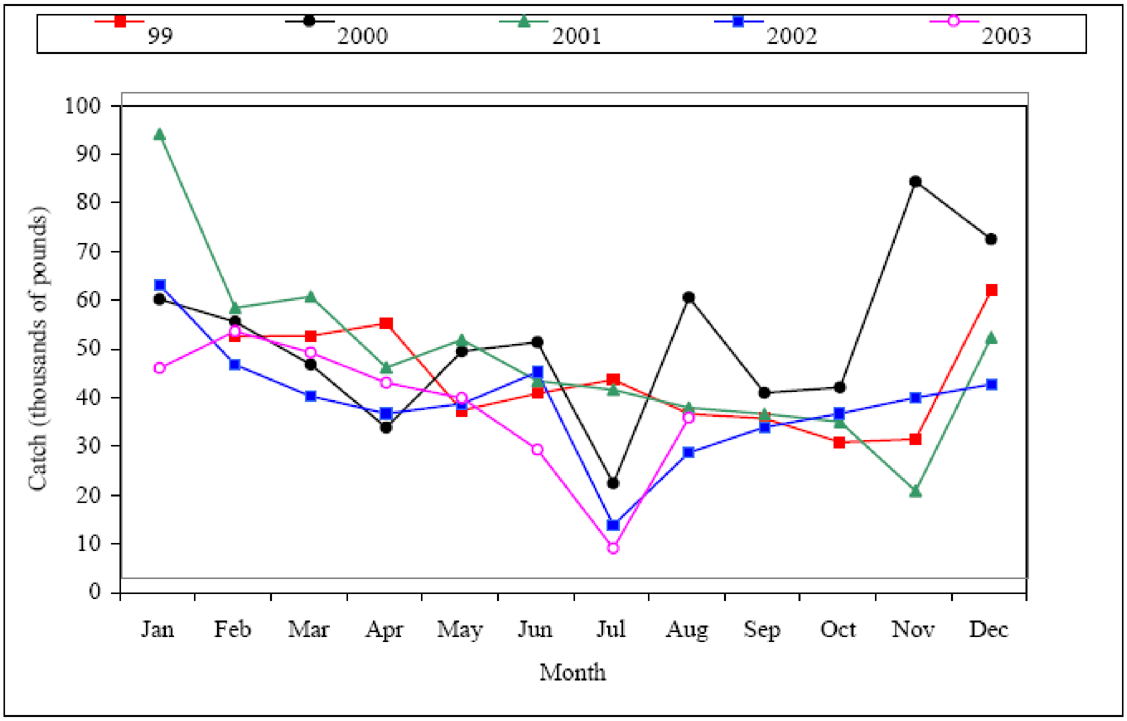


Figure 4.1-11a. Monthly catch of golden crab by year, Middle Zone.

Southern Zone

Forty-eight months of data were added (from June 1998 to May 2002), reflecting 120 additional trips (NMFS 2004 Appendix 1). No data were available from 2003. Southern Zone landings made up approximately 30% of the total across zones for the first five years (1997-2001), but only 10% of the total in 2002 (data available for January through May) (Figure 4.1-10). Southern Zone landings were relatively stable over each year at about 20,000-30,000 lbs/month, except in 1999 when no golden crab were landed until May, followed by unusually high landings greater than 40,000 lbs/month in July and August (Figure 4.1-11b).

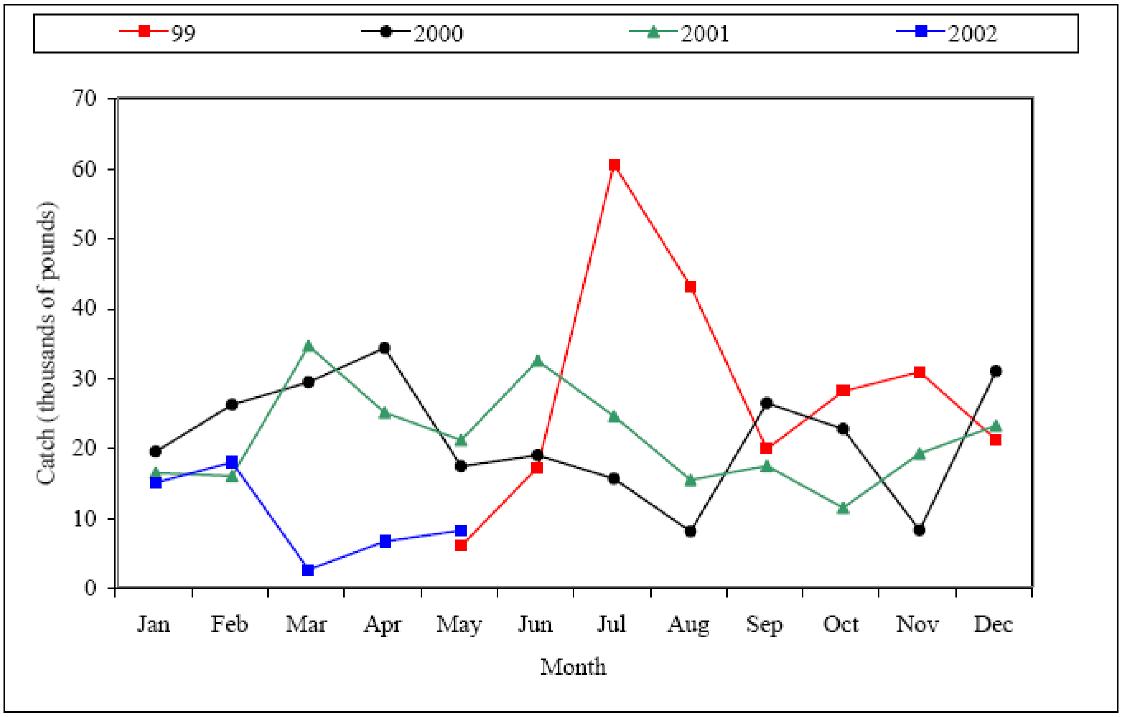


Figure 4.1-11b. Monthly catch of golden crab by year, Southern Zone.

In contrast to the Middle Zone, CPUE in the Southern Zone decreased from 1999 to 2002, stabilizing at about 22-25 lbs per trap from 2000 to 2002 (Figure 4.1-12). CPUE has been lower in the Southern compared to the Middle Zone in every year but 1999 (Figure 4.1-12). CPUE in the Southern Zone was approximately 50%-60% of CPUE in the Middle Zone from 2000 to 2002 (Figure 4.1-12).

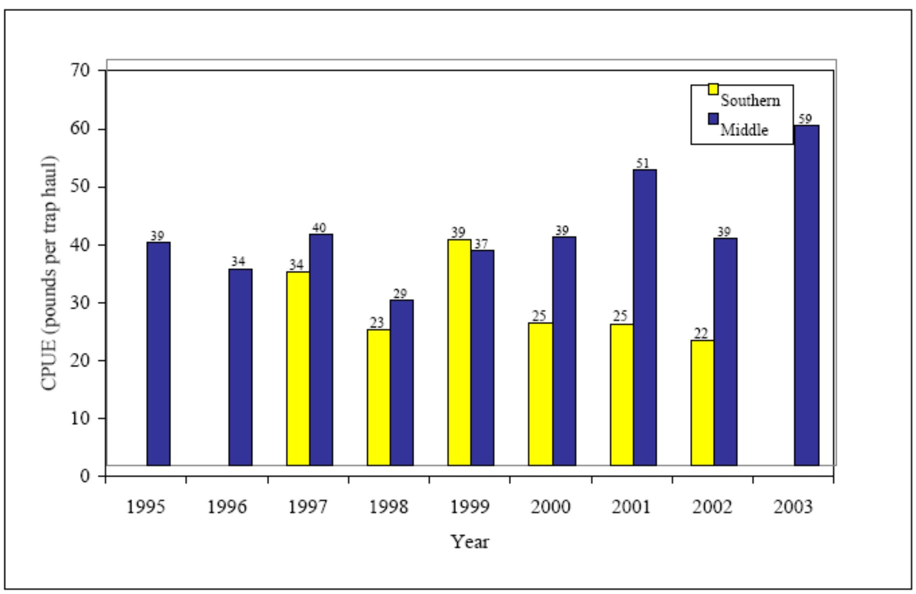


Figure 4.1-12. Golden crab CPUE by year and zone.

Southern Zone CPUE for the first five months of 2002 was at or below average for the period 1999-2002 (Figure 4.1-13b. Monthly CPUE has been more variable in this zone compared to the Middle Zone (Figure 4.1-13b).

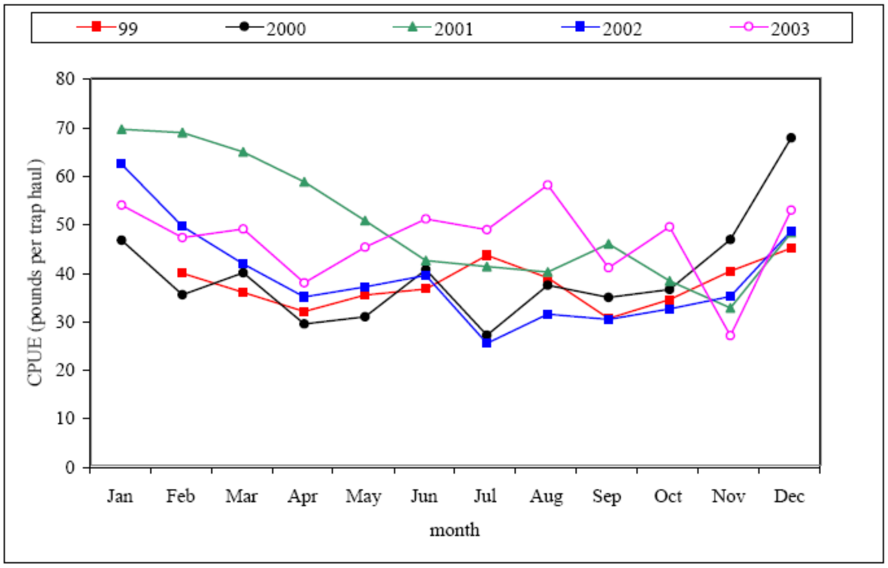


Figure 4.1-13a. Monthly CPUE of golden crab by year, Middle Zone.

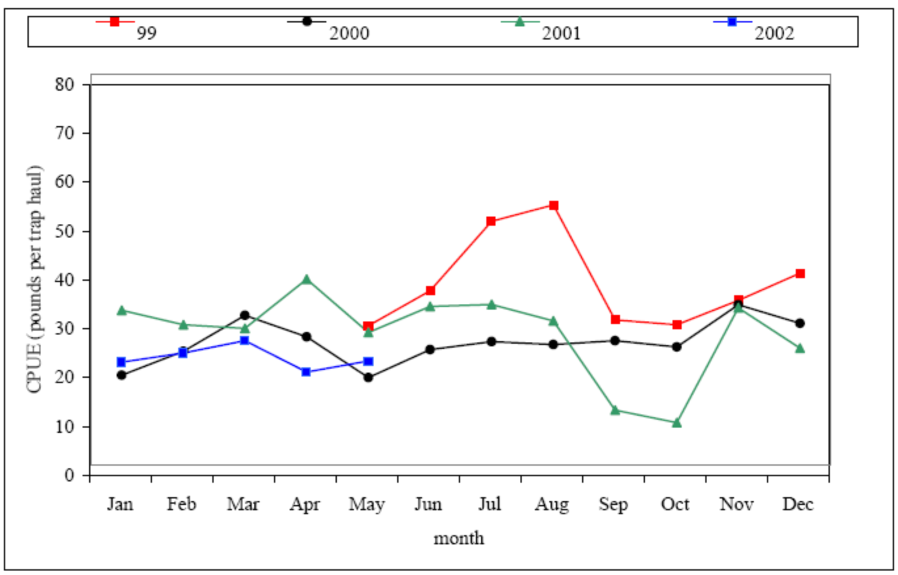


Figure 4.1-13b. Monthly CPUE of golden crab by year, Southern Zone.

TIP Sampling

The 1999 SAFE report presented size data through December 1997. This report includes samples collected through December 2003 (NMFS 2004, Appendix 2). In the interim, 12,269 crabs were measured, bringing the total measured from May 1995 to December 2003 to 17,187. Mean monthly size has been variable, and there have been no obvious trends in size by month across years (Figure 4.1-14). In addition, there has been little evidence of annual trends in mean size, although crabs were smaller in the first five months of 1999 than in other years (Figure 4.1-14, e), and in 1997, crabs were larger in most months than they were in other years (Figure 4.1-14, c).

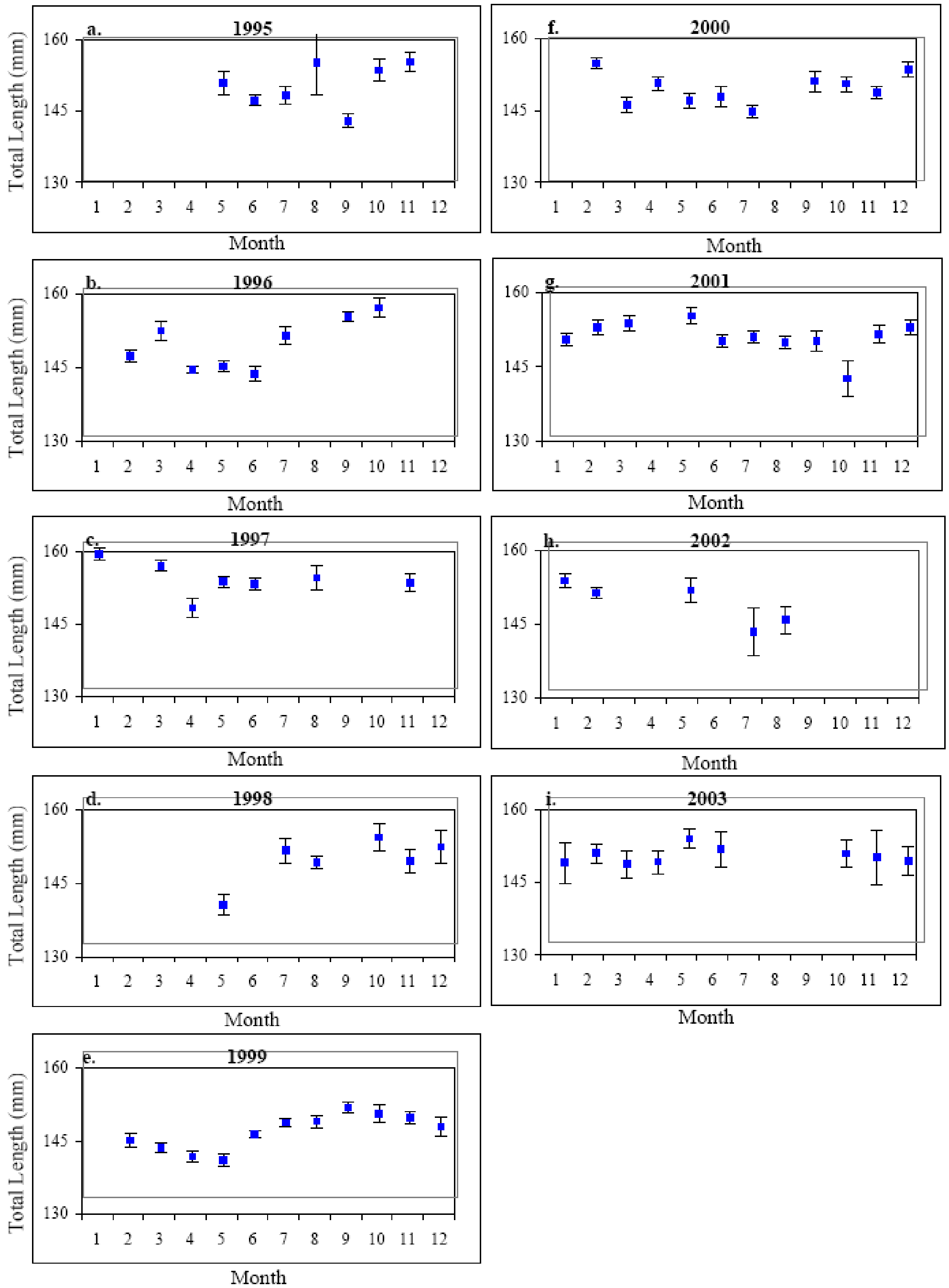


Figure 4.1-14. Mean monthly size of golden crab by year, with 95% C.I.

In contrast to mean monthly size, the length distribution of golden crabs sampled in the TIP survey has been remarkably consistent from 1995 to 2003 (Figure 4.1-15). Except for 1999

(Figure 4.1-16, e), the modal length appears to be very close to 150 mm in all years, and the breadth of sizes observed has also been similar (Figure 4.1-15, d, f-i). The modal length was notably smaller in 1999 than in other years (Figure 4.1-15, e).

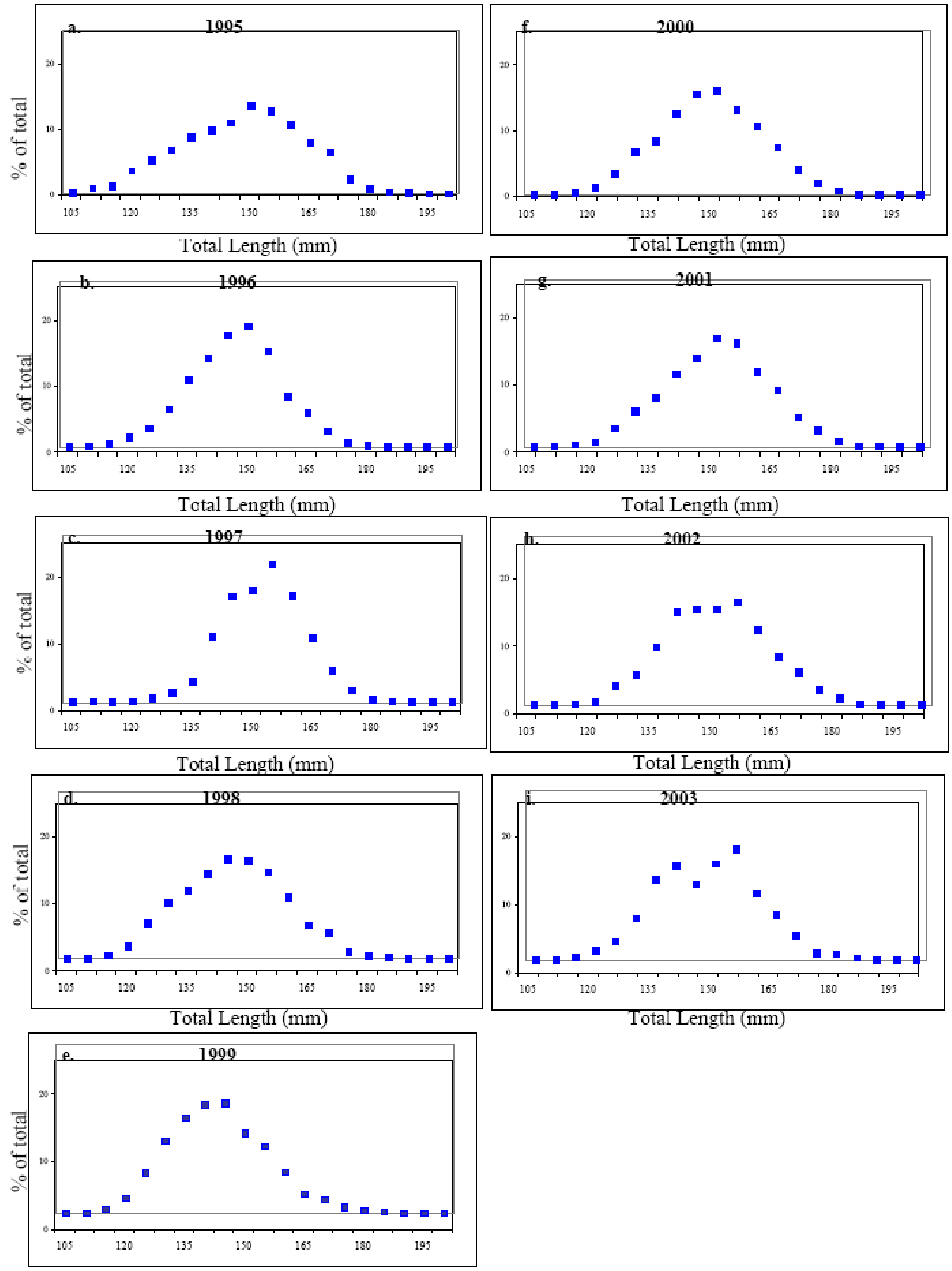


Figure 4.1-15. Length frequency of golden crabs measured in the TIP survey, 1995-2003

Production Model Analysis

Catch and estimated effort data were fit with a non-equilibrium production model to estimate stock status relative to MSY levels. The model was fit to both quarterly and annual estimates of catch and effort. Two paired annual observations of catch and effort were added to the new analysis (1999 and 2000), increasing the number of paired observations to 5 and increasing confidence in the model to some extent (Harper et al. 2000, Appendix 3). Seven quarterly estimates of catch and effort were added to the analysis (May 1998 through January 2000).

Harper et al. (2000) concluded that fitting the model with the five annual catch and effort observations resulted in less certain, although similar, estimates of stock status than did use of quarterly observations. The Harper et al. (2000) assessment concluded that, as of 2000, golden crab were neither overfished nor undergoing overfishing. Current biomass was slightly less than BMSY, but above MSST (Table 4.1-15). Current F was nearly equal to FMSY and MFMT (Table 2). The 2003 Status of Stocks report (NMFS 2004) also indicated the stock was not overfished or undergoing overfishing in 2003.

Table 4.1-15. Stock assessment parameters from the non-equilibrium production model (Harper et al. 2000 and NMFS 2004 Appendix 3).

Parameter	Value - 2000 quarterly analysis
B_{CURR}	818,140 lbs
B_{MSY}	837,400 lbs
MSST ($0.9B_{MSY}$, where M=0.1)	753,660 lbs
MSY (lbs)	684,000 lbs
F_{CURR}	0.20
F_{MSY}	0.21
MFMT (Annual Median F_{MSY})	0.21

4.1.5 Spiny Lobster

Description and Distribution

The Caribbean spiny lobster, *Panulirus argus*, is a crustacean closely related to crabs, shrimp, and crayfish. Common names for this lobster include crayfish, crawfish, langosta, and Florida lobster. There are about 12 species of lobster in Florida; Caribbean spiny lobsters are by far the most abundant. They vary from whitish to a dark red-orange. The two large, cream-colored spots on top of the second segment of the tail section are the diagnostic features for identifying this species. There are also two smaller cream-colored spots adjacent to the tail fan. Spiny lobsters lack the large, distinctive, crushing claws of their northern cousins, the American lobster.

The name "spiny" comes from the strong, forward-curving spines projecting from the hard shell that covers the body of the lobster. The spines are protection from predators and can present a definite hazard to anyone handling the animal without wearing gloves. There are two large prominent spines, sometimes called horns, above the eyes.

A spiny lobster's body has two main parts: the cephalothorax (head section) and the abdomen (tail section). The cephalothorax comprises the head, a cape-like carapace or shell, the mouthparts, antennae, antennules (smaller antennae-like structures), and ten walking legs. Spiny lobsters wave their long, spiny antennae like whips for fighting and defense. They use the shorter antennules to sense movement and detect chemicals in the water. The lobster's mouth, located on the underside of and toward the front of the cephalothorax, is surrounded by large, heavy structures called mandibles, or jaws, and by maxillipeds, or accessory jaws. Both sets of jaws are used for biting and grinding food and directing it into the mouth.

The abdomen, or tail section, is narrower than the cephalothorax. The shell covering the tail section is divided into six ring-like segments, and each segment ends in a spine on each side. Under the tail are four pairs of small leaf-like structures called pleopods (or swimmerets). The tail ends in a flat, flexible fan with a broad center section (the telson) and has two lobes on each side of the telson called uropods. This fan generates the thrust needed for the animal to "tail flip"-- a rapid backward escape mechanism that presents an armored, thorny front to any potential enemy.

To determine the sex of a spiny lobster, examine the underside of the cephalothorax and tail section. The fifth pair of the male's walking legs has sperm-duct openings at the base; these openings become greatly enlarged during the breeding season and the second walking legs of mature males are much longer relative to the other walking legs. The fifth pair of a female's walking legs has hook-like structures at the tips but her second leg does not elongate. On a male, the pleopods beneath the tail section are single and paddle-like. Each pleopod on a female has two lobes; one lobe is paddle-like, and the other lobe resembles small pincers.

The Caribbean spiny lobster occurs throughout the Caribbean Sea, along the shelf waters of the southeastern United States north to North Carolina, in Bermuda, and south to Brazil and the Gulf of Mexico. The origins of the Florida stock remain unknown as information on larval recruitment remains scarce. However, Lyons (1981) concluded that, given the constant recruitment to the fishery despite the reduction in spawning potential of the Florida stock, recruitment is probably in large part exogenous. That conclusion is supported by examination of the genome of *P. argus* populations from Venezuela to Bermuda (Silberman 1994). Restriction fragment length polymorphism analysis of mtDNA identified no differentiation between populations, suggesting a single pan-Caribbean *P. argus* stock, though populations in Brazil are genetically distinct from Caribbean populations and may represent a subspecies, *P. argus westonii* (Sarver et al. 1998).

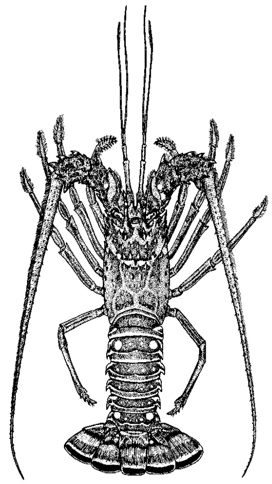


Figure 4.1-16. Spiny lobster, *Panulirus argus*

Reproduction

Mating and spawning of eggs in *P. argus* can occur throughout the range of mature adults which in the Florida Keys includes Hawk Channel, the fore reef, and deeper hardbottom regions. The release of eggs of *P. argus* in the Florida Keys occurs on the offshore reef tract and deeper hardbottom regions, principally from April through September (Bertelsen and Cox 2001; Lyons et al. 1981; Davis 1974). The onset of population-wide reproductive maturation of female lobsters, estimated as the size at which 50% of the population is ovigerous during the peak of the reproductive season, occurs at about 70-75 mm CL, though females as small as 57 mm CL have been observed bearing eggs (Bertelsen and Matthews, 2001). The onset of population-wide functional maturity in males, estimated by the onset of allometric growth of the second pair of walking legs, has been estimated to occur at 98 mm CL (FWC unpublished data). Mating and spawning behavior appear, in part, controlled by environmental factors. Increased day length and water temperatures have been shown to enhance courtship and the frequency of spawning (Lipcius and Herrnkind 1987). There are generally size-specific patterns in mating and spawning. Larger females generally mate, spawn eggs, and release larvae, earlier in the reproductive season than smaller mature females (Lipcius 1985; Bertelsen and Matthews 2001). Smaller adult males molt early in the reproductive season, while larger males mate (Lipcius 1985).

Size-specific differences in the onset of reproductive maturity of female *P. argus* have been noted between the lobster populations in the Florida Keys and the Dry Tortugas. The lobster population in the latter region has historically endured much lower fishing pressure and consequently, the size-structure of the lobsters there is larger than that in the Florida Keys. Females in the Dry Tortugas begin producing eggs at a much larger size than do those in the Florida Keys. It has been speculated that lobsters in both regions begin to produce eggs at the same chronological age, but fishery practices has resulted in comparatively slower growth rates in Florida Keys lobsters (Bertelsen and Matthews 2001).

Development, growth and movement patterns

Growth rates of early-benthic-stage juveniles (i.e., 6 – 35 mm CL) in Florida Bay have been estimated to be 0.82 mm CL per week (Sharp et al. 2000). Growth rates of subadults (i.e., 50-75 mm CL) have been reported as 0.46 mm CL per week, but are lower among injured lobsters (Hunt and Lyons, 1986). Growth rates decrease dramatically between 74 mm CL (0.46 mm per week) and 76 mm CL (0.23 mm per week) as lobsters attain sexual maturity.

Panulirus argus is a highly migratory palinurid lobster species with a complex life cycle in which distinctly different habitat types are occupied during ontogeny. After spawning, the oceanic phyllosome larvae spend an estimated 9 months (Butler and Herrnkind 1992) in the plankton, potentially dispersing thousands of kilometers. Because of the potential for *P. argus* larvae to be transported such enormous distances, understanding the factors that affect their distribution during this stage is complex and remains poorly understood. Extensive effort has been directed at understanding the recruitment dynamics of *P. argus* in south Florida, especially in Florida Bay and along the Florida Keys archipelago, which is the largest and most important expanse of nursery habitat for the species in the region (Davis and Dodrill 1989). These studies have documented that late-stage larvae concentrate at the edge of the Florida Current, and it is there that puerulus post-larvae are first observed (Yeung and McGowan 1991). *Panulirus argus* pueruli are nocturnally active and efficient swimmers capable of speeds of 10 cm/s (Calinski and Lyons 1983).

Recruitment to inshore environments occurs all year round into Florida Bay and nearby regions in monthly pulses coincident with the new moon (Heatwole et al. 1991; Forcucci et al. 1994). Upon arrival nearshore, post-larvae preferentially settle into dense vegetation, especially the architecturally complex macroalgae, *Laurencia* spp. Seagrass meadows also function as settlement habitat (Acosta 1999; Sharp et al. 2000), but the subsequent survival of lobsters settling there appears to be lower compared to those that settle within macroalgae (Herrnkind and Butler 1986). Temperature and salinity regimes restrict *P. argus* settlement to the southernmost reaches of the Bay (Field and Butler 1994). In other areas in the Caribbean, *P. argus* may also settle on mangrove prop roots (Acosta and Butler 1997).

Once settled, *P. argus* pueruli metamorphose into the first benthic instar [~ 6mm carapace length (CL)] (Marx and Herrnkind 1985; Butler and Herrnkind 1991; Forcucci et al. 1994). These "algal-stage" juveniles reside solitarily within vegetation until reaching 15-20mm CL, then emerge and take up refuge in crevice shelters provided by large sponges, octocorals, and solution holes. These "post-algal" juveniles occupy a relatively small home range within the nursery until they reach about 35mm CL, and then become increasingly nomadic (Herrnkind and Butler, 1986). At about 50-80 mm CL lobsters begin to move from the inshore nursery habitat to coral reefs and other offshore habitats (Hunt and Lyons 1986).

Large juvenile and adult lobsters are very mobile and capable of moving several miles during nocturnal foraging. Lobsters have a highly developed capacity to navigate and are capable of returning to specific foraging locations or diurnal shelters like solution holes or reefs, where they often occupy communal dens or holes during daylight hours. They are nocturnal feeders and predominantly prey upon live molluscs and crustacea, including hermit crabs and conch.

Although they will scavenge, they are predominately active predators and will consume up to 20% of their weight in food each night. Individual lobsters also are capable of relatively long distance migrations during spawning and groups of lobsters may also have long distance directional movement. These mass movements are well known to fishermen and have been observed to precede winter storms and hurricanes. Lobsters have been observed moving in long lines or queues during these events. Little is known about the dispersion of lobsters during these mass movements or how much of the lobster population participates in these forays.

There is no definitive research on the advection or retention of phyllosoma larvae in the Florida Keys. The hydrography of this region is dominated by the strong Florida Current, which links the Loop Current in the Gulf of Mexico with the Gulf Stream in the North Atlantic. Although the Loop Current in likely responsible for the aperiodic transport of larvae to Florida West coast on the Northern Gulf of Mexico there are insufficient surveys to resolve if the Loop current and its southern counterpart, the Tortugas Gyre, are sufficient to retain lobster in Florida. Current genetic studies have not identified region differences in lobster populations although more detailed mitochondrial DNA analysis methods that may be suitable for the identification of source populations have not been fully explored. Clarification of this biological-physical coupling will advance our understanding of spiny lobster population dynamics and promote effective management of the fishery stocks.

Ecological relationships

Caribbean spiny lobsters are primarily hard substrate dwellers. During the day, they find refuge in dens in solution holes or under sponges, corals, seagrass roots, or other structures that provide cover. At night, they leave their dens to forage in surrounding areas where prey is abundant. It has been suggested that lobsters help to maintain shelters that provide cover for other species in certain habitat. For example, lobsters may keep solution holes free of sediment, thus making them available for occupation by groupers. However, there is little known on this subject. The role of spiny lobsters in ecosystem function is unclear. Although spiny lobsters are numerically dominant predators in Florida Bay, they are likely not keystone predators there, nor are they likely to be in other systems (Nizinski 1998).

Spiny lobsters are predatory feeders. As planktonic larvae (phyllosomes), they use their legs to spear fish larvae, which they transport and consume over long periods (Moe 1991). All benthic stages of *P. argus* feed preferentially on molluscs, especially gastropods, and crustaceans, but will consume a wide variety of invertebrates as well as dead fish (Herrnkind et al. 1975; Cox et al. 1997; Briones 2003). Molluscs comprise up to 75% of the prey items found in lobster guts (Espinosa et al. 1991; Cox et al. 1997). Larger lobsters consume larger individuals of similar prey items than do smaller lobsters. Differences in diet of juvenile and adult lobsters reflect the difference in prey assemblages between juvenile and adult habitats. Diet is apparently a reflection of the local abundance of available potential prey (Briones 2003) which lobsters locate by probing the sediment with the sensory tips of the tips of the first pair of walking legs (Herrnkind et al. 1975; Cox et al. 1997).

Spiny lobsters are food for a wide variety of predators including snappers, groupers, sharks, rays, turtles, and octopus. Algal phase juveniles are targeted by small grunts, snappers and groupers.

Gray snapper have been shown to prey on small early benthic juvenile lobsters tethered in Florida Bay (Herrnkind and Butler, 1986). Smith and Herrnkind (1992) found a high proportion of early benthic juvenile lobsters in the gut contents of stingrays (*Dasyatis* spp.) and bonnethead sharks (*Sphyrna tiburo*). Nurse sharks (*Ginglyostomata ciratum*) are also known predators of *P. argus* (Cruz and Brito 1986). Eggleston et al. (1990) list potential lobster predators in their study area including: gray snapper (*Lutjanus griseus*), schoolmaster snapper (*L. apodus*), mutton snapper (*L. analis*), yellowtail snapper (*Ocyurus chrysurus*), Nassau grouper (*Epinephelus striatus*), red hind (*E. guttatus*), barracuda (*Sphyraena barracuda*), green moray eel (*Gynmothorax funebris*), spotted moray eel (*G. moringa*), nurse shark (*Ginglyostomata cirratum*), southern stingray (*Dasyatis americana*), bottlenose dolphin (*Tursiops truncatus*), loggerhead turtle (*Caretta caretta*), stone crab (*Menippe mercenaria*), portunid crab (*Portunus spinimanus*), and octopus (*Octopus* spp).

Human fishers, both commercial and recreational, impact spiny lobster populations in more ways than just by direct harvest. The Florida spiny lobster trap fishery is unique in that sub-legal sized lobsters (shorts) are used as live attractants (bait) in traps. Many of these confined lobsters are injured in the process of fishing the traps. Some die from starvation while confined in traps. Others are killed by triggerfish, octopus, or other predators that are able to enter and leave traps at will. Still others die from handling or exposure. Hunt et al. (1986) estimated average mortality rates of bait lobsters at 26.3% for four weeks of confinement. This estimate, however, includes death from exposure, which has presumably been reduced since 1987 as boats are now required to be equipped with live wells in order to keep shorts on board. The mortality rate for lobsters without exposure was 10.1% for four weeks (SEDAR 8 2005).

Recreational lobster divers catch or handle many lobsters for each lobster that they successfully harvest. Depending on their experience level, recreational divers may not be able to judge lobster size without capturing and physically measuring them. Some are released because they are too small, some because they are egg-bearing, and some escape after they are captured. Many of the lobsters are injured in the capture/release process. Approximately 50% of sub-legal and legal-sized spiny lobsters in Biscayne Bay, Florida, possessed injuries after the 1977 regular fishing season (compared to 31% injury immediately before that season opened in 1976; Davis 1981). Sublethal disturbances by recreational divers can increase the frequency of injured lobsters, alter shelter choice behavior, and increase predation-induced mortality of injured lobsters (Parsons and Eggleston 2005).

Abundance and status of stocks

The abundance of the stock has been recently estimated using a modified DeLury model (SEDAR 8). The estimated number of lobsters by fishing year varied from 30.4 million in 1985-86 to 39.3 million in 1999-00 and the estimate for 2003-04 was intermediate at 35.2 million lobsters. Recruitment expressed as age-1 lobsters was bimodal with an early increase in 1987-88 (17.7 million) and then a decline and another increase in 1996-97 (18.9 million) through 1998-99 then dropped reaching a low in 2000-01 (13.1 million) and then a gradual increase afterward with 15.8 million in 2003-04.

The spiny lobster fishery started in Key West in the Florida Keys in the 1800s as a bait fishery and for some local consumption. Reported landings did not exceed a million pounds until 1941 (Figure 4.1-17). These reports made to the Florida Board of Conservation did not make any explanation of the sharp increase in landings reported in 1942 and in the late 1940s. Landings made a major increase after 1965 and have varied without trend after 1970; however, landings in 2001 were the lowest in forty years. There were some landings from other states during the 1960s and early 1970s but these amounts were low and other than 1140 pounds in 1987, commercial landings of spiny lobsters have been from Florida for the last couple of decades and so we focus on Florida. Because the gear used on each trip was not recorded on trip tickets until the latter part of 1991, the proportion of landings by gear from 1978 through 1992 were taken from NOAA Fisheries' General Canvass and from the State of Florida's Marine Resources Information System thereafter. However, gear was not available on a monthly basis in the General Canvass and therefore the breakdown by gear had to be tallied on a calendar year basis even though the fishery operates on a fishing year basis. After Florida's Lobster Trap Certificate Program was implemented in 1993, divers began to produce a larger proportion of the landings as illustrated for 2003 in Figure 4.1-18. Due to the seasonal closure in the fishery, the more common way of referring to landings is by fishing year which is from August 6 through March 31 of the following year. The Florida Keys account for an average of 90% of the landings. The season with the highest landings was 1989-90 with 7.8 million pounds and the 2001-02 season had the lowest with 3.1 million pounds. If we just consider the 1993-94 and later seasons, the 1993- 97 seasons in the Florida Keys averaged 1.8 million pounds more than the five most recent seasons. The trap fishery declined an average of 2.0 million pounds per season while the diver fishery increased their harvest by 0.18 million pounds.

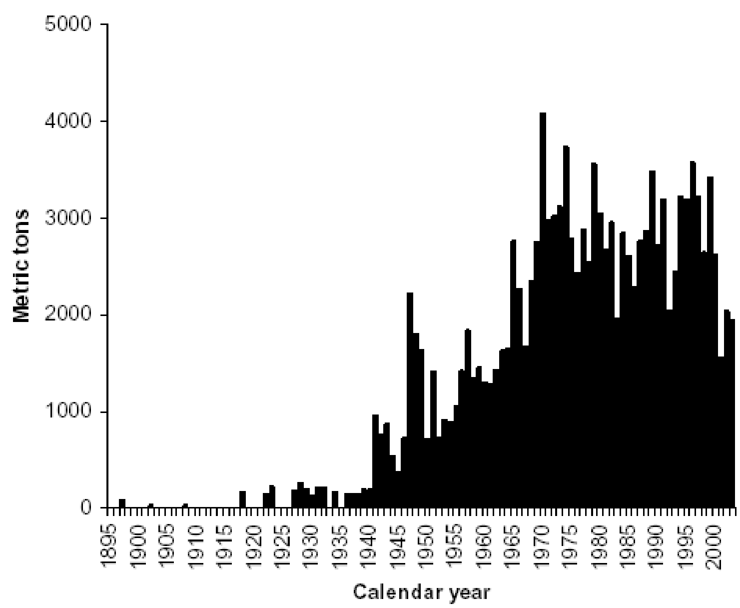


Figure 4.1-17. Commercial landings of spiny lobster in the United States by calendar year.

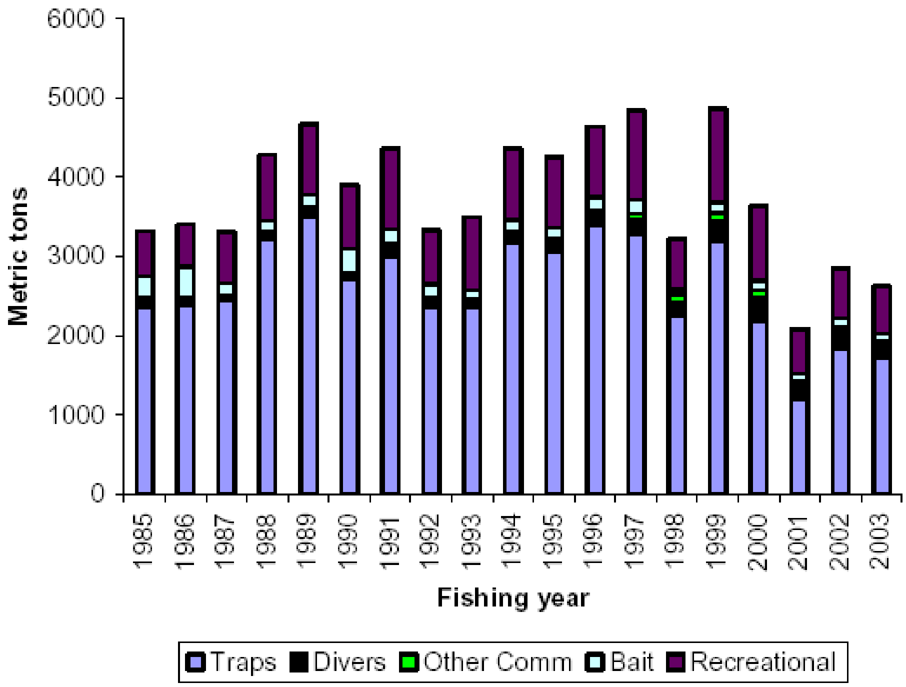


Figure 4.1-18. Allocation of spiny lobster landings in Southeastern U.S. by method or recreational and by year.

Amendment 6 of the Spiny Lobster FMP defined overfishing as fishing at a rate in excess of that associated with a static SPR value of 20% (F20%). With the current life history values and fishery practices, the fishing mortality rate on fully recruited lobsters (age-3) at a static SPR of 20% was 0.49 per year. The spiny lobster fishery in Southeast United States has fluctuated at SPR values around the 20% objective until the three most recent years (Figure 4.1-19) and was deemed to not be overfished because the fishing mortality rate on age-3 in 2003-04 (0.26 per year) was below the Council's Fmsy proxy of F20%. Even when the fishing mortality rate was adjusted for retrospective bias (0.36 per year), the fishing mortality rate in 2003-04 was still below the Council's management objective. As noted above, without a Caribbean-wide stock assessment, we were unable to determine the status of the stock with regard to the spawning biomass at MSY (Bmsy) or the Minimum Stock Size Threshold.

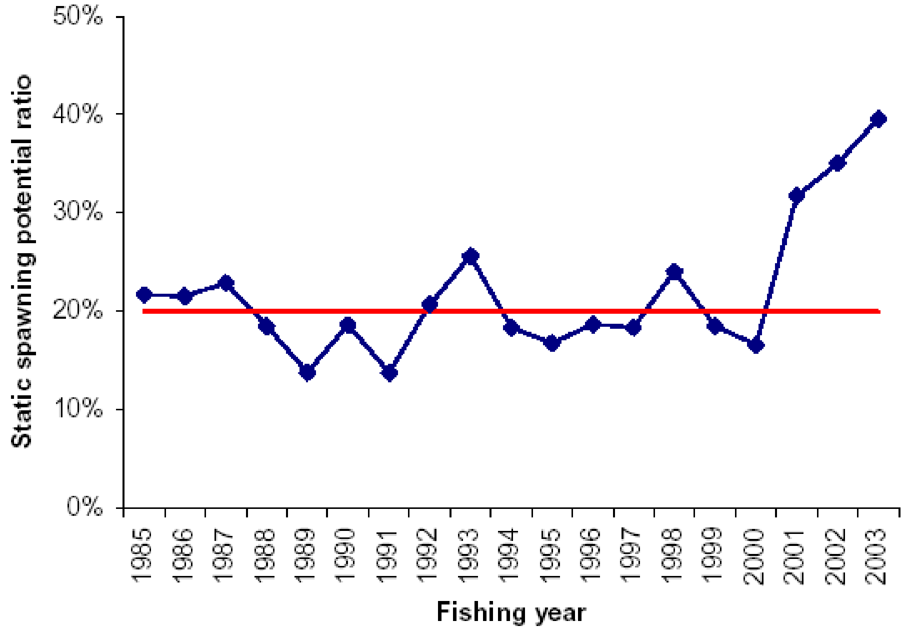


Figure 4.1-19. Spawning Potential Ratio (SPR) by fishing year and management objective of 20%.

Another factor affecting the stock abundance is the commercial trap fishing practice of placing sub-legal sized lobsters into traps to attract other lobsters. These lobsters are referred to as shorts. The question regarding stock abundance is how much additional mortality does the resource endure with this practice. The number of lobsters used for bait can be broken into how many short lobsters are used to bait traps during the season and what is the survival rate of those animals.

The estimated number of trap hauls per fishing year and the lobsters confined as bait are shown in Table 4.1-16. On average, fishers pull almost seven million traps over a typical season and they used 11.0 million sub-legal lobsters and 0.5 million legal sized lobsters as bait. Note that this model captured the effect of Hurricane Georges in 1998 when many fishers lost their traps. There is a strong seasonal pattern to bait usage because until the season has progressed a bit, there are not many sub-legal lobsters available and fishers bait with other baits, legal lobsters and whatever they can. Within a few weeks, more sub-legal lobsters are available and the use of legal lobsters declines and the traps are baited with more sub-legals.

Table 4.1-16. Bait usage and mortality for spiny lobster by fishing year 1993-2000.

Fishing		Bait usage				Bait Mortality			
Year	Landings (lb)	Trap Hauls	Shorts	Legals	Total bait	Ave bait / trap	Shorts	Legals	Total bait
1993	5,109,464	7,178,306	9,722,203	251,608	9,973,811	1.39	413,930	8,686	422,617
1994	6,893,968	7,755,461	11,530,549	676,680	12,207,230	1.57	470,527	21,911	492,439
1995	6,676,451	7,668,209	11,939,043	554,977	12,494,020	1.63	495,107	17,928	513,035
1996	7,335,547	7,733,807	13,090,248	1,009,931	14,100,179	1.82	549,376	34,316	583,692
1997	7,097,950	7,868,428	14,370,630	427,713	14,798,343	1.88	606,392	14,749	621,140
1998	4,864,200	5,433,270	5,757,398	352,503	6,109,901	1.12	264,970	11,006	275,976
1999	6,882,285	6,563,086	12,115,455	510,228	12,625,683	1.92	482,315	15,833	498,148
2000	4,717,168	6,432,743	9,810,643	390,772	10,201,415	1.59	410,927	12,112	423,038
Average	6,197,129	7,079,164	11,042,021	521,802	11,563,823	1.62	461,693	17,068	478,761

4.1.6 Coral, Coral Reefs, and Live/Hardbottom

4.1.6.1 Shallow Water Corals

Description and distribution

Scleractinia and Milleporina (fire corals and stony corals)
Stony corals are marine invertebrates that secrete a calcium carbonate skeleton. Stony corals include members of both the Class Hydrozoa (fire corals) and true stony corals (Order Scleractinia) (Table 4.1-17). The scleractinians can be hermatypic (significant contributors to the reef-building process) or ahermatypic, and may or may not contain endosymbiotic algae (zooxanthellae) (Schumacher and Zibrowius 1985). Zooxanthellate corals, host symbiotic algae from the Genus *Symbiodinium*, which provide a phototrophic contribution to the coral's energy budget, enhance calcification, and give the coral most of its color. The largest colonial members of the Scleractinia help produce the carbonate structures known as coral reefs in shallow tropical and subtropical seas around the world. Rapid calcification rates of stony corals have been linked to the mutualistic association with single-celled dinoflagellate algae, zooxanthellae, found in the gastrodermal cells of the coral tissues (Goreau et al. 1979). The Scleractinia have diversified into multiple families which exploit the ability to form complex colonies. The individual building unit in a colony is termed a polyp: a column with mouth and tentacles on the upper side. Massive and branching stony corals are the major reef framework builders and source of sediment production. Corals provide substrata for colonization by benthic organisms, construct complex protective habitats for a myriad of other species including commercially important invertebrates and fishes, and serve as food resources for a variety of animals.

Table 4.1-17. Classification of corals included under the Council's Coral, Coral reefs and Live/ Hard Bottom Fishery Management Plan.

Phylum Cnidaria
- Subphylum Medusozoa
  - Class Hydrozoa
    - Order Anthoathecata
      - Suborder Capitata
        - Family Milleporidae (fire, stinging corals)
- Subphylum Anthozoa
  - Class Anthozoa
    - Subclass Hexacorallia (or Zoantharia)
      - Order Scleractinia (stony corals)
    - Subclass Octocorallia
      - Order Alcyonacea (soft corals)
        - Suborder Alcyoniidae (soft corals)
        - Suborder Scleraxonia (gorgonians)
        - Suborder Holaxonia (gorgonians)
        - Suborder Calcaxonia (gorgonians)

Nearly 70 species of stony corals are known from the continental shelves of the study area, a vast majority of which have been noted from the Florida Keys and the Dry Tortugas alone (Table 4.1-18). This is a remarkably high number, considering that over 70 species are found in the Caribbean.

Corals that are limited in depth to less than 70 m are generally zooxanthellate, almost exclusively colonial, and have a strong tropical affinity (Caribbean-Bahamas, southeast Florida, Bermuda, with extreme records in Brazil and North Carolina). This group is often referred to as the shallow water reefs corals. Examples of this group include *Acropora palmata*, *Porites porites*, *Diplora labyrinthiformis*, *Mussa angulosa*, and *Eusmilia fastigiata*.

Octocorallia (sea fans, sea whips, etc.)
For the purpose of this plan, includes species belonging to the Class Octocorallia (soft corals and gorgonians), Order Alcyonacea. Similar to stony coral corals, octocorals are colonial animals with a polyp as the individual building unit and may contain endosymbiotic algae (zooxanthellae). Unlike stony coral, octocorals do not secret a calcium carbonate skeleton but have a axial skeleton mainly composed of collagen fibers in a proteinaceous matrix. Although octocorals do not contribute to reef framework, they do contribute greatly to reef complexity and diversity.

The hardbottom, coral reef, and coral community habitats within the management area contain a considerable diversity of octocorals. Table 4.1-19 lists the distribution of the common octocorals within the management area and includes possible endemic species.

Table 4.1-18. Common shallow water scleractinian corals identified in the management area. The distribution zones are divided as follows: (1) Atlantic Coast to NE. Florida (South Atlantic Bight); (2) SE. Florida; (3) Florida Keys and the Dry Tortugas.

Order	Family	Genus species	Distribution
Scleractinia			
	Acroporidae	*Acropora cervicornis*	2, 3
		Acropora palamata	2, 3
		Acropora prolifera	3
	Agariciidae	*Agaricia agaricites*	2, 3
		Agaricia fragilis	2, 3
		Agaricia humilis	2, 3
		Agaricia lamarcki	2, 3
		Leptoseris cucullata	2, 3
	Astrocoeniidae	*Stephanocoenia intersepta*	2, 3
	Caryophylliidae	*Cladocora arbuscula*	2,3
		Eusmilia fastigiata	2, 3
	Dendrophylliidae	*Tubastraea coccinea*	2, 3
	Faviidae	*Colpophyllia natans*	2, 3
		Diploria clivosa	2, 3
		Diploria labyrinthiformis	2, 3
		Diploria strigosa	2, 3
		Favia fragum	2, 3
		Manicina areolata	3
		Montastraea annularis	2, 3
		Montastraea cavernosa	2, 3
		Solenastrea bournoni	2, 3
		Solenastrea hyades	2, 3
	Meandrinidae	*Dendrogyra cylindrus*	2, 3
		Dichocoenia stokesi	2, 3
		Meandrina meandrites	2, 3
	Mussidae	*Isophyllia rigida*	2, 3
		Isophyllia sinuosa	2, 3
		Mussa angulosa	2, 3
		Mycetophyllia aliciae	2, 3
		Mycetophyllia danaana	3
		Mycetophyllia ferox	2, 3
		Mycetophyllia lamarckiana	2, 3
		Mycetophyllia reesi	3
		Scolymia spp.	2, 3
	Oculinidae	*Oculina diffusa*	2, 3
	Pocilloporidae	*Madracis decactis*	2, 3
		Madracis formosa	3
		Madracis mirabilis	2, 3
	Poritidae	*Porites astreoides*	2, 3
		Porites porites	2, 3
	Siderastreidae	*Siderastrea radians*	2, 3
		Siderastrea siderea	2, 3

The temperate region from North Carolina to the southeast Florida coast (North of Palm Beach County, FL) contains no distinctive octocoral elements. Typical species found in this region are *Leptogorgia virgulata*, *L. setacea*, *Lophogorgia hebes*, *Muricea pendula*, and *Titanideum frauenfeldii*.

The area from Palm Beach south to the Dry Tortugas contains a tropical Atlantic fauna, which appears to be fairly homogeneous. Some faunal differences occur along the Florida reef tract in response to water temperature ranges, substrate availability, and other variables. Along this area, octocorals are very abundant component of the reef biota with benthic cover and density generally greater than the stony coral component (Jaap et al. 2004, Gilliam et al. 2007a and b).

Cairns (1977a) published a field guide to the more common gorgonians of the Gulf of Mexico, Caribbean, and Florida. Sanchez and Wirshing (2005) recently published a field guide to western tropical Atlantic octocorals. Wheaton described the octocoral fauna off southeast Florida in 20-50 meter zones (1987), off Key Largo, in 27-57 m depths (1981), at Looe Key (1988), and at Dry Tortugas (1975, 1989). DeVictor and Morton (2007) have produced a shallow water octocoral guide for the South Atlantic Bight from Cape Hatteras, NC to Cape Canaveral, FL.

Protected shallow-water corals

State and Federal laws and regulations protect corals making it illegal to take any scleractinian coral in the United States. *Acropora cervicornis* and *Acropora palmata* were listed as threatened species under the Endangered Species Act in 2006. These species were once dominant on Florida reefs, but their abundance has diminished from historic levels throughout their range in the Caribbean. See section 4.3.6 of this document for a more detailed discussion of these two species.

Reproduction

Stony corals and octocorals have both sexual and asexual reproductive modes. The addition of new polyps to a colony occurs through budding of existing polyps. In this way, colonies grow in size through an asexual means of reproduction. In addition, many coral species, particularly branching ones, are also highly clonal in that they can reproduce asexually by fragmentation. That is, individual branches, when broken off from the parent colony, can re-attach to the substrate and form a new, distinct colony. These characteristics greatly complicate the population biology of corals, particularly branching species.

Table 4.1-19. Common octocoral species from the shallow-water continental shelf regions (less than 200 m or 660 ft) of the southern United States.

Order	**Suborder**	**Family**	**Genus species**	**Distribution**
Alcyonacea				
	Scleraxonia			
		Briareidae		
			Briarium asbestinum	2,3,4
		Anthothelidae		
			Icilogorgia schrammi	1,2,3,4
			Anthothela tropicalis	1
			Erythropodium caribaeorum	2,3,4
			**Titanideum frauenteldii*	1,2
	Holaxonia			
		Plexauridae		
			Plexaura homomalla	2,3,4
			Plexaura flexuosa	2,3,4
			Plexaura kuna	2,3,4
			Pseudoplexaura porosa	2,3,4
			Pseudoplexaura flagellosa	3,4
			Pseudoplexaura wagenaari	2,3,4
			**Eunicea palmeri*	3
			Eunicea mammosa	2,3,4
			Eunicea succinea	2,3,4
			Eunicea fusca	1,2,3,4
			Eunicea laciniata	3,4
			Eunicea tourneforti	2,3,4
			Eunicea asperula	2,3,4
			Eunicea clavigera	2,3,4
			**Eunicea knighti*	3
			Eunicea calyculata	2,3,4
			Muriceopsis flavida	2,3,4
			Muriceopsis petila	1,2,3,4
			Plexaurella dichotoma	2,3,4
			Plexaurella nutans	2,3,4
			Plexaurella fusifera	2,3,4
			Plexaurella grisea	3,4
			Muricea muricata	2,3,4
			Muricea atlantica	2,3,4
			Muricea laxa	2,3,4
			Muricea elongata	2,3,4
			**Muricea pendula*	1,2,3,4
	Holaxonia			
		Gorgoniidae		
			**Leptogorgia cardinalis*	2,3,4
			Leptogorgia hebes	1
			Leptogorgia virgulata	1
			Leptogorgia setacea	1
			Leptogorgia eurale	1
			Pseudopterogorgia bipinnata	3,4
			Pseudopterogorgia acerosa	2,3,4
			Pseudopterogorgia elisabethae	3
			Pseudopterogorgia americana	2,3,4
			Pseudopterogorgia rigida	2,3,4
			Pseudopterogorgia kallos	3,4
			Gorgonia ventalina	2,3,4
			Gorgonia flabellum	3,4
			Pterogorgia citrina	2,3,4
			Pterogorgia anceps	2,3,4
			Pterogorgia guadalupensis	3,4

Note: The distribution zones are divided as follows: (1) Atlantic Coast to NE. Florida (South Atlantic Bight); (2) SE. Florida; (3) Florida Keys; (4) Dry Tortugas. * Indicates species with principal distribution within study area (possibly endemic).

Corals also reproduce sexually, with sperm fertilizing egg, followed by a process of embryonic development into a planula larva. The larvae may survive long periods (i.e., one to a few weeks) floating in the water currents until they settle and metamorphose into a sessile polyp on some hard substrate. Different coral species display different sexual reproduction strategies. Some species have separate sexes while others are hermaphroditic. Some have internal fertilization and retain the developing embryos inside the mother colony to a relatively late stage of development (brooders) while others (broadcast spawners) release their gametes into the water column so that fertilization and the entire larval development phase occurs in an oceanic, highly diluting environment. Among octocorals, another reproductive strategy is surface brooding, where eggs are released passively onto the surface of the colony (Benayahu and Loya 1983; Brazeau and Lasker 1990; Guitiérrez-Rodríguez and Lasker 2004). While sampling female colonies of *Pseudopterogorgia elisabethae*, Guitiérrez-Rodríguez and Lasker (2004) did not find developing embryos or planula inside the polyps, and they suggested that fertilization occurred either internally immediately before the eggs were released or externally on the surface of the maternal colony.

Brooded larvae are often able to settle shortly after release (hence higher recruitment success and lower average dispersal than broadcast spawning species). An advantage of brooding is that the eggs avoid the risk of being advected off of the reef and away from sperm of potential mates (Lasker 2006). Generally, broadcast spawning stony coral species tend to have high longevity, lower recruitment, larger maximum colony size (i.e., K-selected life history traits). Brooding stony corals are generally more weedy species which do not attain large colony size and hence have limited contribution to reef accretion (Szmant 1986). Such inter-specific differences in the mechanisms of fertilization, dispersal, recruitment, and mortality are likely important in determining the species composition of reef corals in different environments. Such differences reflect the differential allocation of energy to the basic life history functions of growth (rate and density of the skeleton), reproduction (fecundity, mode of larval dispersal, recruitment success), and colony maintenance (intra- and interspecific interactions, competitive ability, regeneration) (Connell 1973; Lang 1973; Bak and Engel 1979; Szmant 1986).

Most broadcast spawning corals release gametes only on a few nights per year. In southeast Florida, most species spawn over a few nights clustered around the full moon in late summer. Spawning synchrony is crucial in order for sessile organisms to accomplish external fertilization. Also, in the context of declining population density as is being observed for many shallow reef corals in the region, fertilization may constitute the major life-history bottleneck as dilution between colonies even few to 10s of meters distant may be prohibitive.

Brooding species often release larvae on a lunar cycle over several months or year round. *Porites astreoides*, a brooding stony coral species, releases larvae around the new moon, primarily from April to June in the Florida Keys (McGuire 1997). However, the brooding season has been reported to be from January to September farther south in Puerto Rico (Szmant 1986). *Favia fragum*, another brooding species, releases larvae monthly year-round (Szmant

1986). Surface brooding has been reported in a few octocoral species found in the management area, including *Briarium asbestinum* and *Pseudopterogorgia elisabethae* (Guitiérrez-Rodríguez and Lasker 2004).

In either mode of larval development, planula larvae presumably experience considerable mortality (up to 90% or more) from predation or other factors prior to settlement and metamorphosis (Goreau et al. 1981). The selection of appropriate settlement substrate is not well-understood, but for several coral species, chemical cues from crustose coralline algae and microbial biofilms have been shown to induce settlement and metamorphosis (Morse et al. 1994; Morse and Morse 1996; Webster et al. 2004). Settled larvae undergo metamorphosis by generating a calcium carbonate skeleton. The mouth is situated at the upper end, and a ring of tentacles develops around the mouth. After metamorphosis onto appropriate hard substrata, metabolic energy is diverted to colony growth and maintenance. Because newly settled corals barely protrude above the substratum, juveniles need to reach a certain size to reduce damage or mortality from impacts such as grazing, sediment burial, and algal overgrowth (Bak and Elgershuizen 1976; Birkeland 1977; Sammarco 1985). Cary (1914) points out the obvious advantage of young octocorals over stony coral recruits in that their most rapid growth is perpendicular to the substratum, keeping the most active growing part of the colony in a favorable position for resource allocation. Recent studies examining early survivorship of lab cultured *A. palmata* settled onto experimental limestone plates and placed in the field indicate that survivorship is substantially higher than for *Montastraea faveolata*, another broadcast spawner, and similar to brooding species over the first 9 months after settlement (Szmant and Miller 2006). This pattern corresponds to the size of planulae; *A. palmata* eggs and larvae are much larger than those of *Montastraea* spp.

Development and growth

Most corals are colonial in that they are composed of individual units called polyps. Each polyp is an individual: it captures food, has independent digestive, nervous, respiration, and reproductive systems. A large coral colony has thousands of polyps working semi-independently to sustain the colony. Coral colonies grow via the addition (budding) of new polyps. By the same token, colonies can exhibit partial mortality whereby a subset of the polyps in a colony die, but the colony persists.

Scleractinian Density Banding and Growth

Some species of reef building corals grow into large dome-shaped colonies which can live several hundreds of years. Similar to annual growth rings in trees, these corals form annual density bands which can be revealed though radiography of skeletal slabs (Knutson et al. 1972; Dodge and Thompson 1974; Hudson et al. 1976 and others). The annual density bands result from seasonal changes in the thickness of the skeletal structures comprising the overall colony (Barnes and Devereux 1988, *Porites*; Dodge et al. 1992, *Montastraea*; Helmle et al. 2000, *Diploria*). The changes in thickness of skeletal structures are apparent as bulk-density variation over the thickness of a slab and appear as alternating period of light (high density) and dark (low density) bands on X-radiographic negatives.

Annual density bands provide a record of the linear extension rate (cm/yr) and optic density measurements of the X-radiographs can be used to determine the bulk-density of the skeleton (g/cm^3). A complete understanding of coral growth is best attained by all three parameters of growth: linear extension, bulk-density, and calcification. If two of the three parameters are measure, the third can be calculated by the follow formula:

$$\text{Extension (cm/yr) x Density (g/cm}^3\text{) = Calcification (g/cm}^2\text{/yr)}$$

Coral growth parameter of linear extension, density, and calcification correlate with various locally specific variables including: depth, light, temperature, precipitation, salinity, nutrients. Many of these variables are interrelated, however, their impacts on coral growth can also be identified independently. Coral skeletons have also been used to assess growth responses to anthropogenic perturbations such as crude oil and oil dispersants (Lewis 1971; Knap *et al.* 1983), lead pollution (Dodge and Gilbert 1984), fallout plutonium (Benninger and Dodge 1986), turbidity and sedimentation (Loya 1976), and sediment resuspension (Dodge *et al*. 1974). Historical skeletal growth records (extension, density, and calcification) are useful for testing hypotheses regarding variations in growth attributable to climatic changes such as rising carbon-dioxide levels and sea-surface temperature.

Growth data for some shallow-water scleractinians (brain corals and finger corals) has been summarized by Hubbard and Scaturo (1985), Bright et al. (1981) and Gladfelter et al. (1978). Most growth rates (linear extension) for *Montastraea*, *Porites*, and *Diploria* are less than 1 cm per year. Hubbard and Scaturo (1985) report average extension rates of 0.12-0.45 cm/yr for several species including *Stephanocoenia intersepta*, *Agaricia agaricites*, *Diploria labyrinthiformis, Colpophyllia natans*, *Montastraea cavernosa*, *Porites astreoides*, and *Siderastrea siderea*.

Octocorallia (gorgonians)

For most gorgonian genera, the major axial skeleton component is gorgonin, which is mainly composed of collagen fibers in a proteinaceous matrix (Leversee 1969). Gorgonin is deposited in concentric layers extracellularly around a central, hollow chambered canal, seldom exceeding a diameter of 100 µm. The axis functions as a mechanical support system facilitating the passive suspension feeding by octocorals (Lewis et al. 1992). The axis must be rigid enough to withstand the total water velocities for the particular habitat while supporting the polyps off the substratum (Muzik and Wainwright 1977). Lowenstam (1964) explains that the flexibility of the axial skeleton of gorgonians can apparently be modulated by sclerotization of the collagen within the axial skeleton. Gorgonian axes can be stiffened by the extracellular deposition of carbonates within the collagen interstitial spaces (Jeyasuria and Lewis 1987). Lewis et al. (1992) suggests that this process may be a mechanism for dealing with different hydrodynamic forces encountered at various depths.

Many gorgonian species can be characterized by a distinct colony form and a maximum colony size, indicating determinate growth, which suggests that growth is constrained in some way (Lasker et al. 2003). In two studies on *Pseudopterogorgia elisabethae*, the developmental cycle showed a rapid growth rate after settlement which then decreased dramatically with age, suggesting an age-dependent decrease in growth rate (Lasker et al. 2003; Goffredo and Lasker

2006). This size- or age-dependent decrease in growth rates may be due to interactions between the gorgonian colony and its environment (i.e., the balance between nutrient uptake and metabolic rates) instead of a genetically determined developmental plan (Lasker et al. 2003). A common method to determine growth rates of octocorals is by taking linear height measurements of a tagged colony over a period of time, the results usually varying between species. The most accurate method of estimating the age of a colony is counting growth rings seen within the axial skeleton rather than basing it on growth rates. However, counting growth rings usually requires the collection of the colony. Using both methods, height-age equations can be derived for a species (Grigg 1974).

Growth rates can vary dramatically within a species and between different species. Lasker et al. (2003) studied determinate growth in *Pseudopterogorgia elisabethae*. The resulting branch growth rates varied, ranging from negative values (branch loss) to 17.8 cm per year. A later study on this species performed by Goffredo and Lasker (2006) showed growth rates that decreased as a function of height. Colonies that were 0-10 cm in height had a growth rate of 3.5 cm per year; 20-30 cm colonies had a growth rate of 2.6cm per year; and 40-50cm colonies had a growth rate of 0.5 cm per year. Yoshioka (1979) studied the ecology of *Pseudopterogorgia americana* and *Pseudopterogorgia acerosa*, calculating their linear growth rates to be about 5 cm per year for *P. americana* and 6 cm per year for *P. acerosa*. Growth rates were higher for colonies exposed to higher light levels, showing that environmental factors affect the growth of a colony. Reproduction was delayed for 3–5 years until colonies were mature, ranging 15-30 cm respectively. Growth rates of *Pseudoplexaura porosa* branches can exceed 15cm per year (Lasker unpublished data). Due to these variations in growth rates, calculations determining the accurate age of a given colony should be based on growth rings and colony height (not solely on height).

Ecological relationships

Stony corals and octocorals derive energy from several sources including from sunlight through their photosynthetic, symbiotic zooxanthellae (algae living in the coral tissue), from consumption of zooplankton, from bacteria (which act as biochemical recycling agents), from consumption of detritus, and perhaps even directly from dissolved organics.

Corals are subject to the ecological pressures of predation (by fish and invertebrates), competition for space, and other interactions with associated organisms. In some instances, such as the symbiotic relationship of corals to zooxanthellae, the association is mutually beneficial. At the other end of the spectrum, however, are predatory pressures such as those applied by certain reef fishes and invertebrates that eat corals.

The importance of coral ecosystems and associated habitats has been well documented by numerous studies, reviews, and symposia (e.g., Jones and Endean 1973, 1976; Bright and Pequegnat 1974; Taylor 1977; Bright, Jaap and Cashman 1981; Jaap 1984; Jaap and Hallock 1990; Chiappone 1996). Many of those documents emphasize the complex structure of coral ecosystems, the importance of coral for habitat, the sedentary lifestyle and its implications, the wide geographic and bathymetric distributions, and the many behavioral, physiological, ecological, and physical associations that combine to yield an exceedingly complex biological community. The Magnuson-Stevens Act recognizes these values and lists several corals as continental shelf fishery resources subject to exclusive U.S. use beyond the EEZ.

Ecosystems which include coral (hardbottoms, coral reefs, and coral communities) often represent unique arrays of plants and animals in an integrated ecosystem. The key to many of these systems, if there can be one most important link, is often coral itself, since the corals provide habitat and/or food for most of the other members of the ecosystem. Connell (1973) and Grassle (1973) have studied aspects of population ecology and diversity within coral reefs. Individual biotic components have also been studied -among them, microbes (DiSalvo 1973), algae (Cribb 1973), holothurians (Bakus 1973), shrimps and prawns (Bruce 1976), echinoderms (Clark 1976), fishes (Goldman and Talbot 1976), and others. The resultant coral community is exceedingly complex and productive. Helfrich and Townsley (1965), Odum (1971), DiSalvo (1973), Sorokin (1973c), and others have attempted to quantify and qualify the productivity of corals and their associated biota (e.g., microorganisms) compared to other marine and terrestrial communities.

Because of their vast species diversity, trophic complexity, and productivity, mature coral communities possess numerous mechanisms that past researchers believed may enable them to resist normal disturbances, especially those biological in nature (Endean 1976). However, coral reefs have declined throughout the Caribbean including off the Florida coast over the past several decades. Numerous factors play major roles in coral health and may potentially threaten the continued viability of domestic corals. These factors include water quality, algal blooms, increased water temperatures, physical impacts from ship groundings and marine construction activities, sedimentation, pollution, nutrient enrichment, diver/snorkeler damage, disease, and over-fishing. Most of the coral reefs and coral communities in the management area may be degraded to such a degree that self-regulating mechanisms are no longer functional.

Massive decline of *Acropora* spp. has occurred over the last several decades throughout the Caribbean, including the Florida Keys. Exact cause of the decline is unknown, but it is likely due in part to the spread of disease, particularly white band and white pox. Several other diseases, including white plague and black band have also affected many coral species throughout the region. The etiology is not well-known for many of these diseases. However, their onset often occurs in the summer months indicating that warmer temperatures may promote their spread (Ward et al. 2007).

In addition, bleaching events associated with high sea temperatures have resulted in coral mortality. Bleaching occurs when the symbiotic zooxanthellae (algae) living within coral tissues are expelled or broken down. Because much of the nutrition of corals is derived from the zooxanthellae, the result can be starvation of the corals if the contribution from zooxanthellae is lost. Corals are often able to recover from bleaching depending on the extent, duration, and severity. Unfortunately, rising sea temperatures associated with predicted climate change may lead to more numerous and/or severe bleaching events in the future (Donner et al. 2007).

The special nature of corals as a fishery is further highlighted by their sedentary attached (not mobile) existence, which separates them from the subjects of many other fishery plans. Protection via escape or camouflage is limited by the design of coral skeletons and polyps.

Although some protection is afforded by polyp withdrawal, strict energy budgets restrict the use of such behavior. Hence, in the midst of persistent adversity, (e.g., water pollution, extreme temperatures, sedimentation), corals appear precariously susceptible. The life history of the octocorallian and scleractinian corals is similar to the other invertebrate species. The fruits of coral sexual reproduction are planulae larvae; the larvae are free living (planktonic or benthic). The larvae select settlement sites through chemoreceptors, settle, and undergo metamorphosis to juvenile, sessile corals. Because of their vulnerability to environmental conditions, continued survival of corals will be dependent on management strategies that incorporate more of an ecosystem approach and tackle large scale issues such as water quality.

Abundance and status of stocks

Since the early 1980s, most Caribbean reefs including those of the Florida reef tract have undergone dramatic changes from the classic descriptions of structure and zonation. At this point in history, a sequence of large disturbances seems to have precipitated these dramatic changes in Caribbean reef structure. These disturbances in the early 1980s included a series of bad hurricanes, the Caribbean-wide die-off of the important herbivorous urchin, *Diadema antillarum*, and the widespread mortality of the important reef-building coral species, *A. palmata* and *A . cervicornis*, due to disease. The result of these disturbances was an overall decline in coral cover coinciding with a dramatic increase in the cover of macroalgae (seaweeds). Aronson and Precht (2001) argue that the *Acropora* spp. die-off was the primary cause of this shift in benthic community structure, while Hughes (1994) and other authors maintain that changes in herbivory regime (overfishing and *Diadema* die-off) are primarily responsible. It is clear that this shift was a result of multiple disturbances, much of whose effects have not been abated on a region-wide scale. That is, *Diadema antillarum*, *A. palmata*, and *A. cervicornis* have not shown major recovery, though the Florida reef tract generally retains high herbivorous fish abundances. Simultaneously, macroalgae still dominate many Florida coral-reef substrates. Hence, the classic reef zonation patterns described above do not reflect Caribbean reef structure today, nor in the foreseeable future.

For purposes of discussing relative abundance and status of stocks of shallow-water corals, the management unit may be subdivided into four regions based on general species compositions. Each of these regions is discussed individually below.

North Carolina to Central Florida (Cape Canaveral)

NOAA's Office of Coastal Zone Management (l979d) cited reports that three to 30 percent of the shelf region is covered by live bottom habitats. The coral fauna along the edge of the continental shelf from Cape Hatteras, North Carolina, to Cape Canaveral, Florida, is sparse, in low diversity and is thus not characterized as a coral community. These are hardbottom habitats in which few corals are present. Studies by Menzies, et al. (l966) and Macintyre and Milliman (l970) indicate that Pleistocene algal accumulations account for the ledges, small terraces, and slight rises of the continental margin off North and South Carolina, while oolitic deposits predominate in the more southerly sector. *O. varicosa* is present on the inner and mid-shelf (3 to 40 m) as small discrete colonies (<30 cm diameter, usually <15 cm), and on the outer shelf and upper slope to depths of 152 m either as individual colonies (l to 2 m diameter), thickets, or banks. While *O. varicosa* has been found in water as deep as 128 m (off Cape Lookout, North Carolina) and as far north as

Cape Hatteras, North Carolina, the majority of the thickest growth occurs off the east coast of Florida, from Cape Canaveral to Ft. Pierce, in the area of the Oculina Bank Habitat Area of Particular Concern.

Corals on the outer continental shelf proper are characterized by patches of low relief hardbottom also referred to as live bottom (Struhsaker, 1969). Hardbottom communities throughout this shelf area have been reviewed by Continental Shelf Associates (1979).

These areas are inhabited by tropical and subtropical fishes, coralline algae, sponges, hydroids, and various species of other invertebrates and coral. They have been described at depths of 20 to 40 m (66 to 132 ft) from Onslow Bay, North Carolina, by MacIntyre and Pilkey (l969) and Huntsman and MacIntyre (1971). Four other species of scleractinians were noted: *Balanophyllia floridana* Pourtales; *Phyllangia americana* Milne-Edwards & Haime; *Astrangia danae* Agassiz (= *A. astreiformis* M.-E. & H.); and the ivory brush coral, *Oculina arbuscula* Verrill. Additional scleractinian records for the North Carolina continental shelf include a number of small, mostly solitary species: *Rhizosmilia maculata* (reported as *Bathycyathus maculatus*), *Dasmosmilia lymani*; *Rhizatrochus fragilis* (reported as *Monomyces fragilis*); *Paracyathus defilipii*; and *Cladocora* sp. (Cerame-Vivas and Gray 1966).

Reports from South Carolina and Georgia waters (Powles and Barans 1979; Reed 1978, personal communication, respectively) indicate that the coral fauna is largely the same as off North Carolina, except that coral patches are even more sparsely distributed (Barans 1978, personal communication). Gray's Reef occurs in this region, approximately 33 km (18 nm) east of Sapelo Island, Georgia. This complex rises from a depth of 22 m (72 ft) to a crest at 18 m (59 ft). It is approximately 6 km (3.2 nm) long and 2 km (1 nm) wide. The geology of Gray's Reef has been studied by Hunt (1974). Although the area is not a true coral reef, a number of corals and their associates are found there. Porter (1978, personal communication) noted that the biomass is dominated primarily by a large pink ascidian (probably *Eudistoma* sp.), secondly by the gorgonian *Leptogorqia* sp. (probably *L. virgulata*), and thirdly by scleractinians, *Oculina varicosa* identified by J. K. Reed and eye coral, *Oculina arbuscula*. If confirmed, this identification extends the range of *O. arbuscula* from Charleston to Savannah (McCloskey 1970). Other species noted by Porter include stump coral (*Solenastrea hyades*), star coral (*Montastraea annularis*, uncommon), *Cladocora arbuscula*, *Astrangia poculata*, and *Phyllangia americana*.

Bayer (1961) stated that the shelf octocoral fauna from the East Coast of Florida north of Cape Canaveral is indistinguishable from the fauna from Georgia and the Carolinas. Reports from North Carolina (Menzies et al. 1966; Cerame-Vlvas and Gray 1966), South Carolina (Powles and Barans 1979), and Georgia (Reed 1978, personal communication) appear to confirm this conclusion for both octocorals and scleractinians.

Central Florida to South Florida (Cape Canaveral to Palm Beach)

This shelf region represents a transitional zone for coral fauna and deserves special consideration. The shelf edge contains a conspicuous band of pinnacles, benches, mounds, and troughs (here collectively referred to as hardbottoms) which are often capped by the Ivory Tree Coral, *Oculina varicosa* Lesueur. Although the species occurs at least as far north as Cape

Hatteras, North Carolina (Reed 1980b), its structural development is greatest in this region; thickets 1-2 m (3-6 ft) high are found on pinnacles with up to 25 m relief (Avent et al. 1977, Reed 1980). A major portion of the shelf edge is littered with *Oculina* debris (MacIntyre and Milliman 1970).

The *Oculina* community harbors a rich vertebrate and invertebrate fauna which includes other scleractinians (*Astrangia poculata* (Peters et al. 1988), *Balanophyllia floridana*, *Cladocora debilis*, *Paracyanthus pulchellus*, and *Coenocyathus* species) and octocorals (*Telesto nelleae*, and *Tltanideum frauenfeldii*) (Avent et al. 1977). Two hundred species of mollusks, 47 species of amphipod crustaceans, 21 species of echinoderms, and 50 species of decapod crustaceans have been found directly associated with *Oculina varicosa* (Reed et al. 1982).

Although shelf-edge *Oculina* communities seem not to persist south of Jupiter, Florida, the species is found on coquinoid rock ledges scattered over the shallow shelf south to St. Lucie Inlet and Stuart, Florida (27° 10'N latitude) where *Oculina* is associated with decidedly Carolinian octocorals such as *Lophogorgia* and *Leptogorgia* spp. In spite of the Antillean ecological character of other groups which persist north to Cape Canaveral (Avent et al. 1977; Briggs 1974), the scleractinian and octocorallian fauna became Antillean only south of St. Lucie Inlet (in a similar fashion to the Mollusca studied by Work 1969). The coquinoid ledges here possess the same species noted above, but mixed with tropical genera such as the *Diploria* (brain coral), *Isophyllia* (cactus coral), *Montastraea* (star coral), and the octocorals *Eunicea*, *Pseudopterogorgia*, and *Gorgonia* (Reed 1979, personal communication).

Southeast Florida Coast (Palm Beach to Fowey Rocks)

South of 27° North latitude to near Miami, the continental shelf narrows to 3 to 5 km (1.6 to 2.7 nm) and the warm waters of the Florida current become the most dominant hydrographic feature (Lee and McGuire 1972). Thus, in the vicinity of Palm Beach, Florida, a diverse reef community develops. The coral communities in the southeast Florida region are tropical in character, zoogeographically similar to that of the Florida Keys but less well developed than the majority of the Florida reef tract. Section 3.3.1.1 discusses three coral habitat categories: coral communities patch reefs, and outer bank reefs. Much of the underlying substrate is a Holocene elkhorn coral, *Acropora palmata*, and staghorn coral, *A. cervicornis*, relic reef which lies 15 to 30 m (50 to 100 ft.) below present sea level. The reef has not been actively accreting for the last 8,000 years (Lighty et al. 1977; Banks et al. 2007). The system of coral communities from Palm Beach County to Miami-Dade County can be characterized as a series of discontinuous reef lines that parallel the shoreline. As an example, in Broward County there are generally three lines of reef (terraces); inner reef crests in 3 to 5 m, middle reef crests in 7 to 9 m, and the outer reef in16 to 23 m water depths (Banks et al. 2007; Walker et al. 2007). Nearshore of the Inner Reef is a series of nearshore ridges (Moyer 2003; Banks et al. 2007, Walker et al. 2007).

The coral community found within this region is generally dominated by gorgonian corals (Order Alcyonacea). A number of earlier studies have provided limited descriptions of the reef community in this region. Goldberg (1973a and b) has characterized the deeper zones of this community (20 to 30 m; 66 to 100 ft) by the presence of the gorgonian *Iciligorgia schrammi*. Wheaton and Jaap (1976) and Courtenay et al. (1975) discussed reef zonation off Palm Beach and Miami Beach, respectively. Wheaton described the octocoral fauna on the offshore reef terrace from Palm Beach County to Looe Key (Wheaton 1987). Blair and Flynn (1989) observed coral community structure off Miami. Goldberg (1973) reported an average octocoral density off Palm Beach County of 25.1 colonies/m^2.

Coral, coral reefs, and coral community habitat status is mostly recorded as part of monitoring efforts (Gilliam et al. 2007a and b) originated as impact and mitigation studies from adverse environmental impacts to specific sites (dredge insults, ship groundings, pipeline and cable deployments, and beach renourishment). Beginning in 1997, in response to beach renourishment efforts in Broward County, annual collection of environmental data (sedimentation quantities and rates and limited temperature measurements), and coral (stony corals and gorgonians), sponge, and fish abundance/cover data was conducted at 18 sites. In 2000 five new sites were added and in 2003 two additional sites were added for a total 25 sites (Gilliam et al. 2007a). In 2003, the Florida Department of Environmental Protection (FDEP) was awarded funding for a coral reef monitoring along the southeast Florida coast. Florida DEP contracted this work en toto to the Florida Fish and Wildlife Conservation Commission's Fish and Wildlife Research Institute (FWC-FWRI) who is working with Nova Southeastern University's National Coral Reef Institute. Ten sites were installed: three in Miami-Dade County, four in Broward County, and three in Palm Beach County (Gilliam et al. 2007b). Three additional sites were installed in Martin County in 2006. The Southeast Florida Coral Reef Evaluation and Monitoring Project (SECREMP) is an extension of the Florida Keys Coral Reef Evaluation and Monitoring Project (CREMP) which utilizes the same methods (Beaver et al. 2005).

Stony coral density is generally 2-3 colonies/m^2 and coverage generally 2-3%. Much of stony coral cover in this region is less than 1% but several nearshore areas have coverage greater than 10%. The south Florida region (especially offshore Broward County) has a number of unique staghorn coral, *Acropora cervicornis*, patches. These patches appear to be healthy with measured coverage greater than 30% (Gilliam et al. 2007a and b). Over 30 stony coral species have been identified in this region with common stony corals including *Montastrea cavernosa*, *Siderastrea siderea*, *Porites astreoides*, and *Stephanocoenia intersepta* (Gilliam et al. 2007a).

Octocorals are more abundant that stony corals in this region. Density can approach 20 colonies/m^2 (Gilliam et al. 2007a) with coverage of 20% (Gilliam et al. 2007b). Much less data exist on the species richness due to the difficulty of field identification, but common species include several *Eunicea* species, *Plexaura flexuosa*, *Pseudopterogorgia americana*, and *Muricea muricata*.

Monitoring data has shown that, although some differences were determined between years at some sites, in general stony coral cover on the reefs off Broward County (Gilliam et al. 2007a) has been stable. Regional data collected by the SECREMP project has also shown stability in stony coral and octocoral cover (Gilliam et al. 2007b). SECREMP and CREMP data indicate that southeast Florida reefs generally have reduced stony coral species richness and stony coral cover than the Dry Tortugas or Florida Keys coral reefs. Benthic cover by octocorals is, interestingly, very similar throughout the Florida reef system while southeast Florida reefs appear to have reduced macroalgae cover compared to reefs in the Dry Tortugas and the Florida Keys (Beaver et al. 2005, Gilliam et al. 2007b).

The southeast Florida coral communities lie within three km of the coast offshore a highly urbanized area comprising a population of over 5 million people (the population of Broward County alone exceeds 1.8 million). These reefs are important economic assets: a 2001 economic assessment estimated the annual reef input for Miami-Dade, Broward, and Palm Beach Counties at 5.8 billion dollars (Johns et al. 2003). Potential impacts to the system include those from commercial and recreational fishing and diving, sewer outfalls, marine construction activities (fiber optic cables, channel dredging, gas pipe lines), and major shipping ports and ship groundings. Southeast Florida has three major shipping ports; Port of West Palm Beach, Port Everglades (Broward County), and the Port of Miami. At Port Everglades alone, over 5,300 ships call on an annual basis. This heavy ship traffic very near and within a coral reef system has resulted in nearly one ship grounding per year offshore Broward County since the early 1990's. The overuse and misuse of the coral community resources is currently a major issue affecting the status of these resources and as south Florida continues to grow impacts to the resources will increase.

Florida Keys (Fowey Rocks to the Dry Tortugas)

Coral reefs and coral communities are common within the south Florida coastal ecosystem. Well developed coral reefs similar to those found in the Bahamas and Caribbean occur from Fowey Rocks to Tortugas Banks: 25° 40' – 24° 30'N latitude, 80° 30' – 82° 40'W longitude (Jaap 1984, Jaap and Hallock 1990). High profile bank reefs parallel the island arc in a band four to six miles from shore. Outer bank reefs are characterized by spur and groove formations (Shinn 1963), elkhorn coral (*Acropora palmata*), and *Millepora complanata* (encrusting fire coral) at the reef crest. Patch reefs are found between the coast and the offshore bank reefs and typically are characterized by an irregular ring of large boulder corals (*Montastraea annularis*, *M. cavernosa* (star corals), *Colpophyllia natans*, *Diploria labyrinthiformis*, and *D. strigosa* (brain corals). Between the different habitat types in the Florida Keys, the patch reefs tend to have the highest mean percent coral cover (Beaver et al. 2005). The diversity of corals is quite variable, upwards of 60 stony coral species have been documented on an individual bank reef (Jaap et al. 1989). The diversity and abundance of octocorals tends to be greatest in patch reefs and offshore deep reefs. Functionally, coral reefs enhance the abundance and variety of life, provide a living breakwater that protects the coast from storm waves, provide economic benefit from fisheries and tourism, and are important education and research resources.

The Coral Reef Evaluation and Monitoring Project (CREMP), constitutes the first successful, long-term monitoring project that has documented status and trends of coral reefs throughout the 2,800 square nautical miles Florida Keys National Marine Sanctuary. Between 1996 and 2004, the project reported a 44% reduction in stony coral cover. A significant decline in percent cover of stony corals was documented between 1997 and 1999. From 1999 to 2004, the percent cover of stony corals has remained essentially unchanged. The significant declines in mean percent stony coral cover between 1997 and 1999 were largely due to losses in *M. annularis*, *A. palmata*, and *M. complanata*. The large decline in mean stony coral cover was evident in all three regions in the Florida Keys (Lower, Middle, and Upper Keys) (Beaver et al. 2005).

Many well developed patch and outer bank reefs, such as Carysfort Reef and Key Largo Dry Rocks, occur shoreward of the 18-m (60 ft) isobath and were historically dominated by *Acropora* *palmata* (elkhorn) and *Millepora complanata* (encrusting fire coral) at the crest, followed by *A. cervicornis* (staghorn), *Montastraea annularis* (small star coral), and *M. cavernosa* (large star coral), in successively deeper zones (Shinn, 1963). Prior to the 1990's, specific information on the distribution and abundance of corals on these reefs was available in individual works at localized sites (in spite of their position as the northernmost *Acropora* reefs in the western Atlantic). The Caribbean-wide decline of *Acropora* spp. dating from the mid 1980's has yielded *A. palmata* and *A. cervicornis* rare to absent in most Florida Keys sites. The outer bank reefs of Biscayne National Park to the north have been described by Voss et al. (l969) but quantitative data on distribution and abundance of corals on a single reef were not included. Wheaton (unpublished) surveyed reefs in Biscayne National Park from 1978 to 1981.

Looe Key Reef (12.9 km, 200° off the SW tip of Big Pine Key, 24° 37'N, 81° 24'W) is a representative outer bank reef. The reef was subdivided into reef flat, spur and groove, fore reef, and deep reef habitats to characterize these habitats (Wheaton and Jaap, 1988). Inshore of the reef there is a fan-like mosaic of seagrass and sediments. The reef crest at Looe Key is dominated by *Millepora complanata* (encrusting fire coral), *Porites astreoides* (mustard hill coral), and *Palythoa caribaeorum* (golden sea mat). A spur and groove system extends seaward of the reef crest and is 5 to 9 m (16 to 30 ft) deep at the seaward spur terminus. *Acropora palmata* (elkhorn coral) skeletal material is the principal construction component of the spur formations (Shinn 1963). The numerically abundant corals in spur and grooves include: *Porites astreoides*, *Millepora complanata*, *Agaricia agaricites*, *Montastraea cavernosa*, and *Acropora cervicornis*. Colonies of very large, living *Montastraea annularis* (small star coral), *Diploria strigosa* (brain coral), and *Colpophyllia natans* (boulder brain coral) are also present.

Generally, patch reefs found in the lagoon between the outer reefs and the Florida Keys may include star corals *Montastraea* spp., fire corals *Millepora* spp., regular finger coral *Porites porites* (*P. furcata* or *P. divaricata*), mustard hill coral *P. astreoides*, starlet coral *Siderastrea* spp., brain coral *Diploria clivosa*, and staghorn *Acropora cervicornis*. *Acropora palmata* (elkhorn) is less common on patch reefs than fore-reef crests. Antonius et al. (1978) found that five species composed 50 percent of the stony corals found on the patch reefs at Looe Key; *Millepora complanata*, the star corals *Dichocoenia stokesi*, *Siderastrea siderea*, and *Montastraea annularis* accounted for eight to ten percent each, while staghorn coral *Acropora cervicornis* dominated with 15 percent of the total. However, *A. cervicornis* no longer dominates anywhere in the Florida Keys.

Quantitative information dealing with distribution and abundance of gorgonians is available for several back reef areas in the Florida Keys. Opresko (1973) has analyzed gorgonian data for Boca Chita Pass, Soldier Key, and Red Reef. Bagby (1978) studied three sites off Key Largo, Florida, chosen to provide a view of the influence of increasing oceanic conditions. Bagby (1978) found that *Pseudopterogorgia americana* and *P. acerosa* were the most widespread species. In agreement with the conclusions of Opresko (1973), *P. acerosa* was most common inshore, while *P. americana* was more dominant at offshore patch reefs. Equally widespread, but numerically less dominant, were the species *Plexaurella dichotoma* (double-forked *Plexaurella*) and *Plexaura flexuosa*. Two species, *Eunicea succinea* and *Pterogorgia citrina*, were distributed in abundance at both Soldier Key and Nine Kilometer Reef, but not in intermediate areas. *Pseudoplexaura porosa* was dominant on Five Kilometer Reef and *Plexaura homomalla* (black sea rod) was of considerable importance on Red Reef, but neither was prominent elsewhere in the areas studied. *Plexaura flexuosa* and *Pseudopterogorgia americana* dominated the shallow reefs at Long Key, Dry Tortugas (Wheaton, unpublished). Thus, any or all of these species can be found prominently on inshore or offshore reefs, in shallow water or on outer reefs at depths up to 20 m (66 ft). Their relative abundance on a given reef must therefore be interpreted with caution. Shallow patch reefs near the outer reef tract display a number of clear-water indicator species. *Gorgonia ventalina*, *Muriceopsis flavida*, *Briareum asbestinum*, and *Pseudopterogorgia bipinnata* all fall in this category, in decreasing order of consistency (Opresko 1973; Bagby 1978).

At four pairs of reefs in Biscayne National Park Wheaton (unpublished) surveyed octocoral abundance and density by transect, species count, and photographic analysts. Octocoral colonies usually comprised more than half of the total coral colonies. The five most abundant species (53.9 percent of total octocorals) were *Plexaura flexuosa*, *P. homomalla*, *Gorgonia ventalina*, *Eunicea succinea*, and *Pseudopterogorgia americana*. Mean numbers of octocoral colonies counted along a 20 m (66 ft) transect of the eight reefs were 102.81 and 155.17 (Wheaton unpublished).

4.1.6.2 Live/hardbottom species

Refer to section 3.3.1.2

4.1.6.3 Deepwater Corals

Description and distribution

Refer to section 3.3.1.3

Reproduction

(From SAFMC DWC Research and Monitoring Plan)
Lophelia pertusa has been studied more extensively than other species, using samples from Norway, the Gulf of Mexico and the Florida Straits. Seasonality of gametogenesis appears to vary with location. The gametogenic cycle of samples collected from the Norwegian Fjords began in April and terminated with spawning in March the following year (Brooke and Jarnegren in prep.). In the Gulf of Mexico, however, gametogenesis begins in November and spawning probably occurs in late September/October (S. Brooke unpubl.). Fecundity of both sets of samples is high but quantified data have not yet been compiled. Research into reproduction of octocorals from Alaska and New England is also underway (Simpson unpubl), and some work has been done on reproduction in Alaskan stylasterines, which are all brooders and produce short-lived planulae (Brooke and Stone in review). Larval biology has been described for *O. varicosa* (Brooke and Young 2005) but not for any of the other deepwater corals.

Development and growth

(from SAFMC DWC Research and Monitoring Plan)
The growth of *L. pertusa* has been measured using various methods (Duncan 1877; Dons 1944; Freiwald 1998; Gass and Roberts 2006), which have estimated growth rates between 4-26 mm per year, with the most likely estimates at approximately 5mm per year (Mortensen and Rapp

1998). These methods have measured linear extension rather than calcification rates, but the latter could potentially be calculated from growth rates and skeletal density. Growth rates of some gorgonians and antipatharians have also been measured using rings in the gorgonian skeleton and isotopic analysis (e.g., Sherwood et al. 2005, Andrews et al. 2002, Risk et al. 2002; Williams et al. 2006) and in some cases the colonies are extremely old (hundreds to thousands of years) and have very slow growth rates (e.g., Druffel et al. 1995; C. Holmes et al. unpubl. data).

Field observations on distribution of *L. pertusa* indicate that the upper thermal limit for survival is approximately 12°C, and laboratory studies on *L. pertusa* tolerance to temperature extremes corroborate these observations (S. Brooke unpubl. data). Preliminary experiments with heat shock proteins show expression of HSP-70 in response to exposure of temperature greater than 10°C (S. Brooke unpubl. data). Experiments on tolerance to sediment load indicate that samples of *L. pertusa* from the Gulf of Mexico show >50% survival in sediment loads of 103 mgL-1 for 14 days, and can survive complete burial for up to 2 days (Continental Shelf Associates in review). Given the proximity of some coral habitats to oil and gas extraction sites, tolerance to drilling fluids and fossil fuels should also be investigated.

Further laboratory and field experiments are needed to examine the individual and interactive effects of environmental conditions such as temperature, sedimentation, and toxins. A range of responses or endpoints should be examined including more modern techniques such as cellular diagnostics. These include examination of levels of stress proteins produced by cells in response to external conditions such as heat shock proteins, ubiquitin, etc. There are general classes of cellular products that are known to be indicative of specific stressors such as nutritional stress, xenobiotics, metals, temperature. These techniques are being increasingly used in shallow coral systems as a more sensitive organismal response to stress (i.e., more sensitive than mortality). These responses should be measured in combination with more standard parameters such as growth, respiration, and fecundity.

Coral growth rates provide information on the rates of habitat production in deepwater coral ecosystems while coral mortality and bioerosion counterbalance this production with destruction. Understanding the positive and negative sides of this balance, particularly under the changes in environmental conditions that are anticipated in the coming decade or two, is crucial to the management and conservation of deepwater coral habitat and habitat function (e.g., fishery production).

Ecological relationships

Refer to section 3.3.1.3

Abundance and status of stocks

Refer to section 3.3.1.3

4.1.7 Sargassum

Refer to section 3.3.2.

4.1.8 Dolphin and Wahoo

Description and Distribution

Dolphin

The common dolphin, *Coryphaena hippurus*, is an oceanic pelagic fish found worldwide in tropical and subtropical waters. The range for dolphin in the western Atlantic is from George's Bank, Nova Scotia to Rio de Janeiro, Brazil. They are also found seasonally throughout the Caribbean Sea and the Gulf of Mexico, and they are generally restricted to waters warmer than 20°C (Oxenford 1997). They support economically important fisheries from North Carolina through the Gulf of Mexico and within the Caribbean Sea, including the northeast coast of Brazil.

Pompano dolphin, *Coryphaena equiselis*, a more pelagic species, has been recorded off North Carolina, Florida, Bermuda, and in the central Atlantic, Gulf of Mexico, and Caribbean including off Puerto Rico. Pompano dolphin were found in waters which exceed 24°C (Mather and Day 1954).The common dolphin and pompano dolphin will subsequently be referred to as dolphin because they are not often distinguished in data collection systems.

There is pronounced seasonal variation in abundance. Dolphin are caught off North and South Carolina from May through July. Dolphin caught off Florida's East Coast are caught mainly between April and June. February and March are the peak months off Puerto Rico's coast. Dolphin are caught in the Gulf of Mexico from April to September with peak catches in May through August (SAFMC 1998a).

Wahoo

The wahoo, *Acanthocybium solandri*, is an oceanic pelagic fish found worldwide in tropical and subtropical waters. In the western Atlantic wahoo are found from New York through Colombia including Bermuda, the Bahamas, the Gulf of Mexico, and the Caribbean. Wahoo are present throughout the Caribbean area, especially along the north coast of western Cuba where it is abundant during the winter (from FAO species guide; FAO 1978).

There is pronounced seasonal variation in abundance. They are caught off North and South Carolina primarily during the spring and summer (April-June and July-September), off Florida's east coast year-round, off Puerto Rico and the U.S. Virgin Islands year-round with peak catches between September and March, in the Gulf of Mexico year-round, in the eastern Caribbean between December and June, and in Bermuda between April and September (SAFMC 1998a).

Reproduction

Dolphin

Common dolphin are batch spawners and have a protracted spawning season. Evidence for a continuous spawning season is attributed to the presence of several size classes of eggs found in the ovaries (Beardsley 1967; Oxenford 1985; Perez and Sadovy, 1991). Size at first maturity ranges from 350 mm fork length (FL) (Florida) to 530 mm FL (Gulf of Mexico) for sexes combined. Males first mature at a larger size than females. Size at full maturity ranges from 550 mm FL (Florida) to 600 mm FL (Puerto Rico) for females. Ripe pompano dolphin have been collected in the Atlantic as small as 205 mm standard length (SL) (Gibbs and Collette 1959).

The sex ratios in the catch tend to be female-biased although they vary with size of fish captured. The batch-fecundity-length relationship is strongly exponential ranging from 85,000 (approximately 400-600 mm FL) to 1.5 million (approximately 1300-1400 mm FL) eggs per batch.

Wahoo

Development

Estimates of size at first maturity from North Carolina are 86 cm FL for males and 101 cm FL for females (Hogarth, 1976). Preliminary estimates from Bermuda are similar (males = 102 cm FL; females = 95 cm FL) (Murray 1998). Fecundity estimates from North Carolina range from 560,000 eggs (for a 6.13 kg or 13.52 lb wahoo) to 45 million eggs (for a 39.5 kg or 87.10 lb wahoo) (Hogarth, 1976).

Hogarth (1976) examined wahoo reproductive tissues and determined that the spawning season extends from June through August with peak spawning in June and July. In addition, wahoo caught off North Carolina in September and October were determined to be post-spawners.

Development, growth and movement patterns

Dolphin

Development

Eggs - The eggs of dolphinfish have been described as buoyant, colorless, spherical, and having 1.2~1.6 mm diameter (Mito 1960). Melanophores and xanthophores appear on embryo, yolk and oil globule during later stages of development (Ditty et al. 1994). The yolk is described as a single pale yellow oil globule, approximately 0.3-0.4 mm diameter with coarse segmentation that fades after preservation (Mito 1960). Local studies on the mean mature egg size in the wider Caribbean include estimates of 0.97 mm in Barbados (Oxenford 1986), 1.3 mm diameter off the North Carolina coast (Hassler and Rainville 1975), 1.4 mm diameter (eggs collected in the plankton, not the ovaries) in the Gulf of Mexico (Ditty et al. 1994). Larval length at hatching is reported to be 3.95 mm, and consumption of yolk and oil globule at 5.7 mm (Mito 1960). Ditty et al. (1994) concluded that in water temperatures between 25º and 30º C, dolphin eggs would hatch in 26 to 38 hours. Ditty et al. (1994) believed that all spawning occurred in oceanic waters over or beyond the continental shelf. The average station depth for capture in their study was 1,198 m.

Larvae - Ditty et al. (1994) found larvae abundant throughout the year in the Gulf of Mexico, but small larvae were found primarily during warm months. Peak abundances were from April to November. They found larvae primarily in water temperatures greater than 24º C and salinities greater than 33 ppt. Few larvae were collected at salinities less than 25 ppt. They also found that the catch of dolphin larvae increased with the increasing concentration of Sargassum. In the

Florida Current peak abundance of dolphinfish larvae was noted in early summer (Gibbs and Collette 1959) and from November to May and in August (Beardsley 1967). Several studies of larval collections made off of North Carolina determined that they are present July to September (Beardsley 1967), March and May (Anderson et al. 1957a, b), October (Anderson and Heumann 1956), and late summer (La Monte 1952). In the South Atlantic Bight from May to February—young common dolphinfish were harder to obtain than adults or juveniles of pompano dolphinfish (Gibbs and Collette 1959). No significant diel differences in catch of larvae for either species; overall more common dolphinfish caught than pompano dolphinfish (Fahay 1975). Off of Maine larvae of common and pompano dolphinfish were significantly more abundant at night and catch of larval common dolphinfish increased with concentration of Sargassum (Eldridge et al. 1977). In the Gulf of Mexico dolphinfish were collected from the *Sargassum* off of Texas in July (Pew 1957). In this SEAMAP study, differences in numbers of common and pompano dolphinfish were not significantly different among seasons or between night and day, but overall numbers of common dolphinfish were significantly more abundant than numbers of pompano dolphinfish. Shcherbachev (1973) found larvae to feed on crustaceans, mainly copepods. He noted that larval dolphin start feeding on larval fish when they reach 20 mm standard length.

Juveniles - Juvenile dolphin inhabit the entire Atlantic. Juvenile dolphin are closely associated with floating objects and Sargassum (Gibbs and Collette 1959; Beardsley 1967; and Rose and Hassler 1974). Manooch et al. (1984) found fish to make up the largest portion of juvenile dolphin's diet, but invertebrates also were an important part.

Adults - Beardsley (1967) found that female dolphin mature between 350 mm and 550 mm FL. Males begin to mature at a larger size around 400 to 450 mm (Beardsley 1967). Both sexes reach sexual maturity in their first year of life (Beardsley 1967). Beardsley (1967) found increased numbers of adults in late spring and summer when water temperatures were 26° to 28°C. Adults generally prefer oceanic salinities, although captive dolphins tolerated salinities ranging from 16 to 26 ppt and temperatures from 15° to 29.4° C (Hassler and Hogarth 1977). The diet of adult dolphin mainly includes fish (Gibbs and Collette 1959; Shcherbachev 1973; Rose and Hassler 1974; Manooch et al. 1984; Massuti et al. 1998), although squid and crustaceans are also taken. Rose and Hassler (1974) found that five fish families accounted for 74% of the prey weight. These were Exocoetidae (26%), Scombridae (22%), Carangidae (12%), Balistidae (9%), and Coryphaenidae (5%). *Sargassum* was also present in 28% of the stomachs examined and occurred most frequently in the stomachs of small female dolphin. *Sargassum* was found in stomach contents by Rose and Hassler (1974) and Manooch et al. (1984) but was likely ingested incidentally while dolphin were feeding on the fish residing in *Sargassum* mats. Larger males seem to prefer open ocean habitat while females and smaller males remain associated with *Sargassum* and floating debris. Rose and Hassler (1974) postulated that males were more active feeders than females of similar length. They further theorized that since males are substantially heavier than females of similar age, a greater amount of food is required to sustain their metabolism and this requirement for additional food causes more voracious feeding. The open ocean habitat provides larger prey for the larger male dolphin. Rose and Hassler (1974) used catch records from charter boats as the basis for this hypothesis.

Spawning - Adults reach sexual maturity within their first year of life and spawning take place year-round in waters warmer than 24°C in the Atlantic (Beardsley 1967). Peak spawning seems to take place in the spring and early fall (Beardsley 1967). Like most fish, fecundity in dolphins increases with increasing size (Beardsley 1967). Beardsley (1967) estimated that female dolphins produce 240,000 to 3 million eggs annually. In Barbados the spawning season was reported to be extended (Oxenford 1986). In Bermuda, there was peak spawning in September and October (Migalski 1958). In the Florida Current spawning occurred from November to July with a peak in March (Beardsley 1967). In this work, Beardsley also noted a sudden appearance of Stage V fish in July (3 months after peak spawning) that may be attributed to the migration of the spawning population north, and the arrival of a new population from the south that had already completed spawning. From size data of 78 juvenile dolphinfish of *Coryphaena equiselis*, it was inferred that the species most likely spawned in January and February in the tropical mid-Atlantic (Potthoff 1971). A study off the coast of Maryland estimated peak spawning in July and August (Gibbs and Collette 1959). In Puerto Rico, spawning was at a peak in February (Erdman 1956). In June in the Gulf Stream specimens were caught that were ripe or very close to ripe, and peak spawning was determined to be in June and July (Rose, 1965) and May and June (Schuck 1951). Work by Arocha et al. (1999) in Venezuela found spawning to be biannual in May and October-November. This estimate was based on incidence of mature gonads from 21 females with advanced vitellogenic oocytes collected during four observer-covered longline trips in 1995 (Arocha et al. 1999).

Age and growth
Dolphin grow rapidly and show average first year daily growth rates ranging 1.6 mm FL (North Carolina) to 4.2 mm FL (Gulf of Mexico). The relationship between fork length and weight is presented in Figure 4.1-20. There are a number of estimates of L∞ from the northern area and a value of 1,400 to 1,500 mm FL appears appropriate for this stock (SAFMC, 1998a). A summary of available length-weight relationships for dolphin from the western central Atlantic is presented in Oxenford, 1997.

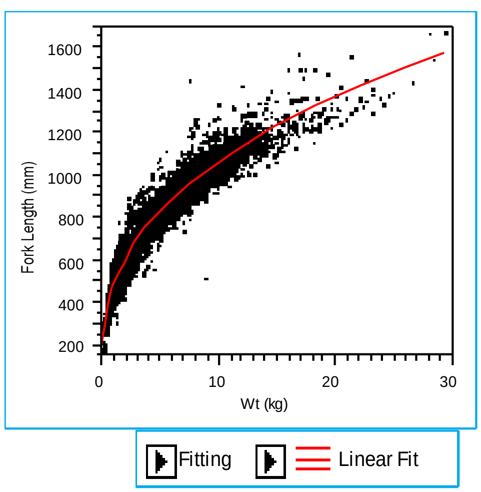


Figure 4.1-20. Dolphin, *Coryphaena hippurus*, length-weight relationship (Source: Goodyear 1999).

Thompson (1999) examined the relationship between dolphin weight and length based on recreational data from MRFSS, the Texas Creel Survey, and the Headboat Survey (N=32,215). The length weight relationship was found to be similar for the Atlantic and Gulf of Mexico and pooling the data provided the resulting relationship: the natural log of the whole weight equals the natural log of the fork length in centimeters minus 10.42 (ln weight = 2.71 ln FL-10.42).

Beardsley (1967) examined 511 dolphin from waters off south Florida ranging in size from 475 to 1,525 mm fork length (FL). Of the 1-year olds, the size range was 475 to 1,175 mm FL. Prager (2000) to provide values for use in empirical estimates of mortality rates for the first stock assessment for dolphin, took a von Bertalanffy growth function and fit it to the grouped length-at-age data of Beardsley (1967). Prager (2000) indicates the following growth function resulting from the analyses describes sizes at age reasonably well:

$Lt = L\infty(1 - \exp(-K(t - t0)))$ $\quad\quad$ $Lt = 1710 (1- \exp(-0.583[t - 0.7]))$

Table 4.1-20. Summary of length-weight relationships for dolphin (*Coryphaena hippurus*) from the western central Atlantic (Source: Oxenford 1997; references found in Oxenford, 1997).

Location	Sex	Range in length (mmFL)	Sample size (no.fish)	a	b	kg at 1000 mmFL	Data source
North Carolina	All	672-966	18	$2.00x10^{-9}$	3.22	9.21	Schuck (1951)*[1]
North	Males	275-1350	176	$0.50x10^{-7}$	2.75	8.89	Rose & Hassler (1968)
Carolina	Females	310-1275	325	$1.27x10^{-7}$	2.59	7.76	
Florida	Males	550-1300	19	$1.45x10^{-7}$	2.58	7.97	Beardsley (1967)*[2]
	Females	500-1225	40	$5.75x10^{-8}$	2.71	7.60	
Puerto	All	381-1479	852	$3.80x10^{-8}$	3.49	891?	Perez *et al.*(1992)*[3]
Rico	Males	490-1479	261	$1.78x10^{-8}$	3.62	1289?	
	Females	445-1310	591	$5.75x10^{-8}$	3.36	691?	
	All	358-1323	332	$1.41x10^{-8}$	2.92	8.11	Perez & Sadovy (1991)
	All	381-1479	170	$3.80x10^{-8}$	2.78	8.31	Rivera Betancourt (1994)
Cuba	All	500-1200	56	$3.21x10^{-5}$	2.67	7.02	Garcia-Arteaga *et al.* (1997)*[4]
Barbados	All	160-1365	365	$1.45x10^{-8}$	2.91	7.85	Oxenford (1985)
	Males	239-1365	123	$1.24x10^{-8}$	2.94	8.31	
	Females	160-1240	207	$2.22x10^{-8}$	2.84	7.58	

*1 Relationship given in original text appears to be in error. Relationship given here was recalculated with data extrapolated from length-weight graph.
*2 Relationships given in original text were wrong (confirmed by pers. comm. with author on 11.5.84.). Relationships given here are recalculated from extrapolation of data shown in the length-weight graph.
*3 Relationships given in original text appear to be in error. Authors have been contacted on 9.10.97.
*4 Relationship is for length in cm.

Mortality rates and longevity

Prager (2000) estimated natural mortality (M) for dolphin to be between 0.68 and 0.80. Prior to the exploratory stock assessment one study reported total instantaneous mortality estimates derived from a Robsen-Chapman estimator of approximately 8.2 for dolphin from the Gulf of Mexico (Bentivolglio 1988). Prager (2000) indicated that the estimate did not seem feasible for the Atlantic where Beardsley (1967) found one 4 year old dolphin in a sample of 511. If one assumes random sampling, then the probability of finding a fish that old in such a small sample was close to zero. Therefore, it is almost certain that the estimate is imprecise or inaccurate, that the vital rates in the Gulf differ greatly from the Atlantic or the vital rates have changed dramatically over time (Prager 2000).

Absent direct estimates of mortality, two empirical methods of Hoenig (1983) and Pauly (1979) were applied to approximate mortality rates of dolphin in the Atlantic. Tables 4.1-21a and 4.1-21b present the estimates of total and natural mortality based on these methodologies. For the range of maximum ages reported in the three studies of 3 to 4 years, the Hoenig method provides estimates of total mortality rate Z from 1.42/yr declining to 1.06/yr (Table 4.1-21b). Estimates of M by Pauly's method are specific to growth parameters and water temperatures. Over the range of mean water temperatures from 20°C to 28°C, M is estimated to be between 0.68/year and 0.80/year (Table 4.1-21c).

Table 4.1-21a. Estimates of instantaneous rate of total mortality and corresponding annual survival fraction; method Hoenig (1983) (Source: Prager 2000).

Maximum age (years)	**Total Mortality rate (Z)**	**Survival Fraction (S)**
2.50	1.71	0.18
2.75	1.55	0.21
3.00	1.42	0.24
3.25	1.31	0.27
3.50	1.21	0.30
3.75	1.13	0.32
4.00	1.06	0.35
4.25	1.00	0.37
4.50	0.94	0.39
4.75	0.89	0.43
5.00	0.85	0.43

Table 4.1-21b. Estimates of instantaneous rate of annual natural mortality M as a function of growth parameters and mean water temperature; method of Pauly (1979) (Source: Prager 2000).

Mean water temp (C°)	**Natural Mortality (M) from Oxenford and Hunte (1983)**	**M from Beardsley (1967)**	**M from Rose and Hassler (1968)**
20	2.254	0.681	0.262
22	2.355	0.712	0.273
24	2.452	0.741	0.285
26	2.545	0.769	0.295
28	2.634	0.796	0.306
30	2.719	0.822	0.316

Movement Patterns and Stock Structure

Though there is a healthy ongoing debate about stock structure for dolphinfish in the Western Central Atlantic, the best available scientific information indicates that the U.S. portion of this range consists of a single stock. Oxenford (1997) conducted a preliminary investigation of the common dolphin stock structure within the western central Atlantic and suggested that there are at least two separate unit stocks located in the northeast and southeast regions of the western central Atlantic. This hypothesis was based on: observed seasonality, months of peak abundance, and mean size of dolphin from commercial and sport fisheries, which suggested two different migratory circuits; a comparison of life history characteristics of dolphin from North Carolina, Florida, and Barbados, which showed marked differences in average first year growth rates, fecundity-length relationships, size and age at first maturity, and mean mature egg size; and on observed differences in allelic frequencies at the IDH-2 locus determined through electrophoresis.

Table 4.1-21c. Estimates of instantaneous rate of annual natural mortality from the Western Central Atlantic (Oxenford 1999).

Location	Mortality Parameter	Mortality Model	Fish Group	Instantaneous Mortality (annual)	Percentage actual mortality (annual)	Reference
Gulf of Mexico	Total (Z)	Robson and Chapman (1961)	All	8.18	99.97	Bentivoglio (1988)
				8.23	99.97	
				8.67	99.98	
Barbados	Total (Z)	Ricker (1975)	All	3.93	98.03	Oxenford (1985)
		Beverton and Holt (1956)		5.84	99.71	
		Hoenig (1983)		4.22	98.53	
	Natural (M)	Pauly (1980)	All	2.56	92.23	Oxenford (1985)
			Males	3.3	96.29	
			Females	2.52	91.94	
St. Lucia	Total (Z)	Ziegler (1979)	All	3.53	97.07	Murray (1985)
	Natural (M)	Pauly (1983)	All	0.66	48.28	Murray (1985)

One conclusion from the Dolphin Wahoo workshop was that the working hypothesis should be a two stock model for the Western Central Atlantic and that the northern stock should include dolphin from the Gulf of Mexico, the U.S. South Atlantic including Puerto Rico, the U.S. Virgin Islands, the Mid-Atlantic, and the New England coasts (SAFMC 1998a).

A genetic study by Robyn S. Wingrove (2000) at the University of Charleston was conducted to test the hypothesis of Oxenford (1997) and investigate the possible presence of additional stocks in the Gulf of Mexico and western central Atlantic using Restriction Fragment Length

Polymorphism (RFLP) analysis of the ND-1 region of the Mitochondrial DNA (mtDNA). Dolphin DNA samples collected in the western central Atlantic originated from the Carolinas, Georgia, Florida, the Gulf of Mexico, Puerto Rico, Bermuda, the Azores, Martinique, Barbados, Tobago, and Brazil. The ND-1 region of each specimen was amplified by Polymerase Chain Reaction (PCR) and digested with five different restriction endonucleases. The results from the analysis of the frequency distribution of composite mtDNA haplotypes and Analysis of Molecular Variance (AMOVA) found no significant differences between samples collected in the western central Atlantic. These analyses support the hypothesis of a single unit stock and a management unit including common dolphin from the Gulf of Mexico, the U.S. South Atlantic including Puerto Rico, the U.S. Virgin Islands, the Mid-Atlantic, and the New England coasts would be appropriate. However, given the extremely limited amount of intermixing necessary to maintain genetic homogeneity between separate stocks, these results should not be taken as proof of a lack of stock structure.

Wahoo

Development

Eggs - No data currently exist on the distribution of wahoo eggs in the Atlantic. Adult wahoo spawn near Cuba in the Straits of Florida and Straits of Yucatan (Wollam 1969). Wollam (1969) also found larvae in these same areas. It is therefore postulated that wahoo eggs are similarly distributed.

Larvae - Wollam (1969) captured twelve larvae ranging from 4.5 to 10.0 mm standard length in the Straits of Yucatan and Florida. All of these larvae were taken in water depths greater than 400 m, except one larvae which was captured in 32 m of water. All larvae were captured between May and October, and none of the larvae were captured in surface waters. The larvae were caught in obliquely towed nets and Wollam (1969) stated that the larvae have a preference for waters below 100 m.

Juveniles - No data exist on the habitat of juvenile wahoo. It is assumed that juveniles inhabit waters with temperatures of 22° to 30° C and are associated with Sargassum. Juvenile wahoo are reported to travel in small schools (Hogarth 1976).

Adults - Adult wahoo in the Atlantic are pelagic in nature and generally associated with Sargassum (Manooch and Hogarth 1983). Rathjen and Squire (1960) recorded wahoo in similar temperature ranges of 22° to 28° C and from May to October off the coast of North Carolina. Adults feed mainly (over 95%) on fish (Hogarth 1976; Manooch and Hogarth 1983). Squids and crustaceans make up the remaining portion of their diet. Representative prey species found by Manooch and Hogarth (1983) were round herring (*Etrumeus teres*), Atlantic flyingfish (*Cypselurus melanurus*), frigate mackerel (*Auxis thazard*), butterfish (*Peprilus triacanthus*), porcupinefish (*Diodon hystrix*), juvenile carangids, and balistids. Round herring, Atlantic flyingfish, and frigate mackerel belong to the fast swimming pelagic community. The others belong to families that are associated with *Sargassum*. Manooch and Hogarth (1983) found that wahoo do not usually eat small food items, nor do they feed readily at the surface. They also found no apparent relationship between size of the wahoo and the size of the prey. They theorized that the wahoo is able to use its sharp teeth to render large fish into consumable sizes.

Spawning - Both females and males mature within the first year of life (Hogarth 1976). Males spawn when reaching a size of 860 mm total length and females when they reach 1,000 mm total length (Hogarth 1976). Wollam (1969) stated that wahoo have a long spawning season that lasts from May to October with a peak in June and occurs near Cuba in the Straits of Florida and Straits of Yucatan. Fecundity is size dependent in wahoo and was found by Hogarth (1976) to be 8.7 million eggs in a 1,365 mm total length female. He further estimated that a 1,550 mm female would produce 12.8 million eggs, a 1,645 mm female would produce 33.2 million eggs, and a 1,753 mm female would produce 45.3 million eggs.

Age and growth
Wahoo appear to be very fast growing in their first year attaining a size of over 39 inches (Hogarth 1976). The relationship between fork length and weight is presented in Figure 4.1-21. Estimates of L_∞ range from 2,210 mm FL (North Carolina) (Hogarth 1976) to 1,560 mm FL (St. Lucia) (Murray 1998). Estimates of k (annual) range from 0.152 (North Carolina) to 0.37 (St. Lucia).

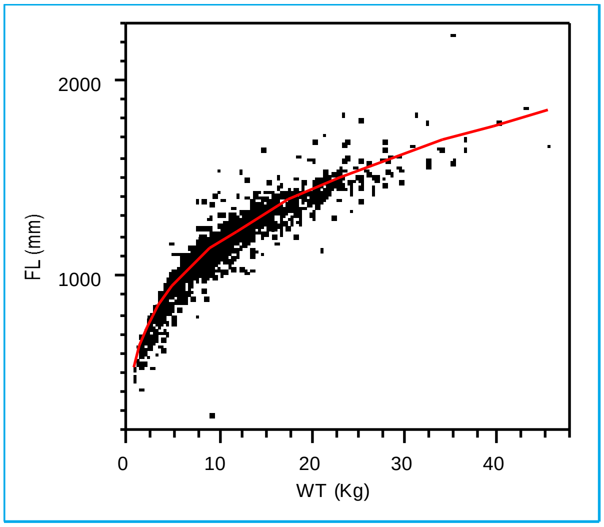


Figure 4.1-21. Wahoo, *Acanthocybium solandri*, length-weight relationship (Source: Goodyear 1999).

Mortality Rates and Longevity
The only mortality estimates available are from a study conducted in St. Lucia (Murray 1998). The values are listed below (Table 4.1-23) for five different years.

Table 4.1-22. Estimates of total and annual mortality for wahoo (Source: Murray 1998).

Mortality Model Used	Total Mortality (Z)	Annual Mortality (A)
Length based catch curve	1.17	68.96%
	1.52	78.13%
	1.45	76.54%
	1.75	82.62%
	2.34	90.37%

Longevity is believed to be at least 5 years based on work from North Carolina (Hogarth 1976).

Movement Patterns and Stock Structure
There have been no investigations of wahoo stock structure. Given this, a working hypothesis could be a single stock model for the western central Atlantic, including the Gulf of Mexico, the U.S. South Atlantic including Puerto Rico, the U.S. Virgin Islands, the Mid-Atlantic, and the New England coasts.

Ecological relationships

Dolphin

Dolphin are voracious, surface water, daytime predators. They eat a wide variety of fish species including: small oceanic pelagic species (e.g., flying fish, halfbeaks, man-o-war fish, Sargassum fish, and rough triggerfish); juveniles of large oceanic pelagic species (e.g., tunas, billfish, jacks, and dolphin); and pelagic larvae of neritic, benthic species (e.g., flying gurnards, triggerfish, pufferfish, and grunts). They also eat invertebrates (e.g., cephalopods, mysids, and scyphozoans) suggesting that they are essentially non-selective, opportunistic foragers. Rose (1966) examined the stomach contents of 373 dolphin off North Carolina and found the following food items by relative weight: Exocoetidae - 24%, Scombridae - 22%, Carangidae - 12%, Invertebrates - 12%, Miscellaneous Fish Families - 11%, Monacanthidae - 7%, Coryphaenidae - 5%, Unidentified Fish - 4%, and Balistidae - 3%. An analysis of prey ranked as to importance in dolphin diets is presented in Table 4.1-23

Predators (from Oxenford 1997; references included in Oxenford 1997):
The diets of other oceanic pelagic species indicate that dolphin, particularly juveniles, serve as prey for many oceanic fish. Their predators include large tuna (Parin 1968; *Thunnus alalunga*: Murphy 1914; *T. albacares*: Penrith 1963, Dragovich and Potthoff 1972, Takahashi and Mori 1973, Matthews et al. 1977), sharks (Parin 1968; *Hexanchus griseus*: Bigelow and Schroeder 1948), marlin (Sund and Girigorie 1966; Parin 1968: *Makaira nigircans*: Farrington 1949; Takahashi and Mori 1942; *Tetrapturus albidus*: Wallace and Wallace 1942; Nakamura 1971; Nakamura and Rivas 1972; *T. audax*: Abitia-Cardenas et al. 1997), sailfish (I*stiophorus platypturus*: Beardsley et al. 1972; Takahashi and Mori 1973) and swordfish (*Xiphias gladius*: Gorbunova 1969).

Wahoo are essentially piscivorous. Based on work in North Carolina (Hogarth 1976), fish accounted for 97.4% of all food organisms. These fish included mackerels, butterfishes, porcupine fishes, round herrings, scads, jacks, pompanos, and flying fishes. Invertebrates, squid, and the paper nautilus comprised 2.6% of the total food.

Table 4.1-23. Dietary importance (by rank) of the five main prey categories of dolphin (*Coryphaena hippurus*) from the western central Atlantic assessed by numerical abundance (Source: Oxenford 1997; references found in Oxenford 1997).

Location		**Southeastern & Gulf states of USA**	**North Carolina**		**Barbados**	
Data source		**Manooch et al. (1984)**	**Gibbs & Collette (1959)**	**Rose & Hassler (1974)**	**Lewis & Axelsen (1967)**	**Oxenford & Hunte**
No. dolphin		2219	46	396	70	397
Fish	Ammodytidae	.	3	.	.	.
	Balistidae	1	5	3	4	4
	Carangidae	5	.	2	.	.
	Coryphaenidae	.	.	4	.	.
	Dactylopteridae	.	.	.	1	1
	Exocoetidae	.	.	.	3	3
	Gempylidae	.	1	.	.	.
	Monacanthidae	.	.	.	2	.
	Nomeidae	.	.	.	5	.
	Ostraciidae	.	.	5	.	.
	Scombridae	.	2	.	.	.
	Syngnathidae	3	.	.	.	.
	Tetraodontidae	.	4	.	.	.
Invertebrates	Cephalopoda	.	.	.	.	5
	Decapoda	4	.	1	.	.
	Mysidacea	.	.	.	.	2
	Stomatopoda	2	.	.	.	.

Wahoo

Abundance and status of stocks

Dolphin

Time-series data seems to indicate neither decline in stock abundance nor a decrease in mean size of individual fish (SAFMC 1998a). Some stock analysis was provided by the Mackerel Stock Assessment Panel (MSAP 1992). Prager (2000) conducted the first comprehensive exploratory stock assessment for dolphin based on landings from the U.S. Atlantic and Gulf of Mexico. This assessment was conducted exclusively from U.S. pelagic longline data for 1986-1997. In the assessment, he estimated that dolphinfish was not overfished in 1998 because biomass was 150 percent of BMSY. Similarly, Prager determined that fishing mortality in 1997 was 50 percent less than FMSY and therefore dolphinfish were not overfished. The estimated MSY for this stock is 12,200 tonnes with an 80 percent confidence interval of 8,500~21,100. No decline in abundance was suggested by the CPUE indices. In fact, the biomass seems to increase significantly from the late 1980s to the early 1990s. The estimates generated by Prager (2000) suggest the species may be able to withstand a relatively high rate of exploitation. The abundance index developed for the assessment indicates an increasing trend in stock size, and the surplus production model based on the index, estimates the recent stock status to be above the biomass at MSY. However, Prager (2000) indicates that the positive indications are balanced by the uncertainty and numerous reasons for caution including: under excessive mortality rates, even a species resistant to exploitation may undergo geographically or temporally localized depletion or be exploited at suboptimal yield per recruit; the current stock structure is only based on limited evidence; and the estimates of vital rates are several decades old. This assessment did not evaluate the impact of the recreational fishery on the dolphinfish population, and according to this research, the mean size of dolphinfish caught has not declined historically although anecdotal evidence from local Miami anglers is to the contrary. The assumption of this assessment is also that the US longline catch is representative of all of the removals of the northern stock of western Atlantic dolphinfish. This is obviously not the case as removals by U.S. and Caribbean recreational anglers, Caribbean commercial fisheries and fisheries of countries such as Venezuela represent a large portion of the removals.

A preliminary stock assessment (Mahon and Oxenford 1999) conducted for dolphin from Barbados has key implications for taking a precautionary approach in the management of dolphin and wahoo resources (SAFMC 1998a):

A. There is a high risk of stock depletion with little warning given that the fishery may remain feasible at low stock levels because of the tendency of the fish to aggregate and the current trends for increasing fishing effort.

B. There is a potential for recruitment overfishing given that fish are economically valuable before size at first maturity and the high interannual variability in abundance apparently driven by environmental factors.

C. That a yield-per-recruit (YPR) approach to selecting a management target is probably inappropriate since even the more conservative F0.1 values are likely to lead to a significant reduction in spawning stock biomass.

D. A precautionary approach to management which in the first instance attempts to maintain the status quo of the fishery is recommended. This will require that current catch levels not be exceeded and that recent conflict between sectors of the fishery (commercial longliners and recreational anglers) be resolved. Status quo might reflect trends (average catch and effort levels) in the fishery over the last five years (through 1997).

Parker et al. (2000) assessed the dolphinfish stock in the eastern Caribbean using two types of length-based models (length-based catch curve and length-based virtual population analysis (VPA)). The results of this analysis suggested that fishing mortality is much greater than the fishing effort at MSY and as a result, catches from the stock are below MSY. These results were deemed to be highly uncertain and dependent on growth parameters that were not well estimated (Die 2004). The results of this research may also be skewed due to the fact that a separate northern and a southern stock is not well supported, and again, the assumption is that the analysis was on a representative portion of the removals for the stock. Therefore, the high mortality may be attributed to a migration from the eastern Caribbean to other regions.

Most recently, Parker and colleagues (2006) compiled catch statistics and a selection of abundance indices from around the Western Central Atlantic and analyzed these data using a non-equlibrium surplus production model called A Stock-Production model Incorporating Covariance (ASPIC) (Prager 1994). Ultimately, they concluded that existing data were insufficient to determine stock status. As is often the case with surplus production models, the dolphinfish model did not converge because of the lack of a clear best-fitting solution. The problem was that a simple explanation of stock dynamics would have been required to explain highly variable and generally increasing catch data with no clear signal of depletion in the abundance indices. Simple surplus production models are highly structured and so unable to provide complex explanations for such data. Yet, adequate data were lacking to support a more complex model. Any interpretation of these data must also take into account their generally poor quality.

Wahoo
To date there has been no attempt at a comprehensive stock assessment for wahoo. Therefore, the status of the stocks is unknown at this time. Proxy MSY estimates were provided by the NMFS SEFSC and were used to specify the status determination criteria in the Dolphin Wahoo FMP.

4.1.9 Calico Scallops

Description and Distribution

Calico scallops, *Argopecten gibbus* (Linnaeus 1758), are part of the bivalve mollusc family Pectinidae that contains all commercial species of scallops (Waller 1991). They are unified by series of minute denticles formed in the notch of the right valve, most visible in early juvenile stages. Waller (2006) indicates there are four major groupings or subfamilies, three of which are monophyletic (Camptonectinae, Palliolinae and Pectininae) and one of which is paraphyletic (Chlamydinae). At least six species in the subfamily Pectininae are commercially exploited: *Aequipecten operularis* (queen scallop), *Argopecten irradians* (bay scallops) and *A. gibbus* in the North Atlantic, *Aequipecten tehuelchus* (Tehuleche scallop) in the South Atlantic, and *Argopecten purpuratus* (Chilean scallop) and *A. ventricosus* (Catarina scallop) in the eastern Pacific.

Identification of calico scallops can be made from shell color and morphology. The upper (left) valve has red or maroon calico markings over a white or yellow base; the lower (right valve) is more lightly pigmented. The calico markings on the shell distinguish this scallop from the solid gray or brown upper valve of the bay scallop, which resembles the calico scallop in size. Calico scallop shell morphology varies with locality (Krause et al. 1994), but generally the species reaches 40 to 60 mm (1.6-2.4 in) in shell height (a straight line measurement of the greatest distance between the umbo and the ventral margin), with a maximum size reported to be about 80 mm (3.2 in) in shell diameter (a straight line measurement of the greatest distance between the anterior and posterior margin) (Roe et al. 1971). The shells are almost equally convex, deeply ridged, with 17 to 23 ribs on the right valve (Waller 1969).

The calico scallop occurs most often at moderate depths of 18-73 m (59-240 ft) and restricted generally to the continental shelf of the western North Atlantic and Gulf of Mexico between about 35° N and 20° N latitude (Broom 1976). The range includes the northern side of the Greater Antilles, throughout the Gulf of Mexico, to Bermuda and slightly north of Cape Hatteras (possibly Delaware Bay) in waters varying from 2 m (6.6 ft) at Bermuda to 370 m (1,214 ft) on the northern side of the Greater Antilles (Allen and Costello 1972). Off the Florida east coast, depth of occurrence was 9 to 74 m (30-243 ft) while off North Carolina, south of Cape Hatteras, calico scallops were reported at depths of 13 to 94 m (43-308 ft) (Allen and Costello 1972). Adults are generally restricted to open marine waters but juveniles do recruit to estuarine areas

(Waller 1969). The closely related species *Argopecten irradians* and *A. nucleus* have overlapping ranges but are more common in estuarine waters, especially seagrass beds.

Calico scallop beds are generally distributed on the continental shelf parallel to the coastline. These beds are most abundant off Cape Lookout, North Carolina; Cape Canaveral, Florida; and Cape San Blas, Florida, in the northeastern Gulf of Mexico (Allen and Costello 1972). Scallop abundance fluctuates at each area, with good years followed by years when none are available. On the Cape Canaveral grounds, scallops occur in long narrow bands, or beds, more than 800 m (2,625 ft) long and several hundred meters wide. A calico scallop bed near Cape Lookout, North Carolina, was elliptical and 15 km (9.3 mi) long. Off Cape San Blas, in 1957, a bed 16 km (9.9 mi) long by 8-16 km (5.0-9.9 mi) wide was located (Bullis and Ingle 1959). The greatest concentrations of these scallops appeared to be near coastal prominences (Allen and Costello 1972). A population of calico scallops was located in 1977 offshore of the South Carolina/Georgia border in 37-45 m (121-148 ft) (Anderson and Lacey 1979). The scallop bed was also elliptically shaped and oriented perpendicular to the coast. Concentrations have also been reported from the eastern Gulf of Mexico between Sanibel Island and Dry Tortugas.

The Cape Canaveral scallop grounds are among the largest in the world, extending over 321.8 km (200 mi) from St. Augustine to near Stuart, Florida. Depths of the heaviest concentrations of calico scallops off Cape Canaveral from 1960-1967 ranged from 26-49 m (85-161 ft), as recorded by exploratory fishing cruises (Miller and Richards 1980). Roe et al. (1971) reported depth distributional differences off Florida, noting scallops south of Cape Canaveral were generally found in shallower water than north of the Cape. However, Sutherland (unpublished report) reported that scallop beds located north of Cape Canaveral were not always found in deeper water than beds south of the Cape. Estimates of the calico stock distribution and abundance from data obtained with RUFAS (Remote Underwater Fishery Assessment System) were used to visually capture the scallop resource (c.f. May et al., 1971). Tumbler dredges were used to obtain ground-truth samples to enable comparison with historic survey and fishery data (Figure 4.1-22). They found the bed width was highly variable and ranged from 6.7 to 2,633.5 m (22 to 8,640 feet). Juvenile calico scallop beds in 1970 surveys accounted for almost 4 percent of scallop distribution. Scallop occurrence was uniformly less than 4 percent of completed transect miles.

Calico scallops occur off North Carolina at water depths of 13-94 m (Schwartz and Porter 1977). In April of 1949, a survey cruise by the Institute of Fisheries Research located calico scallops off New River Inlet (Chestnut 1951). Other beds located by the U.S. Bureau of Commercial Fisheries (now National Marine Fisheries Service) have existed intermittently since 1959. Cummins et al. (1962) reported that the principal calico scallop grounds located near Cape Lookout were described as elliptical in shape and were approximately 16 km long. Other lesser beds were located in 19-37 m depths northeast and southeast of the Cape. Schwartz and Porter (1977) reported that the fishery concentrated in an area located southeast of Cape Lookout in 1971. A bed located 16 to 24 km south of Beaufort, NC in depths of 20-25 m and inside the 28 m contour produced approximately 1 million pounds of meats in 1972 (Schwartz and Porter 1977). The R/V *Dan Moore*, a North Carolina Division of Marine Fisheries (NCDMF) exploratory research vessel, surveyed beds southwest of New River and northeast of Cape Lookout but failed to locate commercial quantities of calico scallops. Exploration by the R/V

Dan Moore in February and April 1975 in an area 20 nautical miles south of Bogue Inlet produced no scallops. This area only had shell material, sponge, coral and starfish (Powell et al. 1975a; Powell et al. 1975b). In 1978, the R/V *Dan Moore* surveyed a calico scallop bed off the coast of South Carolina. This trip was arranged after South Carolina biologists captured small sub-adult scallops incidental to rock shrimp during May of 1977. Trawlers taking rock shrimp were also catching large quantities of small scallops. In January of 1978, scallops were landed in Mount Pleasant, SC. This bed was located 77 km (48 mi) south of Charleston Sea Buoy and was determined to be 11.3 km (7 mi) in width and 8 km (5 mi) in length running perpendicular to the shore (Holland et al. 1978).

Government sponsored surveys in the South Atlantic Bight have been describing calico scallop distribution, along with other important benthic resources like the many species of shrimps, since at least the late 1950s (Bullis and Ingle 1959; Bullis and Cummins 1961). This program used a variety of trawls and dredges because of the large variety of targeted species, and often calico scallops were collected as by-catch of another targeted species. The program continued through at least the mid 1960s (Figure 4.1-22). Additional cruises in the 1970s utilized both dredge and video survey methods (May et al. 1971). During the peak of the fishery in the 1980s, there was some survey activity in Florida (Blake and Moyer 1989; Figure 4.1-23). Much more information was probably gathered by fishermen themselves (Figures 4.1-24 and 4.1-25).

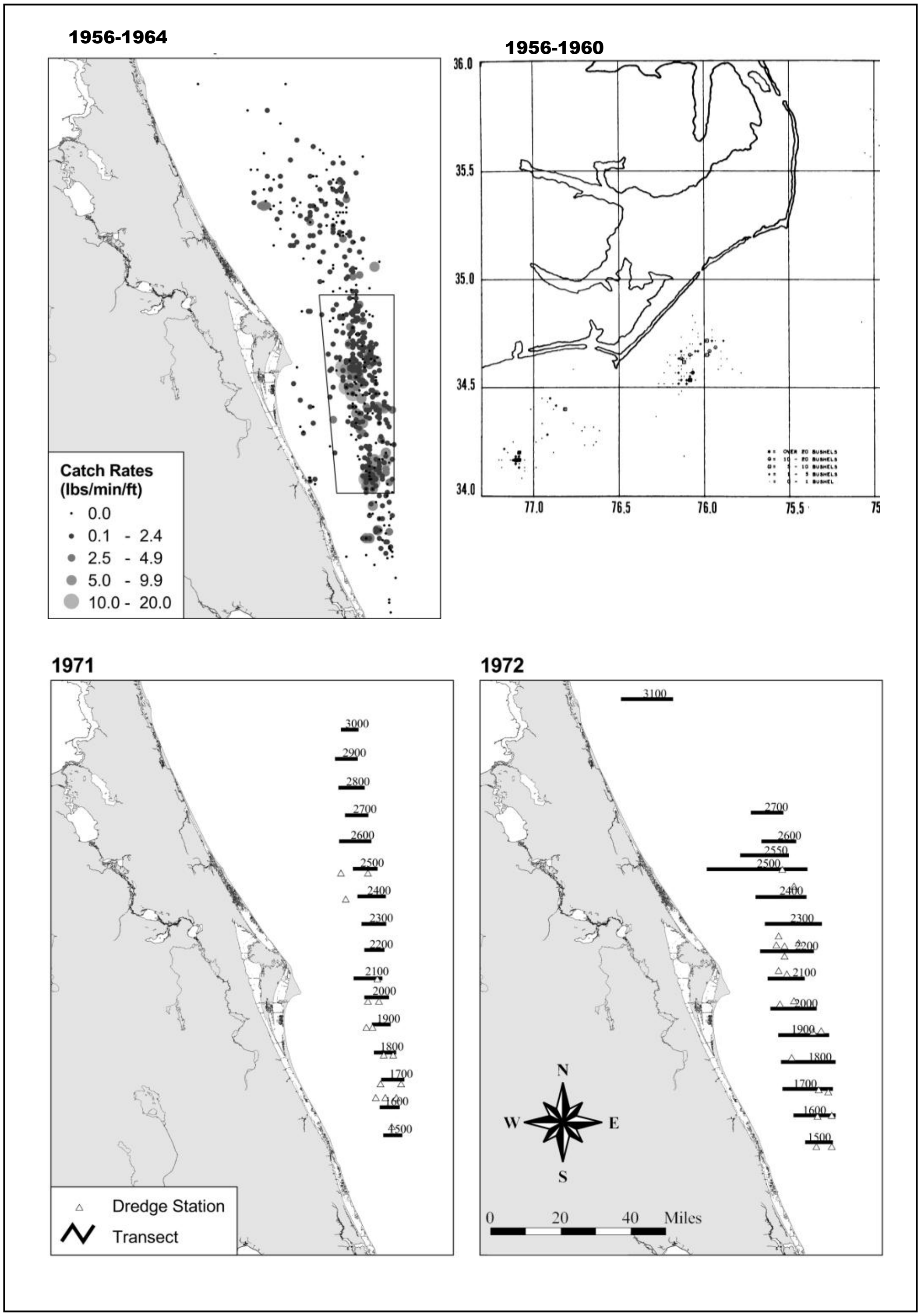


Figure 4.1-22. Historic NOAA calico scallop surveys. Top left, data compiled from the R/V *Silver Bay*. Top right, North Carolina surveys. Bottom, two "RUFAS" cruises.

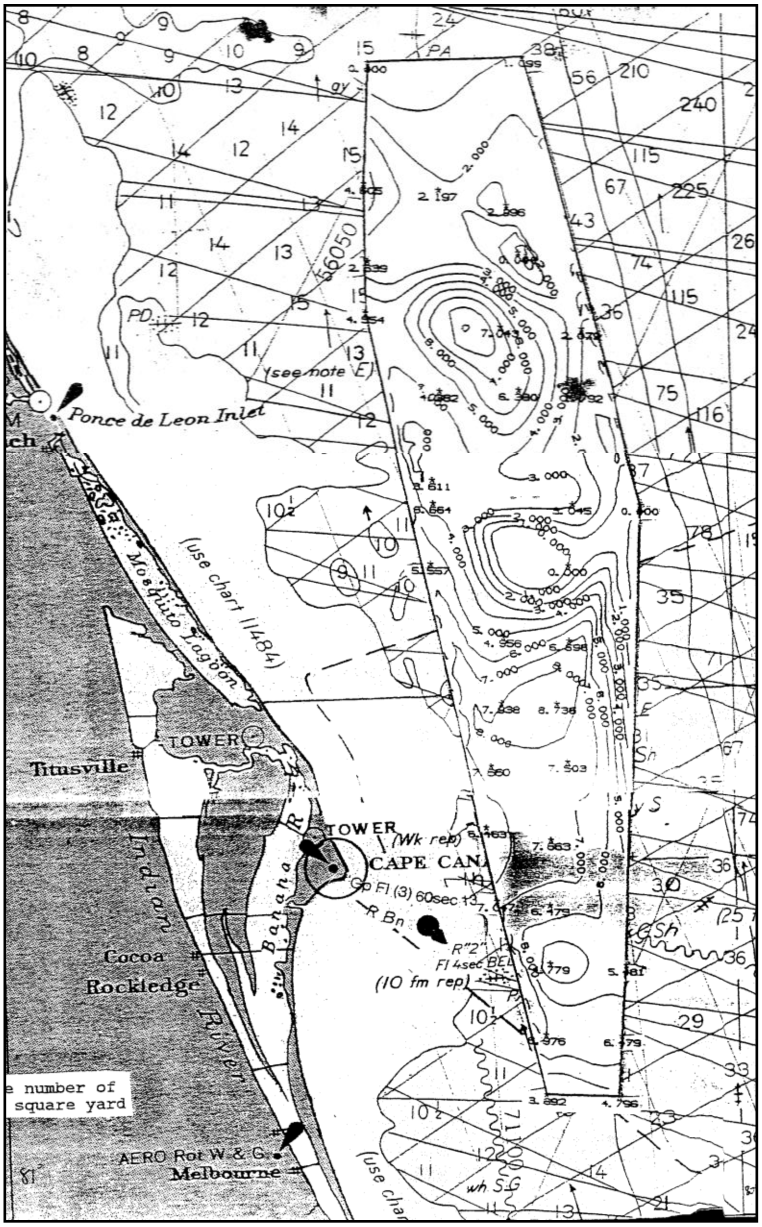


Figure 4.1-23. 1980s survey by Blake and Moyer, contours of estimated scallops per square yard.

Recent Florida surveys are being conducted under NOAA's MARFIN program (Figure 4.1-26). Figures 4.1-24 and 4.1-25 were provided by representatives of the calico scallop industry during scoping meetings and public hearings on calico scallop management and present recent calico scallop harvest areas/distribution, spawning locations, and shell distribution off southeast Florida.

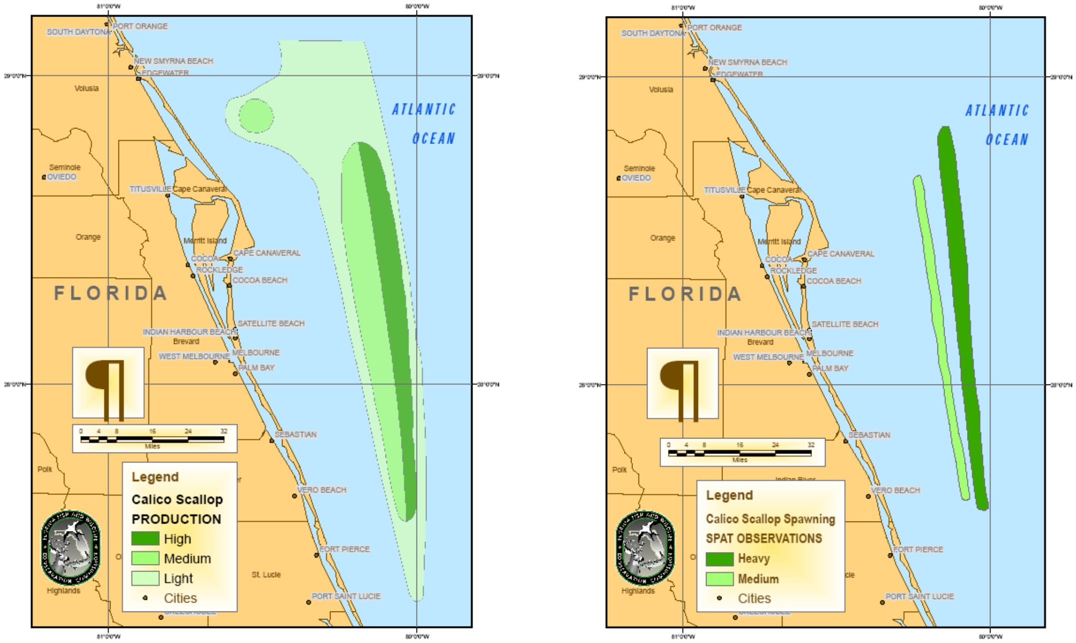


Figure 4.1-24. Calico scallop spawning areas and fishing grounds (Source: William Burkhardt, Calico Scallop Advisory Panel). Reproduced from SAFMC 1998 (Draft Calico Scallop FMP).

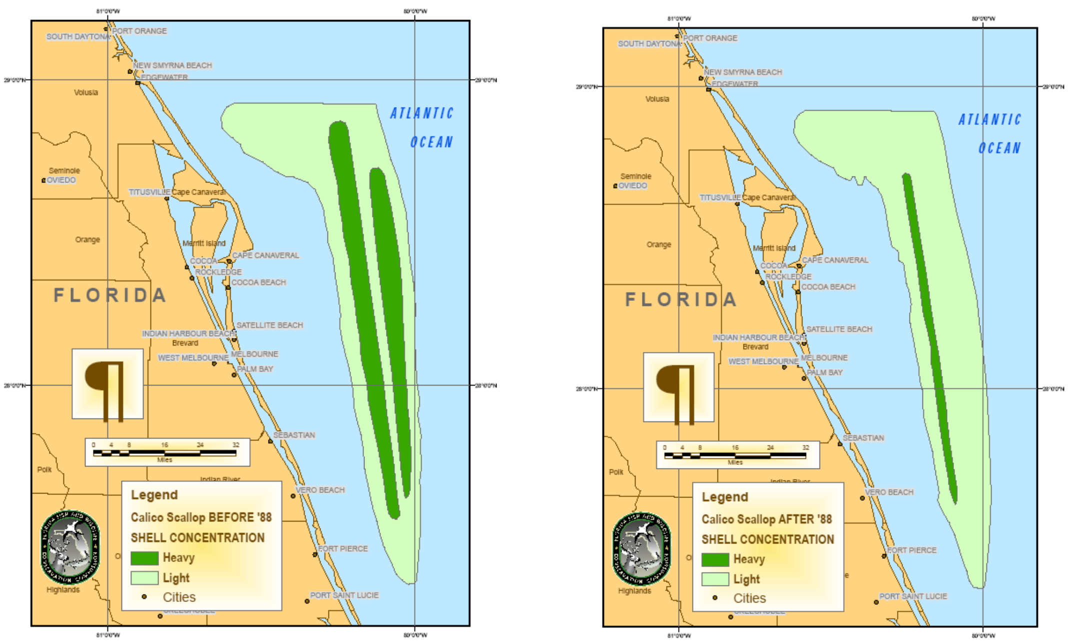


Figure 4.1-25. Calico Scallop shell distribution (Source: William Burkhardt, Calico Scallop Advisory Panel). Reproduced from SAFMC 1998 (Draft Calico Scallop FMP).

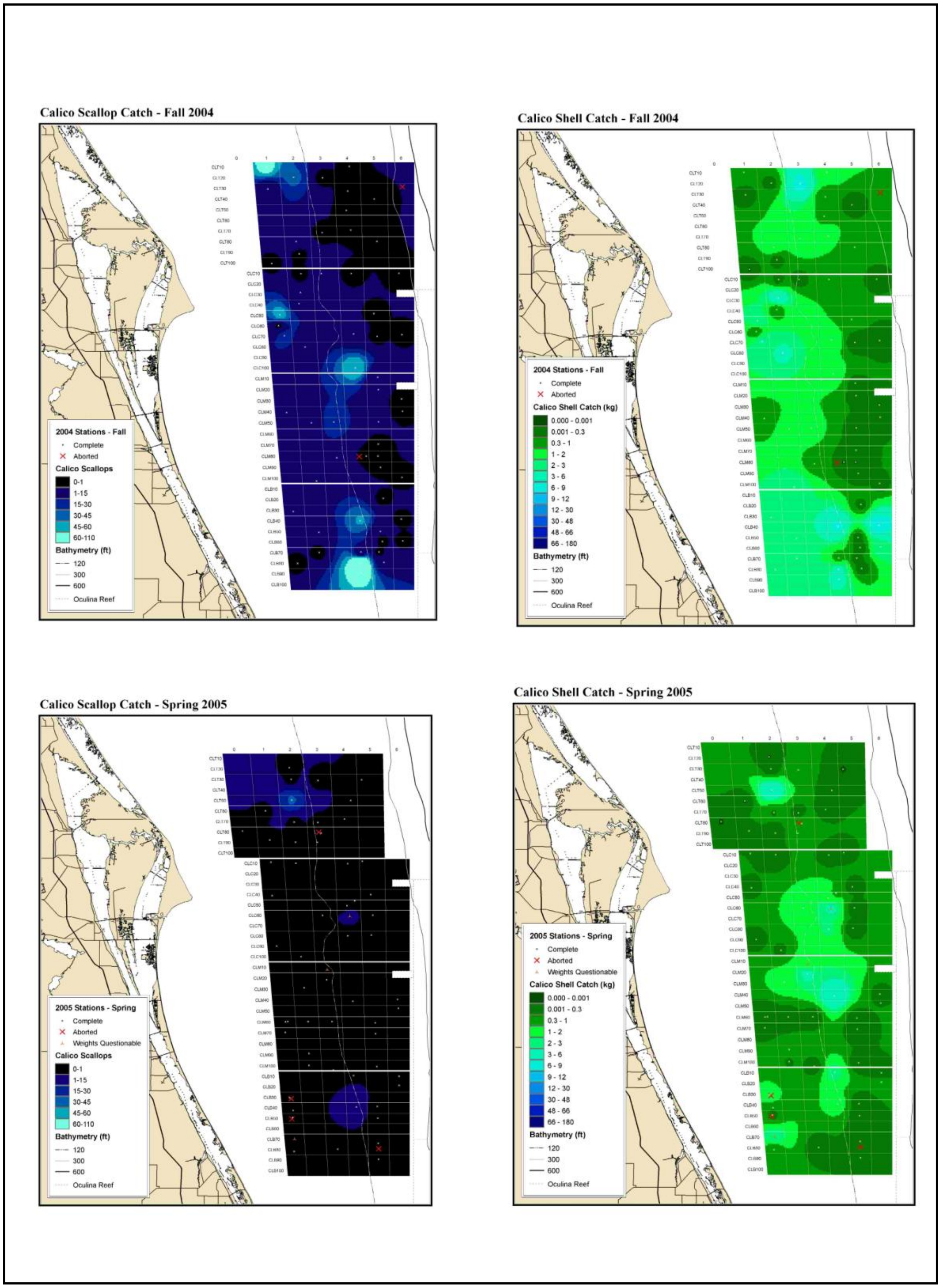


Figure 4.1-26. Current calico scallop distribution (left) and calico scallop shell distribution (right) for two seasons of sampling (FWRI) in the vicinity of Cape Canaveral, FL.

Reproduction

Maturity in Atlantic calico scallops is correlated with age rather than size (Roe et al. 1971). Change in ovarian color was found to correlate with reproductive stage (Miller et al. 1979). Scallops as small as 23.0 mm have been observed with developed gonads, and scallops as small as 20 mm, estimated to be as young as 71 days old, can probably begin spawning (Miller et al. 1979). Atlantic calico scallops are hermaphroditic, ejecting first sperm and then eggs into the water where fertilization occurs. Laboratory spawned calico scallops produced eggs with a diameter of 60 microns (Costello et al. 1973).

Changes in water temperature may stimulate spawning. Peak spawning is thought to occur at temperatures around 18°C (Allen 1979) in both spring and fall but scallops may spawn intermittently many times during the spawning season, and spat have been observed throughout the year. The fall peak is secondary to the spring peak, and does not occur in all years. No data on fecundity of Atlantic calico scallops was located. The closely related bay scallop (*Argopecten irradians*) can produce 12.6 to 18.6 million eggs at age 1 year, and some individuals will produce a second, smaller spawn at an age of 18 months (Bricelj et al. 1987). Based on an age at first reproduction of about 6 months, and a maximum age of 24 months, the oldest calico scallops may survive for up to four spawning seasons. It is difficult to determine if any individual scallop actually spawns more than once, because scallops often suffer increased mortality after a spawn, but multiple, smaller batches of eggs seems likely for this species.

Development, growth and movement patterns

In the laboratory at 23°C and 35 ppt, trochophore larvae were observed at 24 hr and larvae settled at 235-270 micron on day 16 (Costello et al. 1973). Larvae settle as spat in 14 to 16 days and attach to substrates with byssal threads from the foot. Juveniles can reach 10 mm by an age of two months, and thereafter grow at about 0.65 mm per week. Calico scallops reach commercial shell height of 4 to 4.5 cm (1.6 to 1.8 in) in 6 to 8 months, and have a life span averaging only 18 to 20 months, with a maximum age of 24 months (Allen and Costello 1972). The maximum shell height attained is at least 68.9 mm (Waller 1991).

Part of the North Carolina stock may result from larvae transported northward from the Cape Canaveral grounds by the Gulf Stream. Krause et al. (1994) found that the North Carolina stock and Cape Canaveral stocks were more similar morphometrically and genetically than two stocks within Florida waters. However, oceanographic data suggest that most larvae would be retained at Cape Canaveral (Leming 1979). Cyclic movement of bottom waters on and off the continental shelf ranged in period from 2-23 days during the summer (mean around 11.5 days) to 3-6 days in winter. Both were related to fluctuations in wind stress. The results also suggest that the net transport of most larvae would result in displacement from the spawning ground of only 7 - 40 km over the two week larval phase. The author also said that the predicted pattern of dispersal could explain the long, oval shaped beds which have been observed; elongate elipses roughly parallel to the bathymetry. These same patterns of water movement probably generate a high flux of both nutrient rich and food rich water across the shelf edge at depths around 40 m, which are optimal for the rich benthic abundance and diversity present.

Ecological relationships

Most scallops are primarily filter feeders on phytoplankton, benthic microalgae, and to varying degrees suspended particulate organic matter and detritus (Bricelj and Shumway 1991). Although no studies are available for calico scallops, the genus *Argopecten* has been studied extensively. Clearance rates vary from less than 1 liter/hr/g dry tissue weight at very high algal concentrations to over 10 liters/hr/g dry tissue weight at low algal concentrations (MacDonald et al. 2006). Using our rough estimates of 1 billion individuals, with an average dry tissue weight of 2 mg, the calico scallop population could then be estimated to clear 10 billion liter/hr (1 million m^3/hr) or 8.8 billion m^3/yr. In terms of biomass, these rates translate to about 8 mg/hr/g dry tissue weight or 140 million kg of phytoplankton per yr removed from the east Florida shelf waters.

Calico scallops can be among the most abundant members of the benthic community near the shelf edge and thus a large potential prey source for other species. Predators on juvenile and adult scallops include seastars, gastropods, squid, octopus, crabs, sharks, rays, and bony fishes. Schwartz and Porter (1977) found that at least 24 of the 33 most common fishes examined in North Carolina preyed on scallops. Nine species did so commonly: *Spheroides maculatus, Stenotomus aculeatus, Diplectrum formosum, Orthopristes chrysopterus, Monacanthus hispidus, Balistes capriscus, Centropristis striata, Mustelus canis*, and *Synodus foetens*. Two invertebrates, *Luidia clathrata* and *Astropecten articulatus*, were found to be common predators and at least 19 other invertebrates were implicated in scallop predation. One fear is that at-sea shucking of scallops may result in increased abundance of these predators on the scallop beds by attracting them to the discarded viscera. An additional survey in North Carolina waters in the 1980s found a similar collection of incidental species (Table 4-1-24). Economically important species include *Paralichthys albigutta*, *P. lethostigma*, and *P. dentatus*, as well as the penaeid shrimp *Farfantepenaeus duorarum* (Stephan 1989).

Wells et al. (1964) identified 112 species of benthic invertebrates from the North Carolina scallop beds, most of which were found as fouling organ isms on scallops shells. The most abundant was *Balanus amphitrite* (up to 200 per shell) and the polycheates *Pomatoceros caeruleus* (up to 65 per shell) and *Sabellaria floridensis* (up to 28 per shell). All three species were present on essentially every scallop. The dry weight of the associated epifauna weighed 40-50 percent of the dry weight of the shell itself. A similar amount of fouling occurred on the inside surface of the shells of dead scallops.

Table 4.1-24. List of incidental species captured from scallop trawl November 1988 (From Stephan 1989).

Species	Common Name
Finfish	
Bellator militaris	Horned searobin
Centropristis ocyurus	Bank sea bass
C. philadelphica	Rock sea bass
Citharichthyes macrops	Spotted whiff
C. spilopterus	Bay whiff
Diplectrum formosum	Sand perch
Etropus crossotus	Fringed flounder
Gymnachirus melas	Naked sole
Hippocampus erectus	Lined sea horse
Lagodon rhomboides	Pinfish
Monacanthus hispidus	Planehead filefish
Orthopristis chrysoptera	Pigfish
Paralichthys albigutta	Gulf flounder
P. dentatus	Summer flounder
P. lethostigma	Southern flounder
Prionotus evolans	Striped searobin
P. roseus	Bluespotted searobin
P. salmonicolor	Blackwing searobin
P. scitulus	Leopard searobin
Scophthalmus aquosus	Windowpane
Scorpaena sp.	Scorpionfish
Sphoeroides maculates	Northern puffer
Stenotomus chrysops	Scup
Syacium papillosum	Dusky flounder
Symphurus plagiusa	Blackcheek tonguefish
Synotus foetens	Lizardfish
Trachinocephalus myops	Snakefish
Invertebrates	
Aequipecten muscosus	Rough scallop
Arbacia punctulata	Purple urchin
Arcinella cornuta	Florida spiny jewelbox
Astropecten articulatus	Margined sea star
Calappa flamea	Shame-fase crab
Chione latilirata	Imperial venus
Cnidaria	Sea nettles
Glatheidea	Hermit crab
Hepatus epheliticus	Dolly Varden crab
Laevicardium laevigatum	Egg cockle
Ludia clathrata	Slender sea star
Lytechinus variegatus	Short-spined sea urchin
Murex sp.	Murex
Ophiothricidae	Short spined brittle star
Pecten raveneli	Ravenel's scallop
Farfantepenaeus duorarum	Pink shrimp
Portunus gibbessi	Portunid crab
P. spiymanus	Spiny-handed crab
Scyllaridae	Slipper lobster
Sicyonia sp.	Rock shrimp
Xenophora conchyliophora	Atlantic carrier shell

A protistan parasite of the genus *Marteilia* was first recorded from the east Florida calico scallop beds in samples collected during 1991 (Moyer et al. 1993). There is no direct evidence that this parasite caused mortality in the scallop population, but the samples from which the parasite was identified were collected during a major scallop mortality event that occurred in February 1991. Moreover, species of *Marteilia* have been implicated in mass mortalities of oysters in Europe and Asia (Moyer et al. 1993), so this organism certainly has the capability of instigating a mass mortality event in calico scallops. The history of *Marteilia* on the east Florida shelf, and its occurrence in calico scallop populations in the Gulf of Mexico or off North Carolina, is presently unknown.

Several other parasites have been linked to calico scallops but no mortalities have been directly attributed to them: *Echeneibothrium* (cestode) (Singhas et al. 1993), *Pontonia margarita* and *Pinnotheres maculatus* (decapod crustaceans), *Boonea seminude* (gastropod), *Ceratoneries tridentate* and *Polydora websteri* (polychaetes), and *Pinnotheres maculates* (crab) (Wells et al. 1964). The decapod crustaceans which inhabit the mantle cavity are likely commensal, causing little impact on host scallops. Worms that cause blisters (*Polydora* sp., *Pontonia* sp. and *Pinnotheres* sp.) weaken the shell and may increase the incidence of predation or at least cause the host to spend resources repairing injuries to the shell (Wells et al. 1964). *Odostomia seminuda* (ectoparasitic gastropod) will similarly drain resources by attaching to the shell and draining body fluids from the mantle edge (Wells et al. 1964). Eggs and developing larvae of the nematode *Sulcascaris sulcata*, the loggerhead stomach worm, may be found in muscles of calico scallops. This nematode in scallops has also been incorrectly identified as *Paranisakis pectinis* and possibly as a species of *Porrocaecum* (Cheng 1978). Eggs released in turtle feces can be ingested by scallops, and developed larvae can later re-infect turtles that consume scallops (Berry and Cannon 1981). The encysted larvae appear as a 2 - 2.5 mm blemish on the meat. They do not pose any threat to humans because it will be killed during freezing, cooking or even human body temperatures (Otwell and Koburger 1985). Another parasite, the encysted nematode larvae, *Echeneibothrium* sp., has been found in calico scallop gonads. Alteration of intestinal epithelium is the most serious tissue damage observed, but, failure of a local population in North Carolina coincided with the appearance of this parasite (Singhas et al. 1993).

Abundance and status of stocks

Most individuals of this species are probably located in the Cape Canaveral population. The maximum harvest, 42.7 million pounds in 1984, would equate to about 8.54 billion adult scallops, based on an average of 200 meats per pound (assuming 1 pint = 1 pound), assuming all of the scallops present were harvested. Other populations would add significantly to the potential overall abundance. The Florida Gulf of Mexico populations may reach abundances of around 1 billion or more, based on a harvest approaching 5 million pounds of meat 1993, and the North Carolina population might achieve abundances of 0.5 billion based on catches approaching 2 million pounds of meat in 1978. It is unknown if any of the populations are present at those levels today. Based on a 30 year average harvest of 5 million pounds per year, the Florida population would average around 1 billion individuals. The abundance in local populations can change by 50 fold between successive years (Anonymous 1981).

Disappearance of Atlantic calico scallops from a particular area commonly occurs, and the size of the stock shows considerable annual fluctuations. Monthly mortality on the Cape Canaveral bed was estimated at 12% during recruitment periods and 23 % during post-spawn periods, and ranged from 1-31% (Roe et al. 1971). Declines and mass mortalities have occurred on the grounds off North Carolina and Florida. Possible causes include migration, poor larval transport from elsewhere, and increased fishing pressure following introduction of shucking and eviscerating machines. Spawning stock is maintained because (1) not all beds are harvested each year; (2) the spawning stock includes scallops too small to market; and (3) individuals at densities too low to harvest.

The oceanography of the east Florida shelf is highly variable and strongly influenced by the Gulf Stream. Gulf Stream meanders and other topographic and meteorological events can induce upwelling of cold, nutrient rich water onto the continental shelf (Leming 1979). This water may have positive effects on scallop biology by increasing food supply (Atkinson et al. 1984). Negative impacts also are possible, particularly the dispersal of larvae away from the natal habitat as the upwelled water mass is swept northward off the shelf (Leming 1979). The implications of upwelling to calico scallops inhabiting the east Florida shelf are not well known, but such upwelling events are an historic feature of the continental shelf in this area and in other areas where abundant calico scallop populations have been recorded (e.g., Atkinson et al. 1984; Muller-Karger 2000). To the degree that upwelling events on the east Florida shelf reflect larger scale oceanographic events such as the El Niño Southern Oscillation (ENSO) or the North Atlantic Oscillation (NAO), which may cycle on a decadal or even longer time scale, these upwelling events may induce relatively long-term cycles in calico scallop abundance.

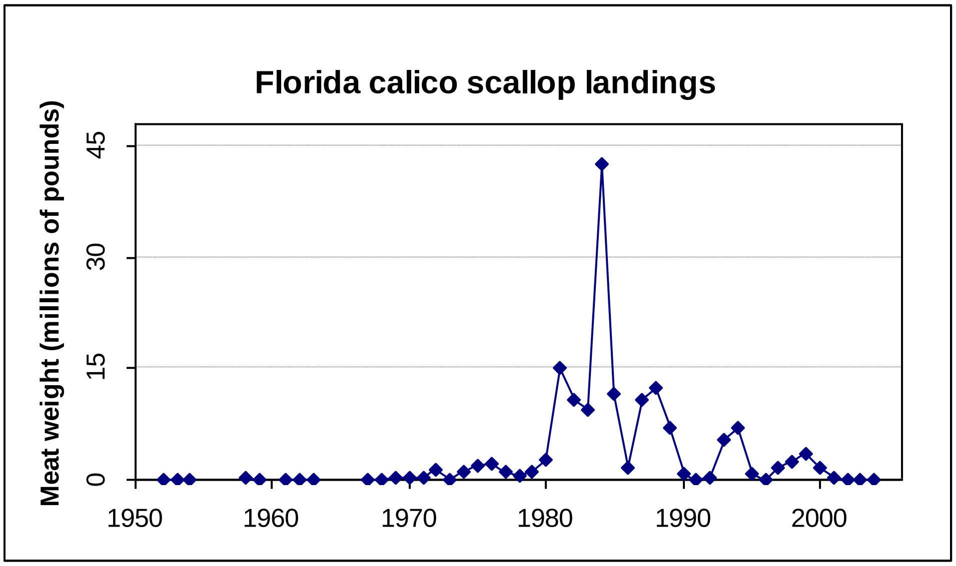
Reliable information on the geographic extent of current fishable stocks, if any, is unavailable. The most reliable data comes from fishery dependant monitoring in Florida and North Carolina (Table 4.1-25; Figure 4.1-27). These sources show that the fishery in NC peaked in 1972 and in Florida in 1984. Despite having annual harvests in Florida averaging 9.6 million pounds of meat per year for over a decade, and harvests that exceeded one million pounds in North Carolina there are no current harvests. Concentrations of scallops have been observed in the Cape Canaveral beds and off Cape San Blas in recent years, but not harvested.

The NCDMF has managed the calico scallop fishery by proclamation since 1974. North Carolina Fisheries Rules state that it is unlawful to land or possess aboard a vessel, calico scallops except at such times as designated by the Fisheries Director by proclamation (15A NCAC 3K .0504). The seasons varied through time based on the availability of calico scallops. Generally, calico scallop season opened in early spring and closed when catches became low. The last opening in North Carolina was in February of 2001 because of some scattered reports of available calicos. However, no landings were made in 2001. Presently, trawlers heading north out of Beaufort Inlet to participate in the summer flounder fishery will sometimes make a tow over the traditional beds to ascertain if commercial quantities of calico scallops exist (David Taylor, NCDMF, personal communication).

Table 4.1-25. Commercial landings and ex-vessel value from North Carolina (NCDMF Trip Ticket Program) and Florida calico scallop fishery.

YEAR	Pounds of Meat	Value $	Pounds of Meat	Value $
1952			275	
1953			3,742	861
1954			184	
1958			248,000	
1959	6,572	$2,629	15,400	
1960	111,726	$44,691		
1961	22,427	$8,971	3,648	1,459
1962			16,453	5,169
1963			176	39
1965	871,100	$244,709		
1966	1,856,760	$368,685		
1967	1,388,606	$308,843	20,736	7,672
1968			29,916	12.787
1969			196,724	179,473
1970	1,574,087	$498,570	195,764	195,764
1971	1,285,304	$432,025	288,575	370,299
1972	1,050,320	$492,899	302,767	407,030
1973	556,315	$353,757	1,624	2,055
1974			1,074,354	587,799
1975			1,882,239	1,249,510
1976			2,268,802	1,621,977
1977			113,244	837,170
1978			477,813	751,912
1979	43,301	$80,973	1,257,292	1,710,469
1980			2,582,471	3,619,497
1981	244,324	$307,215	15,170,881	14,277,460
1982			10,841,988	11,276,834
1983	101,977	$178,476	9,351,781	11,666,133
1984	1,184	$888	42,700,000	23,485,000
1985			11,500,000	18,170,000
1986			1,565,784	2,974,990
1987			10,936,384	21,982,131
1988	668,064	$702,134	12,410,456	22,338,820
1989	335,521	$469,164	6,981,704	11,938,713
1990	384,783	$530,590	874,376	820,165
1991			39,000	38,220
1992			205,111	174,906
1993	2,912	$3,640	5,306,545	4,439,34
1994			6,879,061	3,898,733
1995			949,805	625,912
1997			1,714,849	1,749,365
1998			2,396,511	2,065,041
1999			3,593,596	3,448,072
2000			1,740,000	482,069
2001			314,372	387,802
2002			42,232	63,020
2003			61,704	80,215
2004			0	0
2005			0	0

The intermittent fishery for calico scallops results from the unpredictable nature of scallop stocks. Naturally occurring fluctuations in stocks are attributed to natural mortality, migration, and poor larval recruitment. In addition, stocks may have been depleted by overfishing which stemmed from the introduction of the scallop shucking and eviscerating machines (Schwartz and Porter 1977; NCDMF 1989)



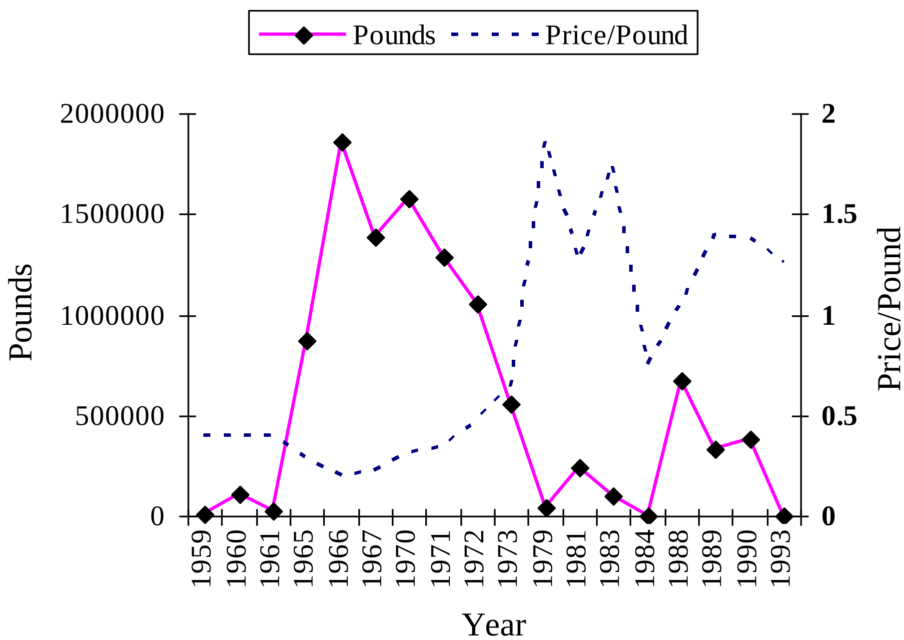


Figure 4.1-27. Ex-vessel value and price per pound for calico scallops (Schwartz and Porter 1977; NCDMF Trip Ticket Program).

The NCDMF has been involved in calico scallop monitoring since 1968 when monitoring was carried out on the R/V *Dan Moore* from 1968-1981. The last survey made by NCDMF was in November of 1988 on the scallop grounds east and west of Cape Lookout Shoals using a 3.7 m scallop trawl (Stephan 1989). Scallops consisting of two cohorts were found on the eastern side of the Cape only. The smaller size cohort consisted of shell heights of less than 46 mm and made up 43% of the total number of scallops. The larger cohort consisted of scallops whose shell height ranged from 48 mm to 64 mm (Figure 7).

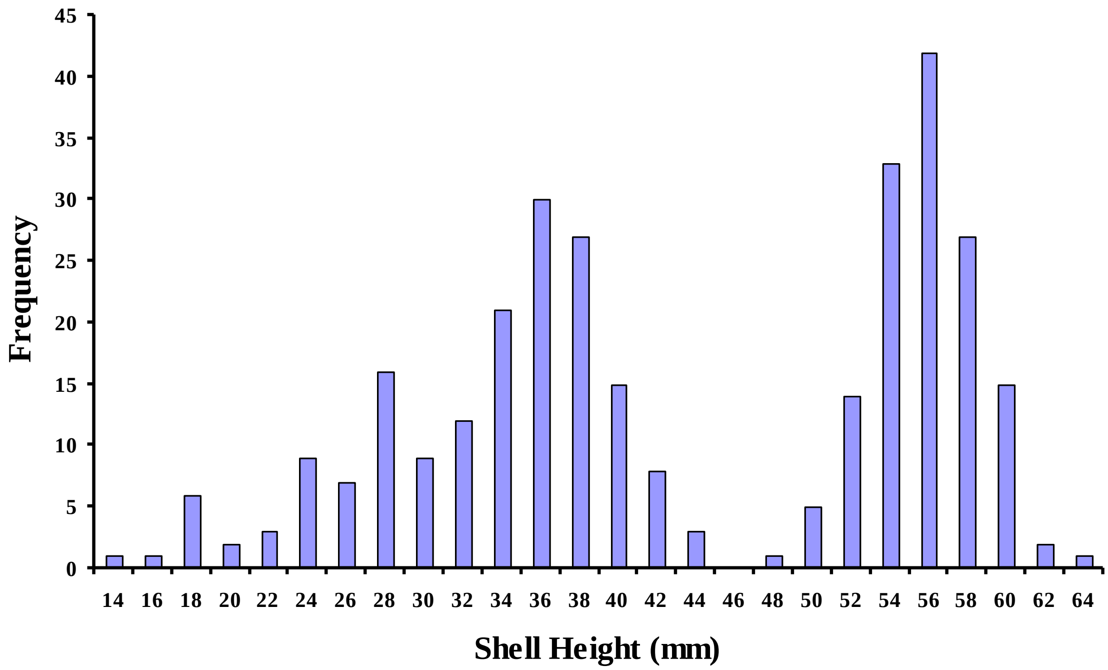


Figure 4.1-28. Shell height frequency for calico scallops collected November 1988 (From Stephan 1989).

4.2 Other Managed Species in the South Atlantic

4.2.1 Atlantic Menhaden

Description and Distribution

Atlantic menhaden are members of the worldwide family Clupeidae, one of the most important families of fishes both economically and ecologically (Ahrenholz 1991). Clupeids are characteristically very numerous and form large, dense schools. Many of the species are filter feeders, being either primary consumers, feeding on phytoplankton, or secondary consumers, feeding on zooplankton, or both. Many clupeids are in turn, prey for various piscivorous predators through virtually their entire life.

Atlantic menhaden are euryhaline species that inhabit nearshore and inland tidal waters from Florida to Nova Scotia, Canada (Ahrenholz 1991). Spawning occurs principally at sea with some activity in bays and sounds in the northern portion of its range. Eggs hatch at sea and the larvae are transported to estuaries by ocean currents where they metamorphose and develop as juveniles. Adults stratify by size during the summer, with older, larger individuals found farther north. During the fall, Atlantic menhaden migrate south and disperse from nearshore surface waters off North Carolina by late January or early February. Schools of adult menhaden reassemble in late March or early April and migrate northward. By June the population is redistributed from Florida to Maine (Ahrenholz 1991).

Atlantic menhaden are abundant in the estuarine and nearshore ocean waters of North America from Nova Scotia to central Florida. They have been taken in commercial quantities from northern Florida to southern Maine. A few individuals have been taken as far north as St. John, New Brunswick, and St. Mary Bay, Nova Scotia. The southern limit seems to be Indian River City, Florida (Hildebrand 1963). Spawning occurs in the ocean, while larvae and juveniles utilize coastal estuaries. The adult population stratifies by age and size, with the older and larger individuals farther northward, and the younger and smaller fish in the southern half of the species' range (Ahrenholz 1991).

Reproduction

Most Atlantic menhaden reach sexual maturity during their third year of life (late age 2) at lengths of 180 - 230 mm fork length (FL). Spawning occurs year-round throughout much of the species' range, with maximum spawning off the North Carolina coast during late fall and winter. Adults then move inshore and northward in spring and stratify by age and size along the Atlantic coast (Rogers and Van Den Avyle 1989). During this northern migration, spawning occurs progressively closer inshore and by late spring, some spawning occurs within coastal embayments. There are definite spring and fall spawning peaks in the Middle and North Atlantic Regions, with some spawning occurring during the winter in the shelf waters of the Mid-Atlantic Region. Larval menhaden have been collected as far as 64km inland in the Santee River channel and backwater sloughs, South Carolina (Meador 1982), suggesting spawning may occur in inland waters.

Atlantic menhaden are relatively prolific spawners. Predicted fecundities range from 38,000 eggs for a small female (180 mm FL) to 362,000 for a large female (330 mm FL) according to an equation derived by Lewis et al. (1987):

$$\text{Number of eggs} = 2563 * e^{0.015*FL}$$

This equation was derived by fitting an exponential model to length-specific fecundity data for fish collected in 1978, 1979 and 1981, as well as data reported in two earlier studies (Higham and Nicholson 1964; Dietrich 1979) for fish collected during 1956-1959 and in 1970. Fish in all three studies were collected from the North Carolina fall fishery, which harvests fish of all ages.

Analysis of eggs and larvae collected at various locations along the Atlantic coast during 1953-75 (e.g., Judy and Lewis 1983) generally confirmed earlier knowledge of spawning times and locations based on observations of adults with maturing or spent ovaries (e.g., Reintjes and Pacheco 1966). During December-March, most spawning-age fish congregate in offshore waters south of Cape Hatteras.

Maximum spawning probably occurs at this time. Checkley et al. (1988) reported maximum spawning off North Carolina in January 1986 during periods of strong northeast winds in upwelled water near the western edge of the Gulf Stream. Spawning continues at a decreasing rate closer inshore as fish migrate north in late March. By May, most spawning is restricted to coastal waters north of Cape Hatteras.

Spawning reaches a minimum in June, but continues at a low level until September north of Long Island. As mature fish migrate south in October, spawning increases from Long Island to Virginia. The capture of a 138 mm juvenile Atlantic menhaden in an estuary on the Maine coast in October 1990 (T. Creaser, Maine DMR, pers. comm.; as cited in ASMFC 1992) suggests that a limited amount of spawning may occur as far north as the Gulf of Maine. Some ripening female menhaden were offloaded on to the Soviet processing ship near Portland, Maine in August and September 1991 (S. Young, Maine DMR observer on the M/V *Riga*, pers. comm.; as cited in ASMFC 1992). Egg and larval surveys have been restricted to waters south of Cape Cod (Judy and Lewis 1983) and, thus, would not have produced any evidence for spawning in the Gulf of Maine.

Development, growth and movement patterns

Atlantic menhaden produce pelagic eggs about 1.5 mm in diameter which hatch within 2.5-2.9 days at an average temperature of 15.5°C (Hettler 1981). Embryonic development is completed in <36 hr at 20- 25°C, but takes about 200 hr at 10°C (Ferraro 1980). Egg mortalities observed in the laboratory were >90% at 10°C, and 48-92% at 15, 20 and 25°C (Ferraro 1980).

A full morphological description of Atlantic menhaden eggs and larvae was provided by Jones et al. (1978). Hettler (1984) compared Atlantic menhaden (*Brevoortia tyrannus*) larvae with gulf and yellowfin menhaden (*B. patronus* and *B. smithi*) larvae. Atlantic menhaden larvae co-occur with yellowfin menhaden larvae along the east coast of Florida to North Carolina, but not with gulf menhaden.

A fourth species (*B. gunteri*) occurs exclusively in the Gulf of Mexico. Powell and Phonlor (1986) also compared early life history characteristics of Atlantic and gulf menhaden.

Yolk-sac larvae hatched at 3-4 mm standard length (SL) and maintained at 16° and 24°C began to feed at 4.5-5 mm SL (Powell and Phonlor 1986). First feeding was a function of size, not age. Larvae raised at 16°C began feeding after 5 days, while larvae raised at 24°C began feeding after only 2 days. Larvae reached 10.7 mm SL after 21 days at 20°C. Caudal and dorsal fins developed at 9 mm, and all fin rays were developed by 23 mm (Reintjes 1969). The swimbladder and acoustico-lateralis system become functional in larvae measuring approximately 20 mm (Hoss and Blaxter 1982).

Low temperatures (<3°C for >2 days) killed most larvae held in laboratory experiments (Lewis 1965, 1966), although mortality depended on acclimation temperature and the rate of thermal change. Best survival occurred at temperatures >4°C and salinities of 10-20 ppt.

Larvae which hatch offshore are transported shoreward and enter estuaries in the south Atlantic region after 1-3 months at sea (Reintjes 1961) at a size of 14-34 mm FL (Reintjes and Pacheco 1966). Larval migration into estuaries occurs during May-October in the north Atlantic region, October-June in the mid- Atlantic, and December-May in the south Atlantic (Reintjes and Pacheco 1966). Larval condition improved rapidly after fish entered two North Carolina inlets (Lewis and Mann 1971).

Metamorphosis to the juvenile stage occurs at about 38 mm total length (TL) during late April-May in North Carolina estuaries and later in the year farther north. Most larvae entered the White Oak estuary (North Carolina) in March and moved upstream to a fresh water-low salinity zone where they transformed into "pre-juveniles" in late March-April and then into juveniles in late April-May (Wilkens and Lewis 1971). Other studies (Weinstein 1979; Weinstein et al. 1980; Rogers et al. 1984) also show young menhaden are more abundant in shallow, low salinity (< 5 ppt) estuarine zones. Metamorphosis to the "pre-juvenile" stage occurs at lengths >30 mm TL and to the juvenile stage beyond 38 mm TL (Lewis et al. 1972). Metamorphosis is rarely successful outside of the low-salinity estuarine zone (Kroger et al. 1974), although Atlantic menhaden have been successfully reared from eggs to juveniles in high salinity water (Hettler 1981).

The morphological changes that occur at metamorphosis are associated with a change in feeding behavior. Larvae feed on individual zooplankters, whereas juveniles rely more heavily on filter feeding (June and Carlson 1971; Durbin and Durbin 1975). This shift in feeding behavior is associated with a loss of teeth and an increase in the number and complexity of the gill rakers through which sea water is filtered as it passes through the gills. Older larvae (25-32 mm) feed on large copepods, but only rarely on small zooplanktonic organisms (Kjelson et al. 1975). Fish larger than 40 mm FL feed primarily on phytoplankton (June and Carlson 1971), but zooplankton has also been reported as an equally important food source in juvenile Atlantic menhaden (Richards 1963; Jeffries 1975). Juveniles are capable of filtering particles as small as 7-9 microns (Friedland et al. 1984) and, thus, directly utilize the abundant small photosynthetic organisms that are not consumed by most other species of fish. Detritus derived from saltmarsh cordgrass (*Spartina alterniflora*) has also been reported as a primary food source for juveniles in North Carolina saltmarshes (Lewis and Peters 1984). Based on calculations incorporating feeding rates and population estimates from eight east coast estuaries, Peters and Schaaf (1981) concluded that juveniles must consume more food during estuarine residency than is available from a strictly phytoplankton-based food chain.

Young-of-the-year menhaden congregate in dense schools as they leave shallow, estuarine waters for the ocean, principally during August to November (earliest in the north Atlantic region) at lengths of 75-110 mm TL (Nicholson 1978). Many of these juveniles migrate south along the North Carolina coast as far as Florida in late fall and early winter and then redistribute northward by size as age-1 fish during the following spring and summer (Kroger and Guthrie

1973; Nicholson 1978). Larvae which enter the estuaries late in the season may remain there for an additional year and emigrate to the ocean at age 1.

Age-1 menhaden migrate north and south along the coast over a greater distance than young-of-the-year juveniles (Nicholson 1978). Abundance and distribution of juvenile Atlantic menhaden is monitored by the marine resource agencies of most Atlantic coast states under a variety of estuarine surveys using trawls and seines. According to a survey conducted by AMAC in February 1990, juvenile menhaden have been taken from Massachusetts to Georgia (there is no survey on the Atlantic coast of Florida). Juvenile menhaden were observed in Gulf of Maine estuaries during 1998 and 1999.

Juveniles collected at 2-3 day intervals have shown growth rates of nearly 1 mm/day (Reintjes 1969). Water temperatures >33°C caused death in young-of-the-year and age-1 Atlantic menhaden (Lewis and Hettler 1968), although the time until death depended, in part, on acclimation factors. Sudden exposure to lethal temperatures, for example, caused greater mortality. Juvenile Atlantic menhaden can adjust rapidly to abrupt changes (increase or decrease) in salinity from 3.5 to 35 ppt and vice-versa (Engel et al. 1987). Juveniles raised in low salinity water (5-10 ppt) were more active, ate more, had higher metabolic rates, and grew faster than juveniles raised in high salinity water (28-34‰) (Hettler 1976).

Adult Atlantic menhaden are strictly filter feeders, grazing on planktonic organisms. They can be observed swimming slowly in circles, in tightly packed schools, with their mouths wide open and their opercula (gill flaps) flaring. In lab experiments (Durbin and Durbin 1975), they fed on small adult copepods as well as phytoplankton. Organisms smaller than 13-16 microns (slightly larger than the minimum size reported by Friedland et al. (1984) for juveniles) were not retained in the gills. Menhaden did not feed on large zooplankton (10 mm brine shrimp) in these experiments. The filtering process is purely mechanical; particles are not selected by size (Durbin and Durbin 1975). These experiments showed that the filtering rate depended on mouth size, swimming speed, food particle concentration, and the mechanical efficiency of the gill rakers. The structure of the "branchial basket," the area underneath the opercula where the extremely fine and closely-spaced gill filaments and gill rakers are located, was described in detail by Friedland (1985).

Growth occurs primarily during the warmer months. Fish as old as age 8 were fairly common during the 1950s and early 1960s, but in more recent years, fish older than age 6 have been rare. Older (age-6) fish reach an average length of 330 mm FL and a weight of 630 g, although growth varies from year to year and is inversely density-dependent. Growth rates appear to be accelerated during the first year when juvenile population size is low and are reduced when juvenile population size is high.

Adults migrate extensively along the entire United States East Coast. Following winter dispersal along the south Atlantic coast, adults begin migrating north in early spring, reaching as far north as the Gulf of Maine in June. Older and larger fish migrate farther than younger, smaller fish. The return southern migration occurs in late fall and early winter.

Stock Structure and Migration
The Atlantic menhaden resource is believed to consist of a single unit stock or population, based on tagging studies (Dryfoos et al. 1973; Nicholson 1978). Adult Atlantic menhaden undergo extensive seasonal migrations north and south along the United States East Coast. Early reports of this migratory behavior were made by Roithmayr (1963) based on the decrease in the number of purse seine sets north of Cape Cod in September. Also, Reintjes (1969) observed the disappearance of fish in October north of Chesapeake Bay and their appearance off the coast of North Carolina in November. Nicholson (1971) examined latitudinal differences in length-frequency distributions of individual age groups at different times of year and described a cyclic north-south movement with the largest and oldest fish proceeding farthest north such that the population stratifies itself by age and size along the coast during summer. A study of length frequencies at the time of first annulus formation on scales (Nicholson 1972) supported the concept of a north-south migratory movement and also indicated that a great deal of mixing of fish from all areas occurs off the North Carolina coast before fish move northward in spring.

Returns of tagged Atlantic menhaden (Dryfoos et al. 1973; Nicholson 1978) have generally confirmed what was already concluded from earlier work and added some important details. Adults begin migrating inshore and north in early spring following the end of the major spawning season off the North Carolina coast during December-February. The oldest and largest fish migrate farthest, reaching the Gulf of Maine in May and June. Adults that remain in the south Atlantic region for the spring and summer migrate south later in the year, reaching northern Florida by fall. Fish begin migrating south from northern areas to the Carolinas in late fall. During November, most of the adult population that summered north of Chesapeake Bay moves south around Cape Hatteras.

Mortality
The Atlantic menhaden population is subject to a high natural mortality rate. There is a somewhat reduced probability of death from natural causes when the population is being harvested. Natural mortality is also higher during the first two years of life than during subsequent years. Ahrenholz et al. (1987a) reported an annual instantaneous natural mortality rate (M) of 0.45 in the absence of fishing; this rate is equivalent to an annual reduction in population numbers of 36%. This rate is quite high compared to other pelagic marine species. Atlantic herring, for example, is characterized by an 18% annual natural mortality rate (Fogarty et al. 1989). During the 1955-1987 period, under exploitation, the annual natural mortality rate for age-1 Atlantic menhaden was 30% and, for ages 2 and older, it was 20% (see Vaughan 1990). Natural mortality removes an estimated 30% of the exploited population at age 1 and 20% each year thereafter.

Menhaden natural mortality is probably due primarily to predation, since the fish are so abundant in coastal waters during the warmer months of the year. All large piscivorous sea mammals, birds, and fish are potential predators on Atlantic menhaden. Menhaden are preyed upon by species such as bluefish, striped bass, king mackerel, Spanish mackerel, pollock, cod, weakfish, silver hake, tunas, swordfish, bonito, tarpon, and a variety of sharks.

Coastal pollution and habitat degradation threaten marine fish species, such as Atlantic menhaden, which spend their first year of life in estuarine waters and the rest of their life in both ocean and estuarine waters.

Other poorly understood sources of natural mortality for Atlantic menhaden are diseases and parasites. A partial list of parasites was given in Reintjes (1969), but there is no information available concerning the extent of parasitism or its possible effect on survival. Ahrenholz et al. (1987b) described the incidence of ulcerative mycosis (UM), a fungal infestation which was observed in menhaden over much of their range in 1984 and 1985 and in a more restricted area in 1986. A large fish kill in Pamlico Sound, North Carolina in November, 1984 was associated with UM, but its primary effect may be to weaken fish, making them more susceptible to other causes of mortality, such as predation, parasites, other diseases, and low dissolved oxygen concentrations. The overall impact of UM on the 1984 and 1985 year classes could not be assessed, but it was not believed to be significant (Ahrenholz et al. 1987b). However, Vaughan et al. (1986b) believed that the mortality effects of a disease or other event must be “truly catastrophic” to be detectable.

Another source of natural mortality for Atlantic menhaden (and many other species) may be “red tide.” The term refers to the color of water caused by the rapid multiplication (a “bloom”) of single-celled planktonic organisms called dinoflagellates, which produce a toxic compound. The toxin accumulates in the tissues of filter-feeding animals which ingest the dinoflagellate. An outbreak of red tide occurred along the coast of the Carolinas during November, 1987 - April, 1988 when Gulf Stream water containing the dinoflagellates was transported into coastal waters. Menhaden recruitment in Beaufort Inlet during this period was severely reduced (S. Warlen, NMFS, Beaufort N.C., pers. comm.; as cited in ASMFC 1992). A new species of toxic dinoflagellate was identified as the causative agent in a major menhaden kill in the Pamlico River, North Carolina, in May, 1991. Problems with toxic phytoplankton organisms may increase in the future since their appearance has been correlated with increasing nutrient enrichment in estuarine and coastal waters which are subject to increasing organic pollution (Smayda 1989).

An additional source of mortality are fish "kills" which occur when schools of menhaden enter enclosed inshore bodies of water in such large numbers that they consume all available oxygen and suffocate. The mean lethal dissolved oxygen concentration for menhaden has been reported to be 0.4 mg/l (Burton et al. 1980). Bluefish are known to follow (or even chase) schools of menhaden inshore, feeding on them, and may contribute to their mortality by preventing them from leaving an area before the oxygen supply is depleted. Oxygen depletion is accelerated by high water temperatures which increase the metabolic rate of the fish; at the same time, oxygen is less soluble in warm water. Menhaden which die from low oxygen stress can immediately be recognized by the red coloration on their heads caused by bursting blood capillaries. Just before death, the fish can be seen swimming very slowly in a disoriented manner just below the surface of the water. This is a common phenomenon which has been observed throughout the range of the species. Menhaden spotter pilots have reported menhaden "boiling up" from the middle of dense schools, and washing up on the beach, apparently from oxygen depletion within the school. This phenomenon was observed during December, 1979 in the ocean off Atlantic Beach, North Carolina (M. Street, NC DMF, pers. comm.; as cited in ASMFC 1992). Smith (1999a) reported a similar event off Core Banks, North Carolina, in December 1997. Other species are not nearly as susceptible simply because they do not enter enclosed inshore waters in such large numbers.

Ecological relationships

Menhaden are extremely abundant in nearshore coastal waters because of their ability to directly utilize phytoplankton, which is the basic food resource in aquatic systems. Other species of marine fish are not equipped to filter such small organisms from the water. Consequently, such large populations of other species cannot be supported. Because menhaden are so abundant in nearshore coastal and estuarine waters, they are an important forage fish for a variety of larger piscivorous fishes, birds, and marine mammals. In ecological terms, menhaden occupy a very important link in the coastal marine food chain, transferring planktonic material into animal biomass. As a result of this, menhaden influence the conversion and exchange of energy and organic matter within the coastal ecosystem throughout their range (Peters and Schaaf 1981; Lewis and Peters 1984; Peters and Lewis 1984).

Because menhaden only remove planktonic organisms larger than 13-16 microns (7 microns for juveniles) from the water, the presence of large numbers of fish in a localized area could alter the composition of plankton assemblages (Durbin and Durbin 1975). Peters and Schaaf (1981) estimated that juvenile menhaden consumed 6-9% of the annual phytoplankton production in eight estuaries on the east coast, and up to 100% of the daily production in some instances. A large school of menhaden can also deplete oxygen supplies and increase nutrient levels in the vicinity of the school. Enrichment of coastal waters by large numbers of menhaden can be expected to stimulate phytoplankton production. Oviatt et al. (1972) measured ammonia concentrations (from excretion) inside menhaden schools that were five times higher than ambient levels 4.5 km away. At the same time, chlorophyll values increased by a factor of five over the same distance, indicating the grazing effect of the fish on the phytoplankton standing crop. Oxygen values were not significantly reduced by the fish, but were much more variable inside the schools than outside them.

Also, in a study of energy and nitrogen budgets (Durbin and Durbin 1981), food consumption rates, energy expenditures, and growth efficiency were examined. Results indicated that swimming speed, the duration of the daily feeding period, and the concentration of plankton in the water controlled the energy and nitrogen budgets for this species.

Predator/Prey Relationships

Atlantic menhaden are a major forage species for a wide number of important predatory fish species including, but not limited to, bluefish, striped bass, weakfish, king mackerel, bluefin tuna and sharks (Grant 1962; Reintjes and Pacheco 1966; Manooch 1973; DeVane 1978; Saloman and Naughton 1983; Juanes et al. 1993; Hartman and Brandt 1995a, 1995b). Marine mammals, including whales and porpoises, also have been reported to feed on menhaden (Bigelow and Schroeder 1953). Since Atlantic menhaden are eaten by predators in several ecosystems, they serve as a direct pelagic link in the food web between detritus and plankton and top predators (Rogers and Van Den Avyle 1989).

Ecological Role

Atlantic menhaden occupy two distinct types of feeding niches during their lifetime. They are size selective plankton feeders as larvae and filter feeders as juveniles and adults. Data on the food of larvae before they enter the estuary is currently unavailable. After entering the estuary, menhaden larvae appear to be extremely selective for prey of certain sizes and species. Larvae from the Newport River estuary, North Carolina, ranging in size from 26-31 mm TL (mean = 29 mm TL), consumed copepods and copepodites of only four taxa, which composed 99% by number and volume of their gut contents (Kjelson et al. 1975). These prey items, ranging from 300 to 1200 microns in length (mean = 750 microns), were eaten despite an abundance of copepod nauplii, barnacle larvae, and small adult copepods in plankton tows. Larvae that were offered copepods in the laboratory ignored all other food items, including *Artemia* and *Balanus* nauplii (June and Carlson 1971). Larval menhaden in the Newport River estuary, North Carolina, fed primarily during daylight (Kjelson et al. 1975).

Juvenile and adult Atlantic menhaden strain particulates from the water column with a complex set of gill rakers. The rakers can sieve particles down to 7-9 microns (Friedland et al. 1984), including zooplankton, larger phytoplankton, and chain-forming diatoms. Biochemical analyses indicated that the gut contents of juveniles vary with prey availability; reliance on zooplankton decreases as the fish move from open waters to marshes (Jeffries 1975). Atlantic menhaden may also be capable of eating epibenthic materials (Edgar and Hoff 1976). Peters and Schaaf (1981) speculated that the annual phytoplankton and phytoplankton based production in east coast estuaries is not sufficient to support the juvenile Atlantic menhaden population during its residency and that the abundant organic detritus may be eaten in addition to copepods, etc. Lewis and Peters (1984) reported that juvenile Atlantic menhaden in North Carolina salt marshes primarily ate detritus.

The role of Atlantic menhaden in systems function and community dynamics has received little attention. Larvae and juveniles are seasonally important components of estuarine fish assemblages (Tagatz and Dudley 1961; Cain and Dean 1976; Bozeman and Dean 1980). Estimates of the mean daily ration for larvae range from 4.9% (Kjelson et al. 1975) to 20% (Peters and Schaaf 1981) of wet body weight.

Assimilation of ingested energy exceeded 80% for plant and animal material (Durbin and Durbin 1981). Because of their tremendous numbers, individual growth rates, and seasonal movements, these fish annually consume and redistribute large amounts of energy and materials, including exchanges between estuarine and shelf waters. Kjelson et al. (1975) noted that the copepod taxa preferred by larval menhaden and other species decreased from a mean value (2 years) of 81% to 48% of the total zooplankton biomass during the period of larval residence. They speculated that this decrease may be partly explained by larval feeding. Durbin and Durbin (1975) suggested that Atlantic menhaden in coastal waters may also alter the composition of plankton assemblages by grazing on certain size ranges.

Related Species and Hybrids

There are two species of menhaden that occur on the Atlantic coast, the Atlantic menhaden, *Brevoortia tyrannus*, and the yellowfin menhaden, *B. smithi*. Yellowfin menhaden range from Cape Lookout, North Carolina, to the Mississippi River delta (Ahrenholz 1991). The numbers of

Atlantic menhaden relative to yellowfin menhaden become reduced proceeding southward along the Atlantic coast of Florida. A large amount of hybridization occurs between these two species and areas with pure strains of yellowfin menhaden have yet to be defined. As the relative density of Atlantic menhaden decreases as one proceeds southward, the number of Atlantic x yellowfin menhaden hybrids increases along with pure strains of yellowfin menhaden. Historically, the menhaden gill net fishery in Indian River, Florida, was dominated by yellowfin menhaden and the Atlantic x yellowfin menhaden hybrid (Dahlberg 1970). Yellowfin menhaden were traditionally targeted by specialized bait fisheries in Florida but this may have changed due to the net ban implemented by that state in 1995.

Abundance and status of stocks

(Source: ASMFC, 2007 FMP Review)
Status of the coastwide stock is determined based on the terminal year (2005) estimate relative to its corresponding limit (or threshold). Benchmarks have been estimated based on the results of the updated base run. The terminal year estimate of fishing mortality rate (F2+) was estimated to be 56% of its limit (and 91% of its target). Correspondingly, the terminal year estimate of population fecundity was estimated at 158% of its fecundity target (and 317% of its limit).

Hence, the coastwide stock is not considered to be overfished, nor is overfishing occurring.

The model used in the assessment (ASMFC 2006) calculates the benchmarks referred to above using the method described in Addendum I of Amendment 1 to the Menhaden FMP. The values used for benchmarks change each assessment as new data are added to the model. For a historical comparison of fishing mortality rate relative to its annually estimated threshold benchmark (F/Frep) and population fecundity relative to its annually estimated target (FEC/FECtarget), please see Figure 7.5 of the Stock Assessment Report.

The current coastwide estimate of F is near the lowest of the time series (1955-2005). However, recent recruitment estimates are of concern because they are below the 25th percentile [Table 6.2, ASMFC 2006]. Most of the concern stems from the decline in juveniles seen in Chesapeake Bay as documented by the Virginia and Maryland seine surveys. The Technical Committee has provided research recommendations in the past to better understand poor recruitment in Chesapeake Bay. Several projects are ongoing to address this issue.

The current stock assessment model has several limitations. It cannot provide details on the status of the menhaden stock in geographical areas smaller than coastwide. However, the Stock Assessment Subcommittee is considering how to incorporate a spatial component into the stock assessment prior to the next peer review. In addition, the model is not capable of addressing questions of multispecies interactions. Many ongoing research projects are being conducted and the MSVPA-X is being implemented to provide more information to answer those questions.

4.2.2 Striped Bass

Description and Distribution

(Source: Amendment 6 to the Striped Bass FMP, ASMFC 2003)

The striped bass is a long-lived (at least up to 29 years of age, Merriman 1941; Secor et al. 1995) species which normally spends the majority of its adult life in the coastal estuaries or the ocean, migrating north and south seasonally, and ascending rivers to spawn in the spring. Mature female striped bass (age 4 and older) produce large quantities of eggs, which are fertilized by mature males (age 2 and older) as they are released into waters of riverine spawning areas. The fertilized eggs drift downstream with currents while developing, eventually hatching into larvae. The larvae and postlarvae begin feeding on microscopic animals during their downstream journey. After their arrival in the nursery areas, located in river deltas and the inland portions of the coastal sounds and estuaries, they mature into juveniles. They typically remain in coastal sound and estuaries for two to four years, and then migrate to the Atlantic Ocean. In the ocean, fish tend to move north during the summer and to the south during the winter. Important wintering grounds for the mixed stocks are located from offshore New Jersey as far south as Cape Hatteras, NC historically including the North Carolina sounds. With warming water temperatures in the spring, the mature adult fish migrate to the riverine spawning areas to complete their life cycle. In general, the Chesapeake Bay spawning areas produce the majority of coastal migratory striped bass.

Atlantic coastal migratory striped bass live along the eastern coast of North America from the St. Lawrence River in Canada to the Roanoke River and other tributaries of Albemarle Sound in North Carolina. Stocks which occupy coastal rivers from the Tar-Pamlico River in North Carolina south to the St. Johns River in Florida are believed primarily endemic and riverine and apparently do not presently undertake extensive Atlantic Ocean migrations as do stocks from the Roanoke River north (Richkus 1990). Striped bass are also naturally found in the Gulf of Mexico from the western coast of Florida to Louisiana (Musick et al. 1997). Striped bass were introduced to the Pacific Coast using transplants from the Atlantic Coast in 1879. Striped bass also were introduced into rivers, lakes, and reservoirs throughout the US, and to foreign countries such as Russia, France and Portugal (Hill 1989).

Reproduction

Spawning

Striped bass spawn in freshwater or nearly freshwater of Atlantic Coast rivers and estuaries. They spawn above the tide in mid-February in Florida but in the St. Lawrence River they spawn in June or July. The bass spawn in turbid areas as far upstream as 320 km from the tidal zone (Hill 1989). The tributaries of the Chesapeake Bay are the primary spawning areas for striped bass, but other major areas include the Hudson River, Delaware Bay and the Roanoke River. Spawning is triggered by increased water temperature (Shepherd 2000). Spawning occurs between 10 and 23 degrees Celsius, but optimal temperature for spawning is between 17 and 19 degrees Celsius. No spawning occurs below 13 degrees Celsius or above 22 degrees Celsius (Bain 1982). Spawning is characterized by brief excursions to the surface by females surrounded by males, accompanied by much splashing. Females release eggs in the water. This is where fertilization occurs (Raney 1952). Striped bass do not eat during spawning but they may eat heavily before and afterward. Spawning occurs in the late afternoon and early evening as well as late evening and early morning.

Development, growth and movement patterns

Eggs and larvae

An egg is only viable for about an hour for fertilization. Following fertilization the fertilized eggs are spherical, non-adhesive, and semi-buoyant and will harden within one to two hours at 18 degrees Celsius (Hill 1989). Eggs need adequate water velocity, from either current or tidal flow, to keep them suspended in the water column. Survival of striped bass eggs is dependent on environmental conditions. A temperature range of 17-19 degrees Celsius is important for egg survival as well as for maintaining appropriate dissolved oxygen

Yolk-sac larvae occur in open water but ultimately form schools and migrate inshore. The fin fold larvae and larger larvae have been collected in mid-channel areas near the bottom. Occurrence of fin fold larvae varied with the time of day and the depth of the river (Hill 1989). Striped bass larvae usually stay in the open surface waters of estuaries.

There are three stages of larval development. These are: yolk-sac larvae, finfold larvae, and post-finfold larvae (Hill 1989). The yolk-sac larvae occur right after hatching and this stage usually lasts for about 3 to 9 days. They are 2.0 to 3.7 mm in length and contain an easily identified yolk-sac. The yolk-sac is the main source of energy for the striped bass during this time. Also during this time, the mouth has not been formed and the eyes are not pigmented (Mansueti 1958). This phase is finished when the yolk-sac is absorbed. The finfold phase lasts for about 11 days and the striped bass reach a length of 12mm. The last phase is the post-finfold larvae which lasts for about 20 to 30 days and the larvae reach a length of 20 mm (Bain 1982).

Survival of the larvae depends on three main factors: temperature, salinity, and dissolved oxygen. The optimal temperature for larvae is 18 to 21 degrees Celsius, but temperatures of 12 to 23 degrees Celsius have been and can be tolerated (Bain 1982). Studies have shown that striped bass larvae do better and have a higher survival rate when they are in low salinity waters rather than freshwater (Setzler et al. 1980). The third factor, dissolved oxygen, is equally critical for larvae as it was for the egg stage. A reduction in the dissolved oxygen level diminishes the chances of survival of the larvae (Turner and Farley 1971). Other factors that also influence the survival of striped bass larvae include turbulence. While at first it is necessary for the larvae to reside in turbulent waters to maintain position, the larvae quickly become motile and then are able to maintain position on their own (Doroshev 1970).

Juveniles

Juvenile striped bass are able to tolerate a wider range in environmental conditions. The habitat requirements for the juvenile fish are much like the habitat required for the adult bass. As the juvenile bass grow, they migrate to nearshore areas and then to higher salinity areas of an estuary (Raney 1952). Juvenile striped bass prefer clean, sandy bottoms but they have been found in gravel beaches, rock bottoms, and soft mud areas. They are usually found in schools of as many as several thousand fish.

However, the location of the schools depends on the age of the fish (Hill 1989).
Striped bass become juveniles at about 30 mm, when the fins are fully developed. At this point they resemble adults. Bluefish, weakfish, and other piscivores prey on striped bass (Buckel et al.

1999; Hartman and Brandt 1995b). The location of the striped bass determines the content of its diet. In the diet of the stock from the York River, where the salinity was higher than other places, the fish fed on mysids. In the James River, where the salinity was lower, the same sized fish fed mostly on insects. This and other evidence showed that there is a relationship between the diet of the stock of striped bass and the salinity of the habitat in which the fish live (Setzler et al.1980).

Adults

Mature adult striped bass leave the estuaries and migrate along the coast where they have similar temperature and dissolved oxygen requirements as juvenile bass (Bain 1982). Tagging studies indicate that fish from all stocks range widely along the Atlantic Coast, generally remaining in state (0-3 miles) waters but in some areas entering the Exclusive Economic Zone (EEZ; 3-200 miles). Studies are presently underway, using Geographic Information Systems (GIS) analysis, to characterize the habitats used by striped bass when they are in nearshore waters during the summer, fall and winter months. Schools of striped bass which winter off North Carolina use nearshore habitats from the surf zone to beyond the state-EEZ boundary line.

Migration Patterns

Migration of striped bass occurs at juvenile and adult stages. Migratory patterns for all life stages vary by location, but in general juveniles migrate downstream in summer and fall, while adults migrate upriver to spawn in spring, afterwards returning to the ocean and moving north along the coast in summer and fall, and south during the winter (Shepherd 2000).

Juvenile striped bass migration varies by locations. In Virginia, the movement of young bass during their first summer was downstream into waters of higher salinity (Setzler et al. 1980). In the Hudson River, the bass began migrating in July. Migration was documented through an increase in the number of juvenile striped bass caught along the beaches and subsequent decline in the numbers in the channel areas after mid-July. Downstream migration continues through late summer, and by the fall, juveniles start to move offshore into Long Island Sound (Raney 1952).

Juvenile striped bass rarely complete coastal migrations, but even though fish that are under the age of two are non-migratory, many do leave their birthplaces when they are two or more years old. From Cape Hatteras, North Carolina, to New England, fish may migrate in groups along the coast. They migrate north in the summer and south in the winter, however, the extent of the migration varies between sexes and populations (Hill 1989). Larger bass, typically the females, tend to migrate farther distances. However, striped bass are not usually found more than 6 to 8 km offshore (Bain, 1982). These coastal migrations are not associated with spawning and usually begin in early spring, but this time period can be prolonged by the migration of bass that are spawning.

Some areas along the coast are used as wintering grounds for adult striped bass. The inshore zones between Cape Henry, Virginia, and Cape Lookout, North Carolina, serve as the wintering grounds for the migratory segment of the Atlantic coast striped bass population (Setzler et al. 1980). There are three groups of fish that are found in nearshore ocean waters of Virginia and North Carolina between the months of November and March, the wintering period. These three groups are bass from Albemarle and Pamlico Sounds, North Carolina, fish from the Chesapeake Bay, and large bass that spend the summer in New Jersey and north (Holland & Yelverton 1973).

Based on tagging studies conducted under the auspices of the Southeast Area Monitoring and Assessment Program (SEAMAP) each winter since 1988, striped bass wintering off Virginia and North Carolina range widely up and down the Atlantic Coast, at least as far north as Nova Scotia, and represent all major migratory stocks (U.S. Fish and Wildlife Service and National Marine Fisheries Service, unpublished data).

Ecological relationships

Striped bass larvae feed only on mobile planktonic food. They pass the prey repeatedly in order to aim and rush at the prey successfully. It was found that the first successful feeding of a 9-day-old larvae occurred at concentrations of 15,000 Cyclops nauplii and copepodites per liter. By the 11th and 12th day, when the air bladder of the larvae is filled, the prey concentration may be reduced to 2,000 and 5,000 per liter. By days 40 to 50, the striped bass feed on plankton and epibenthos and by days 50 to 80, the food of the striped bass larvae includes mysid shrimp, gammarid amphipods, and fish up to 20 mm in length (Doroshev 1970).

Abundance and status of stocks

At the 2006 Annual Winter Board Meetings, the Striped Bass Technical Committee submitted a request to the Striped Bass Management Board to bypass the 2006 annual update stock assessment in favor of having more time to prepare new methods and better data for the 2007 benchmark stock assessment. The Board approved this request, such that the most recent data on the status of the stock are derived from the 2005 stock assessment.

The estimate of total abundance for January 1, 2005 from the ADAPT VPA was 65.3 million age-1 and older fish. This estimate is about 1.2 million fish lower than the 2004 abundance but 10% higher than the average stock size for the previous five years. Population estimates were calculated for the first time this year from tag-based F estimates using the catch equation. The 2004 population estimate of age 3+ fish was 48.5 million fish; that is, roughly 8 million fish higher than the 2003 estimate. This estimate is higher than the ADAPT VPA estimate of 39.2 million age 3+ fish at the beginning of 2004. This discrepancy in population estimates between the two approaches increased with older age classes. The tag-based approach estimated the 2004 population of age 7+ fish to be 17.1 million, whereas the ADAPT VPA estimated the age 7+ population to number 9.4 million fish. The abundance of older fish (age 13+) in the stock estimated from the ADAPT VPA increased from 382,000 fish at the beginning of 2003 to 547,000 fish on January 1, 2005.

The female spawning stock biomass for 2004 was estimated (from the VPA) at 54.8 million pounds, which is above the recommended biomass threshold of 30.9 million pounds (13,956 mt) and the target SSB of 38.6 million pounds (17,500 mt). SSB has declined by 9% since 2002 when it peaked at 60.6 million pounds.

Recruitment of the 2004 cohort for all stocks combined is 12.7 million age-1 fish, which is close to the average age-1 recruitment observed since the stocks were declared recovered in 1995.

Based on VPA results, average age 8-11 fishing mortality in 2004 was estimated at F=0.40 which is below the Amendment 6 threshold of 0.41 but exceeds the target of 0.30. However, it was the consensus of the Technical Committee members that this was likely an overestimate of the 2004 F given the uncertainly with the terminal year estimate from the VPA and the systematic positive bias observed in the retrospective analysis. The 2003 value of F from the 2005 VPA is 0.29, which is substantially lower than the terminal year F from the 2004 VPA run of 0.62. This is due not only to the addition of another year's worth of data, but to the modified suite of tuning indices used in the 2005 VPA and the inclusion of wave 1 (Jan./Feb.) estimates of recreational harvest mortality from NC and VA for 1996 – 2004 (see Data and Uncertainty section in Plan Review Document available at www.asmfc.org).

The 2004 tag-based estimates of F using stock-specific, model-based estimates of fishing mortality and a constant M of 0.15 were as follows. For fish greater than 28 inches, the coast-wide average F was estimated as 0.29 and specific tagging program values ranged from 0.02 in the New York ocean haul survey (NYOHS) to 0.31 in the Maryland (MD) tagging program. This value was similar to the VPA F weighted by N value for age 7-11 fish of 0.32. For fish greater than 18 inches, the coast-wide average F was estimates as 0.29 and specific tagging program values ranging from 0.06 in the Virginia spawning stock (VARAP) program to 0.68 in the New Jersey Delaware Bay (NJDEL) program. This tag-based F estimate was greater than the VPA F weighted by N value for age 3-11 fish of 0.15.

The 2004 variable M tag-based estimates of F for fish greater than 28 inches indicated the coast-wide average F was 0.14, and specific tagging program values ranged from 0.09 in the VARAP program to 0.26 in the Delaware and Pennsylvania (DE-PA) tagging program. These F estimates were less than the VPA F weight by N, for age 7-11 fish, of 0.32. For fish greater than 18 inches, the coast-wide average was 0.11, and specific tagging program F estimates ranged from 0.05 in three different programs to 0.17 in the MD program. This tag-based F estimate is similar to the VPA F weighted by N value for age 3-11 fish of 0.15. Chesapeake Bay fishing mortality in 2004 was estimated as F=0.16 by the direct enumeration study. This F represents mortality during the June 2003 – June 2004 period, so it is not directly comparable to the average, weighted (by N) VPA calendar-year F on age 3-8 striped bass that is equal to 0.12.

4.2.3 Alewife

Description and Distribution

(all information below from draft ASMFC alewife doc)
The alewife, *Alosa pseudoharengus*, is an anadromous, highly migratory, euryhaline, pelagic, schooling species. Both alewife and blueback herring are often referred to as "river herring," a collective term for these two species, which often school together (Murdy et al. 1997). Although this term is often used generically in commercial harvests and no distinction is made between the two species (ASMFC 1985), landings are reported as alewife (Dixon 1996).

The alewife spends the majority of its life at sea, returning to freshwater river systems along the U.S. Atlantic Coast to spawn. There are also some alewife populations that have been successfully introduced into landlocked freshwater systems, such as the Great Lakes and some of the Finger Lakes of New York (Scott and Crossman 1973), as well as those that have been stocked in man-made reservoirs (Bigelow and Schroeder 2002). Their historical coastal range was South Carolina to Labrador and northeastern Newfoundland (Berry 1964; Winters et al. 1973; Burgess 1978), but more recent surveys indicate that they do not occur in the southern range beyond North Carolina (Rulifson 1982; Rulifson et al. 1994). Alewife from the southernmost range are capable of migrating long distances (over 2000 km) in ocean waters of the Atlantic seaboard and patterns of migration may be similar to those of American shad (Neves 1981). Although alewife and bluebacks co-occur throughout much of their range, alewife are typically more abundant than bluebacks in the northern part of their range (Schmidt et al. 2003).

Several long-term data sets were recently analyzed to determine the current status of alewife in large river systems along the Atlantic Coast, including the Connecticut, Hudson, and Delaware rivers. These analyses suggest that alewife are showing signs of overexploitation in all of these rivers, including reductions in mean age, decreases in percentage of returning spawners, and decreases in abundance. Researchers did note that some runs in the northeastern U.S. and Atlantic Canada have been increasing recently (Schmidt et al. 2003). Alewife appear to be doing well in inland waters, colonizing many freshwater bodies, including all five Great Lakes (Waldman and Limburg 2003). Much of the research regarding specific environmental requirements of alewife, such as temperature, dissolved oxygen, salinity, and pH has been conducted on landlocked populations, not anadromous stocks therefore, data should be interpreted with discretion.

Development, growth and movement patterns

Spawning

Adult alewife populations migration to spawning grounds in freshwater and brackish waters progresses seasonally from south to north, with populations further north returning as the season progresses (and water temperatures increase). Fish typically begin spawning from late February in their southern range and June in their northern range (Neves 1981; Loesch 1987). Neves (1981) suggested that alewife migrate from offshore waters north of Cape Hatteras, encountering the same thermal barrier as American shad, then move south along the coast for fish homing to South Atlantic rivers; northbound pre-spawning adults head north along the coast (Stone and Jessop 1992). They spawn in rivers as far south as North Carolina and as far north as the St. Lawrence River, Canada (Neves 1981). Fish may spawn as late as June in the southern range and through August in their northern range (Marcy 1976a). Spawning is triggered most strongly by a change in the water temperature. Movement upstream may be controlled by water flow, with increased movement occurring during higher flows (Collins 1952; Richkus 1974). Although adult alewife will move upstream at various times, peak migration typically occurs during the day, between dawn and noon, and also from dusk to midnight (Richkus 1974; Rideout 1974; Richkus and Winn 1979). High midday movement is restricted to overcast days, and nocturnal movement occurs when water temperatures are abnormally high (Jones et al. 1978). Males are first to arrive at the mouths of spawning rivers, prior to the arrival of females (Cooper 1961; Tyus 1971; Richkus 1974.

There is strong evidence that suggests that alewife home to their natal rivers to reproduce, but some colonize new areas; they have also been found to reoccupy systems from which they have been extirpated (Havey 1961; Thunberg 1971; Messieh 1977; Loesch 1987). Messieh (1977) found that alewife strayed considerably to adjacent streams in the St. Johns River, Florida, particularly during the prespawning period (late winter, early spring), not during the spawning run. It appears that olfaction is the primary means for homing behavior (Ross and Biagi 1990).

In general, alewife are less selective in choosing their spawning sites than blueback herring. Alewife will select slow-moving sections of rivers or streams to spawn, where the water may be as shallow as 30 cm (Jones et al. 1978). They may enter lakes or ponds, including freshwater coves behind barrier beaches (Smith 1907; Belding 1920; Leim and Scott 1966; Richkus 1974; Bigelow and Schroeder 2002). Alewife often spawn in ponds that form the headwaters of most coastal streams in New England and Nova Scotia (Loesch 1987). They are typically more abundant than bluebacks in rivers where there are well-developed headwater ponds in New England. In rivers where headwater ponds are absent or poorly-developed, alewife may be most abundant further upstream in headwater reaches, while bluebacks may select the mainstream proper for spawning (Ross and Biagi 1990). In tributaries of the Rappahannock River, Virginia, upstream areas were found to be more important than downstream areas for spawning alewife (O'Connell and Angermeier 1997). Although earlier studies suggested that alewife will ascend further upstream than bluebacks (Hildebrand 1963; Scott and Crossman 1973), Loesch (1987) noted that both species have the ability to ascend rivers far upstream.

Alewife are noted for their greater ability than American shad for navigating suitable fishways (Dominy 1973). In rivers where dams are an impediment, spawning may occur in shore-bank eddies or deep pools (Loesch and Lund 1977). Alewife will generally spawn 3-4 weeks before blueback herring in areas where they co-occur; however, there may be considerable overlap (Loesch 1987) and peak spawning periods may differ by only 2-3 weeks (Jones et al. 1978). In a tributary of the Rappahannock River, Virginia, O'Connell and Angermeier (1997) found that blueback eggs and larvae were more abundant than those of alewife, but alewife used the stream over a longer period of time. They also reported that there was only a 3-day overlap of spawning by alewife and bluebacks. Although it has been suggested that alewife and bluebacks select separate spawning sites in sympatric areas to reduce competition (Loesch 1987), O'Connell and Angermeier (1997) reported that the two species used different spawning habitat. They suggested that there was a temporal, rather than spatial segregation that minimized the competition between the two species.

Alewife may spawn throughout the day, but do so more commonly at night (Graham 1956). One female fish and as many as 25 male fish broadcast their eggs and sperm simultaneously just below the surface of the water or over the substrate (Belding 1920; McKenzie 1959; Cooper 1961). Spawning lasts 2-3 days for each group or "wave" of fish that arrives (Cooper 1961; Kissil 1969; Kissil 1974), with older and larger fish usually spawning first (Belding 1920; Cooper 1961; Libby 1981, 1982). Upon spawning, spent fish return quickly downstream (Bigelow and Schroeder 2002).

Alewife are repeat spawners, with some fish spawning up to seven or eight times in a lifetime (Jessop et al. 1983). It is not clear whether there is a clinal trend from south to north for repeat spawners (more repeat spawners in the north than the south) (Klauda et al. 1991), or there is a general overall value (i.e. 30-40% repeat spawners throughout their range) (Richkus and DiNardo 1984).

Tables 4.2-1 and 4.2-2 present percentages of repeat spawners observed in several areas of the species range and spawning seasons, respectively

Table 4.2-1. Percentages of repeat spawners by area for alewife, *Alosa pseudoharengus.*

State	Percentage of repeat spawners	References
Nova Scotia	60%	O'Neill 1980
Maryland	30-72%	Weinrich et al. 1987; Howell et al. 1990
York River, Virginia	61%	Joseph and Davis 1965
North Carolina	13.7% (1993); 61% (1995)	Winslow 1995

Table 4.2-2. Reported spawning seasons for alewife, *Alosa pseudoharengus*, by state or region.

State or Region	Reported Spawning Season	References
Bay of Fundy tributaries	late April or early May	Leim and Scott 1996; Dominy 1971, 1973
Gulf of St. Lawrence tributaries	late May or early June	Leim and Scott 1996; Dominy 1971, 1973
Maine	late April to mid-May	Rounsefell and Stringer 1943; Bigelow and Schroeder 1953; Havey 1961; Libby 1981
Massachusetts	early to mid-April	Belding 1920; Bigelow and Schroeder 1953
Mid-Atlantic and southern New England	late March or early April	Cooper 1961; Kissil 1969; Marcy 1969; Smith 1971; Saila et al. 1972; Richkus 1974; Zich 1978; Wang and Kernehan 1979
Chesapeake Bay region	mid-March	Jones et al. 1978; Loesch 1987
North Carolina	late February	Holland and Yelverton 1973; Frankensteen 1976

Adults will typically spend 2 to 4 years at sea before returning to their natal rivers to spawn (Neves 1981). The majority of adults reach sexual maturity at ages-3, 4, or 5, although some adults from North Carolina (Richkus and DiNardo 1984) returned to spawn at age-2 (Jessop et al. 1983). The oldest fish recorded in North Carolina were age-9 (Street et al. 1975; Johnson et al. 1979), and age-10 fish have been caught in New Brunswick (Jessop et al. 1983) and Nova Scotia (O'Neill 1980). Kissil (1974) found that alewife spawning in Bride Lake, Connecticut, spent 3 to 82 days on the spawning grounds, while Cooper (1961) reported that most fish left within 5 days of spawning. Kissil (1974) suggests that alewife might spawn more than once in a season.

Temperature

There is some discrepancy regarding minimum spawning temperatures for alewife. Although running ripe fish of both sexes have been reported at temperatures as low as 4.2°C in the Chesapeake Bay area (Mansueti and Hardy 1967), it is suggested that the minimum temperature at which adults spawn is 10.5°C (Cianci 1965; Loesch and Lund 1977). Marcy (1976a) suggested that the majority of spawning activity in the lower Connecticut River probably occurs at temperatures between 7.0-10.9°C. There does appear to be a broad range of temperatures for spawning in some regions, such as the Chesapeake Bay, where reported ranges are between 10.5-21.6°C (Jones et al. 1978), and 11-19°C in the Patuxent River, Maryland (Mowrer 1982). Cooper (1961) noted that upstream migration ceased in a Rhode Island stream when temperatures reached 21°C, while Edsall (1970) reported that spawning ceases altogether at 27.8°C. Peak spawning has been reported to occur at 13°C in North Carolina (Tyus 1974) and 14.0-15.5°C in Rhode Island (Jones et al. 1978). Although quantitative data were lacking, Pardue (1983) suggested that the optimum spawning temperature for alewife is 15-20° C, based on available information.

Adults have been collected in temperatures ranging from 5.7-32°C (Marcy 1976b; Jones et al. 1978). Upper incipient lethal temperatures (temperature at which 50% of the population survives) ranged from 23.5-24.0°C for adults that were acclimated at temperatures of 10, 15, and 20°C (Otto et al. 1976). Another study reported upper incipient lethal temperatures of 29.8 and 32.8°C at acclimation temperatures of 16.9 and 24.5°C, respectively (Stanley and Holzer 1961). McCauley and Binkowski (1982) reported an upper incipient lethal temperature of 31-34°C after acclimation at 27°C for a northern population of adults.

The lower incipient lethal temperature range for adults acclimated at 15.0 and 21.0°C is between 6-8°C (Otto et al. 1976). At temperatures below 4.5°C, normal schooling behavior was significantly reduced for adult alewife from Lake Michigan (Colby 1973). No fish survived below 3°C, regardless of acclimation temperature (Otto et al. 1976).

In general, alewife may prefer cooler water, and northern populations may be more cold tolerant than other migratory anadromous fish (Stone and Jessop 1992). Richkus (1974) showed that the response of migrating adults to a particular hourly temperature was determined by its relationship to a changing baseline temperature and not on the basis of its absolute value. Stanley and Colby (1971) found that decreased temperatures (from 16 to 3°C at a rate of 2.5°C per day) reduced adult alewife ability to osmoregulate. Adults were also shown to survive temperature decreases of 10°C, regardless of acclimation temperature, if the temperature did not drop below 3°C (Otto et al. 1976).

Depth

Water depth in spawning habitat may be a mere 6 inches (15.2 cm) deep (Bigelow and Schroeder 1953; Rothschild 1962), or as deep as 10 feet (3 m) (Edsall 1964); however, it is typically less than 1 m (3.3 ft) (Murdy et al. 1997). Adults may utilize deeper water depths in order to avoid high light intensities (Richkus 1974).

Salinity

While it is known that alewife can adjust to a wide range of salinities, experimental evidence is lacking (Klauda et al. 1991). Richkus (1974) found that adults that were transferred from freshwater to saline water (32 ppt) and vice versa experienced zero mortality. Leim (1924) studied the life history of American shad in its northern range and noted that they do not ascend far beyond the tidal influence of the river, yet alewife migrate as far upstream as they can travel. He concluded that alewife may be less dependent on salt water for development. Also, unlike American shad, some populations of alewife have become landlocked and are not dependent on salt water (Scott and Crossman 1973).

Water Velocity/Flow
Increased movement upstream occurs during higher water flows (Collins 1952; Richkus 1974), while spawning typically takes place in quiet, slow-moving waters for spawning alewife (Smith 1907; Belding 1921; Marcy 1976a).

Differential selection of spawning areas has been noted by some researchers. For example, in Connecticut, alewife choose slower moving waters in Bride Lake (Kissil 1974) and Higganum and Mill creeks, while bluebacks select fast-moving waters in the upper Salmon River and Roaring Brook (Loesch and Lund 1977). In other areas where alewife and bluebacks are forced to spawn in the same vicinity due to blocked passage (Loesch 1987), alewife generally spawn along shorebank eddies or deep pools, whereas, bluebacks will typically select the main stream flow for spawning (Loesch and Lund 1977). In North Carolina, they select slow moving streams and oxbows (Street et. al. 2005).

Bottom composition
The spawning habitat of alewife can range from sand, gravel or coarse stone substrates, to submerged vegetation or organic detritus (Edsall 1964; Mansueti and Hardy 1967; Jones et al. 1978). Boger (2002) found that river herring spawning areas along the Rappahannock River, Virginia had substrates that consisted primarily of sand, pebbles, and cobbles (usually associated with higher-gradient streams), while areas with little or no spawning were dominated by organic matter and finer sediments (usually associated with lower-gradient streams and comparatively more agricultural land use).

Pardue (1983) evaluated studies of cover component in spawning areas, suggesting that substrate characteristics and associated vegetation were a measure of the ability of a habitat to provide cover to spawning adults, their eggs, and developing larvae. In high flow areas, there is little accumulation of vegetation and detritus, while in low flow areas, detritus and silt accumulate and vegetation has the opportunity to grow. Based on a review of the literature, Pardue suggested that substrates with 75% silt or other soft material containing detritus and vegetation, and sluggish waters are optimal for alewife.

pH
There are only a few studies of pH sensitivity in alewife (Klauda et al. 1991). Byrne (1988) found that the average pH level was 5.0 in several streams in New Jersey where alewife spawning was known to occur. Since blueback herring did not spawn in these streams, he suggested that early life history stages of alewife were more tolerant to acidic conditions than bluebacks. Laboratory tests found that fish from those streams could successfully spawn at a pH as low as 4.5. In one pH change study, adults tolerated changes up to 0.8 units within a range of pH 6.5-7.3 (Collins 1952). When aluminum pulses were administered in the laboratory, critical

conditions for spawning could occur during an acidic pulse between pH 5.5 and 6.2 with concomitant concentrations of total monomeric aluminum ranging from 15-137 µg/L for a pulse duration of 8-96 h (Klauda 1989). Klauda et al.(1991) suggested a range of 5-8.5 as suitable for alewife eggs, but no range was provided for spawning.

Dissolved Oxygen
There is little information regarding sensitivities of various life history stages of alewife to dissolved oxygen (DO) (Klauda et al. 1991). Adults that were exposed to DO ranging from 2.0-3.0 mg/L for 16 hours in the laboratory experienced a 33% mortality rate (Dorfman and Westman 1970). They were able to withstand DO concentrations as low as 0.5 mg/L for up to five minutes, as long as a minimum of 3.0 mg/L was available, thereafter. Jones et al. (1988) suggested that the minimum DO concentration for adults is 5.0 mg/L.

Egg and Larval Habitat
Eggs may hatch anywhere from 50 to 360 hours, depending on water temperature (Fay et al. 1983), but hatch most often within 80-95 hours (Edsall 1970). Fertilized eggs remain demersal and adhesive for several hours (Mansueti 1956; Jones et al. 1978), after which they become pelagic and are transported downstream (Wang and Kernehan 1979). Marcy (1976a) observed eggs more often nearer the bottom than at the surface in the Connecticut River.

Within 2 to 5 days, the yolk-sac is absorbed and larvae will begin feeding exogenously (Cianci 1965; Jones et al. 1978). Post-yolk-sac larvae are positively phototropic (Odell 1934; Cianci 1965). Dovel (1971) observed larvae near or slightly downstream of presumed spawning areas in the Chesapeake Bay, only where the water was less than 12 ppt salinity (Dovel 1971). Larvae were also found in or close to observed spawning areas in Nova Scotia rivers in relatively shallow water (2 m) over sandy substrate (O'Neill 1980).

Temperature
In general, average time to median hatch varies inversely with temperature. Edsall (1970) reported the following hatch times for alewife eggs taken from Lake Michigan: 2.1 days at 28.9° C, 3.9 days at 20.6°C, and 15 days at 7.2°C. Reported hatch times in saltwater by various researchers are comparable: 2-4 days at 22°C (Belding 1921); 3 days at 23.8-23.9°C and 26.7-26.8° C, and 3-5 days at 20° C (Mansueti and Hardy 1976); and 6 days at 15.5°C (Bigelow and Welsh 1925). Laboratory tests conducted by Kellogg (1982) found that eggs from the Hudson River, New York achieved maximum hatching success at 20.8° C. Edsall (1970) reported some hatching at temperatures as low as 6.9°C for eggs from Lake Michigan (below 11° C caused a high percentage of deformed larvae) and as high as 29.4°C, but optimum hatching occurred between 17.2-21.1°C. Although this was the suggested optimal range, Edsall determined that considerable hatch rates and proper development could occur over a broader range from 10.6°C to 26.7° C. In the upper Chesapeake Bay, alewife eggs were collected where temperatures ranged from 7-14°C and 70% of these eggs were found where temperatures were between 12-14°C (Dovel 1971).

Edsall (1970) correlated egg mortality with incubation temperature. He developed an equation for predicting incubation time for alewife eggs from temperature, which is as follows:

$$t = 6.335 \times 106 (T) –3.1222$$

where t = time in days
T = incubation temperature in degrees °F

Several investigations have been conducted to determine the effects of temperature on alewife eggs. One study examined the effects of power plants on alewife eggs found that they suffered no significant mortality or abnormal egg development, after being acclimated at 17°C, then exposed to 24.5°C for 6-60 minutes (Schubel and Auld 1972). Koo et al. (1976) determined that the critical thermal maximum (CTM) for alewife eggs was 35.6°C, acclimated at 20.6°C, with a critical exposure period of 5-10 minutes.

Larval alewife were collected at water temperatures between 4-27°C in the upper Chesapeake Bay although 98% were collected at water temperatures 25° C (Dovel 1971). In laboratory experiments, larvae acclimated at 18.6°C withstood temperatures as high as 33.6°C for one hour (Koo et al. 1976). The upper temperature tolerance limit for yolk-sac larvae from the Hudson River, New York, acclimated at 14-15°C was 31°C (Kellogg 1982); their preferred range when acclimated at 20°C appears to be 23-29°C (Ecological Analysts Inc. 1978; Kellogg 1982).

Although alewife eggs taken from Lake Michigan were able to hatch at temperatures as low as 6.9°C, larvae held at incubation temperatures below 10.6°C had a 69% rate of deformities (Edsall 1970). Dovel (1971) found that growth rates of alewife larvae were much lower in freshwater compared to saltwater (1.0-1.3 ppt) at 26.4°C. He also observed substantial growth increases with small temperature increases above 20.8°C. Average daily weight gain for alewife larvae has been directly correlated to water temperature. The maximum larval growth rate was 0.084 g/day at 29.1°C; net gain in biomass (a function of survival and growth) was highest at 26.4° C (Kellogg 1982).

Based on Kellogg's (1982) observations that the optimum growth temperature (26°C) exceeds peak spawning temperatures by about 10-13°C, he suggested that it is not likely that survival and early development of young alewife would be threatened by rapid warming trends following spawning or by moderate thermal discharges. He further indicated that temperature elevations above normal following spawning and hatching would probably be beneficial to alewife populations.

In their review of the literature, Klauda et al. (1991) provided optimal ranges for both the prolarva and postlarva life stages for alewife. They suggested a suitable range of 8-31°C and 14-28°C, and an optimum range of 15-24°C and 20-26°C, respectively, for these two life stages.

Salinity

Alewife eggs have been collected in the upper Chesapeake Bay in salinities between 0-2 ppt; however, almost 99% of these eggs were collected where the salinity was 0 ppt. Larvae were collected where salinities ranged from 0-8 ppt, but again, most (82%) were collected in freshwater (Dovel 1971). Klauda et al. (1991) suggested that the optimal range for egg development for alewife is 0-2 ppt.

Growth rates of larval alewife were demonstrated to be considerably faster in saltwater (1.0-3.0 ppt) compared to growth in freshwater, at temperatures of 26.4°C (Klauda et al. 1991). Later review by Klauda et al. (1991) suggested that the optimal range for the prolarva life stage was 0-3 ppt and for the postlarva life stage was 0-5 ppt.

Water Velocity/Flow

Sismour (1994) observed a rapid decline in abundance of early preflexion river herring larvae (includes both alewife and blueback herring) in the Pamunkey River, Virginia following high river flow in 1989. He speculated that high flow led to increased turbidity, which reduced prey visibility, leading to starvation of larvae. O'Connell and Angermeier (1997) found that current velocity (and DO) were the strongest predictors of alewife early egg presence in a Virginia stream. Findings from Rhode Island suggest the importance of river flow to alewife stocks. Drought conditions in the summer of 1981 were strongly suspected of impacting the 1984 year class, which was only half of its expected size (ASMFC 1985). In tributaries of the Chowan system, North Carolina, water flow was related to recruitment of larval river herring (O'Rear 1983).

Bottom composition

As with spawning habitat, Pardue (1983) suggested that egg and larval habitat with substrates with 75% silt or other soft material containing detritus and vegetation was optimal.

pH and aluminum

Klauda et al. (1991) suggest that a range of pH 5.0-8.5 for both the alewife egg and prolarva life stage was preferred. Klauda (1987) suggested that during an acidic pulse between pH 5.5.-6.2 critical conditions associated with > 50% direct mortality could occur. Klauda et al. (Klauda et al. unpublished, cited in Klauda et al. 1991) found that larvae subjected to a single 24-hour, acid-only pulse of pH 4.5 experienced no mortality, while those subjected to a 24-hour single acid pulse and 446 µg/L inorganic monomeric aluminum pulse suffered a 96% mortality rate. A single 12-hour acid-only pulse of 4.0 resulted in 38% mortality.

Dissolved Oxygen

Jones et al. (1988) determined that the minimum DO concentration requirement for eggs and larvae is 5.0 mg/L. O'Connell and Angermeier (1997) found that DO (and current velocity) were the strongest predictors of alewife early egg presence in a Virginia stream.

Suspended solids/turbidity

Alewife eggs subjected to suspended solids concentrations up to 1000 mg/L did not exhibit a reduction in hatching success (Auld and Schubel 1978). Despite these results, high levels of suspended sediment may significantly increase rates of egg infections from naturally occurring fungi, as was witnessed in earlier experiments (Schubel and Wang 1973), which can lead to delayed mortalities (Klauda et al. 1991).

<u>Juveniles</u>

In North Carolina, juveniles may spend the summer in the lower ends of rivers where they were spawned (Street et al. 1975). In the Chesapeake Bay, juveniles can be found in freshwater tributaries in spring and early summer, but may head upstream in the summer when saline waters encroach on their nursery grounds (Warriner et al. 1970). Some juveniles in the Chesapeake Bay remain in brackish water through the summer (Murdy et al. 1997).

Juveniles in the Hudson River usually remain in freshwater tributaries until June (Schmidt et al. 1988). Juvenile alewife were found to be most abundant in inshore areas at night in the Hudson River, compared to inshore abundance of American shad and blueback herring during the day (McFadden et al. 1978; Dey and Baumann 1978). Hudson River juveniles were observed in shallow portions of the upper and middle estuary in late June and early July, where they remained for several weeks before moving offshore as they grew (Schmidt et al. 1988). They typically spend 3-9 months in their natal rivers before returning to the ocean (Kosa and Mather 2001).

In summer in the Potomac River, juveniles are abundant near surface waters during the day, but shifted to mid-water and bottom depths in September, where they remained until they emigrated in November (Warriner et al. 1970). Juvenile alewife respond negatively to light and follow diel movements similar to blueback herring. There appears to be some separation between the alewife and blueback as they emigrate from nursery grounds in the fall, most notably at night, when alewife can be found more frequently at midwater depths, while bluebacks are found mostly at the surface (Loesch and Kriete 1980). This may reduce interspecific competition for food (Loesch 1987), given that their diets are similar (Davis and Cheek 1966; Burbidge 1974; Weaver 1975).

Once water temperatures begin to drop in the late summer through early winter (depending on geographic area), juveniles start heading downstream, initiating their first phase of seaward migration (Pardue 1983; Loesch 1987). Some researchers found that movement of alewife peaked in the afternoon (Richkus 1975a; Kosa and Mather 2001), while others found that it peaked at night (Stokesbury and Dadswell 1989). Migration downstream is also prompted by changes in water flow, water levels, precipitation, and light intensity (Cooper 1961; Kissil 1974; Richkus 1975a, 1975b; Pardue 1983). Other researchers have suggested that water flow plays little role in providing the migration cue under riverine conditions. Rather, timing is triggered more by water temperature and moon phases that provide dark nights, generally new and quarter moons (O'Leary and Kynard 1986; Stokesbury and Dadswell 1989). Stokesbury and Dadswell (1989) found that alewife remained in the offshore region of the Annapolis estuary, Nova Scotia for almost a month before the correct migration cues triggered emigration. Large juveniles begin moving downstream before smaller juveniles (Schmidt et al. 1988), moving to saline waters before they begin their seaward migration (Loesch 1969; Marcy 1976a; Loesch and Kriete 1980).

Richkus (1975a) observed waves of juveniles leaving following environmental changes but the number of fish leaving was unrelated to the level of magnitude of change. Most fish (60-80%) emigrated during a small percentage (7-8%) of available days. These waves also lasted 2 to 3 days, regardless of the degree of environmental change. Others have also observed the majority (i.e., >80%) of river herring emigrating in waves (Cooper 1961; Huber 1978; Kosa and Mather 2001). Richkus (1975a) also noted that in some instances, high abundances of juveniles may trigger very early (i.e., summer) emigration of large numbers of small juveniles from the nursery area, which is likely a response to a lack of forage. Juvenile migration of alewife is about one month earlier than that of blueback herring (Loesch 1969; Kissil 1974).

Although most juveniles emigrate offshore their first year, some overwinter in the Chesapeake (Hildebrand 1963) and Delaware bays (Smith 1971). Marcy (1969) suggests that many juveniles (age-1+) spend their first winter close to the mouth of their natal river because he found in the lower portion of the Connecticut River in early spring. Some juvenile alewife may remain in deep estuarine waters through the winter (Hildebrand and Schroeder 1928). There is some indication that alewife in northern states may remain in inshore waters for one to two years (Walton 1981). Since juvenile river herring cannot survive water temperatures of 3°C or below (Otto et al. 1976), they likely do not overwinter in coastal systems where temperatures are below 3°C (Kosa and Mather 2001).

Temperature
Juveniles tolerate a broad range of temperatures. Juvenile alewife have been collected in water temperatures between 4-27°C in the upper Chesapeake Bay. Ninety-eight percent of those were collected at 25°C (Dovel 1971). In the Cape Fear River, North Carolina, juveniles have been collected in seasonally in temperatures ranging from 13.5-29°C (Davis and Cheek 1966). The upper lethal temperature for juvenile alewife is about 30°C (McCauley and Binkowski 1982). Young-of-the-year alewife have critical thermal maxima (CTM) that are 3-6°C higher than adults (Otto et al. 1976).

In Lake Michigan, upper incipient lethal limits, the temperature at which 50% of the population survives, for young-of-the-year alewife acclimated at 10, 20, and 25°C was estimated to be slightly less than 26.5°C, 30.3°C, and 32.1°C, respectively (Otto et al. 1976). A separate study found that juveniles exposed to 35°C waters for 24 hours after acclimation to water at 18.9-20.6°C had a 20% survival rate (Dorfman and Westman 1970). When subjected to decreasing temperatures (15.6-2.8°C) over the course of 15 days, juveniles suffered greater than 90% mortality (Colby 1973).

Pardue (1983) suggests that the overall optimal water temperature for juvenile alewife is 15-20°C. Klauda et al. (1991) suggest a broader range of 10-28°C as suitable. Preferred water temperatures in waters with 4-7 ppt salinity were 17-23°C after acclimation at 15-21°C (Meldrim and Gift 1971; PSEGC 1982). In Lake Michigan, juveniles that were acclimated to ambient inshore water temperatures of 15-18°C preferred waters with temperatures of 25.0°C. Juveniles acclimated at 10°C to 20°C had temperature preferences of 25.0°C and 24.0°C, respectively. This preference declined even further to 21.0°C in November and 19.0°C in December (Otto et al. 1976). Juveniles acclimated to 26°C avoided temperatures ≥34°C (PSEGC 1984).

Juveniles exposed to 9°C, following acclimation at 20°C in 5.5 ppt salinity suffered no mortality. However, when the temperature was decreased to 7°C for 96 h, they suffered 27-60% mortality (PSEGC 1984). The lower limit at which juvenile river herring are unable to survive is 3°C or less (Otto et al. 1976).

Depth
Jessop (1990) reported that juvenile alewife were completely absent from near-surface water during daylight hours. No other information was available regarding depth preferences or optima for juvenile alewife.

Salinity
Richkus (1974) reported that juveniles that were transferred from freshwater to saline water (32 ppt), and vice versa, experienced zero mortality. Similar to alewife larvae, juvenile alewife in the upper Chesapeake Bay are found in salinities that range from 0-8 ppt, but most (82%) were collected in freshwater (Dovel 1971). Pardue (1983) suggested that salinities less than or equal to 5 ppt were considered optimal for the juvenile life stage.

Water Velocity/Flow
Water discharge is an important factor influencing variability in relative abundance and emigration of juvenile alewife. Extremely high discharges may adversely affect juvenile emigration, and high or fluctuating discharges may lead to a decrease in the relative abundance of adults and juveniles (Kosa and Mather 2001). Laboratory experiments suggest juvenile alewife avoid water velocities greater than 10 cm/s, especially in narrow channels (Gordon et al. 1992). In large rivers, where greater volumes of water can be transported per unit of time without substantial increases in velocity, the effects of discharge may differ (Kosa and Mather 2001).

Kissil (1974) observed juveniles leaving Lake Bride, Connecticut between June and October and noted especially high migration occurring during times of heavy water flow. These results are consistent with Cooper's (1961) observations that 98 % of juveniles left after periods of heavy rainfall. Huber (1978) also noted that juvenile emigration in the Parker River, Massachusetts was triggered by an increase in water flow. Jessop (1994) found that the juvenile abundance index (JAI) of alewife decreased with mean river discharge during summer. Daily instantaneous mortality increased with mean river discharge from July-August from the Mactaquac Dam headpond on the Saint John River, New Brunswick, Canada.

Bottom composition
Olney and Boehlert (1988) found juvenile alewife among submerged aquatic vegetation (SAV) beds of the lower Chesapeake Bay and suggested that SAV likely confers some level of protection from predation.

pH and aluminum
Kosa and Mather (2001) report that of juvenile river herring abundance peaks at a pH of 8.2 in coastal systems in Massachusetts and suggest that pH appears to contribute to variations in juvenile abundance.

Dissolved Oxygen
Jones et al. (1988) determined that the minimum DO concentration for juveniles is 3.6 mg/L. Dorfman and Westman (1970) reported that at concentrations below 2.0 mg/L, juvenile alewife became stressed. At concentrations as low as 0.5 mg/L, juveniles survived for approximately five minutes in oxygen. In the Cape Fear River system, juveniles preferred waters where DO levels ranged from 2.4-10.0 mg/L (Davis and Cheek 1966).

<u>Subadults</u>
Some young-of-the-year overwinter in deep, high salinity areas of the Chesapeake Bay (Hildebrand and Schroeder 1928). Dovel (1971) reported juvenile populations in the upper

Chesapeake Bay that did not emigrate until early spring of their second year. Milstein (1981) found that juveniles overwintered in waters approximately 0.6-7.4 km from the shore of New Jersey, at depths of 2.4-19.2 m, in what is considered an offshore estuary (Cameron and Pritchard, 1963). This area is warmer and has a higher salinity than the cooler, lower salinity river-bay estuarine nurseries where they reside in fall. The majority of fish were present during the month of March, when bottom temperatures ranged from 4.4 to 6.5°C and salinity was between 29.0 and 32.0 ppt. Further south, young alewife have been found overwintering off the North Carolina coast from January to March, concentrated at depths of 20.1-36.6 m (Holland and Yelverton 1973; Street et al. 1973). Other sources have noted that during their first year in saltwater, juveniles tend to remain near the surface (Bigelow and Schroeder 1953). In Lake Michigan, age-1 fish were usually pelagic, except in spring and fall, where they often occurred on the bottom; age-2 fish were typically found on the bottom (Wells 1968).

Information on the life history of young-of-the-year and adult alewife after they emigrate to the sea is sparse (Klauda et al. 1991). But it is generally accepted that juveniles join the adult population at sea within the first year of their lives and follow a north-south seasonal migration along the Atlantic coast, similar to that of American shad (Neves 1981). Sexual maturity is reached at a minimum of age-2 but may vary regionally. In North Carolina, sexual maturity occurs mostly at age-3. In Connecticut, most males achieve maturity at age-4, and most females at age-5 (Jones et al. 1978).

No adults older than age IX have been captured in North Carolina; however age X fish have been recorded in New Brunswick and Nova Scotia.

Despite a lack of conclusive evidence, it is thought that alewife are similar to other anadromous clupeids in that they may undergo seasonal migrations within preferred isotherms (Fay et al. 1983).

While at sea, alewife are more available to bottom trawling gear during the day, leading researchers to conclude that they follow the diel movement of plankton in the water column and are sensitive to light (Neves 1981). Thus, feeding and vertical migration are likely controlled by light intensity patterns within thermal preference zones (Richkus and Winn 1979; Neves 1981).

During spring, alewife from the Mid-Atlantic Bight move inshore and north of 40° latitude to Nantucket Shoals, Georges Bank, coastal Gulf of Maine, and the inner Bay of Fundy for the summer; commercial catch data indicated that they were most frequent on Georges Bank and south of Nantucket Shoals (Neves 1981; Rulifson et al. 1987). Distribution in the fall is similar to the summer, but they are concentrated along the northwest perimeter of the Gulf of Maine. In the fall, they move offshore and southward to the mid-Atlantic coast, with catches reported between latitude 40° and 43° north, where they remain until early spring (Neves 1981). It is unknown to what extent they overwinter in deepwater off the continental shelf, but they have rarely been found more than 130 km from the coast (Jones et al. 1978).

Canadian spring survey results also reveal river herring distributed along the Scotian Gulf, southern Gulf of Maine, and off southwestern Nova Scotia from the Northeast Channel north to the central Bay of Fundy, and to a lesser degree, along the southern edge of Georges Bank and in the canyon between Banquereau and Sable Island Banks (Stone and Jessop 1992). A large component of the overwintering population on the Scotian Shelf moves inshore during spring to spawn in Canadian waters, but may also include the U.S. Gulf of Maine region. Summer aggregations of river herring in the Bay of Fundy/eastern Gulf of Maine may consist of a mixture of stocks from the entire Atlantic coast, as do similar aggregations of American shad (Dadswell et al. 1987). However, based on commercial offshore catches by foreign fleets in the late 1960's, it is believed that coastal river herring stocks do not mingle to the extent that American shad stocks apparently do, at least during the seasons during which foreign harvests were being made (ASMFC 1985). They typically migrate in large schools of fish of similar size and may even form mixed schools with other herring species (Bigelow and Schroeder 2002).

Temperature
Alewife were caught offshore from Cape Hatteras to Nova Scotia where surface water temperatures ranged from 2-23°C and bottom water temperatures ranged from 3-17°C; catches were most frequent where the average bottom water temperature was between 4-7°C (Neves 1981). Stone and Jessop (1992) reported a temperature range of 7-11°C for alewife in their northern range off Nova Scotia, the Bay of Fundy, and the Gulf of Maine. They also noted that the presence of a cold (<5°C) intermediate water mass over warmer, deeper waters on the Scotian Shelf (Hatchey 1942), where the largest catches of river herring occurred, may have restricted the extent of vertical migration during the spring. Since few captures were made where bottom temperatures were <5°C during the spring, vertical migration may be confined by a water temperature inversion in this area at this time of the year.

Alewife may prefer, and be better adapted to cooler water than blueback herring (Loesch 1987; Klauda et al. 1991). Northern populations may exhibit more tolerance to cold temperatures (Stone and Jessop 1992). Additionally, antifreeze activity was found in blood serum from an alewife off Nova Scotia, but not for those from Virginia (Duman and DeVries 1974).

Depth
Sixteen years of National Marine Fisheries Service catch data conducted from Cape Hatteras to Nova Scotia (Neves 1981) found that fish offshore were caught most frequently in the 56-110 m zone (sampling was conducted as deep as 200 m). Their position in the water column may be influenced by zooplankton concentrations (Neves 1981), which are at depths <100m in the Gulf of Maine (Bigelow 1926). Stone and Jessop (1992) found that alewife off Nova Scotia, the Bay of Fundy, and the Gulf of Maine were found offshore at mid-depths of 101-183 m in the spring, in shallower nearshore waters at 46-82 m in the summer, and in deeper offshore waters at 119-192 m in the fall. They also found differences in depth distribution, with smaller fish (sexually immature) occurring in shallow regions (<93 m) during spring and fall, while larger fish occurred in deeper areas (≥93 m) in all seasons.

In coastal waters (Neves 1981), juvenile alewife are found deeper in the water column than blueback herring, despite their diets being identical in these locations (Davis and Cheek 1967; Burbidge 1974; Watt and Duerden 1974; Weaver 1975). Jansen and Brandt (1980) reported that a nocturnal depth distribution of adult landlocked alewife differed by size-class, with the smaller fish at shallower depths.

Salinity
As noted above, young-of-the-year alewife have been found overwintering offshore of New Jersey (Milstein 1981), where salinities range from 29.0-32.0 ppt. For sub-adults and non-spawning adults that remain in the open ocean, they will reside in full-strength sea water (33.0 ppt). Since it has been suggested that alewives may follow a north-south seasonal migration along the Atlantic coast, similar to that of American shad (Neves 1981), and prespawning adult American shad may detour into estuaries (Neves and Depres 1979), they may be subject to more brackish waters during migration.

Ecological relationships

<u>Adults</u>
Food
Adults do not feed extensively, or typically not at all, during their upstream spawning run (Bigelow and Schroeder 1953; Colby 1973), but spent fish that have reached brackish waters on their downstream migration will feed voraciously, mostly on mysids (Bigelow and Schroeder 2002). Adults may consume their own eggs during the spawning run (Edsall 1964; Carlander 1969), but it is the juveniles that reportedly feed more actively on them (Bigelow and Schroeder 2002).

Competition and Predation
In freshwater, adults may be preyed upon by osprey, green heron, mink (Colby 1973), lake trout (Royce 1943), Atlantic salmon, striped bass (Scott and Scott 1988), and other fish (Loesch et al. 1987). Erkan (2002) notes that predation of alosines has increased dramatically in Rhode Island rivers in recent years, especially by the double-crested cormorant, which often takes advantage of fish staging near the entrance to fishways. Populations of nesting colonies have increased in size and have expanded into areas in which they have previously not been observed. Predation by otters and herons has also increased, but to a lesser extent (Erkan, Rhode Island DEM, 2003, personal communication).

<u>Eggs and larvae</u>
Food
Once larvae begin feeding exogenously, they select relatively small cladocerans and copepods, adding larger species as they grow (Norden 1968; Nigro and Ney 1982). Alewife larvae are highly selective feeders (Norden 1967), usually favoring cladocerans (mainly Cyclops sp. and Limnocalanus sp.) and copepods over other food types (Norden 1968; Johnson 1983).

Competition and Predation
Alewife eggs may be consumed by yellow perch, white perch, spottail shiner, as well as other alewife (Edsall 1964; Kissil 1969). Alewife larvae are preyed upon by both vertebrate and invertebrate predators (Colby 1973).

<u>Juveniles</u>
Food
Juvenile alewife are opportunistic feeders and usually favor items that are seasonally available (Gregory et al. 1983).). For example, in the Hamilton Reservoir, Rhode Island, juveniles fed

primarily on dipteran midges in July and cladocerans in August and September (Vigerstad and Colb 1978). Juveniles either select their prey individually or switch to a non-selective filter-feeding mode, which they do more at night (Janssen 1976). Grabe (1996) found that juvenile alewife fed on chironomids, odonates, amphipods, and other amphipods during the day and early evening hours in the Hudson River. Juveniles have also been observed consuming epiphytic fauna (Grabe 1996), especially at night (Weaver 1975).

Juveniles may also feed extensively on benthic organisms, including ostracods, chironomid larvae, and oligochaete worms (Watt and Duerden 1974). Morsell and Norden (1968) found that juveniles will consume zooplankton until they reach 12 cm TL, and may then switch to increasing amounts of the more benthic amphipod Pontoporeia sp.

The number of zooplankton per liter is assumed to be critical for the survival and growth of juvenile alewife. Pardue (1983) suggested that habitats that contained 100 or more individuals of zooplankton per liter are optimal. Walton (1987) found that juvenile abundance in Damariscotta Lake, Maine was controlled by competition for zooplankton, rather than parental stock abundance and recruitment. It has been suggested that clupeids evolved so as to synchronize the larval stage with the optimal phase of annual plankton production cycles (Blaxter and Hunter 1982). Several researchers (Vigerstad and Colb 1978; O'Neill 1980; Yako 1998) hypothesize that a change in food availability may provide a cue for juvenile anadromous herring to begin emigrating seaward, but no causal link has been established.

Invasive species may threaten food sources for alewife. There is strong evidence that juveniles in the Hudson River have experienced a reduced forage base as a result of zebra mussel colonization (Waldman and Limburg 2003).

Competition and Predation
Juvenile alewife are consumed by American eel, white perch, yellow perch, grass pickerel, largemouth bass, pumpkinseed, shiners, walleye and other fishes, as well as turtles, snakes, birds, and mink (Kissil 1969; Colby 1973; Loesch 1987). In estuarine waters of Maine, juvenile bluefish preyed heavily on alewife (Creaser and Perkins 1994). In Massachusetts rivers, juvenile alewife were an energetically valuable and a key food source for largemouth bass during late summer (Yako et al. 2000).

It is often noted throughout the literature, that alewife and blueback herring co-exist in the same geographic regions, yet interspecific competition is often reduced through several mechanisms. For example, juveniles of both species in the Connecticut River consume or select different sizes of prey (Crecco and Blake 1983). Juvenile alewife in the Minas Basin, Nova Scotia favor larger, more benthic prey (particulate-feeding strategy) than do juvenile bluebacks (filter feeding strategy) (Stone 1985; Stone and Daborn 1987). In the Cape Fear River, North Carolina, juvenile alewife consumed more ostracods, insect eggs, and insect parts than did blueback herring (Davis and Cheek 1966).

Alewife also spawn earlier than bluebacks, thereby giving juvenile alewife a relative size advantage over juvenile bluebacks, allowing them a larger selection of prey (Jessop 1990). Difference in juvenile diel feeding activity further reduces competition. One study noted diurnal feeding by juvenile alewife was bimodal, with peak consumption about one to three hours before sunset and a minor peak occurring about two hours after sunrise (Weaver 1975). Another study found that juvenile blueback herring began to feed actively at dawn, increasing throughout the day and maximizing at dusk, then diminishing from dusk until dawn (Burbidge 1974).

Contaminants
A 24 hour LC_{50} of 2.25 mg/L for total residual chlorine (TRC) was reported for juveniles exposed for 30 minutes at 10°C (Seegert et al. 1977). Thirty-minute LC_{50} values for TRC were 2.27 mg/L for juveniles exposed at 10°C, and 0.30 mg/L when fish were exposed at 30°C (Brooks and Seegert 1978; Seegert and Brooks 1978). Juvenile alewife held at 15°C in 7 ppt salinity exhibited an avoidance response to 0.06 mg/L TRC (PSEGC 1978). Juveniles held at 19-24° C in freshwater exhibited an avoidance response at <0.03 mg/L (Bogardus et al. 1978). Juvenile alewife subjected to 0.48 mg/L total chlorine for 2 hours in freshwater (at 22°C) suffered 100% mortality.

<u>Subadults</u>
Food
At sea, alewife feed largely on particulate zooplankton including euphausiids, calanoid copepods, mysids, hyperiid amphipods, chaetognaths, pteropods, decapod larvae, and salps (Edwards and Bowman 1979; Neves 1981; Vinogradov 1984; Stone and Daborn 1987; Bowman et al. 2000). Alewife also consume small fishes, including Atlantic herring, other alewife, eel, sand lance, and cunner (Bigelow and Schroeder 2002). They feed either by selectively preying on individuals or non-selectively filter-feeding with their gill rakers. Feeding mode depends mostly on prey density, prey size, and water visibility, as well as size of the alewife (Janssen 1976, 1978a, 1978b). In Minas Basin, Bay of Fundy, alewife diets shifted from micro-zooplankton in small fish to mysids and amphipods in larger fish. Feeding intensity also decreased with increasing age of fish (Stone 1985).

Alewife generally follow the diel movement of zooplankton, feeding most actively during the day; nighttime predation is usually restricted to larger zooplankton, which are easier to detect (Janssen 1978b; Janssen and Brandt 1980; Stone and Jessop 1993). In Nova Scotia, alewife feeding peaked at midday during the summer and mid-afternoon during the winter. Alewife were also found to have a higher daily ration in the summer than in the winter (Stone and Jessop 1993). Although direct evidence is lacking, catches of alewife in specific areas along Georges Bank, the perimeter of the Gulf of Maine, and south of Nantucket Shoals may be related to zooplankton abundance (Neves 1981).

Competition and Predation
At sea, schooling fish such as bluefish, weakfish, and striped bass prey upon alewife (Bigelow and Schroeder 1953; Ross 1991). Other fish such as dusky shark, spiny dogfish, Atlantic salmon, goosefish, cod, pollock, and silver hake also prey on alewife (Rountree 1999; Bowman et al. 2000). Of these species, spiny dogfish had the greatest quantity of alewife in their stomachs (Rountree 1999).

Abundance and status of stocks

Factors affecting stock size

At low stock levels, Havey (1973) and Walton (1987) demonstrated a weak relationship between spawning stock and juvenile migrant alewife. Jessop (1990) found a stock recruitment relationship for the spawning stock of river herring and year-class abundance at age 3. Despite these results, most studies have been unable to detect a strong relationship between adult and juvenile abundance of clupeids (Crecco and Savoy 1984; Henderson and Brown 1985; Gibson 1994; Jessop et al. 1994). Researchers have suggested that although year-class is driven mostly by environmental factors (see subsequent sections), if the parent stock size falls below a critical level, the size of the spawning stock may become a factor in determining juvenile abundance (Kosa and Mather 2001).

The 2006 Plan Review of the Shad and River Herring Fishery Management Plan (ASMFC, 2006) states:

While the FMP addresses four species including American shad, hickory shad, alewife, and blueback herring, lack of comprehensive and accurate commercial and recreational fishery data for the latter three species make it difficult to ascertain the status of these stocks. A stock assessment for American shad was completed in 1997 and submitted for peer review in early 1998 based on new information and Management Board recommended terms of reference. The 1998 assessment estimated fishing mortality rates for nine shad stocks and general trends in abundance for 13 shad stocks. The next stock assessment update to be externally peer reviewed is scheduled for 2007.

4.2.4 American Shad

Description and Distribution

(all information from ASMFC's doc)

American shad (Alosa sapidissima) (Wilson, 1811) are anadromous, coastal pelagic, highly migratory, schooling species (Bigelow and Schroeder 2002), whose original range occurred from Sand Hill River, Labrador, to Indian River, Florida in the Atlantic Ocean (Lee et al. 1980; Morrow 1980). There are no spawning populations north of the St. Lawrence River, Quebec (Leggett 1976). Since their introduction to the Sacramento, Columbia, Snake, and Willamette rivers in California and Oregon, in the late 1800's, their range in the Pacific Ocean has increased to Cook Inlet, Alaska, and the Kamchatka Peninsula, Asia in the north, to Todos Santos Bay, Baja California in the south (Lee et al. 1980; Howe 1981). Attempts to introduce the species in the Gulf of Mexico (Whitehead 1985), Mississippi River drainage, rivers of peninsular Florida, Colorado streams, and the Great Lakes were unsuccessful (Walburg and Nichols 1967). Although a landlocked population exists in a reservoir of the San Joaquin River on the Pacific coast, no landlocked populations have been reported along the Atlantic coast (Zydlewski and McCormick 1997a).

American shad spend most of their life in the Atlantic Ocean then migrate to coastal rivers and tributaries for spawning. It is likely that all accessible rivers and tributaries within their range along the Atlantic coast have historically been used for spawning by this species (MacKenzie et al. 1985). Rivers, bays, and estuaries associated with spawning rivers are used as nursery areas by American shad (ASMFC 1999). During an average life span of 4-5 years at sea, American shad from the southernmost range may travel over 20,000 km (Dadswell et al. 1987).

Reproduction

Spawning

Atlantic coast stocks of American shad have a geographic range that extends from the St. Johns River, Florida to the St. Lawrence River, Canada (Walburg and Nichols 1967). It is estimated that they once ascended at least 130 rivers throughout this range to spawn, but now, fewer than 70 systems have runs (Limburg et al. 2003). The majority of shad return to their natal rivers and tributaries to spawn (Fredin 1954; Talbot 1954; Hill 1959; Nichols 1966; Carscadden and Leggett 1975), with an average straying rate of about 3% (Mansueti and Kolb 1953; Williams and Daborn 1984; Melvin et al. 1985). Hendricks et al. (2002) demonstrated that hatchery-reared American shad not only homed to a specific tributary (Lehigh River, Pennsylvania) within a major river system (Delaware River) several years after stocking, but also that they prefer the side of the river influenced by the plume of their natal river. It is hypothesized that the degree of homing by shad may be dependent on the nature of the drainage system. If this theory is correct, more mixing and consequent straying would likely occur in large and diversified estuarine systems, such as the Chesapeake Bay, while more precise homing could be expected in other systems that have a single large river, such as the Hudson River (Richkus and DiNardo 1984).

Spawning runs begin in the south and move progressively north as the season progresses and water temperatures increase (Walburg 1960). Shad first appear in the St. Johns River, Florida in mid-November, begin spawning as early as December (Williams and Bruger 1972) with peak spawning occurring in January (Leggett 1976); in Georgia and South Carolina rivers, the runs begin in mid-January; in North Carolina and Virginia bays and inlets, shad are returning by mid-February and peak spawning occurs in March; abundance peaks in April in the Potomac River, and early May in the Delaware River; fish begin their upstream migration in the Hudson and Connecticut Rivers at the end of March and continue until June (Walburg and Nichols 1967; Leggett and Whitney 1972). Shad in some Canadian rivers may spawn as late as July, and in some years, as late as August (MacKenzie et al. 1985; Scott and Scott 1988; Bigelow and Schroeder 2002).

Spawning runs typically last 2-3 months, but can vary depending on weather conditions (Limburg et al. 2003). Spawning adult shad migrating up the James River, Virginia were found to ascend mostly between 0900 and 1600 hours (Weaver et al. 2003). Arnold (2000) reported similar results in the Lehigh River where shad passed primarily between 0900 and 1400 hours.

Although Leim (1924) observed spawning by shad in brackish waters, other researchers have claimed that spawning occurs only in freshwater (Massman 1952; MacKenzie et al. 1985). There does not appear to be a minimum distance from brackish waters at which spawning occurs, (Leim 1924; Massmann 1952) but upstream and mid-river segments appear to be favored (Massmann 1952; Bilkovic et al. 2002a). It is not unusual for shad to migrate between 25 to 100 miles upstream to spawn, and some populations historically traveled over 300 miles upstream

(Stevenson 1899; Walburg and Nichols 1967). In the eighteenth and nineteenth centuries, shad runs were reported as far inland as 451 miles along the Great Pee Dee and Yadkin rivers (N.C. Geol. and Econ. Survey 1925) and over 500 miles in the Susquehanna River (Stevenson 1899).

Males arrive on the spawning grounds before females (Leim 1924). Females release their eggs close to the surface, where they are fertilized by one or several males. Eggs are released and fertilized in open water after sunset in clear water, (Leim 1924; Whitney 1961) or during the day in turbid rivers (Chittenden 1976a) or on overcast days (Miller et al. 1982). In the Pamunkey River, Virginia, spawning has been observed throughout the day. This may be due to its relatively turbid waters, which controls light intensity to some degree (Massmann 1952). These findings support the hypothesis that daily spawning is regulated by light intensity (Miller et al. 1982). Spawning activity usually peaks around midnight (Massmann 1952; Miller et al. 1971; 1975).

Fish that spawn north of Cape Hatteras are iteroparous (repeat spawners), while almost all of the fish that spawn to the south are semelparous (die after spawning). This may be due to the fact that south of the Carolinas, the physiological limits of shad are exceeded during the long oceanic migrations, and from the rapidly rising temperatures in southern rivers (Leggett 1969). Shad will spawn repeatedly as they progressively move upriver, (Glebe and Leggett 1981a) which may be a function of their high fecundity (Bigelow and Schroeder 2002). They exhibit asynchronous ovarian development and are batch spawners. Preliminary estimates for the York River, Virginia are 20,000-70,000 eggs per kg somatic weight, spawned every four days (Olney et al. 2001).

Studies have shown that the percentage of adults that are iteroparous increases northward along the Atlantic coast. For example, 3% of adults in the Neuse River, North Carolina were reported as repeat spawners, 24% in the York River, Virginia, 63% in the Connecticut River (Leggett and Carscadden 1978), and 73% in the Saint John River, Canada (Bigelow and Schroeder 2002). Percentage of repeat spawners may change over time within the same river as a result of pollution (Delaware River), fishing pressure (Hudson River), or other unknown causes (Connecticut River) (Limburg et al. 2003). A large percentage (58.5%) of shad in the St. Lawrence River did not spawn every year following the onset of maturation, but skipped one or more seasons (Provost 1987). Some fish spawn up to five times before they die (Carscadden and Leggett 1975).

Earlier studies suggested that southern stocks produce more eggs per unit of body weight than northern populations to compensate for their seeming disadvantage, which would result in about the same lifetime reproductive potential of fish throughout their range (Leggett and Carscadden 1978). Results from another study found that fecundity in shad may be indeterminate, and that previous annual or life-time fecundity estimates may not be accurate (Olney et al. 2001). Researchers examined batch fecundity of American shad in the St. Johns River, Florida (semelparous population), York and Connecticut rivers (iteroparous populations) and found no statistically significant differences in batch fecundity among semelparous and iteroparous populations. Thus, their results do not confirm the findings of Leggett and Carscadden. Until spawning frequency, duration, and batch size throughout the spawning season are known, lifetime fecundity for these stocks cannot be determined and previous methods to determine fecundity throughout the coastal range are inadequate (Olney and McBride 2003).

It is interesting to note that Olney et al. (2001) found that for postspawning females leaving the York River, approximately 70% of post-spawning fish had only partially spent ovaries, suggesting that the annual fecundity of most female shad in the river system is not achieved. Researchers hypothesize that these fish draw upon partially spent ovaries by resorping un-spawned yolked oocytes, which could supplement somatic energy sources as they return to the ocean. These fish would have a greater potential for surviving to become repeat spawners than fish that are fully spent and have no such energy reserves.

Despite a large potential area for spawning in the Connecticut River, shad were observed selecting discrete sites and remaining there for most of the season (Layzer 1974). Sometimes, spawners will forego areas with highly suitable habitats that are further downstream, suggesting that there are other, unaccounted for variables that influence habitat choice (Bilkovic 2000). Choice of spawning habitat may even be unrelated to physical variables and may reflect some unknown ecological selective pressure, such as fewer egg predators in selected habitats (Ross et al. 1993).

Spent adults are very emaciated, and will return to the sea soon after spawning (Chittenden 1976b), sometimes feeding before reaching saltwater (Atkins 1887). Studies along the Connecticut River found that the majority (86%) of spent adult shad emigrated seaward during daylight hours between 0700 and 2100 hours (O'Leary and Kynard 1982; Taylor and Kynard 1984). The oldest reported living shad in the United States was 11 years of age (Cating 1953), while a female from the Annapolis River, Nova Scotia was estimated to be 13 (Melvin et al. 1985).

Studies have attempted to demonstrate a stock-recruitment relationship among clupeids, but most have been unable to detect a strong relationship between adult and juvenile abundance (Crecco and Savoy 1984; Henderson and Brown 1985; Gibson 1994; Jessop 1994). Crecco et al. (1983) have suggested that year-class strength for American shad is driven by environmental factors.

Temperature

Water temperature is the primary factor that triggers spawning, but photoperiod, water flow and velocity, and turbidity also exert some influence (Leggett and Whitney 1972). The oceanic temperature range that triggers fish to begin migrating inshore is quite broad, which is between 5-23°C, (Walburg and Nichols 1967) but is most common in the range of 16-19°C (Leggett and Whitney 1972). Shad moving into nearshore waters of North Carolina were captured where bottom temperatures ranged from 8.6 to 19.9°C, with peak captures occurring at 13.2°C. Based on these results and the temperature range reported by Leggett and Whitney, Parker (1990) suggested that prespawning adults tolerate higher temperatures as they become sexually "ripe" and undergo physiological changes.

Estuarine temperatures along the Atlantic East Coast will vary between 3-15°C, from the time that pre-spawning fish first begin arriving at their natal rivers and peak spawning occurs (Talbot 1954; Massmann and Pacheco 1957; Walburg and Nichols 1967; Leggett 1972; Leggett and Whitney 1972). Egg development in the ovaries may occur slowly at first as water temperatures are increasing, and then mature rapidly at the onset of higher temperatures (DBFWMC 1980).

The southern populations are the first to arrive at South Atlantic rivers since these waters are the first to warm up, with temperatures in the higher range of tolerance. As the year progresses and water temperatures in Middle Atlantic and North Atlantic rivers continue to rise, prespawning adults will return to their natal rivers. Peak movement into east coast rivers occurs when temperatures are between 16.5-21.5° C, (Leggett 1976) but fish have been reported to move into natal rivers when temperatures are 4° C or less (Jones et al. 1978).

Throughout their geographic range, the water temperature at which American shad begin spawning is between 8-26°C, (Walburg and Nichols 1967; Stier and Crance 1985) but generally occurs between 12-21°C (Walburg and Nichols 1967; Leggett and Whitney 1972). At the northern limit of the shad's range, temperatures below 12° C will cause total or partial cessation of spawning (Leim 1924).

Shad ovaries develop more slowly at 12.8°C than at 20-25°C (Mansueti and Kolb 1953). Marcy (1976a) found that peak spawning temperatures varied from year to year. For example, a peak spawning temperature of 22°C was reported in 1968 and 14.8°C in 1969 in the Connecticut River. Stier and Crance (1985) assigned an optimum range for surface water temperature during spawning, between 14-20°C. Later analysis by Ross et al. (1993) suggested raising the upper optimum to 24.5°C.

Depth

Although Witherell and Kynard (1990) observed adult shad in the lower half of the water column as they migrated upstream, depth is not considered a critical factor after they reach their spawning habitat (Weiss-Glanz et al. 1986). Once they reach preferred areas, spawning adults have been found at river depths ranging from 0.45 to 10 m, (Mansueti and Kolb 1953; Walburg and Nichols 1967) but depths less than 4 m are often considered ideal (Bilkovic 2000). Ross et al. (1993) observed that the greatest level of spawning occurred where the water depth was less than 1 m in the Delaware River. Several studies have suggested that adults appear to select river areas that are less than 10 ft deep (3.3 m) or have broad flats (Mansueti and Kolb 1953; Leggett 1976; Kuzmeskus 1977).

Researchers have observed adults residing in slow, deep pools during the day, then moving to shallower water dominated by broad flats (where riffle-pools may be present) in the evening to spawn (Chittenden 1969; Layzer 1974). During the act of spawning, females and males can be found close to the surface during release and fertilization of eggs (Medcof 1957).

Despite little information on optimum and suitable depth ranges for this life stage, a suitability index was developed by Stier and Crance (1985), based on input from qualified researchers. They suggested that for all life history stages, including spawning, egg incubation, larvae, and juveniles, the optimum range for river depth is between 1.5-6.1 m. Depths less than 0.46 m (for spawning adults, larvae, and juveniles) and 0.15 m (for egg incubation), and greater than 15.24 (all life history stages) were designated unsuitable. Recent field studies based on spawning events, rather than egg collection, indicate that optimal habitat may be defined more narrowly. For example, sites deeper than 2 m in the Neuse River, North Carolina were used less extensively for spawning than expected based on their availability within the spawning grounds and over the entire river (Beasley and Hightower 2000; Bowman and Hightower 2001).

Salinity
Prior to migrating upstream, prespawning adults may spend two to three days in estuarine waters prior to moving upriver (Dodson et al. 1972; Leggett 1976). To test whether this acclimation period was necessary, Leggett and O'Boyle (1976) found that fish transferred from seawater to freshwater (accompanied by a 5-6°C temperature increase) over a 2.5-hour period experienced physiologic stress and a 54% mortality rate, 5 hours later. Additionally, adults did not survive transfers from saltwater (27 ppt) to freshwater with an accompanying 14°C temperature increase. Mortality varied from 0-40% for transfers from salinities ranging from 13-25 ppt to freshwater, with accompanying temperature increases up to 5.6°C. Adults appear to be better adapted to transfers from freshwater to saltwater, where they tolerated transfers from 23-24 ppt to freshwater, accompanied by temperature increases up to 9° C (Leggett and O'Boyle 1976).

Spawning typically occurs in tidal (Chittenden 1976a) and non-tidal freshwater regions of rivers and tributaries. In some rivers, adult spawners have historically migrated beyond tidal freshwater areas prior to dam blockages, but can no longer ascend these reaches (Mansueti and Kolb 1953). American shad exhibit a great tolerance to a wide range of salinities during their early developmental stages (Chittenden 1969), as well as, during their adult years (Dodson et al. 1972). Despite their tolerance to a wide range of salinities at this life history stage, American shad eggs are always deposited in freshwater (Weiss-Glanz 1986). Leim (1924) observed that eggs were typically deposited in waters of the Shubenacadie River, Canada slightly above the range of tide. In the Hudson River, shad ascend much further beyond the salt front, as far upstream as they can travel (Schmidt et al. 1988). Limburg and Ross (1995) concluded that the shad's preference for upriver spawning sites may be a genetically fixed character, but its advantage or significance does not appear to lie in salt intolerance of eggs and larvae.

Water velocity/flow
Stier and Crance (1985) considered temperature and water velocity to be the two most important variables for evaluating shad spawning habitat. Areas with high water flows provide a cue for spawning American shad (Orth and White 1993). Walburg (1960) found that spawning and egg incubation most often occurred where water velocity was 0.3-0.9 m/sec. Stier and Crance (1985) suggested that this was the optimum range for spawning areas. Ross et al. (1993) observed that spawning activity was highest in areas that ranged from 0-0.7 m/sec, suggesting that there is no lower suitability limit during this stage and that the upper limit should be modified. Although Bilkovic (2000) observed live eggs where the water velocity ranged from 0-1.0 m/s and larvae where water velocity ranged from 0-0.6 m/s, she further modified the optimum range to 0.3-0.7 m/sec. In order to prevent siltation and to insure that conditions conducive to spawning and egg incubation occur (Williams and Bruger 1972), she reasoned that some minimum velocity is required (Bilkovic 2000).

Appropriate water velocity at the entrance of fishways is also important for fish migrating upstream to spawning areas. Researchers found that water velocities of 0.6-0.9 m/sec at the entrance to pool-and-weir fishways (with a combined difference in pool elevations of 23 cm) was required to sufficiently attract fish (Walburg and Nichols 1967). Entrance velocities of 2-3 m/sec are routinely and effectively used at the Conowingo Dam fish lift on the Susquehanna River (St. Pierre, pers. comm.). At other sites, such as the Holyoke Dam, Massachusetts, American shad had trouble locating fishway entrances among turbulent discharges and avoided the area; thus, too much water velocity may actually deter fish (Barry and Kynard 1986).

Ross et al. (1993) noted that habitat selection seemed evident among spawning adults, which favored mid-river runs, defined as being relatively shallow (0.5-1.5 m) and moderate to high current velocity (0.3-0.7 m/s); to a lesser degree channels (deeper, greater current velocities, little if any SAV) and SAV shallows (inshore, high densities of SAV, low current velocities); and to a much lesser degree pools (wide river segment, deep, low current velocities) and riffle pools (immediately downstream of riffles, deepwater, variable current velocity and direction). They found that pools and riffle pools contain both deep and slow water, physical characteristics that adults seem to avoid. While runs may contain both swift and shallow water characteristics, and channels and SAV shallows may contain one or the other, but not both, this may help explain choice of habitats, which may confer higher survivability to newly spawned eggs. Bilkovic et al. (2002a) also found the greatest level of spawning activity in runs.

In 1985, a rediversion canal and hydroelectric dam with a fish passage facility were constructed between the Cooper River and Santee River, South Carolina, which increased the average flow of the Santee River from 63 m^3/s to 295 m^3/s. (Cooke and Leach 2003). This increased river flow and access to spawning grounds have contributed to increases in American shad populations. Although the importance of instream flow requirements has been previously recognized (Crecco and Savoy 1984; ASMFC 1985; Crecco et al. 1986; Ross et al. 1993), it has usually been with regard to spawning habitat requirements or recruitment potential (Moser and Ross 1994). Cooke and Leach's results suggest that the study of and possible adjustment of river flow may be an important consideration for restoring alosine habitat.

Water velocity may also contribute in some way to weight loss and mortality during the annual spawning migration, especially for males. Since they typically migrate upstream earlier when water velocities are greater, they tend to expend more energy than females (Glebe and Leggett 1973; DBFWMC 1980).

Although Summers and Rose (1987) could not detect direct relationships between stock size and river flow or water temperature, they found that spawning stock size, river flow rate, and temperature were important predictors of future American shad population sizes. They suggest that future studies incorporate a combination of environmental variables, rather than a single environmental variable, to determine what stimuli affect stock size.

Bottom composition

Spawning often occurs far upstream or in adjacent river channels along areas dominated by flats where the bottom substrate often consists of sand, silt, muck, gravel, or boulders (Mansueti and Kolb 1953; Walburg 1960; Walburg and Nichols 1967; Leggett 1976; Jones et al. 1978). Substrate type is not considered an important factor at the spawning site since eggs are released into the water column (Krauthamer and Richkus 1987); however, eggs are semibuoyant and may eventually sink to the bottom. Thus, areas predominated by sand and gravel may be better for survival because there is sufficient water velocity to remove silt or sand to prevent suffocation if eggs settle to the bottom (Walburg and Nichols 1967). Other researchers have also observed shad spawning primarily over sandy bottoms that were free of mud and silt (Williams and Bruger

1972). Bilkovic et al. (2002a) concluded that substrate type was not predictive of spawning and nursery habitat in two Virginia rivers she surveyed, although Layzer (1974) noted that survival rates of shad eggs were highest where gravel and rubble substrates were present. Finally, Hightower and Sparks (2003) hypothesized that larger substrates are important for American shad reproduction, based on their observations of spawning in the Roanoke River, North Carolina.

pH

No information found; refer to discussion of pH under Egg and Larval Habitat Section. Presumably, spawners will avoid waters with adverse pH conditions.

Dissolved oxygen

Shad require well-oxygenated waters in both rivers and at sea (MacKenzie et al. 1985). Jessop (1975) found that migrating adults require minimum dissolved oxygen (DO) levels between 4-5 mg/L in the headponds of the Saint John River, New Brunswick. Levels below 3.5 mg/L have shown sublethal effects (Chittenden 1973a), less than 3.0 mg/L blocked upstream migration in the Delaware River (Miller et al. 1982), and less than 2.0 mg/L caused a high incidence of mortality (Tagatz 1961; Chittenden 1969). Dissolved oxygen levels below 0.6 mg/L will result in 100% mortality of all fish (Chittenden 1969). Although minimum daily DO levels of 2.5-3.0 should be sufficient to allow shad to migrate through polluted areas, Chittenden (1973a) recommended that suitable spawning areas have a minimum of 4.0 mg/L of DO. Miller et al. (1982) proposed even higher minimum DO levels, suggesting that anything below 5.0 ppm (mg/L) should be considered potentially hazardous to adult and juvenile shad.

Suspended solids/turbidity

Adults appear to be quite tolerant of suspended solids, where concentrations as high as 1000 mg/L in the Shuebenacadie River, Nova Scotia, did not deter migrating adults (Leim 1924). Auld and Schubel (1978) found that similar concentrations of 1000 mg/L did not significantly affect hatching success of eggs.

Development, growth and movement patterns

<u>Eggs and larvae</u>

In general, eggs and larvae are found at, or downstream, of spawning locations. In the Mattaponi and Pamunkey rivers, Virginia, eggs were predominantly found in the upper and mid-river segments. Upstream areas typically have extensive deadfall (where important larval and juvenile shad prey items originate), and spawning there may ensure that eggs (and larvae) are retained within favorable habitats (Bilkovic et al. 2002a).

Once eggs are released into the water column, they are initially semibuoyant to demersal. Researchers followed shad eggs after they were broadcast and found that they traveled a distance of 5 to 35 m downstream until they sank or were lodged on the bottom (Whitworth and Bennett 1970). Other researchers (Barker 1965; Carlson 1968; Chittenden 1969) have reported similar observations. Laboratory experiments, which did not factor in hydrodynamic and tidal effects, found that sinking rates for eggs were 0.5-0.7 m/min (1.6-2.4 ft/min), with newly spawned eggs sinking at a quicker rate (Massmann 1952; Chittenden 1969). Other factors can influence how far eggs travel, such as extensive deadfall and other debris, which may prevent eggs from settling far from the spawning site (Bilkovic 2000). Once eggs sink to the bottom, they are swept under rocks and boulders by eddy currents and are kept in place as they increase in diameter from water absorption. They may become dislodged and be swept downstream for short distances, especially to nearby pools (DBFWMC 1980). Survival of eggs is dependent on several factors, including current velocity, dissolved oxygen, water temperature, suspended sediments, pollution, and predation (Krauthamer and Richkus 1987; Bailey and Houde 1989).

Yolk-sac larvae may not use inshore habitat as extensively as post yolk-sac larvae (Limburg 1996). One early study (Mitchell 1925, cited in Crecco et al. 1983) found that yolk-sac larvae were near the bottom and swam to shore as the yolk-sac reabsorbed. Metzger et al. (1992) also found yolk-sac larvae mostly in offshore areas along the bottom, while post yolk-sac larvae were more concentrated in quiet areas nearshorelines (Cave 1978; Metzger et al. 1992). Yolk-sac larvae are typically found deeper in the water column than postlarvae, due to their semi-buoyant nature and aversion to light, while postlarvae are more abundant in surface waters, especially in downstream waters (Marcy 1976a).

After hatching, yolk-sac larvae will exhaust their food supply within 4-7 days (Walburg and Nichols 1967), when they are about 10-12 mm total length (TL) (Marcy 1972). Larval survival may be dependent on water temperature, water flow, food production and density, and predation (State of Maryland 1985; Bailey and Houde 1989; Limburg 1996). Larvae may drift passively into brackish water shortly after hatching occurs, or can remain in freshwater for the remainder of the summer (State of Maine 1982). Larvae often aggregate in eddies and backwaters (Stier and Crance 1985). Ross et al. (1993) reported that shad larvae frequent riffle pools where water is of moderate depth and variable velocity and direction. Larvae in the Mattaponi and Pamunkey rivers, Virginia, were dispersed from the upper through the downriver areas. Unlike the presence of eggs, which could be predicted in most cases using physical habitat and shoreline/land use ratings, distinct habitat associations could not be discerned for larval distributions. This may be due to the fact that larvae are carried further downstream than eggs, dispersing them into more variable habitats (Bilkovic et al. 2002a).

Temperature

Rate of development of shad eggs has been linearly correlated to water temperature (Mansueti and Kolb 1953) and hatching times were observed at the following temperatures: 15.5 (Leim 1924) and 17 days at 12°C (Ryder 1887); 7 days at 16.1°C (Hendricks, cited in Boreman 1981) and 17°C (Leim 1924); 3 days at 24°C (MacKenzie et al. 1985); and 2 days at 27°C (Rice 1878). Within the range of 11-27°C, the time it takes for eggs to develop can be expressed as (Limburg 1996):

$$\text{loge(EDT)} = 8.9 - 2.484 \times \text{loge(T)}$$

where EDT is egg development time in days and T is temperature in degrees Celsius

Most eggs typically hatch in 3 to 6 days (Krauthamer and Richkus 1987). Temperatures below 8-10°C are unsuitable (Bradford et al. 1968), and at 8°C eggs will stop developing (Leim 1924). Several researchers have suggested suitable near-surface water temperatures for development and survival of American shad eggs, including 8-26°C (Walburg and Nichols 1967; Ross et al. 1993) and 10-30°C (Stier and Crance 1985). Leim (1924) suggested that overall optimal conditions for American shad egg development occur at 17°C, 7.5 ppt salinity, and darkness.

Temperatures above 27°C resulted in abnormalities or total cessation of larval development (Bradford et al. 1968). Few larvae have been found living in temperatures above 28° C (Marcy 1971; 1973), and no viable larvae developed from eggs incubated above 29°C (Bradford et al. 1968). The range of suggested suitable water temperatures for the larval stage includes 10-27°C (Bradford et al. 1968), 13.0-26.2°C (Ross et al. 1993), and 10-30° C (Stier and Crance 1985). The optimal temperature range for maximum hatching and egg and larval development combined is suggested to be 15.5-26.5°C (Leim 1924) and 15-25°C (Stier and Crance 1985). Ross et al. (1993) have recommended that further sampling be conducted for postlarval stages at temperatures ≥27°C to confirm upper optimal temperature preferences. In their studies, they found no reduction in density of larvae at the upper thermal limit (26-27°C) in areas sampled along the Delaware River.

Laboratory experiments conducted on shad eggs reveal that they can tolerate extreme temperature changes as long as exposure duration is relatively short (Klauda et al. 1991). Temperature increases after acclimation at various temperatures produced variable results, but of note, is the ability of eggs to withstand temperatures of 30.5°C for 30 minutes and 35.2°C for 5 minutes (Schubel and Koo 1976). Also, sensitivity to increases in temperature decreased as eggs matured (Koo et al. 1976). Larvae could also withstand temperatures as high as 29.5° C after acclimation, but only for 15 minutes (Koo et al. 1976; Koo 1979).

Shoubridge (1977) analyzed temperature regimes in several coastal rivers throughout the range of American shad (Florida to New Brunswick, Canada), and found that as latitude increased: 1) the duration of the temperature optima for egg and larval development decreased; and 2) the variability of the temperature regime increased. Based on Shoubridge's work, Leggett and Carscadden (1978) suggested that variation in shad egg and larval survival, year-class strength, and recruitment also increases with latitude.

Crecco and Savoy (1984) found that low water temperatures (and high rainfall and high river flow) were significantly correlated with low shad juvenile abundance during the month of June in the Connecticut River, while high water temperatures (and low river flow and low rainfall) were significantly correlated with high juvenile abundance (Crecco and Savoy 1984). Depressed water temperatures can retard the onset and duration of shad spawning (Leggett and Whitney 1972), the growth rates of larvae (Murai et al. 1979), and the production of riverine zooplankton (Chandler 1937; Beach 1960).

Depth

Eggs are slightly heavier than water, but may be buoyed by prevailing currents and the tide. Eventually, many of the eggs will eventually settle at or near the bottom of the river during the water-hardening stage (Jones et al. 1978). Shad eggs were found to be distributed almost equally between the surface and the bottom of the Connecticut River, while larvae were more than twice as abundant in surface waters, becoming increasingly pelagic as they moved downstream (Marcy 1976a). Most of the larvae caught by Leim (1924) were obtained in surface tows.

One study in the Connecticut River found that 49 percent of the eggs were found in water less than 10 feet (3.3 m) deep, 30 percent in water between 11 to 20 feet (3.7-6.7 m) deep, and the rest were collected in water between 21 to 30 feet (7-10 m) (Walburg and Nichols, 1967). Massman (1952) reported that five times as many eggs per hour were collected at depths ranging from 1.5 to 6.1 m (4.9-20.0 ft), than in deeper waters of the Pamunkey and Mattaponi rivers. Approximately 40% of spawned eggs were reported at depths less than 3 m (9.8 ft) by Walburg and Nichols (1967).

Despite a lack of data for depth optima, Stier and Crance (1985) developed a suitability index based on input from qualified researchers, and suggested that for all life history stages, including spawning, egg incubation, larvae, and juveniles, the optimum range for river depth is between 1.5-6.1 m. Depths less than 0.46 m (for spawning adults, larvae, and juveniles) and 0.15 m (for egg incubation) and greater than 15.24 (all life history stages) were designated unsuitable. Bilkovic et al. (2002a) found eggs at depths of 0.9-5.0 m along the Mattaponi and Pamunkey rivers, while larvae were more widely distributed in the range of 1-10 m. Thus, she suggested that larval shad may occupy a broader range of optimal depths.

Salinity

Although American shad eggs are always deposited in freshwater, it is unknown whether they hatch only in freshwater, only brackish water, or in both (Weiss-Glanz 1986). Leim (1924) noted that shad in their northern range do not spawn very far beyond the tidal portion of rivers, even though they had the ability to migrate further upstream in some areas. Also, unlike alewives, there are no landlocked populations on the East Coast. His experiments found that successful development of embryos and larvae occurred under low salinity conditions, and larvae were able to survive longer without food compared with freshwater conditions.

Eggs and larvae were observed in salinities ranging from 0-7.6 ppt, but most often at 0 ppt in the Shubenacadie River, Canada. Although larvae could tolerate salinities as high as 15 ppt in laboratory studies, premature death often resulted. At 22.5 ppt, egg development was poor or hatching occurred prematurely (Leim 1924). Early attempts to gradually acclimate larval shad to full-strength seawater resulted in high mortality and 20-24 ppt also met with unfavorable results (Milner 1876). Temperature was found to influence salinity sensitivities, with lower temperatures (12°C) resulting in more abnormalities at 15 and 22.5 ppt, than at higher temperatures (17°C) (Leim 1924).

Limburg and Ross (1995) found that salinities of 10-20% were favorable for post-yolk sac shad larvae under experimental conditions, and concluded that estuarine salinities neither depressed growth rates nor elevated mortality rates of larval American shad, compared with freshwater conditions. They concluded that ecological factors other than the physiological effects of salinity may have played a greater role in influencing spawning site selection by shad.

Water velocity/flow

Kuzmeskus (1977) found fresh spawn in areas where water velocity rates were between 9.5 and 132 cm/sec. Williams and Bruger (1972) noted that increased siltation may result if water velocities are less than 0.3 m/s, causing increased egg mortality from suffocation and bacterial infection. Early studies suggested that optimal conditions for eggs and larval stages occur where water velocity is between 0.3-0.9 m/sec (Walburg 1960; Walburg and Nichols 1967; Stier and Crance 1985). Ross et al (1993) later modified this range to 0-0.7 m/sec. Bilkovic et al. (2002a) collected eggs within a broader range of water velocities of 0-1.0 m/s in the Mattaponi and Pamunkey rivers, Virginia. She suggested that a suitable range for both the egg and larval stage combined would incorporate this range (0-1.0 m/s), but that future research should facilitate the development of distinct models for the egg and larval stages.

Freshwater discharges can influence developing eggs and larvae. Increased river flow can carry eggs from favorable nursery habitat to unfavorable areas that reduce their chance for survival, while lower flows may result in favorable hydrodynamic, thermal, and feeding conditions (Crecco and Savoy 1987a; Limburg 1996). Crecco and Savoy (1987b) observed that larval and juvenile shad selected eddies and backwater areas where water flow was greatly reduced. Limburg's (1996) observations in the Hudson River led her to postulate that high May river discharges, and associated low temperatures and low food availability, contributed to high larval mortality, while larvae hatched after May had a much higher survival rate due to more favorable conditions. Marcy (1976) discovered significant correlations between year-class strength and river flow in the Connecticut River. He found that from 1966 through 1973 during the month of June, increased river flows and decreased water temperatures accounted for reduced year-class abundance. Larval survival rates in the Connecticut River have also been negatively correlated with increased river flow in June and positively correlated with June river temperatures (Savoy and Crecco 1988).

Although hydrographic turbulence may affect larval shad survival rates, the precise mechanisms are uncertain because daily river flow and rainfall levels are nonlinear, time-dependent processes (Sharp 1980) that may act singularly or in combination with other factors. There are numerous potential interactions of flow rates with climatic, physical, and biological processes (Turner and Chadwick 1972). For example, decreased temperatures can delay and shorten the spawning season of shad (Leggett and Whitney 1972), impact the growth rates of larvae (Murai et al. 1979), and affect riverine zooplankton production (Chandler 1937; Beach 1960).   Transparency of the water may also be reduced, compromising the ability of larval fish to see their prey (Theilacker and Dorsey 1980). Increased turbidity may also affect photosynthesis among river phytoplankton, which in turn may lead to elimination of cladocerans and copepods (Chandler 1937; Hynes 1970), a favored prey item among larval shad (Crecco and Blake 1983; Johnson and Dropkin 1995). Thus, there are many ways in which river flow can alter survival rates of shad larvae, and it is unreasonable to assume that a single causal mechanism will operate under all circumstances (Crecco and Savoy 1984).

Bottom composition

Once eggs become fertilized, they can either sink to the bottom, becoming lodged under rocks and boulders, or be swept along by currents, usually to the nearest pool (Chittenden 1969). As discussed above, bottom composition does not appear to be a critical factor for spawning (Krauthamer and Richkus 1987), and Bilkovic (2000) concluded that substrate type was not predictive of spawning and nursery habitat in rivers she surveyed in Virginia. Spawning over sand and/or gravel substrates may be preferred however, because there is sufficient water velocity to remove silt or sand and prevent suffocation, if eggs settle to the bottom (Walburg and

Nichols 1967). Survival rates of shad eggs have been found to be highest for those that settled over gravel and rubble substrates (Layzer 1974).

pH

Early laboratory studies of pH tolerance of American shad from the Shuebenacadie River, Canada found that values between 6.0-9.0 had no negative effects on eggs and larvae (Leim 1924). When subjected to a pH of 10.0 and higher, eggs did not develop properly and larvae were less active. Bradford et al. (1968) found that American shad eggs developed successfully at pH 5.5-9.5 (18-19° C), but most eggs (100-68%) died at a pH of less than 5.2. The lethal dose for 50% of the population (LD50) was calculated at about pH 5.5, but many of the larvae that hatched were deformed. The most successful range for hatching was between 6.0-7.5 and researchers concluded that a pH of at least 6.0 was necessary for suitable egg incubation. When eggs were also subjected to aluminum pulses, critical conditions were met at pH 5.7 + 50 or 200 µg/L Al for 96 h or pH 6.5 + 100 µg/L Al for 96 h (Klauda 1994).

Klauda (1989) concluded that shad larvae required a minimum of pH 6.7 and a maximum of 9.9 for survival; pH >7.0 is considered optimal for larvae (Leach and Houde 1999). Bilkovic et al. (2002a) surveyed shad eggs and larvae within waters with pH values from 5.9-9.3, and observed shad eggs associated with a pH between 6.5-8.5, and larvae in the range of 6.5-9.3.

Yolksac larvae (1-3 days old) that were subjected to an array of acid and aluminum conditions appeared to be more sensitive to acid and aluminum pulses than eggs. The least severe treatment that resulted in critical conditions of acid and aluminum was a 24 h exposure to pH 6.1 with 92 g/L of total dissolved aluminum. The least severe treatment that resulted in a lethal condition was a 24 h exposure to pH 5.5 with 214 g/L of total dissolved aluminum.

Postlarvae (6-16 days old) were found to be more sensitive to acid and aluminum pulses than both eggs and yolksac larvae. Critical conditions occurred at pH 5.2 + 46 µg/L and pH 6.2 + 54 or 79 µg/L aluminum for 8 hours, and lethal conditions occurred at pH 5.2 + 63 µg/L aluminum for 16 hours (Klauda 1994).

In general, fertilized eggs, yolk-sac larvae, and to a lesser degree, post yolk-sac larvae have the highest probability of temporary acidic conditions and elevated aluminum levels in or near their freshwater spawning sites in streams that are poorly buffered (low alkalinity) (Klauda 1989). American shad stocks that spawn in poorly buffered Eastern Shore Maryland rivers, like the Nanticoke and Choptank, may be more vulnerable to storm-induced, toxic pulses of low pH and elevated aluminum, and thus, recover at a much slower rate than stocks that spawn in well-buffered Western Shore rivers. Klauda (1994) hypothesized that whenever the abundance of an acid-sensitive fish species like American shad is as low as most Maryland stocks are today, and annual climatic conditions are less than favorable for good reproduction, even infrequent and temporary episodes of critical or lethal pH and aluminum exposures in the spawning and nursery areas could contribute to significant reductions in egg or larval survival and slow stock recovery. Leach and Houde (1999) noted that sudden drops in pH levels, such as those associated with rainfall, can impose high and sudden mortalities on larvae.

Dissolved oxygen

Few specific egg and larval DO tolerance or optima data were found in the literature, however there are several studies that note presence or absence of eggs and larvae under certain DO conditions (Bilkovic et al. 2002a). American shad eggs were collected in the Neuse River, North Carolina, where DO ranged from 6-10 mg/L (Hawkins 1979). No eggs could be found in the Connecticut River when the DO concentrations were less than 5 mg/L (Marcy 1976a). Bilkovic (2000) found that in the Mattaponi and Pamunkey Rivers, associated DO median values for eggs (10.8, 10.2 mg/L, respectively) were greater than for yolksac larvae (8.2, 9.6 mg/L, respectively) and postlarvae (8.1, 8.2 mg/L, respectively).

One study determined that the LC_{50} values for Connecticut River eggs were between 2.0-2.5 mg/L (Marcy 1976a). In the Columbia River the LC50 was close to 3.5 mg/L for eggs and at least 4.0 mg/L was required for a high percentage of hatched eggs and healthy larvae; less than 1.0 mg/L resulted in total mortality (Bradford et al. 1968). Klauda et al. (1991) concluded that a good hatch with a high percentage of normal larvae required DO levels during egg incubation of at least 4.0 mg/L, based on observations by both Maurice et al. (1987) and Chittenden (1973a). Miller et al. (1982) concluded the minimum DO level for both eggs and larvae is approximately 5 mg/L. This is the value that Bilkovic (2000) assigned for optimum conditions for survival, growth, and development of American shad. Finally, it is worth noting that cleanup of the Delaware River has had a measurably positive effect on increasing DO concentrations there (Maurice et al. 1987).

Suspended solids/turbidity
Eggs seem to be less vulnerable to the effects of suspended solids than larvae. For example, levels of up to 1000 mg/L did not significantly reduce hatching success, while larvae exposed to levels of 100 mg/L or greater significantly reduced survival rates (Auld and Schubel 1978).

<u>Juveniles</u>
Shad larvae are transformed into juveniles 3-5 weeks after hatching at about 28 mm total length (TL), (Jones et al. 1978; Crecco and Blake 1983; Klauda et al. 1991; McCormick et al. 1996) and disperse at or downstream of the spawning grounds, where they spend their first summer in the lower portion of the river where they were spawned. Juvenile American shad (and blueback herring) were found inshore in the Hudson River during the day, while alewives predominated inshore at night (McFadden et al. 1978; Dey and Baumann 1978).

While most young shad use freshwater nursery reaches, (McCormick et al. 1996) it is thought that their early ability to hypo-osmoregulate allows them to utilize brackish nursery areas during years of high juvenile populations (Crecco et al. 1983). American shad juveniles use the headpond of the Annapolis River, Nova Scotia, as a nursery area, which has surface water salinities of 25-30% (Stokesbury and Dadswell 1989).

O'Donnell (2000) found that juveniles in the Connecticut River began their seaward emigration at approximately 80 days post hatch. They are typically 7-15 cm in length before they leave the river and enter the ocean (Talbot and Sykes 1958). Shad were observed remaining in the offshore region of the Annapolis estuary (Nova Scotia) for almost a month before the correct cues triggered emigration (Stokesbury and Dadswell 1989). Some researchers (Chittenden 1969; Limburg 1996) found evidence that juvenile emigration was already underway by midsummer, indicating that movement may be triggered by cues other than declining fall temperatures. Juveniles in northern rivers emigrate seaward first, and those from southern rivers emigrate progressively later in the year (Leggett 1977a). For example, downstream emigration peaks in September and October in the Connecticut River, late October in the Hudson River (Schmidt et al. 1988), and late October through late November in the Upper Delaware River and Chesapeake Bay (Krauthamer and Richkus 1987). Although juveniles were still found in the Cape Fear River, North Carolina in December, seaward migration took place mostly in November (Fischer 1980). Emigration usually peaks at night (i.e. at 1800-2300 hours) (O'Leary and Kynard 1986; Stokesbury and Dadswell 1989).

The combination of factors that trigger juvenile emigration is uncertain, but researchers suggest decreasing water temperatures, reduced water flow, or a combination of both during autumn appear to be key factors (Sykes and Lehman 1957; Walburg and Nichols 1967; Moss 1970). In the Susquehanna River, an increase in river flow from October through November may actually help push juveniles downstream (St. Pierre, pers. comm.). Miller et al. (1973) suggested that water temperature was more important than all other factors, because it directly affects the shad, with time of season being secondary (which also influences temperature). Several researchers (Chittenden 1969; Miller et al. 1973; Limburg 1996; O'Donnell 2000) have observed younger, smaller young-of-the-year fish in upstream reaches, while older and larger (within age cohorts) fish were found downstream earlier in the season, which led them to hypothesize that as fish grow and age, they move downstream. Both Chittenden (1969) and Marcy (1976a) suggested that factors associated with size appear to initiate the earlier stages of seaward emigration; larger fish that were already downstream by mid-summer when temperatures were higher than 21° C was interpreted as emigration in progress.

Results from another study (Stokesbury and Dadswell 1989) suggest that size at emigration may not be an important factor that triggers migration, but that environmental stress may reach a point where seaward movement is necessary regardless of a critical size. O'Leary and Kynard (1986) and Stokesbury and Dadswell (1989) found that shad movement typically occurred during quarter to new-moon periods when water temperatures dropped below 19°C and 12°C, respectively. Decreasing water temperatures and the new moon phase, which provided dark nights, were considered to be more important in providing cues for emigration than increased river flow. The lower lethal temperature limit that triggers the final movement of juveniles from fresh water is approximately 4-6°C (Chittenden 1969; Marcy 1976a). Zydlewski and McCormick (1997a) observed changes in osmoregulatory physiology in migrating juvenile shad, and concluded that these were part of a suite of changes that occur at the time of migration. While this set of changes has been shown to be strongly affected by temperature in several studies, they suggested that other environmental and/or ontogenetic factors may have an influence on timing of migration.

Upon leaving their nursery habitat in the late fall, juveniles may spend their first year near the mouths of streams, in estuaries, and other nearshore waters (Hildebrand 1963; Bigelow and Schroeder 2002), or may move to deeper, higher salinity areas, such as may exist in portions of the Chesapeake Bay (Hildebrand and Schroeder 1928). Milstein (1981) found juveniles overwintering in warmer, higher salinity waters 0.6-7.4 km from the shore of New Jersey, in what is considered an offshore estuary (Cameron and Pritchard 1963). Hammer (1942) reported catches of 1- and 2-year old shad in brackish and fresh water of the Potomac River. Juvenile shad from the Connecticut River may remain in Long Island Sound for one or two years before joining the coastal migratory stocks in the Gulf of Maine during their second or third year of life (Savoy 1993). Juveniles may overwinter in estuarine waters of the lower Neuse River, NC, with emigration occurring as late as February (Holland and Yelverton 1973). In their southern range, some juveniles may stay in the river for up to one full year (Williams and Bruger 1972). In South Carolina, juvenile American shad were found predominantly in deeper, channel habitats of estuarine systems, during fall and winter. Small crustaceans preyed upon by American shad are generally abundant near the bottom in these areas (McCord 2005).

Temperature
Young shad are sensitive to water temperature changes, and actively avoid temperature extremes, if possible. Laboratory tests suggest that juveniles can tolerate temperature increases >1° and <4° C above ambient temperature, but above that, shad will avoid changes, if given a choice (Moss 1970).

The lower range of thermal tolerance for juveniles appears to be about 2°C, but sublethal effects have been observed between 4-6°C (Chittenden 1972). Juveniles have a preference for temperatures of at least 8°C (MacKenzie et al. 1985) and have a natural upper temperature limit near 30° C (Marcy et al. 1972). Juveniles collected from the Connecticut River were found where temperatures ranged from 10-30°C, with one fish found where the temperature was 31°C (Marcy et al. 1972). Leim (1924) found that juveniles captured in the Shubenacadie River, Canada were usually found where temperatures tended to be the highest compared to other regions of the river. Limburg (1996) found that juveniles in the lab had higher initial growth rates at 28.5°C than fish reared at lower temperatures. O'Donnell (2000) concluded that it may be advantageous for fish to hatch later in the year because temperatures are higher and growth rates for juveniles will be faster. Disadvantages to later hatching later in the year include increased competition and predation rates.

The lethal upper water temperature limit that killed 50% of juveniles tested (TL50) was 31.6°C, but acclimation at 24°C prior to exposure, was first necessary (Ecological Analysts Inc. 1978). A critical thermal maximum of 34-35°C has been reported for juveniles in the Neuse River, North Carolina (Horton and Bridges 1973). Unlike shad eggs, juveniles do not appear to be as tolerant to temperature changes. For example, juveniles acclimated to 25°C suffered a 100% mortality rate when the temperature was decreased to 15°C. There was also a 100% mortality rate for juveniles acclimated to 15°C and then subjected to temperatures <5°C. Finally, no survival was reported for juveniles acclimated to 5°C and then exposed to 1°C (PSE&G 1978).

Crance (1985) suggested an optimum range between 15.5-23.9°C for the juvenile life stage. Stier and Crance (1985) suggested an optimal near-bottom temperature range for juveniles during the winter and spring in estuarine waters was 10-25°C, and below 3°C and above 35°C were unsuitable.

In the Connecticut River, seaward migration was observed when temperatures dropped below 19°C (Leggett 1976; O'Leary and Kynard 1986), but juveniles have also been observed moving downstream when temperatures were higher than 19° C (between 26-23°C), which was interpreted by researchers as active emigration (Marcy 1976a). Watson (1970) observed a similar pattern, with juveniles beginning to migrate once temperatures reached 18.3°C, during the month of September. Migration peaks when temperatures decline to 16-9°C (Leggett and Whitney 1972; O'Leary and Kynard 1986). In the Delaware River, emigration was complete at 8.3°C (Chittenden and Westman 1967), and in the Chesapeake Bay watershed, all juveniles had left once temperatures reached 8.3°C (Chesapeake Bay Program 1988). In North Carolina rivers, juvenile peak emigration was observed when temperatures fell below 15.1°C (Neves and Depres 1979; Boreman 1981). Limburg (1996) and O'Donnell (2000) found evidence that emigration downstream had already begun by mid-summer, before fall temperatures decreased. Limburg (1996) suggested that at the population level, temperature may provide the stimulus for fish to emigrate, or it may be a gradual process that is cued by size of fish, with early cohorts leaving first.

Depth

Juveniles have been observed at depths ranging from 0.9 m to 4.9 m in the Connecticut River (Marcy 1976a); however, abundance was related to the distance upstream and not to depth (MacKenzie et al. 1985). Chittenden (1969) observed juveniles in the Delaware River most often in deeper pools away from the shoreline in non-tidal areas during daylight hours, and to a much lesser degree, in shallow riffles. In the Connecticut River, juveniles were caught primarily at the bottom during the day (87%) and all were caught at the surface at night (Marcy 1976a). After sunset, juveniles will scatter and can be found at all depths (Miller et al. 1973).

Although there were a lack of data for depth optima for juveniles, Stier and Crance (1985) developed a suitability index based on input provided by research scientists. They suggested that for all life history stages, including juveniles, the optimum range for river depth is between 1.5-6.1 m. Depths less than 0.46 m and greater than 15.24 were designated as unsuitable.

Salinity

Early studies of juveniles provide conflicting results of responses to changes in salinity. For example, Tagatz (1961) observed 60% mortality for juveniles in isothermal transfers (21° C) from freshwater to 30-ppt seawater, while Chittenden (1973) observed 100% survival in isothermal (17° C) transfers from freshwater or 5 ppt to 32 ppt salinities. Juveniles that were transferred from 30 ppt seawater to freshwater suffered 100% mortality, but no mortalities resulted when they were transferred from 5 ppt to freshwater (Chittenden 1973b). In general, shad are considered to be capable of enduring a wide range of salinities at an early stage in their life, especially if salinity changes are gradual (Chittenden 1969).

When accompanied by temperature changes, juveniles could generally adapt to abrupt transfers from freshwater to saltwater, but high mortality resulted when transferred from saltwater to freshwater (Tagatz 1961). At temperature increases <14°C, all juvenile fish survived abrupt transfers from saltwater (15 ppt and 33 ppt salinity) to freshwater. Conversely, no fish survived transfers from freshwater (at 21.1°C) to saltwater (33 ppt) at 7.2-12.8°C. Freshwater transfers to 15 ppt in association with temperature decreases <4° C also resulted in high mortalities (30-50%).

Experiments conducted on shad and other anadromous fish (Rounsefell and Everhart 1953; Houston 1957; Tagatz 1961; Zydlewski and McCormick 1997a, 1997b) have found that fish undergo physiological changes before emigrating to saltwater. This ability to adapt to changes in salinity occurs at the onset of metamorphosis, between 26 and 45 days post-hatch. Researchers noted that the ability to osmoregulate in full-strength seawater is an important factor that limits the early life history to freshwater and low-salinity estuaries (Zydlewski and McCormick 1997b). It was suggested that a decrease and subsequent loss of hyperosmoregulatory ability in shad may serve as a proximate cue for juveniles to begin their downstream migration (Zydlewski and McCormick 1997b).

Water velocity/flow

Ideal water velocity rates are thought to range between 6-75 cm/sec (0.06-0.75 m/sec) for the juvenile non-migration stage (Klauda et al. 1991). The rate of water velocity is also critical for fish migrating downstream that pass over spillways (MacKenzie et al. 1985). It has been suggested that water flow may serve to orient emigrating juveniles in the downstream direction. Studies conducted on shad in the St. Johns River, Florida led researchers to speculate that lack of current from low water levels could result in the inability of juveniles to find their way downstream (Williams and Bruger 1972).

Bottom composition

Although juveniles were found to be most abundant where boulder, cobble, gravel and sand were present, (Walburg and Nichols 1967; Odom 1997), substrate type is not considered to be a critical factor in nursery areas (Krauthamer and Richkus 1987). Estuarine productivity is linked to freshwater nutrient (detritus) input to the estuary (Biggs and Flemer 1972; Hobbie et al. 1973; Saila 1973; Day et al.1975) and detritus production in the salt marsh (Teal 1962; Odum and Heald 1973; Reimhold et al. 1973; Stevenson et al. 1975). Based on the assumption that the amount of submerged and emergent vegetation will be a qualitative estimate of the estuary's secondary productivity, and therefore, food availability (zooplankton) to juvenile shad, Stier and Crance (1985) suggested that estuarine habitat with 50% or more vegetation coverage is optimal.

It is important to note that, although no link has been made between the presence of SAV and abundance of alosines, there seems to be a general agreement that there is a correlation between water quality and alosid abundance (Sadzinski 2003). Abundance of SAV is often used as an indirect measure of water quality, with factors such as available light (Livingston et al. 1998), salinity, temperature, water depth, tidal range, grazers, suitable sediment quality, sediment nutrients, wave action, current velocity, and chemical contaminants controlling the distribution of underwater grasses (Koch 2001). Maryland has made it a priority to increase the amount of SAV within the Chesapeake Bay watershed in order to improve water quality. If SAV in a given area increases, this can be used as an indicator of improved water quality, which in turn, will likely benefit alosine species (Sadzinski 2003).

Ross et al. (1997) found no overall effect of habitat type on juvenile relative abundance in the upper Delaware River, indicating that juveniles use a wide variety of habitat types to their advantage in many nursery areas. They suggested that in contrast to earlier life stages and spawning adults, premigratory juveniles may be habitat generalists. They did however, find a positive relationship between abundance of juvenile American shad and percent of SAV cover in

SAV habitats only. Odom (1997) found that juvenile American shad favored riffle/run habitat in the James River, especially areas with extensive beds of water stargrass (*Heteranthera dubia*). These areas provided flow-boundary feeding stations where juvenile shad could feed on drifting macroinvertebrates while reducing their energy costs. Finally, it should be noted that Dixon (2004, per. comm.) commented that since juvenile blueback herring (another alosine species) are a pelagic schooling fish, they likely do not rely on SAV to the extent that other anadromous fish do for predator avoidance, such as striped bass.

pH

Areas that are poorly buffered (low alkalinity) and subject to episodic or chronic acidification may provide less suitable nursery habitat than areas that have higher alkalinities and are less subject to episodic or chronic acidification (Klauda et al. 1991). Juveniles may be less at risk to changes in pH because they move downstream to brackish areas that may have a higher buffering capacity (Klauda 1989). No additional information regarding different pH effects on juveniles could be found.

Dissolved oxygen

Seemingly healthy juvenile shad have been collected in the Hudson River, New York, where dissolved oxygen (DO) concentrations were 4-5 mg/L (Burdick 1954). Similarly, in headponds above hydroelectric dams on the St. John River, New Brunswick, DO must be at least 4-5 mg/L for migrating juveniles to pass through (Jessop 1975). Under laboratory conditions, juveniles did not lose equilibrium until DO decreased to 2.5-3.5 mg/L (Chittenden 1969; 1973a). In the Delaware River, DO concentrations less than 3.0 mg/L blocked juvenile migration, and DO below 2.0 mg/L was lethal. Emigrating juveniles have historically arrived at the upper tidal section of the Delaware River by mid-October, but could not continue further seaward movement until November or December, when the pollution/low oxygen conditions dissipated (Miller et al. 1982). Juveniles have been reported to survive brief exposure to DO concentrations of as little as 0.5 mg/L, but survived only if >3 mg/L was available immediately thereafter (Dorfman and Westman 1970).

Because minimum dissolved oxygen values have a more adverse effect upon fish than average dissolved oxygen values, minimum criteria has been recommended. Dissolved oxygen concentrations less than 5.0 mg/L are considered sublethal to juvenile American shad (Miller et al. 1982). As with spawning areas, Bilkovic (2000) assigned a value of >5.0 mg/L dissolved oxygen as optimal for nursery areas.

Turbidity

Ross et al. (1997) suggested that optimal turbidity values for premigratory juveniles in tributaries only is between 0.75-2.2 nephelometric turbidity units (NTU). While preliminary, these results could be cautiously applied to other river systems, but consideration should be given to the range and diversity of habitat types in the river system under study before applying the models.

<u>Subadults</u>

Fish remain in the ocean for 2-6 years before becoming sexually mature, whereupon, they return to their natal rivers to spawn (Talbot and Sykes 1958; Walburg and Nichols 1967). Both sexes mature at a minimum of 2 years, with males maturing on average in 4.3 years and females maturing on average in 4.6 years (Leggett 1969). Fish north of Cape Hatteras are repeat spawners and will return to rivers to spawn when temperatures are suitable. American shad typically live to be 5 to 7 years of age.

Results from 50 years of tagging indicate that discrete aggregations of fish occur at sea, comprised of juveniles and adults (Talbot and Sykes 1958; Leggett 1977a, c; Dadswell et al. 1987; Melvin et al. 1992), at the same time, at widely separated geographic locations (Dadswell et al. 1987). These aggregations are a heterogeneous mixture from many rivers (Dadswell et al. 1987), but it is unknown if fish from all river systems along the East Coast intermingle at all times of the year (Neves and Depres 1979). Populations that return to rivers to spawn are a relatively homogeneous group, (Dadswell et al. 1987) and fish from all river systems can be found entering coastal waters as far south as North Carolina in the winter and spring (Neves and Depres 1979).

Dadswell et al. (1987) summarized the following seasonal time/locations for American shad: 1) January-February – fish are off Florida, the Middle Atlantic Bight, and Nova Scotia and entering streams to spawn from Florida to South Carolina; 2) March and April – fish are moving onshore and northward, from the Middle Atlantic Bight and Nova Scotia, with spawning underway from North Carolina to the Bay of Fundy; 3) Late June – concentrated in the inner Bay of Fundy, in the inner Gulf of St. Lawrence, the Gulf of Maine, and off Newfoundland and Labrador; however, spawning fish are still upstream from the Delaware River to the St. Lawrence River; 4) Autumn – fish leaving the St. Lawrence estuary are captured across the southern Gulf of St. Lawrence, while fish leaving the Bay of Fundy are found from Maine to Long Island, and some have already arrived as far south as Georgia and Florida.

Dadswell et al. (1987) analyzed tag returns, occurrence records, and trawl survey data and found that there are three primary offshore areas where fish aggregations spend the winter at sea: off the Scotian Shelf/Bay of Fundy region, in the Middle Atlantic Bight, and off the Florida coast. It appears that the majority of fish overwintering along the Scotian Shelf region spawn in rivers in Canada (Vladykov 1936; Melvin et al. 1985), and to a lesser degree, in the mid-Atlantic region and off the Florida coast (Williams 1985). Fish aggregations that overwinter off the mid-Atlantic coast represent populations that spawn in rivers from Georgia to Quebec (Talbot and Sykes 1958; White et al. 1969; Miller et al. 1982; Dadswell et al. 1987). Winter habitat in the mid-Atlantic region occurs primarily from Maryland to North Carolina (ASMFC 1999). The regional composition of aggregations overwintering off the Florida coast is unknown. Leggett (1977a) proposed the approximate time and location of fish heading south to overwinter off Florida based on migration rates and an average departure date of October 1 from the Gulf of Maine/Bay of Fundy area: Rhode Island/Long Island coast in mid-to-late October, off Delaware Bay in early November, and off the coast of North Carolina, Georgia, and Florida in early December. Early migration studies of shad found that during mild winters, fish in small quantities sometimes entered sounds of North Carolina during November and December, but disappeared if the weather became cold (Talbot and Sykes 1958).

Most shad populations overwintering off the mid-Atlantic coast migrate shoreward in waters between 36° to 40° N in the winter and early spring. Prespawning adults homing to rivers in the South Atlantic migrate shoreward north of Cape Hatteras, North Carolina, then head south along the coast to their natal rivers. The proximity of the Gulf Stream to North Carolina provides a narrow migrational corridor at Cape Hatteras if fish are to remain within their preferred temperature range of 3-15°C. Although prespawning adults are not required to follow a coastal route to North Atlantic rivers because temperatures in the Mid-Atlantic Bight are well within the shad's range of oceanic occurrence in the spring, tag returns indicate that they most likely enter waters in the lower Mid-Atlantic region, then migrate north along the coast. South of Cape Cod, prespawning shad migrate close inshore (Leggett and Whitney 1972), but north of there, the migration corridor is less clear (Dadswell et al. 1987). Prespawning adults may detour into estuaries during their coastal migration, but the timing and duration of stay is unknown (Neves and Depres 1979). Although poorly documented, immature American shad (age 1+) may also enter estuaries and accompany adults to the spawning grounds, more than 150 km upstream (Limburg 1995, 1998).

Neves and Depres (1979) determined that a second group of fish were found offshore mostly at depths of 50-100 m and limited to near-bottom temperatures of 3-15°C; however, these fish are likely juveniles and nonspawning adults that join spent adults in their summer grounds (Dadswell et al. 1987). Nonspawning adults have also been recorded in brackish estuaries (Hildebrand 1963; Gabriel et al. 1976).

Dadswell et al. (1987) found three primary summer aggregations of shad at sea: the Bay of Fundy / Gulf of Maine, the St. Lawrence estuary, and off the Newfound and Labrador coast. Neves and Depres (1979) also found distinct summer aggregations on Georges Bank and south of Nantucket Shoals. Shad from all river systems, including those from South Atlantic rivers, have been collected in the Gulf of Maine during the summer (Neves and Depres 1979), their summer feeding grounds. Fish from north Atlantic rivers are most abundant in the Bay of Fundy in the early summer, while abundance of fish from the southern range does not peak until mid-summer (Melvin 1984; Dadswell et al. 1987). These migrating shad groups are a mixture of juveniles, immature subadults, and spent and resting adults that originate from rivers along the entire East coast (Dadswell et al., 1983). Since there are very few repeat spawners in the southern range, the majority of fish that migrate to the Bay of Fundy from areas south of Cape Lookout, North Carolina are juveniles (76%) (Melvin et al. 1992).

Fish enter the Bay of Fundy in early summer and move throughout the inner Bay of Fundy in a counterclockwise direction with the residual current, with the entire run lasting four months (Dadswell et al. 1987). As water temperatures decline in the fall, shad begin moving through the Gulf of Maine by October, and continue to their offshore wintering grounds. Offshore, they have been captured in late fall and winter 80-95 km offshore of eastern Nova Scotia (Vladykov 1936), 65-80 km off the coast of Maine, 40-145 k, off southern New England, and the southern part of Georges Bank, 175 km from the nearest land (Bigelow and Schroeder 2002; Dadswell et al. 1987).

Temperature

Early studies by Leggett and Whitney (1972) found that shad moved along the coast within a "migrational corridor" where water temperatures were between 13-18°C. Neves and Depres (1979) later modified the near-bottom temperature range from 3-15°C, with a preferred range of 7-13°C. They also hypothesized that seasonal movements are broadly controlled by climate, and that shad followed paths along migration corridors or oceanic paths of "preferred" isotherms. This theory has been revised with supporting data that indicate shad cross thermal barriers, remain for extended periods in temperatures outside their "preferred" range, and migrate rapidly between regions regardless of currents and temperatures (Melvin et al. 1985; Dadswell et al. 1987). More recent studies have documented nonreproductive shad migrating from wintering grounds in the Mid-Atlantic Bight through the Gulf of Maine during May-June, where a constant sub-surface temperature of 6°C prevails, to reach the Bay of Fundy by mid-summer (Dadswell et al. 1987).

Temperature change and some aspect of seasonality (i.e. day length) may initiate migratory behavior, but timing of the behavior by different fish may be influenced by intrinsic (genetic) factors and life history stage of the fish; chance may also play a small role in determining which direction a fish will follow, at least within a confined coastal region. Dadswell et al. (1987) concluded that extrinsic factors related to ocean climate, seasonality, and currents may provide cues and clues for portions of nongoal-oriented migration, while intrinsic cues and bicoordinate navigation appear to be important during goal-oriented migration.

Depth

While it is known that adults move offshore to deeper waters during the fall and early winter, information regarding preferred depths is lacking. Shad have been found throughout a broad depth range in the ocean, from surface waters to 340 m (Walburg and Nichols 1967; Facey and Van Den Avyle 1986). Catch data analyses showed that they were caught at depths ranging from surface waters to 220 m (Walburg and Nichols 1967), but are most commonly found at intermediate depths of 50-100 m (Neves and Depres 1979). Seasonal migrations are thought to occur mainly in surface waters (Neves and Depres 1979).

The summer and autumn months are a time of active feeding, and analyzing stomach contents has served as a means for inferring distribution in the water column. Studies by Neves and Depres (1979) suggested that American shad follow diel movements of zooplankton, staying near the bottom during the day and dispersing in the water column at night. It was also thought that water temperature preference confined their depth range to 50-200 m. Other researchers (Dadswell et al. 1983) have suggested that light intensity may control depth selection by shad. For example, shad swim much higher in the water column in the turbid waters of Cumberland Basin, Bay of Fundy than they do in clear coastal waters, where they select deeper water. Both areas are within the same light intensity range.

Salinity

During their residence in the open ocean, sub-adults and adults will live in sea water that is approximately 33.0 ppt. During their coastal migration, prespawning adults may detour into estuaries, where water is more brackish, but the timing and duration of stay is unknown (Neves and Depres 1979).

Suspended solids/turbidity

The preference zone for light intensity was found to be limited to surface waters (2-10 m) for shad in the Bay of Fundy during the summer and fall because of extreme turbidity (Dadswell et al. 1983). Although this made them more susceptible to fishing gear that operated near surface waters, these waters are highly productive sources of zooplankton. Sight-oriented planktivores may be at a disadvantage in these turbid waters, but shad, which can use a filter-feeding mechanism, may have a competitive advantage.

Ecological relationships

<u>Adults</u>

Food

Recent feeding studies (Walters and Olney 2003) of American shad during spawning migrations in the York River, Virginia found that fish continued to feed actively as they moved from the open ocean into coastal waters. Diet composition changed as coastal and estuarine copepods (*C. typicus*, *Acartia* spp.) replaced the oceanic *C. finmarchicus* as the major constituents of the diet and the estuarine mysid shrimp *N. americana* increased in importance, replacing euphausids. Feeding intensity decreased as fish entered the estuary, but fish still selected for the most abundant and larger planktonic crustaceans. Minor amounts of other crustaceans were found in stomachs including cumaceans, sevenspine bay shrimp *Crangon septemspinosa*, and gammarid amphipods.

Early researchers thought that adult American shad typically do not feed in freshwater during upstream migration or after spawning until they leave the river (Hatton 1940; Moss 1946; Nichols 1959). One theory was that cessation of feeding may stem from the fact that most of the available food in the freshwater environment may be too small to be retained by adult gill rakers (Walburg and Nichols 1967). Atkinson (1951) proposed that fish stop feeding because of the physical separation from suitable food sources rather than a behavioral or physiological reduction in feeding. Chittenden (1969; 1976b) found minor quantities of insects and juvenile fish in the stomachs of migrating fish, and Atkinson (1951) found that fish would feed in experimental enclosures. Adult shad have even been known to strike at fishing lures. Atkinson's theory would seem to support the observations of these latter studies.

Walter and Olney (2003) found woody and green plant debris in the stomachs of adult shad at the spawning grounds, which has little or no nutritional value; however, they discovered that shad resumed feeding during postspawning migration. Stomach fullness was comparable to those values observed for shad feeding in the open ocean and estuary, with spent and partially spent adults feeding on mostly mysid shrimp. These results further support Atkinson's theory that adults feed if there is suitable prey available. Walter and Olney (2003) suggested that the ability to feed during some portion of migration and soon after spawning may be important in decreasing postspawning mortality. Given their significant energetic expenditures and weight losses during their migration (Glebe and Leggett 1981a; 1981b), the resumption of feeding likely represents a return to natural feeding patterns, which allows the fish to begin regaining lost energy reserves (Walter and Olney 2003). Finally, the ability to survive spawning has been correlated with the degree of energy lost (Glebe and Leggett 1981b; Bernatchez and Dodson 1987), and fish that feed actively before and after spawning may have a higher likelihood of repeat spawning. Fish whose spawning grounds are in closer proximity to estuarine food sources (and don't expend as much energy as fish that have to travel farther), and emigrating fish that have partially spent ovaries that can be resorped for energy (Olney et al. 2001) may have a high frequency of repeat spawning and lower energy expenditures (Walter and Olney 2003).

Competition and predation
Earlier studies found that adult shad were preyed upon primarily by seals and humans (Scott and Crossman 1973), and had few other predators (Scott and Scott 1988). More recent studies (Erkan 2002) have found that predation of alosines has increased dramatically in Rhode Island rivers in recent years, especially by the double-crested cormorant, which often takes advantage of fish staging near the entrance to fishways. Predation by otters and herons has also increased, but to a lesser extent (Erkan 2003). A recent study strongly supports the hypothesis that striped bass predation on adult American shad in the Connecticut River has resulted in a dramatic and unexpected decline in shad abundance since 1992 (Savoy and Crecco in press). Researchers further suggest that striped bass prey primarily on spawning adults because their predator avoidance capability may be compromised at this time, due to their strong drive to spawn during upstream migration. Rates of predation on ages 0 and 1 alosines was also much lower.

In South Atlantic coastal rivers where the percentage of repeat spawning is low or non-existent, adult shad that die after spawning may contribute significant nutrient input from the marine system into freshwater interior rivers (ASMFC 1999). Garman (1992) hypothesized that before recent declines in abundance, the annual input of marine-derived biomass of postspawning alosines was an important seasonal source of energy and nutrients for the non-tidal James River.

<u>Eggs and larvae</u>
Food
Once the yolk sac is absorbed, larvae initially consume zooplankton, and add copepods, immature insects (i.e. midge larvae and midge pupae), and adult aquatic and terrestrial insects as they grow (Leim 1924; Mitchell et al. 1925; Maxfield 1953; Crecco and Blake 1983; Facey and Van Den Avyle 1986). Several studies (Crecco and Blake 1983; Johnson and Dropkin 1995) have noted varying levels of selectivity for copepods and cladocerans, but zooplankton and chironomids generally comprise the bulk of their diets (Maxfield 1953; Levesque and Reed 1972). Feeding occurs most actively in late afternoon/early evening, peaking between 1200 h and 2000 h (Johnson and Dropkin 1995), and least intensively near dawn (Massman 1963; Grabe 1996). They are opportunistic feeders, shifting their diet depending on availability, river location, and their size (Leim 1924; Maxfield 1953; Walburg 1956; Levesque and Reed 1972; Marcy 1976a).

Researchers have also attempted to determine if the patchiness of planktonic prey has any effect on cohort survival. The effect of prey patchiness on cohort survival will vary with overall prey density such that increasing levels of patchiness will enhance survival when productivity or average prey density is low, but will reduce cohort survival when productivity is high. Thus, except when average prey densities of plankton are particularly high, prey patchiness may be a requirement for survival of fish larvae (Letcher and Rice 1997).

Predation and starvation are thought to be the primary causes of mortality among larval fish (May 1974; Hunter 1981), with some studies showing that starving larvae are more susceptible to predation than non-starving larvae (Rice et al. 1987). Newly-hatched larvae must begin feeding within 5 days; otherwise, they will succumb to death from malnutrition (Wiggins et al. 1984). Older larvae have significantly reduced survival rates if they are deprived of food for as little as 2 days (Johnson and Dropkin 1995). Researchers have also found that larvae fed at intermediate prey densities of 500 l-1 survived as well as those fed at high prey densities, and significantly higher than starved larvae, which indicates that some minimal level of feeding in riverine reaches can increase survival (Johnson and Dropkin 1995).

It has been suggested that clupeids evolved so as to synchronize the larval stage with the optimal phase of annual plankton production cycles (Blaxter and Hunter 1982). Shad larval survival rates have been found to vary in proportion to May-July zooplankton densities (Crecco et al. 1983). Limburg (1996) determined that zooplankton densities corresponded with times of larval stages of recruited juveniles, with the year-class being established by cohorts hatched after June 1, despite larval abundance being highest during May. She attributed higher growth rates for fish hatched in June to more favorable conditions that were present then, including warmer temperatures, lower flow rates, and high zooplankton densities.

Competition and predation

American shad eggs and larvae are primarily preyed upon by American eels and striped bass (Mansueti and Kolb 1953; Walburg and Nichols 1967; Facey et al. 1986). Once shad fry hatch from their eggs, they are eaten by minnows, shiners, and likely, any fish that is large enough to consume them (McPhee 2002).

American shad larvae that were stocked in the Susquehanna River, PA were found to experience the lowest percentage mortality at releases of 400,000 to 700,00 larvae (Johnson and Ringler 1998). A high rate of larval mortality at releases up to 400,000 may have been due to depensatory mechanisms operating as small releases, and releases above 700,000 may have resulted in increased predator aggregation at the site. Although individual predators were found to contain up to 900 shad larvae, mortality of shad larvae at the stocking site was usually less than 2%, an insignificant source of mortality.

Contaminants

The lethal dose (LD_{50}) of sulfates for eggs was >1000 mg/L at 15.5°C. The LD_{50} of iron for eggs was greater than 40 mg/L between pH 5.5-7.2 (Bradford et al. 1968). Eggs that were exposed to zinc and lead concentrations of 0.03 and 0.01 mg/L experienced high mortality rates within 36 hours (Meade 1976). When water hardness was low (i.e. 12 mg/L), the toxicity of the zinc and lead were intensified (Klauda et al. 1991).

<u>Juveniles</u>

Food

Juveniles favor zooplankton over phytoplankton (Maxfield 1953; Walburg 1956), and in general, have a wider selection of prey taxa than larvae. Their long, closely-spaced gill rakers enable shad to effectively filter plankton from the water column during respiratory movements (Leim 1924). They are opportunistic feeders, whose freshwater diet includes copepods, crustacean zooplankton, cladocerans, aquatic insect larvae, and adult aquatic and terrestrial insects (Leim 1924; Maxfield 1953; Massmann 1963; Levesque and Reed 1972; Marcy 1976a). Although juveniles consume most of their food from the water column (ASMFC 1999), many of the crustacean organisms that juveniles feed upon are benthic (Krauthamer and Richkus 1987). Leim (1924) speculated that although shad obtain a minor amount of food near the bottom, they do not pick if off the bottom, but capture items as they are carried up into the water column a short distance by tidal currents, including molluscs.

Walburg (1956) found that juveniles fed primarily on suitable organisms that were readily available. In contrast, Ross et al. (1997) found that juveniles in SAV habitat fed principally on chironomids, while those feeding in tributaries fed almost exclusively on terrestrial insects, despite the fact that they were less available than other food sources. Researchers did not attribute the differences to developmental limitations, but concluded that there were true habitat feeding differences. Other studies have noted different selection of organisms along the same river, but at different locations, such as above a dam (Levesque and Reed 1972) or downstream of a dam (Domermuth and Reed 1980).

In waters of Virginia, Massman (1963) found that juveniles upstream consumed more food than juveniles that remained downstream near their spawning grounds. The upstream sections of the river had a greater shoreline to open water ratio that may have provided a greater source of terrestrial insects, a favored prey item (Massman 1963; Levesque and Reed 1972), while the downstream sections provided a greater source of autochthonously-derived prey. In contrast, the lower reach of the Hudson River was found to be more productive (as a function of primary productivity and respiration rates) than upper and middle reaches (Sirois and Fredrick 1978; Howarth et al. 1992). This greater productivity may have led to observed higher fish production in the lower estuary, as well as a higher relative condition of downriver juvenile shad earlier in the season, compared to upriver and midriver fish (Limburg 1994).

Juveniles increase feeding as the day progresses, achieving a maximum at 2000 h (Johnson and Dropkin 1995). Juveniles in the Mattaponi and Pamunkey Rivers, Virginia, were found feeding during the day with stomachs reaching maximum fullness by early evening (Massman 1963). After juveniles leave coastal rivers and estuaries for nearshore waters, they may prey on some fish, such as smelt, sand lance, silver hake, bay anchovy, striped anchovy, and mosquitofish (Leidy 1868; Bowman et al. 2000).

At least one non-native species has proven to have an impact on young-of-the-year shad. In the Hudson River, there is strong evidence that zebra mussel colonization has reduced the forage base of American shad (Waldman and Limburg 2003).

Competition and predation
Juveniles in freshwater may be preyed upon by American eels, bluefish, weakfish, striped bass, and birds (Mansueti and Kolb 1953; Walburg and Nichols 1967; Facey et al. 1986).

There are three species of alosines (American shad, alewife, and blueback herring) common to many east coast river systems, including the Hudson River (hickory shad is more scarce). Differences in distribution, diel activity patterns, and feeding habits are evident in the Hudson River, and are likely mechanisms that may reduce competition between juveniles (Schmidt et al. 1988). For example, several researchers have noted that larger individuals of shad (Chittenden 1969; Marcy 1976a; Schmidt et al. 1988) and alewives (Loesch et al. 1982; Schmidt et al. 1988) move downstream first, which helps to segregate the species. All three Alosa species exhibited diel vertical migrations from near the bottom during the day to the surface at night in the

Mattaponi River, Virginia (Loesch et al. 1982). In addition to vertical segregation, there is also diel, inshore-offshore segregation. Both American shad and blueback herring juveniles occur in shallow nearshore waters during the day. Competition for prey between shad and bluebacks is often reduced by: 1) more opportunistic feeding by shad; 2) differential selection for cladoceran prey; and 3) higher utilization of copepods by blueback herring (Domermuth and Reed 1980). Shad feed most often in the upper water column, the air-water interface (Loesch et al. 1982), and even leap from the water (Massman 1963), feeding on Chironomidae larvae, Formicidae, and Cladocera; they are highly selective for terrestrial insects (Davis and Cheek 1966; Levesque and Reed 1972). Juvenile bluebacks are more planktivorous, feeding on copepods, larval dipterans, and Cladocera (Hirschfield et al. 1966), but not the same cladoceran families that alewives feed on (Domermuth and Reed 1980).

Physical habitat variables
Although considered preliminary, Ross et al. (1997) found optimum suitability for juveniles in the Delaware River at temperatures of 19.5-24.5° C in riffle habitat only. They also found maximum suitability for juveniles at depths between 0.5-1.5 m in SAV habitat only. It is not known if the same conditions in other rivers would have similar results; comparable results may be more likely if the range and proportion of habitat types were similar to those that were studied.

Contaminants
The 48 h lethal concentrations (LC_{50}) for juvenile shad ranged from 2,417-91,167 mg/L for gasoline, No. 2 diesel fuel, and bunker oil. The effects of gasoline and diesel fuel were exacerbated when DO was simultaneously reduced. Juveniles exposed to gasoline concentrations of 68 mg/L at 21-23° C resulted in a lethal time (LT_{50}) of 50 minutes when DO was reduced to 2.6-3.2 mg/L. Juveniles that were exposed to 84 mg/L of diesel fuel at 21-23°C and DO between 1.9-3.1 mg/L experienced an LT_{50} of 270 minutes (Tagatz 1961).

<u>Subadults</u>
Food
While they are offshore, shad are primarily planktivorous, feeding on whatever is most readily available, such as copepods, mysid shrimps, ostracods, amphipods, isopods, euphausids, larval barnacles, jellyfish, small fish, and fish eggs (Willey 1923; Leim 1924, Bigelow and Schroeder 1953; Maxfield 1953; Massmann 1963; Levesque and Reed 1972; Marcy 1976a). In the Bay of Fundy, shad were found to consume mostly planktonic and epibenthic crustaceans, while benthic organisms were rare (Themelis 1986). Differences in dominant prey items were attributed to changing availability of zooplankton assemblages and the size of the shad. Juveniles fed more extensively on copepods than adults and a smaller proportion of their diet was composed of large prey items such as euphausids and mysids. In earlier studies, Leim (1924) reported similar observations, with copepods decreasing in importance in the diets of shad over 400 mm in length. Detritus has also been found in the stomachs of shad, but it probably provides little nutritional value and is simply ingested during the course of feeding (Themelis 1982).

The Bay of Fundy is regarded as the primary summer feeding grounds for American shad, however, the entire Bay does not provide optimal feeding conditions for adults. For example, although both adult and juvenile shad feed readily in the oceanic lower Bay of Fundy, only juveniles feed to a large extent within the turbid and estuarine waters of the upper Bay. This is attributed to their ability to successfully filter smaller prey items that dominate the upper Bay (Themelis 1982).

Competition and predation
Once they are in the ocean, American shad are undoubtedly preyed upon by many species including sharks, tunas, king mackerel, seals, and porpoises, given their schooling nature and their lack of dorsal or opercular spines (Melvin et al. 1985; Weiss-Glanz et al. 1986).

Current research has found that American shad can detect ultrasonic signals to at least 180 kHz, which is within the range that echolocating harbour porpoises and bottlenose dolphins use to track shad and herring. In the laboratory environment, shad have been observed modifying their behavior in response to echolocation beams, such as turning slowly away from the sound source, forming very compact groups, and displaying a quick “panic” response. Although behavior in a natural environment may be different from that observed in experimental tanks, this study suggests that shad may have evolved a mechanism to make themselves less “conspicuous” or less easily preyed upon by echolocating odontocetes (Plachta and Popper 2003).

Abundance and status of stocks

Stock declines have been attributed to overfishing, habitat loss, and pollution over the past 170 years (Limburg et al. 2003). Historic catch levels of 30,000 metric kg at the turn of the century (Walburg and Nichols 1967) have dropped considerably since then, to a low of 0.6 million kg in 1996 (AMSFC 1999). Stocks continue to decline in many of the coastal rivers along the East Coast, including the Hudson River, New York populations. There are some populations, however, that have either stabilized for the time being, or have actually increased in numbers, such as stocks in the Connecticut River, the Pawcatuck River, Rhode Island, and the Santee River, South Carolina (ASMFC 1988; Cooke and Leach 2003). Although overfishing was attributed to the decline in American shad landings in many East Coast rivers during the 1950s-1970s (Talbot 1954; Walburg 1955; Walburg 1963; Williams and Bruger 1972; Sholar 1976;), by 1987, it was determined that overfishing was no longer occurring for 12 coastal stocks, and that stock sizes were generally stable (Gibson et al. 1988). The most recent coastwide assessment of American shad (1998) has re-affirmed that most of the stocks are still not overfished; however, overall stock abundance is still historically low. Thus, researchers have concluded that “The current strategy to restore American shad stocks by improving habitat and fish passage, stocking, and inter-basin transfers will yield much stronger dividends than a strategy of stock restoration based solely on reduction of fishing mortality (Boreman and Friedland 2003).”

Information on adult migration trends, migration physiology, and young-of-the-year ecology is good (Limburg et al. 2003) but data for some habitat requirements are lacking. Much of the information contained in this document was derived from fisheries surveys, and research studies on American shad and other fish from the sub-family Alosinae (also referred to as “alosines”).

Refer to Abundance and Status of Stocks in section 4.2.3.

4.2.5 Atlantic Sturgeon

Description and Distribution

Atlantic sturgeon, *Acipenser oxyrinchus*, are an anadromous species found in Atlantic coastal waters and major river basins from the Hamilton River and George River, Ungava Bay, Labrador, to Port Canaveral and Hutchinson Island, Florida (Van den Avyle 1983). Based on historical records, important sturgeon fisheries existed in essentially all Piedmont river basins on the Atlantic coast (Goode 1887). The early accounts of the sturgeon fishery landings did not distinguish between Atlantic sturgeon and the smaller shortnose sturgeon (*Acipenser breivirostrum*); however it is likely that accounts referred to the larger and more valuable Atlantic sturgeon. Following intense exploitation for food and construction of mainstem river dams during the 19th and early 20th centuries, sturgeon populations were drastically reduced throughout their range and extirpated in some rivers (ASMFC 1998; NMFS and U.S. FWS 1998). Spawning populations of Atlantic sturgeon are thought to be extirpated in the St. Marys River, Georgia, as well as in the Connecticut River and in all Maryland and Pennsylvania tributaries of the Chesapeake Bay (Rogers and Weber 1995; ASMFC 1998; NMFS and U.S. FWS 1998).

This anadromous species is motile, long lived and utilizes a wide variety of habitats. Atlantic sturgeon require either estuaries or upriver habitats for reproduction and early life stages, along with a hard substrate bottom for spawning (Vladykov and Greeley 1963; Huff 1975; T. Smith 1985). Coastal migrations and frequent movements between the estuarine and upstream riverine habitats are characteristic of this species. Historical accounts describe captures of large sturgeon, most probably Atlantics, during the summer and fall months in fall-line habitats on the Savannah River (Lawson 1711). In some systems, Atlantic sturgeon may prefer extensive reaches of higher gradient boulder, bedrock, cobble-gravel, and coarse sand substrates free of siltation for spawning habitat (Brownell et al. 2001). Juvenile and adult Atlantic sturgeon frequently congregate in the upper estuary habitats in the vicinity of the saltwater interface, and may move to and from the upstream areas during the summer and fall months, and during late winter and spring spawning periods. Adult Atlantic sturgeon may spend many years between spawning seasons in marine waters.

Much of the habitat information on Atlantic sturgeon remains incomplete. Due to the relatively low numbers of fish in many river basins, habitat utilization patterns have been difficult to establish with certainty (Collins et al. 2000a). Life history, behavior, and movements have been more thoroughly documented in the Hudson River, while many other river systems are lacking in vital life history information (Gross et al. 2002).

Reproduction

<u>Spawning and Spawning Habitat</u>

Atlantic sturgeon are thought to spawn in freshwater (Van den Avyle 1983), although sturgeon might also spawn in the tidal freshwater regions of large estuaries. This trend however has been seen in the north where obstructions occur on the estuarine portion of the rivers. In the south, where many rivers remain unblocked, sturgeon have been documented ascending hundreds of miles upstream into freshwater rivers to spawn (M. Collins, Personal Communication).

Spawning migrations are likely cued to temperature and occur earlier in the South Atlantic in comparison to those located to the North (T. Smith 1985). In Florida, Georgia, and South Carolina, spawning migrations begin in February. In the Edisto River, South Carolina, ripe males were captured as early as March 2nd and a single ripe female was captured on March 7th (Collins et al. 2000b). Spent males were captured as early as late March, and spent females were caught as late as mid-May (Collins et al. 2000b). In the Chesapeake Bay, spawning migrations historically began in April (Hildebrand and Schroeder 1928), and in the Delaware Bay, spawning migrations occur April through May (Secor and Waldman 1999). Spawning also begins in May in the Hudson River (Dovel and Berggren 1983). In New England and Canada, spawning migrations occur May through July (Bigelow and Schroeder 2002). Hatin et al. (2002) reported that spawning occurred from early June to approximately the 20th of July in the St. Lawrence River, Québec.

In addition to a spring migration, many studies document the occurrence of a fall migration (Smith et al., 1984; T. Smith, 1985; Collins et al., 2000b; Laney et al. in prep). Most fall migrations are movements out of the estuaries into marine habitat. Fall migrations occur from about September through December, again, depending on the latitude (Smith 1985). An alternate fall migration into estuaries has been proposed to be related to spawning (Smith et al. 1984; Collins et al. 2000b; Laney et al. in prep).

Smith et al. (1984) reported an upriver migration of fish in late August and September in South Carolina, but did not identify any further signs of spawning. Collins et al. (2000b) documented similar behavior. They noted the reappearance of ripe males in South Carolina at the end of August and September. By October, 86% of the males were ripe. Furthermore, Collins et al. (2000b) tracked two sturgeon via radio and acoustic transmitters in the Edisto River, South Carolina. After spending the summer in the lower river, these fish migrated upriver to RKM 190 in October. Based on this upriver movement, they hypothesized that a fall spawning migration was occurring. An alternative explanation is that the fall migration represented fish that would reside through the winter and spawn the following spring as reported to occur in Russian sturgeons (D. Secor, Personal Communication.).

In support of fall-spawning, Collins et al. (2000b) observed spent females, including one that had spawned very recently (postovulatory follicles were still present) in late September and October in South Carolina. Although no eggs were collected, a recently spawned female was captured at RKM 56 in the fall at the same location that a ripe female had been captured in a previous year (Collins et al. 2000b). Thus, they concluded that a fall spawning migration might occur in the Edisto River, South Carolina. Laney et al. (in prep) reported a running ripe male captured by electrofishing, and other Atlantic sturgeon seen but not captured in the Pee Dee River, SC in early October. Dovel and Berggren (1983), however, found no evidence of a fall spawning migration in sturgeon in the Hudson River. The general phenomenon of fall spawning remains uncertain and merits further study. Spring spawning, however, has been well documented in the literature (ASMFC 1998; NMFS and U.S. FWS 1998), and may be the dominant behavior by all North American sturgeon species.

Atlantic sturgeon mature at different times along the Atlantic coast, with maturity occurring earlier in the Southern regions (Vladykov and Greeley 1963). Females in South Carolina first spawn at ages 7-19, and males first spawn at 5-13 years. In the Hudson River, New York, females first spawn at 15-30 years and males at 8-20 years (Dovel 1979; Smith et al. 1982; C. Smith 1985; T. Smith 1985; Stevenson and Secor 2000). Scott and Crossman (1973) report that in the St. Lawrence River, Canada, female Atlantic sturgeon mature at 27-28 years, and males mature at 22-34 years. There has not been much work done to verify age determination methods; Stevenson and Secor (2000) used marginal increment analysis and rearing studies to confirm the seasonality of annulus formation, and reported an aging precision of + 5 years for Hudson River Atlantic sturgeon.

Spawning Periodicity

Sexually mature Atlantic sturgeon do not spawn every year (Van Eenennam et al. 1996; Caron et al. 2002). However, some fish participate in spawning migrations even when they do not spawn (T. Smith 1985). In South Carolina, females are thought to spawn every 3 to 5 years, while males spawn at 1 to 5 year intervals (T. Smith 1985). During their study, Collins et al. (2000b) caught and recaught a male sturgeon in 1998 and 1999 that was in spawning condition both years. Vladykov and Greeley (1963) state that females spawn once every 2 to 3 years, while Smith et al. (1982) found that in South Carolina, an average interval of 5.4 years occurred between first and second spawnings, and 3.5 years between second and third spawnings. Results from recent research on gonad histology and hard part analysis of Hudson River Atlantic sturgeon suggest a spawning frequency of 3-5 years (Van Eenennam et al. 1996; Stevenson and Secor 2000). Scott and Crossman (1973) indicated that spawning might occur every year in some females.

Spawning Location

The precise location of most spawning locations remains unknown. To date, spawning sites have never been verified with the collection of eggs. Spawning is thought to occur on fourteen major rivers on the Atlantic coast, with another five possibly supporting spawning stocks of Atlantic sturgeon (NMFS and U.S. FWS 1998).

As of the year 2000, spawning areas have not been identified in any of the southeastern rivers, nor have any spawning conditions been defined (Collins et al. 2000b). However, Collins et al. (2000b) state that it is possible that spawning is occurring in the Combahee and Edisto rivers, South Carolina. Although these locations have not been verified by the collection of eggs, ripe females and one recently spawned female were collected in this area. Based on the capture of ripe, running ripe, and spent adults, Collins et al. (2000b) suggests that spawning is occurring at RKM 105 and RKM 190 in the Edisto River, South Carolina, and at RKM 55 in the Combahee River, South Carolina.

Spawning may be occurring in the Pee Dee River, North Carolina and South Carolina. Electrofishing operations directed at capturing imperiled robust redhorse suckers, conducted in 2003 by Progress Energy Carolinas, Inc., in partnership with federal and state fishery management agencies, detected five Atlantic sturgeon during October. The single sturgeon captured and examined was a running ripe male (Laney et al. in prep).

Most studies indicate that after spawning, Atlantic sturgeon migrate to salt water (Vladykov and Greeley 1963), and that down-estuary migrations may occur over several months (Bain 1997).

Physical factors affecting spawning success

Substrate is a key habitat parameter for Atlantic sturgeon, because a hardbottom substrate is required for successful egg attachment and incubation (Vladykov and Greeley 1963; Huff 1975; T. Smith 1985; Secor et al. 2002). Within rivers, the areas of cobble-gravel, coarse sand, and bedrock outcrops, which occur in the rapids complex, may be considered prime habitat. In northern rivers, these areas are nearer to the estuary than in southern rivers. South of the Chesapeake Bay, nearly all rivers have extensive rapid-complex habitats in and near the fall line zone; generally at least 100km upstream from the saltwater interface (P. Brownell, Personal Communication). This habitat provides Atlantic sturgeon with well oxygenated water, clean substrates for egg adhesion, crevices that serve as shelter for post-hatch larvae, and macroinvertebrates for food (P. Brownell, Personal Communication).

Brownell et al. (2001) developed a Habitat Suitability Index (HSI) model for spawning Atlantic sturgeon and early egg development, and found that cobble/gravel (>64 mm to 250 mm) was the optimal spawning substrate for Atlantic sturgeon. Boulder (250-4000mm) scored the second highest in the model, and silt/sand (<2.0mm) and mud/soft clay/fines scored the lowest. The curve and the data values were based on the shortnose sturgeon model, and factors such as oxygenation, substrate embeddedness, available egg attachment sites, protection of eggs from predators, light intensity, and solar warming were all hypothesized to be available in gravel, boulder, and cobble gravel substrates (Brownell et al. 2001).

Collins et al. (2000b) caught a female in the Edisto River, South Carolina, which was believed to be in the process of spawning, in an area of limestone substrate. Collins et al. (2000b) also found adult Atlantic sturgeon using fine mud, sand, pebbles, and shell substrate as a summer habitat in the Edisto River, South Carolina.

Collins et al. (2000b) reported that adult sturgeon in the Edisto River, South Carolina during the summer were at depths ranging from 1.5-13 m. They reported that the majority of sturgeons were caught at the greatest depths available for the area. The HSI model mentioned above (Brownell et al. 2001) showed that the optimal depth range in the South for spawning Atlantic sturgeon and egg incubation ranged from 2.4 m to 8 m. It should be noted that depth in this model had a maximum range of 8 m, because areas where spawning is likely to occur (areas above the fall zone) in the South are not much deeper than 8 m (Brownell, Personal Communication).

In South Carolina, ripe fish migrating to spawning areas were captured at temperatures as high as 21-23°C; the majority of ripe males were caught in water temperatures between 13-19°C (T. Smith 1985). In late September and October, spent females were caught in the Edisto River, South Carolina in waters that were 17-18°C, and a running ripe female was caught during March when the temperature was 13.6°C (Collins et al. 2000b). Collins et al. (2000b) captured a running ripe male during early March when temperatures were 13.6°C. Smith et al. (1982) recorded water temperatures of 7-8°C during the second and third week of February 1979, 1980, and 1982, in South Carolina during Atlantic sturgeon migrations. During the summer months, Collins et al. (2000b) documented adult Atlantic sturgeon in the Edisto and Combahee Rivers in temperatures as high as 33.1°C. A HSI model (Brownell et al. 2001) showed that the optimal temperature for spawning Atlantic sturgeon was 16-21 A HSI model by Brownell et al. (2001) showed that the optimal temperature for spawning Atlantic sturgeon was 16-21°C.

Atlantic sturgeon spawn in freshwater rivers, and may spawn in the tidal freshwater portion of estuaries in northeastern rivers where appropriate habitats are located in such reaches. Most studies however, report that sturgeon spawn well above the salt wedge in rivers (Dovel 1978; 1979; T. Smith 1985; Van Eenennamm et al. 1996). Collins et al. (2000b) found adult Atlantic sturgeon in salinities varying from 0-28.6 ppt in the Edisto River, South Carolina during the summer.

Sturgeon lay their eggs in flowing water (Vladykov and Greeley 1963; Van den Avyle 1983). Research suggests that the optimal water velocities for Atlantic sturgeon spawning range from 46-76 cm/s. Velocities lower than 6cm/s and higher than 107 cm/s are unsuitable for spawning (Crance 1987). A recent HSI developed for spawning Atlantic sturgeon showed that optimal water velocity for spawning and egg incubation ranged from .2 to .76 m/sec (Brownell et al. 2001).

It has been hypothesized that Atlantic sturgeon do not feed during spawning migrations. Research is currently being conducted to test this hypothesis (M. Collins, Personal Communication).

Eggs are laid into flowing water and become widespread after fertilization. After about twenty minutes, the demersal eggs become strongly adhesive and attach to hard substrates (Murawski and Pacheco 1977; Van den Avyle 1983). The eggs hatch after 94-140 hours, and after a yolksac larval period of about 10 days in the water column, late-stage larvae settle to the demersal habitat. This will be the principal type of habitat for the remainder of the sturgeon's life (NMFS and U.S. FWS 1998).

Atlantic sturgeon eggs hatch in 94-140 hours at temperatures ranging from 18-20°C (Smith et al. 1980). Mohler (2003) states that for cultured sturgeon, a temperature range of 20-21°C is favorable for incubation. Temperatures below 18°C prolong hatching and increase the risk of fungal infestation to dead eggs, which in turn can kill the viable ones. Hatching occurs in 60 hours at this temperature range (Mohler 2003).

Development, growth and movement patterns

<u>Early life stages</u>

Little is known about the habitat of larval Atlantic sturgeon. Larval sturgeon are assumed to be found in the same riverine or estuarine habitats where they were spawned (Kynard and Horgan 2002). Newly hatched larvae are active swimmers and leave the bottom to swim in the water column. Once the yolk sac is absorbed, the larvae exhibit benthic behavior (Smith et al. 1980, 1981). Bath et al. (1981) caught free embryos by active bottom netting near the spawning area, demonstrating that early life stages are benthic. Kynard and Horgan (2002) raised Atlantic sturgeon in chambers. They found that upon hatching, the embryos sought cover and remained there for a few days. The fish left cover and began to migrate around day 8. After a couple of days, the larvae stopped migrating and exhibited foraging behavior. Downstream migration resumed again during the juvenile period when the temperature dropped. Atlantic sturgeon larvae are capable of dispersing long distances. Migration occurs at night during the first half of their migration, and eventually, the fish become active during both the day and night (Kynard and Horgan 2002). Kynard and Horgan (2002) hypothesize that this foraging behavior is a way to reduce daytime predation while the larvae are still developing, yet still enable them to forage when there is daylight to aid in the visual detection of prey. Mohler (2003) found similar results. Cultured Atlantic sturgeon were mostly pelagic after hatching and exhibited a "swim up and drift down" behavior. After 3-4 days fry began to exhibit benthic clumping behavior and swam against the flow direction of the tank. Fry remained benthic for about 4 days, before moving around the tank in search of food. At this stage, the sturgeon were noted to be pelagic, until live brine shrimp were thrown into the tank and the fry moved to the bottom of the tank to feed. Atlantic sturgeon fry did not actively seek out their food source, but waited till the currents brought it to them (Mohler 2003).

There are no studies to indicate what larval Atlantic sturgeon prey upon in the wild. However, it is assumed that after they absorb the yolk sac, they feed on tiny bottom dwelling organisms (Gilbert 1989). Studies of other sturgeon species indicate that larvae in rivers feed on small mobile invertebrates, including cladocerans and copepods (Baranova and Miroshnichenko 1969; Miller et al. 1991). Miller et al. (1991) found that white sturgeon larvae primarily fed on amphipods.

Juveniles

Juvenile sturgeon are thought to remain close to their natal habitats within the riverine portion of the estuary for a year before migrating out to sea (Secor et al. 2000). Migrations out to coastal areas occur between 2 and 6 years of age (T. Smith 1985) and are seasonal, with movement occurring north in the late winter, and south in fall and early winter (Dovel 1978; T. Smith 1985; NMFS and U.S. FWS 1998).

Interestuarine migrations have been documented extensively in the literature (Dovel and Berggren 1983; T. Smith 1985; Welsh et al. 2002; Savoy and Pacileo 2003). These non-natal estuarine habitats serve as nursery areas and are very important to the Atlantic sturgeon's life history. They can provide additional foraging opportunities, as well as thermal and salinity refuges (Moser and Ross 1995). Sub-adults tagged in the Hudson River, New York were recaptured in Nantucket, Massachusetts, and North Carolina (C. Smith 1985). Sub-adults tagged in the lower Delaware River were recaptured within several other estuaries including Pamlico Sound, North Carolina Chesapeake Bay, Virginia/Maryland, the Hudson River, New York, and Narragansett Bay, RI (C. Shirey, Personal Communication). Dovel and Berggren (1983) report that juvenile Atlantic sturgeon were recaptured in estuaries from Massachusetts to Cape Hatteras, North Carolina. T. Smith (1985) stated that fish tagged off South Carolina migrated as far north as Pamlico Sound, North Carolina, and the Chesapeake Bay, Maryland/Virginia. Most data indicates that sturgeon in the northern rivers travel more extensively than those in the southern rivers (ASMFC 1998). However, research in the southern region has not adequately addressed inter-basin movements in the south (P. Brownell, Personal Communication).

Seasonal migrations of juveniles and sub-adults are regulated by changes in temperature gradients between fresh and brackish waters (Van Den Avyle 1983). Juveniles released in the

Chesapeake Bay, Maryland/Virginia, used the brackish waters close to the estuary mouth during the colder months and moved upriver during the warmer months (Secor et al. 2000). This behavior has been seen in a number of river systems including the Delaware River, Hudson River, New York, and the Winyah Bay system, South Carolina (Brundage and Meadows 1982; Smith et al. 1982; Dovel and Berggren 1983; Gilbert 1989). Dovel and Berggren (1983) report a mass down-estuary migration in the Hudson Estuary, New York, of juvenile Atlantic sturgeon when the temperature drops below 20°C. Migrations down-river/down-estuary peak at the end of October. At this time, many juveniles overwinter in deep holes, while others leave the Hudson River and move south along the Atlantic coast (Dovel and Berggren 1983). Moser and Ross (1995) found that juvenile sturgeon in the Cape Fear River, North Carolina, kept the same center of distribution near the saltwater-freshwater interface year round. However, these fish are unable to move upriver because of the location of the Cape Fear Lock and Dam No. 1, just above the estuary (0.5 ppt interface) (P. Brownell, Personal Communication).

Juvenile Atlantic sturgeon tend to congregate in deepwaters (Moser and Ross 1995; Savoy and Pacileo 2003). Moser and Ross (1995) report that juvenile sturgeon use deep and cool areas, particularly in the summertime. They state that in North Carolina, juvenile Atlantic sturgeon utilize very deep holes as thermal refuges in the summer. Juvenile sturgeon caught in the upper Cape Fear River, North Carolina, were found in waters deeper than 10 m, and sturgeon caught in the Brunswick River, North Carolina, were caught in depths less than 7 m.

While the majority of Atlantic sturgeon have been collected at the deepest depths available, they have also been collected in shallower waters (2.5 m) (Savoy and Pacileo 2003). Kynard et al. (2000) reported tracking fish at depths ranging from 2-12 m. The mean depth of the six Atlantic sturgeon tracked was 7 m. Musick et al. (1994) found that juvenile Atlantic sturgeon in the Chesapeake Bay, Virginia were captured in depths less than 20 m, and that the fish were located within 10 km from shore. Similarly, a telemetry study on hatchery-released age-1 juveniles showed that most Atlantic sturgeon used depths <6 m (Secor et al. 2000). In a gill net survey in the Brunswick River, North Carolina, Moser and Ross (1995) captured Atlantic sturgeon over shoals less than 7 m, even though nets extended down to deeper areas. Lazzari et al. (1986) caught juvenile Atlantic sturgeon at depths ranging from 7-16 m in the Delaware River. In the Albemarle Sound, North Carolina, juvenile sturgeons were located in sites ranging from 1.8 to 5.4 m (Armstrong and Hightower 2002). Shirey et al. (1999) conducted biotelemetry studies and found Atlantic sturgeon preferred depths ranging from 5.5-11 m in the lower Delaware River during the summer even though deeper channel areas were nearby.

Sub-adults are known to emigrate out of their natal estuarine habitats and migrate long distances in the marine environment (Murawski and Pacheco 1977); the longest oceanic journey recorded was 1,450 km (Mangin and Beaulieu 1963). A total of 120 tag returns by commercial fisheries of sub-adult Atlantic sturgeon that were originally tagged in Delaware River provide insight into a coastal migration for this life stage that encompasses a broad size range (Delaware Fish and Wildlife, unpublished data). After leaving the Delaware Estuary during the fall, sturgeon were recaptured in the near-shore waters along the coast as far south as Cape Hatteras, North Carolina where they were recaptured from November through early March. Sturgeon moved back and forth across the mouth of the Chesapeake Bay and the Delmarva Peninsula in March and April with a portion of the tagged fish re-entering the Delaware Estuary. However, many continued this northerly coastal migration through the mid-Atlantic and into southern New England waters where they were recovered throughout the summer months, primarily in the waters of Massachusetts, Rhode Island, and Long Island, New York. Movements as far north as Maine were documented. A southerly coastal migration was apparent from tag returns reported in the fall. The majority of these tag returns were reported from relatively shallow nearshore fisheries with few fish reported from waters in excess of 25 m (Shirey, in prep).

Adults

Little is known about the habitat use of adult Atlantic sturgeon during the non-spawning season, particularly when the sturgeon return to marine waters (Bain 1997; Collins et al. 2000b). While at sea, Atlantic sturgeon have been documented using relatively shallow nearshore habitats (10-20 m) (Laney et al. in prep; Stein et al. 2004). It is possible that individual fish select habitats in the same areas, or even possibly school to some extent (Laney et al. in prep; Stein et al. 2004).

A study by Collins et al. (2000b) indicated that adult Atlantic sturgeon in South Carolina utilize a wide variety of habitats during the summer. They found sturgeon in the upper fresh/brackish interface zone, the lower interface zone, and in the high salinity portions of the estuary in the Edisto River, South Carolina. Atlantic sturgeon were present in this river from March to October. During the winter, southern Atlantic sturgeon overwinter in the ocean (Collins et al. 2000b). Adult Atlantic sturgeon in southern rivers exhibit behavior much like gulf sturgeon (*Acipenser oxyrinxhus desotoi*) in that they spend 9 months within the river system and 3 months during the winter in marine waters (M. Collins, Personal Communication).

In marine waters, Stein et al. (2004) reported that Atlantic sturgeon were found mostly over sand and gravel substrate, and that they were associated with specific coastal features, such as the mouths of the Chesapeake and Narragansett Bay, and inlets in the North Carolina Outer Banks. In their study, Stein et al. (2004) found Atlantic sturgeon over four types of substrate in Massachusetts, including silt, sand, clay, and gravel. The authors state that Atlantic sturgeon use any substrate that supports their food resources and that habitat use is strongly associated with prey availability.

Laney et al. (in prep.) found similar results off the coasts of Virginia and North Carolina. They used GIS layers to analyze data from the Cooperative Winter Tagging Cruise, and found that Atlantic sturgeon were located primarily in sandy substrates. However, the authors state that GIS does not depict small-scale sediment distribution, thus only a broad overview of sediment types was used. They also state that sediment sampling done along the North Carolina coast shows that gravel substrates are found a little farther offshore from where the sturgeon were found.

The greatest depth in the ocean at which Atlantic sturgeon were caught was 75 m (Bigelow and Schroeder 2002). Collins and Smith (1997) report that Atlantic sturgeon were captured at depths of 40 m in marine waters off South Carolina. Stein et al. (2004) investigated data collected by on-board fishery observers from 1989-2000 to determine habitat preferences of Atlantic sturgeon. They found that Atlantic sturgeon were caught in shallow inshore areas of the Continental Shelf. Bycatch on the Continental Shelf occurred in areas where the depth was less than 60 m. Sturgeon were captured in depths less than 25 m along the Mid-Atlantic Bight, and in deeper waters in the Gulf of Maine (Stein et al. 2004).

The Northeast Fisheries Science Center bottom trawl survey caught 139 Atlantic sturgeon from 1972-1996 in waters from Canada to South Carolina. They found the fish in depths of 7m to 75m, with a mean depth of 17.3m. Of the fish caught, 40% were collected at 15m, 13% at 13m, and 5% or less at all the depth strata (NEFC, unpublished data, reviewed in Savoy and Pacileo 2003).

Upon entering the marine habitat, Atlantic sturgeon have been documented near the shore in shallow waters where the depths measure less than 20 m (Gilbert 1989; Johnson et al. 1997). During their tagging cruise off the coasts of Virginia and North Carolina, Laney et al. (in prep.) captured Atlantic sturgeon at depths up to 20 ft (~6 m). The majority of sturgeon were found in depths less than 10 m. Vladykov and Greeley (1963) record a maximum depth of at least 60 ft (~18 m).

Ecological relationships

Post-spawning adults remaining in freshwater systems have been documented feeding on gastropods and other benthic organisms (Scott and Crossman 1973). Adult Atlantic sturgeon feed indiscriminately throughout their lives and are considered to be opportunistic feeders (Vladykov and Greeley 1963; Murawski and Pacheco 1977; Van den Avyle 1983; Bigelow and Schroeder 2002). They feed on mollusks, as well as polychaetes, gastropods, shrimps, isopods, and benthic fish in estuarine areas (Dadswell et al. 1984; Bigelow and Schroeder 2002). In freshwater, they feed on aquatic insects, amphipods, and oligochaetes (Bigelow and Schroeder 2002). Hatin et al. (2002) reported that Atlantic sturgeon in the St. Lawrence River fed on oliogochaetes, nematodes, and amphipods.

Adult Atlantic sturgeon appear to have few ecological competitors. They spawn later in the season and in different areas than shortnose sturgeon, thus avoiding competition in areas where their habitat overlaps (Bath et al. 1981; Gilbert 1989; see discussion in Kynard and Horgan 2002). Other species that might utilize the same spawning habitat includes the walleye (*Stizostedion vitreum vitreum*) and the rainbow trout (*Salmo gairdneri*). Both of these species have been introduced into the range of the Atlantic sturgeon (Gilbert 1989).

Kynard and Horgan (2002) hypothesize that larval and juvenile Atlantic sturgeon have a low predation risk. This is based on the idea that migration upon hatching is stimulated by predation risk to embryos. Species that undergo high predation tend to migrate from the area immediately after hatching (Kynard and Horgan 2002). While this has not been fully tested, Kynard and Horgan (2002) have found that shortnose sturgeon embryos have few predators. After sampling predators in a spawning area, they found that only one fish, the fallfish (*Semotilus corporalis*), had sturgeon eggs in its stomach.

The range of salinities in which Atlantic sturgeon are found vary greatly. Some Atlantic sturgeon may occupy freshwater habitats for a couple of years, while others move downstream to brackish waters when the water temperature drops (Scott and Crossman 1973; Dovel 1978; Hoff

1980; Lazzari et al. 1986). Dadswell (1979), Brundage and Meadows (1982), T. Smith (1985), and Haley et al. (1996) report that young sturgeon primarily use brackish water habitats. Large juvenile sturgeon are found predominately in areas where salinity is greater than 3 ppt (Appy and Dadswell 1978). Haley et al. (1996) generally caught Atlantic sturgeon in the Hudson River, New York in areas where salinity ranged from 3-16 ppt. Dovel and Berggren (1983) found that juvenile sturgeon were concentrated in areas with a salinity range of 0-6 ppt. In their study, Moser and Ross (1995) reported that the majority of Catch Per Unit Effort (CPUE) in the Brunswick River, North Carolina, occurred in an area near the head of the salt wedge where the salinity did not exceed 10 ppt.

Dissolved oxygen is a very important habitat parameter for Atlantic sturgeon. As a result of decreased dissolved oxygen, much of sturgeon nursery habitat has been degraded (see sections II and III). Secor and Niklitschek (2001) report that in habitats with less than 60% oxygen saturation, young of the year fish age 30-200 days, will experience a loss in production. This level is 4.3-4.7 mg/L for summer temperatures ranging from 22°C to 27°C. Mortality of Atlantic sturgeon has been observed for summer temperatures at levels of <3.3 mg/L (Secor and Niklitschek 2001). Secor and Gunderson (1998) also found that juvenile sturgeon were affected negatively by high temperatures and low oxygen. In their experiment, mortality occurred at 26C and ~3 mg/L. Recently, the Chesapeake Bay Program adopted dissolved oxygen guidelines based upon levels that would protect Atlantic and shortnose sturgeon, which show unusually high sensitivity to low oxygen among estuarine living resources (Secor and Niklitschek 2002; Anon. 2003).

Pottle and Dadswell (1982) examined the gut contents of juvenile sturgeon. They found that juvenile Atlantic sturgeon fed on diptera and trichoptera, as well as amphipods in the St. Johns River, Florida. Secor et al. (2000) found that juvenile Atlantic sturgeon in the Chesapeake Bay preyed upon annelid worms, isopods, amphipods, chironomid larvae, and mysids. Moser and Ross (1995) found polycheate worms, isopods, and mollusk shell fragments in the stomachs of juvenile sturgeon in North Carolina. An examination of 12 juvenile Atlantic sturgeon in the Connecticut and Merrimack Rivers showed a mix of amphipods and polychaetes (Kynard et al. 2000). In freshwater, juvenile sturgeon ate plant and animal matter, sludgeworms, chironomid larvae, mayfly larvae, isopods, amphipods, and small bivalve mollusks (Scott and Crossman 1973). Scott and Crossman (1973) also noted that sturgeon consumed mud while rooting on the bottom.

Both juvenile Atlantic sturgeon and shortnose sturgeon occupy the same freshwater/saltwater interface nursery habitat (Dadswell 1979; Dovel and Berggren 1983; Dovel et al. 1992). However, shortnose sturgeon tend to be located in freshwater, while Atlantic sturgeon utilize more saline areas (Dovel and Berggren 1983; Dovel et al. 1992; Kieffer and Kynard 1993; Haley et al. 1996). Haley et al. (1996) collected the majority of juvenile Atlantic sturgeon in the Hudson River in deeper, mesohaline (3.0-16.0 ppt) regions of the river, while juvenile shortnose sturgeon were found most often in the shallower, freshwater (<.5 ppt) zones of the river. Furthermore, bioenergetic comparisons show that age-1 Atlantic sturgeon showed better growth in brackish water (1-10 ppt), than sympatric shortnose sturgeon juveniles (Niklitschek 2001).

Haley et al. (1996) hypothesize that the freshwater/saltwater interface where both sturgeon species concentrate, may serve as a foraging ground, and that Atlantic and shortnose sturgeon may compete for food in this area. However, Pottle and Dadswell (1982) found that juvenile Atlantic and shortnose sturgeon in the St. Johns River preyed on different species. They found that Atlantic sturgeon preyed upon diptera, trichoptera, and some amphipods, while shortnose sturgeon preyed mostly upon cladocerans, amphipods, mollusks, and insect larvae (Pottle and Dadswell 1982).

In the more southern rivers, juvenile Atlantic sturgeon and adult shortnose sturgeon may share parts of the river with similar salinity levels. This has been documented in the Savannah River during the fall and winter and in the Altamaha River, during warm summers (Reviewed in Kieffer and Kynard 1993).

Atlantic sturgeon juveniles and sub-adults would be expected to compete with other demersal feeding fishes in estuaries. In mid-Atlantic estuaries these include catfishes, white perch, carp, spot, croaker, and hogchokers (Murdy et al. 1997).

There is little information regarding the marine diet of Atlantic sturgeon. Johnson et al. (1997) suggest that this is because of the low population density of sturgeon offshore, and the fact that most studies have focused on rivers and estuaries. A stomach content study by Johnson et al. (1997) found that Atlantic sturgeon off the coast of New Jersey preyed upon polychaetes, isopods, decapods, and amphipods. They also found that mollusks and fish contributed little to the diet, and that sand and organic debris were major components (Johnson et al. 1997). Scott and Crossman (1973) stated that in marine waters, Atlantic sturgeon fed on mollusks, polychaete worms, gastropods, shrimps, amphipods, isopods, and small fish (particularly sand lances).

Gilbert (1989) lists suckers (*Moxostoma* sp.), winter flounder (*Pleuronectes americanus*), tautog (*Tautoga onitis*), cunner (*Tautogolabrus adspersus*), porgies (Sparidae), croakers (Sciaenidae), and stingrays (*Dasyatis* sp.) as possible competitors. Scott and Crossman (1973) report that Atlantic sturgeon are killed by sea lampreys, *Petromyzon marinus*, and in South Carolina, longnose gar have been reported attacking sturgeon (Reviewed in T. Smith 1985).

Abundance and status of stocks

Due to a variety of anthropogenic impacts, including river blockages, water quality deterioration, and overfishing, an estimated 38-59% (based on 14 of the 21 extant stocks reproducing, of 39 historically present) of Atlantic sturgeon stocks are extirpated and the rest are likely at historically low levels (ASMFC 1998; NMFS and U.S. FWS 1998). In 1991, Atlantic sturgeon was listed as a candidate species (56 FR 26797) under the Endangered Species Act (ESA) and remained on the revised list in 1997 (62 FR 37560). In 1998, a status review of Atlantic sturgeon found that the continued existence of Atlantic sturgeon was not threatened by any of the five ESA listing factors. Therefore, Atlantic sturgeon was not listed as a threatened or endangered species (NMFS and U.S. FWS 1998). However, in 2006 the Atlantic sturgeon was listed as a Federal Candidate species. In 1990, the Atlantic States Marine Fisheries Commission wrote a Fisheries Management Plan (FMP) for Atlantic sturgeon and amended it in 1998. In 1998, the ASMFC closed all sturgeon fisheries coastwide in the United States and recommended a 20-40 year moratorium, so that the spawning stock could be restored to a level where 20 protected year classes of adult females are present (ASMFC 1998).

(from the 2006 ASFMC FMP Review)
Reported landings of Atlantic sturgeon peaked in 1890 at 3.4 million kilograms and declined precipitously thereafter. Currently, populations throughout the species' range are either extirpated or at historically low abundance. Recruitment is variable at low levels in most regions. Survival of Atlantic sturgeon during the 20th Century implies that enough spawning and nursery habitats exist to perpetuate the species. In the absence of major threats to existing habitat, reduced fishing mortality is of greater importance to stock restoration efforts than habitat limitations. Adult population abundance in some systems may be so low as to significantly impede reproduction success and timely recovery.

The target fishing rate was defined as that level of F that generated an eggs-per-recruit (EPR) equal to 50% of the EPR at F = 0.0 (i.e., virgin stock). This rate (F50) equals 0.03 (annual harvest rate of 3%) for a restored population. This target is far below recent estimates of F prior to enactment of fishing moratoria, which ranged from 0.01 - 0.12 for females and 0.15 - 0.24 for males in the Hudson River. These numbers may not apply to southern stocks, where more signs toward recovery are being seen.

Based on information presented at a technical workshop in November 2003, the population abundance in various rivers appears to vary substantially. The Hudson River stock may be showing a small increase in abundance, little or no signs of recovery are apparent in most if not all northern stocks, while certain rivers in Georgia and South Carolina are showing increasing numbers of sub-adults, suggesting some population rebuilding.

Currently, all states and the National Marine Fisheries Service have enacted bans on harvest and possession of Atlantic sturgeon and sturgeon parts. As per Amendment 1, these moratoria will remain in effect until stocks exhibit a minimum of 20 protected year classes of spawning females and the FMP is modified to permit harvest and possession.

Addendum I to the Interstate Fishery Management Plan for Atlantic sturgeon exempts the State of Florida from the possession moratorium for the purposes of developing private aquaculture facilities for cultivation and propagation of the species. Addendum II exempts a private company in North Carolina from the moratorium on possession, propagation, and sale of Atlantic sturgeon meat and eggs. Addendum III was approved on November 17, 2006, exempting a private company in North Carolina from a moratorium on possession, propagation, and sale of Atlantic sturgeon meat and eggs and exempting a Canadian exporter from exporting Atlantic sturgeon fry and fingerlings into North Carolina.

The November 2003 technical workshop on status of Atlantic sturgeon identified several new issues regarding bycatch of Atlantic sturgeon. Another workshop focused on recovery techniques was held in November 2004 and provided more recommendations for dealing with bycatch. ASMFC hosted an Atlantic sturgeon bycatch workshop in February 2006 that: (1) evaluated genetic and mark-recapture data and approaches to identifying stock composition of bycatch; (2) reviewed and summarized jurisdictional reports on bycatch; and (3) estimated fishery-specific bycatch and bycatch mortality of Atlantic sturgeon during the past ten years in New England and Mid-Atlantic waters. In early 2007, ASMFC will host another bycatch workshop that will focus on the NMFS observer dataset for the period of 2000-2005.

4.2.6 Blueback Herring

Description and Distribution

Blueback herring are anadromous, highly migratory, euryhaline, pelagic, schooling species. Both blueback herring and alewife are often referred to as "river herring," a collective term for these two species combined, which often school together (Murdy et al. 1997). Although this term is often used generically in commercial harvests and no distinction is made between the two species (ASMFC 1985), landings are reported as alewife (Loesch 1987). Bluebacks spend most of their life at sea, returning to freshwater only to spawn (Bigelow and Schroeder 2002). Their range is commonly cited as the St. Johns River, Florida (Hildebrand 1963; Williams et al. 1975) to Cape Breton, Nova Scotia (Scott and Crossman 1973) and the Miramichi River, New Brunswick (Bigelow and Schroeder 1953; Leim and Scott 1966); however, Williams and Grey (undated) reported that they occur as far south as Tomoka River, a small freshwater tributary of the Halifax River in Florida (a brackish coastal lagoon). There are also some landlocked populations in the Southeast (Klauda et al. 1991), but landlocking occurs less in bluebacks than in alewife (Schmidt et al. 2003).

Results from 16 years of catch data reveal that blueback herring are distributed throughout the continental shelf from Cape Hatteras, NC to Nova Scotia during the spring. Most are found south of Cape Cod, but, unlike alewife, no blueback catches were recorded for Georges Bank. During the summer, they move north and inshore, but catch records were too infrequent to determine summer occurrence for bluebacks, although several catches were made near Nantucket Shoals and Georges Bank and they were never collected south of 40°N. By early fall, they are found along Nantucket Shoals, Georges Bank, the inner Bay of Fundy, but concentrated mostly along the northwest perimeter of the Gulf of Maine (Neves 1981). In the autumn, they begin moving southward and offshore to the mid-Atlantic coast to overwinter until early spring (Neves 1981; Rulifson et al. 1987). Although winter sampling stations were inadequate to define wintering grounds, the few catches that were reported were primarily between latitude 40° and 43° N. It is unknown to what extent they overwinter in deepwater off the continental shelf of the U.S. (Neves 1981). They have been found offshore as far as 200 km (Bigelow and Schroeder 1953; Netzel and Stanek 1966), but they are rarely collected more than 130 km from shore (Jones et al. 1978).

Reproduction

Spawning and Spawning Habitat

Blueback herring generally spawn in freshwater above the head of tide; brackish and tidal areas are rarely used for spawning by this species (Nichols and Breder 1927; Hildebrand 1963; Fay et al. 1983; Murdy et al. 1997). In areas where blueback herring and alewife co-occur (sympatric region), bluebacks prefer to spawn over gravel and clean sand substrates, where the flow is relatively swift, and actively avoid areas with slow-moving or standing water (Bigelow and Welsh 1925; Marcy 1976b; Loesch and Lund 1977; Johnston and Cheverie 1988). Bluebacks are also abundant in tributaries and flooded low-lying areas adjacent to main streams (Erkan 2002). If bluebacks and alewife are forced to spawn in the same vicinity (i.e. due to blocked passage) (Loesch 1987), some researchers have suggested that the two species occupy separate spawning sites to reduce competition. For example, Loesch and Lund (1977) note that bluebacks will typically select the main stream flow for spawning, while alewife will spawn along shorebank eddies or deep pools. In rivers where headwater ponds are absent or poorly-developed, alewife may be most abundant further upstream in headwater reaches, while bluebacks select the mainstream proper for spawning (Ross and Biagi 1990).

In the allopatric range, where there is no co-occurrence with alewife (south of North Carolina), bluebacks favor lentic sites, but may also occupy lotic sites (Loesch 1987; Klauda et al. 1991). In the allopatric range, bluebacks select a greater variety of spawning habitat types (Street 1970; Frankensteen 1976; Christie 1978), including small tributaries upstream from the tidal zone (ASMFC 1999), seasonally flooded rice fields, small densely vegetated streams, cypress swamps, and oxbows, where the substrate is soft and detritus is present (Adams and Street 1969; Godwin and Adams 1969; Adams 1970; Street 1970; Curtis et al. 1982; Meador et al. 1984). Despite the fact that bluebacks generally do not spawn in ponds in their northern range (possibly to reduce competition), they have the ability to do so (Loesch 1987).

Bluebacks will ascend freshwater far upstream (Massman 1953; Davis and Cheek 1967; Perlmutter et al. 1967; Crecco 1982), their distribution being a function of habitat suitability and hydrological conditions, such as swifter waters (Loesch and Lund 1977). Earlier suggestions that bluebacks do not ascend as far upstream as alewife are unfounded (Loesch 1987). In tributaries of the Rappahannock River, VA, upstream areas were found to be more important for spawning than downstream areas (O'Connell and Angermeier 1997).

Blueback herring will generally spawn 3-4 weeks after alewife in areas where they co-occur; however, there may be considerable overlap (Loesch 1987) and peak spawning periods may differ by only 2-3 weeks (Hildebrand and Schroeder 1928). In a tributary of the Rappahannock River, VA, O'Connell and Angermeier (1997) found that blueback eggs and larvae were more abundant than those of alewife, but alewife used the stream over a longer period of time. They also reported that there was only a 3-day overlap of spawning by alewife and bluebacks. Although it has been suggested that alewife and bluebacks select separate spawning sites in sympatric areas to reduce competition (Loesch 1987), O'Connell and Angermeier (1997) did not find that the two species used different spawning habitat in the areas they examined. They suggested that there was a temporal, rather than spatial segregation that minimized the competition between the two species.

Spawning may occur during the day, but most spawning activity is greatest from late afternoon (Loesch and Lund 1977) into the night (Johnston and Cheverie 1988). A female and two or more males will swim approximately 1m below the surface of the water, whereupon they will dive to the bottom (Loesch and Lund 1977), simultaneously releasing eggs and sperm over the substrate (Bigelow and Schroeder 2002). Spawning typically occurs over an extended period, with groups or "waves" of migrants staying 4-5 days before quickly returning to sea (Hildebrand and Schroeder 1928; Bigelow and Schroeder 1953; Klauda et al. 1991). The majority of spent adult blueback herring emigrating from the Connecticut River moved through fish passage facilities between 1700 and 2100 hours (Taylor and Kynard 1984).

Spawning typically begins in the given regions at the following times: 1) Florida – as early as December (McLane 1955); 2) South Carolina (Santee River) – present in February (Bulak and Christie 1981), but spawning begins in early March (Christie 1978; Meador 1982); 3) Chesapeake Bay region - lower tributaries – early April and upper reaches – late April (Hildebrand and Schroeder 1928); 4) Mid-Atlantic region – late April (Smith 1971; Zich 1978; Wang and Kernehan 1979); 5) Susquehanna River - abundance peaks in early to mid-May (St. Pierre, pers. comm.); 6) Connecticut River – present in lower river mid-April, but spawning begins in mid-May (Loesch and Lund 1977); and 7) Saint John River, New Brunswick – present in May (Messieh 1977; Jessop et al. 1983), but spawning doesn't commence until June and may run through August (Leim and Scott 1966; Marcy 1976b).

Blueback herring are repeat spawners at an average rate of 30-40% (Richkus and DiNardo 1984). In general, there appears to be a general increase in repeat spawners from south to north (Rulifson et al. 1982). About 44-65% of the spawners in the Chesapeake Bay tributaries had previously spawned (Joseph and Davis 1965), while 75% of those in Nova Scotia had previously spawned (O'Neill 1980). In the Chowan River, North Carolina virgins comprised as high as 78% (Winslow and Rawls 1992) and as low as 35.9% of the spawning population (Winslow 1995). First spawning occurs when adults are between 3 and 6 years old, but virgin spawners are strongly represented by age 4 fish (Messieh 1977; Loesch 1987). Joseph and Davis (1965) reported some bluebacks spawning as many as six times in Virginia. The average life expectancy of blueback herring is less than that of alewife, with adults living up to 7 to 8 years of age (Kocik 2000).

Loesch (1987) has reported that blueback herring can adapt their spawning behavior under certain environmental conditions and disperse to new areas if the conditions are suitable. This was demonstrated in the Santee-Cooper System, South Carolina, where the creation of a rediversion canal and resultant hydrological alterations led to changes in spawning site selection in both rivers. In the Cooper River, bluebacks lost access to formerly impounded rice fields along the river, which were important spawning areas. Following the construction of the rediversion canal, there was an increase in the number and length of tributaries along the river that were used as spawning habitat. In the adjacent Santee River, adults dispersed into the rediversion canal itself in favor of their former habitat, which was further upstream (Eversole et al. 1994).

Jessop (1990) found a stock recruitment relationship for the spawning stock of river herring and year-class abundance at age 3. Despite these results, most studies have been unable to detect a strong relationship between adult and juvenile abundance of clupeids (Crecco and Savoy 1984; Henderson and Brown 1985; Gibson 1994; Jessop 1994). Researchers have suggested that although year-class is driven mostly by environmental factors, if the parent stock size falls below a critical level, the size of the spawning stock may become a factor in determining juvenile abundance (Kosa and Mather 2001). To the extent that environmental factors have been linked to year-class abundance, they will be discussed in subsequent sections.

O'Connell and Angermeier (1997) found that temperature was the strongest predictor of blueback herring adult and early egg presence in a tributary of the Rappahannock River, VA. Blueback herring are reported to spawn at temperatures ranging from a minimum of 13°C (Hawkins 1979; Rulifson et al. 1982) to a maximum of 27°C (Loesch 1968). Loesch and Lund (1977) noted that spawning adults were found in the lower Connecticut River in mid-April when water temperatures were as low as 4.7°C, but spawning did not occur till several weeks later when water temperature had risen. Meador et al. (1984) noted that rapid changes in water temperature appeared to be an important factor influencing the timing of spawning. Optimal spawning temperature range is suggested to be 21-25°C (Cianci 1969; Marcy 1976b; Klauda et al. 1991) and 20-24°C (Pardue 1983). Fish in the laboratory acclimated to 15° C and 29 ppt salinity exhibited a final temperature preference of 22.8°C (Terpin et al. 1977).

During their freshwater migration, blueback herring swim at midwater depths (compared to deeper water used by American shad) (Witherell 1987). They are reported to spawn in both shallow (Jones et al. 1978) and deep streams (Johnston and Cheverie 1988).

Adults, eggs, larvae, and juveniles can tolerate a wide range of salinities (Klauda et al. 1991), but may prefer a more narrow range, depending on life history stage. For example, spawning may occur in salinities ranging from 0-6 ppt, but typically occurs in waters that are less than 1 ppt (Klauda et al. 1991). Boger (2002) modified Klauda et al.'s salinity range for Virginia rivers, suggesting that a suitable salinity range for spawning adults is 0-5. Spawning adults have also been found in brackish ponds at Woods Hole, Massachusetts (Nichols and Breder 1927; Hildebrand 1963).

In the sympatric range, blueback herring prefer spawning in large rivers and tributaries where the flow is relatively swift, actively avoiding areas with slow-moving or standing water (Bigelow and Welsh 1925; Marcy 1976b; Johnston and Cheverie 1988). In such areas, they will concentrate and spawn in the main stream flow, while alewife favor shorebank eddies or deep pools for spawning (Loesch and Lund 1977). In Connecticut, bluebacks were found to select fast-moving waters of the upper Salmon River and Roaring Brook, while alewife chose the slower-moving waters of Higganum and Mill creeks (Loesch and Lund 1977) and Bride Lake (Kissil 1974); researchers suggested that there was differential selection of spawning in these areas. In regions where bluebacks do not co-occur with alewife (allopatric range), they may select slower-flowing tributaries and flooded low-lying areas adjacent to main streams with soft substrates and detritus (Street et al. 1975; Sholar 1975; 1977; Fischer 1980; Hawkins 1980).

Meador et al. (1984) found that high flows (and accompanying low water temperatures) associated with flood control discharges in the Santee River immediately prior to the spawning season resulted in lower numbers of larvae that year. The preceding year, spawning occurred further upstream, when no flood control discharges occurred. Furthermore, ripe adults were found below the sampling site heading downstream the year that high flows occurred, apparently without having spawned (Bulak and Christie 1982). Other studies (Bulak and Curtis 1977; West et al. 1988) have found spawning adults moving downstream from spawning areas, following a sudden change in water discharge.

In 1985, a rediversion canal and hydroelectric dam with a fish passage facility were constructed between the Cooper River and Santee River, South Carolina, which increased the average flow of the Santee River from 63 m^3/s to 295 m^3/s. (Cooke and Leach 2003). Following the rediversion, bluebacks did not concentrate below the dam and few were attracted into the fish lock during periods of zero discharge. Too much water flow also posed a problem, as bluebacks were found concentrating below the dam during periods of discharge, but were unable to locate the entrance to the fish lock due to high turbulence (Chappelear and Cooke 1994). As a result, blueback herring changed migration patterns, by abandoning the Santee River and followed the dredged canal to the higher flow of the St. Stephen Dam. Access to spawning grounds was increased, which contributed to increases in blueback herring populations. Although the importance of instream flow requirements has been previously recognized (Crecco and Savoy 1984; ASMFC 1985; Crecco et al. 1986; Ross et al. 1993), it has usually been with regard to spawning habitat requirements or recruitment potential (Moser and Ross 1994). Cooke and Leach concluded that the study of and possible adjustment of river flow may be an important consideration for restoring alosine habitat.

Bottom composition: In the sympatric range, adults often spawn in areas of rivers where there is gravel or clean sand substrates (Bigelow and Welsh 1925; Marcy 1976b; Loesch and Lund 1977; Johnston and Cheverie 1988). In the allopatric range, where water flow is more sluggish, there is more opportunity for detritus and silt to accumulate. Pardue (1983) considered substrates with 75% or more silt and other soft materials containing detritus and vegetation as optimal for spawning in these areas because it provides cover for eggs and larvae. Boger (2002) found that river herring spawning areas along the Rappahannock River, Virginia had substrates that consisted primarily of sand, pebbles, and cobbles (usually associated with higher-gradient streams), while areas with little or no spawning were dominated by organic matter and finer sediments (usually associated with lower-gradient streams and comparatively more agricultural land use).

Adult bluebacks captured in the Santee-Cooper River system, South Carolina, were always found within a range of pH 6.0-7.5 (Christie and Barwick 1985; Christie et al. 1981). Further north, within tributaries of the Delaware River, New Jersey spawning runs were found within a broader range of pH 4.7-7.1 (average 6.2) (Byrne 1988). Based on suggested ranges for eggs (cited in Klauda et al. 1991), Boger (2002) suggested a suitable range of 6-8 and an optimal range of 6.5-8 for spawning habitat. No other information could be found regarding tolerances or optima.

Adult bluebacks require a minimum of 5.0 mg/L of DO (Jones et al. 1978). Adults caught in the Cooper and Santee Rivers, South Carolina were always captured in areas that had a DO of 6 mg/L or higher (Christie et al. 1981).

Development, growth and movement patterns

<u>Development</u>

On average, eggs are hatched within 38-60 hours of being fertilized (Adams and Street 1969). Yolk-sac larvae drift passively downstream with the current to slower moving water, where they grow and develop into juveniles (Johnston and Cheverie 1988). Yolk-sac absorption occurs in 2-3 days after hatching, and soon thereafter, larvae will begin to feed exogenously (Cianci 1969).

Larvae are sensitive to light, and abundance at the surface increases as dusk approaches and reaches a maximum by dawn (Meador 1982).

Eggs were found adhered to sticks, stones, gravel, and aquatic vegetation along the bottom of a fast-flowing stream in the Gulf of St. Lawrence. Initially they are demersal, but during the water-hardening stage, they are less adhesive and become pelagic (Johnston and Cheverie 1988). In general, blueback herring eggs are buoyant in flowing water, but settle along the bottom in still water (Ross and Biagi 1990).

Blueback herring eggs were collected in the upper Chesapeake Bay where temperatures ranged from 7-14°C; 90% were collected at 14°C (Dovel 1971). There was no reported significant reduction in hatching success for eggs acclimated at 15-18.3°C and exposed to temperatures of 22-28.3°C for 5-30 minutes in the laboratory (Schubel 1974), as well as those acclimated at 17.9-21.1°C and then exposed to 31.1°C for 30 minutes (Schubel and Koo 1976). Eggs acclimated at 32.9-36.1°C for 5-15 minutes experienced significant mortality, with total egg mortality occurring at 37.9°C. In their review of the literature, Klauda et al. (1991) concluded that suitable and optimal temperature ranges for eggs were 14-26° C and 20-24°C, respectively.

Incubation is complete after 80-94 hours at 20-21° C (Kuntz and Radcliffe 1917; Jones et al. 1978) and 55-58 hours at 22.2-23.7°C (Cianci 1969; Klauda et al. 1991). Typically, blueback herring eggs require 38-60 hours for hatching (Adams and Street 1969; Cianci 1969; Morgan and Prince 1976).

Larval blueback herring have been collected in the upper Chesapeake Bay where water temperatures ranged from 13-28°C; 96% were collected at 23-28°C (Dovel 1971). Blueback herring eggs and larvae collected from the Washademoak River, New Brunswick were acclimated at 19°C, then exposed to 29 and 34°C for 1-3 hours in the laboratory (Koo and Johnston 1978). While egg mortality and hatchability were deemed poor indicators of the effects of temperatures, larval deformity was considered a good indicator. Deformity rates were 0-25% at 29°C with a maximum exposure time of 3 hours, and 100% at 34°C (also 3 hours); such deformities were permanent and would have been lethal in the natural environment. In their review of the literature, Klauda et al. (1991) concluded that suitable temperature ranges for prolarvae and postlarvae were 14-26°C and 14-28°C, respectively; optimal ranges were not suggested.

Both Wang and Kernehan (1979) and Meador et al. (1984) observed that larval blueback herring achieved the greatest density at the surface during the night than at midday. This pattern of diel periodicity has also been described for the juvenile life stage (Loesch and Lund 1977; Loesch et al. 1982; Johnson et al. 1978).

Although spawning often occurs in freshwater, eggs and larvae can survive in salinities as high as 18-22 ppt (Johnston and Cheverie 1988). Klauda et al. (1991) suggested an optimal range of 0-2 ppt for eggs only.

Year-class size of blueback herring decreased with increasing discharge during May-June from the headpond at the Mactaquac Dam (Saint John River, New Brunswick) (Jessop 1990).

Researchers speculated that this was due to low abundance of phyto- and zooplantkon that larvae rely on at first feeding, which can result when high discharges occur (Laberge 1975). This effect was not observed for alewife, which spawn 2-3 weeks earlier than alewife. Sismour (1994) also observed a rapid decline in abundance of early preflexion river herring larvae (includes both alewife and blueback herring) in the Pamunkey River, Virginia following high river flow in 1989. As with Jessop, he speculated that high flow led to increased turbidity, which reduced prey visibility, leading to starvation of larvae.

Dixon (1996) found that seasonally high river flow and low water temperature during one season in several Virginia rivers were associated with later larval emergence, reduced relative abundance, depressed growth rate and increased mortality compared with the previous season. He suggested that high river flow may be a forcing mechanism on another abiotic factor, perhaps turbidity, which directly affects larval growth and survival.

Bottom composition: As with spawning habitat, Pardue (1983) suggested that substrates with 75% silt or other soft materials containing detritus and vegetation were optimal for eggs and larval habitat.

Klauda (1989) conducted laboratory research on fertilized eggs and yolk-sac larvae, and suggested that critical acidity conditions (defined as laboratory and field test exposures associated with >50% direct mortality) for successful blueback herring reproduction in Maryland coastal plain streams occur during a single 8-96 hour pulse of acid, pH 5.5-6.2, with concomitant total monomeric aluminum concentrations of 15-137 µg/L. Eggs that were subjected to four treatments ranging from pH 5.7-7.5 and five aluminum treatments of 0-400 µg/L at a continuous exposure time between 96-120 h revealed the following results: four-hour old embryos were sensitive to aluminum in the test treatments of pH 5.7-6.7; 12-hour old embryos were most sensitive to pH 5.7 with no aluminum present; and 24-hour old embryos suffered no mortality at all pH and aluminum levels (Klauda and Palmer 1987a).

Laboratory tests by Klauda et al. (1987) found a pH-induced mortality threshold for yolk-sac larvae of pH 5.7-6.5, and a 96-hour LC50 pH of 6.37 (pH that induced 50% mortality); no aluminum was administered. At pH 6.7, the mortality rates were highly variable (3-75%). Additional tests by Klauda and Palmer (1987b) found that as the exposure time was doubled (12 to 24 hours), mortality rates increased among yolk-sac larvae (25-49%) at a pH value of 5.5. When coupled with a concomitant exposure of total aluminum maxima of 100-150 µg/L, mortality increased to 19, 66, 98, and 100% after 4, 8, 12, and 24 hours exposure, respectively. Tests also revealed highly variable mortality rates (3-75%) for yolk-sac larvae at a pH of 6.7. In general, the data indicated that larvae were more sensitive to lower pH values (5.7 and 6.2) with no aluminum added, and were more tolerant of higher pH values (6.7 and 7.5). Yolk-sac larvae were more sensitive than four-hour old embryos to pH and aluminum treatments (Klauda and Palmer 1987a). Klauda et al. (1991) suggested overall suitable ranges for eggs and prolarvae of 5.7-8.5 and 6.2-8.5, respectively; optimal ranges were suggested to be 6.0-8.0 and 6.5-8.0, respectively.

Median pH values where bluebacks were spawning in the Rappahannock River, VA (6.27) reported by O'Connell and Angermeier were within the lethal range (5.7-6.5) and below a 96-h

LC50 of 6.37 for larvae. Reduced pH levels may represent episodic events, such as acid precipitation, but additional study is required to determine what the effects of occasional pH depressions might be.

Larvae require a minimum of 5.0 mg/L of dissolved oxygen for survival (Jones et al. 1978). No further information was found for egg tolerances or optima.

As with alewife, blueback herring eggs have proven extremely tolerant to suspended solids, with no significant reduction in hatching success at concentrations up 1000 mg/L (Auld and Schubel 1972). Schubel and Wang (1973) demonstrated that high levels of suspended solids during and after spawning significantly increased the rate of egg infections from naturally occurring fungi in alewife, which caused delayed mortalities; thus, it may be likely that the same effects would be observed in blueback herring eggs (Klauda et al. 1991). Several in situ studies (Klauda and Palmer 1987b; Greening et al. 1989) noted that yolk-sac larvae appear to be more sensitive to suspended solids than eggs, but given that observations were made following storm events, which also resulted in changes to pH and current velocity, the effects of turbidity alone were inconclusive. Klauda et al. (1991) later noted a suitable range of <500 mg/L for the prolarva life stage.

An 80 h LC_{50} of 0.33 mg/L total residual chlorine (TRC) for blueback herring eggs incubated at 20.9° C in freshwater was reported. The LC_{50} for one-day old larvae exposed to TRC for 48 and 54 h ranged from 0.24-0.32 mg/L; LC_{50} for 2-day old larvae was between 0.25-0.32 mg/L (Morgan and Prince 1977). Concentrations that were greater than or equal to 0.30 mg/L increased the percentage of abnormally developed larvae (Morgan and Prince 1978).

Juveniles

Recruitment to the juvenile stage for blueback herring begins later in the year than for other alosines because they spawn later and have a shorter growing season (Hildebrand and Schroeder 1928; Schmidt et al. 1988). The juvenile stage is reached when fish are about 20 mm TL (Klauda et al. 1991), with growth occurring very rapidly (Bigelow and Schroeder 2002); typically this stage is reached in approximately 25-35 days post-hatch (Watson 1968).

Nursery areas of the Neuse River, North Carolina have been characterized as relatively deep, slow-flowing, black waters that drain hardwood swamps (Hawkins 1980). Massman (1953), Warriner et al. (1969), and Burbidge (1974) have reported that juveniles were most abundant upstream of spawning grounds in waters of Virginia. Burbidge noted a greater prey density at these locations, but was unsure if fish were actually moving upstream in large numbers, if survival rates upstream were higher compared to survival rates downstream, or if fish were simply moving out of tributaries and oxbows into these areas.

In Chesapeake Bay tributaries, juveniles (young-of-the-year) can be found throughout tidal freshwater nursery areas in spring and early summer, but subsequently head upstream in the summer when saline waters encroach on their nursery grounds (Warriner et al. 1970). Schmidt et al. (1988) reasoned that juvenile bluebacks in the Hudson River remained in the vicinity of their natal areas throughout the summer because they were relatively absent downriver until late September. In other studies, they were found to be most abundant in nearshore waters during the day (McFadden et al. 1978; Dey and Baumann 1978). In North Carolina waters, Street et al. (1975) found that juveniles typically reside in the lower ends of the rivers in which they were spawned. Odom (pers. comm. 2002) noted that juvenile bluebacks selected the pelagic main channel portion of tidal waters of the Potomac River, while American shad juveniles selected shallower nearshore flats adjacent to and within submerged aquatic vegetation (SAV) beds. Odom speculated that these species tend to partition this habitat.

Juveniles spend 3-9 months in their natal rivers before returning to the ocean (Kosa and Mather 2001). Observations by Stokesbury and Dadswell (1989) found that blueback herring remained in the offshore region of the Annapolis estuary (Nova Scotia) for almost a month before the correct migration cues triggered emigration. These waters are 25-30% seawater. Once water temperatures begin to drop in the late summer through early winter (depending on geographic area), juveniles start heading downstream, initiating their first phase of seaward migration (Pardue 1983; Loesch 1987). Migration downstream is also prompted by changes in water flow, water levels, precipitation, and light intensity (Kissil 1974; Pardue 1983). Other researchers have suggested that water flow plays little role in providing the migration cue under riverine conditions, but is more dependent on water temperature and new to quarter moon phases, which provide dark nights (O'Leary and Kynard 1986; Stokesbury and Dadswell 1989).

In the Connecticut River, juveniles were found to move out rapidly, within a 24-hour period, peaking in the early evening at 1800 hours (O'Leary and Kynard 1986). Kosa and Mather (2001) studied juvenile river herring movement from 11 small, coastal systems in Massachusetts and found most emigrated between 1200 and 1600 hours. Emigration by juvenile bluebacks in the Annapolis River, Nova Scotia peaked at night, between 1800 and 2300 hours (Stokesbury and Dadswell 1989).

Juvenile blueback herring (age 1+) were found in the lower portion of the Connecticut River in early spring by Marcy (1969), which led him to speculate that many juveniles likely spend their first winter close to the mouth of the river. Some young-of-the-year may overwinter in deeper, higher salinity areas of the Chesapeake Bay (Hildebrand and Schroeder 1928). Dovel (1971) reported juvenile populations in the upper Chesapeake Bay that did not emigrate until early spring of their second year. Juveniles have also been reported overwintering in the Delaware Bay (Jones et al. 1978). Since juvenile river herring do not survive temperatures of 3° C or less (Otto et al. 1976), they would not be expected to overwinter in coastal systems where such temperatures persist (Kosa and Mather 2001).

Juveniles have been collected throughout a broad range of temperatures from 11.5 to 32°C in the Cape Fear River, North Carolina (Davis and Cheek 1966), and a range of 6.7-32.5°C from a discharge canal along the Connecticut River (Marcy 1976b). In the upper Chesapeake Bay, juveniles have been collected in water temperatures of 13-28°C; 96% were collected at 23-28° C. Klauda et al. (1991) suggest that a suitable range for juveniles is 10-30°C.

Juveniles collected from the Delaware River, New Jersey, selected temperatures in the laboratory that were between 20 and 22°C, when acclimated at 15-20°C and 4-6 ppt salinity (Meldrim and Gift 1971). In laboratory studies, juvenile blueback herring acclimated to 25 and 26°C at 7-8 ppt salinity preferred a temperature range of 24-28°C; an avoidance temperature of 36°C was reported (PSE&G 1978). When juveniles were acclimated at 19 and 22.7°C, mortality was 100 and 61.7%, respectively, after exposure at 32-33°C for four to six minutes (Marcy and Jacobson 1976). Mortality was also 100% when acclimated at 15° C and exposed to 30.5°C for six minutes (PSE&G 1984). In saltwater, juveniles that were acclimated at 15°C in 29 ppt salinity had a 100% survival rate when exposed to 20 and 25°C, but total mortality occurred within six minutes when fish were exposed to 32°C (Terpin et al. 1977).

In the Connecticut River, emigration began when the water temperatures dropped to 21°C in September, peaking at 14-15°C, and ending when the temperature dropped to 10°C, in late October or early November (O'Leary and Kynard 1986). Milstein (1981) found juveniles overwintering in an offshore estuary of the coast of New Jersey where bottom temperatures ranged from 2.0-10.0°C. These waters were warmer and had a higher salinity than the cooler, lower salinity river-bay estuarine nurseries where they reside in the fall.

In minimum temperature tolerance studies, juveniles that were acclimated at 25°C in 6.5-7 ppt salinity survived exposure at 12-13°C, but suffered 100% mortality at 10° C (PSE&G 1978). Additionally, juveniles that were acclimated at 5°C in 8.5-10 ppt salinity survived exposure at 3° C, but total mortality occurred at 0.2°C. Pardue (1983) concluded that optimal surface water temperatures for juveniles over the range of their habitat was between 20-30°C.

Unlike alewife, juvenile bluebacks in the Potomac River remained at the surface or at mid-water depths during daylight hours from July through November, with almost no fish appearing at the bottom. At night, over half of them were taken in bottom trawls (Warinner et al. 1970). Burbidge (1974) also reported that juvenile blueback herring were more abundant in surface waters of the James River, Virginia during the day. Contrary to these results, Jessop (1990) found that abundance of juvenile bluebacks was greater in surface waters at night than during the day, but fish did not exhibit a strict negative phototropism. One explanation for these observed differences is the minimal sewage treatment that was required during the 1970's, which led to major phytoplankton and algal blooms in freshwater areas, reducing light penetration. Since then, water clarity has greatly improved (Dennison et al. 1993).

Dixon (1996) found that juvenile bluebacks were more available to surface sampling gear approximately 30 minutes after sunset and before sunrise, where there was a corresponding light intensity of 10-2 to 10-3 uE/m2/s. Because he did not detect a corresponding change in availability of primary zooplankton prey, he concluded that juveniles migrate to the surface water within a specific isolume with changes in incident light intensity, not as a response to prey movement. A light intensity of 10-2 to 10-3 uE/m2/s may be a threshold that controls retinomotor responses to support selective feeding and schooling behavior in this species. Dixon (1996) concluded that juveniles find a depth and isolume that optimizes schooling (for predation protection) and selective feeding during the day, balancing predation risks vs. preferred food availability. These results further support and refine Loesch et al.'s (1982) observations, who first reported the diel changes in movement of juveniles.

Juveniles are found most often in waters of 0-2 ppt prior to fall migration (Jones et al. 1988), but are tolerant of much higher salinities early in life. Pardue (1983) concluded that juveniles prefer low salinities in the spring and summer, with an optimal range between 0-5 ppt. Chittenden

(1972) captured older juveniles in freshwater and subjected them to 28 ppt salinity at 22° C and all but one fish survived (mortality may have been due to handling stress). Klauda et al. (1991) suggested that 0-28 ppt was a suitable range for juveniles. Their ability to tolerate salinities as low as 0 ppt and as high as 28 ppt allows them to utilize both freshwater and marine nursery areas. Both Loesch (1968) and Kissil (1968) found that juvenile bluebacks remained in freshwater up to one month longer than juvenile alewife. In the Chowan River, North Carolina juvenile bluebacks became scarce in sampling areas following drought conditions during the summer of 1981, which resulted in saline waters encroaching further upriver into nursery areas. Researchers suggested that bluebacks had possibly moved further upstream to freshwater areas to avoid the saltwater intrusion (Winslow et al. 1983).

Discharge is an important factor influencing variability in relative abundance and emigration of juvenile river herring across smaller systems. Extremely high discharge may adversely affect juvenile emigration, and high or fluctuating discharge may decrease relative abundance of adult and juvenile bluebacks (Meador et al. 1984; West et al. 1988; Kosa and Mather 2001). In laboratory experiments, juvenile river herring avoided higher water velocities greater than 10 cm/s, especially in narrow channels (Gordon et al. 1992). In large rivers, where greater volumes of water can be transported per unit of time without substantial increases in velocity (Gordon et al. 1992), the effects of discharge may differ (Kosa and Mather 2001). Jessop (1994) found that the juvenile abundance index (JAI) of blueback herring decreased and daily instantaneous mortality increased with mean July-August river discharge from the Mactaquac Dam headpond on the Saint John River, New Brunswick, Canada. Impacts may have been the result of advection from the headpond, or from mortality as a result of reduced phytoplankton and zooplankton prey.

Juvenile blueback herring have been found among SAV beds of the lower Chesapeake Bay and it has been suggested that they may benefit from reduced predation in such areas (Olney and Boehlert 1988). It is important to note though, that no link has been made between the presence of SAV and abundance of alosines. Rather, SAV is known to improve the water quality, which may affect abundance of alosines (Sadzinski 2003). Juvenile blueback herring are a pelagic schooling fish, which likely do not rely on SAV to the extent that other anadromous fish do, such as striped bass (Dixon pers. comm.).

Juveniles have been collected in the Cape Fear River, North Carolina, where pH was between 5.2-6.8 (Davis and Cheek 1966), but the length of time spent within these areas was unknown. Abundance of juvenile river herring peaked at a pH of 8.2 in coastal systems in Massachusetts. Researchers speculated that between 7.2 and 8.2, increases in river herring abundance may be related to changes in system productivity (Kosa and Mather 2001). Although researchers were unable to determine the exact mechanism for the impact of pH on river herring, they suggested that pH does appear to contribute to variations in juvenile abundance.

Juveniles have been collected in waters of the Cape Fear River, North Carolina, where DO ranged from 2.4-10.0 mg/L (Davis and Cheek 1966). Juveniles that were exposed to DO of 2.0-3.0 mg/L for 16 hours experienced a 33% mortality rate (Dorfman and Westman 1970). Researchers determined that the juveniles were unable to detect and avoid waters with low DO. Mass mortalities of juveniles resulted from low DO in the Connecticut River over several years during June and July, most notably in the early morning hours when DO was below 3.6 mg/L and temperature was 27.6°C (Moss et al. 1976). Klauda et al. (1991) concluded that juveniles require a minimum of 4.0 mg/L of dissolved oxygen.

Dixon's study (1996) noted that the size and age of juveniles in the nursery zone increased in the downstream direction. Burbidge (1974) made similar observations that larger blueback herring juveniles were found in downstream reaches of the James River. Dixon (1996) noted that the relative age distribution and density of juveniles (center of abundance) persisted in the nursery zone throughout the sampling season, which precluded the hypothesis that cohorts move downriver as a function of age and size. Instead, Dixon referenced Sismour's (1994) theory that as river herring larvae hatch at different times and locations along the river, they will encounter varying concentrations and combinations of potential prey. It is these differences that will affect larval nutrition and survival. In early spring, larvae that are closer to the center of the chlorophyll maxima along the river (which likely support development and expansion of zooplankton assemblages [Dixon 1996]) are more likely to find suitable prey items. Early in the season, sufficient prey in upriver areas may be lacking. As the season progresses and the zooplankton prey field expands to upriver reaches, larvae in these areas may find suitable prey quantities and grow to the juvenile stage (Sismour 1994). Burbidge (1974) demonstrated a direct relationship between density of zooplankton and distribution and growth of blueback herring. This differential survival rate within the nursery zone over time may account for younger juveniles in upstream reaches (Dixon 1996).

Juveniles were captured in the Cape Fear River system, North Carolina, where the alkalinity ranged from 5-32 mg/L (Davis and Cheek 1966). This same study also found that juveniles selected areas where free carbon dioxide was between 4 and 22 ppm. Another study found that juveniles held in freshwater avoided 0.1 mg/L total residual chlorine (TRC) at 17.5°C (PSE&G 1978).

Juvenile river herring have been found overwintering in waters 0.6-7.4 km from the shore of New Jersey, at depths of 2.4-19.2 m (Milstein 1981), in what is considered an offshore estuary (Cameron and Pritchard 1963). This area is warmer and has a higher salinity than the cooler, lower salinity river-bay estuarine nurseries that they reside in the fall. The majority of fish were present during the month of March, when bottom temperatures ranged from 4.4 to 6.5°C and salinity was between 29.0 and 32.0 ppt. Further south, young bluebacks have been found overwintering off the North Carolina coast from January to March, concentrated at depths of 5.5-18.3 m (Holland and Yelverton 1973; Street et al. 1975).

Adults

Sexual maturity is reached at age 3-6 for blueback herring. Information regarding life history of young-of-the-year and adult blueback herring after they emigrate to the sea, and before they return to freshwater to spawn, is incomplete (Klauda et al. 1991). It is assumed that most juveniles join the adult population at sea within the first year of their lives and follow a north-south seasonal migration along the Atlantic coast, similar to that of American shad. Changes in temperature likely drive oceanic migration (Neves 1981).

Despite conclusive evidence, it is speculated that bluebacks are similar to other anadromous clupeids, in that they may undergo seasonal migrations within preferred isotherms (Fay et al. 1983). Neves (1981) found that bluebacks were caught in the offshore area where surface water temperatures were between 2-20°C and bottom water temperatures ranged from 2-16°C, but almost all of the fish were caught in water temperatures <13°C. Catches were most frequent where bottom temperatures averaged between 4-7°C.

Stone and Jessop (1992) found that the presence of a cold (<5°C) intermediate water mass over warmer, deeper waters on the Scotian Shelf (Hatchey 1942), where the largest catches of river herring occurred, may have restricted the extent of vertical migration during the spring. Since few captures were made where bottom temperatures were <5°C during the spring, vertical migration may be confined by a water temperature inversion in this area at this time of the year.

It is unknown to what extent blueback herring overwinter in deepwaters off the continental shelf. Fish have been caught most frequently at 27-55 m throughout their offshore range from Cape Hatteras, North Carolina, to Nova Scotia. While at sea, blueback herring were more available to bottom trawling gear during the day, which led early researchers to conclude that they were aversive to light and followed the diel movement of plankton in the water column (Neves 1981). In the Gulf of Maine region, zooplankton concentrations are at depths <100m (Bigelow 1926). Since bluebacks are rarely found in waters greater than 100 m in this area, it was speculated that zooplankton influence the depth distribution of blueback herring at sea (Neves 1981). Dixon's more recent study (1996) of juveniles within the riverine environment (see Juvenile Depth section), found that they migrate to the surface within a specific isolume as light intensity changes.

Stone and Jessop (1992) found that blueback herring off Nova Scotia, the Bay of Fundy, and the Gulf of Maine were found offshore at mid-depths of 101-183 m in the spring, in shallower nearshore waters at 46-82 m in the summer, and in deeper offshore waters at 119-192 m in the fall. They also found differences in depth distribution, with smaller fish (sexually immature) occurring in shallow regions (<93 m) during spring and fall, while larger fish occurred in deeper areas (≤93 m) in all seasons. The semi-pelagic nature of juveniles may have provided them with protection from the effects of overfishing (Dadswell 1985).

Adults have been collected in salinities over the range of 0-35 ppt (Klauda et al. 1991). Chittenden (1972) subjected adults to gradual and abrupt changes in salinity, including direct transfers from fresh to salt water and vice versa, with no mortality. For non-spawning adults that do not ascend freshwater streams, they could be expected to be found mostly in seawater, and possibly brackish estuaries as they make their way up the coast to their summer feeding grounds.

Blueback herring from the southernmost range are capable of migrating long distances (over 2000 km) in ocean waters of the Atlantic seaboard and their patterns of migration may be similar to those of American shad (Neves 1981). They are most abundant from warmer waters of the Chesapeake Bay southward (Manooch 1988; Scott and Scott 1988), occurring in virtually all tributaries to the Chesapeake Bay, in the Delaware River, and in adjacent offshore waters (Jones et al. 1978). Although bluebacks and alewife co-occur throughout much of their range, bluebacks are more abundant by one or perhaps two orders of magnitude along the middle and southern parts of their ranges (Schmidt et al. 2003).

Ecological relationships

Larvae

First-feeding larvae in the Connecticut River fed primarily on rotifers, then shifted to cladocerans as they grew larger (Crecco and Blake 1983). In general, it has been suggested that clupeids evolved so as to synchronize the larval stage with the optimal phase of annual plankton production cycles (Blaxter et al. 1982).

Juveniles

Juveniles in nursery areas feed mostly on copepods, cladocerans (Domermuth and Reed 1980), and larval dipterans (Burbidge 1974; Grabe and Schmidt 1978). Burbidge (1974) found that juveniles selected highly for larger items in the James River, Virginia, such as adult copepods, rather than smaller prey, such as *Bosmina* sp., except where there was a high relative abundance of them. Juveniles fed primarily on small copepods and dipteran larvae in the Cape Fear River, North Carolina (Davis and Cheek 1966). As much as 40% of their diet may consist of benthic organisms (Watt and Duerden 1974).

Juveniles feed mostly at the surface, below the surface of the water, and to a much lesser degree, on benthic prey (Domermuth and Reed 1980; Bigelow and Schroeder 2002). Several researchers (Burbidge 1974; Jessop 1990) observed juveniles feeding at dawn and increasing throughout the day with a maximum at dusk, then declining overnight. It is suggested that during the day, juveniles will remain within or near their zone of preferred light intensity, and feed in a selective mode (Dixon 1996), such as a "particulate" feeding mode (Janssen 1982). Pardue (1983) considered habitats that contained 100 or more individuals of zooplankton per liter as optimum, which he suggested was critical for survival and growth at this stage. Several researchers (Vigerstad and Colb 1978; O'Neill 1980; Yako 1998) have hypothesized that a change in food availability may provide a cue for juvenile anadromous herring to begin emigrating seaward, but no causal link has been established.

Young-of-the-year bluebacks are fed upon by many freshwater and marine fishes, birds, amphibians, reptiles, and mammals. Eels, yellow perch, white perch, and bluefish, are among the fish species that prey on bluebacks (Loesch (1987; Juanes et al. 1993). It has been suggested that excessive predation by striped bass may be contributing to the decline of blueback herring stocks in the Connecticut River (Savoy and Crecco 1995). Juvenile blueback herring were found to be energetically valuable and a potentially key prey for largemouth bass in two Massachusetts rivers during the late summer once they reached a suitable size. Although largemouth bass do not consistently consume blueback herring, they are energy-rich prey, which provide the highest growth potential (Yako et al. 2000).

It is often noted throughout the literature, that alewife and blueback herring co-exist in the same geographic regions, yet interspecific competition is often reduced through several mechanisms. For example, juveniles of both species in the Connecticut River consume or select different sizes of prey, leading researchers to conclude that intraspecific competition may be greater than interspecific competition (Crecco and Blake 1983). This was also evident in a study in the Minas Basin, Nova Scotia, where juvenile bluebacks favored smaller and more planktonic prey (filter feeding strategy) than did juvenile alewife (particulate-feeding strategy) (Stone 1985; Stone and Daborn 1987). Alewife also spawn earlier than bluebacks, thereby giving juvenile alewife a relative size advantage over juvenile bluebacks, allowing them a larger selection of prey (Jessop 1990). Differences in juvenile diel feeding activity further reduces competition. One study noted diurnal feeding by juvenile alewife was bimodal, with peak consumption about one to three hours before sunset and a minor peak occurring about two hours after sunrise (Weaver 1975). Another study found that juvenile blueback herring began to feed actively at dawn, increasing throughout the day and maximizing at dusk, then diminishing from dusk until dawn (Burbidge 1974). Additionally, bluebacks were found closer to the surface at night than alewife, which were found at mid-water depths, which may further reduce interspecific competition for food between the species (Loesch 1987).

Blueback herring and American shad juveniles also occur in shallow nearshore waters during the day, but competition for prey is often reduced by: 1) more opportunistic feeding by shad; 2) differential selection for cladoceran prey; and 3) higher utilization of copepods by blueback herring (Domermuth and Reed 1980). Juvenile bluebacks are more planktivorous, feeding on copepods, larval dipterans, and cladocerans (Hirschfield et al. 1966, Burbidge 1974).

Adults

Blueback herring are size-selective zooplankton feeders (Bigelow and Schroeder 1953), whose diet at sea consists mainly of ctenophores, calanoid copepods, amphipods, mysids and other pelagic shrimps, and small fish (Brooks and Dodson 1965; Neves 1981; Stone 1985; Stone and Daborn 1987; Scott and Scott 1988; Bowman et al. 2000). In Minas Basin, Bay of Fundy, smaller blueback herring fed mostly on microzooplankton, while larger fish consumed larger prey, including mysids and amphipods; feeding intensity also decreased with increasing age of fish (Stone 1985). Neves' (1981) analysis of offshore survey results led to the conclusion that blueback herring follow the diel movement of zooplankton while at sea. As discussed above (see Juvenile Depth section), Dixon's (1996) study in freshwater concluded that juvenile bluebacks followed diel movements in response to light intensity, not prey movement. Although direct evidence is lacking, catches of blueback herring in specific areas along Georges Bank, the perimeter of the Gulf of Maine, and south of Nantucket Shoals may be related to zooplankton abundance (Neves 1981).

Competition and Predation: Complete information on predation at sea is lacking for blueback herring (Scott and Scott 1988). Fish that are known to prey on bluebacks in the marine environment include spiny dogfish, American eel, cod, Atlantic salmon, silver hake, white hake, Atlantic halibut, as well as, larger schooling species including bluefish, weakfish, and striped bass (Dadswell 1985; Ross 1991; Rountree 1999; Bowman et al. 2000). Seals, gulls, and terns may also feed on bluebacks in the ocean.

In freshwater, information is lacking regarding which species prey on adults during their spawning runs, but it is assumed that they are consumed by other fish, reptiles (snakes and turtles), birds (i.e. ospreys, eagles, cormorants), and mammals (i.e. mink) (Loesch 1987; Scott and Scott 1988). Erkan (2002) notes that predation of alosines has increased dramatically in

Rhode Island rivers in recent years, especially by the double-crested cormorant, which often takes advantage of fish staging near the entrance to fishways. Populations of nesting colonies have increased in size and have expanded into areas in which they have previously not been observed. Predation by otters and herons has also increased, but to a lesser extent (Erkan 2003).

Several researchers have found evidence of striped bass predation on blueback herring (Trent and Hassler 1966; Manooch 1973; Gardinier and Hoff 1982). A recent study strongly supports the hypothesis that striped bass predation in the Connecticut River on adult blueback herring has resulted in a dramatic and unexpected decline in blueback herring abundance since 1992 (Savoy and Crecco in press). Researchers further suggest that striped bass prey primarily on spawning adults because their predator avoidance capability may be compromised at this time, due to their strong drive to spawn during upstream migration. Rates of predation on ages 0 and 1 alosines was much lower than that of adults.

All life stages of blueback herring, including the egg and larval stages, are important prey for freshwater fishes, birds, amphibians, reptiles and mammals (Klauda et al. 1991). The bluebacks' ability to feed extensively on rotifers is offered as an explanation for their dominance over American shad in some rivers along the East Coast (Marcy 1976a; Loesch and Kriete 1980).

Blueback herring have also shown signs of being impacted by invasive species. There is strong evidences that juveniles in the Hudson River have experienced a reduced forage base as a result of zebra mussel colonization (Waldman and Limburg 2003).

Abundance and status of stocks

Several long-term data sets were recently analyzed to determine the current status of blueback herring in large river systems along the East Coast, including the Connecticut, Hudson, and Delaware rivers. Bluebacks show signs of overexploitation in all of these rivers, including reductions in mean age, decreases in percentage of returning spawners, and decreases in abundance. Although researchers did not include smaller drainages in the analysis, they did note that some runs in the northeastern U.S. and Atlantic Canada have been increasing recently (Schmidt et al. 2003).

Refer to Abundance and Status of Stocks in Section 4.2.3.

4.2.7 Hickory Shad

Description and Distribution

Hickory shad, *Alosa mediocris*, are anadromous fish that spend most of their adult lives at sea, entering brackish and freshwater only to spawn (Bigelow and Schroeder 2002). Little is known about their life history and specific habitat requirements; however, coastal migrations and habitat requirements are thought to be similar to that of other alosines, especially American shad (Klauda et al. 1991). Very few spawning studies have been conducted in recent years (O'Dell and Mowrer 1984; Odom, et al. 1988). This may be, in part, because of a lack of interest in studying this species relative to other alosines (Klauda et al., 1991), and also because finding evidence of spawning in the form of eggs and larvae has proven difficult to scientists (Mansueti 1962).

Hickory shad are thought to be currently distributed along the East Coast from Cape Cod, Massachusetts (Batsavage and Rulifson 1998), to Cape Canaveral; waters south of here are unsuitable due to rising water temperatures that become semi-tropical in nature (Williams and Grey 1975). Although it is known that hickory shad are a schooling species, almost nothing is known about their distribution and movements once they return to the ocean (Street 1970; Richkus and DiNardo 1984). They have been caught in fisheries along coastal southern New England in the summer and fall (Bigelow and Schroeder 1953) and off Long Island, New York (Schaefer 1967). Anglers report catching them in nearshore waters at Cape May, New Jersey from May to November, and then capturing them in inlets from November through December (W. Gordon, pers. comm.). Unlike American shad that migrate in large numbers to the Gulf of Maine/upper Bay of Fundy during the summer, hickory shad are very rarely found there (M. Dadswell, pers. comm.). It is speculated that they do not move far from land while at sea (Mansueti and Hardy 1967).

Reproduction

Spawning Habitat

Hickory shad ascend coastal rivers during spring migration. Although it is assumed that they return to their natal rivers to spawn like other alosines, there is no documented evidence of this (Batsavage and Rulifson 1998). Their distribution in the riverine environment is similar to that of American shad (Rulifson et al. 1982). In North Carolina, the freshwater reaches of coastal rivers are the major spawning sites for hickory shad. They have also been found in the Neuse River, North Carolina in flooded swamps, and sloughs off channels of tributary creeks, but not the mainstem river (Pate 1972). In Georgia, hickory shad apparently spawn in flooded areas off the channel of the Altamaha River, and not in the mainstem of the upper reaches (Adams 1970). Major spawning sites in Virginia have been found in mainstem rivers at the fall line, further downstream, and in tributaries (Davis et al. 1970). Mansueti (1962) found that hickory shad spawned approximately 6-10 km (3.7-6.2 miles) upriver of major spawning sites of American shad in the mainstem of the Patuxent River, Maryland. In contrast, hickory shad in the St. Johns River, Florida did not migrate as far upstream as American shad (Moody 1961).

Adult hickory shad have been found in the St. Johns River, Florida as early as December (possibly November) (McBride 2000) and were absent by late January to mid-February (FF&WCC 1973). Spawning in the Santee and Cooper rivers, South Carolina may occur between early March through mid-May (Bulak and Curtis 1979). In the Chesapeake Bay, spawning may begin in early April (Mansueti and Hardy 1967), typically peaks in early May (Mansueti 1962), but may occur as late as June in freshwaters of Virginia (Davis et al. 1970). A second run of spawners has been reported to occur in the Chesapeake Bay, albeit to a much lesser degree (Hildebrand and Schroeder 1928). It is unknown if the fish that spawn during the fall run also participate in the spring run (Schaeffer 1976). Although spawning has been documented as far north as the Connecticut River (ASMFC 1999), most hickory shad spawning occurs from Maryland south (Klauda et al. 1991). One angler has documented recent spawning events at the Fairmount Dam in Philadelphia (W. Gordon, pers. comm.).

Large variations in size of young fish have been reported at given spawning sites, which has led researchers to hypothesize that they have a protracted spawning period, with eggs being released in small numbers over a long period (Mansueti 1962; DesFosse et al. 1994). Mansueti (1962) found very few ripe-running or spawnable hickory shad on the spawning grounds in the Chesapeake Bay area, leading him to hypothesize that maturation of gonads occurs rapidly and spawning occurs at night. In the Albemarle Sound region of North Carolina, hickory shad are reported to have a prolonged and seasonally earlier spawning period than other alosines (Batsavage and Rulifson 1998). It is unknown how long adults remain in freshwater after they have spawned, but it is assumed that they move gradually downstream and return to the ocean by mid-summer (Street 1970). In the Potomac River, it is believed that adults may lag slightly behind American shad before returning to the Atlantic Ocean after spawning (Klauda et al. 1991). Anglers have reported catching spent hickory shad that are very thin and actively feeding on minnows, in the nearshore region off Cape May Point, New Jersey. The adults will typically appear the first week of May and stay until mid-June (W. Gordon, pers. comm.).

There are very few studies of spawning behavior (Klauda et al. 1991), but it is assumed that female hickory shad broadcast their eggs into the water between dusk and midnight, and are fertilized by one or more males, similar to spawning behavior of American shad (Mansueti 1962; Jones et al. 1978). Hickory shad are repeat spawners, with fish spawning on average between three and five times before dying; one male was found to have spawned seven times (Schaeffer 1976). In general, hickory shad are repeat spawners, but unlike American shad, there is no progressive increase in spawning frequency from south to north. Most river systems have high incidences of repeat spawners, with percentages as high as 70-80% (Street and Adams 1969; Loesch et al. 1979; Rulifson 1982; Richkus and DiNardo 1984). Recent data from Maryland rivers indicated that 72% of females and 62% of males had previously spawned (Richardson, pers. comm.). The Cape Fear River, North Carolina appears to be an exception, where 19% of the males and only 9% of the females were reported to be repeat spawners (Sholar 1977).

The age distribution of adult hickory shad in coastal rivers from Florida to North Carolina ranges from two to eight years (Rulifson et al. 1982). The majority (80%) of males in the Octoraro Creek, Maryland were found to be sexually mature at age II (Schaeffer 1976). Further south, in the Altamaha River, Georgia 75% of females and only 49% of males were sexually mature by age II (Street and Adams 1969). Recent data from Maryland rivers found that only 50% of males and 36% of females were sexually mature at age II; by age III, 89% of males and 90% of females had spawned (Richardson, pers. comm.). In general, the majority of females are likely to become sexually mature a year or more later than males (Klauda et al. 1991; Batsavage and Rulifson 1998).

Spawning activity has been reported when water temperatures range from 8-22°C, but typically peaks when it is between 15-19°C (Mansueti 1962; Street 1970; Pate 1972; Rulifson et al. 1982; Batsavage and Rulifson 1998). Several reported temperature ranges in the southeast include 13-21°C for the Albemarle area, North Carolina (Street et al. 1975), 14-19°C for the Tar River, North Carolina (Marshall 1976), and 15-22°C for the Altamaha River, Georgia (Street 1970). Spawning in Maryland waters has been reported to occur at 7.8-20.5°C (Richardson, pers. comm.).

Hawkins (1980) noted that hickory shad prefer deep and dark-water tributaries in the Neuse River, North Carolina for spawning. Moody (1961) found that hickory shad were more abundant (by frequency of occurrence and by weight) in deeper water than American shad in the St. Johns River, Florida.

In the St. Johns River, Florida, adult hickory shad were collected where salinities ranged from 2.0-10.7 ppt (McLane 1955). In Maryland waters, spawning was reported where water was 0 ppt (Richardson, pers. comm.).

Hawkins (1980) reported that hickory shad may prefer slow-flowing areas of the Neuse River, North Carolina for spawning. Conversely, hickory shad in Maryland have been reported to favor habitat with faster moving water than that of American shad (Richardson, pers. comm.).

Richardson (pers. comm.) reports catching adult hickory shad in waters of Maryland rivers, where structures, such as ledges and fallen trees are present. Bottom composition for spawning in these waters tends to be mud, sand, and gravel.

Adults were found spawning in Maryland waters where the DO was between 5.7-11.8 mg/l (Richardson, pers. comm.)

Development, growth and movement patterns

Abundance of hickory shad has historically been less than other alosines (Atran et al. 1983; Speir 1987). The historical range of hickory shad is thought to have occurred as far north as the Gulf of Maine (possibly to the mouth of the Bay of Fundy) and possibly as far as Campobello Island, New Brunswick (Hildebrand 1963). Their current northern range is Cape Cod, Massachusetts (Batsavage and Rulifson 1998), with abundance occurring mostly from New York southward. It appears that spawning does not occur north of Maryland with much frequency (Klauda et al. 1991). They are commonly reported to occur as far south as the St. Johns River, Florida (Hildebrand 1963), but Williams and Grey (1975) have reported them as far south as Tomoka River, a small freshwater tributary of the Halifax River (a brackish coastal lagoon). Waters south of Cape Canaveral are unsuitable due to rising water temperatures that become semi-tropical in nature (Williams and Grey 1975).

<u>Development</u>

Observations suggest that eggs are released in small quantities over a longer period of time than other alosines in response to unknown stimuli and may become ripe very quickly. Eggs are generally adhesive and will typically sink to the bottom in undisturbed or moderately agitated water, but are semi-demersal in slow moving currents and buoyant under turbulent conditions (Mansueti 1962).

Early efforts to artificially propagate fish in the laboratory were difficult and initial experiments failed. Mansueti (1962) was finally able to successfully hatch eggs in the laboratory at 18.3°C and 21.1°C, with hatching occurring 5-10 hours sooner under the latter conditions. Prolarvae hatching occurred 2-3 days after fertilization, with an average hatch time of 55 to 60 hours. No postlarvae were observed feeding in the laboratory after hatching and all postlarvae died within 10 days. More recent culture of hickory shad eggs by the state of Maryland reported successful incubation at 64°F (17.8°C), with hatching occurring in 5-6 days (Richardson, pers. comm.). Recently-developed tank-spawning methods have been highly successful and larvae and fingerlings have been transplanted in large quantities in the Chesapeake Bay tributaries (Hendricks 2003).

Prolarvae fully absorb the yolk sac after 4-5 days, and postlarvae will begin feeding exogenously at this point. The size range of postlarvae is 5.5-7.0 mm (Mansueti 1962).

Hickory shad eggs have been collected in water temperatures between 9.5-22° C in rivers of North Carolina (Street 1970; Pate 1972, Marshall 1976, Hawkins 1980). Eggs that were reared under laboratory conditions hatched in 48-72 hours at temperatures between 18-21° C (Mansueti 1962). The state of Maryland reports culturing hickory shad eggs at 64° F (17.8° C), which typically hatch in 5-6 days (Richardson, pers. comm.).

Mansueti (1962) noted that fish in the 9-20 mm range were taken 35-40 miles upstream from the mouth of the Patuxent River, at a depth of 20 feet.

Eggs have been found in the pH range of 6.4-6.6 in the Neuse River, North Carolina (Hawkins 1980).

Viable hickory shad eggs have been collected in the Neuse River, North Carolina, where dissolved oxygen (DO) concentrations were between 5-10 mg/L (Hawkins 1980).

Postlarval shad begin transforming into juveniles when they are 10-35 mm long (Ulrich et al. 1979; Krauthamer and Richkus 1987). The minimum size at which they are considered fully-developed juveniles is 35 mm (Mansueti and Hardy 1962). Captures of juveniles in Maryland rivers often occur at sharp dropoffs, in schools of several dozen, indicating strong schooling behavior (Richardson, pers. comm.). Several studies suggest that most young hickory shad leave their freshwater and brackish habitats in early summer and migrate to estuarine nursery areas at an earlier age than other anadromous alosines (Mansueti 1962; Adams 1970; Pate 1972; Sholar 1977). Catches of juveniles that have been reported in the surf zone off Long Island, New York from April to November also support this hypothesis (Schaefer 1967). In the Altamaha River, Georgia, juveniles drift downstream and reach the estuary by late spring (Street 1970), which may be their nursery area (Smith 1968). Juveniles also drift down the Pee Dee and Waccamaw rivers, South Carolina earlier than young American shad, and enter Winyah Bay by July, remaining there throughout the first summer. By early fall, they have moved into oceanic waters (Crochet et al. 1976). Almost no juvenile fish could be found in rivers of Virginia, except for a few in the Rappahannock and York River systems collected in the 1970's (Klauda et al. 1991).

Other juvenile hickory shad may forego estuarine waters altogether and move directly into saltwater, unlike other alosines that use freshwater nurseries before moving into marine waters (Pate 1972; Sholar 1977). This ability to move directly into saltwater is believed to occur at an earlier age than for other anadromous alosines (Mansueti 1962; Schaefer 1967; Adams 1970; Pate 1972; Sholar 1977). Juvenile hickory shad from Albemarle Sound, North Carolina region did not use estuarine waters as a nursery ground, but instead, migrated to the ocean much earlier than other juvenile alosines (Batsavage and Rulifson 1998). Several researchers suggested that juvenile hickory shad move to shallow offshore areas off Georgia near the mouth of the Altamaha River and then disperse further by August and September (Godwin and Adams 1969; Street 1970). Anglers that catch spent adults in early May through mid-June at Cape May Point, New Jersey have reported that juveniles begin replacing adults as the summer progresses (W. Gordon, pers. comm.).

Juvenile hickory shad that are larger than average compared to other alosines have been captured in Maryland (Mansueti 1962; Virginia (Atran et al. 1983) and Georgia rivers (Adams 1970). These findings suggest that juvenile hickory shad are larger in size due to an earlier spawning period and have a faster growth rate (Godwin and Adams 1969).

Although no temperature optima or tolerances could be found in the literature, juveniles were found in the Roanoke River, North Carolina in temperatures ranging from 22.6 –28.0°C (Batsavage and Rulifson 1998). Richardson (pers. comm.) has reported catching juveniles in Maryland rivers at temperatures between 16-31°C from early July through early October. They have been reported to remain in freshwater until temperatures drop in October and November in Virginia, then move downstream as temperatures continue to decrease (Davis 1973).

Juveniles in Maryland were captured where salinities ranged from 0-7.2 ppt (Richardson, pers. comm.). Juveniles were found in estuarine waters of the Altamaha River, Georgia, in the summer, where salinities reached 10 ppt in the summer, and August and December, where salinities ranged from 10-20 ppt (Street 1970). As noted above, juveniles may forego the oligohaline portion of the estuary in favor of a more saline nursery environment (Pate 1972).

Juveniles in Maryland waters have been captured where DO ranges from 4.1-10.9 mg/l (Richardson, pers. comm.).

Ecological relationships

Pate (1972) could find no stomach contents in over 400 adult migrating hickory shad that he examined from the Neuse River, North Carolina. However, adults in the St. Johns River, Florida were found actively feeding, with 62.4% of the food items consisting of fish, and to a lesser extent, crustaceans (Williams et al. 1975) (see discussion under American shad by Walter and Olney, 2003)

Although no information was found in the literature, striped bass have been reported preying heavily on hickory shad beginning in early April at Deer Creek, Maryland (W. Gordon, pers. comm., Richardson, pers. comm.).

Adults are piscivorous, feeding on sand lance, anchovies, cunner, herring, scup, and silversides. They may also feed on squid, fish eggs, small crabs, and pelagic crustaceans (Hildebrand and Schroeder 1928; Williams et al. 1975; Bigelow and Schroeder 2002).

Abundance and status of stocks

This species has supported minor commercial fisheries because the meat is bony and regarded as inferior to American shad (Whitehead 1985); however, their roe is considered by some to be more delectable than any of the other river herrings (Nichols 1959). Hickory shad is highly sought after by sport fishermen when adults ascend rivers and tributaries during their spawning run (Mansueti 1962; Pate 1972). Although there is a lack of accurate monitoring of hickory shad, there is information that indicates some stocks are healthy. Since 1989, the Albemarle Sound, North Carolina population has experienced a surge in numbers, which supports a growing sport fishery on the Roanoke River and increased commercial fishing in Albemarle Sound. A short life span and low fecundity makes this population vulnerable to overharvest (Batsavage and Rulifson 1998). It should be noted that in other areas of its range, the hickory shad is considered highly fecund, with egg production estimated to be as high as 509,749 eggs per female in the Altamaha River, Georgia (Street 1970). Since the mid-1990's, hickory shad numbers have increased in the upper Chesapeake Bay and its tributaries (ASMFC 1999), including the lower Susquehanna, Potomac near Washington, D.C., upper Rappahannock, and James rivers (R. St. Pierre, pers. comm.). The National Marine Fisheries Service estimated that 5.6 metric tons of hickory shad were landed in 1990, and by 1999, estimated landings dramatically increased to 61.9 metric tons (Waldman and Limburg 2003).

Refer to Abundance and Status of Stocks in Section 4.2.3.

4.2.8 American eel

Description and Distribution

American eel are found in fresh, brackish, and coastal waters from the southern tip of Greenland to northeastern South America. They are ubiquitous in many habitats, and can contribute up to more than 25% of the total fish biomass in some individual systems (Smith and Sauders 1955; Ogden 1970; Jacobs et al. 2003; James McCleave, personal communication). In Connecticut rivers, the American eel was 4 times more abundant than any other species (Jacobs et al. 2003). American eel habitats include the open ocean, estuaries, large coastal tributaries, rivers, small freshwater streams, lakes, and ponds. They utilize habitats from the entire east coast of North America and the northern portion of South America, into the inland areas of the Mississippi River, the Great Lake drainages (Primarily Lake Ontario), and north into the Canadian province tributaries. American eels are also sometimes found in land locked lakes, particularly in the northeastern United States (Facey and Van den Avyle 1987). The latitudinal range for the American eel has been documented as 5° to 62°N (Bertin 1956), and their range covers more than 10,000 km of coastline (Boëtius and Harding 1985). American eels are thought to occupy the broadest array of habitats of any fish in the world (Helfman et al. 1987).

Americans eel are catadromous; they reproduce in salt water, and after an oceanic larval stage, migrate to brackish or fresh water where they grow to maturity. Upon reaching maturity, the eels migrate back to the ocean to spawn. Spawning occurs in the early winter and spring in the Sargasso Sea, and the newly hatched larvae (pre-leptocephalus and leptocephalus stages) passively drift and swim toward the continental shelf where they metamorphose into glass eels (Kleckner et al. 1983; Kleckner and McCleave 1985; McCleave et al. 1987).

The transformation into a glass eel includes a decrease in length and weight due to a reduction of water content, changes in the shape of the head and jaw, and accelerated development of the digestive system (Fahay 1978). Glass eels are miniature transparent eels and are morphologically similar to elvers (the next life stage), but they are unpigmented. As American eels develop pigment, they begin to migrate into freshwater. These young pigmented eels are termed elvers. Some elvers remain in coastal rivers and estuaries, while others may continue movements upstream in the winter and the spring (Facey and Van den Avyle 1987).

The next life stage is the yellow eel. This growth stage is characterized by a lack of sexual maturity and may last many years. Towards the end of this life stage, some of the eels become sexually differentiated. The maturation process into an adult, or silver eel, involves gradual changes, including a color change to metallic bronze black sheen, color change of the pectoral fins from yellow-green to black, fattening of the body, thickening of the skin, enlargement of the eyes and changes in visual pigments in the eye, (Vladykov 1973; Beatty 1975), increased length of capillaries in the rete of the swim bladder (Kleckner and Kruger 1981), and degeneration of the digestive tract. These changes make the eel more suited for migration at deeper depths (Vladykov 1973; Beatty 1975; Kleckner and Kruger 1981). During maturation, American eels migrate downriver to marine waters, then to the Sargasso Sea, where they spawn once and die.

American eels represent one panmictic population, meaning that they are a single breeding population that exhibits random mating. Thus, for example, an eel from the northern portion of their range could mate with an eel from the southern portion of their range, and the offspring could inhabit any portion of that range. As a result, recruits to a particular system are likely not the offspring of the adults from that system (ASMFC 2000).

Life history information for American eels remains incomplete, and for some life stages, habitat specific information is lacking. There is much uncertainty regarding how much variation in life history traits occurs across the whole population. Knowledge is lacking on the silver eel's migration from freshwater to the sea, as well as the egg, leptocephali, and glass eel life stages while in marine waters. Furthermore, while a potential spawning area of the eel has been identified in the Sargasso Sea, the specific location remains unknown (ASMFC 2000).

Reproduction

Silver eel (spawning habitat)

American eel spawn in the Sargasso Sea; a large portion of the western North Atlantic Ocean east of the Bahamas and south of Bermuda. Spawning occurs during the winter and the spring, from February to April, and possibly beyond April (Kleckner et al. 1983; McCleave et al. 1987). No other information exists on the spawning requirements, behavior, or exact location of spawning in the Sargasso Sea. Tesch (1977), who reviewed work by Schmidt (1923), and Vladykov and March (1975) determined that a spawning area existed south of Bermuda and north of the Bahamas. This zone is centered at about 25°N and 69°W. McCleave et al. (1987) reported spawning in the area from 52° to 79°W longitude and 19° to 29°N latitude.

Kleckner et al. (1983) and Kleckner and McCleave (1988) note that within this area, breeding occurs in the subtropical front systems of the oligotrophic subtropical gyres. This frontal zone, which is located within the North Atlantic Subtropical Convergence, occurs yearly during the suspected spawning season. The area is marked by abrupt horizontal temperature changes, and its position varies annually, seasonally, or even daily due to mesoscale eddies. This front is a shallow water phenomenon that occurs in the upper 500 m. It separates the permanently stratified, warm saline water mass in the southern Sargasso Sea from a cooler, less saline, seasonally stratified surface water mass in the northern Sargasso Sea. It is thought that spawning occurs on the warm side of this front (McCleave and Kleckner 1985; McCleave et al. 1987). However, no direct spawning of American eels has been observed and no adult American eels have been captured in the Sargasso Sea. Thus, the exact location of spawning area has only been inferred from the collection of leptocephali, or larvae, less than 7mm in size (Kleckner et al. 1983; Klekner and McCleave 1985).

The northern limit of the spawning area for American eel appears to be the thermal fronts that separate the northern and southern water masses of the Sargasso Sea (Kleckner et al. 1983). Kleckner et al. (1983) found that the smallest leptocephali collected during their study (3.9-5.5mm) were located on the warm side of these fronts. Kleckner and McCleave (1985) suggest that the northern limit for spawning occurs at 24-29°N, and the Bahamas/ Antilles Arc form the southern and western borders. So far, the eastern limit of American eel spawning has not been defined (Kleckner and McCleave 1985). Kleckner and McCleave (1985) suggest that this limit may be controlled by a directional orientation mechanism used by American eel adult to locate the spawning area.

It remains unknown to biologists how American eel locate the spawning area in the Sargasso Sea and what cues cause them to cease migrating. McCleave and Kleckner (1985) offer three hypotheses relating to how American eel migrate in the open ocean. The first is that swimming in one general compass direction (south), in addition to oceanic circulation, allows the eels to reach the spawning area. The second is that only a moderate directional orientation will result in successful migrations. The final hypothesis is that migration occurs within the upper three hundred meters of water, which McCleave and Kleckner (1985) speculate is significant with regard to the mechanism of migration. Stasko and Rommel (1977) suggest that the eels orient themselves using geoelectrical fields generated by ocean currents.

Kleckner et al. (1983) suggest that American eel cease migrating when they cross the frontal zone located at 24-29°N, which meanders from east to west for hundreds of kilometers. They believe that some feature of the surface water south of the front cues the American eel to cease migrating. It has been suggested that temperature and odor might be that cue (Ekman 1932, McCleave and Kleckner 1985). The temperature between the zones may vary as much as 2°C, and the northern and the southern zones exhibit differing species compositions of phytoplankton, zooplankton, and mesopelagic fishes, which could account for a change in odor (McCleave and Kleckner 1985). Furthermore, the upper layers in the pycnocline in the Sargasso Sea may contain dissolved amino acids, which are known to be potent to American eel (Liebezeit et al. 1980; Silver 1979). McCleave and Kleckner (1985) suggest it is possible that the leptocephali larvae imprint to this area in the same way that salmon imprint to a home stream.

American eel are thought to be semelparous, meaning that they die after spawning. Evidence for this includes no observations of adult eels migrating upriver, and no spent eels reported in the literature (Facey and Van den Avyle 1987).

Bottom composition is not known to be important to spawning adults, as spawning is thought to occur in the mid-upper water column (Kleckner et al. 1983; Kleckner and McCleave 1985).

Kleckner et al. (1983) and Kleckner and McCleave (1985) suggest that morphological and physiological evidence indicate that spawning occurs in the upper few hundred meters of the water column. This is based on the fact that larval American eel (less than 5mm long) have been found in water 50-350 m deep.

Temperatures may be important to spawning adults, as they spawn on the warmer side of the front in the Sargasso Sea (Kleckner et al. 1983; Kleckner and McCleave 1985). Spawning is thought to occur in the warm waters of the Sargasso Sea in an area where water temperatures are characterized by 18-19°C isotherms between 200-300m (Kleckner et al. 1983). Kleckner and McCleave (1985) describe the hypothesized spawning area as having temperatures greater than 18.2°C.

Salinity might be a key habitat parameter for spawning adults, as spawning occurs on the side of the front in the Sargasso Sea that has warmer temperatures and more saline waters (Kleckner et al. 1983; Kleckner and McCleave 1985). The spawning grounds of the American eel occur in a high salinity region of the Sargasso Sea where the salinity reaches a maximum of 36.6 ppt (Kleckner and McCleave 1985).

Development, growth and movement patterns

Eggs and leptocephali

There is little information existing on the environmental requirements or the incubation period of American eel eggs. It is assumed that the eggs hatch in the same area as they are spawned in the Sargasso Sea (See discussion in above section). Hatching is thought to occur from February through April in the Sargasso Sea, with a peak occurring in February (Kleckner et al. 1983).

After hatching, American eel undergo a brief pre-larval stage, and then enter the larval leptocephali life stage. Lepocephali are flattened from side to side and resemble a willow leaf (ASMFC 2000). They grow to about 55-65 mm before metamorphosis to the glass eel stage (Kleckner and McCleave 1985). While growing, the leptocephali drift and swim in the upper water column for up to a year (Kleckner and McCleave 1985). Their distribution is a result of the oceanic circulation patterns and the swimming behavior of the larvae (ASMFC 2000).

Kleckner and McCleave (1985) reported on the spatial and temporal distribution of leptocephali by collecting specimens and analyzing data collected by Schmidt in the 1920s. They found that leptocephali 7-10mm in length were caught from mid-February to the end of April. Specimens >45 mm were taken during all months. Kleckner and McCleave (1985) identified two year classes that occurred from February to mid-June as indicated by a bimodal distribution in length. Kleckner and McCleave (1985) collected the majority of leptocephali between 11°00'N to 42°

33.5'N latitude and 43°50'W longitude. One leptocephalus was collected at 49°43'N, 20°45'W and measured 70 mm TL. Kleckner and McCleave (1985) stated that all leptocephali 10 mm TL or less and all 0-group leptocephali collected were found within a 550 km arc east of the Bahaman Islands and north of Hispanola Islands. These specimens were found from February to March. From April to May, only one 0-group leptocephali was collected in the eastern Sargasso Sea from 23° to 28°N and 51° and 63°W (Kleckner and McCleave 1985).

Kleckner and McCleave (1985) found 0-group American eel in the Caribbean Current along the west shore of the Yucatan Channel, in the Straits of Florida, and in the Gulf Stream to the east of Cape Hatteras in April and May. Through June and July, specimens were taken in the Caribbean, Gulf Loop, Florida, and Gulf Stream currents (Kleckner and McCleave 1985).

By August, larvae 40-67 mm occupy the entire Gulf Stream area up to the Gulf of Maine. From August through October, only a few large leptocephali, or newly metamorphosed glass eels remain far out in the Western Atlantic coast. Kleckner and McCleave (1985) report that during August and September, they collected leptocephali from stations in the southern Caribbean sea, Gulf Loop Current, Florida Current, Gulf Stream, and North Atlantic Current. From this time onward, eels approach the North American continent and Greenland as glass eels (Kleckner and McCleave 1980; Kract and Tesch 1981). Kleckner and McCleave (1985) found that American eel leptocephali were found in collections in the Caribbean Sea from south of Puerto Rico to the Yucatan Channel in October and November. They were also collected at this time south of the northeastern United States and in the Canadian Maritime Provinces.

Kleckner and McCleave (1985) found that 1-group American eels were scattered widely in collections taken in the Caribbean Sea and western North Atlantic Ocean during February and March and April and May. Many specimens were taken near the Bahama Islands and near the Florida Current off the Southeastern United States (Kleckner and McCleave 1985). They also found that metamorphosing American eel leptocephali were found north of the Gulf Stream between 65°42'W and 73°30'W. Additionally, metamorphosing leptocephali were taken 55 km southwest of Bermuda and approximately 45 km southeast of Cape Hatteras. One specimen was taken 110km North of Campeche Bank in the Gulf of Mexico.

Larvae are transported northwest from the spawning grounds to the eastern seaboard by the Antilles current, Florida current, and the Gulf Stream (Facey and Van den Avyle 1987). The proposed route of American eel larvae is a westward drift from the spawning grounds in the Sargasso Sea via the Antilles Current, and then North with the Florida Current to join the Gulf Stream north of Bermuda (Kleckner and McCleave 1985; McCleave 1993; McCleave et al. 1998; Reviewed in Knights 2003).

A small portion of leptocephali reach the Caribbean, Gulf of Mexico, and the Straits of Florida. The proposed route of these larvae occur to the west and southwest of the spawning grounds via the Windward Passage and Mona Passages, which transport the American eel leptocephali to the Caribbean Sea. From here, eddies could carry them along the Caribbean coast, or the Caribbean current could convey them through the Yucatan Channel into the Gulf of Mexico and the Gulf loop current (Nof and Olsen 1983; Olsen et al. 1984; Kleckner and McCleave 1985 and sources within; McCleave and Kleckner 1987 and sources within). Leptocephali entering the Straits of

Florida likely were carried by the Gulf Loop Current, which flows out of the Gulf of Mexico as the Florida Current. Additionally, they may be conveyed into the Straits of Florida from the Bahamas/Antilles archipelago by currents through the Old Bahama Channel, then the Nicholas and Santaren Channels north of Cuba, or through the Northwest Providence Channel south of Grand Bahaman Island (Kleckner and McCleave 1985 and sources within).

It is possible that some eel larvae become trapped in the Sargasso Sea for over a year by recirculating currents (Knights 2003). This occurs when the larvae become trapped in the sub-gyre where the Florida and Antilles Currents interact, thus causing the larvae to drift north, or recirculate back into the oligotrophic Sargasso Sea from the Gulf Stream (Boëtius and Harding 1985).

As the larvae approach the edge of the continental shelf, they metamorphose into miniature transparent eel, called glass eels (ASMFC 2000).

Bottom substrate is not important to this lifestage, as American eel larvae are planktonic and float and drift in the water column. Thus, no bottom substrate is used during this life stage (Kleckner and McCleave 1985).

The importance of depth to the American eel egg and larval life stage is not stated in the literature. No information exists on the depth that eel eggs are found, as eggs have ever been collected in the Sargasso Sea (ASMFC 2000).

Once American eel enter the leptocephalus stage, they are found in the upper 250 m of the water column (Castonguay and McCleave 1987). Larvae less than 5mm long have been captured at depths between 50 and 350 m. Larvae between 5-10 mm appear to vertically migrate, as they are found between 100m and 150m during the day, and between 50 m and 100 m during the night (Castonguay and McCleave 1987; McCleave et al. 1987).

No studies have concluded the temperature requirements of American eel in the wild. However, the Japanese eel (*Anguilla japonica*) eggs hatch in 38-45 hours at 23°C (Yamamoto and Yamauchi 1974).

The salinity requirements of eggs and larvae have not been documented in literature. Facey and Van den Avyle (1987) state that postlarval American eels are tolerant of a broad range of salinities because postlarval American eel occur both in freshwater and in marine habitats. Leptocephali are in near-ionic equilibrium with seawater (Hulet et al. 1972).

<u>Glass eels and elvers</u>

American eel metamorphose into glass eels over the Continental Shelf. Shortly after, the unpigmented glass eels enter estuaries and eventually migrate to freshwater and ascend rivers during the late winter and early spring. It is thought that glass eels and elvers use olfaction to locate freshwater (Sheldon 1974; Sorensen 1986; Sorensen and Bianchini 1986); however, the specifics of this theory are mostly unknown. Creutzberg (1959, 1961) demonstrated that European eels were able to detect the odor of freshwater, and alter their behavior accordingly.

Sorensen (1986) reported that American eels were attracted to the smell of brook water, as well as the smell of decaying leaf detritus.

Vladykov (1966) stated that the migration upriver occurs earlier in the southern portion of the range and later in the north. However, other studies show variations and overlaps in migration timing (Facey and Van den Avyle 1987). Migrating eels in the Southeastern states and the Mid-Atlantic have been collected from January through May (Jeffries 1960; Smith 1968, Fahay 1978; Hornberger 1978; Sykes 1981; Helfman et al. 1984). In the northern states, migrating elvers reach estuaries as early as late winter (Jeffries 1960), although the main migration occurs in the spring. In the East River, Chester, Nova Scotia, Jessop (2000) reported eel recruitment in the river mouth from May through June, and upstream migrations occurring from July through September. Dutil et al. (1987a) reported that the glass eel and elver migration to the St. Lawrence estuary occurred in the second half of June and was over by the end of July. American eels in Maine have been documented arriving upstream from the end of March to the beginning of May (Facey and Van den Avyle 1987). Ricker and Squires (1974) and Sheldon (1974) report that the run in Maine is from late April to June. In Rhode Island, migrations peak during April and May (Facey and Van den Avyle 1987). In North Carolina, Rulifson et al (2004) found that recruitment of elvers occurred from January through April, with the highest density of eels occurring from March to April.

Glass eels enter estuaries by drifting on flood tides and holding position near the bottom of ebb tides, and by actively swimming along shore in estuaries above tidal influence (Barbin and Krueger 1994). Movements are primarily nocturnal (Dutil et al. 1987a). Glass eels in estuaries eventually change into pigmented elvers (Haro 1991).

During the elver life stage, American eels are active mostly at night. During the day they either burrow or remain in deepwaters (Deelder 1958). Elvers move back up into the water column on flood tides and return to the bottom during ebb tides (Pacheco and Grant 1973; McCleave and Kleckner 1985; McCleave and Wippelhauser 1986).

Eels have been documented stalling their inward migration before they enter freshwater (McCleave and Kleckner 1985). Cues that trigger this behavior are unknown. It is thought that eels may be able to detect the odor of freshwater (Creutzberg 1959, 1961; Sorensen 1986). Stalling at the freshwater interface may allow the eels to adjust physiologically and behaviorally before entering the new environment (Sorensen and Bianchini 1986). This upstream migration is possibly triggered by water chemistry changes caused by the intrusion of estuarine water during the high spring tides (Sorensen and Bianchini 1986). Elvers eventually begin their upstream migration and become more active during the day (Sorensen and Bianchini 1986). Tesch (1977) reported that European elvers oriented themselves with river currents for upstream movement. If the current was too weak or strong, the eels moved into backwater areas and delayed their migration. Since American eels and European eels have similar behaviors, it is possible that fast or slow currents also affect American eels.

Factors that are thought to influence the daily abundance of migrating elvers include nightly tidal height, river water temperature and discharge, and difference between bay and river temperature (McCleave and Kleckner 1985; Sorensen and Bianchini 1986; Ciccotti et al. 1995; McCleave and Wipplehauser 1987; Wipplehauser and McCleave 1987; Martin 1995; Jessop 2003). Migration occurs in waves and is initially triggered by an increase in temperature to about 12-14°C. After initiating migration, temperature does not appear to have an effect on migrating elvers (Jellyman and Ryan 1983; Martin 1995; Jessop 2003). River discharge appears to control the daily abundance of upstream migrants, with decreases in abundance occurring with increases in river discharge. Jessop (2003) states that increased tidal height acts to deliver an increasing abundance of elvers to the river mouth. Temperature then acts to initiate upstream migration, while discharge controls the rate of movement upstream.

While most American eel elvers migrate into freshwater, some may cease migration in coastal waters and estuaries and remain there from the time they are a year of age until they reach the mature silver eel stage and begin the spawning migration (Morrison et al. 2003). In addition to the upriver migration, fall and spring migrations have been documented (Smith and Saunders 1955; Medcof 1969).

Substrate may be an important habitat parameter for American eel, as elvers are noted burrowing during the day and in between movements upstream. American eels appear to use many different types of substrates. Facey and Van den Avyle (1987) stated that migrating elvers make use of soft undisturbed bottom sediments as shelter. A study by Edel (1976) demonstrated that American eel are less active when there is shelter present. Fahay (1978) stated that postlarval eels are benthic and utilize burrows, tubes, snags plant masses, other types of shelter, and the substrate itself. Eels have been documented burrowing in both mud and sand (P. Geer, Pers Comm).

Creutzberg (1961) reported that at night, unpigmented European eels in coastal waters are found in a variety of depths throughout the water column during incoming tides. During the day, elvers move to the bottom and bury themselves in the substrate (Deedler 1958).

Temperature is important to elvers because it is thought to trigger upstream migration. Migrations of eels begin when temperature increases above 10°C, with the majority of the movement taking place at temperatures greater than 20°C (Moriarty 1986; Haro and Krueger 1991; Hartley 1992; Thibault and Verreault 1995; Richkus and Whalen 1999; Bernard and Desrochers 2002; Jessop 2003). Jessop (2003) found that elvers in the East River, Chester, Nova Scotia, actively moved upstream when river temperatures reached 10-12°C, and the first wave of migrants peaked at 11-16°C. Water temperatures of less than 10-12°C had a gating effect on the elvers (Jessop 2003). Other researchers have found similar results. Helfman et al (1984) noted migrations in Georgia at 11°C, Soreson and Bianchini (1986) found a range of 10-15°C in Rhode Island, with a peak at 14°C, and Smith (1955) and Groom (1975) found a temperature range of 10-12°C for migrating eels in New Brunswick. Bernard and Desrochers (2002) found that most of the eels were caught in the St. Lawrence River, Quebec in July and August when the water temperature was above 20°C. While temperature is thought to play an active role in stimulating migration, other factors also play a role in the abundance of eels migrating upstream (Jessop 2003).

Other than stimulating migration, temperature does not appear to play a key role in the elver life cycle. Juvenile American eels utilize a broad range of habitats and are likely to have flexible temperature requirements. Glass eels were documented in Penobscot, Maine in temperatures ranging from 3.9°C to 13.8°C (Sheldon and McCleave 1985). Elvers have been documented in a wide variety of temperatures, including cold freshwater streams and lakes, to warm brackish coastal bays and lakes. They have been found at temperatures as low as -0.8°C (Jeffries 1960).

Little is known about the salinity requirements of juvenile American eels. Sheldon and McCleave (1985) document glass eels in Penobscot, Maine, in salinities ranging from 0-25.2 ppt.

Sheldon and McCleave noted that in Penobscot, Maine, glass eels accumulated on the surface when surface currents on the ebb tide decreased below 15 cm/s. River discharge and its effects on water velocity were found to be the primary factor influencing the rate of elver upstream migrations (Jessop 2000). In velocities exceeding 35-40 cm/s, elvers had difficulty swimming and maintaining their position (McCleave 1980; Barbin and Krueger 1994). Jessop (2000) found that most elvers will not swim at water velocities exceeding 25 cm/s, and instead will remain resting in the substrate. Delays or prevention of upstream elver migration can be caused by high flows (Lowe 1951; Jessop and Harvie 2003). Lowe (1951) noted that high flows on the Bann River, Ireland, delayed European eel (*A. Anguilla*) elver migrations for many weeks.

Yellow eels

Some yellow eels continue migrating upstream until they reach maturity, while others remain in the lower portions of coastal estuaries and rivers (Haro 1986; Richkus and Whalen 1999; ASMFC 2000; Morrison et al. 2003). Morrison et al. (2003) studied the migration histories of yellow eels using otolith microchemistry. Yellow eels in the Hudson River, New York showed three modes of habitat use: 1) Those eels captured in freshwater, utilized only freshwater during their elver and yellow life stages; 2) over half of those captured in brackish water resided in freshwater for at least 2 years before migrating back to brackish water; and 3) the rest of the eels captured in brackish water habitats either resided entirely in brackish water, without ever utilizing fresh water environments (Morrison et al. 2003).

Few young eels are found in inland lakes (Hurley 1972; Facey and LaBar 1981; Kolenosky and Hendry 1982), as upstream migrants tend to be older, larger, more mature eels. Upstream migrations occur primarily at night from dusk to dawn. However, migrations do sometimes occur during the day (Helfman 1986; Dutil et al. 1988; Facey and Van Den Avyle 1987; McGrath et al. 2003; Verdon et al. 2003). Some studies have indicated that American eels migrate in response to the lunar cycle, with eels being less active during moonlit periods (Winn et al. 1975; Tesch 1977; Sorensen and Bianchini 1986; Cairns and Hooley 2003). Yellow eels remain in freshwater and brackish systems up to 20 years before maturing into silver eels and migrating to the sea to spawn (Tesch 1977; Helfman et al. 1987).

Migrations upstream occur from March through October, and peak in May and July depending on location (Richkus and Whalen 1999). In the St. Lawrence River, migration peaks between mid-July and mid-August. McGrath et al. (2003a) found that the numbers of American eels in the St. Lawrence River, New York approaching the Moses-Saunders Power Dam peaked in early July and early October. Verdon et al (2003) found that American eels in the Richelieu River, Quebec began upstream migrations as early as June 11th and ended late September.

Some yellow eels cease migrating in the brackish portions of rivers, while others continue into the upper rivers (Hardy 1978; Fahay 1978). There is some evidence that some American eels establish a home range (Gunning and Shoop 1962; Vladykov 1971; Helfman et al. 1983; LaBar and Facey 1983; Bozeman et al. 1985; Ford and Mercer 1986; Dutil et al. 1988; Parker 1995). A home range is defined as the area in which the animal normally travels (Gerking 1953). Ford and Mercer (1986) found some evidence of a home range and territoriality, and found that larger eels were located primarily in large creeks, while smaller eels were found in narrow creeks at the back of the marsh, in the Great Sippewisset Marsh, Massachusetts. They estimated a home range of <100m (Ford and Mercer 1986). Other home range estimates include 28 ha in Lake Champlain, Vermont (LaBar and Facey 1983), 0.1-2 ha in a Georgia tidal creek (Helfman et al 1983; Bozeman et al. 1986) and 0.5-2 ha in a tributary of the St. Lawrence River (Dutil et al. 1988).

Parker (1995) found that homing in yellow phase American eels in the Penobscot Estuary, Maine was precise. More than half of the displaced eels returned to within 50m of the capture site and remained there for several days. He also found that 9 of the 16 eels displaced returned to within 300 m of their capture site, and 3 eels moved towards their capture sites, but did not arrive there while under observation. Parker (1995) found a home range of 300 ha. The size of the home range can be influenced by food availability, competition, and predator densities (Bozeman et al. 1985; Parker 1995). Displaced eels use selective stream transport to return to their prior sites (Parker and McCleave 1997).

Many studies indicate that sex ratios within individual rivers are highly skewed (Facey and LaBar 1981; Helfman et al. 1987; McCleave 1996; Krueger and Oliveira 1997; Oliveira et al. 2001; Goodwin and Angermeier 2003). Sex ratios have shown varied results regarding sex demographic patterns in American eels. Some studies state that males are more prevalent in estuaries, while females dominate in the freshwater portions of rivers (Vladykov 1966; Helfman et al. 1984; McCleave 1996; Bigelow and Schroeder 2002). Helfman et al. (1984) reported that 64% of the eels found in a Georgia estuary were male, while 94% of the eels found in freshwater were female. Hansen and Eversole (1984) reported that in South Carolina, females were about twenty times more abundant than males. Many studies found that eels in St. Lawrence River and Lake Ontario are mostly female (Vladykov 1966; Dutil 1987b). Oliveira et al. (2001) found that 52-98% of American eels in the Chandler, East Machias, and Sheepscot Rivers, Maine were male. Females have been reported as dominant in most Canadian habitats (Hurley 1972; Dolan and Power 1977; Jessop 1987.) Age, size, and sex patterns are unknown for most of the species range.

Recently, evidence suggests that density plays the key role in determining the sex of American eel; males are produced in high density areas, and females in low density areas. Thus, females are more common in upper reaches of rivers where eel density is lowest (Krueger and Oliveira 1999). Oliveira (1999) and Oliveira et al. (2001) hypothesize that males are produced in areas where crowding is occurring. Males favor areas closer to the sea and spawning ground in more productive habitats, where they can grow and mature faster (Helfman et al. 1987). On the other hand, females tend to disperse widely within their range and utilize all suitable habitats. They favor slower growth and greater size, thus increasing fecundity and swimming ability (Krueger and Oliveira 1999; Goodwin and Angermeier 2003). In upper reaches of rivers, American eels tend to mature at older ages and larger sizes (Helfman et al. 1987).

Yellow phase American eels are bottom/substrate oriented and may show little movement (Eales 1968; Ogden 1970; LaBar and Facey 1983). The substrate preference of American eel is not documented in literature. Geer (2003) found that in the Chesapeake Bay, Virginia, eels were mostly found over detritus, hydroid, or shell bottoms. Chaput et al. (1997) state that American eels in the St. Lawrence River use soft sediments to burrow during the winter. Krause (1961) also found that European eels in Germany burrowed themselves in the mud.

Little information exists regarding the depths at which American eels are found. Due to the diverse range of habitats that American eel utilize, depth range probably varies greatly. Geer (2003) found that the majority of yellow eels were caught in the upper tributaries of the Chesapeake Bay. In these areas, the depth ranged from 4 to 10m.

The onset of upstream migration in yellow eels is thought to be linked to water temperature (Moriarty 1986; Haro and Krueger 1991; Hartley 1992; Thibault and Verreault 1995; EPRI 1999). Knights and White (1998) found that European eels are stimulated to migrate by temperatures greater than 14-16°C and increases in migrations occur at temperatures greater than 20°C. Verdon et al. (2003) found similar results in the Richelieu River, Quebec. They found that migration occurs earlier in this river than in the upper St. Lawrence River, and hypothesize that in larger systems, like the St. Lawrence, temperature increases are more gradual and less variable, causing a later upstream migration. In the upper St. Lawrence River, upstream migration begins in late June and peak at the end of July (Verdon and Desrochers 2003). Verdon and Desrochers (2003) found that eels captured in the St. Lawrence River peaked when the temperatures reached 22-23°C, and a decrease in captures coincided with a decrease in water temperature from 24°C to 21°C. Once the temperatures fell below 21°C, captures of American eels became scarce (Verdon and Desrochers 2003). McGrath et al. (2003a) noted a decrease in migrant yellow eels at the Moses-Saunders Power Dam in the St. Lawrence River, when temperatures declined to 10°C in the fall. Geer (2003) reported that eels in the Chesapeake Bay, Virginia were found between 13°C and 27°C. They were most abundant in waters where the temperature was 26-28°C and least abundant in waters less than 8°C. Low catch rates at these temperatures suggests inactivity.

Yellow eels live in a variety of habitats, including, cold, high-elevation or high-latitude freshwater streams and lakes, to warm, brackish coastal bays and estuaries in the Gulf of Mexico (Facey and Van den Avyle 1987). Walsh et al. (1983) documented that yellow eel were held at 5°C for over five weeks. Also, American eels have been reported to survive passage through a nuclear power plant, where they were exposed to elevated temperatures for 1 to 1.5 hours (Marcy 1973).

It is likely that salinity is not a key habitat parameter, as American eel are found in a wide variety of salinities. The importance of salinity to the yellow phase of American eel was not found in the literature. Geer (2003) reported that in the Chesapeake Bay, Virginia, more American eels were present in the upper tributaries near or above the freshwater interface. Eighty-nine percent of the catch was in salinities below 12 ppt, and 27% of the catch occurred in waters less than 2 ppt.

Yellow eels are likely not velocity dependent, as high densities of eels have been found in lakes and ponds where velocity is low or nonexistent (Kevin McGrath, Personnel Communication). However, in their study of physical habitat relationship for American eel, Wiley et al (2004) found that in Maryland, velocity-depth diversity was the only important stream habitat variable in relation to eel density. The highest densities of eel occurred in sites that had 4 velocity-depth regimes; slow (<0.3m/s)-deep (>0.5m), slow-shallow (<0.5m), fast (>0.3m/s)-deep, and fast-shallow. Sites with only one of two velocity-depth regimes had significantly lower eel densities (Wiley et al. 2004).

Rulifson et al. (2004) found that catch was affected by dissolved oxygen rates in North Carolina. They found that dissolved oxygen was a strong predictor in the distribution of American eels. High catches of eels were almost always in waters with dissolved oxygen levels above 4mg/L (Rulifson et al. 2004). Geer (2003) found that 82% of the American eels caught in the Chesapeake Bay, Virginia were found in waters with dissolved oxygen levels between 5 and 9mg/L. However, no association was found between dissolved oxygen and catch (Geer 2003). This could be due to the fact that sampling was conducted only in the areas with dissolved oxygen levels above 5 mg/L (Rulifson et al. 2004).

Silver eels

Geographic and temporal patterns: Once American eel enter the final life stage, termed silver eel, they are sexually mature and begin migrating out to sea. In New England tributaries, spawning migrations begin in the late summer and continue through fall. Eels migrate later in the southeastern states and in the Middle Atlantic than in the northern states. It is hypothesized that this delay helps to synchronize the arrival of the eels at the spawning grounds in the Sargasso Sea (Wenner 1973; Facey and Halfman 1985; Helfman et al. 1987).

Yellow eels transform into silver eels before migrating out to sea. Little is known about this phase of their life (ASMFC 2000). Downstream migrations occur in spurts with long periods of no movement and peaks of intensive movements (Barbin et al. 1998). The rate of migration varies, with stalls in migrations occurring while the silver eels wait for specific environmental cues (Reviewed in Richkus and Whalen 1999). Migration begins at different times depending on location, and occurs primarily in the fall, although winter migrations have been documented (Facey and Helfman 1985; Euston et al. 1997, 1998). In Newfoundland, the largest eel migrations occur in late September, and early October (Bouillon and Haedrich 1985). McGrath et al. (2003b) found that American eels in the upper portion of the St. Lawrence River migrated downstream from the end of June to the beginning of October, and that the primary migration in the lower estuarine portion of the River occurred in October.

Migration of eels is thought to occur mostly at night (Haro and Castro-Santos 2000; McGrath et al. 2003c). Haro and Castro-Santos (2000) stated that silver eels in the Connecticut River, Massachusetts, migrated primarily at night, within several hours after sunset. The eels remained inactive during the day (Haro and Castro-Santos 2000). The variables thought to influence downstream migration in silver eels include water temperature, river and stream discharge, odor, and light-intensity, including moon phase (Hain 1975; Westin 1990; Haro 1991; Richkus and Whalen 1999; Richkus and Dixon 2003). Research has indicated that catch rates of American eels are higher during the dark phases of the moon and when cloud cover is highest (Winn et al. 1975; Tesch 1977; Cairns and Hooley 2003; McGrath et al. 2003c). Cairns and Hooley (2003) found that in tidal bays and estuaries in Prince Edward Island, Canada, catch per unit effort (CPUE) for silver and yellow eels decreased at full moon. CPUE was negatively correlated with the proportion of moon fullness and was negatively correlated with the illuminance index (Cairns and Hooley 2003). Cairns and Hooley (2003) suggest that this is a mechanism to avoid predation. Some studies indicate that eels exhibit an endogenous lunar cycle of activity (Boëtius 1967; Hain 1975; Edel 1976).

Rainfall, which leads to increased river discharge, may also have an impact on migrations (Lowe 1952; Winn et al. 1975; Mitchell 1995; Euston et al. 1997, 1998). Winn et al. (1975) noted increased migrations after rains, as well as during the third and forth lunar quarter. Haro et al. (2003) found in Maine that more eels were captured on days with rain, then on days without rain.

Age and size at which migration begins varies geographically. American eels in the northern part of the range exhibit slower growth and remain longer in freshwater and estuarine systems before beginning migration back to sea (Facey and LaBar 1981). Various studies in Newfoundland, Lake Ontario, and Lake Champlain have shown that American eels migrate back to sea after about 12 to 13 years, and at a mean size of 69cm (Gary and Andrews 1971; Hurley 1972; Facey and LaBar 1981; McGrath 2003b). In the southern part of their range, American eels begin migrating earlier than in the north (Hansen and Eversole 1984; Helfman et al. 1984; Owens and Greer 2003). Hansen and Eversole (1984) found that in the Cooper River, South Carolina, American eels older than 7 years old and greater than 65cm in length were sparse, suggesting that eels migrate at a younger age and smaller size. Helfman et al. (1984) found similar results in the Altamaha River, Georgia, and more recently Owens and Greer (2003) found that populations in Virginia tidal rivers were made up mostly of eels less than 7 years old.

There is little information documented in the literature on the substrate requirements of American eel. One study by Valdykov (1955) reported that silver American eels in the northern habitats utilize muddy substrates during the winter months. Goodwin and Angermeier (2003) found that the highest catch of eels in the Shenandoah River drainage streams appeared to be associated with site characteristics including leaf packs, rootwads, woody debris, and flowing water.

Depth does not appear to be an important habitat characteristic for American eels, as many authors have documented them using a wide range of depths during their migrations. Haro and Castro-Santos (2000) found that silver eels in the Connecticut River, Massachusetts used all depths. They were unable to quantify the shallow depth range used by American eels, but in deeper waters, they found that silver eel depths ranged between 6.6 and 10m. The tagged eels tended to occupy the deepest third of the study site. However, eels were also observed swimming at night near the surface of the water (Haro and Castro-Santos 2000). McGrath et al (2003c) found similar results. They found during their surface and midwater trawling study that American eels were caught at the highest rates between 6 and 10 m. However, they state that they are unsure if these findings are significant since sampling was limited near the bottom (18-

24m). Haro and Carlos-Santos (1997) recorded eels in the Connecticut River at depths greater than 16ft (5 m), and at least one specimen near the bottom at 32ft (10m) deep. Barbin et al. (1998) documented the same thing in the Penobscot Estuary, Maine. They found that American eels moved freely from between surface waters and the bottom, and that when movement occurred, the eels were near the surface on ebbing tides.

Upon entering the ocean, American eel appear to migrate in the upper water column. Evidence for this includes physiological changes, including the color change to a countershaded silver eel, changes to the visual system, and morphological changes to the swimbladder (McCleave and Kleckner 1985). The color change from yellow to silver provides the American eel with a darker dorsal area and a lighter ventral area. This countershading is only useful in the photic zone of the ocean, possibly only in the upper 600 m (McCleave and Klekcner 1985). Fishes found below 600 m are often dark and not countershaded (Marshall 1971, 1972). American eels also undergo changes in vision, including an increased eye diameter, increase in retinal surface area, addition of new rod cells, increase of convergence of rods on each neural pathway, decreases in cone density, and changes in vision pigments (Winn et al. 1975; Beatty 1975; Pankhurst 1982; Pankhurst and Lythgoe 1982; Pankhurst and Lythgoe 1983). These changes allow the American eel to adapt to dim, monochromic, blue light, conditions which are found in the mesopelagic zone during the day and in the epipelagic zone at night (Jerlov 1976; McCleave and Kleckner 1985). Lastly, the swimbladder changes during metamorphosis, allowing eels to maintain an inflated swim bladder at greater depths (Kleckner 1980).

Tesch (1978a, 1978b) tracked European silver eels (*Anguilla anguilla*) over the European continental slope and found that eels swam at depths between 50 and 400 m; the maximum depth in this area was 2000 m. However, the tracking was terminated prematurely due to pressure-transmitter failure. Wenner (1973) documented American eels at depths ranging from 15-68 m in the Chesapeake Bay, MD and Cape Cod, MA.

Temperature may be an important trigger for migrating silver eels. Commercial fishermen in the Elbe estuary have noted that lingering summer temperatures into the fall cause a delay in migration (Tesch 2003). Vollestad et al. (1986) documented that migrating European eels in Norwegian streams showed the most activity in a temperature range of 9-18°C. Like juveniles, mature silver eels utilize a broad range of habitats, and thus are likely to tolerate a wide range of temperatures (Facey and Van den Avyle 1987).

A few studies have been done to determine the preferred temperatures of American eels. Barila and Stauffer (1980) reported a temperature preference of 16.7°C, while Karlsson et al. (1984) found that American eels preferred temperature of 17.4 + 2.0°C. Activity in eels increases at temperatures above 13°C (Van den Avyle 1982). Haro and Castro-Santos (2000) caught downstream migrating eels on the Connecticut River, Massachusetts, where the temperature ranged from 9.5°C to 9.7°C.

American eels migrate during the fall and winter months. Barbin et al. (1998) documented American eels migrating in September and October in the Penobscot Estuary, Maine in water temperatures ranging from 9.6°C to 17.6°C.

The importance of salinity to silver American eels has not been documented in the literature. As a habitat generalist, the American eel utilize a wide variety of salinities from freshwater to saltwater, thus migrations occur through a broad range of salinities. Barbin et al. (1998) suggest that salinity structure (see comment in draft ASMFC doc).could be used as a mechanism to help orient eels out of estuaries. They documented American eels in the Souadabscook stream (tributary to the mouth of the estuary) and the Penobscot Estuary, Maine in salinities ranging from 0-30 ppt.

Ecological relationships

Once the spawning migration begins, American eel cease feeding and their digestive systems atrophies. Lipid is stored and used to provide the energy required for downstream migration, production of gametes, and the actual act of spawning (Fontaine and Olivereau 1962).

Both American eels and European eels (*Anguilla anguilla*) use the Sargasso Sea for spawning grounds (McCleave et al. 1987). However, McCleave et al. (1987) speculate that American eel spawn from February to April from approximately 19° to 29°N latitude and 52° to 79°W longitude, while European eels spawn from March to June from approximately 23° to 30°N latitude and 48° and 74°W longitude. Thus, their overlap area is not very large.

One study by Appelbaum (1982) suggests that predation on American eel larvae in the Sargasso Sea may be minimal. Appelbaum (1982) found that of 1,000 pelagic fish representing 25 species, only the myctophid, *Ceratoscopelus warmingii*, had American eel larvae in its stomach. More research is needed in this area.

Dutil et al. (1987a) found that the stomachs of elvers contained 90% Chironomidae and 8% Simuliidae. No food remains were found in the stomachs or intestines of glass eels (Dutil et al. 1987a).

Yellow phase American eels are preyed upon by many fish species including striped bass. Eel were found in 20% of striped bass stomachs in the Merrimack River, New Hampshire. Additionally, migrations of striped bass coincide with upstream elver migrations (Reviewed in Richkus and Whalen 1999). Jessop (2000) found that a major source of predation on American eel elvers in the East River, Chester, Nova Scotia, was cannibalism by larger American eels. Other authors have also reported cannibalism on younger eels (Tesch 1991; Barker 1997).

Yellow phase American eel are thought to be opportunistic feeders; preying upon whatever is available in their habitat (Bigelow and Schroeder 2002). Mature eels have been documented feeding on invertebrates including insects, crayfish, snails, worms, and small fish (Ogden 1970; Scott and Crossman 1973; Facey and LaBar 1981). They have also been documented consuming plant material (Moriarity 1978) and carrion (Ogden 1970). Cannabalism on smaller eels has also been documented extensively in the literature (Tesch 1991; Barker 1997).

Godfrey (1957) found that 90% of the eel's diet consisted of insects, while 10% consumed whole fish. Facey and LaBar (1981) reported that eel feed heavily upon benthic organisms. They found that 43% of the eels examined contained insects, and 26% contained fish. Smaller eels have been reported feeding on mayflies, magalopterans, and cassisflies (Smith 1985). Rulifson et al. (2004) found that in North Carolina, large eels consumed crayfish and fish (mullet and centrarchids). Smaller eels fed on arthropods, small mullet and minnows, polychaetes, unidentifiable matter, and plant. Fish, crustaceans, and arthropods were the most important prey items (Rulifson et al. 2004).

Wenner and Musick (1975) state that yellow eels fed on fish during the winter and spring, and on insects and molluscs in the spring and fall. Smaller eels (less than 40cm) in New Jersey streams mostly fed on aquatic insects larvae, including ephemeroptera, megaloptera, and trichoptera, while the larger eels consumed fish and crustaceans (Ogden 1970). Sorensen et al. (1986) report that in Rhode Island eels feed primarily at night, and that activity peaks at nightfall. Yellow eels have also been reported feeding on crustaceans, like the blue crab, and bivalves, such as soft-shelled clams and polychaetes (Wenner and Musick 1975).

Lookabaugh and Angermeier (2003) also found that prey size increased with eel size. In the piedmont regions of the James River drainage, Virginia, small eels fed primarily on aquatic insects, whereas larger eels consumed fish and crayfish. In the coastal plain, microcrustaceans and aquatic insects were preyed upon by small and medium sized eels, while large eels fed on crayfish.

Silver phase American eels do not feed during their migration to the Sargasso Sea.

Silver phase American eels are preyed upon by many different species, including fish, aquatic mammals, birds, and mammals (mink) (Sinha and Jones 1967; Seymour 1974). However, the importance of American eel as a food source for other animals has not been well documented in literature (ASMFC 2000).

Abundance and status of stocks

(from the 2006 Addendum to the ASMFC 1999 FMP)
Current stock status for American eel is poorly understood due to limited and non-uniform stock assessment efforts and protocols across the range of this species. Reliable indices of abundance of this species are scarce. Limited data from indirect measurements (harvest by various gear types and locations) and localized stock assessment information are currently collected.

Although eel have been continuously harvested, consistent data on harvest are often unavailable. Harvest data are often a poor indicator of abundance because harvest is dependent on demand and may consist of annually changing mixes of year classes. Most of the data collections were of short duration and were not standardized between management agencies. Harvest data from the Atlantic coastal states (Maine to Florida) indicate that harvest has declined after a peak in the mid-1970s. Annual eel catch ranged from 913,251 pounds to 3,626,936 pounds between 1970 and 2000. The lowest harvest (between 1970 and 2001) was 898,459 pounds and occurred in 2001.

Because fishing effort data is unavailable, finding a correlation between population numbers and landings data is problematic. In 2003, declarations from the International Eel Symposium (AFS

2003, Quebec City, Quebec, Canada) and the Great Lakes Fishery Commission (GLFC) highlighted concerns regarding the health of American eel stock. Available data point to decreasing recruitment combined with localized declines in abundance. This information is cause for concern and represents an opportunity for cooperation with other entities such as the GLFC to preserve the American eel stock.

In 2005, the ASMFC American Eel Stock Assessment Subcommittee (SASC) conducted a stock assessment for American eel. This assessment was reviewed by the ASMFC American Eel Technical Committee and underwent an independent peer review in December 2005. The results of the peer review can be found on the Atlantic States Marine Fisheries Commission website, www.asmfc.org.

4.2.9 Red Drum

Description and Distribution

Red drum are members of the family Sciaenidae which inhabit tropical and temperate waters worldwide (Johnson 1978). Chao (1976) reviewed the sciaenids of the western Atlantic, and determined that they encompassed 56 species in 21 genera. Sciaenids are commonly known as drums because many of them, including red drum, produce characteristic drumming sounds by contracting muscles on either side of their swimbladder (Jordan and Evermann 1896; Bigelow and Schroeder 1953; Fish and Mowbray 1970; Guest and Laswell 1978).

The accepted scientific name for red rum is *Sciaenops ocellatus*. The preferred common name for *Sciaenops ocellatus*, according to the American Fisheries Society's *A List of Common and Scientific Names of Fishes from the United States and Canada* (Robins et al. 1980) is red drum. Other common names include: channel bass, spottail bass, red bass, bass, sea bass, spotted bass, redfish, bull redfish, spottail, rat red, pescado colorado, drum, banded drum, puppy drum (Hildebrand and Schroeder 1928), sweet William and billy bass (Wenner 1988).

Along the Atlantic coast, red drum range from the Chesapeake Bay to Key West, Florida. Historically, red drum were found as far north as Massachusetts in large enough numbers to support a moderate commercial fishery in New Jersey in the early 1930s (Lux and Mahoney 1969; Ross et al. 1995). On the Gulf of Mexico coast, they are found from extreme southwest Florida to Tuxpan, Mexico (Simmons and Breuer 1962; Matlock 1987). Red drum are distributed in oceanic waters and estuarine areas in relation to their maturity stage.

Reproduction

Red drum spawn primarily during late summer and fall throughout its range along the Atlantic and Gulf coasts. Early studies indicated that spawning occurs from July through December with a peak in late September/October along the Atlantic coast (Hildebrand and Schroeder 1928; Mansueti 1960; Yokel 1966; Spitsbergen and Wolff 1974; Wolff 1976; Weinstein 1979). There is some evidence that within-season spawning peaks tend to coincide with the full moon (Peters and McMichael 1987; Comyns et al. 1991; Johnson and Funicelli 1991).

Early studies led investigators to conclude that red drum spawned in nearshore areas in the vicinity of inlets and passes throughout their range (Pearson 1929; Miles 1950; Simmons and Breuer 1962; Yokel 1966; Jannke 1971; Setzler 1977; Music and Pafford 1984; Holt et al.1985). However, evidence now suggests that red drum also utilize high-salinity estuarine areas along the south Atlantic coast (Murphy and Taylor 1990; Johnson and Funicelli 1991; Nicholson and Jordan 1994; Woodward 1994). Presumably, these expansive areas offer adequate conditions for survival of eggs and larvae and favorable circulation patterns that help transport larvae to suitable nursery areas (Ross and Stevens 1992). In the South Atlantic, red drum spawning has been documented from nearshore waters, in the vicinity of passes and inlets and inside estuaries such as Pamlico Sound and Mosquito Lagoon (Murphy and Taylor 1990; Wenner et al. 1990; Johnson and Funicelli 1991; Ross and Stevens 1992; Ross et al. 1995).

North Carolina

Nelson et al. (1991) summarized data on the spatial distribution and relative abundance of all life stages of red drum in southeastern estuaries. In North Carolina, spawning adults were reported to be common in salinities above 25 ppt in Bogue Sound and the Cape Fear River. Spawning adults were present but not frequently encountered in Pamlico Sound and the New River.

Ross and Stevens (1992) cited reports of red drum schooling over shoal and channel areas in Pamlico Sound near Hatteras, Ocracoke and Drum inlets, and near the mouths of bays and rivers on the western side of the Sound from August through early October. Red drum gather in these areas every year, presumably to spawn, since all fish landed from these schools have been in spawning condition. Marks and DiDomenico (1996) investigated movements, maturity and spawning seasonality of red drum in North Carolina coastal and estuarine waters. They report capturing the majority of spawning red drum (60%) in inlets and around shoals 2 - 5 km inside Oregon, Hatteras, Ocracoke and Drum inlets. In addition, 30% of reproductively active fish were captured in several areas of western Pamlico Sound between the Neuse and Pamlico rivers. Luczkovich et. al (1999) recently confirmed suspected spawning areas using hydrophone equipment to detect drumming sounds associated with spawning activity. Ichthyoplankton surveys were also used to corroborate spawning activity. Red drum spawning aggregations were identified in Pamlico Sound near Ocracoke and Hatteras inlets, and in the Bay River during August, September and October with peak activity in September. The authors deemed the mouth of the Bay River to be particularly critical for red drum spawning within the study area.

South Carolina

Nelson et al. (1991) reported spawning red drum to be common in Winyah Bay, Charleston Harbor, St. Helena Sound and the Broad River in salinities above 25 ppt in South Carolina. However, drumming activity, indicative of active spawning, (Holt et al. 1985) has not been detected in all of these estuaries. Hydrophone surveys were conducted along coastal South Carolina, from Winyah Bay to Calibogue Sound in 1994 (Roumillat and Tyree, unpubl.). Drumming activity was only recorded in two areas: a 40 m deep hole in the main channel leading to Charleston Harbor and two shallower areas (~ 12 m deep) off Morgan Island, near the mouth of the Coosaw River in St. Helena Sound. The latter two areas were located approximately 10 km inshore of ocean beaches. The occurrence of spawning aggregations of red drum at the mouth of Charleston Harbor has been further confirmed by the collection of viable eggs. The latter were positively identified as red drum eggs using a genetic analysis technique (Knott III 1998).

Wenner (2000) concluded that spawning activity in Charleston Harbor and in St. Helena Sound would explain recruitment of red drum to estuaries in the central and southern portion of the South Carolina coast. However, this does not explain the abundance of young red drum found in areas to the north of Charleston Harbor. Spawning in nearshore waters between Charleston Harbor and Georgetown, such as shoal areas around the Cape Romain Wildlife Refuge, would be a source of recruits to estuarine areas north of Charleston. However, this has not yet been investigated.

Georgia

Music and Pafford (1984) cited information obtained from anglers who target large red drum as evidence for spawning activity taking place in Georgia offshore waters. Anglers reported no fish in spawning condition from inshore waters. In addition, the study failed to obtain red drum larvae or postlarvae in ichthyoplankton samples. At the time, adult red drum occurred in low numbers off the Georgia coast; their greatest concentration was at the mouth of the Altamaha River in the central portion of the coast.

Nelson et al. (1991) reported spawning adults to be rare in all of Georgia's estuaries. However, more recent investigations (Woodward 1994) reported capturing reproductively active fish (based on external examination and the extrusion of oocytes from females) inside the Altamaha River estuary. Many of the females captured contained hydrated oocytes or were spent. Similarly, Nicholson and Jordan (1994) reported capturing females in pre-spawn condition as far as 20 km up the Altamaha River delta. Fish remained in these “pre-spawn staging areas” for up to 13 days, moved down to the ocean inlets for several days and then returned to the upriver sites.

Florida

Along the Atlantic coast of Florida, red drum also spawn in nearshore waters and inside estuaries. Nelson et al. (1991) reported spawning red drum to be abundant in salinities above 25 ppt in the St. Johns River and the Indian River. Murphy and Taylor (1990) reported capturing female red drum in spawning condition 35 km south of Ponce de Leon Inlet and 90 km north of Sebastian inlet. Johnson and Funicelli (1991) corroborated estuarine spawning inside Mosquito Lagoon using hydrophone surveys conducted at dusk (when red drum courtship behavior and drumming presumably take place) and surface plankton tows to collect recently spawned eggs. Mosquito Lagoon extends over 54 km long and 4 km wide and is separated from the Atlantic Ocean by a narrow barrier beach. Ponce de Leon Inlet connects the lagoon to the Atlantic Ocean at its northern end and Haulover Canal (a manmade structure) links it to the Indian River at its southern end. Depth ranges from 0.1 - 5 m and salinity averages 32 ppt. Tidal fluctuations are minimal (less than 15 cm seasonally) and water movements result from wind-driven circulation (Dubbleday 1975; Smith 1987). Eggs collected within Mosquito Lagoon and Ponce de Leon Inlet were successfully hatched in the laboratory thus confirming spawning of red drum in these locations. Sites where drumming activity was recorded yielded the largest number of viable eggs; however, eggs were also collected in areas where drumming activity was not detected.

In North Carolina, Ross and Stevens (1992) reported that juvenile red drum (10-30 mm) recruited to nurseries during September-October. More recently, Ross et al. (1995) determined that spawning took place from August through early October. In South Carolina, Wenner et al. (1990) examined histological sections of red drum ovaries and determined that spawning activity lasted from early August through September. Music and Pafford (1984) collected six juvenile red drum in mid-July and mid-November in Georgia waters. Based on this, the authors stated that red drum in Georgia probably spawn from as early as June to as late as December. Woodward (1994) maintained that spawning in coastal Georgia occurs from as early as August and into October. Spawning on both coasts of Florida peaked from September through October (Murphy and Taylor 1990). Spawning red drum in Florida have been reported as early as July (Peters and McMichael 1987) and as late as November (Johnson and Funicelli 1991) and there is evidence that some spawning may also occur during early spring (Yokel 1966; Jannke 1971).

In the northern Gulf of Mexico, Fitzhugh et al. (1988) reported evidence for a spawning season extending from August through October. More recently, Wilson and Nieland (1994) used mean monthly gonosomatic index (GSI) values and histological data to establish the spawning season. They determined that the latter extends from mid August through October. Similarly, Comyns et al. (1991) reported that spawning in the north-central portion of the Gulf of Mexico took place from August through late October or early November with a peak in September. Perret et al. (1980) reported that spawning along the Gulf side of the Florida coast probably begins in September and peaks in October. Similarly, spawning in Alabama begins in mid-August, peaks in mid-September through October, and extends through December. In Louisiana, red drum are reported to spawn from August through November.

Red drum are reportedly only second to the most fecund species among sciaenids (Wilson and Nieland 1994). However, estimates of fecundity among wild red drum are few due to difficulty in sampling the spawning population. Estimates of red drum fecundity in the wild range from 0.5 to 15.8 million oocytes per season (Pearson 1929; Miles 1950; Holt et al. 1983a). Overstreet (1983) reported fecundity estimates for Mississippi red drum of 62 million and 95 million oocytes using gravimetric and volumetric methods, respectively. Fecundity estimates obtained through laboratory experiments have ranged from 2.9 to 60 million ova per season (Colura 1974; Arnold et al. 1977; Roberts et al. 1978; Arnold 1988). Batch fecundity estimates for wild red drum in the Gulf of Mexico were initially provided by Fitzhugh et al. (1988). The authors provided the first evidence of group-synchrony among red drum and described ovarian development based on histological samples. Mean batch fecundity for red drum caught off Louisiana in the month of September was 1.7 million eggs, whereas that for October was 0.7 million. The authors used the hydrated oocyte method (Hunter and Macewicz 1985) to determine the mean number of oocytes per gram of ovarian weight. Significant differences in oocyte densities were reported between left and right ovarian lobes and among anterior, mid and posterior locations within each lobe. It was suggested that differences could have resulted from variations in the rate of hydration among locations. Wilson and Nieland (1994) expanded on the work begun by Fitzhugh et al. (1988) and estimated batch fecundity of wild red drum in the northern Gulf of Mexico. Analysis of 51 specimens yielded batch fecundity estimates ranging from 0.16 million to 3.27 million oocytes per batch with a mean batch fecundity of 1.54 million ova. Murphy and Crabtree (1999) recently provided batch fecundity estimates for red drum sampled offshore west-central Florida in 1996-1998. Their estimates were based upon examination of 77 females and ranged from 114,934 to 2,318,315 oocytes.

Spawning frequency is probably not constant over the duration of the spawning season for red drum and other group-synchronous spawners (Wilson and Nieland 1994). There is evidence that spawning peaks of red drum may coincide with new and full moons (Peters and McMichael 1987; Comyns et al. 1991). Hence, ideally, spawning frequencies should be estimated on a monthly basis for the duration of the spawning season. Wilson and Nieland (1994) calculated spawning frequency using two different methods. The postovulatory follicle method yielded variable estimates of spawning frequency between once every 3 days to once every 80 days. The average spawning frequency for the seven-season duration of the study was 8.8 days. The time-calibrated method (takes into account the proportion of day-0 females -- imminent spawners -- and day-1 females -- those showing evidence of a previous night's spawn) yielded frequencies of one spawn every 2-4 days. Given the above estimates of batch fecundity and spawning frequency, annual fecundity was estimated at 20-40 million ova for the average red drum female in the northern Gulf of Mexico. Comyns et al. (1991), used a mean batch fecundity of 2.128 million ova (obtained from data provided by Wilson and Nieland during September 1986, 1987 and 1988) and daily egg production estimates (derived from larval densities) to arrive at adult red drum biomass in the north-central Gulf of Mexico. However, the authors cautioned that the batch fecundity fraction was probably an underestimate since data were obtained from animals sampled with purse seines which are fished only during daylight hours. The mean spawning fraction, was reported as 0.20, indicating a spawning frequency of once every 5 days during the month of September.

Development, growth and movement patterns

Throughout their range, red drum exhibit differential maturity between the sexes. Males generally mature at younger ages and smaller sizes than females. Studies carried out to determine age and size at maturity of red drum have generally shown differences among them due mainly to the use of different maturity schedules. Wilson and Nieland (1994) noted that discrepancies in maturity schedules could result not only from geographical variation, but also from lack of consistency in the methodologies used to assess reproductive status. It is crucial that assessments of ovarian development be established using histological criteria (West 1990). However, it was not until relatively recently that histological techniques have been utilized to reliably establish sex and maturity.

Recent studies have reported discrepancies in size at maturity for red drum (Table 4.2-3). Differences may result not only from natural variations over the species geographical range, but also from misinterpretation of reproductive states. The latter can in turn be due to inappropriate methodology or sampling at a time when it becomes difficult to differentiate between an immature individual from one that is in between spawning events. Furthermore, sizes appear in the literature as total length (TL) as well as fork length (FL) thus obscuring direct comparisons among studies. In order to provide comparable sizes, therefore, the following length conversions (Wenner 2000) were used:

$$FL = 0.921\ TL + 17.573 \qquad r^2 = 0.999 \qquad N = 3374$$

$$TL = 1.084\ FL - 18.425 \qquad r^2 = 0.999 \qquad N = 3374$$

Table 4.2-3. Published estimates of age and size at first maturity (since 1990) and age and size at 50% maturity for male and female red drum in the South Atlantic and Gulf of Mexico. Fork lengths were converted to mm TL using the above relationships.

Source	First Maturity				P_{50} Maturity			
	Males		Females		Males		Females	
	TL	Age	TL	Age	TL	Age	TL	Age
Ross *et al*. (1995)	523	1	742	3	656	2	847	3
Marks and DiDomenico (1996)	--	--	--	--	722	--	885	--
Wenner *et al*. (1990)	545	3	825	4	--	--	--	--
Wenner (2000)	573	2	691	3	713	3.5	792	4.3
Woodward (1994)	777	--	805	--	824	--	825	--
Murphy and Taylor (1990) - FL east coast	397	1 or 2	614	3	571	2	993	5
Murphy and Taylor (1990) - FL gulf coast	451	1 or 2	665	3	591	2	911	5
Wilson and Nieland (1994)	660	2	665	3	733	--	766	--

Eggs and larvae

Information on the distribution of red drum eggs along the South Atlantic coast is very limited. Nelson et al. (1991) reported red drum eggs to be commonly encountered in several southeastern estuaries, in salinities above 25 ppt. Laboratory experiments in Texas (Neill 1987; Holt et al. 1981) established that optimum temperature and salinity for hatching and survival of red drum larvae are 25°C and 30 ppt, respectively. The spatial distribution and relative abundance of eggs in southeastern estuaries, as expected, mirrors that of spawning adults (Nelson et. al. 1991). Hence, eggs and early larvae utilize high salinity waters inside inlets and passes and in the estuary proper.

In Florida, Johnson and Funicelli (1991) collected viable red drum eggs in Mosquito Lagoon, Florida, with average daily water temperatures of 20 - 25°C and average salinities of 30 to 32 ppt. The largest number of eggs collected during the study was in depths ranging from 1.5 to 2.1 m with the highest concentrations of eggs found at the edge of the channel.

Upon hatching, red drum larvae are pelagic (Johnson 1978) and evidence from laboratory studies indicates that development is temperature-dependent (Holt et al. 1981). They make the transition between pelagic and demersal habitats upon reaching the nursery grounds when they are approximately 5 to 8 mm in length (Pearson 1929; Peters and McMichael 1987; Comyns et al. 1991; Rooker and Holt 1997). During this portion of their life cycle, they may utilize tidal currents (Setzler 1977; Holt et al. 1989) or density-driven currents (Mansueti 1960) for transport to low-salinity nurseries in the upper reaches of estuaries (Bass and Avault 1975; Setzler 1977; Weinstein 1979; Holt et al. 1983b; Holt et al. 1989; Peters and McMichael 1987; McGovern

1986; Daniel III 1988). Once in the nurseries, red drum larvae grow rapidly. Evidence suggests that red drum may select nursery areas based on the presence of environmental conditions that contribute to rapid growth (Baltz et al. 1998).

Limited information exists on the distribution of red drum larvae along the Atlantic coast. They are reportedly common in most major southeastern estuaries, with the exception of Albemarle Sound, and they are abundant in the St. Johns and Indian River estuaries, Florida (Nelson et al. 1991). Data on the spatial distribution of red drum larvae in the Gulf of Mexico has been summarized by Mercer (1984). More recently, Lyczkowski-Shultz and Steen (1991) investigated the distribution of red drum larvae in offshore and nearshore waters in the north central Gulf of Mexico east of the Mississippi River delta and south of the Mississippi barrier islands over the east Louisiana-Mississippi-Alabama shelf. They reported evidence of diel vertical stratification among red drum larvae found in depths < 25 m at both offshore and nearshore locations. Larvae (1.7 - 5.0 mm mean length) were found at depth during the night and higher in the water column during the day. At the time of this study, water was well mixed and temperature ranged between approximately 26 and 28°C. No consistent relationship between the distribution of larvae and tidal stage was detected.

In the Gulf of Mexico, red drum larvae (<7 mm) have been collected in nearshore oceanic waters, passes and inlets to estuarine waters, and within estuaries (Mercer 1984). Peters and McMichael (1987) collected red drum larvae mostly from the lower reaches of Tampa Bay although some were collected on shallow water grass beds near the middle of the Bay. There was a general increase in size of larvae from the mouth of Tampa Bay up the bay toward its headwaters. In smaller estuaries, e.g. in South Florida, red drum may spawn further offshore and larvae are transported by currents to the mouth of the estuaries where, as small juveniles, they become concentrated on their way to nursery areas in the estuary. Red drum larvae have been collected within Mosquito Lagoon along Florida's Atlantic coast where adults readily spawn far from any estuarine inlet (Johnson and Finucane 1991). Surface water temperatures and salinities for collections containing larvae in Tampa Bay were 18.3-29.7° C and 16-34 ppt, respectively (Peters and McMichael 1987).

Juveniles and subadults

Estuarine distribution of juvenile red drum varies seasonally as the fish grow and begin to disperse. Along the South Atlantic coast, they utilize a variety of inshore habitats. Included are tidal freshwater habitats and the low-salinity reaches of estuaries, estuarine emergent vegetated wetlands (flooded salt marshes, brackish marsh and tidal creeks), estuarine scrub/shrub (mangrove fringe), submerged aquatic vegetation (SAV), oyster reefs and shell banks, and unconsolidated bottom (soft sediments) (SAFMC 1998b).

In general, juvenile red drum are found throughout South Atlantic estuaries in all of the habitat types described above. In the Chesapeake Bay, juveniles (20-90 mm TL) were collected in shallow waters from September to November, but no indication as to the characteristics of the habitat was given (Mansueti 1960). According to Nelson et al. (1991), South Atlantic estuaries where juveniles (including subadults) are abundant are Bogue Sound, North Carolina; Winyah Bay, South Carolina; Ossabaw Sound, and St. Catherine/Sapelo Sound, Georgia; and the St.

Johns River, Florida. They are highly abundant in the Altamaha River and St. Andrew/St. Simon Sound, Georgia, and the Indian River, Florida.

Red drum begin the subadult phase of their life cycle upon leaving the shallow nursery habitat at approximately 200 mm TL (10 months of age). They are considered subadults until they reach sexual maturity at 3-5 years (C. Wenner, pers. comm.). It is at this stage in their life cycle that red drum utilize a variety of habitats within the estuary and when they are most vulnerable to exploitation (Pafford et al. 1990; Wenner 1992). Tagging studies conducted throughout the species' range indicate that most subadult red drum tend to remain in the vicinity of a given area (Beaumarriage 1969; Osburn et al. 1982; Music and Pafford 1984; Wenner, et al. 1990; Pafford et al. 1990; Ross and Stevens 1992; Woodward 1994; Marks and DiDomenico 1996). Movement within the estuary is most likely related to changes in temperature and food availability (Pafford et al. 1990; Woodward 1994).

North Carolina

The state of North Carolina has 147,000 acres of designated Primary Nursery Areas (PNA) and Secondary Nursery Areas (SNA) that generally comprise the upper reaches of tidal creeks and rivers and may include coastal wetlands, shell-bottom and soft sub-tidal bottom habitats (NCDMF 2001). The North Carolina Division of Marine Fisheries (NCDMF) surveys of juvenile red drum have documented their presence from the Cape Fear River, north through Buzzards Bay in Dare County (Ross and Stevens 1992). Juvenile red drum were consistently abundant in shallow waters (< 5 feet) near the mouths of the Pamlico and Neuse Rivers and in smaller bays and rivers between them. In general, habitats supporting juvenile red drum in North Carolina can be characterized as detritus or mud-bottom tidal creeks in western Pamlico Sound, and mud or sand bottom habitat in other areas (Ross and Stevens 1992).

North Carolina, unlike South Carolina and Georgia, possesses SAV beds that red drum presumably utilize as nursery areas as their current range overlaps SAV distribution (Laney 1997). The NC DMF has documented high abundance of late age-0 red drum in shallow, high salinity seagrass beds behind the Outer Banks (NC DMF 2000). However, investigations have shown juveniles to prefer areas with patchy grass coverage over sites with homogeneous vegetation (Mercer 1984; Ross and Stevens 1992; Rooker and Holt 1997). The extent to which red drum utilize SAV beds in North Carolina is unclear. This habitat does constitute important foraging grounds for 1 and 2-year old fish (SAFMC 1998). The NMFS recently identified approximately 200,000 acres of seagrass beds in coastal North Carolina. Expanses of seagrass are concentrated in the shallow areas of Core Sound and Pamlico Sound along the backside of the barrier islands. Seagrass extends south to the New River and is distributed patchily in Albemarle and Currituck Sounds, in western Pamlico Sound, and along the shores of the Pamlico and Neuse Rivers and their tributaries (NC DMF 2000).

Tagging studies indicate that late age-0 and 1 year-old red drum are common throughout the shallow portions of the estuaries and are particularly abundant along the shorelines of rivers and bays, in creeks, and over grass flats and shoals of the sounds. During the fall, those subadult fish inhabiting the rivers move to higher salinity areas such as the grass flats and shoals of the barrier islands and the front beaches. Fish that reside near inlets and along the barrier islands during the summer are more likely to enter the surf in the fall. During the winter, most subadults are recaptured in the estuaries, although some are taken in the surf and inlets. During spring and summer, recaptures are common along the barrier islands, near coastal inlets, and in the surf zone, with a large number of the subadults continuing to frequent the rivers. By their second and third year of growth, red drum are less common in rivers. Instead, they are found along the barrier islands, inhabiting the shallow water areas around the outer bars and shoals of the surf and in coastal inlets over inshore grass flats, creeks or bays.

South Carolina

In South Carolina estuaries, juvenile red drum have been collected over a range of salinities in shallow tidal creeks and in tidal impoundments. Daniel (1988) collected post-larval and juvenile red drum (6-13 mm SL) in the upper reaches of the Wando River estuary and off the Intracoastal Waterway from August through December. Collection sites were characterized by shell hash, sand and mud bottom. Juveniles were rare in the tidal creeks throughout the winter and they reappeared in the collections again in the spring. Similarly, Wenner et al. (1990) collected post-larval and juvenile red drum from June 1986 through July 1988 in shallow tidal creeks in temperatures from 9 to 30o C and salinities from 0.8 to 33.7 ppt. Smallest juveniles were observed in the creeks from August through October, indicating that this is the time when red drum recruit to nursery areas in South Carolina. With the onset of winter temperatures, juveniles left the shallow creeks for deeper water in the main channels of rivers (9-15 m) and returned again to the shallows in the spring. Juveniles are also present in areas where low-salinities do not occur, i.e. behind the barrier islands on the Isle of Palms, Capers Island, Bulls Island (C. Wenner, pers. comm.). Thus, the shallow areas of tidal creeks that run through Spartina alterniflora dominated marshes throughout the coast are the primary nursery areas for red drum in South Carolina.

Subadult red drum have been observed in larger tidal creeks and rivers, near inlets, jetties, sandbars, and even nearshore artificial reefs (Wenner 1992). Some of the subadult red drum in South Carolina also temporarily inhabit the front beaches of barrier islands. During winter months, schools of subadult red drum have been sighted in sheltered, shallow inshore areas. During 1994 and 1995, the Inshore Fisheries Section of the South Carolina DNR conducted several aerial surveys to attempt to evaluate abundance and habitat utilization of subadult red drum along the South Carolina coast. Aerial surveys were generally deemed inefficient at estimating the number of fish inhabiting particular areas, especially inlets and beachfront areas because the visibility of schools from the air depends on the interplay of temporal, climactic, topographic and behavioral factors. On the occasions when red drum schools were reliably located, they were found in flats at the confluence of rivers, inside inlets, creeks, sounds and bays. Aerial surveys proved useful to characterize the general topography of subadult red drum habitat in the intertidal and shallow-subtidal portions of the coast. It appears that typical habitats where subadult red drum are found in South Carolina are of two general types. In the northern portion of the coast, typical subadult habitat consists of broad (up to 200 m or more in width), gently sloping flats often leading to the main channel of a river or sound. Along the southern portion of the coast, subadult red drum habitat consists of more narrow (50 m or less), fairly level flats traversed by numerous small channels, typically 5-10 m wide by less than 2 m deep at low tide).

Georgia

Dahlberg (1972) collected juvenile red drum along beaches, in tidal canals, and low- and high-salinity tidal pools of the Sapelo Sound and St. Catherine's Sound estuarine systems in Georgia. A telemetry study conducted more recently on subadult and young adult red drum in Georgia (Nicholson et al. 1996) found that subadults co-occurred with adult fish in schools along beaches and shoals during fall months, and at natural and artificial reefs in offshore waters during the winter.

Florida

Along the east coast of Florida, juvenile red drum probably utilize similar habitats as those used by their west coast counterparts. Peters and McMichael (1987) collected more juveniles in quiet backwater areas of Tampa Bay than at other sampling locales, but caught a significant number of small juveniles (10-20 mm SL) in seagrass beds.

Juvenile red drum (>6 and <75 mm SL) are found along estuary margins where they move into protected backwater areas as they grow (Peters and McMichael 1987). There is a wide range of acceptable habitat for juveniles: protected coves and lagoons with seagrass over sand or mud bottoms (Pearson 1929; Miles 1950), unvegetated, "open water" shores (Kilby 1955), and unvegetated muddy bottom (Springer and Woodburn 1960). Juveniles were usually collected in the shallow shore zones of the Indian River Lagoon (Snelson 1983).

Pre-recruit red drum (>70 and <450 mm TL) aggregate in the rivers, bays, canals, tidal creeks, boat basins, and passes within an estuary (Peters and McMichael 1987). They also move into shallow nearshore waters and seagrass beds. In colder areas, juveniles may move into passes or to nearshore continental shelf waters during the winter (Mercer 1984). At this size they usually occur in large aggregations and their voracious appetites make them vulnerable to fishing pressure (Peters and McMichael 1987). Red drum are euryhaline and have been collected on the east coast of Florida at salinities from 0-22.3 ppt (Springer 1960; Tagatz 1967). Springer (1960) collected red drum from 2-29o C in the St. Lucie and Indian Rivers, Florida.

Fully recruited red drum (>449 mm TL) include large, immature "subadults" and sexually mature adults. Subadults frequent many of the same habitats preferred by pre-recruits and can be found in large aggregations on seagrass beds, over oyster bars, mudflats and sand bottom. Adults are also found within the estuary as well as nearshore continental shelf waters (Mercer 1984; Murphy and Taylor 1990). Adults appear to remain in the Mosquito/Indian River Lagoon throughout their lives (Johnson and Finucane 1991). Along the Florida Atlantic coast red drum are common in the benthic-open shelf habitat and occur in the surf zone, inlets, and lagoons (Gilmore et al. 1981; Snelson 1983). Tagging studies in Florida indicate that most subadult red drum remain close to the tag-release location for several years. However, Creek habitat was utilized by 10-26 month old red drum in the northern Indian River, Florida (Adams and Tremain 2000). Some fish repeatedly used this important habitat for up to 18 months.

Adults

Adult red drum migrate inshore and/or north and offshore and/or south in spring and fall, respectively, throughout their range along the Atlantic coast. Overall, adults tend to spend more time in coastal waters after reaching sexual maturity; however, they continue to frequent inshore waters on a seasonal basis.

North Carolina

In North Carolina, large schools of adult red drum have been observed in offshore waters south of Cape Hatteras in April and north of Cape Hatteras in May and June. Adult red drum are caught in large numbers in the Outer Banks region from late March through May and from October through November. Movements of adult red drum in coastal North Carolina have been documented based on the presence of adult fish in recreational and commercial landings, as well as information obtained from North Carolina's Adult Drum Volunteer Tagging Program. In the spring, around the month of April, adult fish move from offshore wintering grounds to North Carolina beaches. Large aggregations have been observed around Ocracoke, Hatteras and Oregon Inlets. They occur along the beaches near inlets for one to two months, with a large portion of the population moving inside Pamlico Sound during the summer months. Schools of adult fish are common in coastal inlets and in Pamlico Sound, particularly in the mouth of the Pamlico and Neuse rivers in August and September. During this time, spawning takes place. By late September most adult drum are found around the coastal inlets and along the beaches where they remain through November before moving offshore for winter. Anglers have reported catches of large red drum around the shoals and outer bars of the barrier islands, as well as around submerged structure up to a couple of kilometers offshore during December. Mercer (1984) reported schools of large red drum moving down from Virginia waters and along the coastal beaches of the Outer Banks during the fall. By late December, most large red drum have moved offshore where they are no longer available to nearshore fishing activity. The movement is reversed in spring, with large schools of adult red drum moving inshore and along the beaches from Cape Lookout to Cape Hatteras. Fish then proceed north with many of them utilizing coastal inlets to enter Pamlico Sound where they spend the summer. Other schools are reported to continue moving north to the Chesapeake Bay and the Virginia barrier islands.

South Carolina

The South Carolina Department of Natural Resources' Finfish Management Section initiated a study in 1994 to develop techniques for sampling adult red drum in the coastal ocean habitat. Initial sampling was conducted in spring 1994 near barrier island beaches in the vicinity of Charleston Harbor. Bottom longline sets were made perpendicular or parallel to the beach. However, the gear and platform that were used proved unsuitable and no fish were collected. Nonetheless, adult red drum are successfully captured by surf fishermen off South Carolina barrier island beaches during spring months.

Adult red drum have been collected in the Morgan River (St. Helena Sound), in the channel adjacent to Pelican Bank in late spring-early summer. SC DNR personnel have also documented adult red drum congregations at the tip of the north Charleston Harbor jetty. This is a high current area with patchy live-bottom along the edge of the drop-off into the main navigation channel. It is rich in food availability and attracts large concentrations of other species such as sandbar and finetooth sharks. Adult red drum have been collected in the area as early as May and as late as December.

Most sampling for adult red drum in South Carolina has concentrated on live-bottom habitats located 5-8 nm off beaches to the southeast and east of Charleston Harbor. These areas are characterized by scattered, low-relief (<1.5 m) limestone outcrops encrusted with sessile invertebrates that attract large aggregations of bait fish and portunid crabs. The current plume extending from Charleston Harbor creates considerable variations in turbidity in these areas. Resident species of finfish include black seabass, pinfish, spottail pinfish and toadfish. Offshore migrating red drum utilize these areas heavily during the fall. However, schools do not appear to spend much time in these areas, as evidenced by the lack of recaptures of tagged fish on subsequent days sampling in the same location. Rather, schools seem to "pulse" through these areas to feed as they move offshore.

In addition to natural live-bottom areas off South Carolina, adult red drum also utilize “created live-bottom” areas and artificial reefs during their fall migration. Created live-bottom exists in an area southeast of Charleston Harbor referred to as “The Humps.” This area is located to the south and west of the offshore dredge disposal area for Charleston Harbor. A substantial berm of large chunks of marl 2-3 m above the surrounding bottom was created by spoil disposal barges. These marl lumps are heavily colonized with anemones and other sessile invertebrates. Crabs are abundant and the bottom profile also attracts schools of bait fish and high numbers of resident black seabass. Catches of adult red drum are sometimes high in this area albeit not as consistently as over natural live bottom.

Charter boat captains and private boat anglers report nearshore artificial reefs to be productive areas for large adult red drum, particularly in the fall. Anglers have reported large schools of red drum at the Capers and 4KI reefs. The Fish America and Whitewater reefs in the southern part of the state are also productive areas for large red drum according to charterboat logbooks.

The Inshore Fisheries Section of the SC DNR has been conducting routine sampling of the shallow areas of several South Carolina estuaries since 1985. Trammel nets have been the predominant gear used. Although the sampling design of this particular project does not target adult red drum, they are usually captured inshore throughout the year, but greatest catches have typically occurred in July-September in 20-25 ppt salinity. The area around Fort Johnson and the mouth of Charleston Harbor have yielded the greatest catches of adult red drum over the years (SC DNR unpublished data).

Georgia

Studies conducted in Georgia have revealed the importance of the Altamaha River estuary to adult red drum for spawning activity (Woodward 1994; Nicholson and Jordan 1994). After the spawning season ends, adult red drum leave the delta and move to shoal and sandbar areas near inlets. They remain in these areas until mid-November, when a drop in temperature (below 20°C) prompts them to move to nearshore waters.

Nicholson and Jordan (1994) found adult red drum from late November until the following May at natural and artificial reefs along tide rips or associated with the plume of major rivers. Data from this study suggested high seasonal fidelity to a specific area. Fish that were tagged in the fall along shoals and beaches were relocated 9-22 km offshore during winter months and back at the original capture site in the spring. In the summer, fish moved up the Altamaha River as far as 20 km to what the authors refer to as “pre-spawn staging areas” and returned to the same shoal or beach again in the fall.

Florida

In eastern Florida, adult red drum are found mostly in nearshore waters and within the Mosquito/Indian River Lagoon system (Muller 1999). Extensive tagging in the northern Gulf also has shown only limited movement, although fish tagged off Louisiana have been captured as far east as Cape San Blas, Florida. Along Florida’s Atlantic coast adults tagged during an age-validation study showed very little movement in the Mosquito or northern Indian River Lagoons (Murphy and Taylor 1991). Carr and Chaney (1976) tracked a large red drum in this area and observed it entering almost every estuarine creek that it encountered, moving 140 m up one of the creeks at night. However, some mature adults appear to move between adjacent estuarine systems, but without any apparent seasonal pattern (M. Murphy, Florida Fish and Wildlife Conservation Commission unpublished data).

Age and Growth

Larvae and juveniles

Growth and mortality in early life dictate recruitment success and subsequent year-class strength among marine fishes. These parameters are in turn affected by both biotic and abiotic factors that can be highly variable. Growth of red drum larvae and juveniles has been shown to be affected by temperature (Holt et al. 1981; Lee et al. 1984; Holt 1987; Baltz et al. 1998) and prey availability (G. J. Holt, unpubl. data in Rooker et al. 1999). Rooker and Holt (1997) found that recent growth of newly settled red drum in the Aransas Estuary, Texas, was positively related to temperature with a 2% increase in growth rate per degree Centigrade increase. However, the authors point out that the observed difference in recent otolith growth may not be directly related to somatic growth since there is evidence for a lapse in the former compared to the growth of the animal (Neilson and Geen 1984). Long-term growth rates, however, did not exhibit a significant relationship to water temperature in the Aransas Estuary. Comyns et al. (1989), showed a strong positive relationship between growth and water temperature among red drum larvae sampled in the north-central Gulf of Mexico. Growth rates were substantially higher than those reported for laboratory reared animals (Lee et al. 1984).

Early publications (Pearson 1929; Miles 1950; Simmons and Breuer 1962; Bass and Avault 1975; Theiling and Loyacano 1976; Wakeman and Ramsey 1985) reported growth rates for larval and juvenile red drum based on analyses of the temporal sequence of length frequency distributions. Estimates of growth obtained in this manner, however, may be biased by factors such as gear avoidance, recruitment, emigration and mortality. More reliable estimates of age and growth can be established through examination of daily growth rings on otoliths. Peters and McMichael (1987) reported similar growth rates between juvenile red drum in Tampa Bay, Florida, and juvenile red drum in other areas of the Gulf of Mexico (Pearson 1929; Miles 1950; Simmons and Breuer 1962; Bass and Avault 1975) and the Chesapeake Bay (Hildebrand and Schroeder 1928; Mansueti 1960). However, their growth equations yielded higher growth estimates than those resulting from length-frequencies. The authors used growth increments on otoliths to establish age-at-size and size-at-age relationships and verified daily growth ring formation on otoliths of red drum larvae using laboratory reared specimens. The resulting relationship between observed number of rings and fish age indicated that rings were laid down once per day beginning on the day of hatch. Daily growth ring deposition on otoliths of young red drum has also been validated in the laboratory with the use of chemical marks on otoliths of known-age individuals (S. A. Holt, unpubl. data as referenced in Rooker et al. 1999). Comyns et al. (1989) investigated growth rates of wild red drum larvae in the north-central Gulf of Mexico in September and October of 1983 and 1984, and in September of 1985. Growth of red drum larvae < 4 mm was slower than that of larger larvae. Length estimates derived from growth equations in this study were similar to those obtained by Peters and McMichael (1987) for red drum larvae in Tampa Bay, Florida. Similarly, Rooker and Holt (1997), examined growth rates among cohorts of newly settled red drum in the Aransas Estuary during the recruitment period (September to December) of 1994. They found that fish exhibited rapid growth rates ranging from 0.5 to 0.8 mm d-1. Growth rates were considerably variable among cohorts and were highest for mid-season cohorts and lowest for early and late cohorts. More recently, Rooker et al. (1999) reported instantaneous growth coefficients of newly settled red drum ranging from 0.049 in 1994 to 0.051 in 1995 in the Aransas Estuary.

Subadults and adults

Age determination in this species is typically carried out through analysis of thin sections of sagittal otoliths. Analysis of checkmarks on scales only offers reliable ages for subadult red drum ages 0-4 (C. Wenner, pers. comm.). Early published reports agree that the first annular mark in this species does not appear until the second year, when fish are from 14 to 18 months old (Pearson 1929; Rohr 1964; Theiling and Loyacano 1976; Hysmith et al. 1983; Wakefield and Colura 1983; Matlock 1984, referenced in Murphy and Taylor 1990). More recently, it has been maintained that the first annular mark forms during the second winter or spring when the animal is between 18 and 21 months old, depending on the hatch date used (Wenner et al. 1990; Murphy and Taylor 1990; Pafford et al. 1990; Ross et al. 1995).

Marginal increment analysis is used to establish the time of annulus formation on both scales and otoliths. Among red drum, annulus formation occurs during spring months (Beckman et al. 1989; Murphy and Taylor 1990; Wenner et al. 1990; Pafford et al. 1990; Ross et al. 1995). The frequency of ring deposition can be validated by mark-recapture studies and/or analysis of otoliths from fish injected with a chemical marker such as oxytetracycline (OTC). In red drum, growth ring deposition has been established to occur only once per year (Beckman et al. 1988, 1989; Murphy and Taylor 1990; Pafford et al. 1990; Murphy and Taylor 1991; Ross et al. 1995).

Red drum is a long-lived species. The oldest and largest red drum have historically been reported from waters between Cape Lookout and the Virginia barrier islands (Ross et al. 1995). Among fish, the potential to attain maximum growth may be inversely related to the length of the spawning season (Conover 1990). Hence, it is not surprising that the oldest and largest individuals inhabit the high latitude fringes of their range. Along the Atlantic coast of the United States, individuals as old as 57 years (Foster, unpublished, as referenced in Ross et al. 1995) have been reported off North Carolina. In South Carolina, the oldest fish captured was 41 years old (Wenner et al. unpublished data), whereas Georgia (Woodward 1994) and eastern Florida (Murphy and Taylor 1990) have reported individuals as old as 51 years and 33 years, respectively. Along the Gulf coast, red drum have been aged up to 24 years in Florida (Murphy and Taylor 1990) and 37 years in the northern Gulf of Mexico (Beckman et al. 1989).

Growth in fishes has historically been described by means of the von Bertalanffy (1938) growth model. This model was utilized by early investigators to describe growth in red drum until Condrey et al. (1988) introduced the double von Bertalanffy growth curve. The latter combines growth for fish younger and older than a transitional age that separates two distinct growth phases in the life history of the species: rapid growth during the subadult period and diminishing growth as individuals attain and live beyond sexual maturity. The transitional age, tx, is equal to (K2 t2 - K1 t1) / (K2 - K1) where K1 and t1 correspond to individuals younger than tx and K2 and t2 are for individuals older than tx. Estimates of double von Bertalanffy parameters were summarized in the 1989 red drum stock assessment report (Vaughan and Helser 1990) for the South Atlantic states (Table 4.2-4).

Table 4.2-4. Estimates of double von Bertalanffy parameters for red drum by state. Data from Vaughan and Helser (1990).

State	L_{max}	K 1	K 2	t 1	t 2	t x
North Carolina	1,168.2	0.26	0.07	-0.80	-15.9	4.7
South Carolina	1,041.9	0.29	0.07	-0.61	-18.1	5.7
Georgia	1,148.9	0.24	0.03	-1.88	-44.6	3.9
Florida	1,037.0	0.30	0.14	-1.15	-7.5	4.7

Additional parameter estimates have appeared in the literature since then. Ross et al. (1995) used a double von Bertalanffy model to describe growth of red drum sampled in North Carolina from October 1987 through December 1990. The following parameter estimates were reported: Lmax = 1,163 mm FL, K1 = 0.30/year, K2 = 0.07/year, t1 = -0.33 year, t2 = -15.4 years, tx = 4.4 years.

The 1992 red drum stock assessment report (Vaughan 1993) introduced a different model to describe growth in this species. In this model (developed by Geaghan at LSU and referenced in Hoese et al. 1991) Lmax is not constant as it is assumed to be in the regular von Bertalanffy model. Instead, it is a linear function of age: Lmax = b0 + b1 * t where Lmax and b0 are total lengths, b1 is total length per year, and t is age. The linear von Bertalanffy curve has been found appropriate for describing the rapid growth of red drum at early ages and their slower growth in later years (Vaughan 1996). Table 4.2-5 (adapted from Vaughan 1996) summarizes estimates of single and linear von Bertalanffy parameters for the north and south regions of the Atlantic coast from 1986 through 1994.

Few studies describing the growth of red drum have been published since 1990. Murphy and Taylor (1990) sampled commercial and recreational catches of red drum from the east (Mosquito/Upper Indian River Lagoon) and west (Tampa Bay) coasts of Florida between 1981-1983. They reported rapid growth until ages 4 or 5 and a marked decline in growth rate thereafter. Growth rates did not differ between male and female subadult red drum (ages 1-3) nor was there a difference for von Bertalanffy growth parameters K and t0. However, asymptotic length, L4, was greater for Atlantic coast red drum. Estimates of von Bertalanffy parameters for the Atlantic coast were Lmax = 978.8 mm FL, K = 0.148/year, t0 = -0.149. Estimates for Gulf coast red drum were Lmax = 934.1 mm FL, K = 0.460/year, t0 = 0.029. Maximum observed lengths for Atlantic and Gulf coast fish were 1,110 mm FL and 980 mm FL, respectively.

Table 4.2-5. Red drum growth described by single and linear von Bertalanffy models weighting inversely by number of fish at age. Lmax and b0 are total lengths in millimeters, K is the growth coefficient, and t0 is years. Data are for the period 1986 - 1994 (Numbers in parentheses are standard errors). Data from Vaughan (1996).

Single von Bertalanffy parameters

Type	**n**	**L_{max}**	K	t0
North region	1969	1,186.4	0.18 (0.004)	-1.47 (0.009)
South region	19,383	1,055.8	0.283 (0.001)	-0.23 (0.01)

Linear von Bertalanffy parameters

Type	**b0**	**b1**	**K**	**t0**
North region	1,043.4	0.15 (0.03)	0.363 (0.009)	-0.12 (0.05)
South region	992.9	0.09 (0.01)	0.344 (0.002)	-0.04 (0.01)

Wenner et al. (1990) reported single von Bertalanffy parameter estimates derived from analysis of otolith sections, scales, and tag-recapture for subadult red drum sampled in estuarine areas of South Carolina. Estimates derived from otolith analysis were as follows: Lmax = 979 mm TL, K = 0.035/year, t0 = 1.095. Lengths-at-age for the models were similar to mean observed lengths at age and were in agreement with those reported earlier by Music and Pafford (1984) for subadult red drum sampled in Georgia.

Ross et al. (1995) sampled red drum from October 1987 through December 1990 in North Carolina waters. Growth was rapid until fish reached 5 years of age and was described by means of single and double von Bertalanffy models. Parameters for the single growth curve were Lmax = 1,114 mm FL, K = 0.19/year, t0 = -1.48. As reported by Murphy and Taylor (1990) and Vaughan and Helser (1990), growth rates did not differ between the sexes. Maximum observed lengths for male and female red drum were 1,250 mm FL and 1,343 mm FL, respectively.

Movements/Migration Patterns

North Carolina

The movements of juvenile and adult red drum in North Carolina have been summarized by Mercer (1984) and described from tagging studies conducted by NC DMF from 1986 through 1995 (Ross and Stevens 1992; Marks and DiDomenico 1996). Tagging studies in North Carolina, which are currently ongoing, have consisted of two segments: tagging of primarily subadult red drum by Division staff and tagging of larger adult red drum by anglers participating in a state-sponsored volunteer tagging program. Since the mid-1980s greater than 25,000 red drum have been tagged (Figure 4.2-1). Overall, both adult and subadult red drum tagged in North Carolina's estuaries have shown limited movement, with greater than 99% of all recaptures occurring within coastal waters.

The NC DMF has focused on tagging subadult (primarily one-year old) red drum. While most of the effort has been concentrated in the Pamlico River and over the grass flats located behind the barrier islands of Pamlico Sound during the months of June through October, tagging efforts have occurred year round throughout state coastal waters. Late age-0 and age-1 red drum have consistently shown limited movement. During the study period 1991-1995 over 65% of the 1,197 tagged red drum <18 inches were captured within 10 km of the release site. Late age-0 and age-1 red drum are common throughout the shallow portions of North Carolina's estuaries and are particularly abundant along the shorelines of rivers and bays, in creeks, and over grass flats and shoals common in many of the sounds. During the fall, increased tag returns indicate that a portion of the subadult fish residing in the rivers move toward higher salinity areas such as the grass flats and shoals of the barrier islands and inlets and the surf. Those subadults that reside near the coastal inlets and along the barrier islands during the summer are more likely to enter the surf in the fall. During the winter, tag return rates are low with most subadults recaptured in the estuaries, although some are taken in the surf and inlets. During spring and summer, recaptures are common along the barrier islands, near coastal inlets, and in the surf zone, with a large number of the subadults continuing to be recaptured in the rivers.

Movements of adult red drum have been documented based on the presence of adult fish in recreational and commercial landings, as well as by information obtained from North Carolina's Adult Drum Volunteer Tagging Program. In the spring, around the month of April, adult fish move from offshore wintering grounds towards North Carolina beaches. Large aggregations have been observed around Ocracoke, Hatteras and Oregon Inlets. They occur along the beaches near inlets for one to two months, with a large portion of the population moving inside Pamlico Sound during the summer months. In August and September schools of adult fish are common in coastal inlets and in Pamlico Sound, particularly in the mouth of the Pamlico and Neuse rivers. During this time, spawning activity takes place. By late September most adult drum are found around the coastal inlets and along the beaches where they remain through November before moving offshore for winter. Anglers have reported catches of large red drum around the shoals and outer bars of the barrier islands, as well as around submerged structures up to a couple of kilometers offshore during December. Mercer (1984) reported schools of large red drum moving down from Virginia waters and along the coastal beaches of the Outer Banks during the fall. By late December, most large red drum have moved offshore where they are no longer available to nearshore fishing activity. During the spring the movement is reversed with large schools of adult red drum moving inshore and along the beaches from Cape Lookout to Cape Hatteras. Fish then proceed north with many of them utilizing coastal inlets to enter Pamlico Sound where they will spend the summer. Other schools of fish are reported to continue moving north to the Chesapeake Bay and the Virginia barrier islands.

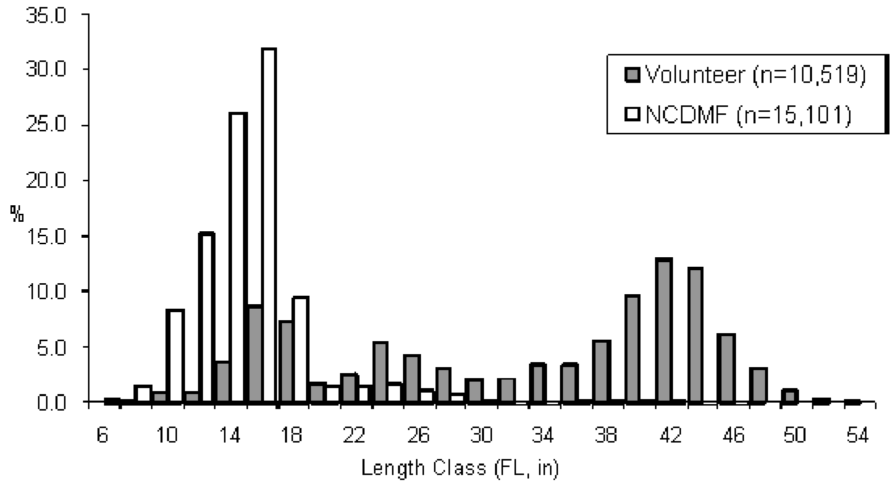


Figure 4.2.-1. Length frequency of red drum tagged in North Carolina (all gears combined), 1983-1998. Data are divided into fish tagged by Division staff and those tagged by recreational anglers through cooperative volunteer tagging program (Source: NC DMF unpublished data).

South Carolina

The Marine Resources Division of the South Carolina Department of Natural Resources (SC DNR) has conducted fishery-independent tagging of red drum in inshore waters along the coast since 1986. A total of 27,881 red drum have been tagged since then with close to 4,000 individuals tagged in 1996 alone

Project personnel recaptured over 7,500 fish whereas anglers recaptured 5,600. Among angler recaptures, 90% occurred within 9 nautical miles from the site of release whereas 99.4% of red drum recaptured by DNR personnel have remained within 9 nautical miles of the release site. The longest distance traveled by an individual was 233 nautical miles.

Of the animals that have been recaptured over 150 nautical miles from the site of release (7 in all), 4 were recaptured in Florida, one in Georgia and 2 in North Carolina. Interestingly, all long-distance travelers were 2 years old or younger. Tagged red drum have remained at large up to 2,350 days. Slightly over 45% of the animals reported by anglers have remained at large from 1 to 149 days. Similarly, about 46% of those recaptured by DNR personnel have been at large less than 150 days.

Wenner (1999) summarized data for 1994 through 1997 as part of a fishery-independent assessment of subadult red drum in the South Atlantic Bight. A total of 3,610 red drum were tagged in South Carolina waters in three strata: Charleston Harbor, Cape Romain, and lower Stono - Kiawah Rivers. Over 50% of the red drum tagged during the study were recaptured near the mark-and-release site. Approximately 20% were recaptured less than one nautical mile away from the release site. Anglers recaptured over 87% of the tagged fish 5 nautical miles or less from the point of marking. Approximately 5% of the total number of fish recaptured by anglers (n = 593) moved more than 25 nautical miles and only 2 individuals moved over 100 nautical miles. Marked red drum were at large from 1 to 1,076 days. As can be expected, the number of days at liberty was a function of the distribution of fishing effort throughout the year.

In addition to employing fishery-independent surveys to provide life-history information and assess the status of the red drum population in South Carolina, the Marine Division has also conducted a Marine Gamefish Tagging Program since 1974 as a vehicle for promoting conservation through catch-and-release. The latter is the largest state-sponsored public gamefish tagging program in the Southeastern United States. Since its inception, over 12,000 anglers have participated in the program.

Close to 45,000 red drum have been tagged by anglers since 1989 with a recapture rate of about 13%. Trends in the seasonality of the fishery are evident. Most tagging and recapture activity takes place in the fall, resulting mostly from a "fair weather fishermen" effect rather than an increase in the availability of fish during this time. Recapture data from the tagging program shows that movement of red drum, in particular sub-adults, is minimal. The majority of recaptures have occurred less than 3 nautical miles from the release site. In instances where fish moved more than 30 nautical miles, approximately one third were adult fish.

The Inshore Fisheries Section of the Marine Division also conducts a fishery-dependent program to obtain harvest data and supplement life-history information on several target species, including red drum. Anglers are asked to donate their filleted fish carcasses by placing them in chest freezers located in several locations along coastal South Carolina. Data from the South Carolina freezer program, which was initiated in 1995, indicate that most of the harvest of red drum occurs during the fall of the year, specifically during October and November.

Georgia

Woodward (1994) conducted a tagging and population dynamics study in coastal Georgia. Movement of subadult red drum was limited to within 5 km of the site of release. Only 4% of the immature fish that were tagged and released were recovered more than 30 km from the release site. Music and Pafford (1984) and Pafford et al. (1990) report a similar pattern for subadult red drum. Adults leave shoal and sandbar areas around mid-November and enter nearshore waters of the Atlantic Ocean were they form large aggregations entering estuaries on a seasonal basis. One such aggregation was sampled for age composition, and was found to comprise individuals from 5 to 35 years of age (Woodward 1994).

Based on relocations of telemetered subadult and young adult red drum in coastal Georgia, Nicholson et al. (1996) determined that young adult red drum exhibit a similar movement pattern and seasonal distribution to that observed among adults. Their use of biotelemetry tracking methods revealed the importance of the Altamaha River delta to adult red drum in Georgia. Adults in pre-spawning condition were found in inshore waters (6-12 m deep) during the summer months and offshore from late November through the following May.

Mortality

Natural mortality (M) is estimated from the relationship to size at age in Boudreau and Dickie (1989). Separate estimates were made of M for subadults (mean of 0.20 for the northern region and 0.23 for the southern region from ages 1-5) and adults (mean of 0.12 for the northern region and 0.13 for the southern region from ages 6 and older).

Salinity
Red drum are euryhaline, tolerating salinities between 0 to 35 ppt (Peters and McMichael 1987; Daniel 1988). In Florida, red drum have been collected in salinities ranging from 0 to 35 ppt (Tagatz 1967; Jannke 1971; Funicelli et al. 1988; Johnson and Funicelli 1991). Daniel (1988) collected 2,716 red drum (4-450 mm SL) in salinities from 7 to 36 ppt in the Charleston Harbor estuary, South Carolina. Also in South Carolina, tagged subadult red drum have been captured in fresh water up the Ashley and Cooper rivers and recreational anglers commonly fish for red drum in those areas (J. Archambault, pers. comm.). In North Carolina estuaries, red drum (10-391 mm TL) were collected over a salinity range of 0 to 33 ppt (Ross et al. 1987). Neill (1987), in a review of environmental requirements for red drum, noted that adult and subadult red drum are most often found in salinities of 20 to 40 ppt and rarely above 50 ppt while juveniles ranged into the freshest parts of estuaries. The author stated that eggs and newly hatched larvae required salinities above 25 ppt, but salinities between 5 and 10 ppt were optimum for juveniles 1-10 cm SL. Crocker et al. (1981) evaluated growth and survival of red drum larvae and juveniles in fresh and salt water. They found that tolerance to freshwater was size-dependent. Red drum larvae (23 days old, 6.2 mm SL) showed 5% survival, postlarvae (34 days old, 16.2-19.7 mm SL) had 70% survival and juveniles (57 days old, 56.9 mm SL) showed 95% survival when subjected to dechlorinated freshwater for 96 hours. Survival in control salinities of 10 ppt was 90% or greater. Similarly, Yokel (1966) suggested a direct relationship between size and salinity preference, with juveniles preferring lower salinities and larger individuals more common at higher salinities. However, both larval and juvenile red drum are present in areas where low salinities do not generally occur, i.e. behind barrier islands along the South Carolina coast (C. Wenner, pers. comm.). Wakeman and Wolschlag (1983) studied osmotic adaptation with respect to blood serum osmolality and oxygen uptake in hatchery-reared (1.3-3.8 g) and wild, juvenile red drum. They observed rapid stabilization of serum osmolalities and standard metabolic rates suggesting that red drum are well adapted to rapid salinity changes.

Temperature
Red drum are eurythermal and have been collected over a temperature range of 2-33°C, although they tend to move to deeper water at extreme temperatures (Simmons and Breuer 1962). In Florida, Funicelli et al. (1988) collected red drum in water temperatures ranging from 2-31°C, and Peters and McMichael (1987) collected juveniles in 8.9-33°C water in Tampa Bay. In North Carolina, red drum (10-415 mm FL) were collected in temperatures ranging from 7.5-30°C (Ross, pers. comm.; as cited in SAFMC 1990b).

Daniel (1988) collected red drum (4-450 mm TL) with a low surface temperature of 7.3°C in January 1987 and a high of 32°C in July 1986, in a South Carolina estuary. Neill (1987) noted that the optimum temperature for survival of red drum larvae and hatching of red drum eggs was 25°C (at 30 ppt salinity) and suggested that this temperature may be the overall optimum for the species. Similarly, Holt et al. (1987) found that red drum larvae developed optimally in water temperatures between 25-30°C in salinities between 25-30 ppt. More recently, Rooker et al. (1999) conducted a study on post-settlement red drum in the Aransas Estuary, Texas, and reported that growth and survival are enhanced in temperatures ranging around 26°C.

Estuarine animals such as red drum can typically tolerate rapid changes in environmental variables. However, red drum have exhibited marked susceptibility to cold temperatures as indicated by periodic fish kills in coastal areas during severe winters. Gunter (1947) reported that larger juveniles and adults were more susceptible to the effects of winter cold waves than were small fish. High red drum mortality in Texas during freezes was documented by Gunter (1941) and Gunter and Hildebrand (1951). Red drum were killed in three out of nine severe cold spells at Sanibel Island, Florida, but mortality was not severe (Storey and Gudger 1936). In South Carolina, dead red drum were found in Hamlin Sound, Clark Sound, and on the front beach of Dewees Island after the Christmas 1989 freeze (C. Wenner, pers. comm.). Red drum were found dead or dying in the power plant intake canal and on shoals that had iced over in the lower Cape Fear River estuary, North Carolina during the severe winters of 1976 and 1977 (Schwartz et al. 1981).

Experiments conducted by Neill (1987) suggested that juvenile red drum (10-40 mm SL) can survive a gradual decrease in temperature to values as low as 8-10o C in 5-10 ppt water with high hardness (> 100 ppm Ca++). More recently, Whitehurst and Robinette (1994) found no mortality of juveniles (131-158 mm TL) subjected to gradual temperature declines to below 4o C at 9 ppt salinity. The authors attributed the high survival rates in part to salinities close to 11 ppt, a value that Wakeman and Wolschlag (1983) determined to be isosmotic to red drum blood. When the ambient salinity is isosmotic with the blood, red drum presumably experience less physiological stresses (Craig et al. 1995) thus improving their ability to withstand environmental challenges. Whitehurst and Robinette (1994) also speculated that the quality of the water used in their bioassay helped to increase tolerance of juvenile red drum to cold temperatures since some opportunistic pathogens were probably removed by their filtering mechanism.

Ward et al. (1993) conducted experiments to compare critical thermal maxima (CTMax) and minima (CTMin) between juvenile red rum from Texas and North Carolina. CTMax and CTMin are the mean of the upper and lower temperatures at which an organism is so affected as to be unable to escape lethal conditions. The CTMax for Texas juveniles (29.84°C) was slightly greater than that for North Carolina fish (29.23°C), although this difference was considered to lack biological significance. However, the authors noted that juveniles acclimated to sublethal low temperatures had higher survival rates when exposed to low temperature stress than fish acclimated to higher temperatures. In a similar study, Procarione and King (1993) found that juvenile red drum from South Carolina did not resist low water temperatures better than Texas fish at any acclimation temperature.

Ecological relationships

Red drum larvae begin feeding exogenously at 4 days post hatch, once food reserves in the yolk-sac are exhausted (Johnson 1978). As larvae, red drum feed mainly on copepods (Simmons and Breuer 1962; Bass and Avault 1975; Holt et al. 1983b; Steen and Laroche 1983; Baltz et al. 1998) and mysids, the latter comprising up to 97% of the diet by number and 86% by volume (Peters and McMichael 1987). Other important items in the diet of larval red drum are copepod nauplii and eggs (Steen and Laroche 1983). Generally, red drum larvae have been found to have little dietary overlap with other size classes (Peters and McMichael 1987).

Red drum utilize the entire water column when feeding. However, they concentrate on locating prey on the bottom (Yokel 1966). When feeding in shallow estuarine waters, it is not uncommon to observe the fish "tailing," a feeding behavior whereby the fish's caudal and dorsal fins protrude outside the water as the animal searches the bottom for prey items (Gunter 1945; Simmons and Breuer 1962; Yokel 1966; Overstreet and Heard 1978). Red drum may also occasionally feed at the surface when preying on fish such as menhaden (Matlock 1987).

Upon reaching the juvenile stage, red drum prey mainly on amphipods, mysids, and palaemonetid shrimp. However, the importance of these prey items in the diet of juveniles can vary among regions. Daniel (1988) performed stomach content analysis on red drum 30-500 mm SL in Charleston Harbor, South Carolina. Mysids were not found to be an important prey item except among red drum 16-30 mm SL (34% by volume). Amphipods were also prey to juvenile red drum, but were not a significant item in their diet. Peters and McMichael (1987) found mysids to be present in the diet of all size classes examined > 8 mm, although total volumes were small, especially among larger juveniles (> 75 mm). Amphipods were found in stomachs of juvenile red drum, becoming the dominant prey item for fish 30-60 mm. Juvenile red drum also consumed shrimp (*Palaemonetes pugio*, *Hippolite zostericola* and one species of Alphaeidae), but they were not an important item in the diet except for juveniles 75-90 mm, where shrimp comprised 56% of the food volume. Llanso et al. (1998) found non-decapod crustaceans, mainly amphipods and mysids, to be the most abundant prey item in the diet of red drum < 200 mm living in an impounded area of Tampa Bay, Florida. Similarly, Bass and Avault (1975) found that red drum 10-49 mm preyed on mysid shrimp almost exclusively. Mysids were found in stomachs of juvenile drum from 10-169 mm. Other items commonly reported in the diet of juvenile red drum are polychaetes and decapod post-larvae (Steen and Laroche 1983; Llanso et al. 1998).

Decapod crustaceans become an increasingly important part of the diet of red drum as they grow (Bass and Avault 1975; Music and Pafford 1984). Daniel (1988) found decapod crustaceans, primarily mud crabs, *Panopeus herbstii*, and fiddler crabs, *Uca* spp. to be the predominant component in the diet of red drum 200-300 mm SL making up almost 96% of the total prey volume. Llanso et al. (1998) reported that as red drum grew over 200 mm, crabs (*Rithropanopeus harisii*, *Pinnixia* spp., *Uca* spp., *Upogebia affinis*) were added to the diet. Wenner et al. (1990) noted that red drum in South Carolina consume all three species of fiddler crabs, *Uca minax*, *U. pugilator*, and *U. pugnax*, whereas these species are not as important in the diet of fish inhabiting the Gulf of Mexico. Apparently, this difference in resource utilization is due partly to differential abundances of fiddler crab species between the two regions and partly to decreased accessibility to the habitats of fiddler crabs in the Gulf of Mexico. Bass and Avault (1975) maintain that, in the Gulf of Mexico, decapod crustaceans begin forming part of the diet when red drum are approximately 20 mm. Decapods that are consumed, in order of appearance, are grass shrimp, penaeid shrimp, and crabs, with the blue crab, *Callinectes sapidus* being the predominant prey species. Boothby and Avault (1971) and Overstreet and Heard (1978) found that blue crabs and penaeid shrimp were predominant in the diet of red drum in Mississippi Sound and Louisiana, respectively. Fish also make up an important part of the red drum diet; their importance also increases among larger red drum. Daniel (1988) found that fishes -- mostly juveniles of the spot, *Leiostomus xanthurus*, and mummichog, *Fundulus heteroclitus* -- were most significant in the diet of larger red drum in Charleston Harbor, South Carolina. Wenner et al. (1990) and Music and Pafford (1984) found that red drum in South Carolina and Georgia preyed on the same fish species, with the exception of the ophicthid eel, *Ophicthus ophis*, which was prey to red drum in Georgia but not in South Carolina. Menhaden are one of the predominant species consumed by red drum in the Gulf of Mexico (Boothby and Avault 1971; Matlock 1987).

Juvenile red drum may spend the first four or five years of life within estuaries (Pearson 1929) where they compete with other estuarine species for food. Young-of-the-year red drum (15-245 mm TL) in North Carolina estuaries were frequently collected with bay anchovy, inland silverside, Atlantic silverside, sheepshead minnow, striped mullet, menhaden, spot, Atlantic croaker, mojarras, gobies, summer flounder, and southern flounder (ASMFC 1984). Red drum may compete with other sciaenid species for benthic resources.

Adult red drum occur offshore, often under schools of blue runner and little tunny in the Gulf of Mexico. When nearshore, schools of red drum often occur near black drum Atlantic tarpon, and pompano (Overstreet 1983).

Abundance and status of stocks

Gold and Richardson (1991) identified weakly differentiated subpopulations occurring in the northeast Gulf of Mexico, Mosquito Lagoon, Florida, and along the North and South Carolina coast. Seyoum et al. (2000) also found genetic evidence for separate populations on the Atlantic and Gulf of Mexico coasts of Florida, but found no evidence of a separate population in Mosquito Lagoon. Red drum along the Gulf of Mexico side of the Florida peninsula may be somewhat isolated from red drum in the northern and western Gulf of Mexico. Tagging studies conducted by SC DNR revealed a high fidelity of returns to state waters where subadult red drum were tagged and released (C. Wenner, pers. comm). Less than 5% of the returns came from adjacent state waters. No adults tagged and released in South Carolina have been recaptured in other states.

Stock Assessment Summary

An assessment of the status of the Atlantic stock of red drum was conducted using recreational and commercial fishery data from 1986 through 1998 (Vaughan and Carmichael 2000). This assessment updated data and analyses from the 1989, 1991, 1992 and 1995 stock assessments (Vaughan and Helser 1990; Vaughan 1992, 1993, 1996).

It is important to remember that the population models used in the coast wide assessments (specifically yield per recruit and static SPR) are based on equilibrium assumptions. Previous estimates of escapement rates (relative survival of red drum from age at entry to fishery to age 4) for 1992-94 ranged from 10.4% for the northern region and 17.2% for the southern region (Vaughan 1996). Escapement rate estimates for Florida Atlantic coast red drum (through age 4) during 1992-94 ranged from 51-69% assuming the size structure of released fish was the same then as it is now (Murphy 2005). This may mean that rates in Georgia and South Carolina are lower than the regional estimate. Estimates of static SPR (the ratio of spawning stock biomass per recruit with and without fishing mortality) ranged from 9% for the northern region to 14%

for the southern region. This may be an overestimate because during this period most states north of North Carolina allowed a fishery for adults and the analysis assumes no adult fishing mortality or any discard mortality from commercial fishing operations and recreational use of commercial (gillnet) gear.

Based on the most recent full assessment (Vaughan and Carmichael 2000), results for the northern region indicated that escapement rates were on the order of 18%, but may be overestimated due to the lack of discard data from both the commercial fishery and recreational netting practices. Also, the estimate for the southern region (15%) may not be reflective of escapement rates throughout the region, where there appears to be significant regional differences between Florida and Georgia/South Carolina. Estimates of escapement rates on Florida's Atlantic coast have shown a slow decline since peaking during 1988 at 94% following two years of near-complete moratoria on fishing (Murphy 2005). After fishing for red drum reopened in 1989, escapement began to decline reaching 51-69% during 1992-1994 and 32-43% during 2001-2003.

As summarized in Vaughan and Carmichael (2000) available length-frequency distributions and age-length keys were used to convert recreational and commercial catches to catch in numbers at age. Separable and tuned virtual population analyses were conducted on the catch in numbers at age to obtain estimates of fishing mortality rates and population size (including recruitment to age-1). In turn, these estimates of fishing mortality rates combined with estimates of growth (length and weight), sex ratios, sexual maturity and fecundity were used to estimate yield per recruit, escapement to age-4, and static (or equilibrium) spawning potential ratio (static SPR, based on both female biomass and egg production).

Population models used in this assessment (specifically yield per recruit and static spawning potential ratio) are based on equilibrium assumptions: because no direct estimates are available as to the current status of the adult stock, model results imply potential longer term, equilibrium effects. Because current status of the adult stock is unknown, a specific rebuilding schedule cannot be determined. However, the duration of a rebuilding schedule should reflect, in part, a measure of the generation time of the fish species under consideration. For a long-lived, but relatively early spawning species such as red drum, mean generation time would be on the order of 15 to 20 years based on age-specific egg production. Maximum age is 50 to 60 years for the northern region, and about 40 years for the southern region.

The next stock assessment is scheduled for the spring of 2009 through the full Southeast Data Assessment and Review (SEDAR) process. In 2005, additional funds were provided from Congress to the ASMFC to address a number of research priorities. One of these priorities was to determine stock status of red drum. With these additional funds, NC, SC and GA are developing state specific sampling protocols to provide a fisheries-independent index of abundance for adult red drum. This adult index will be used in the red drum assessment process, and will aid managers in determining biological reference points.

<u>North Carolina</u>
Red drum in North Carolina are classified as overfished (SPR <30%) due to high fishing mortality rates and low recruitment of juvenile fish to the adult stock (NCDMF 2001).

Information necessary to estimate abundance at age for adult red drum and calculate spawning stock biomass (SSB) are lacking because slot limits restrict the age classes that may be harvested, and fishery-independent survey data are not available for the adult fish. Therefore, the primary benchmarks used in determining the status of red drum are spawning potential ratio (SPR) and escapement or survivability to age-4. Although early assessments evaluated the Atlantic Coastal red drum population as a single stock, recent assessments are divided into northern and southern components to better account for the limited migration of the species (Vaughan 1996). Northern region assessment results are largely representative of the North Carolina stock, since North Carolina accounts for an average of 96% of the commercial landings, an average of 85% of the recreational landings, and the only fishery-independent data that are available for the region.

The most recent estimates of SPR for the northern region are based on data from 1992 through 1997. This period represents the changes adopted by North Carolina as a result of Amendment 1. Regulations in the period were a recreational bag limit of 5 fish, an 18-27" slot limit, including one fish which could exceed 27"; commercial regulations included an 18-27" slot limit on the sale of red drum and one red drum exceeding 27" was allowed for personal consumption per day. In addition to changes implemented through Amendment 1, North Carolina also imposed a 250,000 pound quota on the commercial fishery to prevent this fishery from expanding beyond historical harvest levels. The best estimate of SPR for the North Carolina stock is 18% for 1992-1997, still well below the overfishing definition of 30%, but significantly improved over the 1.3% for 1986-1991. Escapement increased from 1.2% in the early period to 18% in the later period, while fully recruited fishing mortality declined from F=1.67 for 1986-1991 to F=0.71 for 1992-1997. In addition, the selectivity of age classes 3 to 5 also declined between the early and late period, indicating that older fish were subjected to less fishing pressure in the later period, likely the result of a reduced bag limit on red drum >27" total length.

Although the red drum stock in North Carolina is currently considered to be overfished, it should be noted that this designation is based on data through 1997 and does not reflect the full impacts of the harvest restrictions implemented by the NCDMF and NCMFC late in the 1998 fishing season as part of the development of a state level red drum FMP. There are two primary goals of the recent regulatory changes: 1) reduce the recreational and commercial harvest rates to levels which prevent overfishing and 2) reduce unnecessary and unquantifiable bycatch of red drum in the gill net fishery. Actions taken include a reduction in the recreational bag limit from 5 to 1 fish, an 18-27"slot limit on all harvest, no possession of red drum >27", a daily commercial trip limit which has ranged from 100 lbs. to five fish and a requirement to attend small mesh gill nets (<5" stretch mesh) from May 1 through October 31 in areas known to be critical juvenile red drum habitat. Additionally, in the last year, the NCDMF has maintained a daily commercial trip limit ranging from 5 to 10 fish and also requires that at least 50% of the landings by weight for an individual trip consist of edible finfish other than red drum making this exclusively a bycatch fishery. This most recent action is intended to prevent any directed effort in the commercial fishery, while still allowing unavoidable bycatch to be landed and therefore accounted for in future assessments.

South Carolina

A stratified-random, fishery independent trammel net survey in South Carolina estuaries has shown a steady decline in the abundance of sub-adult red drum (ages <1 to age 4+). The mean CPUE has dropped from ~8 fish in 1991 to less than 2 fish in 2000. The abundance of age-1 fish in the survey has also decreased. The survey catch data are correlated with the recreational harvest indicating that the fisheries independent survey tracks the MRFSS. Along with declining mean catches, the research survey demonstrated a declining trend in the frequency of occurrence of red drum in net sets as well as the frequency of occurrence of "pods" of red drum larger than 10 fish. In summary, these data show that:

(1) the abundance of sub-adults inside the estuary has declined over time;
(2) recruitment of age-1 fish to the fishery has shown a decline over the decade with the exception of the brief upward tick in the time series in 1995 which resulted from the abundance of the 1994 year class;
(3) frequency of encounter of red drum in the survey has declined which suggests that the spatial distribution of the fish has contracted with decreasing abundance;
(4) the occurrence of larger aggregations of red drum in the estuaries has declined as overall abundance has declined;
(5) the trend in the survey catches is reflected in the recreational estimates of the harvest from the MRFSS;
(6) declining trends in abundance of sub-adult red drum was similar in all estuarine systems sampled.

South Carolina initiated a statewide, fishery-independent survey of its recreational fishery in 1986 (State Finfish Survey). Standardized annual data sets for length composition are available from 1988 to the present and for CPUE data from 1990 to the present, based on the private boat fishery in inland waters. South Carolina has also had a mandatory, universal trip logbook system for the charterboat fishery in place since July, 1992 that provides a CPUE database. The state uses these sources of fishery-dependent data in addition to the MRFSS, due in part to concerns about the accuracy of the MRFSS in regards to South Carolina's recreational fishery. Specific problems are the allocation of MRFSS private boat effort between inland and nearshore (0-3 miles) ocean areas since 1995 and estimation of effort in the charterboat mode. State personnel believe that the allocation of private boat effort to inland waters has been disproportionately low in recent years versus the historical pattern, resulting in underestimation of the red drum catch. State personnel also believe that the MRFSS has attributed excess effort to the charterboat mode, resulting in significant overestimation of the red drum catch for this mode in some years. There is also concern about the relatively small sample sizes and geographic distribution of the length composition and CPUE data for red drum in the MRFSS.

The interpretation of the data from the state's fishery-dependent sources is somewhat contradictory to the conclusions drawn from the trammel net survey. The private boat CPUE data suggest increasing recruitment from 1990-1996, followed by a moderate decline in 1997. Since then, CPUE has remained rather stable in the central and northern parts of the state, but a continuing decline in recruitment is indicated in the southern part of the state. The charterboat CPUE data, based on somewhat larger fish, suggest that the population of that component is either stable or increasing slightly.

The state has also conducted two statewide opinion polls of saltwater recreational fisheries license holders regarding their perceptions of the status of the red drum stocks in South Carolina. In 1996, 72% of the survey respondents thought that the population had either increased or showed no change during the previous five years. In the 2001 survey, a smaller majority (59%) of the respondents were in this category.

Georgia

According to the most recent assessment (Vaughan and Carmichael 2000), red drum in the southern region are overfished, and it can then be inferred that red drum in Georgia are overfished. However, the southern region includes both South Carolina and Florida, and there is no separate analysis of data for Georgia. Therefore, the assessment may not accurately represent the situation in Georgia with regard to escapement and SPR within the populations found in that state's waters. Consequently, the results of the southern region assessment must be carefully interpreted when discussing the status of red drum in Georgia.

Mark-recapture studies and trammel net surveys conducted from 1994-1997 showed high mortality within the population resident in the St. Simons estuary, particularly for red drum less than age-2. However, estimates of instantaneous total mortality determined from catch curves based on trammel net data were significantly less that those estimated from fishery-dependent data (MRFSS) for all of coastal Georgia. This suggests that survival to age-5 may have been greater than indicated in regional stock assessments completed in the early 1990s. However, the aforementioned trammel net and tagging surveys were terminated in 1997, so there is no recent fishery-independent information from which to estimate either fishing or total mortality.

Pafford et al. (1990) reported on the age composition and relative abundance of cohorts within a sample of approximately 300 adult red drum collected from the Altamaha River delta. This sample showed a spawning biomass comprised of fish from age 5 to age 40. Young adults (<age-10) were a much smaller portion of the sample than expected, suggesting that recent recruitment had been low. However, there have been no surveys of the age composition of the adult stock in Georgia since that time. Therefore, nothing is known about the current status of the adult portion of the stock, either in terms of age composition or absolute abundance.

The estimated catch of red drum within the recreational fishery as determined from the MRFSS shows no evident trends during the 1990s or since the implementation of current harvest regulations. The total catch declined in the late 1990s only to rebound in 2000 to a level similar to that estimated in the years of the early 1990s. It is unclear whether the reduced catches of the late 1990s are attributable to inadequacies within the MRFSS or to low abundance of red drum. In either case, it is impossible to draw strong conclusions from fishery-dependent data in the absence of an index of juvenile or sub-adult abundance.

Florida

Fishing mortality rates for red drum appeared to increase on the Atlantic coast during the late 1990s. The harvest of red drum increased sharply in 2000. The number of fishing trips made by anglers catching or seeking red drum had varied without trend for much of the latter half of the 1990s but increased to peak or near peak levels in 2000. Total-catch rates for anglers were steady during the late 1990's before dropping in 2000.

A precise analysis of the condition of the red drum stocks in Florida is not possible because there is no information on the size of red drum that make up a large portion of the harvest. Creel clerks measure some of the harvested red drum they encounter on their surveys and while they can ask anglers the number of red drum disposed of or released dead or alive, they do not gather information on the size of these fish. Since 1998, 19-34% of the harvest has been attributable to these unseen fish. In Murphy (2002) the size of red drum in this unseen harvest were assumed; 1) the same as the size in the examined harvest, 2) the same as scientific samples of red drum from haul seines, 3) distributed as 95% undersized, 5% legal, and 5% over-sized, or 4) distributed as 40% undersized, 30% legal, and 30% over-sized.

The abundance of young newly recruited age-0 red drum declined during the latter half of the 1980s but has since increased. The estimates of absolute abundance of red drum ages 1-3 depended heavily on the assumed lengths of the unseen harvest but had a midpoint of about 0.55 million fish on the Atlantic coast of Florida. Since the mid 1990s the model estimates of total abundance for ages1-3 have not changed significantly.

Estimates of equilibrium (year-specific) escapement rates were highly dependent on the scenario chosen for the length structure of the unseen harvest. Florida Atlantic coast estimates ranged from 24% if the unseen harvested was mostly under-sized red drum (scenario #3 above) to 48% if the unseen harvest was mostly legal and over-sized fish (scenario #4 above). Year-class-specific escapement rates indicate that the level of escapement in 2000 is clearly higher than the Florida Fish and Wildlife Commission's target if the unseen red drum harvest is mostly legal and over-sized fish or is distributed the same as the lengths of red drum sampled by FWC-FMRI scientists using haul seines (scenario #2 above). However, if the unseen harvest is distributed as mostly under-sized fish, then it is unlikely that escapement rates are meeting the 30% target.

4.2.10 Weakfish

Description and Distribution

(information from the ASMFC’s Weakfish FMP, 2002)
The weakfish is a moderately-lived (at least up to 17 – 18 years of age but larger fish have not been aged; Mercer 1985, 1989) species that normally spends the majority of its adult life in coastal estuaries and the ocean, migrating north and south and onshore/offshore seasonally.

The larvae and post-larvae begin feeding on microscopic animals during their journey from spawning areas to coastal nursery areas and continue to feed on these small animals after their arrival in the nursery areas, located in the deeper portions of coastal rivers, bays, sounds and estuaries. Here they grow into juveniles. Studies in North Carolina sounds indicated that juvenile weakfish were most abundant in shallow bays or navigational channels characterized by moderate depths, slightly higher salinity’s, and presence of sand and /or sand-seagrass bottom. Juveniles remain in coastal sounds and estuarine until October through December of their first year, after which they migrate to the coast. Weakfish in the northern end of the range leave the inshore areas earlier than weakfish in the southern end of the range.

In the ocean, weakfish appear to move north and inshore during the summer, and to the south and offshore during the winter. Important wintering grounds for the stock are located on the Continental Shelf from Chesapeake Bay to Cape Lookout, North Carolina. With warmer water temperatures in the spring, the mature adult fish migrate to the spawning areas to complete their life cycle.

Reproduction

Mature female weakfish (ages 1 and older) produce large quantities of eggs, that are fertilized by mature males (ages 1 and older) as they are released into waters of nearshore and estuarine spawning areas. Length at maturity is less for southern fish than for northern fish. Southern fish are suggested to produce more eggs at smaller sizes than northern fish do. Work on weakfish fecundity indicated that weakfish, like other sciaenids, are batch rather than total spawners. In other words, females release their eggs over a period of time rather than all at once. Weakfish are indeterminate batch spawners meaning one cannot count all the eggs they will produce in a year in the ovaries at the beginning of spawning season because they continuously produce eggs during spawning season. This may mean that annual fecundity varies for the same fish. However, the relative amount of eggs produced appears proportional to female weight in a given year for both spotted seatrout *Cynoscion nebulosus* (W. Roumillat, SC DNR, personal communication) and weakfish (J. Nye, University of Delaware, personal communication). In the case of weakfish, spawning stock biomass and percent maximum spawning potential based on female weight are assessed. The fertilized eggs hatch into larvae in 36 – 40 hours at temperatures of 20-21°C. Spawning occurs in nearshore and estuarine areas from March through September, with a peak during April to June.

Development, growth and movement patterns

<u>Spawning</u>

Weakfish spawn in estuarine and nearshore habitats throughout the species range. The principal spawning area is from North Carolina to Montauk, NY (Hogarth et al. 1995b), although extensive spawning and presence of juveniles has been observed in the bays and inlets of Georgia and South Carolina (pers. Comm, D. Whitaker, SCDNR). Spawning occurs after the spring inshore migration. Timing of spawning is variable, beginning as early as March in North Carolina, and as late as May to the north. Peak spawning occurs from April to June in North Carolina. Peaks in the New York Bight estuarine occur in May and June.

<u>Eggs and Larvae</u>

Nursery habitats are those areas in which larval weakfish reside or migrate after hatching until they reach sexual maturity (90% by age 1, 100% by age 2). These areas include the nearshore waters as well as the bays, estuaries, and sounds to which they are transported by currents or in which they hatch.

<u>Juveniles</u>

Juvenile weakfish inhabit the deeper waters of bays, estuaries, and sounds, including their tributary rivers. They also use the nearshore Atlantic Ocean as a nursery area. In North Carolina and other states, they are associated with sand or sand/seagrass bottom. They feed initially on zooplankton, switching to mysid shrimp and anchovies as they grow. In Chesapeake and Delaware Bays, they migrate to the Atlantic Ocean by December.

Adults

Adult weakfish reside in both estuarine and nearshore Atlantic Ocean habitats. Warming of coastal waters in the spring keys migration inshore and northward from the wintering grounds to bays, estuaries and sounds. Larger fish move inshore first and tend to congregate in the northern part of the range. Catch data from commercial fisheries in Chesapeake and Delaware Bays and Pamlico Sound indicate that the larger fish are followed by smaller weakfish in summer. Shortly after their initial spring appearance, weakfish return to the larger bays and nearshore ocean to spawn. In northern areas, a greater portion of the adults spends the summer in the ocean rather than estuaries.

Weakfish form aggregations and move offshore as temperatures decline in the fall. They move generally offshore and southward. The Continental Shelf from Chesapeake Bay to Cape Lookout, North Carolina, appears to be the major wintering ground. Winter trawl data indicate that most weakfish were caught between Ocracoke Inlet and Bodie Island, NC, at depths of 18 -– 55 meters (59 – 180 feet). Some weakfish may remain in inshore waters from North Carolina southward.

Ecological relationships

Weakfish feed primarily on penaeid and mysid shrimps, anchovies, and clupeid fishes (menhaden, river herring, shad). Juvenile weakfish feed mostly on mysid shrimp and anchovies. Older fish feed on cluepeids, anchovies and other fishes including butterfish, herrings, sand lance silversides, juvenile weakfish, Atlantic croaker, spot, scup and killifishes. Invertebrates in the diet in addition to shrimps include squids, crabs, annelid worms and clams. Weakfish are important top carnivores in Chesapeake Bay where they consume high percentages of blue crabs and spot while along the edges of eelgrass habitats as well as other 'edge habitats' such as along channel edges, rock and oyster reefs. Weakfish are also found in estuaries without eelgrass, such as in the bays and estuaries of South Carolina.

Abundance and status of stocks

A weakfish stock assessment of data through 1998 was conducted in 1999 and reviewed by the Stock Assessment Review Committee for peer review at the 30th Northeast Regional Stock Assessment Workshop (NMFS 2000). This report indicated that weakfish were "at a high level of abundance and subject to low fishing mortality rates." This assessment was updated in 2002 with data through 2000.

The 2002 update (Kahn 2002) also indicated that weakfish were at a high level of abundance and fishing mortality was low, suggesting that the management measures put in place in Amendment 3 had resulted in positive trends for the weakfish population. However, it was also noted that the absolute magnitude of impact should be viewed with caution given the uncertainty of the fishing mortality and spawning stock biomass estimates for the most recent year of the assessment (which is often the case with final year estimates).

While these traditional single species assessments were generating high stock size estimates, the recreational and commercial landings of weakfish along the Atlantic coast plummeted to all-time lows between 1999 and 2003 (Figure 4.2-2). This dichotomy of assessment results and fishery performance lead the Weakfish Technical Committee to consider less traditional assessment techniques in their most recent stock assessment covering the period of 1982-2003, which was conducted in 2004-2006 (ASMFC 2006).

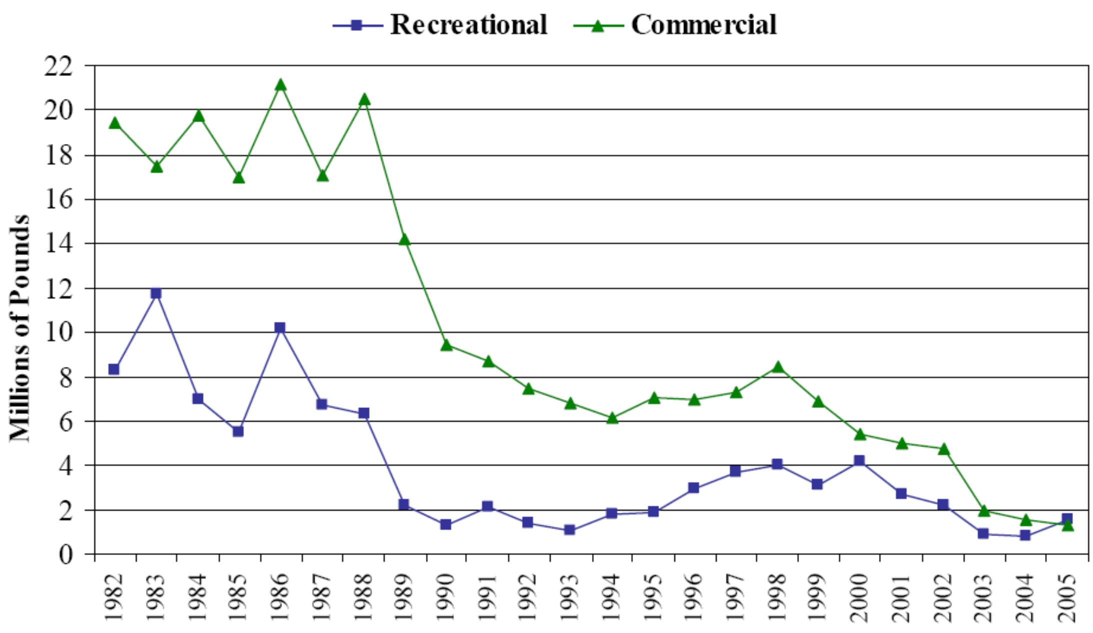


Figure 4.2-2. Annual coastwide weakfish landings (1982-2005). Commercial landings for 2005 are considered preliminary; Massachusetts landings are not included; Georgia landings are confidential but no more than 100 lbs; this maximum value was used in the calculation.

Results from the alternative approaches revealed that a large rise in natural mortality that started in the mid-1990s largely caused weakfish biomass and size structure to decline greatly by 2003 (Figure 4.2-3, Figure 4.2-4). These declines could not be attributed to a slight rise in fishing mortality, which had fallen to moderate levels by 1994 due to conservative management measures. The rapid decline in biomass starting in the late 1990s is reminiscent of rapid transitions between extended periods of high or low commercial landings dating back to the late 1920s. In theory, these rapid changes could reflect an underlying environmental driver whose effect has been accelerated by high fishing or predation rates.

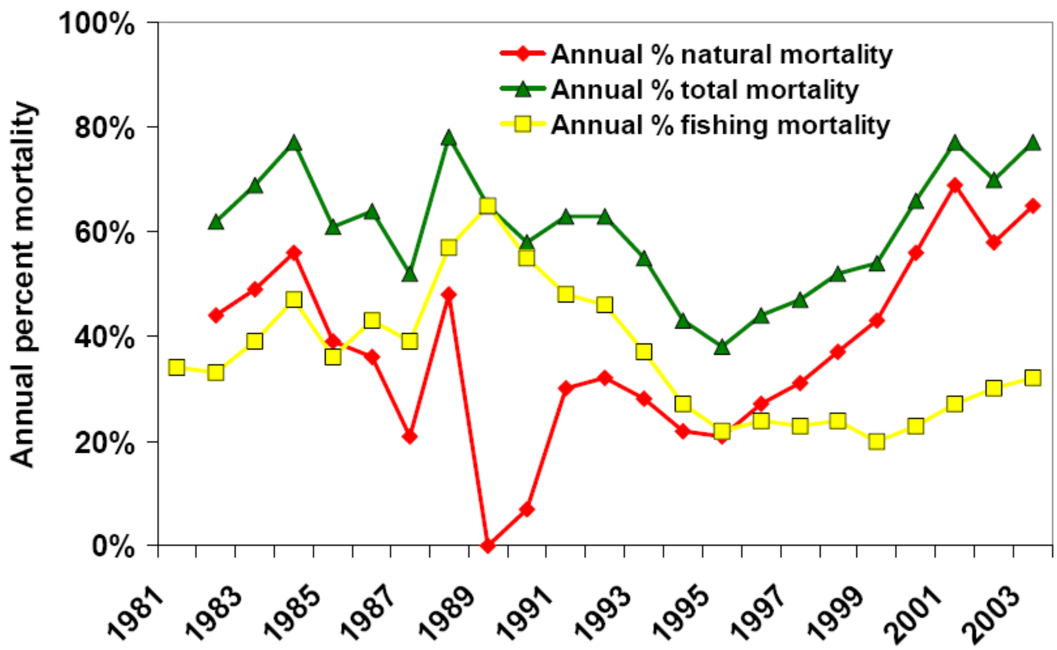


Figure 4.2-3. Coastwide weakfish annual total, natural, and fishing mortality percentages Rates were translated into annual percentages, thus fishing and natural mortality are not additive (Weakfish Technical Committee, 2006).

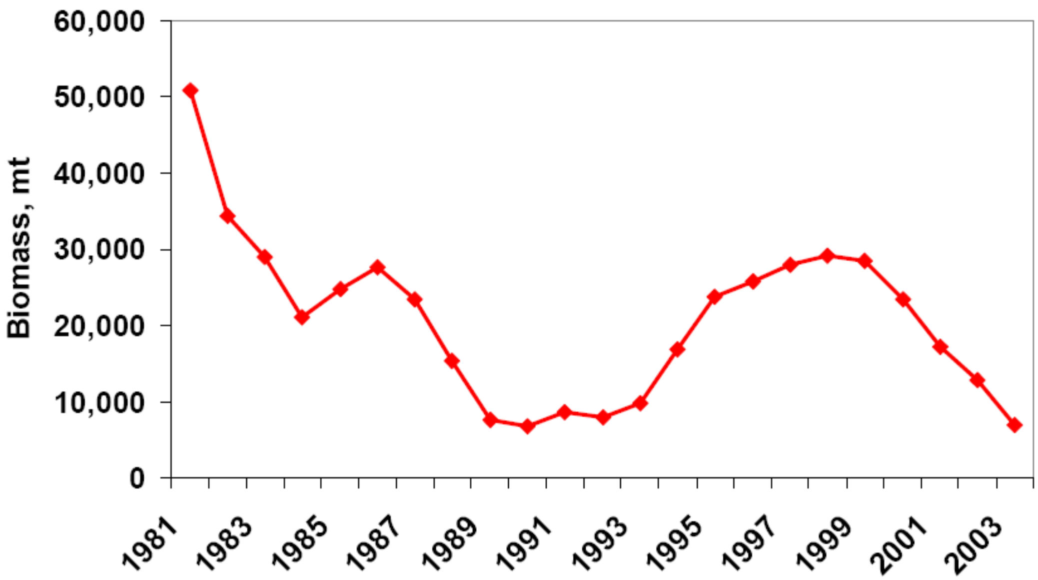


Figure 4.2-4. Estimated coastwide weakfish biomass (Weakfish Technical Committee, 2006).

For the recent stock assessment, the Technical Committee developed and tested specific hypotheses to evaluate candidate predator/competitors (striped bass, summer flounder, bluefish, spiny dogfish and Atlantic croaker), forage species (Atlantic menhaden, bay anchovy, and spot), environmental factors (water temperature and North Atlantic Oscillation index), high bycatch losses, and overfishing. Insufficient forage, especially Atlantic menhaden, and increased predation by striped bass have emerged as leading hypotheses that support rising natural mortality as cause for stock decline (Figure 4.2-5), but contributions by other species or factors may not have been completely detected or tested. While this result does not provide much leverage for recovery by managing the fishery alone, projections did indicate that cuts in fishing mortality are needed for timely recovery if natural mortality declines.

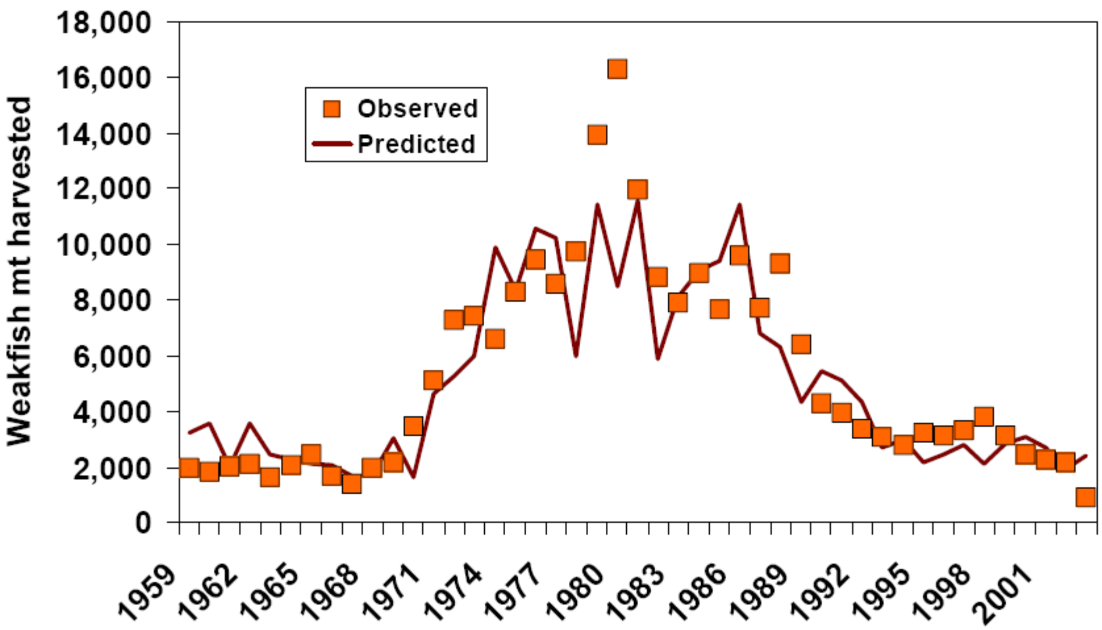


Figure 4.2-5. Food web hypothesis. Weakfish commercial landings are predicted by indices for large bass and menhaden juveniles (multiple regression; both terms significant; menhaden partial r2 = +0.73; bass partial r2 = -0.03) (Weakfish Technical Committee, 2006).

While this assessment was not upheld by an external peer review panel, the Board has accepted for management use five conclusions from the report: 1) the stock is declining; 2) total mortality is increasing; 3) there is not much evidence of overfishing; 4) something other than fishing mortality is causing the decline in the stock; and 5) there is a strong chance that regulating the fishery will not, in itself, reverse stock decline. Due to the difficulty with this last stock assessment and pending management measures, the Technical Committee has been tasked with developing more qualitative techniques for tracking management progress in 2007.

4.2.11 Atlantic Croaker

Description and Distribution

(From SCDNR factsheet available at http://www.dnr.sc.gov/cwcs/pdf/Croaker.pdf)
The Atlantic croaker, *Micropogonias undulatus*, is the only representative of the genus in the western North Atlantic. This species gets its name from the deep croaking sounds created by muscular action on the air bladder. It is one of 23 members of the family Sciaenidae found along the Atlantic and Gulf of Mexico coasts (Mercer 1987). The species has a typical fusiform shape, although it is somewhat vertically compressed. The fish is silvery overall with a faint pinkish-

bronze cast. The back and upper sides are grayish, with brassy or brown spots forming wavy lines on the side (Manooch 1988). The gill cover has three to five prominent spines and there are three to five small chin barbels. It has a slightly convex caudal fin.

It occurs in coastal waters from Cape Cod, Massachusetts to Campeche Bank Mexico, and possibly from southern Brazil to Argentina (Mercer 1987). The species spawns in offshore waters on the continental shelf during fall. Adults in spawning condition have been found in depths of 7 to 131 m (23 to 430 feet) north of Cape Hatteras, and from 5 to 50 km (3 to 31 miles) offshore of South Carolina in depths of 40 to 91 m (131 to 298 feet) (Bearden 1964).

Reproduction

Atlantic croaker spawn in tidal inlets, estuaries, and on the continental shelf, at depths ranging from 7 to 81 m (26 to 266 ft) and in polyhaline and eurohaline zones (Diaz and Onuf 1985). Exact spawning locations may be related to warm bottom waters (Miller et al. 2002). Spawning is reported to occur at water temperatures of 16-25o C in North Carolina (Street et al. 2005). Atlantic croaker have a long spawning season that generally starts in late summer and continues to early spring, with peak reproductive activity occurring in late fall and winter (Diaz and Onuf 1985). In the Chesapeake Bay and North Carolina, spawning begins as early as August and usually peaks in October, whereas peak spawning occurs in November, in the Gulf of Mexico (USFWS 1996).

Development, growth and movement patterns

Eggs and larvae

Pelagic eggs are found in polyhaline and euryhaline waters. After hatching, larvae drift into estuaries by passive and active transport via floodtides, upstream bottom currents, and other large-scale oceanographic processes. Older and larger larvae actively swim into these areas (Miglarese et al. 1982, Petrik et al. 1999). Arrival time into estuaries varies regionally. Larvae are present in the Chesapeake Bay and on the North Carolina and Virginia coasts as late as September and as early as June on the Louisiana coast (USFWS 1996). Localized processes like currents and tidal regimes influence the dispersal of larvae to nursery areas (Petrik et al. 1999). Upon initial arrival in the estuary, larval croaker are restricted to the surface water. However during ebbing tides, larval croakers move to the brackish, bottom waters where they complete their development into juveniles (Miller 2002). Larvae can tolerate colder water temperatures than adults, but extremely cold temperatures may be a major source of larval mortality.

Juveniles

Juveniles use estuaries and tidal riverine habitats along the U.S. Atlantic coast from Massachusetts to northern Florida, and in the Gulf of Mexico, but are most common in coastal waters from New Jersey southward (Able and Fahey 1998; Robbins and Ray 1986; Diaz and Onuf 1985). Recruitment of juveniles into estuaries may be influenced by tidal fluxes in estuaries. For example, in the Pamlico Sound, North Carolina, a shallow estuary where tidal fluxes are largely controlled by wind, recruitment of juveniles is slower than the Cape Fear estuary, where tidal fluxes dictated by lunar cycles average 1.5 meters (Ross 2003). The Cape Fear estuary is representative of most drowned river valley Atlantic Coast estuaries. Juveniles remain in these habitats until early to mid-summer (USFWS 1996). Juveniles migrate downstream as they develop and by late fall, most juveniles emigrate out of the estuaries for open ocean habitats (Miglarese et al. 1982).

Juveniles are associated with areas of stable salinity and tidal regimes and often avoid areas with large fluctuations in salinity. The upper, less saline parts of the estuaries provide the best environment for high growth and survival rates (Ross 2003, Peterson et al. 2004). Juveniles concentrate in oligohaline and mesohaline waters (0.5 to 18 ppt), although they may tolerate more extreme salinities (Diaz and Onuf 1985, Ross 2003). Ross (2003) showed that, juveniles experience reduced mortality in less saline areas. Lower mortality in the less saline areas may be because of lower physiological stress in those environments (Ross 2003). Growth rates in juveniles may be affected by fluctuating salinities and temperatures (Peterson et al. 2004; Chao and Musick 1977). Large changes in salinity can alter the activity of croakers in a way that reduces local abundance; however, smaller changes do not appear to affect juveniles. Sharp fluctuations in salinity can cause intermediate growth rates and increase the bioenergetic costs for juveniles (Peterson et al. 2004). Able and Fahey (1997) suggested that survival in cold December waters in Delaware Bay are not conducive to survival of young croaker. Juvenile croaker prefer deeper tidal creeks because the salinity changes are usually less than in shallow flats and marsh creeks (Diaz and Onuf 1985). Salinity may affect the size distribution of juveniles within an estuary, which may be a result of changing physiological requirements as the juveniles develop (Miglarese et al. 1982). In Delaware Bay, Nemerson and Able (2004) found that the largest concentrations of newly recruited Atlantic croaker were collected over soft bottom habitat having high abundance of benthic invertebrates. Annelids were an important prey component of their diet.

Substrate plays a large role in determining juvenile croaker distribution. Juveniles are positively correlated with mud bottoms with large amounts of detritus that provides sufficient prey (Cowan and Birdsong 1988). Sand and hard substrates are not suitable. Juvenile are often found in more turbid areas of estuaries with higher organic loads that provide a food source for the croakers, but low turbidity is not a limiting factor in juvenile distribution (Diaz and Onuf 1985). The latter stages of young croaker are found more commonly in grass bed in Chesapeake Bay (Olney and Boehlert 1988).

Juvenile Atlantic croaker live at a variety of depths, depending on the estuary. North Carolina estuaries and the coast of the Gulf of Mexico have small tidal fluctuations. In these areas, juvenile croakers amass in shallow, peripheral areas. In estuaries with greater tidal fluctuations such as the Delaware Bay, Chesapeake Bay, or the Cape Fear River Estuary, juvenile croaker assemble in deep channels (Diaz and Onuf 1985).

Field and laboratory data indicate that juveniles are more tolerant of lower temperatures than adults. Juveniles have been found in waters from 0.4° C to 35.5° C (USFWS 1996) but extreme temperature changes can incapacitate juvenile croakers (Diaz and Onuf 1985). Juveniles may favor conditions that can result in low dissolved oxygen, although juveniles will move out of an area if dissolved oxygen levels decrease beyond preferred tolerances (Diaz and Onuf 1985).

Atlantic croaker was described by Petrik et al. (1999) as a habitat generalist. Field surveys of post-settlement croaker in estuarine nursery areas, found no significant differences in abundances among submerged aquatic vegetation, marsh edge, and sandy bottom (Petrik et al. 1999). In a wetland system, Atlantic croaker along the gulf coast preferred non-vegetated bottom adjacent to wetlands, rather than the marsh itself (Rozas and Zimmerman 2000). In North Carolina, Atlantic croaker have been documented to utilize SAV, wetlands, unvegetated soft bottom, and to a lesser extent, shell bottom (Street et al. 2005). Juvenile croaker utilize these habitats for refuge and foraging and as a corridor through the estuary. In North Carolina, Atlantic croaker is one of the dominant juvenile fish species in North Carolina estuaries (DMF, unpub. data). Because croaker utilizes multiple habitats, the effect of habitat change and condition on fish population is difficult to assess.

Juvenile croaker may be affected by hydrological modifications, water quality degradation, or habitat alterations. Hydrological modifications such as ditching and channelization increase the slope of the shoreline and water velocities in the altered stream. Higher water velocity and reduced natural wetland filtration can result in increased shoreline erosion, increasing sediment and non-point pollutant loading in channelized water bodies (White 1996; EPA 2001). Several studies have found that the size, number, and species diversity of fish in channelized streams are reduced and the fisheries associated with them are less productive than those associated with unchannelized reaches of streams (Tarplee et al. 1971; Hawkins 1980; Schoof 1980). Pate and Jones (1981) compared nursery areas in North Carolina that were altered and unaltered by channelization and found that Atlantic croaker and other estuarine-dependent species were more abundant in nursery habitats with no man-made drainage. They attributed this to the unstable salinity conditions that occurred in areas adjacent to channelized systems following moderate to heavy rainfall (>1 inch/24 hr).

Pollutants negatively affect growth and physical condition of juvenile Atlantic croaker, with significantly reduced growth rates and condition occurring with increasing pollutant conditions (Burke et al. 1993). Low concentrations of heavy metals can accumulate in fine-grained sediments, particularly organic-rich muddy substrates, to toxic levels, and can be resuspended into the water column (Riggs et al. 1991). Primary nursery areas in North Carolina often consist of such fine-grained sediments and are therefore susceptible to toxic contamination of bottom sediments (Street et al. 2005).

Severe hypoxia of bottom water and sediments, often associated with eutrophication, can adversely affect croaker populations through suffocation, reduced growth rates, loss of preferred benthic prey, changes in distribution, or disease (Street et al. 2005). Mass mortality of benthic infauna associated with anoxia has been documented in the deeper portions of the Neuse River estuary in North Carolina, in association with stratification of the water column in the summer (Lenihan and Peterson 1998; Luettich et al. 1999). During these events, oxygen depletion caused mass mortality of up to 90% of the dominant infauna within the affected area (Buzelli et al. 2002). Utilizing a statistical model and field data, it was estimated that the extensive benthic invertebrate mortality, resulting from intensified hypoxia events, reduced total biomass of demersal predatory fish and crabs during summer months by 17-51% in 1997-1998 (Baird et al. 2004). The decrease in available energy from reduced benthos greatly reduced the ecosystem’s ability to transfer energy to higher trophic levels at the time of year most needed by juvenile fish (Baird et al. 2004).

Alteration of natural shorelines has been shown to have a negative impact on juvenile Atlantic croaker populations. In a study along the Gulf coast comparing fish abundance between unaltered and altered shorelines (bulkheads or rubble), croaker was most abundant at the unaltered unvegetated shoreline (Peterson et al. 2000). Other anthropogenic activities that can potentially degrade shallow shoreline habitat conditions include dredging and proliferation of docks and marinas (Street et al. 2005).

Adults

Atlantic croaker is one of the most common bottom dwelling, estuarine species on the Atlantic Coast. Atlantic croaker range from the coastal waters of Cape Cod, Massachusetts to Florida, but croaker are uncommon north of New Jersey. Croakers are also found along the Gulf of Mexico coast with high abundances in Louisiana and Mississippi (Lassuy 1983). Temperature and depth are strong predictors of adult croaker distribution and the interaction between the two variables may also influence distribution (Eby and Crowder 2002). Adult croaker generally spend the spring and summer in estuaries, moving offshore and to southern latitudes along the Atlantic coast in the fall. Adults are found in waters from 5° C to 35.5° C, but most catch occurs in temperatures over 24° C (Miglarese et al. 1982). Generally fish over 1 year old are absent in waters below 10° C (Lassuy 1983). Optimal temperatures for growth and survival are not known (Eby and Crowder 2002).

Adult Atlantic croaker prefer muddy and sandy substrates in waters shallow enough to support submerged aquatic plant growth. Adults have also been collected over oyster, coral, and sponge reefs, as well as man-made structures such as bridges and piers. Adult Atlantic croaker also use *Thalassia* sp. beds for refuge although abundance in the seagrass beds is temperature-dependent and changes seasonally (TSNL 1982).

Adults are found in salinity ranges from 0.2-70 ppt, but are most common in waters with salinities ranging from 6-20 ppt (Lassuy 1983, Eby and Crowder 2002). Catch of adult croakers is negatively correlated with increasing salinities (TSNL 1982), but catch also varies with season. In spring, most catch of adult Atlantic croaker is in salinity ranges from 3-9ppt, but in summer, catch peaks in two ranges: the low salinities ranging from 6-12ppt, and high salinities ranging from 24-27 ppt (Miglarese et al. 1982). Generally, adults avoid the mid-salinity ranges (Miglarese et al. 1982, Peterson et al. 2004). Mean total length positively correlates with bottom salinities (Miglarese et al. 1982). Turbidity, nitrate-nitrogen concentrations, and total phosphate-phosphorous concentrations also correlate positively with croaker abundance and catch (TSNL 1982).

The distribution and extent of hypoxic zones in estuaries may also influence habitat use and distribution (Eby and Crowder 2002). Croaker generally shift from deep, hypoxic water to shallow, oxygenated waters during hypoxic events. Their distribution is further limited when hypoxic conditions occur in shallower waters. The lower threshold of dissolved oxygen for Atlantic croaker is about 2.0 mg/L. Below this limit, Atlantic croaker may not survive or may experience sublethal effects. Studies have shown that Atlantic croaker are virtually absent from waters with dissolved oxygen levels below 2.0 mg/L, suggesting they are very sensitive to the amount of dissolved oxygen present (Eby and Crowder 2002).

The size of a hypoxic zone influences habitat use as well. When hypoxic conditions spread in an estuary, Atlantic croaker are forced to use less suitable habitat. Atlantic croaker could incur increased physiological and ecological costs in these areas. For example, Atlantic croaker may face increased intra- and interspecific competition for available space or food in what are essentially compressed habitat zones. To avoid the increased ecological cost, the croaker may return to waters with lower dissolved oxygen (Eby and Crowder 2002).

In spring and fall in moderate water temperatures, moderate hypoxia may not be a limiting factor to Atlantic croaker distribution. However, in summer when water temperatures are higher Atlantic croaker may avoid moderately hypoxic zones in order to avoid the additional physiological costs of staying in waters with less dissolved oxygen (Eby and Crowder 2002). As hypoxia increases in severity and scope within estuarine waters, croaker typically move to shallower parts of an estuary. Large hypoxic zones may limit adult croaker depth and temperature distribution, suggesting a shift in habitat use driven by the severity of a hypoxic event (Eby and Crowder 2002). Atlantic croaker may actually be limited to areas with higher temperatures than their preferred temperatures during hypoxic events (Eby and Crowder 2002).

Abundance and status of stocks

(from the 2006 FMP Review)
The latest stock assessment was completed in 2004 and reviewed by the SEDAR peer review panel. The stock assessment committee used an Age Structured Production Model. This assessment only accounts for the mid-Atlantic region (North Carolina and north). There is currently not enough data to assess the South Atlantic region (South Carolina through Florida).

In this assessment, fishing mortality rates (F) are based on the average population weighted F for ages 1-10+. Fishing mortality rates for Atlantic croaker exhibit a cyclical trend over the time series. From 1977 to 1979, F rose rapidly reaching a maximum of 0.5 in 1979. From 1980 onwards, F rapidly declined reaching its lowest levels in 1992 (Figure 4.2-6). Since 1993, F has gradually increased and stabilized in 2002 at around 0.11 (ASMFC 2005a).

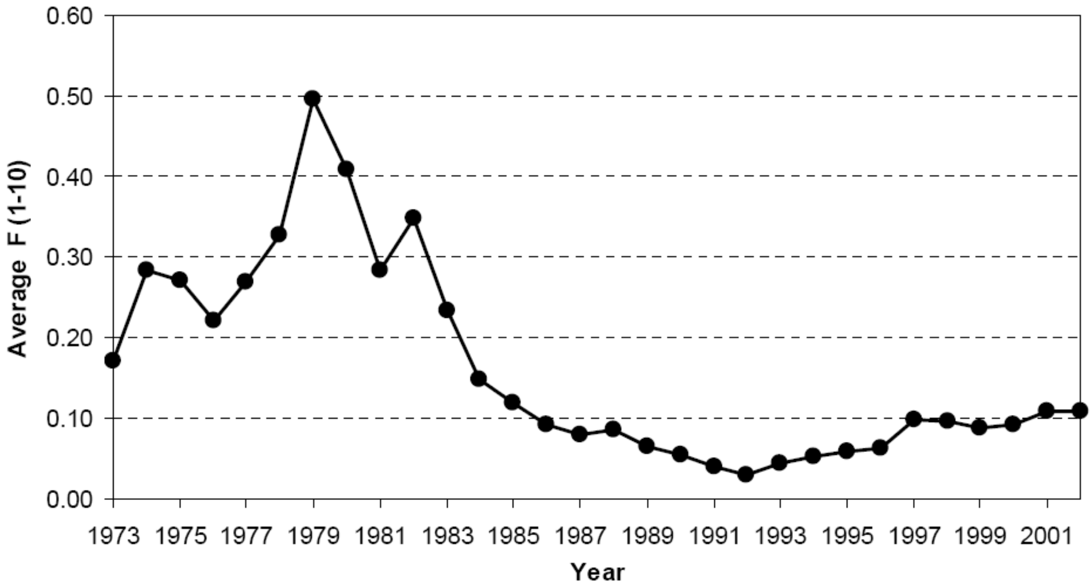


Figure 4.2-6. Average fishing mortality rates (ages 1 –10) for Atlantic croaker in the mid-Atlantic (ASMFC 2005a).

For the base mid-Atlantic run, the trend in population abundance indicates a step-wise increase reaching a peak of 974 million fish in 1999. Population estimates from 1999 to 2002 have ranged from 663 to 974 million fish. Spawning stock biomass (SSB) estimates exhibit a cyclical trend over the time series. From the early 1970's to 1983, SSB declined to its lowest level (11,746 MT). Since 1984, SSB has increased in three distinct phases, with estimates reaching a maximum of 96,686 metric tons in 1996 (Figure 4.2-7). Between 1997 and 2002, SSB estimates range between 80-91,000 metric tons.

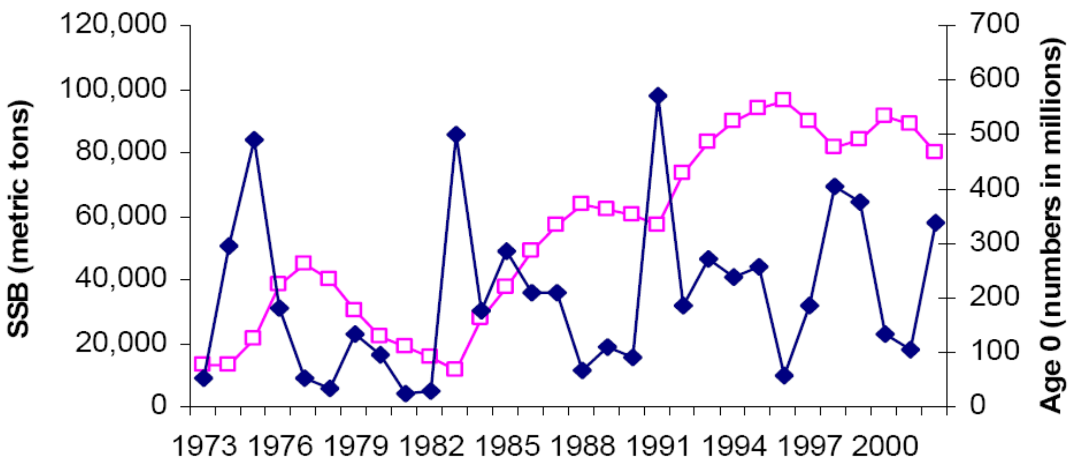


Figure 4.2-7. Spawning stock biomass (metric tons) and age 0 recruits (millions of fish) estimates from the base mid-Atlantic model (ASMFC 2005a).

The mid-Atlantic model, which is the core of the population, indicates fishing mortality rates were high in the mid-1970s, abruptly declined, and has been low and stable since the mid 1990s. Between 1973 and 2002 the relationship between the different sources of removals has changed. In particular, estimates of scrap/discards reached their peak in 1979 (3,200 MT) and since then declined to their lowest levels in 2002 (425 MT).

Between 1973 and 1995, scrap/discard removals averaged 1,687 MT per year, whereas between 1996-2002 scrap/discards averaged 595 MT per year. It appears that the significant reduction in removals of predominantly age 1 and younger fish may have contributed to relatively stable fishing mortality and spawning stock biomass estimates since the mid 1990's. In relation to the proposed reference points the Atlantic croaker population is not overfished or experiencing overfishing. The commercial and recreational catch-at-age data from recent years also shows an increasing age distribution, with a few fish of 12 years being observed in the commercial landings. Anecdotal evidence from the mid-Atlantic indicates an expansion of the population at the northern part of the range. For example, in Delaware, fishery independent indices indicate a recent increase in abundance of Atlantic croaker in the region (D. Kahn Delaware Div. Fish and Wildlife, personal communication). In addition, both commercial and recreational landings from New Jersey and Delaware have increased recently. The population has benefited from good recruitment in recent years, which may also be tied to the regulatory changes that have affected some of the fisheries that indirectly target Atlantic croaker.

While this analysis does not capture all of the sources of uncertainty, examination of the effects of alternate weightings of the likelihood components and alternate steepness and natural mortality estimates indicate that reference points derived from the base run are relatively robust.

The reference points suggest that there was less than a 10% chance that the population is overfished or undergoing overfishing. Sensitivity analysis evaluating the inclusion/non-inclusion of shrimp bycatch estimates, indicate that SSBmsy estimates are sensitive to the inclusion of Atlantic croaker caught as shrimp bycatch. However, increased SSBmsy estimates are also accompanied by higher SSB estimates. The ratio of SSB_{2002}:SSB_{msy} when shrimp bycatch is included indicates that the stock is unlikely to be below the threshold estimates. Of concern would be management goals that define biomass reference points in absolute terms. There appears to be some justification for revising the reference points for the biomass target and threshold to relative terms until a more comprehensive evaluation of Atlantic croaker from shrimp bycatch can be carried out.
The next stock assessment is scheduled for the fall of 2009, an update assessment through the SEDAR process.

4.2.12 Spot

Description and Distribution

(from SCDNR spot factsheet available at http://www.dnr.sc.gov/cwcs/pdf/Spot.pdf) and the ASMFC Species Profile for Spot)
Spot is a common member of the family Sciaenidae that was first described by Lacepede (1802). Johnson (1978) provides the following description of morphology. The body of the spot is deep

and compressed laterally; the back is strongly elevated; the head is obtuse and short with the small mouth positioned ventrally. Spot are bluishgray above and somewhat golden below. They have 12 to 15 oblique dark streaks that may become indistinct in larger specimens. A single large black spot is located above the gill cover.

Spot occur along the U.S. Atlantic coast in estuarine and coastal waters from the Gulf of Maine to Florida, although they are most abundant from Chesapeake Bay south to South Carolina.

Development, growth and movement patterns

(from SC DNR spot factsheet available at http://www.dnr.sc.gov/cwcs/pdf/Spot.pdf)
Following entry to the estuary, spot associate with shallow habitats, particularly tidal creeks. Due to its high productivity, this habitat provides ample prey for spot, which feed mostly on small bottom dwelling worms and crustaceans (Chao and Musick 1977). The habitat is shallow and structurally complex, providing a physical refuge from predators. In addition, spot are well adapted to live in the physiologically stressful low dissolved oxygen, high carbon dioxide environment of small tidal creeks (Cochran 1994). Research in Rose Bay, North Carolina suggests that during their first summer, spot grow and disperse from shallow edges of the bay to all depths (Currin 1984).

While offshore, spot inhabit sandy or muddy bottoms in depths up to 60 meters (197 feet). Following spawning, larvae may take advantage of tidal mechanisms such as tidal bores and internal waves to migrate inshore (Williams 1993). Spot larvae are most dense in midwater and near the bottom during the day, and migrate into surface waters at night. Nearshore, they are most dense on the bottom both day and night, possibly utilizing the salt wedge to enter the estuary.

Spot are strongly associated with the bottom as juveniles and adults and are seasonally dependent on the estuary. Along the east coast of the United States, spawning takes place on the outer continental shelf from October through March. Peak spawning occurs during December and January off the North Carolina coast. As larvae mature, they are passively transported toward shore by currents (Warlen and Chester 1985). Near inlets, the larvae begin to metamorphose into juveniles (Phillips et al. 1989). Young-of-the-year spot typically move first into the upper reaches of the estuary and then disperse to the lower reaches as they mature through their first season. Young-of-the-year may remain in the estuary during their first winter, while older fish migrate offshore to spawn.

Ecological relationships

(from SC DNR spot factsheet by Phil Maier http://www.dnr.sc.gov/cwcs/pdf/Spot.pdf)
Spot represent a significant link in the transfer of energy from the estuary to the waters of the adjacent continental shelf. Because of their abundance, they are considered to be ecologically important, influencing the structure and function of estuarine systems (Kjelson and Johnson

1976); as such, spot have the potential to act as an indicator species for estuarine systems. In addition, spot are important to both recreational and commercial anglers in the Mid-Atlantic Region where they comprise the major proportion of the biomass and numbers of fish present (Phillips et al. 1989).

(from the ASMFC Species Profile for Spot)
Spot are opportunistic bottom feeders, eating mainly worms, small crustaceans and mollusks, as well as organic material. The post-larvae prey on plankton, but become bottom feeders as juveniles or adults. Such predators as striped bass, weakfish, summer flounder, bluefish, and sharks eat them in turn.

Abundance and status of stocks

(from ASMFC's 2006 update to the spot FMP)
No coastwide assessment has been performed for spot; however, spot are a target or component of several state surveys using trawl, gillnet, or seine net to sample. Florida assessed the abundance of spot in the Indian River Lagoon in 1997, finding stable juvenile abundance between 1990 and 1996, except for a very high 1993 index, and stable adult abundance during the same time series (McRae et al. 1997). An analysis of spot catches in Maryland's juvenile seine survey showed a trend of increasing abundance from 1957 to l976, and then, a protracted decline, that has been punctuated by occasional high years. The 2005 abundance index increased drastically, reaching its highest value since 1988, but fell back to low levels in 2006 (Durrell 2006). Spot young-of-year abundance in the VIMS Virginia Chesapeake Bay Trawl Survey was relatively high from 1981 through 1991, but remained low from 1992 to 2005, except for fair to moderate-sized year classes in 1997 and 2005 (Montane & Fabrizio 2006). The abundance of juvenile spot in the North Carolina Pamlico Sound Survey has fluctuated without trend since 1979. The area of greatest abundance on the Atlantic Coast extends from Chesapeake Bay to South Carolina (ASMFC 1987).

4.2.13 Summer Flounder

From the NEFSC EFH source document for Summer Flounder (1999).

Description and Distribution

The geographical range of the summer flounder or fluke, *Paralichthys dentatus* (Figure 4.2-8), encompasses the shallow estuarine waters and outer continental shelf from Nova Scotia to Florida (Ginsburg 1952; Bigelow and Schroeder 1953; Anderson and Gehringer 1965; Leim and Scott 1966; Gutherz 1967; Gilbert 1986; Grimes et al. 1989), although Briggs (1958) gives their southern range as extending into the northern Gulf of Mexico. The center of its abundance lies within the Middle Atlantic Bight from Cape Cod, Massachusetts, to Cape Hatteras, North Carolina (Hildebrand and Schroeder 1928). North of Cape Cod and south of Cape Fear, North Carolina, summer flounder numbers begin to diminish rapidly (Grosslein and Azarovitz 1982). South of Virginia, two closely related species, the southern flounder (*Paralichthys lethostigma*) and the gulf flounder (*Paralichthys albigutta*) occur and sometimes are not distinguished from summer flounder (Hildebrand and Cable 1930; Byrne and Azarovitz 1982).

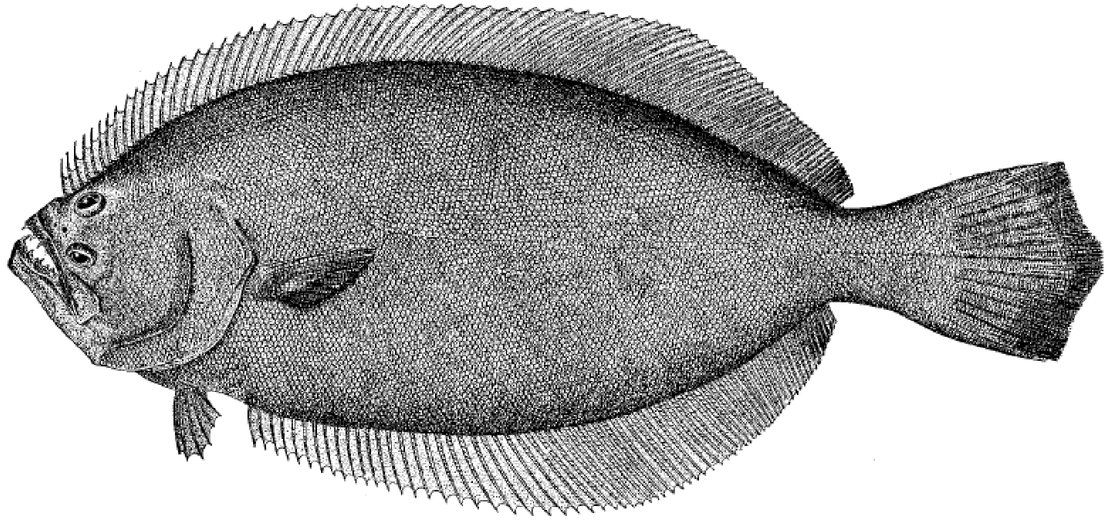


Figure 4.2-8. The summer flounder, *Paralichthys dentatus* (from Goode 1884).

Summer flounder exhibit strong seasonal inshore offshore movements, although their movements are often not as extensive as compared to other highly migratory species.

Adult and juvenile summer flounder normally inhabit shallow coastal and estuarine waters during the warmer months of the year and remain offshore during the fall and winter. See Development, Growth and Movement Patterns below for a detailed description of movement patterns.

Reproduction

Powell (1974) noted that the minimum size at maturity of summer flounder from Pamlico Sound, North Carolina was 35.0 cm TL. In the South Atlantic Bight, Wenner et al. (1990a) estimated the L50 to be 28.9 cm TL for males and 30.7 cm TL for females, corresponding to fish approaching age 2. Based on the study by O'Brien et al. (1993) on the L50 of summer flounder sampled from 1985-1989 from Nova Scotia to Cape Hatteras, this report will use the female size of 28 cm (age 2.5) as the divide between all juvenile and adult individuals. The median length at maturity for males in the O'Brien et al. (1993) study was 24.9 cm (age 2). However, as O'Brien et al. (1993) notes, a revision to aging convention (Smith et al. 1981; Almeida et al. 1992) has resulted in median lengths being attained a year earlier than those reported above; thus, for example, the ages of O'Brien et al. (1993) are also off by a year (i.e., the age 2.5 female fish are now age 1.5). These conclusions have been supported by more recent growth studies (Able et al. 1990; Szedlmayer et al. 1992).

Fecundity and length exhibit a curvilinear relationship, but with logarithmic transformations, Morse (1981) expressed the relationship as:

$$\log_{10} \text{Fecundity} = \log_{10} a + b\,(\log_{10} \text{length})$$

where the intercept (a) = -3.098 and the slope (b) = 3.402.

The relationship between fecundity and weight and ovary weight were expressed by Morse (1981) as:

$$\text{Fecundity} = a + bX$$

where the intercept (aweight) = -101,865.5 and the slope (bweight) = 908.864, and the intercept (aovary weight) = 52,515.161 and the slope (bovary weight) = 10,998.048.

Powell (1974) estimated that females ranging from 50.6-68.2 cm TL have 1.67-1.70 million ova per fish, while Morse (1981) reported fish between 36.6 and 68.0 cm TL have 0.46-4.19 million ova. The relative fecundity, number of eggs produced per gram of total weight of spawning female, ranged from 1,077-1,265 in Morse's (1981) study.

The increase in variability in fecundity estimates as weight increases tends to obscure the true relationship. The high egg production to body weight is maintained by serial spawning. In fact, the weight of annual egg production, assuming an average egg diameter of 0.98 mm and 1.0 specific gravity, equals approximately 40-50% of the biomass of spawning females (Morse 1981).

Morse (1981) calculated the percent of ovary weight to total fish weight as an index for maturity. The mean maturity index increased rapidly from August to September, peaked in October-November, then gradually decreased to a low in July. The wide range in the maturity indices during the spawning season indicates nonsynchronous maturation of females and a relatively extended spawning season. The length and peak spawning time as indicated by the maturity index agree with results determined by egg and larval occurrence (Herman 1963; Smith 1973).

Spawning occurs over the open ocean areas of the shelf. Summer flounder spawn during the fall and winter while the fish are moving offshore or onto their wintering grounds; the offshore migration is presumably keyed to declining water temperature and decreasing photoperiod during the autumn. The spawning migration begins near the peak of the summer flounder`s gonadal development cycle, with the oldest and largest fish migrating first each year (Smith 1973).

The seasonal migratory/spawning pattern varies with latitude (Smith 1973); i.e., gonadal development, spawning and offshore movements occur earlier in the northern part of their range (Rogers and Van Den Avyle 1983). For example, in Delaware Bay, gonads of summer flounder appear to ripen from mid-August through November (Smith and Daiber 1977), while peak gonadal development occurs during December and January for fish around Cape Hatteras (Powell 1974). Spawning begins in September in the inshore waters of southern New England and the Mid-Atlantic. As the season progresses, spawning moves onto Georges Bank as well as southward and eastward into deeper waters across the entire breadth of the shelf (Berrien and Sibunka 1999).

Spawning continues through December in the northern sections of the Middle Atlantic Bight, and through February/March in the southern sections (Smith 1973; Morse 1981; Almeida et al. 1992). Spawning peaks in October north of Chesapeake Bay and November south of the Bay

(Smith 1973; Able et al. 1990; note that the latter statement on spawning south of the Bay in November appears to contradict the published information above concerning peak gonadal development occurring December-January near Cape Hatteras). The half year spawning season reduces larval crowding and decreases the impact of predators and adverse environmental conditions on egg and larval survival (Morse 1981). In the South Atlantic Bight, maturity observations by Wenner et al. (1990a) suggest that spawning begins as early as October, and may continue through February and possibly early March.

Development, growth and movement patterns

Eggs of summer flounder are pelagic and buoyant. They are spherical with a transparent, rigid shell; yolk occupies about 95% of the egg volume. Mean diameter of mature unfertilized eggs is 0.98 mm. Eggs are most abundant between Cape Cod/Long Island and Cape Hatteras; the heaviest concentrations have been reported within 45 km of shore off New Jersey and New York during 1965-1966 (Smith 1973), and from New York to Massachusetts during 1980-1986 (Able et al. 1990). Able et al. (1990) discovered that the highest frequency of occurrence and greatest abundances of eggs in the northwest Atlantic occurs in October and November, although, due to limited sampling in December south of New England, December could be under represented. Festa (1974) also notes an October-November spawning period off New Jersey. Keller et al. (1999) found eggs (maximum density 19.5/100 m^3) from February to June in Narragansett Bay during a December 1989 to November 1990 sampling period. In southern areas, eggs have been collected as late as January-May (Smith 1973; Able et al. 1990). The eggs have been collected mostly at depths of 30-70 m in the fall, as far down as 110 m in the winter and from 10-30 m in the spring.

Planktonic larvae (2-13 mm) are often most abundant 19-83 km from shore at depths of around 10-70 m, and are found in the northern part of the Middle Atlantic Bight from September to February, and in the southern part from November to May, with peak abundances occurring in November (Smith 1973; Able et al. 1990). The smallest larvae (< 6 mm) were most abundant in the Mid-Atlantic Bight from October-December, while the largest larvae (≥11 mm) were abundant November-May with peaks in November-December and March-May (Able et al. 1990). Off eastern Long Island and Georges Bank, the earliest spawning and subsequent larval development occurs as early as September (Able and Kaiser 1994). By October, the larvae are primarily found on the inner continental shelf between Chesapeake Bay and Georges Bank. During November and December they are evenly distributed over both the inner and outer portions of the shelf. By January and February the remaining larvae are primarily found on the middle and outer portions of the shelf. By April, the remaining larvae are concentrated off North Carolina (Able and Kaiser 1994).

From October to May larvae and postlarvae migrate inshore, entering coastal and estuarine nursery areas to complete transformation (Merriman and Sclar 1952; Olney 1983; Olney and Boehlert 1988; Able et al. 1990; Szedlmayer et al. 1992). Larval to juvenile metamorphosis, which involves the migration of the right eye across the top of the head, occurs over the approximate range of 8-18 mm SL (Burke et al. 1991; Keefe and Able 1993; Able and Kaiser 1994). They then leave the water column and settle to the bottom where they begin to bury in the sediment and complete development to the juvenile stage, although they may not exhibit complete burial behavior until mid-late metamorphosis when eye migration is complete, often at sizes as large as 27 mm SL (Keefe and Able 1993, 1994). However, burying behavior of metamorphic summer flounder is also significantly affected by substrate type, water temperature, time of day, tide, salinity, and presence and types of predators and prey (Keefe and Able 1994).

In North Carolina, the highest densities of larvae are found in Oregon Inlet in April, while farther south in Ocracoke Inlet, the highest densities occur in February (Hettler and Barker 1993). J.P. Monaghan, Jr. (North Carolina Dept. of Nat. Res. and Commer. Dev., Morehead City, NC, personal communication) mentions that for the years 1986-1988, peak immigration periods of larvae through Beaufort Inlet and into North Carolina estuaries were from late February through March. In the Cape Fear River Estuary, North Carolina, it has been reported that postlarvae first enter the marshes in March and April and are 9-16 mm SL during peak recruitment (Weinstein 1979; Weinstein et al. 1980b).

Schwartz et al. (1979a, b) also notes that age 0 flounder appear in the Cape Fear River between March and May, depending on the year. Warlen and Burke (1990) found larvae (mean 13.1 mm SL) in the Newport River estuary just inside Beaufort Inlet from February-April, 1986, with peak abundance in early March.

Powell and Robbins (1998) reported larval summer flounder adjacent to live-bottom habitats (rock outcroppings containing rich invertebrate communities and many species of tropical and subtropical fishes) in Onslow Bay (near Cape Lookout) in November (at stations of 17-22 m depth), February (28-30 m depth), and May (14-16 m and 17-22 m depth). Burke et al. (1998) conducted night-time sampling for transforming larvae and juveniles in Onslow Bay, Beaufort Inlet, and the Newport River estuary in February- March 1995. Although flounders were captured both in Onslow Bay and in the surf zone during the immigration period, densities were low and all were transforming larvae (7-15 mm SL). After the immigration period, flounders were absent, as juveniles were not caught. Within the Newport River estuary, flounders were locally very abundant as compared to within Onslow Bay and initial settlement was concentrated in the intertidal zone. During February most were transforming larvae, in March some were completely settled juveniles (11-21 mm SL).

In South Carolina, Burns (1974) captured summer flounder larvae (14.9-17.5 mm) in New Bridge Creek, North Inlet estuary in February-March, while Bearden and Farmer (1972) recorded larvae and postlarvae in Port Royal Sound estuary from January-March.
During 1986-1988, Wenner et al. (1990a) found that ingress of recently transformed larval and juvenile summer flounder (10-20 mm TL) into Charleston Harbor, South Carolina estuarine marsh creeks began in January and continued through April. Larvae and postlarvae were also found during this period in the Chainey Creek area (Wenneret al. 1986).

As stated above, juveniles are distributed inshore and in many estuaries throughout the range of the species during spring, summer, and fall (Deubler 1958; Pearcy and Richards 1962; Poole 1966; Miller and Jorgenson 1969; Powell and Schwartz 1977; Fogarty 1981; Rountree and Able 1992a, b, 1997; Able and Kaiser 1994; Walsh et al. 1999). During the colder months in the north there is some movement to deeper waters offshore with the adults, although many juvenile summer flounder will remain inshore through the winter months while some juveniles in southern waters may generally overwinter in bays and sounds (Smith and Daiber 1977; Wilk et al. 1977; Able and Kaiser 1994). In estuaries north of Chesapeake Bay, some juveniles remain in their estuarine habitat for about 10 to 12 months before migrating offshore their second fall and winter; in North Carolina sounds, they often remain for 18 to 20 months (Powell and Schwartz 1977). The offshore juveniles return to the coast and bays in the spring and generally stay the entire summer. Fogarty (1981) examined the distribution patterns of prerecruit (≤ 30.5 cm) summer flounder caught during the 1968-1979 spring surveys and found a striking absence of small fish in northern areas. Both spring and autumn bottom trawl survey data indicated that the concentration of young-of-year summer flounder was south of 39^{o} latitude. The importance of the Chesapeake Bight to this species is demonstrated by the fact that almost all of the young-of-year caught during those spring surveys were from this area.

In Mid-Atlantic estuaries, first year summer flounder can grow rapidly and attain lengths of up to at least 30.0 cm (Poole 1961; Almeida et al. 1992; Szedlmayer et al. 1992).
Young-of-the-year summer flounder in New Jersey marsh creeks have average growth rates of 1.3-1.9 mm/d, an increase from about 16.0 cm TL at first appearance in late July to around 26.0 cm by September (Rountree and Able 1992b; Szedlmayer et al. 1992). First year fish from Pamlico Sound, North Carolina obtained mean lengths of 16.7 cm for males and 17.1 cm for females (Powell 1982).

In Charleston Harbor and other South Carolina estuaries from 1986-1988, Wenner et al. (1990a) found transforming larvae were recruited into the estuarine creeks when 1-2 cm TL. Growth accelerated in May and June when they reached modal sizes of 8 and 14 cm TL, respectively. By September, modal size was 16 cm TL and reached from 23-25 cm TL through October and November. Modal lengths of yearlings ranged from 23-25 cm in January through June and generally reached 28 cm by October. In Georgia, lab studies by Reichert and van der Veer (1991) found that juveniles from Duplin River of 28-46 mm SL had a maximum growth rate of about 1.3-1.4 mm/d at laboratory temperatures of 23.7-24.8°C.

Juvenile summer flounder make use of several different estuarine habitats. Estuarine marsh creeks are important as nursery habitat, as has been shown in New Jersey (Rountree and Able 1992b, 1997; Szedlmayer et al. 1992; Szedlmayer and Able 1993), Delaware (Malloy and Targett 1991), Virginia (Wyanski 1990), North Carolina (Burke et al. 1991) and South Carolina (Bozeman and Dean 1980; McGovern and Wenner 1990; Wenner et al. 1990a, b). Other portions of the estuary that are used include seagrass beds, mud flats and open bay areas (Lascara 1981; Wyanski 1990; Szedlmayer et al. 1992; Walsh et al. 1999). Patterns of estuarine use by the juveniles can vary with latitude.

Tagged summer flounder have been recaptured from inshore areas to the northeast of their release sites in subsequent summers, leading to the hypothesis that their major nursery areas are the inshore waters of Virginia and North Carolina, and as they grow older and larger, they would return inshore to areas farther north and east of these nursery grounds (Poole 1966; Murawski 1970; Lux and Nichy 1981). However, tagging studies by Desfosse (1995) indicate that it is not the older and larger fish, but rather the smaller fish (length at tagging) which return to inshore areas north of Virginia. Summer flounder that were recaptured north of their release site in subsequent years were smaller (length at tagging) than those recaptured at their release sites, or to the south, in later years. Desfosse (1995) suggests that while Virginia waters do indeed form part of the nursery grounds for fish which move north in subsequent years, they are primarily a nursery area for fish which will return to these same waters as they grow older and larger.

The estuarine waters of North Carolina, particularly those west and northwest of Cape Hatteras (Monaghan 1996) and in high salinity bays and tidal creeks of Core Sound (Noble and Monroe 1991), provide substantial habitat and serve as significant nursery areas for juvenile Mid-Atlantic Bight summer flounder. Powell and Schwartz (1977) found that juvenile summer flounder were most abundant in the relatively high salinities of the eastern and central parts of Pamlico Sound, all of Croatan Sound, and around inlets. Young-of-the-year disappeared from the catch during late summer, suggesting that the fish are leaving the estuaries at that time (Powell and Schwartz 1977). Upon leaving the estuaries, the juveniles enter the north-south, inshore-offshore migration of Mid-Atlantic Bight summer flounder (Monaghan 1996). Although North Carolina also provides habitat for summer flounder from the South Atlantic Bight, these fish do not exhibit the same inshore-offshore and north-south migration patterns as do Mid-Atlantic Bight fish (Monaghan 1996). Summer flounder > 30 cm are rarely found in the estuaries of North Carolina, although larger fish are found around inlets and along coastal beaches. Powell and Schwartz (1977) also noted that juvenile summer flounder were most abundant in areas with a predominantly sandy or sand/shell substrate, or where there was a transition from fine sand to silt and clay.

Surveys by Hoffman (1991) in marsh creeks in Charleston Harbor, South Carolina showed that recently settled summer flounder were abundant over a wide variety of substrates including mud, sand, shell hash, and oyster bars.

Ecological relationships

Food Habits

The timing of peak spawning in October/November coincides with the breakdown of thermal stratification on the continental shelf and the maximum production of autumn plankton which is characteristic of temperate ocean waters of the northern hemisphere, thus assuring a high probability of adequate larval food supply (Morse 1981).

Previous studies have inferred that larval and postlarval summer flounder initially feed on zooplankton and small crustaceans (Peters and Angelovic 1971; Powell 1974; Morse 1981; Timmons 1995). Grover (1998) studied the food habits of oceanic larval flounder collected north and east of Hudson Canyon. The diets of all stages of larvae were dominated by immature copepodites. The size of other prey was directly related to larval size. Preflexion larvae (1.9-6.9 mm SL) fed on, in order of importance: immature copepodites, copepod nauplii, and tintinnids, as well as bivalve larvae and copepod eggs. Flexion larvae (3.7-7.2 mm SL) fed on immature copepodites (mostly calanoids) and adult calanoid copepods. Premetamorphic (4.8-7.6 mm SL) and metamorphic (5.8-9.0 mm SL) larvae also fed on immature copepodites, but adult calanoid copepods (mostly *Centropages typicus*) and appendicularians were also prey items.

Studies on the food habits of late larval and juvenile estuarine summer flounder reveal that while they are opportunistic feeders and differences in diet are often related to the availability of prey, there also appears to be ontogenetic changes in diet. Smaller flounder (usually < 100 mm) seem to focus on crustaceans and polychaetes while fish become a little more important in the diets of the larger juveniles.

Burke (1991, 1995) in his North Carolina field surveys in the Newport and North Rivers discovered that late larval and early juvenile summer flounder are active infaunal predators. Prey of summer flounder during the immigration period (11-22 mm SL) consisted of common estuarine crustaceans including harpactacoid copepods, polychaetes, and parts of infaunal animals such as polychaete tentacles (primarily from the dominant spionid *Streblospio benedicti*) gills and clam siphons. The appendages of temperature and food availability (i.e., delay of initial feeding) and their effects on survival and growth of summer flounder larvae hatched from Narragansett Bay and Long Island Sound broodstock. Their laboratory observations occurred from the time of hatching throughout the period of feeding on rotifers. The larvae withstood starvation for benthic animals appear to be the most important prey item for postlarval flounders. The increasing importance of polychaetes and clam siphons was suggested with development, while feeding on harpactacoid copepods and amphipods was independent of stage. For juveniles 20-60 mm SL, polychaetes, primarily spionids (*S. benedicti*), were the most important part of the diet.

Burke (1991, 1995) suggests that the distribution of these dominant polychaetes may influence the distribution of summer flounder in this estuary and could explain the movement of juvenile summer flounder into marsh habitat. Other prey items for this size class of summer flounder included invertebrate parts, primarily clam siphons; shrimp, consisting of the mysids *Neomysis americana* and palmonid shrimp; calanoid copepods, primarily *Paracalanus*; amphipods of the genus *Gammarus*; crabs, primarily *Callinectes sapidus*; and fish.

Powell and Schwartz (1979) reported that larger juvenile (100-200 mm TL) summer flounder feed mainly on mysids (mostly *Neomysis americana*) and fishes throughout the year in Pamlico Sound, North Carolina. Mysids were found in relatively greater quantities in the smaller flounder, but as their size increased, the diet consisted of shrimps and fishes in similar quantities.

In South Carolina, Wenner et al. (1990a) reported that juveniles between 50-125 mm TL consumed only mysids and caridean shrimps (*Palaemonetes* sp., *P. pugio*, *P. vulgaris*). The importance of fish (mostly bay anchovy, *Anchoa mitchilli*, and mummichogs) in the diet increased as summer flounder size increased.

In Georgia, Reichert and van der Veer (1991) found that juveniles from the Duplin River of around < 40 mm SL fed principally on harpacticoid copepods; they also report that *Paralichthys* species > 25 mm fed on increasing numbers of other crustaceans including mysids, crabs, *Palaemonetes,* as well as polychaetes. Summer flounder > 100 mm also fed on fish.

Adult summer flounder are opportunistic feeders with fish and crustaceans making up a significant portion of their diet. Differences in diet between habitats or locations may be due to prey availability. The flounder are most active during daylight hours and may be found well up in the water column as well as on the bottom (Olla et al. 1972). Included in their diet are: windowpane (Carlson 1991), winter flounder, northern pipefish, Atlantic menhaden, bay anchovy, red hake, silver hake, scup, Atlantic silverside, American sand lance, bluefish, weakfish, mummichog, rock crabs, squids, shrimps, small bivalve and gastropod mollusks, small crustaceans, marine worms and sand dollars (Hildebrand and Schroeder 1928; Ginsburg 1952; Bigelow and Schroeder 1953; Poole 1964; Smith and Daiber 1977; Allen et al., 1978; Langton and Bowman 1981; Curran and Able 1998).

In South Carolina, Wenner et al. (1990a) showed that flounder 50-313 mm TL consumed mostly decapod crustaceans, especially caridean shrimps (*Palaemonetes* sp., *P. pugio*, *P. vulgaris*). The importance of fish (mostly bay anchovy, Anchoa mitchilli, and mummichogs) in the diet increased as summer flounder size increased.

Co-occurring Species and Predation

Larval and juvenile summer flounder undoubtedly are preyed upon until they grow large enough to fend for themselves. Results of food habit studies by the Northeast Fisheries Science Center (NEFSC) from 1969-1972 showed that Pleuronectiformes occurred in the stomachs of the following piscivores: spiny dogfish, goosefish, cod, silver hake, red hake, spotted hake, sea raven, longhorn sculpin, and fourspot flounder (Bowman et al. 1976). These data do not indicate the proportion of summer flounder among the flatfish prey taken, but it is likely that they are represented.

Lab studies in Georgia by Reichert and van der Veer (1991) on juveniles from the Duplin River found potential predators to be blue crabs (*Callinectes* spp.) and sea robins (*Prionotus* spp.).

Spatial co-occurrence and dietary overlap among summer flounder, scup, and black sea bass have been previously documented (Musick and Mercer 1977; Gabriel 1989; Shepherd and Terceiro 1994). For example, the composition and distribution of fish assemblages in the Middle Atlantic Bight was described by Colvocoresses and Musick (1979) by subjecting NEFSC bottom trawl survey data to the statistical technique of cluster analysis. Summer flounder, scup, northern sea robin, and black sea bass, all warm temperate species, were regularly classified in the same group during spring and fall. In the spring this group was distributed in the warmer waters on the southern shelf and along the shelf break at depths of approximately 152 m. During the fall this group was distributed primarily on the inner shelf at depths of less than 61 m where they were often joined by smooth dogfish.

All of the natural predators of adult summer flounder are not fully documented, but larger predators such as large sharks, rays, and goosefish probably include summer flounder in their diets. Laboratory studies by Lascara (1981) on flounder from lower Chesapeake Bay suggest that in patchy seagrass/sand habitats, the flounder may avoid predation by staying in the sand near the seagrass beds, rather than in the grass beds themselves.

Abundance and status of stocks

The Northeast Fisheries Science Center's Southern Demersal Working Group met in June 2006 to conduct an annual evaluation of summer flounder stock status. The assessment update indicates that the stock is not overfished but overfishing is occurring relative to the biological reference points detailed in Amendment 12. The fishing mortality rate estimated for 2005 is 0.53, which is a significant decline from the 1.32 estimated for 1994 but above the threshold F of 0.276. In addition, total stock biomass has increased substantially since 1989 to 105 million lb (47.8 million kg) in 2005, slightly above the current biomass threshold of 102 million lb (46.3 million kg). Spawning stock biomass has increased since 1993 to 67.5 million lb (30.6 million kg) in 2005.

Recruitment declined from 1983 to 1988, with the 1988 year class being the weakest at only 13 million fish. Recruitment since 1988 has generally improved, although the 2005 year class is estimated to be well below the median at 14.5 million fish.

An update and peer review of the summer flounder assessment and reference points was conducted by the National Marine Fisheries Service (NMFS) Office of Science and Technology (S&T) during September 14-15, 2006. The 2006 S&T Peer Review Panel recommendations required revision to the summer flounder VPA, biological reference point, and projection calculations. The revised analytical results supersede those presented in the Terceiro (2006) assessment.

The summer flounder stock is not overfished but overfishing is occurring relative to the 2006 S&T Peer Review Panel updated biological reference points. Fishing mortality calculated from the average of the currently fully recruited ages (3-5) was very high during 1982-1997, varying between 0.9 and 2.2. The fishing mortality rate has declined since 1997 and was estimated to be about 0.4 during 2003-2005. The estimate of F for 2005 (0.407) is 45% above the updated FMSY proxy = Fmax = 0.280; therefore overfishing is occurring. The estimate of F for 2005 may understate the actual fishing mortality, as retrospective analysis shows that the current assessment method tends to underestimate recent fishing mortality rates, continuing the pattern observed in recent assessments (NEFSC 2000, MAFMC 2001, NEFSC 2002, Terceiro 2003, SDWG 2004, NEFSC 2005, Terceiro 2006). Over the last 5 years, the annual retrospective increase in fishing mortality has averaged 34%.

Stock biomass (Jan 1; age 1+) increased substantially during the 1990s and through 2005 but decreased slightly in 2006 to 51.317 mt. Spawning stock biomass (SSB; Age 0+) declined 69% from 1983 to 1989 (22,582 mt to 7,025 mt), but with improved recruitment and decreased fishing mortality had increased to 47,498 mt by 2005. The estimate of SSB for 2005 (47,498) is 53% of the updated BMSY proxy = SSBmax = 89,411 mt; therefore the stock is not overfished. Retrospective analysis shows a tendency to overestimate the SSB in the most recent years, continuing the pattern observed in recent assessments (NEFSC 2000, MAFMC 2001, NEFSC 2002, Terceiro 2003, SDWG 2004, NEFSC 2005, Terceiro 2006). Over the last 5 years, the annual retrospective decrease in SSB has averaged 12%.

The 1982 and 1983 year classes were the largest of the VPA series, at 74 and 80 million fish, respectively. The 1988 year class was the smallest of the series, at only 13 million fish. The arithmetic average recruitment from 1982 to 2005 is 37 million fish at age 0, with a median of 33 million fish. The 2005 year class is estimated to be the smallest since 1988, at about 15 million fish.

Retrospective analysis shows a variable pattern in the estimation of recruitment; over the last 5 years, the annual retrospective increase in recruitment has averaged 4%.

The precision and bias of the 2005 fishing mortality rates, 2006 stock sizes, and 2005 SSB estimates are presented in Appendix A of the ASMFC 2006 Plan Review document (ASMFC, 2006). Bias was generally less than 10% for estimated parameters estimated. The bootstrap estimate of the 2005 SSB was relatively precise, with a corrected CV of 11%. There is an 80% chance that SSB in 2005 was between 39,900 and 57,200 mt. The bootstrap estimate of the 2005 F had a corrected CV of 43%. There is an 80% chance that F in 2005 was between about 0.33 and 0.57.

4.2.14 Bluefish

From the NEFSC EFH source document for Bluefish (2006).

Description and Distribution

The bluefish, *Pomatomus saltatrix*, ranges in the western North Atlantic from Nova Scotia and Bermuda to Argentina, but it is rare between southern Florida and northern South America (Robins et al. 1986). They travel in schools of like-sized individuals and undertake seasonal migrations, moving into the Middle Atlantic Bight (MAB) during spring and south or farther offshore during fall. Within the MAB they occur in large bays and estuaries as well as across the entire continental shelf. Juvenile stages have been recorded from all estuaries surveyed within the MAB, but eggs and larvae occur in oceanic waters (Able and Fahay 1998). Bluefish growth rates are fast and they may reach a length of 1.1 m (3.5 ft) and a weight of 12.3 kg (27 lbs) (Bigelow and Schroeder 1953). They live to ages 12 and greater (Salerno et al. 2001).

Juveniles occur in estuaries, bays, and the coastal ocean of the MAB and South Atlantic Bight (SAB), where they are less common. They occur in many habitats, but do not use the marsh surface. Juveniles begin to depart MAB estuaries in October and migrate south to spend the winter months south of Cape Hatteras.

The spring and fall distributions of juvenile bluefish (< 30 cm) relative to bottom water temperature, depth, and salinity are based on 1963-2003 Northeast Fisheries Science Center (NEFSC) bottom trawl surveys from the Gulf of Maine to Cape Hatteras. In the spring, they were found over a temperature range of 8-23°C, with most spread between about 10-19°C. They were found at shallow depths ranging from 1-40 m, with the majority at 1-30 m. Their salinity range was between 33-36 ppt, with a peak in occurrence and catch at 33 ppt. In the fall, the juveniles were spread over a temperature range of 10-28°C, with most between about 17-25°C. They were also found at shallow depths of 1-50 m, with > 60% found at 11-20 m. Their salinity range was between 29-35 ppt, with the majority at 31-32 ppt.

Adult bluefish are blue-green above, silvery below, moderately stout-bodied, and armed with stout teeth along both jaws (Figure 4.2-9). The snout is pointed and the mouth is large and oblique. The caudal fin is large and forked. The fin ray formulae are first dorsal: 7-9 spines; second dorsal: 1 spine and 23-26 rays; anal: 2-3 spines and 25- 28 rays. Vertebrae number 26. The maximum length is about 115 cm and maximum weights are 4.5-6.8 kg, although an occasional heavier fish has been taken. The maximum age is 12 years. The sex ratio is 1:1 for all age groups (Boreman 1982), although Lassiter (1962) reported a ratio of two females per male in North Carolina and Hamer (1959) found a ratio of three females to two males in New Jersey.

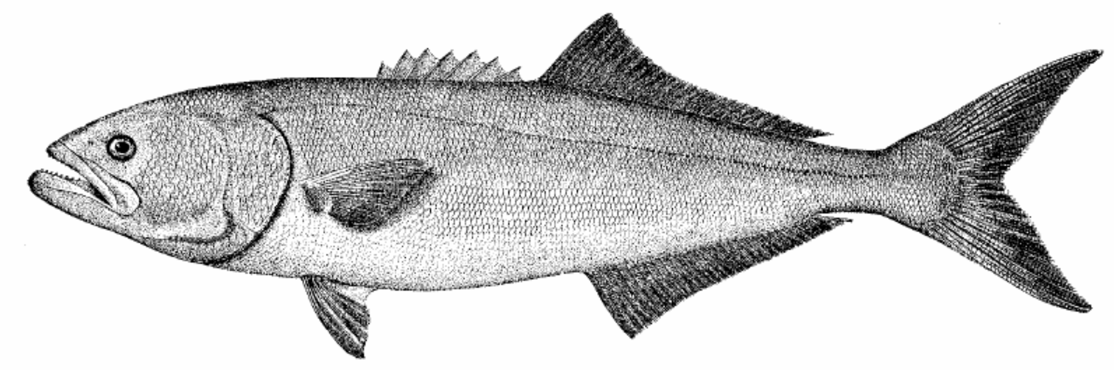


Figure 4.2-9. The adult bluefish, *Pomatomus saltatrix* (from Goode 1884).

Adult bluefish occur in the open ocean, large embayments, and most estuarine systems within their range. Although they occur in a wide range of hydrographic conditions, they prefer warmer temperatures and are not found in the MAB when temperatures decline below 14-16°C.

Reproduction

A seminal study, based largely on the distribution of eggs and larvae, concluded that there were two discrete spawning events in western Atlantic bluefish. The first occurs during March-May near the edge of the continental shelf of the SAB. The second occurs between June and August in the MAB (Kendall and Walford 1979). Recent studies have re-examined this conclusion and refined our knowledge of a complex reproductive pattern, and support the concept of a single, migratory spawning stock (Hare and Cowen 1993; Smith et al. 1994). Sexual maturity and gonad ripening occur in early spring off Florida, early summer off North Carolina, and late summer off New York (Hare and Cowen 1993). In the New York Bight, gonadosomatic studies indicate that both sexes are ripe or ripening between June and September with a strong peak in July (Chiarella and Conover 1990). Larvae re-occur in the SAB in the fall (Collins and Stender 1987) and there are also indications that gonads reach a second peak in ripeness in fish off Florida in September. Most bluefish are mature by age 2 (Deuel 1964). A recent study using histological methods indicates that bluefish are likely group-synchronous batch spawners (Reiss et al. 2002). In South Africa, individuals may spawn repeatedly over a period of 5-6 months (Van der Elst 1976), but there is no comparable information for the U.S. population.

Development, growth and movement patterns

Eggs from the MAB are pelagic and spherical with a diameter of 0.95-1.00 mm. They have a smooth, transparent shell and a homogeneous yolk. The single oil globule is 0.26-0.29 mm in diameter and the perivitelline space is narrow (Fahay 1983). Incubation times depend on temperature. At 18.0-22.2°C, hatching occurs after 46-48 h (Deuel et al. 1966). Eggs from the SAB have not been described.

Larvae are 2.0-2.4 mm long when they hatch; the eyes are unpigmented and the mouth parts are undeveloped. Characteristic pigment includes parallel lines of melanophores along the dorsal fin base, body midline, and anal fin base. Teeth are well developed at 4.3 mm and fin rays are complete at a size of about 13- 14 mm (Fahay 1983). Larvae rarely occur deeper in the water column than 15 m; most are concentrated at a depth of about 4 m during the day, but they are about equally distributed between that depth and the surface at night (Kendall and Naplin 1981). The bluefish transforms from a larva to a "pelagic-juvenile" stage that is specially adapted for an oceanic, near-surface existence after completion of fin ray development. This specialized stage is characterized by a silvery, laterally compressed body, with dark blue counter-coloration on the dorsum. This transition occurs at an age of 18-25 d and at a size of 10-12 mm SL (Hare and Cowen 1994). Scales begin to form at about 12 mm on the posterior part of the lateral line region, then proceed forward, until the head is completely scaled at about 37 mm (Silverman 1975).

Swimming ability in many fish species dramatically improves during this transformation (e.g. Hunter 1981; Stobutzki and Bellwood 1994; Leis et al. 1996) and this improvement presumably applies to bluefish as well. It is during this stage that bluefish arrive at nursery areas in the central part of the MAB, after advection via the Gulf Stream from spawning areas in the SAB and after crossing the Slope Sea (Hare and Cowen 1996; Hare et al. 2001) and the continental shelf (Cowen et al. 1993).

Active larval migration across the shelf is believed to be aided by oceanographic features such as warm-core ring streamers and Gulf-Stream filaments (Hare et al. 2001), or Eckman transport (Munch and Conover 2000). This transport (active or passive) is crucial to the recruitment of these progeny to vital estuarine nursery areas, and therefore this life history stage might be considered a critical bottleneck.

Juveniles have a usual fish shape without unusual features. The caudal fin is forked and the body is somewhat laterally compressed, with a silvery, unpatterned color. The mouth is large and oblique and all fin spines are strong. Two distinct dorsal fins touch at their bases; the second dorsal fin is about the same length as the anal fin base (Able and Fahay 1998). The spring-spawned cohort is 60-76 d old with a mean size of 60 mm when they recruit to estuarine habitats in the MAB in late May to mid-June (McBride and Conover 1991; Cowen et al. 1993). The summer-spawned cohort either remains in coastal nursery areas (Kendall and Walford 1979; Able and Fahay 1998; Secor et al. 2002; Able et al. 2003) or enters estuarine nurseries in mid- to late August when they are 33-47 d old with a mean length of 46 mm (McBride and Conover 1991).

Juveniles of both cohorts depart MAB estuaries and coastal areas in October and migrate to waters south of Cape Hatteras, North Carolina. At this time, members of both cohorts range from 4-24 cm long (Able and Fahay 1998, Able et al. 2003). During most years, the spring-spawned cohort dominates in the emigrating young-of-the-year, although during the past decade, the summer-spawned cohort was dominant (Conover et al. 2003).

Ecological relationships

Food Habits

During their oceanic larval stage, bluefish primarily consume copepods. Fish begin to be included in their diet at sizes of 30 mm, and by 40 mm, fish are the major diet item. Soon after this shift in diet, juveniles migrate inshore to occupy estuarine habitats (Marks and Conover 1993). The results of several studies suggest that bluefish juveniles and adults eat whatever taxa are locally abundant (Table 4.2-6). The components of young-of-the-year bluefish diet in Sandy Hook Bay, New Jersey and the effects of those components on condition were studied over a three-year period (Friedland et al. 1988). Fish dominated the diet during 1981, while crustaceans and polychaetes were more important during 1983 and 1984. Weight-length relationships indicated that weight at length was significantly greater in 1981 than in the other two years. Thus, not only does the quality of diet differ between estuaries, but the method of foraging may also differ; more benthic foraging was evident in bluefish from Sandy Hook Bay than in bluefish sampled in estuaries in Delaware (Grant 1962) and North Carolina (Lassiter 1962). In the Chesapeake Bay, oyster bar and reef habitats provide an important source of benthic prey, particularly during time periods when preferred small pelagic fish prey are less abundant (Harding and Mann 2001). Depending on age class, diets might change through a season. Spring spawned young-of-the-year prey on invertebrates such as small and shrimp in early summer when the preferred fish prey are less available (Juanes et al. 2001). In Chesapeake Bay, diets of three age classes differed through the summer (Table 4.2-6), but all three concentrated on *Brevoortia tyrannus* in the fall (Hartman and Brandt 1995a, b).

In ocean habitats, young-of-the-year bluefish switch to piscivory with increasing size, similar to estuarine habitats. By 80-100 mm FL bay anchovy become the primary fish prey along ocean beaches in New Jersey (Able et al. 2003). Similar dietary patterns have been observed in juvenile bluefish utilizing ocean habitat in coastal Maryland (Secor et al. 2002) and throughout the MAB (Table 4.2-6). During offshore residence as larger adults, bluefish target larger schooling species of prey such as squids, clupeids and butterfish (Table 4.2-6) (Buckel et al. 1999).

Table 4.2-6. Dietary items of bluefish from several study areas.

Source	**Life History Stage and Study Location**	**Diet Items (in order of importance)**
Texas Instruments Incorporated (1976)	Young-of-the-year, Hudson River (tidal)	*Anchoa mitchilli* (dominated diet through summer), Clupeidae, *Microgadus tomcod*, *Alosa sapidissima*, *Notropis hudsonius*, Cyprinodontidae
Festa (1979)	11-20 cm, Little Egg Harbor estuary, NJ	*Fundulus* spp., Atherinidae, *Anchoa* spp., *Callinectes sapidus*, *Brevoortia tyrannus*, *Crangon septemspinosa*
Friedland et al. (1988)	Juvenile, Sandy Hook, NJ	1981: Teleosts, Crustacea, Polychaeta 1982: Crustacea, Teleostei, Polychaeta 1983: Crustacea, Teleostei, Polychaeta

		(weight at length significantly greater in 1981)
Hartman and Brandt (1995a, b)	Age 0, Age 1, and Age 2, Chesapeake Bay (Diets of all age classes changed through season)	Age 0: *Anchoa mitchilli*, *Menidia menidia*, *Brevoortia tyrannus* Age 1: *Leiostomus xanthurus*, *A. mitchilli*, *M. menidia*, *B. tyrannus* Age 2: *Micropogonias undulatus*, *A. mitchilli*, *B. tyrannus* (*B. tyrannus* becomes important in diets of all age classes in Sep-Oct.)
Buckel and Conover (1997)	Young-of-the-year, Hudson River estuary	Unidentified fish, *Anchoa mitchilli*, *Alosa* spp., *Morone saxatilis*, *Morone americana*
Buckel et al. (1999)	Young-of-the-year, Hudson River estuary	*Morone saxatilis*, *Anchoa mitchilli*, *Menidia menidia*, *Alosa* spp.
Buckel et al. (1999)	Georges Bank and Middle Atlantic Bight continental shelf Young-of-the-year Adult	1994-1995 Bay anchovy, squid, butterfish, striped anchovy, round herring Squid, butterfish, and clupeids.
Juanes et al. (2001)	Young-of-the-year, Great South Bay, NY	Sand shrimp, YOY *Menidia* spp., unidentified fish, menhaden, sand worms
Harding and Mann (2001)	20 – 40 cm Chesapeake Bay	Other fish, polychaete worms, clupeids, unidentified fish, crustacea.
Buckel and McKown (2002)	New York Bight embayments (western Long Island and Staten Island) Young-of-the-year	*Menidia menidia*, *Anchoa mitchilli*, unidentified fish, sand shrimp, mysids, amphipods, polychaete worms, other invertebrates
Able et al. (2003)	Coastal NJ, ocean beaches Young-of-the-year	*Anchoa* spp., unidentified fish, decapods, *Menidia* spp., copepods, amphipods
NEFSC food	All ages (mean	1973-1980: Unidentified fish, *Illex* spp.,

Habits database [sampling conducted during seasonal surveys on the continental shelf from the Gulf of Maine to Cape Hatteras from 1973 to the present; see Link and Almeida (2000) for methodology]	size 35.6 mm FL), continental shelf, Georges Bank and Middle Atlantic Bight Small (< 30 cm FL) Medium (>30 cm to < 70 cm FL) Large (> 70 cm FL)	*Etrumeus teres*, *Loligo* spp., *Peprilus triacanthus*, Cephalopoda 1981-2003: *Anchoa* spp., Unidentified fish, *Peprilus triacanthus*, *Ammodytes dubius*, *Loligo* spp., *Clupea harengus* 1981-2003: *Clupea harengus*, Unidentified fish, squids, *Peprilus triacanthus*, *Anchoa* spp., 1981-2003: Unidentified fish, squids, *Clupea harengus*, gadids, *Ammodytes* spp., *Anchoa* spp., flatfish, sculpins, butterfish

Predation
Sharks, tunas, and billfishes are the only predators large and fast enough to prey on adult bluefish. They are a major component in the diet of shortfin mako shark, composing 77.5% of the diet by volume (Stillwell and Kohler 1982; Wood 2002). Stillwell and Kohler (1982) estimated that this shark may consume between 4.3 and 14.5% of the bluefish resource between Georges Bank and Cape Hatteras. Bluefish also ranked fourth in number and occurrence and third in volume in swordfish diets, especially off the Carolinas (Stillwell and Kohler 1985). A study of bluefin tuna diet in New England ranked bluefish as one of the top prey items (Chase 2002). Blue sharks and sandbar sharks also prey on bluefish (Kohler 1988; Medved et al. 1985). Young-of-the-year are preyed upon by four oceanic bird species, the Atlantic puffin, Arctic tern, common tern, and roseate tern (Creaser and Perkins 1994; Safina et al. 1990). Cannibalism has only rarely been reported, but occurs in age 1 and older year classes in North Carolina (Lassiter 1962), and bluefish compose a minor component of the diet of larger bluefish collected during NEFSC bottom trawl surveys on the continental shelf from the Gulf of Maine to Cape Hatteras [NEFSC food habits database; see Link and Almeida (2000) for details on methodology].

Migrations
Bluefish are warm water migrants and do not occur in MAB waters at temperatures < 14-16°C (Bigelow and Schroeder 1953). They generally move north in spring-summer to centers of abundance in the New York Bight and southern New England and south in autumn-winter to the waters in the SAB as far as southeastern Florida. There is a trend for larger individuals to occur farther north during the summer (Wilk 1977). Larger adults may limit their southward migration and spend the winter on the outer part of the continental shelf of the MAB, culminating in an aggregation of fish near Cape Hatteras, NC by March.

This winter distribution is suggested by the occurrence of bluefish in commercial catches as reported in vessel logbooks (Shepherd et al., in press). This conclusion is also supported by historical anecdotal evidence. One report witnessed a single fish landed from about 100 m deep off Martha's Vineyard during mid-January 1950 and several hauls of 80-640 kg from the vicinity of Hudson Canyon during early February of the same year (Bigelow and Schroeder 1953). Another study simply reported "boats engaged in the winter trawl fishery for fluke and scup along the outer margin of the continental shelf often bring in a few bluefish" (Hamer 1959). These reports have been perpetuated since (Lund 1961; Miller 1969; Lund and Maltezos 1970; Hardy 1978). Recent winter trawl surveys indicate the presence of bluefish in the MAB during winter near the shelf edge off Cape Hatteras.

Abundance and status of stocks

The Southeast Area Monitoring and Assessment Program (SEAMAP) surveys sampled the coastal region between Cape Hatteras, North Carolina and Cape Canaveral, Florida [see Reid et al. (1999) for details]. After an initial several years when gear and methods were not standardized, methodology became synoptic and standardized between 1990 and 1996 (Beatty and Boylan 1997; Boylan et al. 1998). Bluefish collected during the latter survey period are shown in Figure 4.2-10a. Length frequencies of these collections indicate most were young-of-the-year or age 1 (Figure 4.2-10b). Information on distributions over the offshore portions of the SAB shelf are lacking for any size class. Monthly occurrences of these bluefish are shown in Figure 4.2-10c. Occurrences decreased during spring, were at low levels during summer, and increased during October beginning in the northern part of the bight, which suggests an influx of migrating young-of-the-year from the MAB.

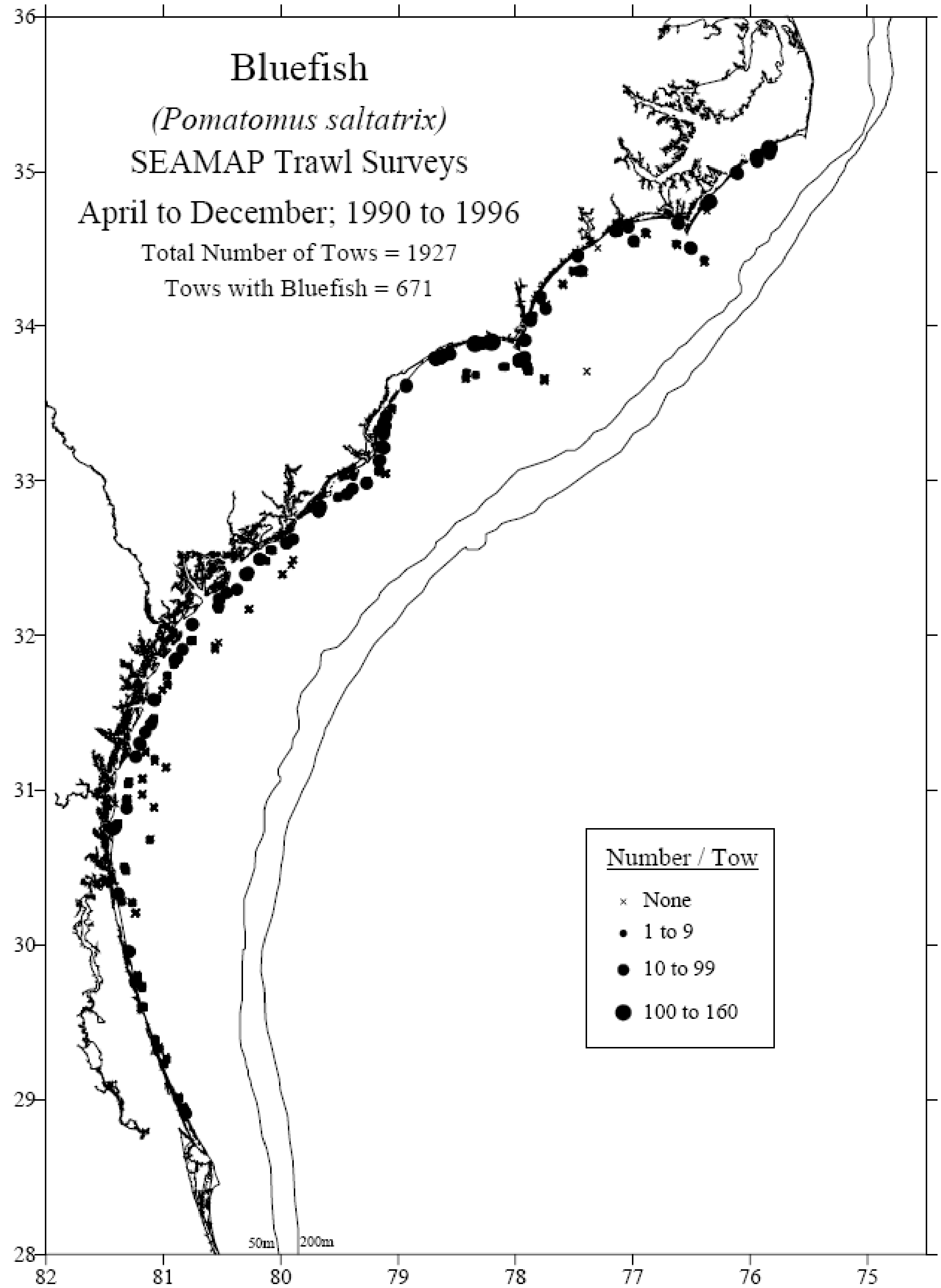


Figure 4.2-10a. Distribution and abundance of bluefish in the South Atlantic Bight collected during SEAMAP bottom trawl surveys [1990-1996, all years combined; see Reid et al. (1999) for details].

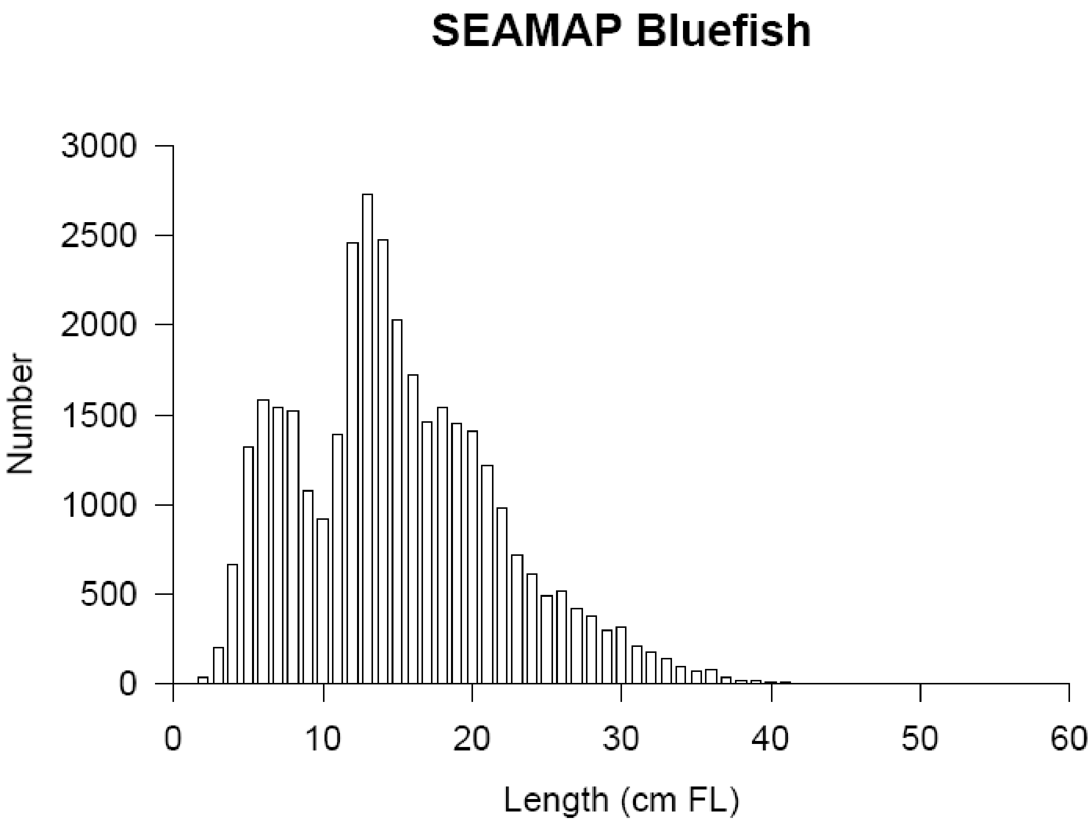


Figure 4.2-10b. Length frequency distribution of bluefish in the South Atlantic Bight collected during SEAMAP bottom trawl surveys (1990-1996, all years combined).

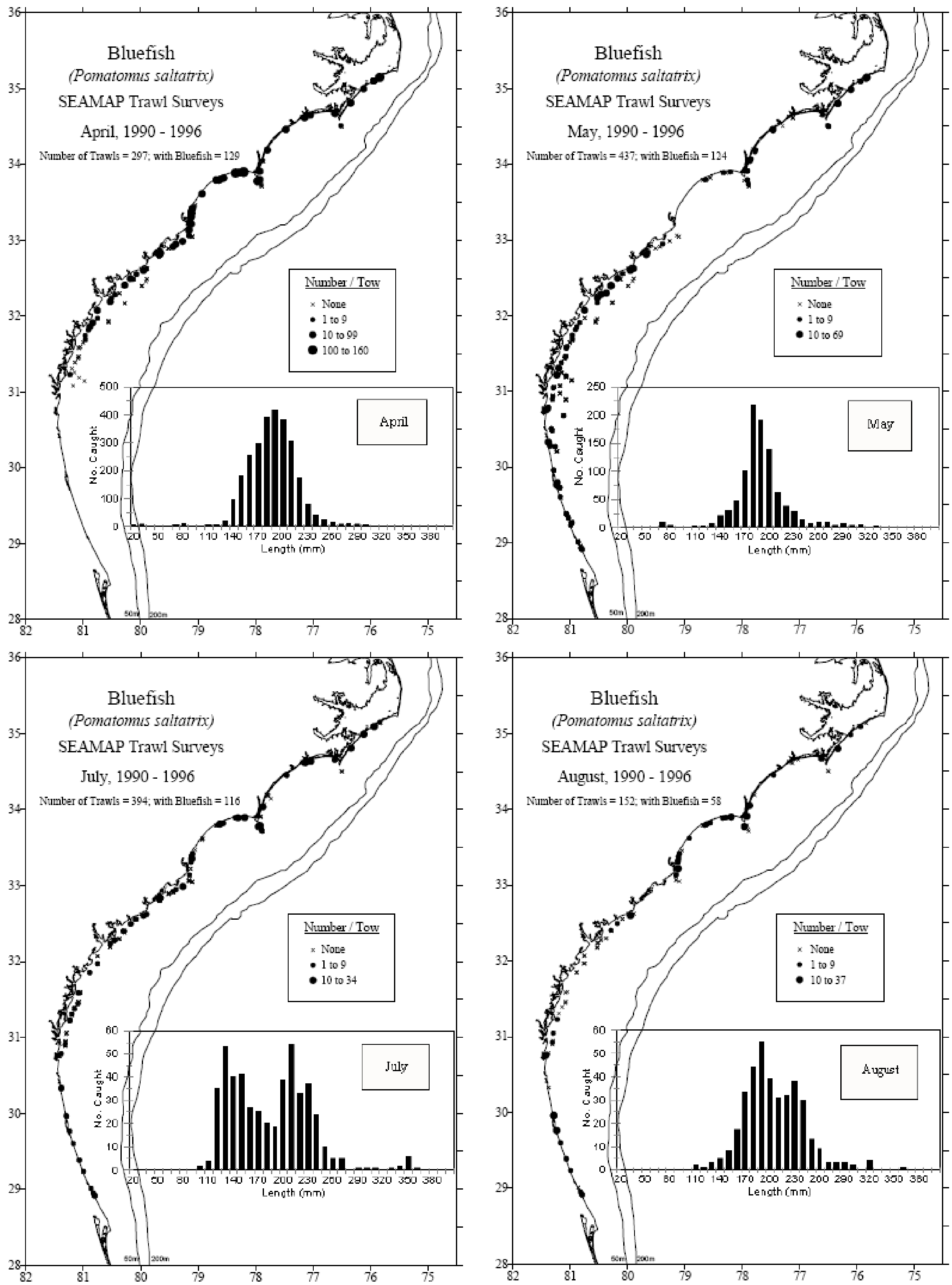


Figure 4.2-10c. Monthly distribution, abundance, and length frequency distribution of bluefish in the South Atlantic Bight collected during SEAMAP bottom trawl surveys (1990-1996, all years combined).

The 2003 update on the status of the stock indicated that fishing mortality rates on bluefish peaked in 1987 at F=0.718 and declined to F=0.184 in 2002. The current stock assessment estimates F=0.19, well below the 2003 and 2004 targets, 0.41 and 0.31, respectively. According to the biological reference points in Amendment 1, the stock is overfished but overfishing is not occurring. However, new biological reference points updated in 2005, but yet to be peer approved, suggest that the stock is not overfished and overfishing is not occurring. The total stock biomass is estimated at 92.3 million pounds for 2004.

4.2.15 Horseshoe Crab

Description and Distribution

(excerted from Horseshoe Crab Species Profile ASMFC 1998)
Although they are called horseshoe "crabs," they are neither a decapod nor a crustacean but are in their own class that is more closely related to the arachnids (i.e., spiders).
Horseshoe crabs have existed for more than 200 million years; however, some identify the evolutionary existence of horseshoe crabs to be over 400 million years.

Horseshoe crab distribution extends along the Atlantic coast from northern Maine to the Yucatan Peninsula and the Gulf of Mexico. Along the U.S. Atlantic coast, horseshoe crabs are most abundant between Virginia and New Jersey, with the Delaware Bay at the center of the species distribution and the location of the largest population.

Horseshoe crabs are typically associated with estuarine habitats. Adults either remain in the estuary or migrate to the continental shelf during the winter months. Migrations resume in the spring when the horseshoe crabs move to beach areas to spawn.
Juveniles hatch from the beach environment and spend the first two years in nearshore shallow, subtidal flats.

Reproduction

Spawning usually coincides with the high tide during the full and new moon. Breeding activity is consistently higher during the full moon than the new moon and is also greater during the night. Adults prefer sandy beach areas within bays and coves that are protected from surf. Eggs are laid in clusters or nest sites along the beach with females laying approximately 88,000 eggs per year in different egg clusters.

(from ASMFC's Horseshoe Crab FMP 1998)
Spawning adults prefer sandy beach areas within bays and coves that are protected from wave energy. Beach habitat also must include porous, well-oxygenated sediments to provide a suitable environment for egg survival and development (Botton et al. 1988). Optimal spawning areas are limited by the availability of suitable sandy beach habitat. However, spawning may occur along peat banks if there is sand in the upper intertidal regions and along the mouths of salt marsh creeks (Botton 1995). Shuster (1996) states that spawning may occur along muddy tidal stream banks, but not on peat banks because adults are sensitive to hydrogen sulfide and anaerobic conditions.

Spawning habitat varies throughout the horseshoe crab range. In Massachusetts, New Jersey, and Delaware, beaches are typically coarse-grained and well-drained as opposed to Florida beaches, which are typically fine-grained and poorly drained. These differences affect nest-site selection and nesting synchrony (Penn and Brockmann 1994).

Thompson (1998) found that preferentially selected spawning sites were located adjacent to large intertidal sand flat areas, which provide protection from wave energy and an abundance of food for juveniles.

Development, growth and movement patterns

Nursery Habitat

The shoalwater and shallow water areas of bays (e.g., Delaware Bay and Chesapeake Bay) are essential nursery areas (Botton 1995). Juveniles usually spend their first two years on intertidal sand flats (Rudloe 1981).

Thompson (1998) also found significant use of sand flats by juvenile horseshoe crabs in South Carolina. However, older juveniles and adults are exclusively subtidal, except during spawning.

Adult Habitat

Specific requirements for adult habitat are not known. Although horseshoe crabs have been taken at depths >200 meters, Botton and Ropes (1987a) suggest that adults prefer depths <30 meters. The NMFS Northeast Fishery Center bottom trawl surveys collected 92 percent of their horseshoe crabs at these depths, even though 73 percent of the sampling effort was expended in depths >27 meters. During spawning season adults typically inhabit bay areas adjacent to spawning beaches and feed on bivalves. In the fall, adults may remain in bay areas or migrate into the Atlantic Ocean to overwinter on the continental shelf.

Ecological relationships

(excerted from Horseshoe Crab Species Profile ASMFC 1998)

Horseshoe crab eggs play an important ecological role in the food web for migrating shorebirds and finfish. The Delaware Bay Estuary is the largest staging area for shorebirds in the Atlantic Flyway and an estimated 425,000 to one million migratory shorebirds converge on the Delaware Bay to feed and rebuild energy reserves prior to completing their northward migration. Horseshoe crabs also provide an important food source for Atlantic loggerhead turtles.

Juvenile and adult horseshoe crabs feed mainly on mollusks, although they also prey on a variety of benthic organisms and vascular plants. The horseshoe crab must molt or shed its chitinous exoskeleton to grow and can increase size by up to 25 percent after each molt. Molting occurs several times during the first two to three years of a horseshoe crab’s life. As it grows larger, more time occurs between molts. It usually takes 17 molts to reach sexual maturity (9 – 12 years).

Shorebirds

The Delaware Estuary is the largest staging area for shorebirds in the Atlantic Flyway and is the second largest staging site in North America (New Jersey Division of Fish, Game and Wildlife 1994). An estimated 425,000 to 1,000,000 migratory shorebirds converge on the Delaware Bay to feed and rebuild energy reserves prior to flying an additional 4,000 kilometers to complete their northward migration (Wander and Dunne 1982; Dunne et al. 1982; Clark et al. 1993). Migratory shorebirds arrive in Delaware Bay and adjacent areas along the Atlantic coast at the peak of horseshoe crab mating in mid-May through early-June, typically spending two weeks in the area. Clark (1996) stated that the number of shorebirds coming to the Delaware Bay on spring migrations is between 900,000 and 1.5 million from six species. At least 11 species of migratory birds use horseshoe crab eggs to replenish their fat supply during their trip from South American wintering areas to Arctic breeding grounds (Myers 1986). The principal shorebirds observed include ruddy turnstone (*Arenaria interpres*), red knot (*Calidris canutus*), semipalmated sandpiper (*Calidris pusilla*), sanderling (*Calidris alba*), dowitcher (*Limnodromus* spp.), and dunlin (*Calidris alpina*) (Dunne et al. 1982). Other shorebirds frequenting sandy beaches include western sandpiper (*Calidris mauri*), the federally listed (threatened) piping plover (*Charadrius melodus*), black-bellied plover (*Pluvialis squatarola*), semipalmated plover (*Charadrius semipalmatus*), and willet (*Catoptrophorus semipalmatus*) (Burger et al. 1977). The dominant species of shorebirds that use the Delaware Bay for staging are the red knot, ruddy turnstone, semipalmated sandpiper, and sanderling, representing approximately 88 percent of all shorebirds within the Delaware Bay (Gelvin-Innvaer 1996).

The Delaware Bay staging area is unique and of particular importance to shorebirds for the following reasons: shorebirds use few major stopovers during the spring migration; shorebirds arrive at stopover sites with little or no fat reserves; and, shorebirds demonstrate fidelity to staging areas (Wander and Dunne 1982). An estimated 80 percent and 30 percent of the hemispheric population of red knots and sanderlings, respectively, use the Delaware Bay as a staging area (American Bird Conservancy 1997).

Despite high shorebird abundance within the Delaware Bay, counts of sanderlings and semipalmated sandpipers declined significantly over a 7-year period from 1985 to 1992 (Clark et al. 1993). The decline in shorebirds in the Delaware Bay between 1986 and 1997 is statistically significant ($p<0.05$) (Clark and Niles, unpublished data 1997).

The Delaware Division of Fish and Wildlife also reports a 45 percent decline in peak counts of shorebirds from 1990-1996 compared to data from 1986-1989. The International Shorebird Survey also indicated a decline in sanderlings between 1975 and 1983. Declines in shorebird numbers may be the result of several threats, including the potential overharvest of horseshoe crabs.

During the 2-3 week staging period, shorebirds undergo weight gains of 40 percent or more (e.g., increasing body weight from 54 to 79 grams over 3 weeks) (Myers 1986). Much of this weight gain results from feeding on horseshoe crab eggs. In particular, sanderlings are estimated to consume as much as 30.9 grams of eggs per day per bird (approximately 8,300 eggs / day / bird). However, the estimated overall metabolic efficiency is low (i.e., 39 percent) and is among the lowest recorded value of a vertebrate feeding on food of animal origin, based on experiments on captive birds (Castro et al. 1989). Low metabolic efficiency is attributable to the high percentage of eggs that pass through the bird's digestive tract unbroken. Metabolic efficiency of broken horseshoe crabs eggs is much higher (e.g., 69 percent) than the metabolic efficiency of unbroken horseshoe crab eggs (Castro et al. 1989).

Tsipoura and Burger (1998) indicate that under natural conditions, assimilation efficiency of horseshoe crab eggs may be higher than suggested by Castro et al. (1989) because sand in the diet may assist in breaking and grinding down horseshoe crab eggs. Shorebirds require high daily energy inputs due to their high basal metabolic rates. In addition, shorebirds typically have high daily energy expenditures, and are among the longest-distance migrant animals in the world (Kersten and Piersma 1987; Myers et al. 1985). Castro et al. (1989) concluded that sanderlings (and possibly other shorebirds) compensate for low metabolizable energy of horseshoe crab eggs by consuming large quantities of eggs. This is possibly due to the sheer abundance of eggs, the ease in obtaining them, and the rapidity in which they pass through the digestive tract. Rather than probing below the surface of the substrate, shorebirds typically forage for horseshoe crab eggs as the eggs are uncovered by successive waves of nesting crabs and erosion from localized storms (Botton et al. 1994).

Horseshoe crab eggs are the most abundant food item on Delaware Bay beaches during the migratory staging of shorebirds. Botton et al. (1994) found few other available macroinvertebrates and concluded that shorebirds are feeding primarily on horseshoe crab eggs, largely because of their abundance. However, it is likely that shorebirds supplement their diet with ingestion of other food items during the stopover period (Botton 1984b).

Macroinvertebrate densities on the Delaware Bay beaches rarely exceeded 200/m2 during horseshoe crab spawning season and are several orders of magnitude less than horseshoe crab egg densities. As a result, shorebirds showed a preference for beaches with higher number of horseshoe crab eggs (Botton et al. 1994). Access to horseshoe crab eggs by shorebirds may be limited by tidal cycle, human disturbance, and competition among shorebirds and gulls. Burger et al. (1996) concluded that a mosaic of habitat types ranging from mudflats to high marshes is essential to sustain the high population of shorebirds using Delaware Bay during spring migration. In addition, Burger et al. (1996) documented the importance of marshes for foraging in several species of shorebirds. Shorebirds do abandon beaches at night to roost in isolated marshes. This is believed to be related to reducing risk of predation by nocturnal wildlife (Bryant and Pennock 1991). Clark et al. (1993) estimated that only 15-20 percent of semipalmated sandpipers and up to 30 percent of dunlins were observed in salt marshes (feeding on prey other than horseshoe crab eggs), as opposed to beaches.

Forage data (stomach contents) collected from sanderlings, ruddy turnstones, least sandpipers, semipalmated sandpipers, dunlins, and red knots on Delaware Bay beaches along the New Jersey coast (N=70) indicate that horseshoe crab eggs represent the majority of food items taken by shorebirds (15 to 95 percent) in 1996 and 1997, averaging 57.3 percent (Tsipoura and Burger 1998). As such, horseshoe crab eggs were not taken to the exclusion of other items, such as polychaete worms and arthropods. Based on fat-free weights, red knot, ruddy turnstone, sanderling, and semipalmated sandpiper increased body mass up to 70 to 80 percent while staging on Delaware Bay (Tsipoura and Burger 1998). This rate of weight gain is the highest recorded for any stopover site in the world and is considered to be the result of feeding on horseshoe crab eggs. Additionally, Tsipoura and Burger (1998) reported that the mass movement of shorebirds (from the New Jersey side to the Delaware side of the Delaware Bay) is correlated with availability of horseshoe crab eggs. The ruddy turnstone provides one possible exception to the interaction between horseshoe crab egg availability and bird distribution. These birds use their bill to dig into the sand and make holes that are several inches deep, thereby reaching the eggs that are buried deeper in the substrate.

Tsipoura and Burger (1998) found high concentrations of egg membranes in gut samples of ruddy turnstones that were captured on Thompson's Beach, New Jersey and hypothesized that the decline in abundance of surface eggs may not have been a deterrent to the foraging success of this species, as long as there were still sufficient numbers of eggs available in the lower strata.

Despite significant shorebird predation on horseshoe crab eggs, such activity probably has little impact on the horseshoe crab population (Botton et al. 1994). Horseshoe crabs place egg clusters at depths greater than 10 centimeters, which is deeper than most short-billed shorebirds can reach. Horseshoe crab eggs brought to the surface by wave action and burrowing activity by spawning horseshoe crabs that are available for shorebird predation would probably not survive to hatching due to heat stress or desiccation (Botton et al. 1994). Additionally, horseshoe crabs continue to spawn at least one month after the departure of most of the shorebirds. Horseshoe crab larval densities have been observed regularly exceeding 100,000/m2 in July and August (Botton et al. 1992). For these reasons, it is unlikely that shorebird predation has a substantial adverse impact on the reproductive success of horseshoe crabs in Delaware Bay.

The food supply provided by horseshoe crab eggs in Delaware has been estimated at 320 tons (Delaware Department of Natural Resources and Environmental Control 1987). Castro and Myers (1993) estimated the total energy requirement of shorebirds and calculated that 539 metric tons of horseshoe crab eggs would be needed to sustain the spring migration of shorebirds through the Delaware Bay (assuming the shorebirds ate only horseshoe crab eggs). Based on this estimate, Castro and Myers (1993) estimated that the total number of females needed to lay the eggs consumed by shorebirds is approximately 1,820,000. Assuming a sex ratio of 1:1, approximately 3,640,000 horseshoe crabs are required to sustain the shorebird migration stopover in Delaware Bay. However, these calculations assume that shorebirds feed exclusively on horseshoe crab eggs. Tsipoura and Burger (1998) indicated that horseshoe crab eggs are a significant part of shorebirds diet, but that diet is supplemented by other food resources. Botton et al. (1994) estimated that an average of 44,000 eggs/m^2 would be needed to sustain the entire shorebird population in the Delaware Bay. Their data indicate these densities currently occur within most Delaware Bay beaches. A significant decrease in the number of horseshoe crabs could leave a large portion of migrating shorebirds without either the necessary food resources to complete their trip to the Arctic breeding grounds or the necessary fat reserves upon arrival to initiate egg laying and incubation.

Finfish

Horseshoe crab eggs and larvae are a seasonal food item of invertebrates and finfish. In the Delaware River from May through August, striped bass (*Morone saxatilis*) and white perch

(*Morone americana*) eat horseshoe crab eggs. American eel (*Anguilla rostrata*), killifish (*Fundulus* spp.), silver perch (*Bairdiella chrysoura*), weakfish (*Cynoscion regalis*), kingfish (*Menticirrhus saxatilis*), silversides (*Menidia menidia*), summer flounder (*Paralichthys dentatus*), and winter flounder (*Pleuronectes americanus*) also eat eggs and larvae (Shuster, 1982). All crab species and several gastropods, including whelks, feed on horseshoe crab eggs and larvae. Shuster (1982) reported a large leopard shark (*Triakis semifasciatum*) preying on adult horseshoe crabs in southern Florida.

<u>Sea Turtles</u>
Lutcavage and Musick (1985) examined the stomach contents or excreta from 527 loggerhead turtles from Chesapeake Bay and nearby coastal waters and found that the most common prey was horseshoe crab. Musick et al. (1983) examined 27 loggerhead turtles and found horseshoe crabs commonly in stomach contents. Similarly, Lutcavage (1981) found that horseshoe crabs represented up to 42 percent of the diet of loggerhead turtles from Chesapeake Bay (N=6), averaging 22 percent. Data collected by the NMFS Sea Turtle Stranding and Salvage Network along the Atlantic Coast identified horseshoe crabs in 75 percent of loggerhead stomach contents in 1996 (N=8) and 55 percent in 1997 (N=11) (Evans, pers. comm., 1998). Morreale and Standora (1993) found no evidence of horseshoe crabs in loggerhead turtle diets in New York's Long Island Sound; however, diet largely depends on the relative abundance of prey species. Maintaining abundant stocks of adult horseshoe crabs may be an important component of ensuring the long-term survival of loggerhead sea turtles in the Chesapeake Bay area.

Abundance and status of stocks

(excerpted from the Horseshoe Crab FMP Review, ASMFC 2007)
The initial horseshoe crab stock assessment and peer review was conducted in 1998 (ASMF**C** 1999; ASMFC 1998). The Stock Assessment Subcommittee (SAS) and the Peer Review Panel (PRP) concluded that there was inadequate information for a coastwide stock assessment.

Information was not available to establish biological reference points, fishing mortality rates, or recruitment estimates. The Technical Committee and PRP, based on their assessment of the available data, recommended a conservative, risk-averse management approach. This recommendation was based on localized population declines, increased catch and effort, slow maturation, susceptibility of spawning crabs to harvest, population resiliency, and the need for a superabundance of horseshoe crab eggs in the Delaware Bay.

Under the five-year trigger, a horseshoe crab stock assessment update was conducted in 2003 (ASMFC 2004), which employed trend, power and meta-analyses. The addition of several new datasets and the longer time series allowed for improved trend detection. Once again, the assessment methodology was not, in itself, considered a complete stock assessment as it did not provide estimates of biological reference points or stock status. Such estimates are not expected until sufficient data are obtained and incorporated into a model proposed by the Horseshoe Crab Stock Assessment Subcommittee (HSC SAS 2000).

Results from the most recent assessment indicated that horseshoe crab abundance trends varied regionally/sub-regionally. There was no evidence of a decline in the Southeast Region between

1995 and 2003. Four of five indices in western Long Island Sound showed significant or marginally significant positive trends. No trend was detected in eastern Long Island sound.

However, indices trended downward since their peak in the early to mid-1990s and are at levels near or below those encountered in the mid-1980s. In the New England region, the Narragansett Bay data sets indicated population decline from the mid-1970s to present; however, the trends around Cape Cod were less clear. There was evidence that horseshoe crab abundance in Cape Cod was stable or declining.

Abundance measures in the Delaware Bay declined significantly during the 1990s. Declines from the late 1980s to early 1990s appear to be steeper than declines in recent years. However, the slopes of these declines were not statistically significant. The redesigned Delaware Bay spawning survey showed that bay-wide spawning activity has been stable from 1999 to 2006.

The SAS reviewed the results of three models/studies that focused on horseshoe crab population dynamics and abundance in the Delaware Bay region. It looked at a surplus production model, mark-recapture study, and age-structured model. The general picture that emerges from a synthesis of the assessments indicates that

1) relative abundance has declined through the 1990s to present,
2) relative fishing mortality rate has exceeded F_{MSY} since the mid-1990s with the F/F_{MSY} ratio peaking around 1998 and, on average, declining since then, and
3) current harvest rate is below 10%, but appears to be in excess of F_{MSY}.

4.2.16 Highly Migratory Pelagics

(excerpted from the 2006 Consolidated Highly Migratory Species FMP)

Tunas

Life History and Biology

Atlantic Bluefin Tuna

Atlantic bluefin tuna are distributed from the Gulf of Mexico to Newfoundland in the West Atlantic, from roughly the Canary Islands to south of Iceland in the East Atlantic, and throughout the Mediterranean Sea. Historically, catches of bluefin were made from a broad geographic range in the Atlantic and Mediterranean.

Atlantic bluefin tuna can grow to over 300 cm and reach more than 650 kg. The oldest age considered reliable is 20 years, based on an estimated age at tagging of two years and about 18 years at liberty, although it is believed that bluefin tuna may live to older ages. Bluefin tuna are, thus, characterized by a late age at maturity (thus, a large number of juvenile classes) and a long life span. These factors contribute to make bluefin tuna well adapted to variations in recruitment success, but more vulnerable to fishing pressure than rapid growth species such as tropical tuna species. Bluefin tuna in the West Atlantic generally reach a larger maximum size compared to bluefin caught in the East Atlantic.

Bluefin tuna in the West Atlantic are assumed to first spawn at age eight compared to ages four to five in the east Atlantic. Distribution expands with age; large bluefin are adapted for migration to colder waters. Bluefin tuna are opportunistic feeders, with fish, squid, and crustaceans common in their diet. In the West Atlantic, bluefin tuna are thought to spawn from mid-April into June in the Gulf of Mexico and in the Florida Straits. Juveniles are thought to occur in the summer over the continental shelf, primarily from about 35°N to 41°N and offshore of that area in the winter. In the East Atlantic, bluefin tuna generally spawn from late May to July depending on the spawning area, primarily in the Mediterranean, with highest concentrations of larvae around the Balearic Islands, Tyrrhenian Sea, and central and eastern Mediterranean where the sea-surface temperature of the water is about 24°C. Sexually mature fishes have also been recently observed in May and June in the eastern Mediterranean (between Cyprus and Turkey). Bluefin tuna are known to be highly migratory and the nature and extent of their ability to conduct transoceanic migrations are the subject of significant research (see FEP Volume V).

Atlantic Bigeye Tuna

The geographical distribution of bigeye tuna is very wide and covers almost the entire Atlantic Ocean between 50°N and 45°S. This species is able to dive deeper than other tuna species and exhibits extensive vertical movements. Similar to the results obtained in other oceans, pop-up tagging and sonic tracking studies conducted on adult fish in the Atlantic has revealed that they exhibit clear diurnal patterns being much deeper in the daytime than at night. Spawning takes place in tropical waters when the environment is favorable. From the nursery areas in tropical waters, juvenile fish tend to diffuse into temperate waters as they grow larger. Catch information from the surface gears indicate that the Gulf of Guinea is a major nursery ground for this species.

Dietary habits of bigeye tuna are varied such that prey organisms like fish, mollusks, and crustaceans are found in stomach contents. A growth study based on otolith and tagging data resulted in the adoption by the International Convention for the Conservation of Atlantic Tunas (ICCAT)'s Standing Committee on Research and Statistics (SCRS) of a new growth curve. The curve shows bigeye tuna exhibit relatively fast growth: about 105 cm in fork length at age three, 140 cm at age five and 163 cm at age seven. Bigeye tuna become mature at about age three and a half. Young fish form schools mostly mixed with other tunas such as yellowfin and skipjack. These schools are often associated with drifting objects, whale sharks and sea mounts. This association appears to weaken as bigeye tuna grow larger.

An estimate of natural mortality (M) for juvenile fish was provided based on the results of a tagging program. According to this study, mortality for juvenile fish only is at a similar level of M as that currently used for the entire Atlantic stock as well as the level of M used for all other oceans. Various evidence including; a genetic study, the time-area distribution of fish, and movements of tagged fish, suggest an Atlantic-wide single stock for this species, which is currently accepted by the SCRS. However, the possibility of other scenarios, such as north and south stocks, should not be disregarded.

Atlantic Yellowfin Tuna

Yellowfin tuna is a cosmopolitan species distributed mainly in the tropical and subtropical oceanic waters of the three oceans, where they form large schools. The sizes exploited range from 30 cm to 170 cm fork length (FL). Smaller fish (juveniles) form mixed schools with skipjack and juvenile bigeye, and are mainly limited to surface waters, while larger fish are found in surface and sub-surface waters. The majority of the long-term recoveries of tagged fish have been tagged in the western Atlantic and recovered in the eastern Atlantic, where several recaptures are recorded each year.

Sexual maturity occurs at about 100 cm FL. Reproductive output among females has been shown to be highly variable, although the extent of this is unknown. The main spawning ground is the equatorial zone of the Gulf of Guinea, with spawning occurring from January to April. Juveniles are generally found in coastal waters off Africa. In addition, spawning occurs in the Gulf of Mexico, in the southeastern Caribbean Sea, and off Cape Verde, although the relative importance of these spawning grounds is unknown.

Although such separate spawning areas might imply separate stocks or substantial heterogeneity in the distribution of yellowfin tuna, a single stock for the entire Atlantic is assumed as a working hypothesis (Atlantic Yellowfin Working Group, Tenerife, 1993), taking into account the transatlantic migration (from west to east) indicated by tagging, a 40-year time series of longline catch data that indicates yellowfin are distributed continuously throughout the entire tropical Atlantic Ocean, and other information (e.g., time-area size frequency distributions and locations of fishing grounds).

Growth patterns are variable with size, being relatively slow initially, and increasing by the time the fish leave the nursery grounds. Males are predominant in the catches of larger sized fish. Natural mortality is assumed to be higher for juveniles than for adults. Tagging studies for Pacific yellowfin supports this assumption. New data on biology and catches obtained from the Brazilian longline fishery were presented in 2004.

Atlantic Albacore Tuna
Albacore is a temperate tuna widely distributed throughout the Atlantic Ocean and Mediterranean Sea. For assessment purposes, the existence of three stocks is assumed based on available biological information: northern and southern Atlantic stocks (separated at 5°N), and a Mediterranean stock. Albacore spawning areas in the Atlantic are found in subtropical western areas of both hemispheres and throughout the Mediterranean Sea. Spawning takes place during austral and boreal spring-summer.

Sexual maturity is considered to occur at about 90 cm FL (age five) in the Atlantic, and at smaller size (62 cm, age two) in the Mediterranean. Until this age they are mainly found in surface waters, where they are targeted by surface gears. Some adult albacore are also caught using surface gears but, as a result of their deeper distribution, they are mainly caught using longlines. Young albacore tuna are also caught by longline in temperate waters.

Atlantic Skipjack Tuna
Skipjack tuna is a gregarious species forming schools in the tropical and subtropical waters of the three oceans. Skipjack spawn opportunistically throughout the year in vast areas of the Atlantic Ocean. The size at first maturity is about 45 cm for males and about 42 cm for females in the East Atlantic, while in the West Atlantic sexual maturity is reached at around 51 cm for females and 52 cm for males. Skipjack growth is seasonal, with substantial differences according

to the latitude. There remains considerable uncertainty about the variability of the growth parameters between areas. It is, therefore, a priority to gain more knowledge on the growth schemes of this species.

Skipjack is a species that is often associated with floating objects, both natural objects or fish aggregating devices (FADs) that have been used extensively since the early 1990s by purse seiners and baitboats (during the 1991 to 2003 period, about 55 percent of skipjack were caught with FADs). The concept of viscosity (low interchange between areas) could be appropriate for the skipjack stocks. A stock qualified as "viscous" can have the following characteristics:

- It may be possible to observe a decline in abundance for a local segment of the stock;
- Overfishing of that component may have little, if any, repercussion on the abundance of the stock in other areas; and,
- Only a minor proportion of fish may make large-scale migrations.

The increasing use of FADs could have changed the behavior of the schools and the migrations of this species. It is noted that, in effect, the free schools of mixed species were much more common prior to the introduction of FADs than now. These possible behavioral changes ("ecological trap" concept) may lead to changes in the biological parameters of this species as a result of the changes in the availability of food, predation and fishing mortality. Skipjack caught with FADs are usually found associated with other species. The typical catch with floating objects is comprised of about 63 percent skipjack, 20 percent small yellowfin, and 17 percent juvenile bigeye and other small tunas. A comparison of size distributions of skipjack between periods prior to and after the introduction of FADs show that, in the eastern Atlantic, there has been an increase in the proportion of small fish in the catches, as well as a decline in the total catch in recent years in some areas.

The SCRS reviewed the current stock structure hypothesis that consists of two separate management units, one in the east Atlantic and another in the West Atlantic, separated at 30^{o}W. The boundary of 30^{o} West was established when the fisheries were coastal, whereas in recent years the East Atlantic fisheries have extended towards the west, surpassing this longitude, and showing the presence of juvenile skipjack tuna along the Equator, west of 30°W, following the drift of the FADs. This implies the potential existence of a certain degree of mixing. Nevertheless, taking into account the large distances between the east and west areas of the ocean, various environmental constraints, the existence of a spawning area in the east Atlantic as well as in the northern zone of the Brazilian fishery, and the lack of additional evidence (e.g. transatlantic migrations in the tagging data), the hypothesis of separate east and west Atlantic stock is maintained as the most plausible alternative. On the other hand, in taking into account the biological characteristics of the species and the different fishing areas, smaller management units could be considered.

Abundance and status of stocks

(text in this section excerpted from Chapter 3 of the Consolidated HMS FMP)

Atlantic Bluefin Tuna

The last full stock assessments for western Atlantic Bluefin tuna were conducted in 2002 with the next scheduled for 2006. Although the next stock assessment will not be conducted until mid-2006, the 2005 SCRS reported a significant number of new research reports and studies (see FEP Volume V). The assessment results are similar to those from previous assessments (see Table 4.2-7 and Figure 4.2-11). They indicate that the spawning stock biomass (SSB) declined steadily from 1970 (the first year in the assessment time series) through the late 1980s, before leveling off at about 20 percent of the level in 1975 (which has been a reference year used in previous assessments). A steady decline in SSB since 1997 is estimated and leaves SSB in 2001 at 13 percent of the 1975 level. The assessment also indicates that the fishing mortality rate during 2001 on the SSB is the highest level in the series.

A noteworthy pattern of change in the fisheries since 1998 has been the trend of increase followed by a trend of decrease in catches to below TAC level. The reported total catches of western Atlantic bluefin tuna increased from about 2600 mt in 1998 to about 3,200 mt in 2002 and have subsequently fallen below 2,000 mt in 2004. The 2002 catches were the highest since 1981; however the 2004 catches were the lowest since 1982, when ICCAT catch restrictions were first established.

The Japanese longline fishery catch in the West Atlantic in 2003 was a substantial decrease from its 2002 catch level, but increased in 2004 to a level somewhat below its average catch from 1993 – 2002. This variation resulted from the adjustments made by Japan for previous quota overages. The Canadian reported landings remained at relatively stable levels over the past decade. Recent declines in U.S. landings have been attributed to a general lack of availability of large fish in the fisheries off the northeastern U.S. coast for the past several years.

Estimates of recruitment of age one fish have been generally lower since 1976. However, recruitment of age one fish in 1995 and 1998 is estimated to be comparable in size to some of the year classes produced in the first half of the 1970s. While the large decline in SSB since the early 1970s is clear from the assessment, the potential for rebuilding is less clear. Key issues are the reasons for relatively poor recruitment since 1976, and the outlook for recruitment in the future. One school of thought is that recruitment has been poor because the SSB has been low.

If so, recruitment should improve to historical levels if SSB is rebuilt. Another school of thought is that the ecosystem changed such that it is less favorable for recruitment and thus recruitment may not improve even if SSB increases. To address both schools of thought, the SCRS considered two recruitment scenarios as described below and summarized in Table 4.2-7 (East Atlantic Bluefin tuna summary data are also provided for comparison purposes). For both scenarios, the assessment indicates that the fishing mortality on the western Atlantic bluefin resource exceeds FMSY and the SSB is below BMSY (thus overfished according to ICCAT's objective of maintaining stocks at the MSY-biomass level and as indicated in NMFS, Report to Congress, Status of Fisheries, 2005).

Table 4.2-7. Summary Table for the Status of West Atlantic Bluefin Tuna. (Source: ICCAT, 2005.)

Age/size at Maturity	Age 8/~ 200 cm fork length
Spawning Sites	Primarily Gulf of Mexico and Florida Straits
Current Relative Biomass Level *Minimum Stock Size Threshold*	SSB_{01}/SSB_{75} (low recruitment) = .13 (.07-.20) SSB_{01}/SSB_{75} (high recruitment) = .13 (.07-.20) SSB_{01}/SSB_{msy} (low recruitment) = .31 (.20-.47) SSB_{01}/SSB_{msy} (high recruitment) = .06 (.03-.10) $0.86B_{MSY}$
Current Relative Fishing Mortality Rate *Maximum Fishing Mortality Threshold*	F_{01}/F_{MSY} (low recruitment) = 2.35 (1.72-3.24) F_{01}/F_{MSY} (high recruitment) = 4.64 (3.63-6.00) F/F_{MSY} = 1.00
Maximum Sustainable Yield	Low recruitment scenario: 3,500 mt (3,300-3,700) High recruitment scenario: 7,200 mt (5,900-9,500)
Catch (2004) including discards	~2,000 mt
Short Term Sustainable Yield	Probably > 3,000 mt
Outlook	Overfished; overfishing continues to occur

Summary Table for the Status of East Atlantic Bluefin Tuna. Source: ICCAT, 2005.

Age/size at Maturity	Age 4-5
Spawning Sites	Mediterranean Sea
Current Relative Biomass Level	SSB_{00}/SSB_{1970} = .86
Current Relative Fishing Mortality Rate	F_{00}/F_{MAX} = 2.4
Maximum Sustainable Yield	Not estimated
Current (2004) Yield	26,961 mt
Replacement Yield	Not estimated
Outlook	Overfished; overfishing continues to occur.

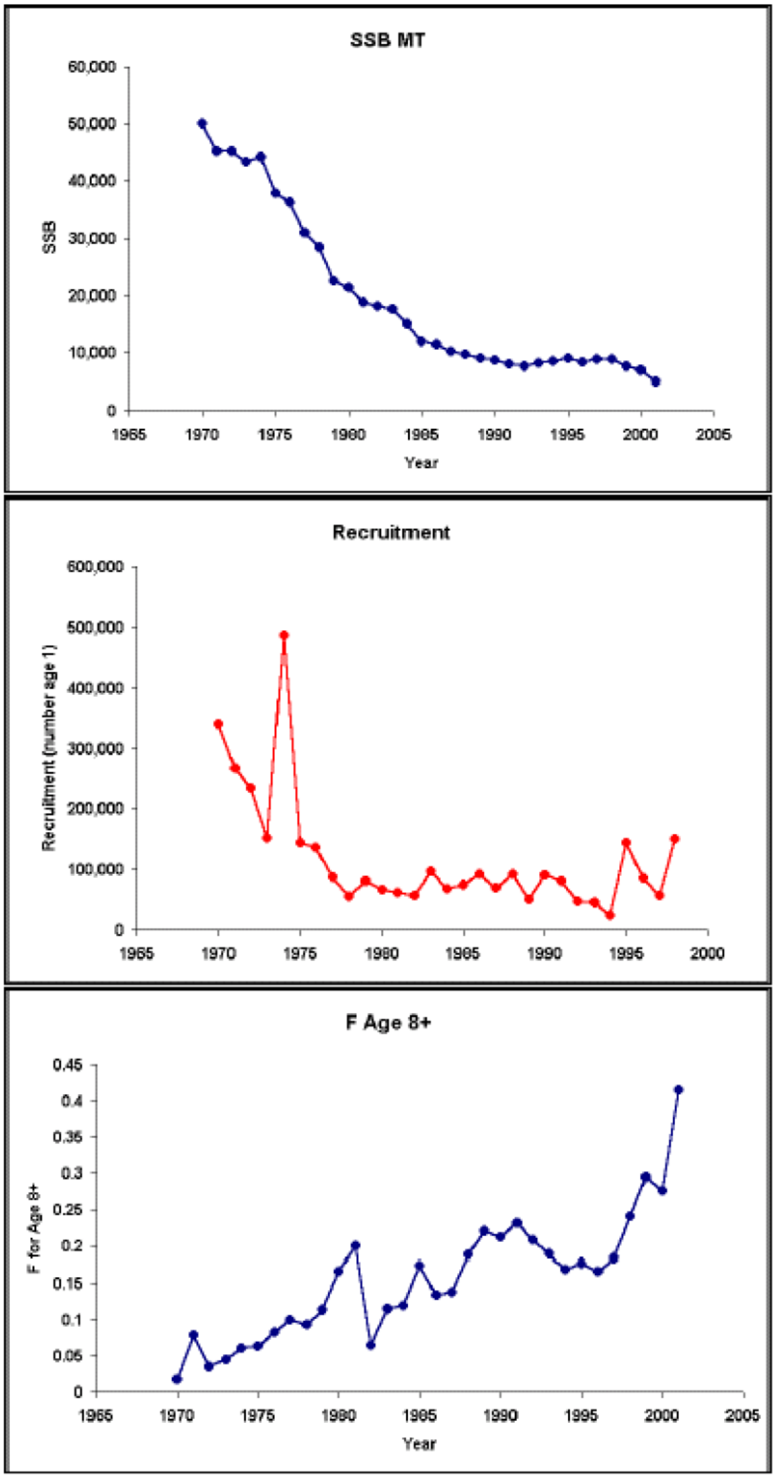


Figure 4.2-11. Western Atlantic bluefin tuna spawning biomass (t), recruitment (numbers) and fishing mortality rates for fish of age 8+, estimated by the Base Case VPA run. Source: ICCAT, 2004.

In general, the outlook for bluefin tuna in the West Atlantic is similar to the outlook reported based on the 2000 western Atlantic bluefin tuna assessment session.

The assessment and projection results for the present assessment are somewhat less optimistic than in 2000 but the confidence in the strength of the 1994 year class has increased. Therefore, the increases associated with different levels of future catch projected for the short-term are smaller but are estimated more confidently. It should be noted that the 1995 year class was estimated to be strong in 2000, but it is now estimated to be only of average strength.

Western Atlantic bluefin tuna catches have not varied very much since 1983 (the range over this period is 2,106 to 3,011 mt), and the estimated spawning stock size (Spawning Stock Biomass (SSB) measured as the biomass of fish age 8+) has been relatively stable, notwithstanding the indication of a decline in the most recent years. Thus, over an extended period of time, catches around recent levels have maintained stock size at about the same level, in spite of several past assessments that predicted the stock would either decline or grow if the current catch was maintained. This observation highlights the challenge of predicting the outlook for this stock.

In order to provide advice relative to rebuilding the western Atlantic bluefin resource, the SCRS conducted projections for two scenarios about future recruitment. One scenario assumed that future average recruitment will approximate the average estimated recruitment (at age one) since 1976, unless spawning stock size declines to low levels (such as the current level estimated in the assessment, but generally lower than estimates during most of the assessment history). The second scenario allowed average recruitment to increase with spawning stock size up to a maximum level no greater than the average estimated recruitment for 1970 to 1974. These scenarios are referred to as the low recruitment and high recruitment scenarios, respectively. The low and high recruitment scenarios implied that the BMSY (expressed in SSB) is 42 percent and 183 percent of the biomass in 1975, respectively. With the current information the SCRS could not determine which recruitment scenario is more likely, but both are plausible, and recommended that management strategies should be chosen to be reasonably robust to this uncertainty.

Table 4.2-8 below summarizes the results of projections of both scenarios at different catch levels. The projections for the low recruitment scenario estimated that a constant catch of 3,000 mt per year has an 83 percent probability of allowing rebuilding to the associated SSBMSY by 2018. A constant catch of 2,500 mt per year has a 35 percent probability of allowing rebuilding to the 1975 SSB by 2018.

The results of projections based on the high recruitment scenario estimated that a constant catch of 2,500 mt per year has a 60 percent probability of allowing rebuilding to the 1975 level of SSB, and there is a 20 percent chance of rebuilding SSB to SSBMSY by 2018. If the low recruitment scenario is valid, the TAC could be increased to at least 3,000 mt without violating ICCAT's rebuilding plan. If the high recruitment scenario is valid, the TAC should be decreased to less than 1,500 mt to comply with the plan.

The estimate of SSBMSY for the high recruitment scenario is critical to inferences regarding the probability of achieving rebuilding under different future levels of catch, and also less well determined by the data than SSBMSY for the low recruitment scenario.

In particular, the estimates of SSBMSY based on the high recruitment scenario are substantially larger than the largest spawning stock size included in the assessment. This extrapolation considerably increases the uncertainty associated with these estimates of SSBMSY. Previous meetings have used SSB1975 as a rebuilding target in the context of interpreting projections. Arguably SSB1975 is appropriate as a target level for interpreting the implications of projections based on the high recruitment scenario. Under such a target level for the high recruitment scenario, a TAC of 2,700 mt has an estimated probability of reaching the rebuilding level of about 50 percent.

The SCRS cautioned that these conclusions do not capture the full degree of uncertainty in the assessments and projections. An important factor contributing to uncertainty is mixing between fish of eastern and western origin. Furthermore, the projected increases in stock size are strongly dependent on estimates of recent recruitment, which are a particularly uncertain part of the assessment. A sensitivity test in which the estimates of the below average 1996 and the strong 1997 year classes were excluded from the analysis gave somewhat less optimistic results in terms of the estimated probabilities of recovery by 2018. However, these projections still predicted increases in spawning biomass for both recruitment scenarios, except for extreme increases in catch.

Table 4.2-8. Probability of western Atlantic bluefin tuna achieving rebuilding target by 2018. Source: ICCAT, 2004.

Catch	Low Recruitment Scenario		High Recruitment Scenario	
(MT)	SSB_{1975}	SSB_{MSY}	SSB_{1975}	SSB_{MSY}
500	95 %	100 %	98 %	73 %
1,000	89 %	100 %	96 %	62 %
1,500	77 %	100 %	87 %	47 %
2,000	60 %	99 %	75 %	30 %
2,300	45 %	98 %	66 %	24 %
2,500	35 %	97 %	60 %	20 %
2,700	26 %	95 %	52 %	17 %
3,000	14 %	83 %	38 %	11 %
5,000	0 %	1 %	2 %	0 %

Atlantic Bigeye Tuna
ICCAT's SCRS conducted a new stock assessment for bigeye tuna in July 2004 using various types of models. However, there were considerable sources of uncertainty arising from the lack of information regarding (a) reliable indices of abundance for small bigeye from surface fisheries, (b) the species composition of Ghanaian fisheries that target tropical tunas, and (c) details on the historical catch and fishing activities of Illegal, Unregulated, Unreported (IUU) fleets (e.g., size, location and total catch).

Three indices of relative abundance were available to assess the status of the stock (Figure 4.2-12). All were from longline fisheries conducted by Japan, Chinese Taipei and United States. While the Japanese indices have the longest duration since 1961 and represent roughly 20 - 40 percent of the total catch, the other two indices are shorter and generally account for a smaller fraction of the catch than the Japanese fishery. These three indices primarily relate to medium and large-size fish.

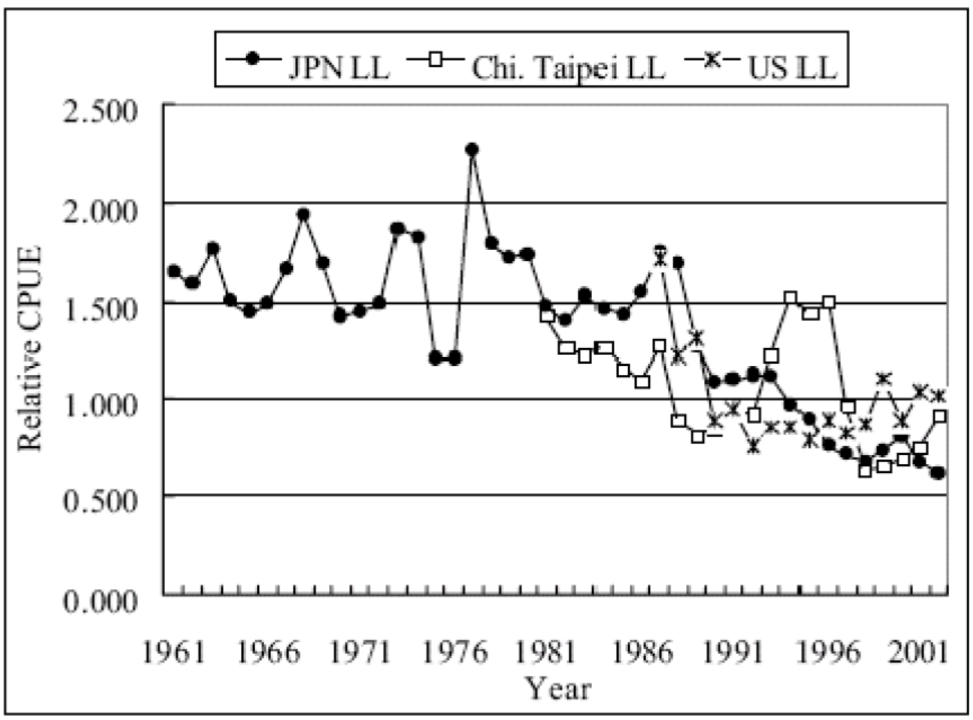


Figure 4.2-12. Abundance indices in numbers of Bigeye Tuna. All ages are aggregated. Source: ICCAT, 2004.

Various types of production models were applied to the available data and the SCRS notes that the current year's model fits to the data were better than in past assessments, although they required similar assumptions regarding stock productivity.

The point estimates of MSY obtained from different production models ranged from 93,000 mt to 113,000 mt. The lower limit of this range is higher than the one estimated in the 2002 assessment, probably due to the revised indices and the addition of a new index. An estimate obtained from another age-aggregated model was 114,000 mt. The inclusion of estimation uncertainty would broaden this range considerably.

These analyses estimate that the total catch was larger than the upper limit of MSY estimates for most years between 1993 and 1999, causing the stock to decline considerably, and leveling off thereafter as total catches decreased. These results also indicate that the current biomass is slightly below or above (85 – 107 percent) the biomass at MSY (Figure 4.2-13), and that current fishing mortality is also in the range of 73 percent to 101 percent of the level that would allow production of MSY (Table 4.2-9).

However, indications from the most targeted and wide ranging fishery are of a more pessimistic status than implied by these model results. Several types of age-structured analyses were conducted using the above-mentioned longline indices from the central fishing grounds and catch-at-age data converted from the available catch-at-size data. In general, the trajectories of biomass and fishing mortality rates are in accordance with the production model analyses. Model fits appeared improved over those of past assessments, apparently as a result of using a new growth curve for the calculation of catch at age.

The most noteworthy trend in fisheries observed is the general declining trend in catches for all gears after a high peak (121,000 mt) in 1999. After that, the total annual catch has steadily declined to a current low of 72,000 mt for 2004. The decline of longline catch is mostly attributable to the decrease of Japanese and estimated IUU catches while the other country/entity’s catches are generally maintained. Other gears (purse seine and baitboat) also indicated a similar but more variable decline. The decline of the Japanese catch is related to the reduced fishing effort as well as the declined CPUE in the major fishing grounds in tropical waters.

Among the fisheries catching bigeye, two changes are noted. One is an increase in catch from the northern Islands (Azores and Madeira) area due to baitboat fisheries after four years of low catch for 2000 – 2003. Another change is also observed for the fishing area of Japanese longline fishery. Since around 2001, some of the fleet had operated in central north Atlantic between 25°N – 35°N and 40°W – 75°W. In addition to the above changes in fisheries, several countries increased their individual catch levels in 2004, although the overall catch total did not significantly increase. Such increases are reported for Philippines (1,850 mt), Venezuela (1,060 mt) and Korea (630 mt). The current reported catch of Chinese Taipei for 2003 is considered under-estimated. Chinese Taipei will re-estimate the bigeye catch for 2003 in near future. The new estimate is expected to be higher than the current reported catch.

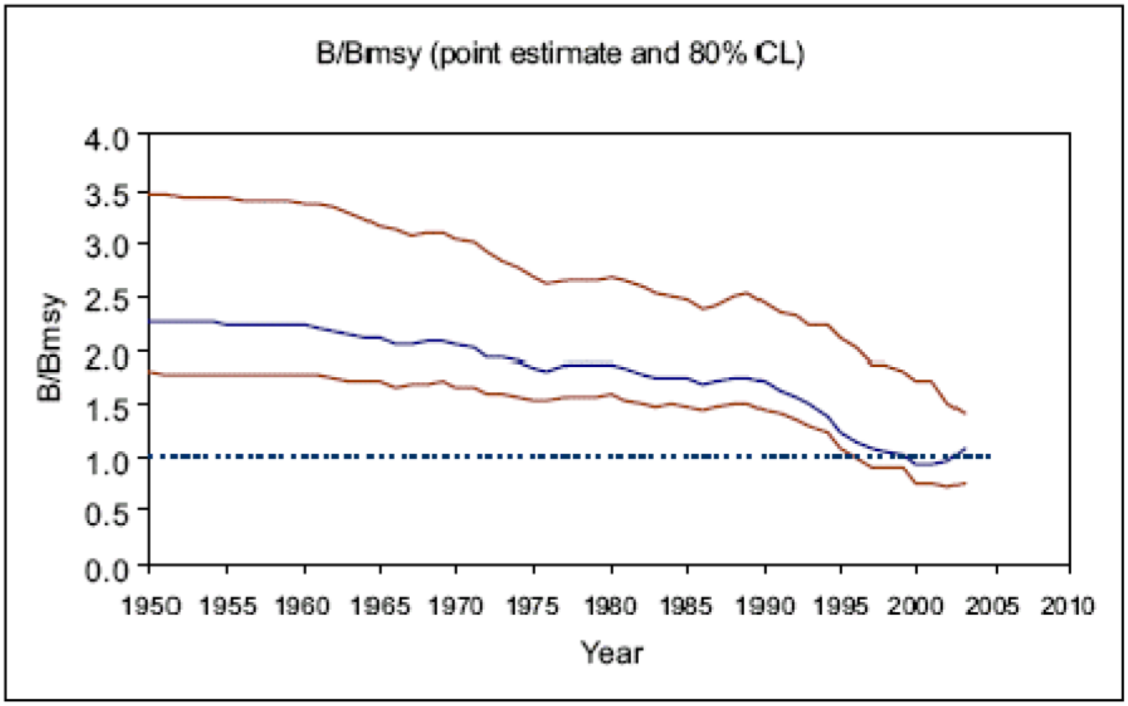


Figure 4.2-13. Trajectory of the Bigeye Tuna biomass modeled in production model analysis (middle line) bounded by upper and lower lines denoting 80 percent confidence intervals. Source: ICCAT, 2004.

Table 4.2-9. Summary Table for the Status of Atlantic Bigeye Tuna. Source: ICCAT, 2005.

Age/size at Maturity	Age 3/~100 cm curved fork length
Spawning Sites	Tropical waters
Current Relative Biomass Level *Minimum Stock Size Threshold*	B_{03}/B_{MSY} = 0.85 - 1.07 $0.6B_{MSY}$ (age 2+)
Current Relative Fishing Mortality Rate *Maximum Fishing Mortality Threshold*	F_{02}/F_{MSY} = 0.73-1.01 F_{year}/F_{MSY} = 1.00
Maximum Sustainable Yield	93,000 - 114,000 mt
Current (2003) Yield	85,000 mt
Current (2003) Replacement Yield	89,000 - 103,000 mt
Outlook	Overfished; overfishing is occurring

This assessment indicated that the stock has declined due to the large catches made since the mid-1990s to around or below the level that produces the MSY, and that fishing mortality exceeded FMSY for several years during that time period. Projections indicate that catches of more than 100,000 mt will result in continued stock decline. ICCAT should be aware that if major countries were to take the entire catch limit set under the ICCAT Recommendations and other countries were to maintain recent catch levels, then the total catch could exceed 100,000 mt. The SCRS highly recommended that catch levels of around 90,000 mt or lower be maintained at least for the near future for ICCAT to rebuild the stock.

Atlantic Yellowfin Tuna

A full assessment was conducted for yellowfin tuna in 2003 applying various age-structured and production models to the available catch data through 2001. Unfortunately, at the time of the assessment meeting, only 19 percent of the 2002 catch had been reported (calculated relative to the catch reports available at the time of the SCRS Plenary). The results from all models were considered in the formulation of the SCRS's advice.

The variability in overall catch-at-age is primarily due to variability in catches of ages zero and one (note that the catches in numbers of ages zero and especially one were particularly high during the period 1998 - 2001). Both equilibrium and non-equilibrium production models were examined in 2003 and the results are summarized in Table 4.2-10. The estimate of MSY based upon the equilibrium models ranged from 151,300 to 161,300 mt; the estimates of F2001/FMSY ranged from 0.87 to 1.29. The point estimate of MSY based upon the non-equilibrium models ranged from 147,200 - 148,300 mt. The point estimates for F2001/FMSY ranged from 1.02 to 1.46. The main differences in the results were related to the assumptions of each model. The SCRS was unable to estimate the level of uncertainty associated with these point estimates. An age-structured virtual population analysis (VPA) was made using eight indices of abundance. The results from this model were more comparable to production model results than in previous assessments, owing in part to a greater consistency between several of the indices used. The VPA results compare well to the trends in biomass (Figure 4.2-14) and fishing mortality (Figure 4.2-15) estimated from production models. The VPA estimates that the spawning biomass (Table 4.2-10) and the levels of fishing mortality (Table 4.2-10) in recent years have been very close to MSY levels. The estimate of MSY derived from these analyses was 148,200 mt.

In summary, the age-structured and production model analyses implied that although the 2001 catches of 159,000 mt were slightly higher than MSY levels, effective effort may have been either slightly below or above (up to 46 percent) the MSY level, depending on the assumptions. Consistent with these model results, yield-per-recruit analyses also indicated that 2001 fishing mortality rates could have been either above or about the level which could produce MSY. Yield-per-recruit analyses further indicated that an increase in effort is likely to decrease the yield-per-recruit, while reductions in fishing mortality on fish less than 3.2 kg could result in substantial gains in yield-per-recruit and modest gains in spawning biomass-per-recruit.

Table 4.2-10. Summary Table for the Status of Atlantic Yellowfin Tuna. Source: ICCAT, 2004.

Age/size at Maturity	Age 3/~110 cm curved fork length
Spawning Sites	Tropical waters
Relative Biomass Level *Minimum Stock Size Threshold*	B_{01}/B_{MSY} = 0.73 - 1.10 $0.5B_{MSY}$ (age 2+)
Relative Fishing Mortality Rate *Maximum Fishing Mortality Threshold*	F_{01}/F_{MSY} = 0.87 - 1.46 F_{year}/F_{MSY} = 1.00
Maximum Sustainable Yield	147,200 - 161,300 mt
Current (2003) Yield	124,000 mt
Replacement Yield (2001)	May be somewhat below the 2001 yield (159,000 mt)
Outlook	Approaching an overfished condition

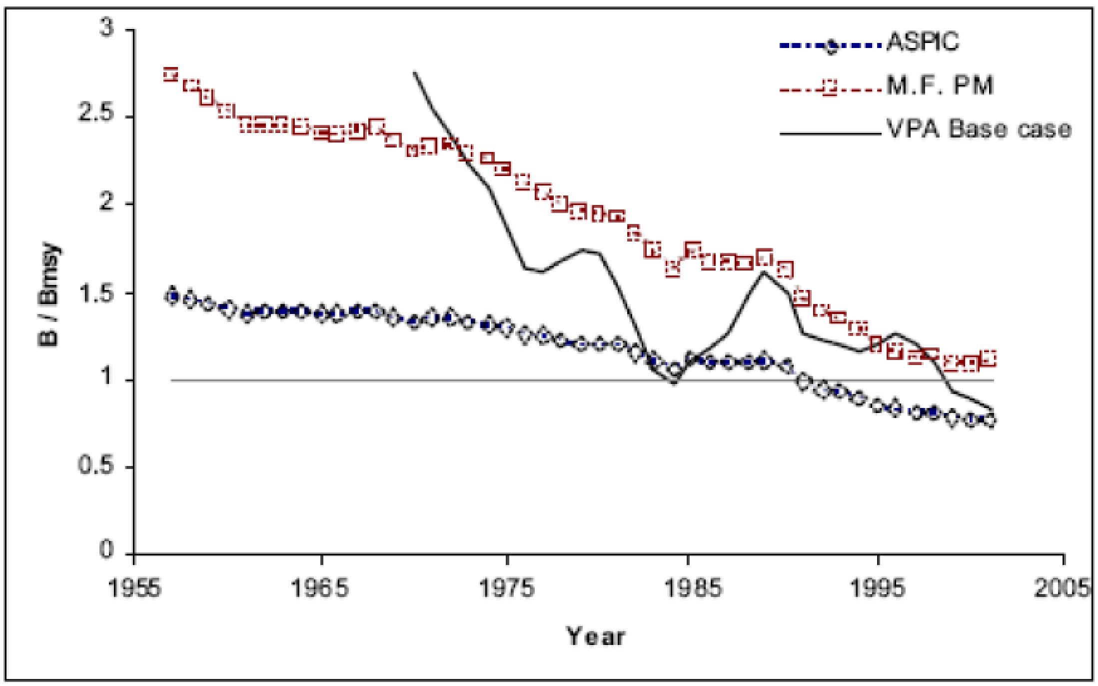


Figure 4.2-14. Comparison of relative biomass trends calculated using VPA and non-equilibrium production models. Source: ICCAT, 2004.

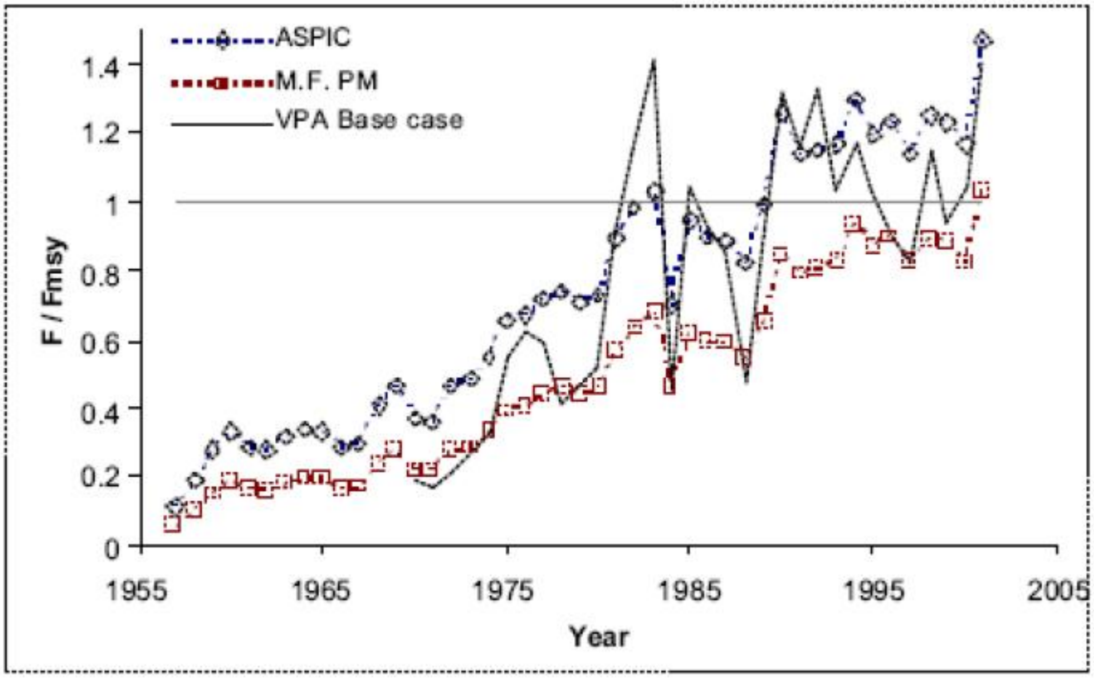


Figure 4.2-15. Comparison of relative fishing mortality trends calculated using VPA and non-equilibrium production models. Source: ICCAT, 2004.

In contrast to the increasing catches of yellowfin tuna in other oceans worldwide, there has been a steady decline in overall Atlantic catches since 2001. Atlantic surface fishery catches have shown a declining trend from 2001 to 2004, whereas longline catches have increased. In the eastern Atlantic, purse seine catches declined from 89,569 mt in 2001 to 58,632 mt in 2004, a 35 percent reduction. Baitboat catches declined by 23 percent, from 19,886 mt to 15,277 mt. This decrease is almost entirely due to reduced catches by Ghana baitboats, which resulted from a combination of reduced days fishing, a lower number of operational vessels, and the observance of the moratorium on fishing using floating objects. Catches by other baitboat fleets were generally increasing. In the western Atlantic, with the majority of the landings reported by the United States, Mexico, Venezuela, Brazil and St. Vincent and Grenadines, purse seine catches declined from 13,072 mt to 3,217 mt, a 75 percent reduction. In addition, baitboat catches also declined by eight percent from 7,027 mt to 6,735 mt. However, for the same time period, longline catches were increasing. In the eastern Atlantic, longline catches increased from 5,311 mt to 10,851 mt, a 104 percent increase. In the western Atlantic, longline catches increased from 12,740 mt to 15,008 mt, an 18 percent increase. At the same time, the nominal effort in the purse seine fishery was declining. As an indicator, the number of purse seiners from the European and associated fleet operating in the Atlantic declined from 46 vessels in 2001 to 34 vessels in 2004. On the other hand, the European and associated baitboat fleet increased from 16 to 22 vessels during the same period.

Of the relevant scientific documents presented to the 2005 SCRS, most were descriptive of the catches by country fleets. Three papers discussed observer programs in Ghana, Uruguay, and Spain, and three papers analyzed catches in the context of the moratorium. No new standardized catch rate information has been presented since the last assessment. However, examination of nominal catch rate trends from purse seine data suggest that catch-per-unit effort was stable or possibly declining since 2001 in the East Atlantic, and was clearly declining in the West Atlantic.

Since effort efficiency was estimated to have continued to increase, adjustments for such efficiency change would be expected to result in a steeper decline. Also, the average weights in European purse seine catches have been declining since 1994, which is at least in part due to changes in selectivity associated with fishing on floating objects.

Recent signals in the fishery data could result in a substantially different evaluation of stock status than that which is summarized above. It is important that the next assessment take these and other indicators (such as age of vessels and any loss of regional yellowfin fisheries) into account.

Atlantic Albacore Tuna

The last assessment of the northern stock was conducted in 2000, using data from 1975 to 1999, and that of the southern stock in 2003; no assessment of the Mediterranean stock has ever been carried out. To coordinate the timing of the assessments of northern and southern albacore tuna, the stock assessment for northern albacore was postponed at the 2004 ICCAT meeting from 2006 to 2007 (note the management measures for northern albacore expire at the end of 2006). The SCRS noted the considerable uncertainty that continues to remain in the catch-at-size data for the northern and southern stocks, and the profound impact this has had on attempts to complete a satisfactory assessment of northern albacore tuna.

North Atlantic

In 2003, the SCRS concluded that it was inappropriate to proceed with a VPA assessment based on the catch-at-age until the catch-at-size to catch-at-age transformation is reviewed and validated. In 2005, a document was presented on the analyses of catch-at-size and identifying the source of bias in the catch-at-age of the North Atlantic albacore stock. The SCRS recommends holding a data preparatory working group meeting to allow for a thorough revision of the North Atlantic stock prior to the next assessment in 2007. Consequently, the current state of the northern albacore stock is based primarily on the last assessment conducted in 2000 together with observations of CPUE and catch data provided to the SCRS in 2003. The results, obtained in 2000, showed consistency with those from previous assessments (Table 4.2-11a).

The SCRS noted that CPUE trends have varied since the last assessment in 2000, and in particular differed between those representatives of the surface fleets (Spain Troll age two and Spain Troll age three) and those of the longline fleets of Japan, Chinese Taipei, and the United States. The Spanish age two troll series, while displaying an upward trend since the last assessment, nonetheless declined over the last ten years. For the Spanish age three troll series, the trend in the years since the last assessment is down; however, the trend for the remainder of the last decade is generally unchanged. For the longline fleets, the trend in CPUE indices is either upwards (Chinese Taipei and United States) or unchanged (Japan) in the period since the last assessment. However, variability associated with all of these catch rate estimates prevented definitive conclusions about recent trends of albacore catch rates.

Equilibrium yield analyses, carried out in 2000 and made on the basis of an estimated relationship between stock size and recruitment, indicate that spawning stock biomass was about 30 percent below that associated with MSY. However, the SCRS noted considerable uncertainties in these estimates of current biomass relative to the biomass associated with MSY (BMSY), owing to the difficulty of estimating how recruitment might decline below historical levels of stock biomass. Thus, the SCRS concluded that the northern stock is probably below BMSY, but the possibility that it is above it should not be dismissed (Figure 4.2-16). However, equilibrium yield-per-recruit analyses made by the SCRS in 2000 indicate that the northern stock is not being growth overfished (F < Fmax).

In terms of yield per recruit, the assessment carried out in 2000 indicates that the fishing intensity is at, or below, the fully exploited level. Concerning MSY-related quantities, the SCRS recalls that they are highly dependent on the specific choice of stock-recruitment relationship. The SCRS believed that using a particular form of stock-recruitment relationship that allows recruitment to increase with spawning stock size provided a reasonable view of reality. This hypothesis together with the results of the assessment conducted in 2000 indicate that the spawning stock biomass (B1999) for the northern stock (29,000 mt) was about 30 percent below the biomass associated with MSY (42,300 mt) and that current F (2000) was about 10 percent above FMSY. However, an alternative model allowing for more stable recruitment values in the range of observed SSB values would provide a lower estimate of SSB at MSY, below the current value.

South Atlantic
In 2003, an age-structured production model, using the same specifications as in 2000, was used to provide a base case assessment for southern Atlantic albacore. Results were similar to those obtained in 2000, but the confidence intervals were substantially narrower in 2003 than in 2000 (Table 4.2-11b). In part, this may be a consequence of additional data now available, but the underlying causes need to be investigated further. The estimated MSY and replacement yield from the 2003 base case (30,915 mt and 29,256 mt, respectively) were similar to those estimated in 2000 (30,274 mt and 29,165 mt). In both 2003 and 2000, the fishing mortality rate was estimated to be about 60 percent of FMSY. Spawning stock biomass has declined substantially relative to the late 1980s, but the decline appears to have leveled off in recent years and the estimate for 2002 remains well above the spawning stock biomass corresponding to MSY.

Catches of albacore in the South Atlantic in 2001 and 2002 were above replacement yield, and were below estimates of MSY in 2003. Nevertheless, both the 2000 and 2003 albacore assessments estimated that the stock is above BMSY. There is now greater confidence in these estimates of MSY and therefore there is justification to base a TAC recommendation on MSY instead of replacement yield estimates from the model as in 2000. This results from the SCRS's view that current stock status is somewhat above BMSY and catch of this level, on average, would be expected to reduce the stock further towards BMSY. Recent estimates of high recruitment could allow for some temporary increase in adult stock abundance under a 31,000 mt catch, but this result is uncertain.

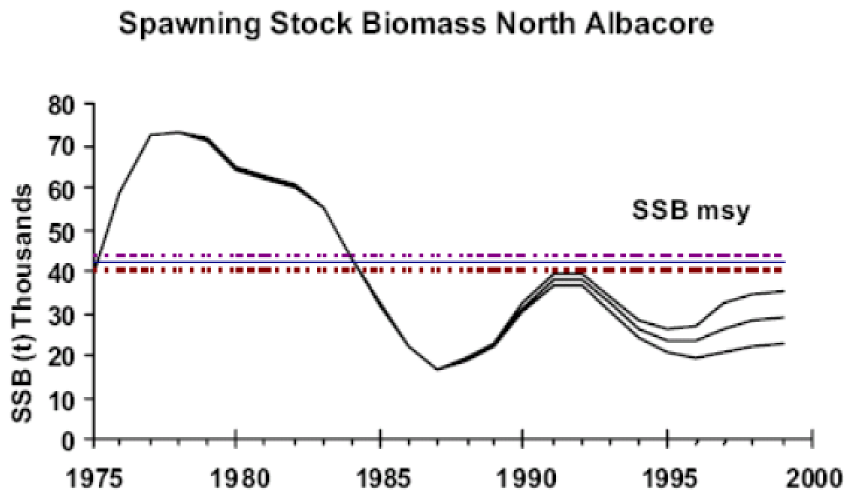


Figure 4.2-16. North Atlantic albacore spawning stock biomass and recruits with 80 percent confidence limits. Source: ICCAT, 2004.

Table 4.2-11a. Summary Table for the Status of North Atlantic Albacore Tuna. Source: ICCAT 2005.

Age/size at Maturity	Age 5/~90 cm curved fork length
Spawning Sites	Subtropical western waters of the northern Hemisphere
Current Relative Biomass Level *Minimum Stock Size Threshold*	B_{99}/B_{MSY} = 0.68 (0.52 - 0.86) $0.7B_{MSY}$
Current Relative Fishing Mortality Rate *Maximum Fishing Mortality Threshold*	F_{99}/F_{MSY} = 1.10 (0.99 - 1.30) F_{year}/F_{MSY}= 1.00
Maximum Sustainable Yield	32,600 mt [32,400 - 33,100 mt]
Current (2004) Yield	25,460 mt
Current (2004) Replacement Yield	not estimated
Outlook	Overfished; overfishing is occurring

Table 4.2-11b. Summary Table for the Status of South Atlantic Albacore Tuna. Source: ICCAT 2005.

Age/size at Maturity	Age 5/~90 cm curved fork length
Spawning Sites	Subtropical western waters of the southern Hemisphere
Current Relative Biomass Level	B_{02}/B_{MSY} = 1.66 (0.74 - 1.81)
Current Relative Fishing Mortality Rate	F_{02}/F_{MSY} = 0.62 (0.46 - 1.48)
Maximum Sustainable Yield	30,915 mt (26,333 - 30,915)
Current (2004) Yield	22,468 mt
Current (2004) Replacement Yield	29,256 mt (24,530 - 32,277)
Outlook	Not overfished; overfishing is not occurring

Atlantic Skipjack Tuna

The last ICCAT/SCRS assessment on Atlantic skipjack tuna was carried out in 1999 (Table 4.2-12). The state of the Atlantic skipjack stock(s), as well as the stocks of this species in other oceans, show a series of characteristics that make it extremely difficult to conduct an assessment using current models. Among these characteristics, the most noteworthy are:

- The continuous recruitment throughout the year, but heterogeneous in time and area, making it impossible to identify and monitor the individual cohorts;
- Apparent variable growth between areas, which makes it difficult to interpret the size distributions and their conversion to ages; and
- Exploitation by many and diverse fishing fleets (baitboat and purse seine), having distinct and changing catchabilities, which makes it difficult to estimate the effective effort exerted on the stock in the east Atlantic.

For these reasons, no standardized assessments have been carried out on the Atlantic skipjack stocks. Notwithstanding, some estimates were made, by means of different indices of the fishery and some exploratory runs were conducted using a new development of the generalized production model.

Eastern stock

Standardized catch rates are not available. However, an analysis was made, for the 1969 – 2002 period, of the different indices of the purse seine fishery that could provide valuable information on the state of the stock. For the majority of the indices, the trends were divergent, depending on the area, which may indicate the viscosity of the skipjack stock, with limited mixing rates between areas. Because of the difficulties in assigning ages to the skipjack catches, the estimates of the values of natural mortality by age and obtaining indices of abundance (especially for the eastern stock), no catch-by-age matrices were developed and, consequently, no analytical assessment methods were applied.

There is no quantified information available on the effective fishing effort exerted on skipjack tuna in the East Atlantic. It is supposed, however, that the increase in fishing power linked to the introduction to improved technologies on board the vessels as well as to the development of fishing under floating objects have resulted in an increase in the efficiency of the various fleets. An estimate of the increase in the coefficient of total mortality (Z) between the early 1980s and the end of the 1990s was carried out with a model using tagging data (Workshop on the mortality of juveniles in July 2005). For the range of sizes considered (about 40 – 60 cm FL), the increase in Z on the order of a factor 3 would reflect this increase in efficiency. This interpretation is supported by a comparison of skipjack size distributions in the East Atlantic between the periods prior to, and following, the use of FADs as an increase is observed in the proportion of small fish in the catches.

A document on the Spanish observer program on board purse seiners, presented during the 2005 SCRS, shows that for the 2001-2005 period the average rate of discards of skipjack tunas under FADs in the East Atlantic is estimated at 42 kg per ton of skipjack landed. In the West Atlantic, fishing effort of the Brazilian baitboats (which comprises the major skipjack fishery) decreased by half between 1985 and 1996, but seems to be stabilized since, after a slight increase.

Western stock

Standardized abundance indices up to 1998 were available from the Brazilian baitboat fishery and the Venezuelan purse seine fishery, and in both cases the indices seem to show a stable stock status. Uncertainties in the underlying assumptions for the analyses prevent the extracting of definitive conclusions regarding the state of the stock. However, the results suggest that there may be over-exploitation within the FAD fisheries, although it was not clear to what extent this applies to the entire stock. The SCRS could not determine if the effect of the FADs on the resource is only at the local level or if it had a broader impact, affecting the biology and behavior of the species. Under this supposition, maintaining high concentrations of FADs would reduce the productivity of the overall stock. However, since 1997, and due to the implementation of a voluntary Protection Plan for Atlantic tunas, agreed upon by the Spanish and French boat owners in the usual areas of fishing with objects, which later resulted in an ICCAT regulation on the surface fleets that practice this type of fishing, there has been a reduction in the skipjack tuna catches associated with FADs. Maintaining this closure would continue to have a positive effect on the resource. The development of nominal abundance indices of Brazilian baitboat fisheries and Venezuelan purse seiners, obtained up to 2004, seemed to show a stable stock status.

Table 4.2-12. Summary Table for the Status of West Atlantic Skipjack Tuna. Source: ICCAT 2005.

Age/size at Maturity	Age 1 to 2/~50 cm curved fork length
Spawning Sites	Opportunistically in tropical and subtropical waters
Current Relative Biomass Level *Minimum Stock Size Threshold*	*Unknown* *Unknown*
Current Relative Fishing Mortality Rate F_{2003}/F_{MSY} *Maximum Fishing Mortality Threshold*	*Unknown* $F_{year}/F_{MSY} = 1.00$
Maximum Sustainable Yield	*Not Estimated*
Current (2004) Yield	26,910 mt
Current Replacement Yield	*Not Estimated*
Outlook	*Unknown*

Swordfish

Life History and Biology

Swordfish are members of the family Xiphiidae, in the suborder Scombroidei. Atlantic swordfish (*Xiphias gladius*) are one of the largest and fastest predators in the Atlantic Ocean, reaching a maximum size of 530 kg (1165 lb). Like other highly migratory species, they have developed a number of specialized anatomical, physiological, and behavioral adaptations (Helfman et al. 1997). Swordfish are distinguished by a long bill that grows forward from the upper jaw. This bill differs from that of marlins (family Istiophoridae) in that it is flattened rather than round in cross section, and smooth rather than rough. Swordfish capture prey by slashing this bill back and forth in schools of smaller fish or squid, stunning or injuring their prey in the process. They may also use the bill to spear prey, or as a defense during territorial encounters. Broken swordfish bills have been found embedded in vessel hulls and other objects (Helfman et al. 1997).

Atlantic swordfish are usually found in surface waters but occasionally dive as deep as 650 meters. These large pelagic fishes feed throughout the water column on a wide variety of prey including groundfish, pelagics, deep-water fish, and invertebrates.

Swordfish show extensive diel migrations and are typically caught on pelagic longlines at night when they feed in surface waters (SCRS 2004). They are capable of migrating long distances to maximize prey availability and, as noted above, can prey upon various trophic levels during their daily vertical migrations (NMFS 1999). As adults and juveniles, swordfish feed at the highest levels of the trophic food chain, implying that their prey species occur at low densities. The foraging behavior of swordfish reflects the broad distribution and scarcity of appropriate prey; they often aggregate in places where they are likely to encounter high densities of prey, including areas near current boundaries, convergence zones, and upwellings (Helfman et al. 1997).

Swordfish move thousands of kilometers annually and are distributed globally in tropical and subtropical marine waters. Their broad distribution, large spawning area, and prolific nature have contributed to the resilience of the species in spite of the heavy fishing pressure being exerted on it by many nations. During their annual migration, North Atlantic swordfish follow the major currents which circle the North Atlantic Ocean (including the Gulf Stream, Canary and North Equatorial Currents) and the currents of the Caribbean Sea and Gulf of Mexico.

The primary habitat in the western north Atlantic is the Gulf Stream, which flows northeasterly along the U.S. coast, then turns eastward across the Grand Banks. North-south movement along the eastern seaboard of the United States and Canada is significant (NMFS 2003). They are found in the colder waters during summer months and all year in the subtropical and tropical area (SCRS 2003). Additional information on life history relating to habitat can be found in the 2006 Consolidated Highly Migratory Species FMP (NMFS 2006).

Like most large pelagic species, swordfish have adapted body contours that enable them to swim at high speeds. Their streamlined bodies are round or slightly compressed in cross section (fusiform), and their stiff, deeply forked tails minimize drag. This streamlined physical form is enhanced by depressions or grooves on the body surface into which the fins can fit during swimming. The extremely small second dorsal and anal fins of the swordfish may function like the finlets of tuna, reducing turbulence and enhancing swimming performance.

Their method of respiration, known as ram gill ventilation, requires continuous swimming with the mouth open to keep water flowing across the gill surfaces, thereby maintaining an oxygen supply. This respiratory process is believed to conserve energy compared to the more common mechanism whereby water is actively pumped across the gills (Helfman et al. 1997). In addition to the benefits of speed and efficiency, their search for prey is aided by coloring that provides camouflage in pelagic waters. This shading is darker along the dorsal side and lighter underneath, enhanced by silvery tones.

Swordfish exhibit other physiological characteristics that enable them to extend their hunting range. For example, swordfish can maintain elevated body temperatures, conserving the heat generated by active swimming muscles. Swordfish have developed a heat exchange system that allows them to swim into colder, deepwater in pursuit of prey. Because warm muscles contract faster than cool ones, heat conservation is believed to enable these predatory fishes to channel more energy into swimming speed. The internal temperatures of these fishes remain fairly stable even as they move from surface waters to deepwaters. Swordfish have also adapted specialized eye muscles for deepwater hunting. Because their eye muscles do not have the ability to contract, they produce heat when stimulated by the nervous system, locally warming both the brain and eye tissues (Helfman et al. 1997). With this modification, swordfish are able to hunt in the frigid temperatures of deep-water ocean environments without experiencing a decrease in brain and visual function that might be expected under such harsh conditions.

Juvenile swordfish are characterized as having exceptionally fast growth during the first year (NMFS 1999). Swordfish exhibit dimorphic growth, where females show faster growth rates and attain larger sizes than males. Young swordfish grow very rapidly, reaching about 130 cm lower jaw-fork length (LJFL) by age two. Swordfish are difficult to age, but 53 percent of females are considered mature by age 5, at a length of about 130 cm LJFL (SCRS, 2003; SCRS, 2004). Approximately 50 percent of males attain maturity by 112 cm LJFL (Arocha, 1997). All males are mature by 145 to 160 cm LJFL (37 to 50 kg ww), approximately age five, and all females are mature by 195 to 220 cm LJFL (93 to 136 kg ww), approximately age nine. In general, swordfish reach 140 cm LJFL (33 kg ww) by age three and are considered mature by age five. Individual females may spawn numerous times throughout the year (NMFS 1999).

Swordfish stocks consist of several age classes, a condition that may serve as a buffer against adverse environmental conditions and confer some degree of stability on the stocks.

Swordfish are also at a high trophic level, which may make the species less vulnerable to short-term fluctuations in environmental conditions (NMFS 1999).

When ICCAT's SCRS scientists assess the status of Atlantic swordfish, the stock is split between the North Atlantic, South Atlantic, and Mediterranean Sea. The SCRS continues to examine existing information, including spawning data, tagging information, genetic studies, and abundance indices to better define stock structure. For the purposes of domestic management, the swordfish population is considered to consist of two discrete stocks divided at 5° N.

Abundance and status of stocks

The most recent assessment of North and South Atlantic swordfish stocks was conducted in 2002. In that assessment, updated CPUE and catch data through 2001 were examined. Sex and age-specific (North Atlantic) and biomass standardized catch rates (North and South Atlantic) from the various fleets were updated. The updated North Atlantic CPUE data showed similar trends to previous years, and also showed signs of improvement in stock status since 1998. In particular, the recruitment index (1997 – 2001) and the catch-at-age used in the 2002 North Atlantic assessment showed signs of substantially improved recruitment (age one), which has manifested in several age classes and the biomass index of some fisheries, and have allowed for increases in spawning biomass and a more optimistic outlook. The strong recruitments of the late 1990s promoted improvement in spawning stock biomass and should result in further improvement, if these year classes are not heavily harvested. The CPUE patterns in the South Atlantic by fleet showed contradictory patterns. Lack of important CPUE information from some fleets fishing in the South Atlantic prevented the SCRS from reconciling these conflicts (SCRS, 2004).

North Atlantic Swordfish (all weights are given in whole weight)
An updated estimate of maximum sustainable yield from production model analyses is 14,340 mt (range 11,500 to 15,500 mt). Since 1997, North Atlantic swordfish catches have been estimated to have remained below 14,340 mt, but the most recent years are provisional and probably represent underestimates. Details of catches for recent years are presented below. The biomass at the beginning of 2002 was estimated to be 94 percent (range: 75 to 124 percent) of the biomass needed to produce MSY. This estimate is up from an estimate of 65 percent of MSY in the 1998 assessment. The 2001 fishing mortality rate was estimated to be 0.75 times the fishing mortality rate at MSY (range: 0.54 to 1.06). The replacement yield for the year 2003 and beyond was estimated to be about the MSY level. As the TAC for North Atlantic swordfish for 2002 was 10,400 mt, it was considered likely that biomass would increase further under those catch levels. The TAC set for 2003 – 2005 was 14,000 mt (ICCAT Recommendation 02 – 02). Given recent fishing mortality patterns, the spawning biomass likely will increase largely owing to the very large recruitments estimated for 1997 – 2000 (SCRS 2005). Further, given that recent (2002 – 2003) reported catch has been below estimated replacement yield, the North Atlantic swordfish biomass may have already achieved the BMSY level. However, noting the uncertainties inherent in the assessment, the SCRS warned against large increases over the current TAC (SCRS 2004). The next assessment is scheduled for 2006.

South Atlantic Swordfish
The SCRS noted that reported total catches have been reduced since 1995, as was recommended by the SCRS. SCRS had previously expressed serious concern about the trends in stock biomass of South Atlantic swordfish based on the pattern of rapid increases in catch before 1995 that could result in rapid stock depletion, and in declining CPUE trends of some bycatch fisheries. For the 2002 stock assessment, standardized CPUE series were available for three fleets, the targeted fishery of European Community (EC) - Spain, and the bycatch fisheries of Chinese Taipei and Japan. There was considerable conflict in trends among the three CPUE series and it is unclear which, if any, of the series tracks total biomass. It was noted that there was little overlap in fishing area among the three fleets, and that the three CPUE trends could track different components (or cohorts) of the population. To address this possibility, an age structured production model was run as a sensitivity test. For the base case production model, the Committee selected the bycatch CPUE series combined using a simple unweighted mean and the targeted CPUE series. Due to some inconsistencies in the available CPUE trends reliable stock assessment results could not be obtained (SCRS 2004). As stated above, the next assessment is scheduled for 2006.

Reported catches of Atlantic swordfish, including discards for the period 1950 – 2004 can be found in Figure 4.2-17. Estimated fishing mortality rate relative to the FMSY for the period 1959

– 2001 can be found in Figure 4.2-18a. Annual yield for North Atlantic swordfish relative to the estimated MSY can be found in Figure 4.2-18b. A summary of Atlantic swordfish stock status can be found in Table 4.2-13.

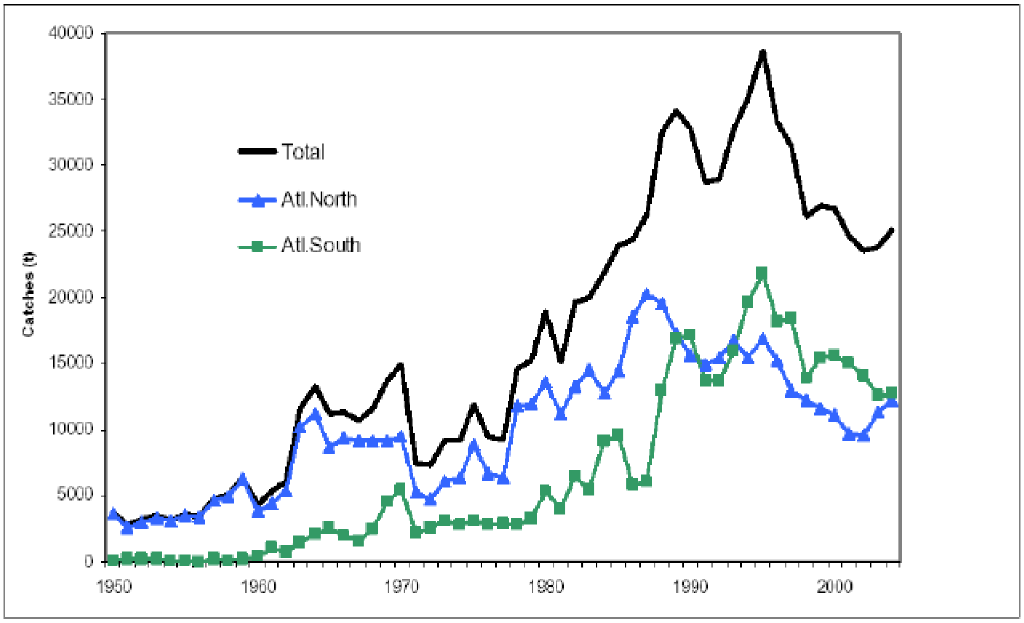


Figure 4.2-17. Reported catches (mt whole weight) of Atlantic Swordfish, including discards for 1950-2004. Source: SCRS 2005.

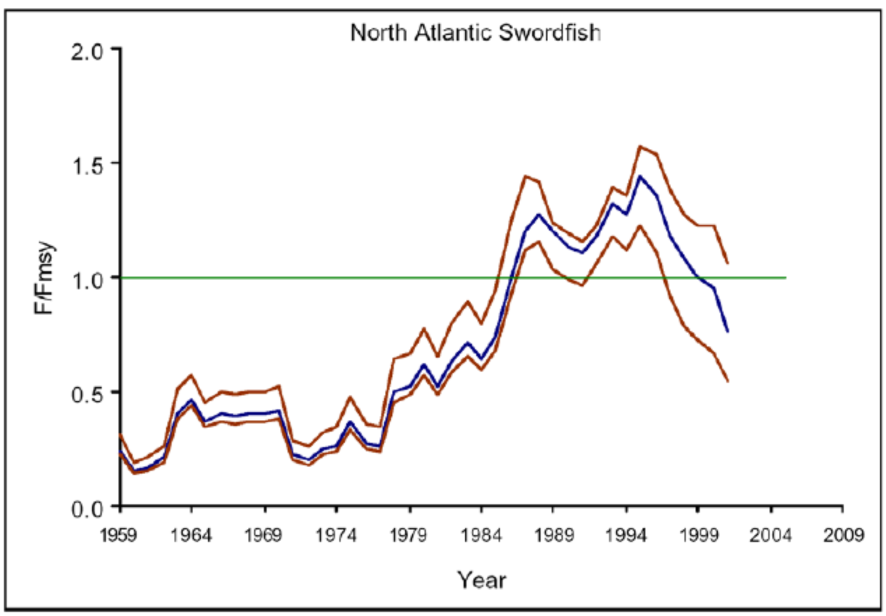


Figure 4.2-18a. Estimated fishing mortality rate relative to FMSY (F/FMSY) for the period 1959-2001 (median with 80 percent confidence bounds based on bootstrapping are shown). Source: SCRS 2004.

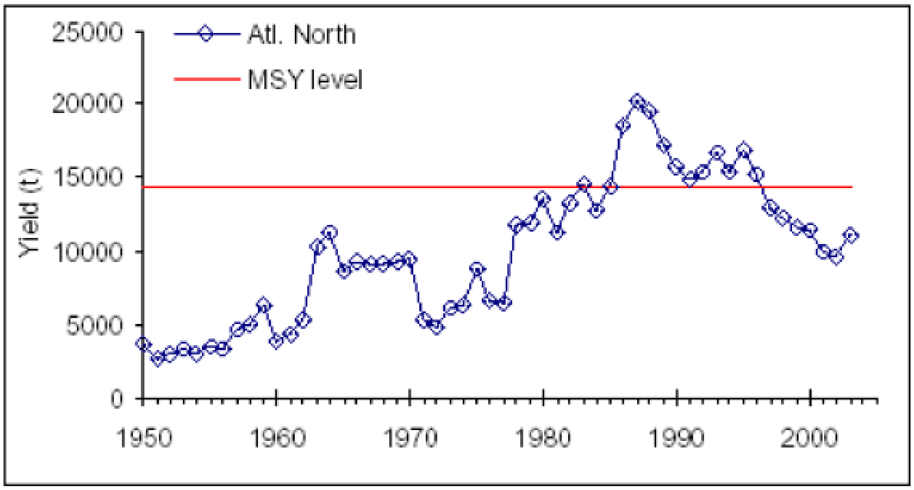


Figure 4.2-18b. Annual yield (mt) (whole weight) for North Atlantic swordfish relative to the estimated MSY level. Source: SCRS 2004.

Table 4.2-13. Atlantic Swordfish Stock Summary (weights given in mt ww). Source: SCRS 2005.

ATLANTIC SWORDFISH SUMMARY

	North Atlantic	**South Atlantic**
Maximum Sustainable Yield[1]	14,340 t (11,580-15,530)[4]	Not estimated
Current (2004) Yield[2]	12,283 t	12,779 t
Current (2002) Replacement Yield[3]	about MSY	Not estimated
Relative Biomass (B_{2002}/B_{MSY})	0.94 (0.75 - 1.24)	Not estimated
Relative Fishing Mortality		
F_{2001}/F_{MSY}[1]	0.75 (0.54 - 1.06)	Not estimated
F_{2000}/F_{max}	1.08	Not estimated
$F_{2000}/F_{0.1}$	2.05	Not estimated
$F_{2000}/F_{30\%SPR}$	2.01	Not estimated
Management Measures in Effect	Country-specific TACs [Rec. 02-02]; 125/119 cm LJFL minimum size.	TAC target [Ref. 02-03]; 125/119 cm LJFL minimum size [Rec. 02-02].

[1] Base Case production model results based on catch data 1950-2001.
[2] Provisional and subject to revision.
[3] For next fishing year.
[4] 80% confidence intervals are shown.

Billfish

Life History and Biology

Billfish are classified into the family Istophoridae in the suborder Scombroidei. These fishes are some of the largest and fastest predators in the sea and are distinguished by a long, round, rough bill (swordfish have a flat, smooth bill). Billfish capture prey fish by swimming through schools while slashing the bill back and forth to stun prey. Spearing fish can also be used for defensive purposes or during territorial encounters.

Billfish move thousands of kilometers annually throughout the world's tropical, subtropical, and temperate oceans and adjacent seas. Blue and white marlin are found throughout tropical and temperate waters of the Atlantic ocean and adjacent seas, and range from Canada to Argentina on the west side, and from the Azores to South Africa on the eastern side. Sailfish and spearfish have a pan-tropical distribution.

As adults and juveniles they feed at the top of the food web on a wide variety of fish and squid and are found predominately in the open ocean near the upper reaches of the water column.

Blue Marlin

Blue marlin (*Makaira nigricans*) range from Canada to Argentina in the western Atlantic and from the Azores to South Africa in the eastern Atlantic. Blue marlin are large apex predators with an average weight of 100 – 175 kg (220 – 385 lb). Female blue marlin grow faster and reach a larger maximum size than males. Young blue marlin are one of the fastest growing teleosts, reaching 30 – 45 kg (66 – 99 lb) after the first year. The maximum growth rate of these fish is 1.66 cm/day (0.65 inches/day) which occurs at 39 cm LJFL (15.3 inches) (NMFS 1999).

Life expectancy for blue marlin is between 20 – 30 years based on age and growth analyses of dorsal spines. Estimates of natural mortality rates for juvenile and adult billfish would be expected to be relatively low, generally in the range of 0.15 to 0.30, based on body size, behavior and physiology (NMFS, 1999). Sagitta otolith weight is suggested to be proportional to age, indicating that both sexes are equally long-lived, based on the maximum otolith weight observed for each sex. Predicting age from length or weight is imprecise due to many age classes in the fishery, and otoliths may provide a more accurate measure of age.

Blue marlin have an extensive geographical range, migratory patterns that include trans-Atlantic as well as trans-equatorial movements, and are generally considered to be a rare and solitary species relative to the schooling Scombrids (tunas). Graves et al. (2002) captured eight blue marlin with recreational fishing gear and then implanted fish with satellite pop-up tags. These fish moved 74 – 248 km (40–134 nautical miles (nm)) over five days, with a mean displacement of 166 km (90 nm). Fish spent the vast majority of their time in waters with temperatures between 22 and 26°C (71–78°F) and at depths less than 10 m. Prince et al. (2005) tagged one blue marlin with a PSAT tag off the coast of Punta Cana, Dominican Republic and found that this fish moved 406.2 km (219.3 nm) during a 40-d deployment (10.15 km/day (5.48 nm/day)). The maximum time at liberty recorded of a tagged individual was 4,024 days (about 11 years) for a blue marlin that was estimated to weigh 29.5 kg (65 lb) at the time of release. Junior et al. (2004) found the depth of capture for blue marlin with pelagic longline gear ranged from 50 – 190 m (164 – 623 feet), with most individuals captured at 90 m (295 feet).

The Cooperative Tagging Center (CTC) program has tagged 24,108 and recaptured over 220 blue marlin and found that these fish moved an average of 903 km (488 nm) (Ortiz et al. 2003). Some individuals have exhibited extended movement patterns, and strong seasonal patterns of movement of individuals between the United States and Venezuela are evident. A blue marlin released off Delaware and recovered off the island of Mauritius in the Indian Ocean represents the only documented inter-ocean movement of a highly migratory species in the history of the CTC. The minimum straight-line distance traveled for a blue marlin was 14,893 km (8,041 nm) and the maximum number of days at large was 4,024 d.

Adults are found primarily in the tropics within the 24°C (75°F) isotherm, and make seasonal movements related to changes in sea surface temperatures. In the northern Gulf of Mexico they are associated with the Loop Current, and are found in blue waters of low productivity rather than in more productive green waters. Off of Puerto Rico, the largest numbers of blue marlin are caught during August, September, and October. Equal numbers of both sexes occur off northwest Puerto Rico in July and August, with larger males found there in May and smaller males in September. Very large individuals, probably females, are found off the southern coast of Jamaica in the summer and off the northern coast in winter, where males are caught in December and January.

There has not been an Atlantic wide survey of spawning activity for blue marlin, however, these fish generally reproduce between the ages of two and four, at 220 – 230 cm (86 – 90 inches) in length, and weigh approximately 120 kg (264 lb). Female blue marlin begin to mature at approximately 47 – 60 kg (104 – 134 lb), while males mature at smaller weights, generally from 35 – 44 kg (77 – 97 lb). There are likely two separate spawning events that occur at different times in the North and South Atlantic. South Atlantic spawning takes place between February and March (NMFS 1999). Peak spawning activity in the North Atlantic Ocean occurs between July and October, with females capable of spawning up to four times per reproductive season (de Sylva and Breder 1997). Prince et al. (2005) conducted 23 neuston tows in the vicinity of Punta Cana, Dominican Republic between 23 April and 17 May and successfully identified four larval blue marlin; the size of the larvae indicated that spawning activity was taking place in the same general area where these samples were conducted. Serafy et al. (2003) identified 90 blue marlin larvae in the vicinity of Exuma Sound, Bahamas in the month of July, indicating that spawning activity had taken place 18 days prior to sampling.

During the spawning season, blue marlin release between one and eleven million small (1 – 2 mm), transparent pelagic planktonic eggs. The number of eggs has been correlated to interspecific sizes among billfish and the size of individuals within the same species. Ovaries from a 147 kg (324 lb) female blue marlin from the northwest Atlantic Ocean were estimated to contain 10.9 million eggs, while ovaries of a 125 kg (275 lb) female were estimated to contain seven million eggs. Males are capable of spawning at any time.

Blue marlin are generalist predators feeding primarily on epipelagic fish and cephalopods in coastal and oceanic waters, however, mesopelagic fish and crustaceans associated with rocky, sandy, and reef bottoms are also important components of the diet. Feeding in mesopelagic areas probably takes place at night (Rosas-Alayola et al. 2002). Diet studies of blue marlin off the northeastern coast of Brazil indicate that oceanic pomfret (*Brama brama*) and squid (*Ornithoteuthis antillarum*) were the main prey items and present in at least 50 percent of stomachs. Other important prey species vary by location and include dolphin fishes, bullet tuna (*Auxis*. spp) around the Bahamas, Puerto Rico, and Jamaica, and dolphin fishes and scombrids in the Gulf of Mexico. Stomach contents have also included deep-sea fishes such as chiasmodontids.

Constant ingestion of small quantities of food is necessary. Blue marlin have relatively small stomachs, reducing the proportion of the body allocated for visceral mass, and allocating more volume to musculature for swimming speed and endurance (Junior et al., 2004). In the Pacific Ocean, changes in the diet observed are related more with abundance and distribution of prey than preferences in food items, with Auxis spp. (bullet and frigate tunas) well represented in all locations. Predators of blue marlin are relatively unknown. Sharks will attack hooked blue marlin, but it is not known if they attack free-swimming, healthy individuals.

White Marlin

White marlin (*Tetrapturus albidus*) are found exclusively in tropical and temperate waters of the Atlantic Ocean and adjacent seas, unlike sailfish and blue marlin, which are also found in the Pacific Ocean. White marlin are found at the higher latitudes of their range only in the warmer months. Junior et al. (2004) captured white marlin with pelagic longline gear off northeastern Brazil in depths ranging from 50 – 230 m (164 – 754 feet), with no obvious depth layer preference. White marlin generally prefer water temperatures above 22°C (71° F) with salinities between 35 – 37 ppt (NMFS 1999). They may occur in small, same-age schools, however, are generally solitary compared to the Scombrids (tunas). Catches in some areas may include a rare species (*Tetrapturus georgei*) which is superficially similar to white marlin. The so-called "hatchet marlin" may also represent (*T. georgei*), and has been caught occasionally in the Gulf of Mexico and South Atlantic (NMFS 1999).

White marlin are generally 20 – 30 kg (44 – 66 lb) at harvest. These fish grow quickly, with females attaining a larger maximum size than males, and have a life span of 18 years (SCRS 2004). Adult white marlin grow to over 280 cm (110 inches) TL and 82 kg (184 lb). White marlin exhibit sexually dimorphic growth patterns; females grow larger than males, but the dimorphic growth differences are not as extreme as noted for blue marlin.

This species undergoes extensive movements, although not as extreme as those of the bluefin tuna and albacore. Trans-equatorial movements have not been documented for the species. There have been 31,483 white marlin tagged and released by the CTC program, with 577 reported recaptures (1.83 percent of all releases) (Ortiz et al. 2003). The majority of releases took place in the months of July through September, in the western Atlantic off the east coast of the United States.

Releases of tagged white marlin also occurred off Venezuela, in the Gulf of Mexico, and in the central west Atlantic. The longest distance traveled is 6,517 km (4,049 miles) and the maximum days at large is 5,488 days (approx. 15 years). A substantial number of individuals moved between the Mid-Atlantic coast of the United States and the northeast coast of South America. Overall, 1.1 percent of documented white marlin recaptures have made trans-Atlantic movements. The longest movement was for a white marlin tagged during July 1995 off the east coast near Cape May, NJ and recaptured off Sierra Leone, West Africa, in November, 1996. The fish traveled a distance of at least 6,517 km (3,519 nm) over 476 days (NMFS 1999). Prince et al. (2005) tagged six white marlin off the coast of Punta Cana, Dominican Republic and found their displacement to be between 58.7 and 495.8 km (31.7 – 267.7 nm), ranging from 2.1 – 13.3 km/day (mean = 6.3 km/day).

White marlin spawn in the spring (March through June) in the northwestern Atlantic Ocean and females are generally 20 kg (44 lb) in mass and 130 cm (51.2 inches) in length at sexual maturity. White marlin spawn in tropical and sub-tropical waters with relatively high surface temperatures and salinities (20 – 29°C (68 – 84°F) and over 35 ppt) and move to higher latitudes during the summer. There has not been an Atlantic-wide study of the spawning behavior of white marlin. Spawning seems to take place in more offshore areas than for sailfish, although larvae are not found as far offshore as blue marlin. Females may spawn up to four times per spawning season (de Sylva and Breder 1997). It is believed there are at least three spawning areas in the western north Atlantic: northeast of Little Bahama Bank off the Abaco Islands; northwest of Grand Bahama Island; and southwest of Bermuda. Prince et al. (2005) found eight white marlin larvae in neuston tows in April/May off the coast of Punta Cana, Dominican Republic indicating that there had been recent spawning activity in this general area.

Larvae have also been collected from November to April, but these may have been sailfish larvae (*Istiophorus platypterus*), as the two can not readily be distinguished (NMFS 1999). Spawning concentrations occur off the Bahamas, Cuba, and the Greater Antilles, probably beyond the U.S. EEZ, although the locations are unconfirmed.

Concentrations of white marlin in the northern Gulf of Mexico and from Cape Hatteras, NC to Cape Cod, MA are probably related to feeding rather than spawning (NMFS 1999).

White marlin are primarily piscivorous. Oceanic pomfret and squid were the most important food items in a study that sampled stomachs collected off the coast of Brazil in the southwestern Atlantic Ocean (Junior et al. 2004). The number of food items per stomach ranged from 1 – 12 individuals. The largest prey observed in white marlin stomachs were snake mackerel (*Gempylus serpens*), that were 40 – 73 cm (15.7 – 28.7 inches) in length (Junior et al. 2004). Squid, dolphin, hardtail jack, flying fish, bonitos, mackerels, barracuda, and puffer fish are the most important prey items in the Gulf of Mexico.

Data from a large sport fishery for white marlin that occurs during the summer between Cape Hatteras, NC and Cape Cod, MA indicates that white marlin inhabit offshore (148 km (80 nm)) submarine canyons, extending from Norfolk Canyon in the Mid-Atlantic to Block Canyon off eastern Long Island. Concentrations of white marlin are associated with rip currents and weed lines (fronts), and with bottom features such as steep drop-offs, submarine canyons, and shoals. Sport fishing for white marlin also occurs in the Straits of Florida, southeast Florida, the Bahamas, and off the north coasts of Puerto Rico and the Virgin Islands. Summer concentrations in the Gulf of Mexico are found off the Mississippi River Delta and at DeSoto Canyon, with a peak off the delta in July, and in the vicinity of DeSoto Canyon in August. In the Gulf of Mexico, adults appear to be associated with blue waters of low productivity, being found with less frequency in more productive green waters. While this is also true of the blue marlin, there appears to be a contrast between the factors controlling blue and white marlin abundance, as higher numbers of blue marlin are generally caught when catches of white marlin are low, and vice versa. It is believed that white marlin prefer slightly cooler temperatures than blue marlin.

Sailfish
Sailfish (*Istiophorus platypterus*) have a pan-tropical distribution and prefer water temperatures between 21 and 28°C (69 – 82°F). Although sailfish are the least oceanic of the Atlantic billfish and have higher concentrations in coastal waters (more than any other Istiophorid), they are also found in offshore waters. They range from 40°N to 40°S in the western Atlantic and 50°N to 32°S in the eastern Atlantic. No trans-Atlantic movements have been recorded, suggesting a lack of mixing between east and west. Although sailfish are generally considered to be rare and solitary species relative to the schooling Scombrids, sailfish are known to occur along tropical coastal waters in small groups consisting of at least a dozen individuals. Junior et al. (2004) captured sailfish in the southwestern Atlantic Ocean with pelagic longline gear at depths between 50 – 210 m (164 – 688 feet), with most individuals captured at 50 m.

Sailfish are the most common representative of the Atlantic Istiophorids in U.S. waters (SCRS, 2005). Female sailfish grow faster, and attain a larger maximum size, than males while both sexes have a life expectancy of 15 years (NMFS 1999).

In the winter, sailfish are found in schools around the Florida Keys and eastern Florida, in the Caribbean, and in offshore waters throughout the Gulf of Mexico. In the summer, they appear to migrate northward along the U.S. coast as far north as the coast of Maine, although there is a population off the east coast of Florida year-round. During the summer, some of these fish move north along the inside edge of the Gulf Stream. In the winter, they regroup off the east coast of Florida. Sailfish appear to spend most of their time above the thermocline, which occurs at depths of 10 – 20 m (32.8 – 65.6 feet) and 200 – 250 m (656 – 820 feet), depending on location. The 28EC (82°F) isotherm appears to be the optimal temperature for this species.

Sailfish are mainly oceanic but migrate into shallow coastal waters. Larvae are associated with the warm waters of the Gulf Stream (NMFS 1999). A total of 65,868 sailfish have been tagged and released through the efforts of the CTC program, with reported recapture of 1,204 sailfish (1.83 percent of all releases). Most releases occurred off southeast Florida, from north Florida to the Carolinas, the Gulf of Mexico, Venezuela, Mexico, the northern Bahamas and the U.S. Virgin Islands. One tagged and recaptured specimen traveled from Juno, FL to the Mid-Atlantic, a distance of 2,972 km (1,745 miles). The longest movement tracked by tagging was 3,861 km (2,084 miles) and the longest time at large was 6,658 days (18.2 years) (Ortiz et al. 2003). During the winter, sailfish are restricted to the warmer parts of their range and move farther from the tropics during the summer.

The summer distribution of sailfish does not extend as far north as for marlins, especially white marlin. Tag-and-recapture efforts have recovered specimens only as far north as Cape Hatteras, NC. Few trans-Atlantic or trans-equatorial movements have been documented using tag recapture methods (NMFS 1999).

Most sailfish examined that have been caught off Florida are under three years of age. Mortality is estimated to be high in this area, as most of the population consists of only two year classes. The longest period a recaptured-tagged animal was found to be at-large was 16.1 years. Unfortunately, the size at release is not available for this fish. Growth rate in older individuals is very slow (0.59 kg/yr (1.3 lb/year). Sailfish are probably the slowest growing of the Atlantic istiophorids. Sexual dimorphic growth is found in sailfish, but it is not as extreme as with blue marlin (NMFS 1999).

Female sailfish spawn at age three and are generally 13 – 18 kg and 157 cm (28.6 – 39.6 lb and 61.8 inches), whereas males generally mature earlier at 10 kg and 140 cm (22 lb and 55.1 inches). Spawning takes place between April and October (de Sylva and Breder 1997). Spawning has been reported to occur in shallow waters 9 – 12 m (30 – 40 ft) around Florida, from the Florida Keys to the region off Palm Beach on the east coast. Spawning is also assumed to occur, based on presence of larvae, offshore beyond the 100 m (328 feet) isobath from Cuba to the Carolinas, from April to September. However, these spawning activities have not been observed. Sailfish can spawn multiple times in one year, with spawning activity-moving northward in the western Atlantic as the summer progresses. Larvae are found in Gulf Stream waters in the western Atlantic, and in offshore waters throughout the Gulf of Mexico from March to October (NMFS 1999). Serafy et al. (2003) found three larval sailfish in Exuma Sound, Bahamas, in the month of July indicating that there had been recent spawning activity in this vicinity. In the Pacific Ocean, sailfish spawn in waters between 27 – 30°C (Hernandez-H and Ramirez-H 1998).

Sailfish are generally piscivorous, but also consume squid. Larvae eat copepods early in life then switch to fish at 6.0 mm (0.2 inches) in length (NMFS, 1999). The diet of adult sailfish caught around Florida consists mainly of pelagic fishes such as little tunny (*Euthynnus alletteratus*), halfbeaks (*Hemiramphus* spp.), cutlassfish (*Trichiurus lepturus*), rudderfish (*Strongylura notatus*), jacks (*Caranx* spp.), pinfish (*Lagodon rhomboides*), and squids (*Argonauta argo* and *Ommastrephes bartrami*). Sailfish are opportunistic feeders and there is evidence that they may feed on demersal species such as sea robin (Triglidae), cephalopods and gastropods found in deepwater. Sailfish collected in the western Gulf of Mexico contained a large proportion of shrimp in their stomachs in addition to little tunny, bullet tuna (*Auxis* spp.), squid, and Atlantic moonfish (*Vomer setapinnis*). Junior et al. (2004) determined that squid were actually the second most important food item in the southwestern Atlantic off the coast of Brazil. Number of food items per stomach ranged from 1-14, and 6 percent of the stomachs were empty upon collection (Junior et al. 2004). Adult sailfish are probably not preyed upon often, but predators include killer whales (*Orcinus orca*), bottlenose dolphin (*Tursiops truncatus*), and sharks.

Participants from many nations target sailfish in both the western and eastern Atlantic Ocean. Sailfish are found predominantly in the upper reaches of the water column and are caught in directed sport fisheries (recreational) and as bycatch in the offshore longline fisheries for swordfish and tunas and as a directed catch in coastal fisheries. In coastal waters, artisanal fisheries use many types of shallow water gear to target sailfish (NMFS 2003).

Longbill Spearfish

The longbill spearfish (*Tetrapturus pfluegeri*) are the most rare of the Atlantic istiophorids, and were identified as a distinct species in 1963. There is relatively little information available on spearfish life history. A related istiophorid, the Mediterranean spearfish (*Tetrapturus belone*), is the most common representative of this family in the Mediterranean Sea.

Longbill spearfish are known to occur in epipelagic waters above the thermocline, off the east coast of Florida, the Bahamas, the Gulf of Mexico, and from Georges Bank to Puerto Rico. Junior et al. (2004) captured spearfish off the coast of Brazil at depths ranging from 50 – 190 m (164 – 623 feet). The geographic range for this species is from 40°N to 35°S. Spearfish spawn from November to May and females are generally 17 – 19 kg (37.4 – 41.8 lb) and 160 – 170 cm (63 – 66 inches) at first maturity.

These fish are unique among istiophorids in that they are winter spawners. Larval spearfish have been identified from the vicinity of the Mid-Atlantic ridge from December to February, indicating that this species spawns in offshore waters (de Sylva and Breder 1997).

Common prey items include fish and squid. Specifically, Junior et al. (2004) observed 37 stomachs and found that oceanic pomfret and squid comprised 63 percent of the items identified in stomachs. Most prey items were between 1 and 10 cm (0.39 – 3.9 inches) in length, with a mean length of 6.7 cm (2.63 inches). The maximum number of prey items found in any individual stomach was 33.

Similar to sailfish, spearfish are caught incidentally or as bycatch in offshore longline fisheries by many nations. There are also artisanal fisheries that take place in the Caribbean Sea and in the Gulf of Guinea. Directed recreational fisheries for spearfish are limited due to the fact that the fish are generally located further offshore than other istiophorids. The reported catches of sailfish/spearfish (Task I) for 2003 are 1,310 and 416 mt (2,888,055 and 917,123 lb) for the west and east Atlantic, respectively. The 2001 – 2003 reported catch of unclassified billfish was 12 percent of the reported catch for all billfish and, for some fisheries, this proportion is much greater. This is a problem for species like spearfish for which there is already a paucity of data (SCRS 2004).

Abundance and status of stocks

Blue Marlin

Since 1995, blue marlin have been managed under a single stock hypothesis because of tagging data and mitochondrial DNA evidence that are consistent with one Atlantic-wide stock. The last stock assessment for blue marlin was in 2000 using similar methods to the previous assessment (1996), however, data was revised in response to concerns raised since the 1996 assessment. The assessment reflects a retrospective pattern wherein improvement in estimated biomass ratios result in estimated lower productivity. The 2000 assessment was slightly more optimistic than the 1996 assessment. Atlantic blue marlin are at approximately 40 percent of BMSY and overfishing has taken place for the last 10 – 15 years. BMSY is estimated at 2,000 mt (4,409,245 lb) and current fishing mortality is approximately four times higher than FMSY (Table 4.2-14) (SCRS 2005). There is uncertainty in the assessment because the historical data is not well quantified. The 2000 assessment estimated that overfishing was still occurring and that productivity (MSY and a stock's capacity to replenish) was lower than previously estimated. Therefore, it is expected that landings in excess of estimated replacement yield would result in further stock decline (SCRS 2005).

No additional assessment information became available in 2005 to modify recommendations currently in force. The current assessment indicates that the stock is unlikely to recover if the landings contemplated by the 1996 ICCAT recommendation continue into the future. While there is additional uncertainty in stock status and replacement yield, estimates are not reflected in bootstrap results, these uncertainties can only be addressed through substantial investment in research into habitat requirements of blue marlin and further verification of historical data. The SCRS recommended that the ICCAT take steps to reduce the catch of blue marlin as much as possible, including: reductions in fleet-wide effort, a better estimation of dead discards, establishment of time area closures, and scientific observer sampling for verification of logbook data. The SCRS noted that future evaluation of management measures relative to the recovery of the blue marlin stock are unlikely to be productive unless new quantitative information on the biology and catch statistics of blue marlin, and additional years of data are available (SCRS 2004 and 2005).

A summary of Atlantic blue marlin stock assessment data can be found in Table 4.2-14. Estimated catches of Atlantic blue marlin by region for the period 1956 – 2001 can be found in Figure 4.2-19. A composite CPUE series for blue marlin for the period 1955 – 2000 can be found in Figure 4.2-20. The estimated median relative fishing mortality trajectory for Atlantic blue marlin can be found in Figure 4.2-21. Estimated catches (including landings and dead discards in t) of blue marlin in the Atlantic by region (1950-2004) is shown in Figure 4.2-22. A stock assessment for blue marlin is scheduled for 2006.

Table 4.2-14. Summary of Atlantic Blue Marlin Stock Assessment data. Weights are in metric tons, whole weight. Source: SCRS 2005.

ATLANTIC BLUE MARLIN SUMMARY[1]	
	Total Atlantic
Maximum Sustainable Yield (MSY)	~ 2,000 t (~ 1,000 ~ 2,400 t)[2]
2002 Yield	2,626 t
2003 Yield	2,713 t
2004 Yield[4]	2,076 t
1999 Replacement Yield	~ 1,200 t (~ 840 - 1,600 t)[2]
Relative Biomass (B_{2000}/B_{MSY})	~ 0.4 (~ 0.25 - 0.6)[2]
Relative Fishing Mortality (F_{1999}/F_{MSY})	4.0 (~ 2.5 - 6.0)[2]
Management Measures in Effect	- Reduced pelagic longline and purse seine landings to 50% of 1996 or 1999 levels, whichever is greater [Recs. 00-13[3], 01-10[3] and 02-13].

[1] Assessment results are uncertain. Uncertainty in these estimates is not fully quantified by bootstrapping.
[2] Approximate 80% CI from bootstrap for ASPIC model.
[3] These measures did not take effect until mid-2001.
[4] Reported Task I value, which is likely to be a substantial underestimate of the total catch.

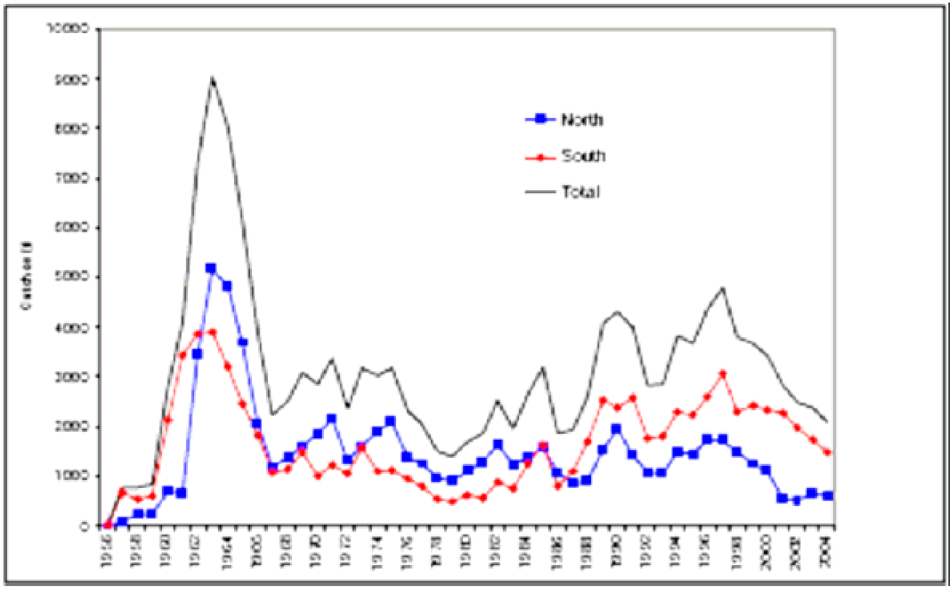


Figure 4.2-19. Estimated catches (including landings and dead discards in mt) of blue marlin in the Atlantic by region. The 2003 catch reported to ICCAT is preliminary and is not included in this figure. Weights are in metric tones, whole weight. Source: SCRS 2005.

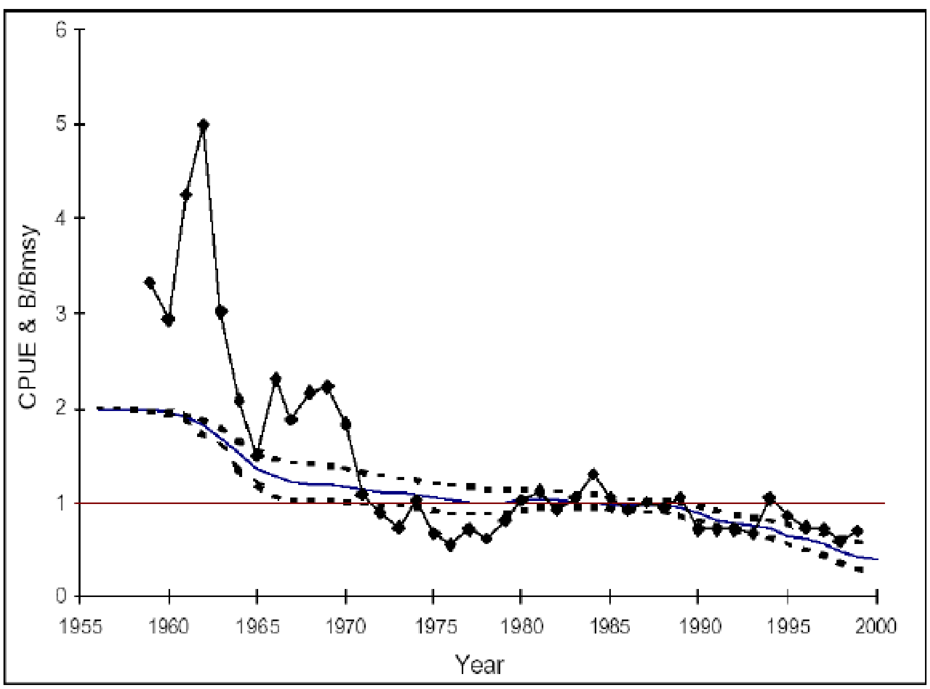


Figure 4.2-20. Composite CPUE series (symbols) used in the blue marlin assessment compared to model estimated median relative biomass (solid lines) from bootstrap results (80 percent confidence bounds shown by dotted lines). Source: SCRS 2005.

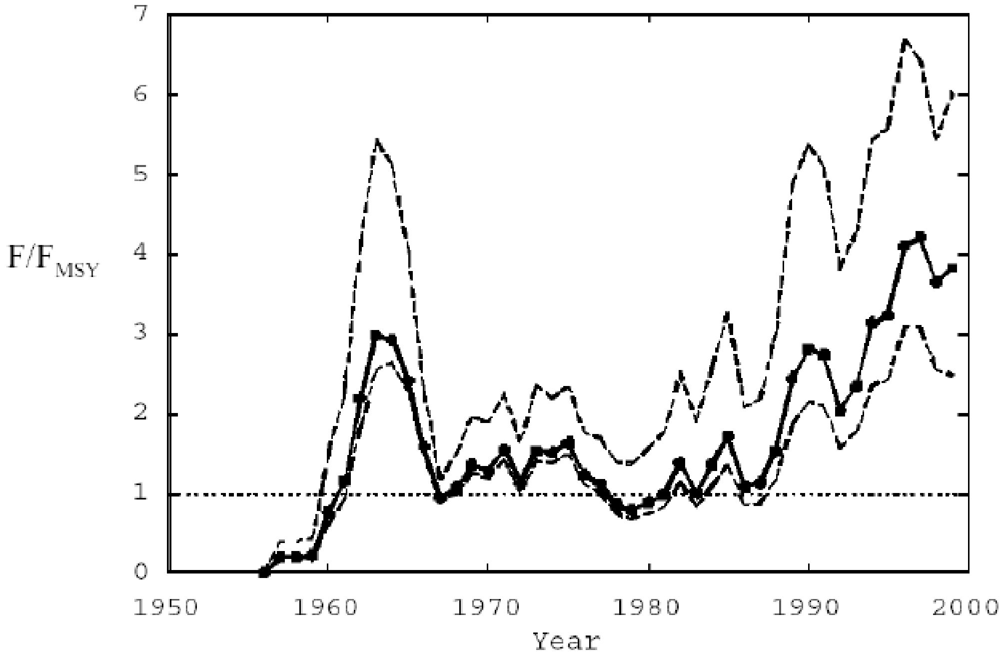


Figure 4.2-21. Estimated median relative fishing mortality trajectory for Atlantic blue marlin (center, dark line) with approximate 80 percent confidence range (light lines) obtained from bootstrapping. Source: SCRS 2005.

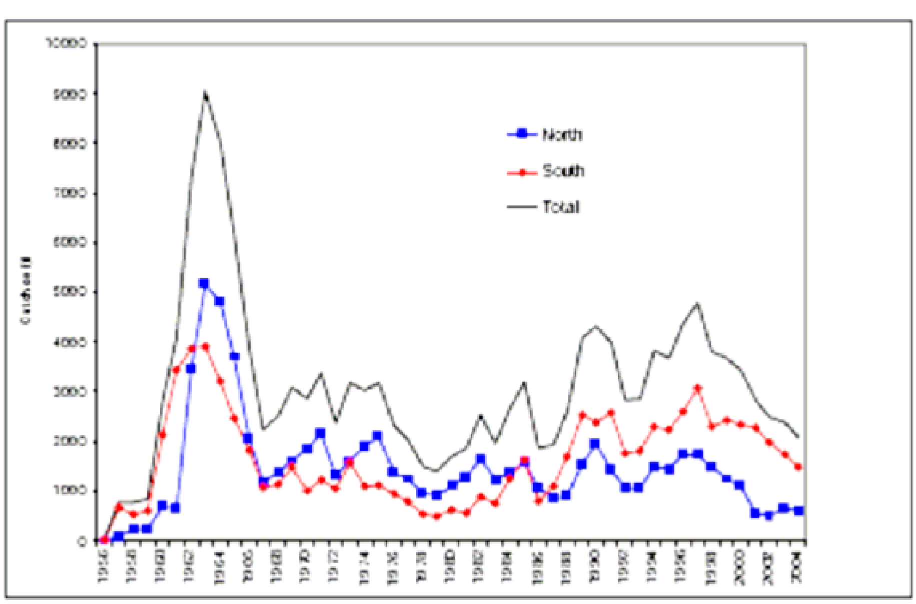


Figure 4.2-22. Estimated catches (including landings and dead discards in t) of blue marlin in the Atlantic by region (1950-2004). Source: SCRS 2005.

White Marlin

White marlin have been managed under a single stock hypothesis by ICCAT since 2000. The most recent stock assessments for white marlin (1996, 2000, and 2002) all indicated that biomass of white marlin has been below BMSY for more than two decades and the stock is overfished. In 2004, the SCRS indicated that in spite of significant improvements in the relative abundance estimates made available during the last three assessments, they are still not informative enough to provide an accurate estimate of stock status (SCRS 2004). The 2002 assessment indicated that the relative fishing mortality is 8.28 times that permissible at FMSY (Figure 4.2-23). Given that the stock is severely depressed, the SCRS concluded that ICCAT should take steps to reduce the catch of white marlin as much as possible, first by increasing observer coverage to improve estimates of catch and dead discards of white marlin. Furthermore, SCRS recommended that Contracting Parties conduct research into habitat requirements and post-release survival of white marlin and take steps to verify historical fishery data.

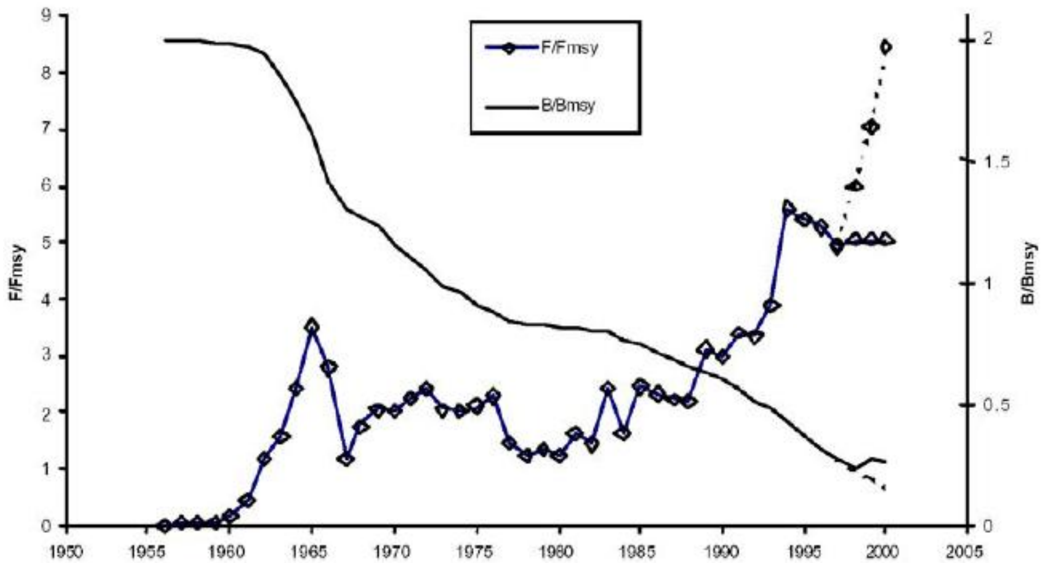


Figure 4.2-23. Estimated biomass ratio B2000/ BMSY (solid line, no symbols) and fishing mortality ratio F2000/FMSY (solid line with symbols) from the production model fitted to the continuity case for white marlin. Ratios of last three years have been adjusted for retrospective pattern. Broken lines show unadjusted ratios. Note that scales are different for each ratio. Source: SCRS 2004.

The SCRS suggested that ICCAT take steps to make sure that the intended reductions in catch are complied with, and monitored, so that proper evaluation can be carried out in the future.

The SCRS recommended improving observer programs so that better estimates of catch and dead discards of white marlin are obtained. The SCRS further recommended that, in the absence of observing a change in population status resulting from the most recent management measures, the potential for increasing stock size of white marlin may require future catches to be reduced beyond the level apparently intended by its most recent recommendations. However, the SCRS also stated that more definitive advice should be available after several years of data become available. The SCRS also noted that future evaluation of management measures relative to the recovery of the white marlin stock is unlikely to be productive unless new quantitative information on the biology and catch statistics of white marlin, and additional years of data, are available (SCRS 2004). As such, ICCAT postponed the next white marlin assessment until 2006. A summary of Atlantic white marlin stock assessment data can be found in Table 4.2-15. Reported catch of white marlin in the North and South Atlantic by gear is shown in Figure 4.2-24.

New standardized catch rate information was presented in 2005, updating catch rates from U.S. recreational fisheries in the northwest Atlantic and Gulf of Mexico and the Venezuelan longline and artisanal fisheries. In spite of the progress made, the SCRS cannot interpret the historic CPUE trends for white marlin (SCRS 2005). In 2002, an ESA listing review was completed by NMFS. NMFS determined that listing Atlantic white marlin under the Endangered Species Act was not warranted at that time. NMFS has committed to conducting another ESA listing review in 2007.

Table 4.2-15. Summary of Atlantic White Marlin Stock Assessment data. Weights are in metric tons, whole weight. Source: SCRS 2005.

ATLANTIC WHITE MARLIN SUMMARY[1]				
	Likely value	*Continuity case[2] estimate (80% conf. limit)*	*Retrospective adjusted estimate[3]*	*Range of sensitivity[4] estimates*
Maximum Sustainable Yield	Below 2000 Yield	964 t (849-1070)		323-1,320 t
2002 Yield	822 t	--		--
2003 Yield	615 t	--		--
2004 Yield[5]	532 t			
2001 Replacement Yield	Below 2000 Yield	222 t (101-416)	371 t	102-602 t
Relative Biomass (B_{2001}/B_{MSY})	<1 (Over-fished)	0.12 (0.06-0.25)	0.22	0.12-1.76
Relative Fishing Mortality (F_{2000}/F_{MSY})	>1 (Over-fishing)	8.28 (4.5-15.8)	5.05	0.80-10.30
Management Measures in Effect:	- In 2001 and 2002, PS and LL fisheries limit landings to 33% of max (1996, 1999) level. [Rec. 00-13], [Rec. 01-10] and [Rec. 02-13].			

[1] Assessment results are highly uncertain.
[2] The data used are not sufficiently informative to choose a "best case". For consistency, the continuity case presented here is based on data and assumptions that closely resemble the analyses made in 2000. Confidence limits from bootstrapping are conditional on this model-data set and thus may underestimate the real uncertainty.
[3] These results are for the continuity case except that they were adjusted for retrospective biases.
[4] The sensitivity analyses made were not chosen in a systematic way; the range is presented only for qualitative guidance.
[5] Reported Task I value for 2004, which is likely an underestimate of total catch.

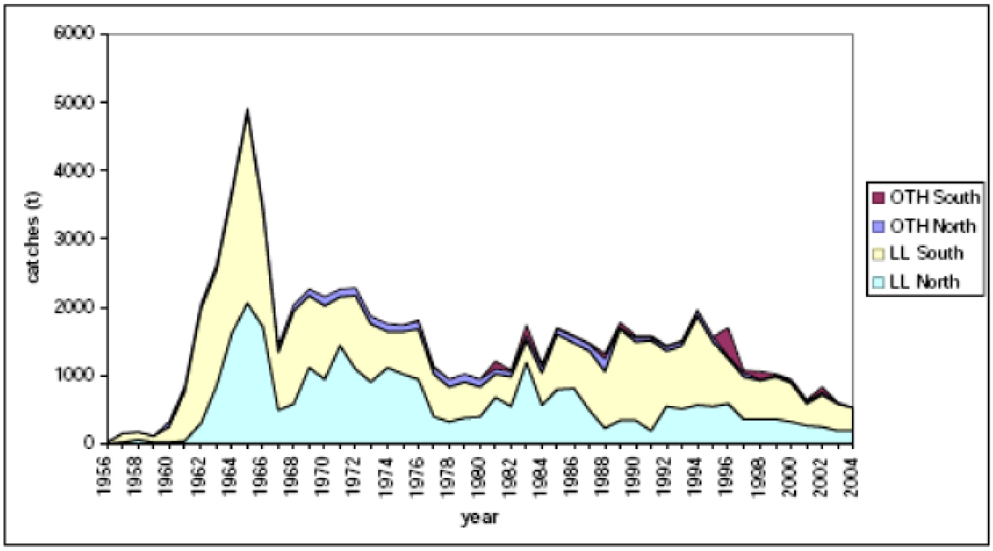


Figure 4.2-24. Reported catch of white marlin (Task I) in the North and South Atlantic for longline (LL) gear and other (OTH) gears. Source: SCRS 2005.

Sailfish

Sailfish and longbill spearfish landings have historically been reported together in annual ICCAT landing statistics. An assessment was conducted in 2001 for the western Atlantic sailfish stock based on sailfish/spearfish composite catches and sailfish "only" catches. The assessment tried to address shortcomings of previous assessments by improving abundance indices and separating the catch of sailfish from that of spearfish in the offshore longline fleets. The 2001 assessment looked at catches reported between 1956 and 2000 and all the quantitative assessment models used produced unsatisfactory fits, therefore the SCRS recommended applying population models that better accounted for these dynamics in order to provide improved assessment advice. For the western Atlantic stock, annual sailfish catches have averaged about 700 mt (1,543,235 lb) over the past two decades and the abundance indices have remained relatively stable. The 2000 yield was 506 mt (1,115,539 lb) (Table 4.2-16). The reported catches of sailfish/spearfish (Task I) for 2004 were 1,017 and 1,088 mt for the west and east Atlantic, respectively. Recent analyses did not provide any information on the MSY or other stock benchmarks for the 'sailfish only' stock. In the eastern Atlantic, abundance indices based on coastal/inshore fisheries for sailfish have decreased in recent years, while those attained from the Japanese longline fishery indicate constant estimates of abundance since the mid-1970s (SCRS 2004).

Based on the 2001 assessment, it is unknown if the western or eastern sailfish stocks are undergoing overfishing or if the stocks are currently overfished. Therefore, SCRS recommended that Contracting Parties consider methods to reduce fishing mortality rates, overall, and that western Atlantic catches should not be increased above current levels. Furthermore, the SCRS expressed concern about the incomplete reporting of catches, particularly in recent years.

A summary of Atlantic sailfish stock assessment data is given in Table 4.2-16. The evolution of estimated sailfish/spearfish catches in the Atlantic during the period 1956 – 2002 for both east and west stocks is given in Figure 4.2-25. Available CPUE for western Atlantic sailfish/spearfish for the period 1967 – 2000 is shown in Figure 4.2-25b. Estimated sailfish only catches from 1956 – 2000 are shown in Figure 4.2-25c Evolution of estimated sailfish/spearfish catches in the Atlantic (landings and dead discards, reported and carried over) in the ICCAT Task I database during 1956-2004 for the east and west stocks is shown in Figure 4.2-25d.

Table 4.2-16. Summary of Atlantic Sailfish Stock Assessment data. Weights are in metric tons, whole weight. Source: SCRS 2004.

ATLANTIC SAILFISH "ONLY" SUMMARY		
	West Atlantic	**East Atlantic**
Maximum Sustainable Yield (MSY)	Not estimated	Not estimated
Recent Yield (2000)[1]	506 t[2]	969 t[2]
2000 Replacement Yield	~ 600 t	Not estimated
Management Measures in Effect	None	None

[1] Estimated yield includes that carried over from previous years.
[2] Recent yield (2000) was estimated during the 2001 sailfish assessment. To estimate the 2001, 2002 and 2003 yield, catches of sailfish and spearfish would have to be separated. A separation similar to the one conducted in the 2001 assessment has not yet been conducted.

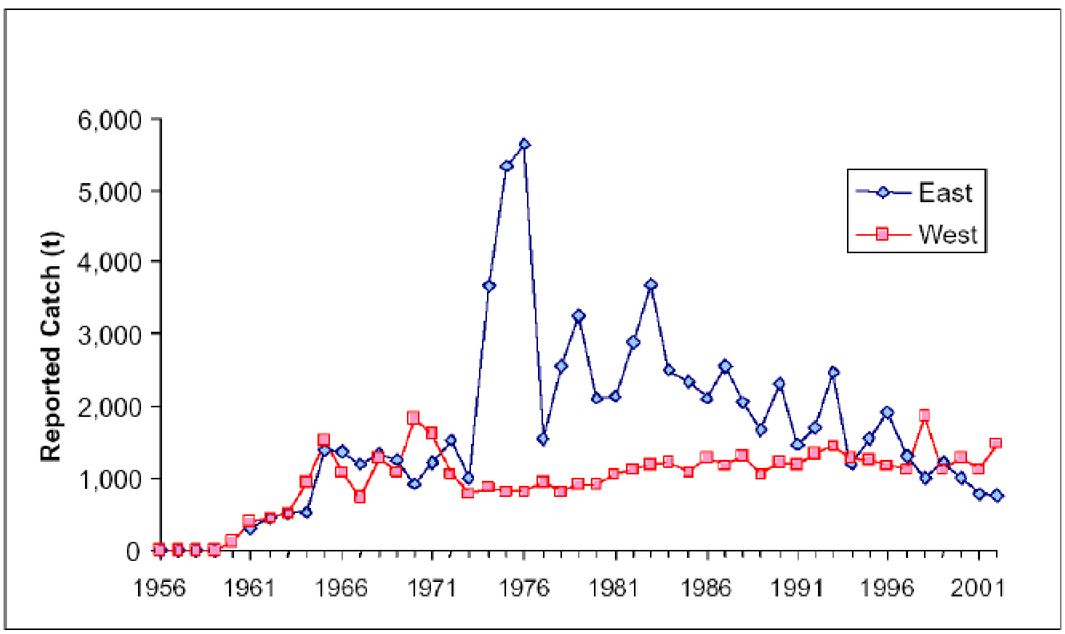


Figure 4.2-25a. Evolution of estimated sailfish/spearfish catches in the Atlantic (landings and dead discards, reported and carried over) in the ICCAT Task I database during 1956-2002 for the east and west stocks. The 2003 catch reported to ICCAT is preliminary and is not included in this figure. Weights are in metric tons, whole weight. Source: SCRS 2005.

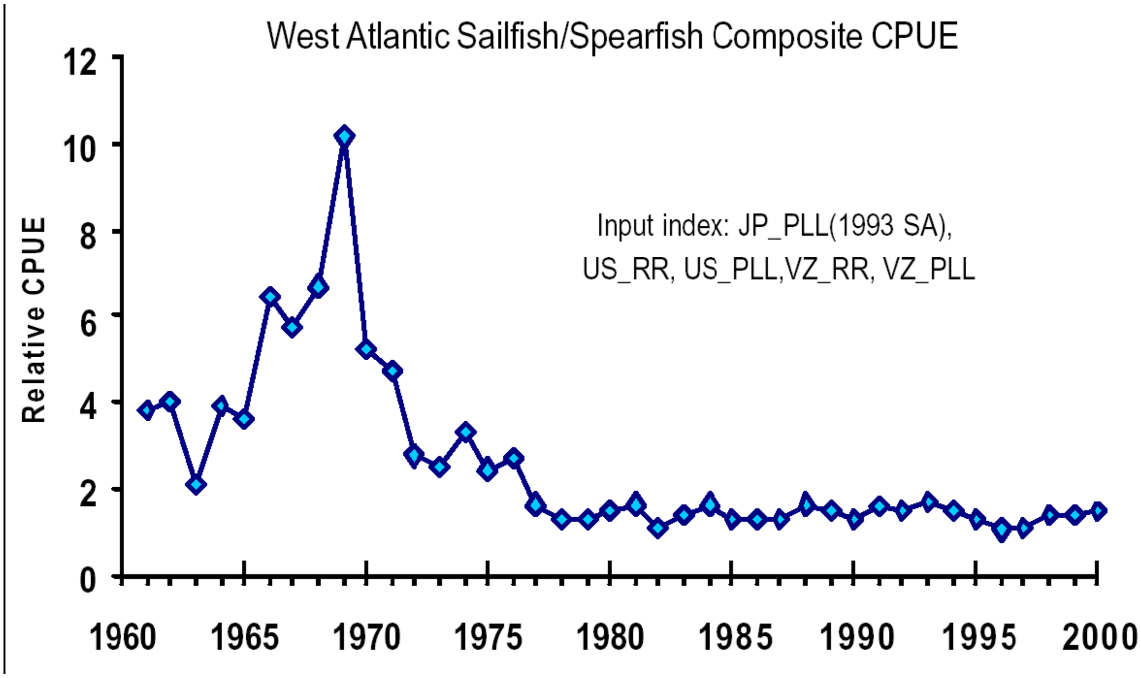


Figure 4.2-25b. Available standardized CPUE for western Atlantic sailfish/spearfish for the period 1967-2000, including Japanese, U.S., and Venezuelan time series data. Source: SCRS 2005.

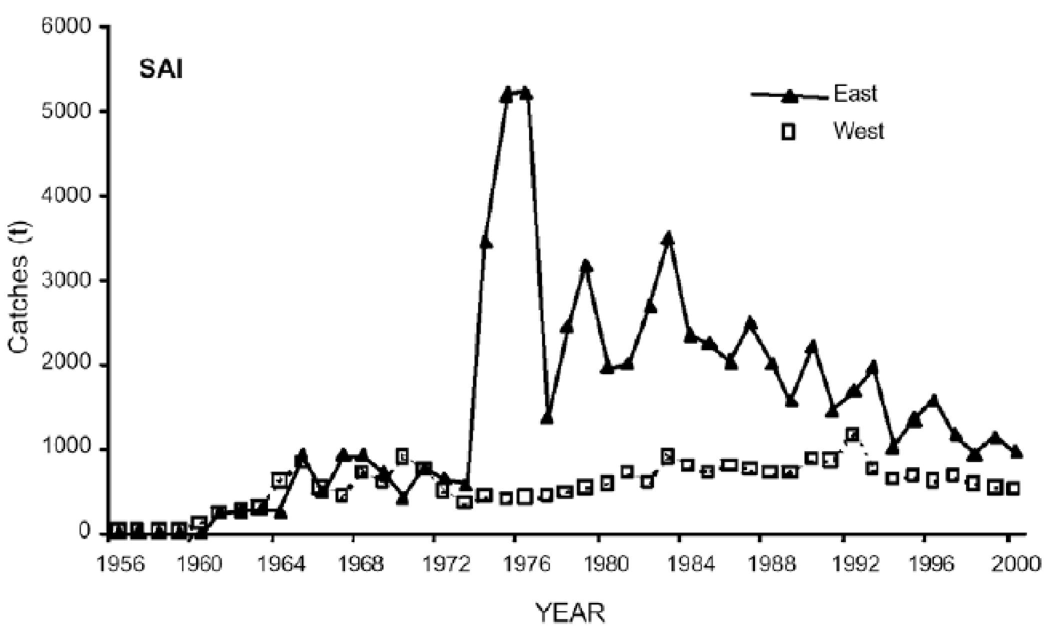


Figure 4.2-25c. Estimated sailfish "only" catches based on the new procedure for splitting combined sailfish and longbill spearfish catches from 1956-2000. Weights are in metric tons, whole weight. Source: SCRS 2005.

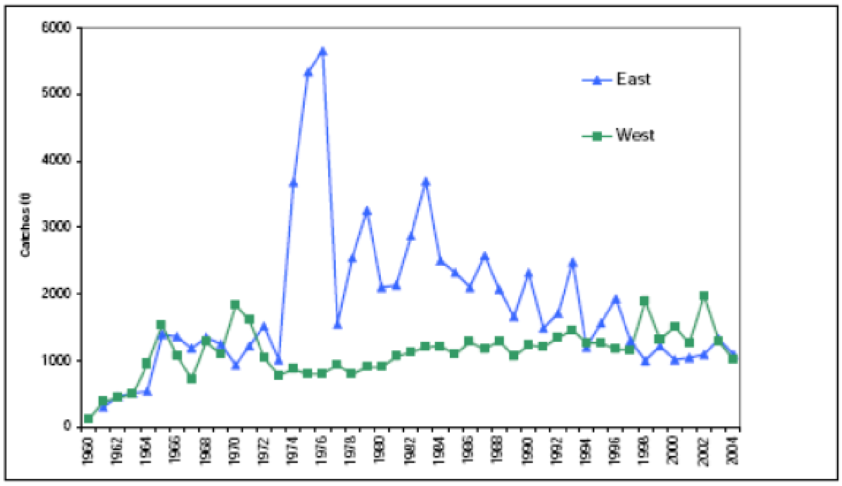


Figure 4.2-25d. Evolution of estimated sailfish/spearfish catches in the Atlantic (landings and dead discards, reported and carried over) in the ICCAT Task I database during 1956-2004 for the east and west stocks. Source: SCRS 2005.

Longbill Spearfish

Initial stock assessments conducted on spearfish aggregated these landings with sailfish. As mentioned in the Sailfish section, the 2001 assessment included a 'sailfish only' in addition to an aggregate sailfish/spearfish assessment. West Atlantic catch levels for sailfish/spearfish combined seem sustainable because, over the past two decades, CPUE and catch levels have remained constant, however, MSY is unknown. As a result, it is unknown whether or not spearfish are experiencing overfishing or are overfished. Spearfish catch levels are shown in Figure 4.2-26. The SCRS recommends implementing measures to reduce or keep fishing mortality levels constant and evaluating new methods to split sailfish and spearfish indices of abundance (SCRS 2004).

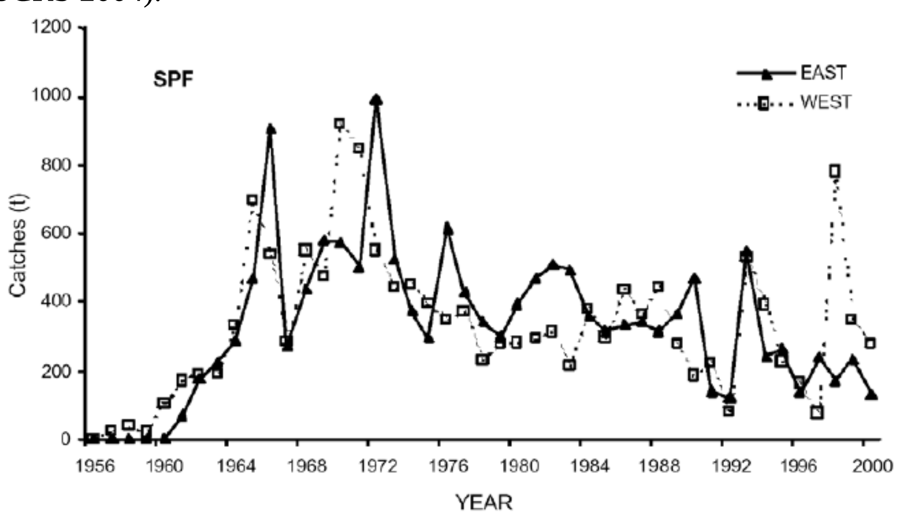


Figure 4.2-26. Estimated spearfish "only" catches in the Atlantic based on the new procedure for splitting combined sailfish and spearfish catches from 1956-2000. Weights are in metric tons, whole weight. Source: SCRS 2005.

Atlantic Sharks

Life History and Biology

Sharks belong to the class Chondrichthyes (cartilaginous fishes) that also includes rays, skates, and deepwater chimaeras (ratfishes). From an evolutionary perspective, sharks are an old group of fishes characterized by skeletons lacking true bones. The earliest known sharks have been identified from fossils from the Devonian period, over 400 million years ago. These primitive sharks were small creatures, about 60 to 100 cm long, that were preyed upon by larger armored fishes that dominated the seas. The life span of all shark species in the wild is not known, but it is believed that many species may live 30 to 40 years or longer.

Relative to other marine fish, sharks have a very low reproductive potential. Several important commercial species, including large coastal carcharhinids, such as sandbar (*Carcharhinus plumbeus*) (Casey and Hoey 1985; Sminkey and Musick 1995; Heist et al. 1995), lemon (*Negaprion brevirostris*) (Brown and Gruber 1988), and bull sharks (Branstetter and Stiles 1987), do not reach maturity until 12 to 18 years of age. Various factors determine this low reproductive rate: slow growth, late sexual maturity, one to two-year reproductive cycles, a small number of young per brood, and specific requirements for nursery areas. These biological factors leave many species of sharks vulnerable to overfishing.

There is extreme diversity among the approximately 350 species of sharks, ranging from tiny pygmy sharks of only 20 cm (7.8 in) in length to the giant whale sharks, over 12 meters (39 feet) in length. There are fast-moving, streamlined species such as mako (*Isurus* spp.) and thresher sharks (*Alopias* spp.), and sharks with flattened, ray-like bodies, such as angel sharks (*Squatina dumerili*). The most commonly known sharks are large apex predators including the white (*Carcharadon carcharias*), mako, tiger (*Galeocerdo cuvier*), bull (*Carcharhinus leucas*), and great hammerhead (*Sphyrna mokarran*). Some shark species reproduce by laying eggs, others nourish their embryos through a placenta. Despite their diversity in size, feeding habits, behavior and reproduction, many of these adaptations have contributed greatly to the evolutionary success of sharks.

The most significant reproductive adaptations of sharks are internal fertilization and the production of fully developed young or "pups." These pups are large at birth, effectively reducing the number of potential predators and enhancing their chances of survival. During mating, the male shark inseminates the female with copulatory organs, known as claspers that develop on the pelvic fins. In most species, the embryos spend their entire developmental period protected within their mother's body, although some species lay eggs. The number of young produced by most shark species in each litter is small, usually ranging from two to 25, although large females of some species can produce litters of 100 or more pups. The production of fully developed pups requires great amounts of nutrients to nourish the developing embryo. Traditionally, these adaptations have been grouped into three modes of reproduction: oviparity (eggs hatch outside body), ovoviviparity (eggs hatch inside body), and viviparity (live birth).

Adults usually congregate in specific areas to mate and females travel to specific nursery areas to pup. These nurseries are discrete geographic areas, usually in waters shallower than those inhabited by the adults. Frequently, the nursery areas are in highly productive coastal or estuarine waters where abundant small fishes and crustaceans provide food for the growing pups. These areas also may have fewer large predators, thus enhancing the chances of survival of the young sharks. In temperate zones, the young leave the nursery with the onset of winter; in tropical areas, young sharks may stay in the nursery area for a few years.

Shark habitat can be described in four broad categories: (1) coastal, (2) pelagic, (3) coastal-pelagic, and (4) deep-dwelling. Coastal species inhabit estuaries, the nearshore and waters of the continental shelves, e.g., blacktip (*Carcharhinus limbatus*), finetooth, bull, lemon, and sharpnose sharks (*Rhizoprionondon terraenovae*). Pelagic species, on the other hand, range widely in the upper zones of the oceans, often traveling over entire ocean basins. Examples include shortfin mako (*Isurus oxyrinchus*), blue (*Prionace glauca*), and oceanic whitetip (*Carcharhinus longimanus*) sharks. Coastal-pelagic species are intermediate in that they occur both inshore and beyond the continental shelves, but have not demonstrated mid-ocean or transoceanic movements. Sandbar sharks are examples of a coastal-pelagic species. Deep dwelling species, e.g., most cat sharks (*Apristurus* spp.) and gulper sharks (*Centrophorus* spp.) inhabit the dark, cold waters of the continental slopes and deeper waters of the ocean basins.

Seventy-three species of sharks are known to inhabit the waters along the U.S. Atlantic coast, including the Gulf of Mexico and the waters around Puerto Rico and the U.S. Virgin Islands. Thirty-nine species are managed by HMS; spiny dogfish also occur along the U.S. coast, however management for this species is under the authority of the Atlantic States Marine Fisheries Commission as well as the New England and Mid-Atlantic Fishery Management Councils. Deep-water sharks were removed from the management unit in 2003. Based on the ecology and fishery dynamics, the sharks have been divided into four species groups for management: (1) large coastal sharks, (2) small coastal sharks, (3) pelagic sharks, and (4) prohibited species (Table 4.2-17).

Table 4.2-17. Common names of shark species included within the four species management units under the purview of the HMS management division.

Management Unit	Shark Species Included
Large Coastal Sharks (11)	Sandbar, silky, tiger, blacktip, bull, spinner, lemon, nurse, smooth hammerhead, scalloped hammerhead, and great hammerhead sharks
Small Coastal Sharks (4)	Atlantic sharpnose, blacknose, finetooth, and bonnethead sharks
Pelagic Sharks (5)	Shortfin mako, thresher, oceanic whitetip, porbeagle, and blue sharks
Prohibited Species (19)	Whale, basking, sandtiger, bigeye sandtiger, white, dusky, night, bignose, Galapagos, Caribbean reef, narrowtooth, longfin mako, bigeye thresher, sevengill, sixgill, bigeye sixgill, Caribbean sharpnose, smalltail, and Atlantic angel sharks

Abundance and status of stocks

NMFS is responsible for conducting stock assessments for the Large and Small Coastal

Shark complexes (LCS and SCS) (Cortes 2002; Cortes et al. 2002). ICCAT and the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) have recently conducted assessments of three pelagic shark species. Stock assessments were conducted for the LCS and SCS in 2002. NMFS is conducting stock assessments for LCS and SCS in 2006 and 2007, respectively. NMFS also recently released a stock assessment for dusky sharks (May 25, 2006, 71 FR 30123). Species-specific assessments for blacktip and sandbar sharks within the LCS complex and finetooth sharks, Atlantic sharpnose sharks, blacknose sharks (*Carcharhinus acronotus*), and bonnethead sharks (*Sphyrna tiburo*) within the SCS complex, were also conducted in 2002. The conclusions of these assessments are summarized in Table 4.2-18 and Table 4.2-19 and are fully described in Amendment 1 to the 1999 Atlantic Tunas, Swordfish, and Sharks FMP. Summaries of recent stock assessments and reports on several species of pelagic sharks (blue sharks, shortfin mako sharks, and porbeagle sharks (*Lamna nasus*) by Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and ICCAT are also included in this section.

Large Coastal Sharks

The last LCS stock assessment was held in June 2002, however, results from a new stock assessment should be released in 2006. Discussions of the 2002 stock assessment focused on the availability of four additional years worth of catch estimates, biological data, catch rate series, and the types of models that should be used. The modeling itself was performed after the Shark Evaluation Workshop and incorporated new catch and effort estimates for the years 1998 – 2001 as well as over 20 catch-per-unit-effort (CPUE) series for the LCS complex, sandbar, and blacktip sharks (Table 3.17).

A variety of stock assessment models were used to investigate the population dynamics of LCS including: (1) a non-equilibrium Schaefer biomass dynamic model using the sampling/importance re-sampling (SIR) algorithm (Bayesian SPM) and several weighting schemes; (2) a non-equilibrium Schaefer state-space surplus production model (SSSPM) using a Markov Chain Monte Carlo (MCMC) method for numerical integration; (3) a lagged recruitment, survival, and growth (SSLRSG) state-space model; (4) the maximum likelihood estimation model (MLE); and (5) a fully age-structured, state-space population dynamic model (ASPM).

General descriptions of these models can be found in the stock assessment. The use of multiple approaches in evaluating stock status can reduce uncertainty in the best available data and can balance individual model strengths and weaknesses. Due to concerns that catch series may underestimate mortality from the commercial fishery, four separate catch scenarios were considered to evaluate catch histories: updated, baseline, and the alternative scenarios. The updated catch scenario was comprised of catches used in the 1998 SEW, including data through 1997, and additional catches for 1998 – 2001. The baseline catch scenario included similar information and discards from the menhaden fishery, and Mexican catches, bottom longline discards back to 1981, and commercial and recreational catches back to 1981. The alternative scenario reconstructed historical catches back in time (calendar years 1960 – 2001) and applied to the LCS complex only.

The age-structured models for sandbar and blacktip shark included both updated and baseline scenarios in which specific catch series were linked to specific catchability and selectivity parameters. The alternative scenarios were used for sandbar and blacktip shark catch history evaluation.

Catch rates were also analyzed for other species included in the LCS complex such as tiger, hammerhead, dusky, and silky shark. Generally, commercial data indicate increasing catch rates for tiger shark (Brown and Cramer 2002; Cortes et al. 2002) as well as decreasing trends for dusky shark, sand tiger shark, and hammerhead shark (Brown 2002; Cortes et al. 2002; Brown and Cramer 2002). Recreational catch data for hammerhead and bull shark point towards declining trends for both species (Cortes et al. 2002).

Considering the outputs of all model analyses combined, the assessment results were considerably more pessimistic for the LCS aggregate as compared to those for individual species within the complex (i.e., sandbar and blacktip sharks). While results illustrate improvements in the LCS complex since 1998, all of the models and catch scenarios described above, with the exception of the Bayesian SPM scenario which used only fishery-independent CPUE series, indicate that overfishing may be occurring and that the LCS complex may be overfished. Table 4.2-18 provides biomass and fishing mortality estimates used to make these determinations.

As such, the stock assessment finds that at least a 50-percent reduction in 2000 catch levels for the complex could be required for the biomass to reach maximum sustainable yield (MSY) in 10, 20 or 30 years. Furthermore, a 20-percent reduction in 2000 catch levels for the complex would result in less than a 50-percent probability of achieving MSY even after 30 years of implementation under those catch levels. Overall, the stock assessment found that the LCS complex as a whole is overfished and overfishing is occurring (Cortes et al. 2002).

The assessment acknowledges that the results between the complex and sandbar and blacktip sharks may be considered conflicting, given that sandbar and blacktip sharks comprise the majority of LCS commercial harvests. Specifically, sandbar and blacktip sharks make up approximately 44 percent of the total commercial catch (Burgess and Morgan 2003) and over 70 percent of the landings (Cortes and Neer 2002). The remainder of the catch is comprised mostly of tiger, scalloped hammerhead, silky, and sand tiger, with catch composition varying by region (Burgess and Morgan 2003). These species are less marketable and are often released, so they are reflected in the overall catch but not the landings. Nonetheless, the complex represents a variety of species beyond sandbar and blacktip shark, some of which are in apparent decline.

In December 2002, the peer review process of the 2002 LCS stock assessment was completed as required by a court settlement agreement. The peer reviews were conducted by three separate non-NMFS reviewers who were asked to respond to five questions regarding the appropriateness of specific modeling approaches and the selection there of, consideration of available data and the quality of data sets, application of available data in selected models, reliability of projections, and the effects of various catch scenarios on stock trajectories. Peer review findings were generally positive in that reviewers agreed that a state-of-the-art assessment was performed and that the best available science was employed. Reviewers noted assessment strengths including (1) compilation of several indices of abundance, (2) consideration of multiple stock assessment models, including Bayesian analyses, (3) discussion of myriad alternative harvest policies, and (4) analytical changes to address concerns raised by previous reviewers.

Further investigation of catch series indices, assessment of individual species within the LCS complex, investigation of age and age-sex-area assessment models, consideration of alternative harvest policies in contrast to the current constant-catch policy, and NMFS support for observer programs to obtain fishery independent estimates of abundance were among the recommendations offered for improvements to future stock assessment for LCS.

The 2005/2006 stock assessment for LCS follows the Southeast Data, Assessment, and Review (SEDAR) process. This process is a cooperative program designed to improve the quality and reliability of the stock assessments. The SEDAR process emphasizes constituent and stakeholder participation in the assessment development, transparency in the assessment process, and a rigorous and independent scientific review of the completed stock assessment. The Data Workshop for the stock assessment, which documented, analyzed, reviewed, and compiled the data for conducting the assessment, was held from October 31 to November 4, 2005, in Panama City, FL (September 15, 2005, 70 FR 54537; correction October 5, 2005, 70 FR 58190). The Assessment Workshop, which developed and refined the population analyses and parameter estimates, was held from February 6 to February 10, 2006, in Miami, FL (December 22, 2005, 70 FR 76031). At the time of writing this Final HMS FMP, the last workshop, the Review Workshop, had not yet occurred. At the Review Workshop, independent scientists should review the assessment and data. This Workshop should be held on June 5 to June 9, 2006, in Panama City, FL (March 9, 2006, 71 FR 12185). The final results should be released after the review workshop. All reports are posted on SEDAR webpage when complete (http://www.sefsc.noaa.gov/sedar/).

Recently, the SEFSC released the first dusky shark stock assessment (May 25, 2006, 71 FR 30123). Results from all of the models used were similar with all models indicating that the stock is heavily exploited. The stock assessment summarizes relevant biological data, discusses the fisheries affecting the species, and details the data and methods used to assess the stock. At the time of writing this Final HMS FMP, NMFS is reviewing the stock assessment and considering implications for management.

Small Coastal Sharks

A stock assessment for small coastal sharks (SCS) was also conducted in 2002. This was the first assessment since 1992 and as such the assessment included new information regarding SCS age and growth, reproduction, and population dynamics. Additional information relative to commercial and recreational catches as well as extended bycatch estimates for the shrimp trawl fishery were also considered.

Trends in catch were analyzed for the SCS complex as well as the four species comprising this aggregate grouping (Table 4.2-19). Overall, SCS commercial landings exceeded recreational harvest in all years since 1996, with the exception of 2000. Of the four species of SCS analyzed, bonnetheads contributed to over 50 percent of all SCS commercial landings in 1995, but Atlantic sharpnose and finetooth sharks each accounted for over 30 percent of the commercial landings in years 1996 – 1999 and 1998 – 2000 respectively. Atlantic sharpnose dominated recreational catch in all years between 1995 and 2000.

Also, in 2002, researchers at the Mote Marine Laboratory and the University of Florida, conducted a stock assessment for SCS using similar data but different models. The results were similar to the NMFS assessment in that current biomass levels for Atlantic sharpnose, bonnethead, and blacknose were at least 69 percent of the biomass in 1972 while the current biomass level for finetooth sharks was only nine percent the level in 1972 (Simpfendorfer and Burgess 2002). Both stock assessments note that the data used for finetooth sharks is not as high a quality as the data used for Atlantic sharpnose due to shorter catch-per-unit-effort (CPUE) and catch series, lack of bycatch estimates, and no catches reported in some years.

NMFS intends to conduct a new stock assessment for SCS starting in 2007. The new stock assessment would follow the SEDAR process.

Finetooth Sharks

Additional information on finetooth sharks and the results specific to this species from the 2002 SCS stock assessment are provided in this section because finetooth sharks were the only exception to the results of the assessment, in that fishing mortality in the final five years of data considered was above the mortality level associated with producing MSY. As such, finetooth sharks are not overfished, however, overfishing is occurring (Table 4.2-20a and Table 4.2-20b).

Finetooth sharks inhabit shallow coastal waters to depths of 10 m (32.8 feet) near river mouths in the Gulf of Mexico and South Atlantic Ocean between Texas and North Carolina. These fish often form large schools and migrate to warmer waters when water temperatures drop below 20°C (68°F). Finetooth sharks are relatively productive compared to other sharks as fish are sexually mature at 3.9 (TL = 118 cm (46 inches)) and 4.3 (TL = 123 cm (48 inches)) years for males and females, respectively (Carlson et al., 2003). Reproduction in finetooth sharks is viviparous with yolk sac placenta and embryos nourished through a placental connection. Females move into the nursery areas in late May and gestation is approximately 12 months. Each litter can have 1 – 6 pups with individuals measuring 51 – 64 cm (20 – 25 inches) in length.

The finetooth shark feeds primarily on mullet, Spanish mackerel, spot, Atlantic menhaden, cephalopods, and crustacean (Bester and Burgess 2004).

In 2002, NMFS conducted a stock assessment for all SCS, including finetooth sharks. Five catch rate series were used, including fishery-independent and -dependent data. The fishery-independent data sources included the NMFS Pascagoula and Panama City Laboratory longline surveys (NMFS SE LL and NMFS LL PC), and the NMFS Panama City Laboratory Gillnet Survey (NMFS GN). Fishery-dependent catch series data were included from the combined recreational series and the Directed Shark Gillnet Fishery Observer Program (DSGFOP). This catch rate series data were combined with life history information for finetooth sharks and evaluated with several stock assessment models. There were four models utilized for the assessment and numerous scenarios within each model, producing a range of point estimates for fishing mortality, relative fishing mortality, biomass, relative stock biomass, maximum fishing mortality threshold, minimum stock size threshold, and other parameters.

Of the catch series data used in the analysis, three of the five showed a positive trend (i.e., had positive slopes) in catch over time, suggesting an increase in finetooth shark abundance. The catch series data showing positive trends were DSGFOP (0.03), NMFS SE LL (0.34), and NMFS LL PC (0.04); however only the slope for the DSGFOP catch series data was statistically significant different from zero (P = 0.03). However, it should be noted that data were missing from some years in the NMFS SE LL and the DSGFOP catch series data; therefore, one cannot necessarily assume that finetooth sharks are increasing in abundance. The other two datasets, NMFS LL PC and NMFS GN PC, had negative trends in catch over time as indicated by their negative slopes (-0.24 and -0.11, respectively) but neither trend was statistically significant from zero. Overall, the slopes for the small coastal shark (SCS) complex as a whole and other individual species were relatively flat, indicating that the relative abundance of the stocks remained fairly stable during the exploitation phase (Cortés 2002).

Four different stock assessment models were used to evaluate the status of SCS using Bayesian statistical techniques. Results of both surplus production models and the Lagged Recruitment Survival and Growth State Space model (LRSG) (using several different scenarios) indicate that the current level of removals is sustainable for the SCS aggregate and the individual species within the complex. Relative stock biomass and fishing mortality trajectories obtained with the Bayesian state-space Schaefer surplus production model (SPM) for the small coastal aggregate and the Atlantic sharpnose sharks followed similar trends, since the catches were dominated by these species. The model predicted that the stock biomass for the small coastal shark complex in any given year from 1972 – 2000 exceeded the biomass producing MSY.

Relative fishing mortality (F/FMSY) was generally below one for the SCS complex, but for finetooth sharks, the final five values of F in the series (1996 – 2002) estimated by the model were above the level of F corresponding to MSY.

Results for finetooth sharks were directly influenced by the catch series used, which did not include any bycatch estimates, and this, in turn, influenced certain parameters of the Bayesian models (specifically, the priors chosen for K, which describes uncertainty in assessment models) (Cortés 2002). The lack of bycatch data in the catch series data lead to low values of MSY predicted for finetooth sharks in the SCS stock assessment (especially those obtained through the SPM models). This lack of bycatch data and shorter catch and catch per unit effort (CPUE) series, coupled with no catches reported in some years, led to some uncertainty in the stock assessment for finetooth sharks. In the case of finetooth sharks, model estimates of recent F levels are above FMSY, indicating that recent levels of effort directed at this species, if continued, could result in an overfished status in the relatively near future. The various stock assessments models used and sensitivity analyses run support these general conclusions (Cortés 2002). Future work should continue to monitor the status of this individual species (Cortés 2002).

Landings of finetooth sharks in other fisheries are extensive; however, catch series data from these fisheries are currently unavailable. The inclusion of such data in future stock assessments will provide better information on both fishing effort and estimates of MSY. Thus, it may be prudent to develop a plan to prevent overfishing that first investigates other sources of fishing mortality before initiating a particular set of management actions. In order to capture additional catch series data on fisheries contributing to finetooth fishing mortality, NMFS is expanding observer programs to include DSGFOP observers on all boats that have directed or incidental shark permits to determine if these gillnet vessels in the South Atlantic are contributing to the majority of fishing mortality. A continuation of a pilot program initiated in the spring of 2005 that placed observers on board additional gillnet vessels targeting other fish species will improve data collection efforts. Furthermore, contacting Regional Fishery Management Councils and Interstate Marine Fisheries Commissions to determine sources of mortality occurring under other fishery management plans, and having finetooth sharks included as a select species for sub-sampling of bycatch in the Gulf of Mexico Shrimp Trawl Observer Program will provide additional landings data necessary for appropriate management and conservation actions in the future.

Table 4.2-18. Summary Table of Biomass and Fishing Mortality for Large Coastal Sharks (LCS). Source: Cortes et al. 2002.

Species/Complex	2001 Biomass (N_{2001})	2001 Relative Biomass (N_{2001}/N_{MSY})	Fishing Mortality Rate (F_{2001})	Maximum Fishing Mortality Threshold (F_{MSY})	Outlook
Large Coastal Complex	2,940-10,156	0.46-1.18	0.07-0.21	0.05-0.10	Overfished; Overfishing is occuring
Sandbar Sharks	1,027-4.86 E-8	3.25E4-2.22	0.0001-0.70	0.05-0.46	Not overfished; Overfishing is occuring
Blacktip Sharks	5,587-3.16 E7	0.79-1.66	0.01-0.21	0.06-0.18	Not overfished; No overfishing occuring

Table 4.2-19. Summary Table of Biomass and Fishing Mortality for Small Coastal Sharks (SCS) Source: Cortes 2002.

Species/Complex	MSY mill lb dw	2001 Relative Biomass Level (B_{2001}/B_{MSY})	Minimum Stock Size Threshold MSST = $(0.5)B_{MSY}$ if M>=0.5 MSST = (1-M)Bmsy if M<0.5	Fishing Mortality Rate (F_{2000})	Maximum Fishing Mortality Threshold (F_{MSY})	Outlook
Small Coastal Sharks (SCS)	7.0-2.2	1.38-2.39	16.2-50.2	0.03-0.24	0.04-0.28	Not overfished; No overfishing occuring
Bonnethead Sharks	1.8-0.5	1.46-2.78	2.3-7.3	0.03-0.18	0.05-0.53	Not overfished; No overfishing occuring
Atlantic Sharpnose Sharks	7.8-1.9	1.69-3.16	11.5-33.4	0.02-0.06	0.04-0.42	Not overfished; No overfishing Occurring
Blacknose Sharks	0.8-0.2	1.92-3.15	1.6-4.5	0.02-0.19	0.03-0.32	Not overfished; No overfishing Occurring

Table 4.2-20a. Summary table of the status of the biomass of finetooth sharks. Sources: 2002 SCS stock assessment; E. Cortes, personal communication. LRSG=lagged recruitment, survival, and growth model; SPM=surplus production model.

Species	Model	Current Biomass B_{2001}	B_{MSY}	Current Relative Biomass Level B_{2001}/B_{MSY}	Over-fished?	Minimum Stock Size Threshold MSST = (1-M)B_{MSY} if M<0.5 MSST = 0.5 B_{MSY} if M>=0.5	Minimum Biomass Flag Bflag = (1-M)B_{OY}	Biomass Target B_{OY} = 125%B_{MSY}	MSY (million lb dw)	Outlook
Finetooth Sharks	Bayesian LRSG using Gibbs sampler	1.9	0.8	2.37	No	0.4 to 0.7	0.5 to 0.8	1.00	0.26 (118)	Stock not overfished $B_{2001} > B_{OY}$
	Bayesian SPM using Gibbs sampler	2.3	1.65	1.39	No	0.8 to 1.4	1.0 to 1.7	2.06	0.05 (23)	

Table 4.2-20b. Summary table of the status of the fishing mortality of finetooth sharks. Sources: 2002 SCS stock assessment; E. Cortes, personal communication. LRSG=lagged recruitment, survival, and growth; SPM=surplus production model.

Species	Model	Current F F_{2000}	Maximum Fishing Mortality Threshold MFFT = F_{MSY}	Current Relative fishing Mortality Rate F_{2000}/F_{MSY}	Over-fishing?	Fishing Mortality Target $F_{OY} = 0.75F_{MSY}$	Management Measures to Reduce Fishing Mortality Required? $F_{2000} > F_{OY}$	Outlook
Finetooth Sharks	Bayesian LRSG using Gibbs sampler	1.50	0.44	3.42	YES	0.33	YES	OVERFISHING
	Bayesian SPM using Gibbs sampler	0.13	0.03	4.13	YES	0.02	YES	

Pelagic Sharks

Pelagic sharks are subject to exploitation by many different nations and exhibit transoceanic migration patterns. As a result, ICCAT's SCRS Subcommittee on Bycatch has recommended that ICCAT take the lead in conducting stock assessments for pelagic sharks.

An ICCAT meeting was held in September 2001 to review available statistics for Atlantic and Mediterranean pelagic sharks. Newly available biological and fishery information presented for review included age and growth, length/weight relationships, species identification, species composition of catch, catch per unit effort, mortality (both natural and fishing estimates for blue sharks), bycatch, and tagging and migration studies. Landings estimates, which incorporated data for both the Atlantic and Mediterranean populations of blue shark, suggested that landings declined in 2000 (3,652 mt) following a peak of 32,654 mt in 1999. Landings of porbeagles peaked in 1997, with an estimated total of 1,450 mt, and have slowly declined each year since that time period (1998 – 2000). Similarly, landing estimates for Shortfin mako also peaked in 1997 (5,057 mt) and have declined by 83 percent (863 mt in 2000) since that time. Meeting participants expressed concern regarding the lack of information pertaining to the number of fleets catching sharks, landing statistics, and dead discards for sharks.

The SCRS decided to conduct an assessment of Atlantic pelagic sharks beginning in 2004. Emphasis was placed on blue sharks and shortfin mako sharks. Several models such as nonequilibrium production and statistical age/length-structured models will be considered to analyze the population dynamics of pelagic shark species.

ICCAT Stock Assessment on Blue and Shortfin Mako Sharks
At the 2004 Inter-Sessional Meeting of the ICCAT Subcommittee on bycatch, stock assessments for Atlantic blue shark (*Prionace glauca*) and shortfin mako (*Isurus oxyrinchus*) were conducted. This work included a review of their biology, a description of the fisheries, analyses of the state of the stocks and outlook, analyses of the effects of current regulations, and recommendations for statistics and research. The assessment indicated that the current biomass of North and South Atlantic blue shark seems to be above MSY (B>BMSY), however, these results are conditional and based on assumptions that were made by the committee. These assumptions indicate that blue sharks are not currently overfished, again, this conclusion is conditional and based on limited landings data. The committee estimates that between 82,000 and 114,000 mt ww (180,779,054 – 251,326,978 lb) of blue shark are harvested from the Atlantic Ocean each year.

The North Atlantic shortfin mako population has experienced some level of stock depletion as suggested by the historical CPUE trend and model outputs. The current stock may be below MSY (B<BMSY), suggesting that the species may be overfished. Overfishing may also be occurring as between 13,000 and 18,000 mt ww (28,660,094 – 39,683,207 lb) of shortfin mako are harvested in the Atlantic Ocean annually. South Atlantic stocks of shortfin mako shark are likely fully exploited as well, but depletion rates are less severe than in the North Atlantic.

The results of both of these assessments should be considered preliminary in nature due to limitations on quality and quantity of catch data available (SCRS, 2004). The subcommittee stated that catch data currently being reported to ICCAT does not represent the total catch actually landed, and are very limited with regard to size, age, and sex of shark harvested or caught incidentally. In order to attain a more accurate estimate of total landings, and improve future stock assessments, the committee made several recommendations, including: increase the infrastructure investment for monitoring the overall catch composition of sharks, standardize catch per unit effort (CPUE) from major fishing fleets, expand use of trade statistics(fins) to extend historical time series, and include scientists from all Contracting Parties with significant blue and shortfin mako catches in future assessments (SCRS 2004).

COSEWIC Stock Assessment on Porbeagle
The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) conducted a species report and assessment for porbeagle in 2004. They suggest that significant declines in porbeagle abundance have occurred as a result of overexploitation in fisheries. In 2001, porbeagle biomass was estimated at 4,409 mt ww (9,720,181 lb), a decline of 89 percent from the pre-fishing biomass in 1961 (COSEWIC 2004). The model employed predicts that populations declined precipitously after the fishery was developed in 1961, recovered slightly in the 1980s, and then declined again to the current level. Porbeagle quotas have been reduced

significantly for Canadian fisheries. NMFS is interested in working with the Canadian government to address concerns raised by the COSEWIC report. Currently, NMFS has a species-specific quota of 92 mt dw (202,823 lb) for porbeagle. These fish are generally harvested incidentally in the pelagic longline fisheries. Between 2000 and 2003, landings of porbeagle were approximately 3.4 mt dw for the four fishing years, combined (0.85 mt dw/year). NMFS is currently reviewing the latest Canadian stock assessment in terms of the overfishing and overfished thresholds defined in the FMP. At this time, the status of porbeagle sharks is unknown; however, if the stock is found to meet the thresholds, the status would be redefined.

4.3 Protected Species

4.3.1 Marine Mammals

(Source: pers. Comm.. A. Herndon, NMFS, June 4, 2007)
There are 32 cetacean and one sirenian species that may occur in the South Atlantic region (Table 4.3-1). All of these species are protected under the Marine Mammal Protection Act. Ten of those species are considered rare within the region or too little data are available to effectively evaluate their presence. Twelve species occur occasionally within the region and are generally found in the waters at or seaward of the continental shelf ('offshore'). All 22 species noted above rarely, if ever, interact with fishers participating in fisheries managed by the South Atlantic Fishery Management Council due to depth preferences and/or infrequency of occurrence. The remaining eleven species are common within the region or have additional regulatory protection under the Endangered Species Act (ESA). Below is a brief discussion regarding the species found rarely or infrequently within the South Atlantic and those species found primarily seaward of the areas of operations for SAFMC managed fisheries. A more comprehensive discussion of the marine mammal species commonly found in the South Atlantic region and/or those with additional protection under the ESA is also provided. Much of the information presented below regarding species occurrence in the South Atlantic can be found in Wynne and Schwartz (1999) and Waring et al. (2007).

Marine Mammals Considered Rare in the South Atlantic Region

Nine of the thirty-three marine mammal species listed above are seen only rarely in the South Atlantic region. These species either occur in low numbers naturally, or occur in the waters adjacent to the South Atlantic (i.e., Gulf of Mexico or waters off the northeastern U.S.) but only occasionally, if ever, appear in the South Atlantic. The false killer whale, pygmy killer whale, killer whale (Katona et al. 1998), melon-headed whale, rough-toothed dolphin, Fraser's dolphin, and spinner dolphin are examples of these species. The harbor porpoises and spinner dolphins (CeTAP 1982; Mullin and Fulling 2003; Palka et al. unpub. Ms) may also occur the in South Atlantic region when they travel to the southernmost portions of their ranges. However, sightings of these species north of Cape Hatteras, North Carolina are far more common. Cuvier's beaked whale is a species that may occur within the region but very little is known about its distribution (Leatherwood et al. 1976).

Table 4.3-1. Marine mammal species that may occur in the South Atlantic.

Rare Species	
False Killer Whale	*Pseudorca crassidens*
Pygmy Killer Whale	*Feresa attenuate*
Cuvier's Beaked Whale	*Ziphius cavirostris*
Killer Whale	*Orcinus orca*
Harbor Porpoise	*Phocoena phocoena*
Melon-Headed Whale	*Peponocephala electra*
Rough-Toothed Dolphin	*Steno bredanensis*
Fraser’s Dolphin	*Lagenodelphis hosei*
Spinner Dolphin	*Stenella longirostris*
Striped Dolphin	*Stenella coeruleoalba*
Occasional/Offshore Species	
Dwarf Sperm Whale	*Kogia sima*
Pygmy Sperm Whale	*Kogia breviceps*
Long-Finned Pilot Whale	*Globicephala melas*
Short-Finned Pilot Whale	*Globicephala macrorhynchus*
Risso's Dolphin	*Grampus griseus*
Common Dolphin	*Delphinus delphis*
True's Beaked Whale	*Mesoplodon mirus*
Gervais' Beaked Whale	*Mesoplodon europaeus*
Blainville's Beaked Whale	*Mesoplodon densirostris*
Sowerby's Beaked Whale	*Mesoplodon bidens*
Pantropical Spotted Dolphin	*Stenella attenuata*
Clymene Dolphin	*Stenella clymene*
Common/ESA Protected Species	
Blue Whale*	*Balaenoptera musculus*
Fin Whale*	*Balaenoptera physalus*
Humpback Whale*	*Megaptera novaeangliae*
Northern Right Whale*	*Eubalaena glacialis*
Sei Whale*	*Balaenoptera borealis*
Sperm Whale*	*Physeter macrocephalus*
West Indian Manatee (Florida Stock)**	*Trichechus manatus latirostris*
Atlantic Spotted Dolphin	*Stenella frontalis*
Bottlenose Dolphin (Coastal Stock)	*Tursiops truncatus*
Bottlenose Dolphin (Offshore Stock)	*Tursiops truncatus*
Minke Whale	*Balaenoptera acutorostrata*

*ESA-listed species

**The U.S. Fish and Wildlife Service have ESA jurisdiction for manatees.

Marine Mammals Occurring Occasionally or Offshore in the South Atlantic Region

The range of the long-finned pilot whale, Risso’s dolphin, common dolphin, and Clymene dolphin includes the northern portions of the South Atlantic region. These species occur in the waters from Cape Hatteras, North Carolina, north. When these four species and the short-finned pilot whale, striped dolphin, dwarf sperm whale, pygmy sperm whale and the four beaked whale species (Mesoplodon spp.) occur in the South Atlantic, they are generally found at or beyond the continental shelf (≥ 200 m). The areas where these species are commonly found are generally deeper and further offshore than those utilized by fishers participating in fisheries managed by the SAFMC (volume III of this document). Waring et al. (2007) noted no interactions between these species and SAFMC managed fisheries.

Marine Mammals Common to South Atlantic Region or with Additional ESA Protection

Blue Whale

Description and Distribution

Blue whales, *Balaenoptera musculus*, are long bodied and slender. The dorsal fin is proportionately smaller than those of other balaenopterid whales. It is also set far back, nearer to the tail flukes than to the middle of the body. Viewed from above, the blue whale has a broad, flat rostrum. Blue whales have a mottled gray color pattern which appears light blue when seen through the water. The background color can be dark gray, interrupted by irregular light gray markings, with dark gray splotches (NMFS 1998).

The blue whale is a cosmopolitan species of baleen whale (Gambell 1979; Yochem and Leatherwood 1985; Mead and Brownell 1993). The overall range of blue whales in the North Atlantic extends from the subtropics north to Baffin Bay and the Greenland Sea (Jongsård 1955; Yochem and Leatherwood 1985). The species was regularly hunted from land stations in Newfoundland and Labrador, the Gulf of St. Lawrence, West Greenland, Iceland, Norway, Ireland, and the islands of Shetland, the Hebrides and the Faroes (True 1904; Thompson 1928; Sergeant 1953, 1966; Jonsgård 1955, 1977; Kapel 1979; Sigurjónsson and Gunnlaugsson 1990).

Blue whales are rare in the shelf waters of the eastern U.S. Individuals have occasional been sighted off Cape Cod, Massachusetts, in summer and fall (Wenzel et al. 1988). Farther north in Canadian waters, a few sightings have been made on the Scotian Shelf (CeTAP 1982, Sutcliffe and Brodie 1977), and two blue whales were sighted in August 1995 in the lower Bay of Fundy (newspaper reports). A stranding at Ocean City, Maryland, in October 1891 (True 1904) is the southernmost confirmed record on the east coast. Several records (pre-1970) of blue whale strandings in the Gulf of Mexico (J. G. Mead, pers. comm., 27 October 1997) suggest occasional straying into that area. A large blue whale was killed at Cristobal, Panama, in the Caribbean Sea entrance to the Panama Canal in January 1922 (Harmer 1923).

Reproduction

The gestation period for the blue whale is approximately 10-12 months, and calves are nursed for about 6-7 months. Most reproductive activity, including births and mating, takes place in the winter season. Weaning probably occurs on, or en route to, the summer feeding areas. The average calving interval is estimated at two to three years. The age of sexual maturity is uncertain but is thought to be 5-15 years (Mizroch et al. 1984; Yochem and Leatherwood 1985).

Only nine blue whales classified as "calves" were observed during 19 seasons of observations along the north shore of the Gulf of St. Lawrence (R. Sears, pers. comm., October 1997). Either blue whale populations are segregated in such a way that lactating females reside mainly in areas other than those in which observations have been made, or weaning occurs prior to their arrival in these areas. R. Sears (pers. comm. October 1997, in NMFS 1998) also suggested the lack of calf observations could be because this population is producing relatively few calves.

Ecological Relationships

Diet, Development, and Growth

Based on stomach content analysis, the food of blue whales in the North Atlantic has been reported to consist entirely of "krill," (i.e., relatively large euphausiid crustaceans [Jonsgård 1955; Sergeant 1966; Christensen et al. 1992b]). The species *Thysanoessa inermis* and *Meganyctiphanes norvegica* are particularly important in the eastern North Atlantic (Hjort and Ruud 1929; Christensen et al. 1992b). The species *Thysanoessa raschii* and *M. norvegica* are said to represent important food sources of blue whales in the Gulf of St. Lawrence, based on observations of feeding whales and sampling of the nearby water column (Sears et al. 1987). Some other prey species, including fish and copepods, have been mentioned in the literature (e.g., see the review by Kawamura 1980), but these are not likely to contribute significantly to the diet of blue whales. Sears et al. (1987) suggested that the whales' apparent preference for the 100 m contour during daylight hours along the north shore of the Gulf of St. Lawrence is explained by krill concentrations found regularly at depths of 90-120 m.

The blue whale is the largest animal ever known to have lived on Earth. Adults in the Antarctic have reached a maximum body length of about 110 ft. (33 m) and can weigh more than 330,000 lbs. (150,000 kg). Blue whales in the Northern Hemisphere are generally smaller than those in the Southern Ocean. Although a 92 ft [28.1 m] blue whale is reported in whaling statistics from Davis Strait (R. Sears pers. comm., October 1997, in NMFS 1998). The largest blue whales reported from the North Pacific are a female that measured 88 ft (26.8 m) taken at Port Hobron in 1932 (Reeves et al. 1985) and a 89 ft (27.1 m) female taken by Japanese pelagic whaling operations in 1959 (J. Gilpatrick, pers. comm., June 1998). As is true of other baleen whale species, female blue whales are somewhat larger than males (Ralls 1976).

The question of whether blue whales are food-limited in the Northern Hemisphere has not been addressed. All baleen whale species that are sympatric with the blue whale eat euphausiids to some extent and are, therefore, potential competitors (Nemoto 1970). However, there is currently little or no direct evidence for interspecific competition involving blue whales anywhere (Clapham and Brownell 1996), and it seems unlikely that resource competition would be an important factor in preventing the recovery of blue whale stocks. The high mobility of blue whales should enable them to take advantage of transitory concentrations of prey over a very large area.

Migration and Movement

Blue whales are present in the Gulf of St. Lawrence for most of the year (records are for March to February according to R. Sears, pers. comm., October 1997), but most leave by early winter to avoid ice entrapment and do not return until the ice breaks up in spring. Two peaks or pulses of sightings occur in most years along the north shore of the Gulf: one in April to early June, the other from August into at least late October (R. Sears, pers. comm., August 1995, in NMFS 1998). Blue whales are especially common along the north shore during the summer and fall feeding season, with a peak in sightings from June to November (Sears et al. 1987, R. Sears, pers. comm., October 1997). Whaling records suggest that the occurrence of blue whales is seasonal in most areas, but the lack of whaling effort during the period from late fall to spring may explain the lack of records in those seasons (e.g., see Thompson 1928).

In the Gulf of St. Lawrence, individual blue whales rarely spend more than about ten days in a particular area, and they have been described as "very nomadic, with generally low local resident times" (Sears et al. 1990). Four individuals were documented to have traveled more than 400 km in a two-week period during the summer and fall (Sears et al. 1990). However, some individuals have been documented as remaining in the same area for a month or more (R. Sears pers. comm., August 1995, in NMFS 1998). The main sighting areas are off the Gaspé Peninsula, along the Quebec north shore of the Gulf, around Anticosti Island, and in the St. Lawrence River estuary to as far upriver as Tadoussac (R. Sears pers. comm., October 1997, in NMFS 1998).

Abundance and Status of Stock

Little is known about the population size of blue whales except for in the Gulf of St. Lawrence area. Here, 308 individuals have been catalogued (Sears et al. 1987), but the data were deemed to be unusable for abundance estimation (Hammond et al. 1990). However, this figure of 308 individuals is considered to be a minimum population estimate for the western North Atlantic stock (Waring et al. 2007). Mitchell (1974) estimated that the blue whale population in the western North Atlantic may number only in the low hundreds. R. Sears (pers. comm., in Warning et al. 2007) suggests that no present evidence exists to refute this estimate.

There are insufficient data to determine population trends for this species and the status of this stock relative to the optimum sustainable population in the U.S. Atlantic EEZ is unknown (Waring et al. 2007). Off western and southwestern Iceland, an increasing trend of 4.9% a year was reported for the period 1969-1988 (Sigurjónsson and Gunnlaugsson 1990), although this estimate should be treated with caution given the effort biases underlying the sightings data on which it was based.

Fin Whale

Description and Distribution

Fin whales, *Balaenoptera physalus*, are the second-largest whale species by length. They are long-bodied and slender, with a prominent dorsal fin set about two-thirds of the way back on the body. The basic body color of the fin whale is dark gray dorsally and white ventrally, but the pigmentation pattern is complex. The lower jaw is gray or black on the left side and creamy white on the right side. This asymmetrical coloration extends to the baleen plates as well, and is reversed on the tongue. Individually distinctive features of pigmentation, along with dorsal fin shapes and body scars, have been used in photo-identification studies (Agler et al. 1990).

The fin whale has an extensive distribution in the North Atlantic, occurring from the Gulf of Mexico (Jefferson and Schiro 1997) and Mediterranean Sea, northward to the edges of the arctic pack ice (Jonsgård 1966a, 1966b; Sergeant 1977, IWC 1992). In general, fin whales are more common north of approximately 30°N latitude, but considerable confusion arises about their occurrence south of 30°N latitude, because of the difficulty in distinguishing fin whales from Bryde's whales (Mead 1977). Extensive ship surveys led Mitchell (1974) to conclude that the summer feeding range of fin whales in the western North Atlantic was mainly between 41°20'N and 51°00'N, from shore seaward to the 1,000-fathom contour.

The local distribution of fin whales during much of the year is probably governed largely by prey availability (Ingebrigtsen 1929; Jonsgård 1966a, 1966b). For example, the positions off southwestern Iceland where fin whales were caught correlated well with the known distribution of spawning krill (*Meganyctiphanes norvegica*), their preferred prey in that area (Rørvik et al. 1976). In general, fin whales in the central and eastern North Atlantic tend to occur most abundantly over the continental slope and on the shelf seaward of the 200 m isobath (Rørvik et al. 1976). In contrast, off the eastern U.S. they are centered along the 100 m isobath but with sightings well spread out over shallower and deeper water, including submarine canyons along the shelf break (Kenney and Winn 1987, Hain et al. 1992). Fin whales accounted for 46% of the large whales and 24% of all cetaceans sighted over the continental shelf during aerial surveys between Cape Hatteras and Nova Scotia during 1978-82 (CeTAP 1982).

Segregation seems to occur at least in summer, with the larger (mature) whales arriving at feeding areas earlier, and departing later, than the smaller individuals (Rørvik et al. 1976). Within the Gulf of Maine, lactating females and their calves primarily occupy, or at times are the only ones occupying, this southern portion of their summer feeding range (Agler et al. 1993).

Fin whales are locally common in the River and Gulf of St. Lawrence during the summer and fall, especially on the north shore shelf (Edds and Macfarlane 1987; Borobia et al. 1995; Kingsley and Reeves 1998). Sergeant (1977) suggested that they associate with steep contours of the Laurentian Channel, either because tidal and current mixing along such gradients drives high biological production or because changes in depth aid their navigation.

Reproduction
The gestation period is probably somewhat less than a year, and fin whale calves are nursed for 6-7 months (Haug 1981; Gambell 1985). Most reproductive activity, including births and mating, takes place in the winter season (November to March; peak December/January) (Haug 1981; Mitchell 1974), although "out-of-season" births do occur off the eastern U.S. (Hain et al. 1992).

The average calving interval has been estimated at about two years, based on whaling data (Christensen et al. 1992b). In unexploited populations, the interval may be somewhat longer. Agler et al. (1993) used photo-identification data to estimate an average interval of 2.7 years for fin whales in the Gulf of Maine although they acknowledged that this value was probably biased upward by incomplete sighting histories. If certain females calved in "missed" years (i.e., years in which they were not photo-identified in the study area), the mean interval could have been as low as 2.24 years (Agler et al. 1993). Breiwick (1993) found that the annual pregnancy rate (defined as the percentage of mature females that are pregnant in a given year) was significantly lower in the population hunted from Blandford, Nova Scotia, than in the population hunted from

Williamsport and South Dildo, Newfoundland. Among the hypotheses that could explain this difference is that fin whales show a density-dependent response by shortening the birth interval (and/or the time to sexual maturity) and that the Nova Scotia population was less depleted than the Newfoundland population, at the time of sampling.

Fin whales in populations near carrying capacity may not attain sexual maturity until ten years of age or older, whereas those in exploited populations can mature as early as six or seven years of age (Gambell 1985). It should be noted, however, that the question of whether whaling data from the Southern Hemisphere do or do not demonstrate density-dependent responses in the reproductive cycle of fin whales is controversial (Mizroch and York 1984, Sampson 1989).

The gross annual reproductive rate of fin whales in the Gulf of Maine (calves as a percentage of the total population) was about 8% during the 1980s (Agler et al. 1993). Sigurjónsson (1995) gave the range of pregnancy rates for the species (proportion of adult females pregnant in a given year) as 0.36-0.47.

Ecological Relationships

Diet, Development, and Growth

Fin whales in the North Atlantic eat pelagic crustaceans (mainly euphausiids or krill, including *Meganyctiphanes norvegica* and *Thysanoessa inermis*) and schooling fish such as capelin (*Mallotus villosus*), herring (*Clupea harengus*), and sand lance (*Ammodytes* spp.) (Hjort and Ruud 1929; Ingebrigtsen 1929; Jonsgård 1966a; Mitchell 1974; Sergeant 1977; Overholtz and Nicolas 1979; Christensen et al. 1992b; Borobia et al. 1995). The availability of sand lance, in particular, is thought to have had a strong influence on the distribution and movements of fin whales along the east coast of the U.S. (Kenney and Winn 1986; Payne et al. 1990; Hain et al. 1992).

Although there may be some degree of specialization, most individuals probably prey on both invertebrates and fish, depending on availability (Watkins et al. 1984; Edds and Macfarlane 1987; Borobia et al. 1995). Sergeant (1977) suggested that euphausiids were the "basic food" of fin whales and that they took advantage of fish when sufficiently concentrated, "particularly in the pre-spawning, spawning, and post-spawning adult stages on the Continental Shelf and in coastal waters."

Migration and Movement

Fin whale populations exhibit differing degrees of mobility, presumably depending on the stability of access to sufficient prey resources throughout the year. Most groups are thought to migrate seasonally, in some cases over distances of thousands of kilometers. They feed intensively at high latitudes in summer and fast, or at least greatly reduce their food intake, at lower latitudes in winter. Some groups apparently move over shorter distances and can be considered resident to areas with a year-round supply of adequate prey. The fin whale is a cosmopolitan species with a generally anti-tropical distribution centered in the temperate zones. Two subspecies, a large Southern Hemisphere form and a smaller Northern Hemisphere form, have been recognized by some authorities (Tomilin 1946, 1967; Sokolov and Arsen'ev 1994; Rice 1998).

Although fin whales are certainly migratory, the overall migration pattern is confusing and likely complex (Christensen et al. 1992a). Regular mass movements along well-defined migratory corridors, with specific end-points, have not been documented by sightings. However, acoustic recordings from passive-listening hydrophone arrays, indicate a southward "flow pattern" occurs in the fall from the Labrador-Newfoundland region, south past Bermuda, and into the West Indies (Clark 1995). Fin whales occur year-round in a wide range of latitudes and longitudes, but the density of individuals in any one area changes seasonally. Thus, their aggregate movements are patterned and consistent, but movements of individuals in a given year may vary according to their energetic and reproductive condition, climatic factors, etc. In some parts of their range, such as the Gulf of St. Lawrence and the Newfoundland shelf, ice formation in winter forces fin whales offshore, and its disintegration in spring, allows them to move back inshore (Jonsgård 1966a, Sergeant 1977). One or more "populations" of fin whales were thought by Norwegian whalers to remain year-round in high latitudes, actually moving offshore, but not southward, in late autumn (Hjort and Ruud 1929; Jonsgård 1966a). These observations were recently reinforced by acoustic evidence that fin whales occur throughout the winter in the Norwegian and Barents Seas, apparently in considerable numbers (Clark 1995).

While much remains unknown, the magnitude of the ecological role of the fin whale is impressive (Waring et al. 2007). In the U.S. Atlantic Exclusive Economic Zone (EEZ), fin whales are probably the dominant large cetacean species during all seasons, having the largest standing stock, the largest food requirements, and therefore the largest impact on the ecosystem of any cetacean species (Kenney et al. 1997; Hain et al. 1992).

Abundance and Status of Stock

Two estimates of fin whale abundance are available. A 1995 sighting survey, covering the waters from Virginia to the mouth of the Gulf of St. Lawrence, estimated 2,200 individuals (CV=0.24) (Palka 1995). A more recent estimate of 2,814 (CV=0.21) fin whales was derived from a 1999 sighting survey, covering waters from Georges Bank to the mouth of the Gulf of St. Lawrence (NMFS unpublished data, Palka 2006). The 1999 estimate is considered the best available for the western North Atlantic fin whale stock because it is relatively recent. However, this estimate must be considered extremely conservative (Waring et al. 2007).

The status of this stock relative to the optimum sustainable population in the U.S. Atlantic EEZ is unknown, but the species is listed as endangered under the ESA. There are insufficient data to determine the population trend for fin whales. This is a strategic stock because the fin whale is listed as an endangered species under the ESA (Waring et al. 2007).

Humpback Whale

Description and Distribution

Humpback whales, *Megaptera novaengliae*, have uncommonly long flippers, with a more robust body, fewer throat grooves, and more variable dorsal fin than other Balaenopterid whales. Their vocalizations are also longer and more complex than other whales Balaenopterid whales (NMFS 1991a). Their overall length varies slightly depending on geographic location, but the maximum length recorded was 60 ft. (Winn and Reichley 1985). Humpbacks are generally dark on the back, their flippers, underside, and flukes generally have substantial areas of white pigmentation (NMFS 1991a).

Humpbacks are distributed worldwide but are less common in arctic waters. During the winter months, humpbacks are most common in temperate and tropical waters (10°N-23°N latitude). In the summer, they will frequently head to more biological productive waters in the higher latitudes (35°N-65°N) (Winn and Reichley 1985). Humpbacks are generally thought to inhabit the waters over continental shelves and around some oceanic islands (Balcomb and Nichols 1978; Whitehead 1987).

Reproduction

Humpbacks reach sexual maturity between the ages of four and six (NMFS 1991a) and the mean length at sexual maturity for humpbacks off California was 48 ft. (14.5 m) for females and 44 ft. (13.5 m) for males (National Marine Mammal Laboratory, unpublished data). Mating and birthing is thought to occur during the migration to over-wintering areas. Sexually mature females give birth approximately every two to three years, although annual and multi-year (five years or more, Baker et al. 1988) have been observed (Chittleborough 1965; Glockner-Ferrari and Ferrari 1984, 1985; Clapham and Mayo 1987, 1990; Perry et al. 1988); gestation and lactation last 10-12 months (Nishiwaki 1959; NMML unpublished data; Rice 1963).

Ecological Relationships

Diet, Development, and Growth

In the western North Atlantic, humpback whales feed during spring, summer, and fall over a geographic range encompassing the eastern coast of the U.S. (including the Gulf of Maine), the Gulf of St. Lawrence, Newfoundland/Labrador, and western Greenland (Katona and Beard 1990). Humpback whales are frequently piscivorus when in New England waters, feeding on herring (*Clupea harengus*), sand lance (*Ammodytes* spp.), capelin (*Mallotus villosus*) and other small fishes. Atlantic mackerel (*Scomber scombus*), small pollock (*Pollachius virens*) and haddock (*Melanogrammus aeglefinus*) are also occasionally preyed upon (NMFS 1991a). In the northern Gulf of Maine, euphausiids are also frequently taken (Paquet et al. 1997). Humpbacks may dive as deep as 650 ft. (200 m) in pursuit of food (NMFS 1991a), though shallower dives are more common.

Humpbacks also use a wide variety of feeding methods, more so than any other baleen whale. Known humpback feeding behaviors are: (1) the use of columns, clouds or nets of expelled bubbles to concentrate krill or fish; (2) herding/disabling prey by pounding or flicking their flukes and flippers; (3) using the water surface as a barrier against which they can trap and concentrate prey; (4) feeding in formation ("echelon feeding"); (5) using acoustic cues to synchronize feeding lunges; (6) apparent short- and long-term cooperation between individuals (Ingebritsen 1929; Jurasz and Jurasz 1979; Watkins and Schevill 1979; Hain et al. 1982; Weinrich 1983; Baker and Herman 1985; Baker 1985; Hays et al. 1985; Winn and Reichley 1985; D'Vincent et al. 1985). There are also reports of humpbacks approaching fishing vessels in the process of hauling gear to take fish concentrated by the net (W.A. Watkins, J. Sigurjonsson pers. comm. in NMFS 1991a) or feeding on portions of catch that escaped through the trawl mesh (D.E. Sergeant pers. comm. in NMFS 1991a). Humpbacks also appear to feed off prey stirred up from the bottom during shrimping operations (von Ziegesar 1984).

Migration and Movement

Humpbacks exhibit two general types of migration and movement: (1) in season movement throughout portions of their summer range and (2) long distance migrations between summering and wintering areas (NMFS 1991a).

During winter, whales from most identified Atlantic feeding areas (including the Gulf of Maine) mate and calve in the West Indies, where spatial and genetic mixing among subpopulations occurs (Clapham et al. 1993; Katona and Beard 1990; Palsbøll et al. 1997; Stevick et al. 1998). A few whales of unknown northern origin migrate to the Cape Verde Islands (Reiner et al. 1996). In the West Indies, the majority of whales are found in the waters of the Dominican Republic, notably on Silver Bank, Navidad Bank, and in Samana Bay (Balcomb and Nichols 1982; Whitehead and Moore 1982; Mattila et al. 1989, 1994). Seawater temperatures in these locations can reach 28°C, which is among the highest experienced by any balaenopterid (NMFS 1991a). Humpback whales are also found at much lower densities throughout the remainder of the Antillean arc, from Puerto Rico to the coast of Venezuela (Winn et al. 1975; Levenson and Leapley 1978; Price 1985; Mattila and Clapham 1989).

Not all whales migrate to the West Indies every winter, and significant numbers of animals are found in mid and high-latitude regions at this time (Clapham et al. 1993; Swingle et al. 1993). An increased number of sightings of humpback whales near the Chesapeake and Delaware Bays occurred in 1992 (Swingle et al. 1993). Wiley et al. (1995) reported 38 humpback whale strandings occurred during 1985-1992 in the U.S. mid-Atlantic and southeastern states. Humpback whale strandings increased, particularly along the Virginia and North Carolina coasts, and most stranded animals were sexually immature. In addition, the small size of many of these whales strongly suggested that they had only recently separated from their mothers. Wiley et al. (1995) concluded that these areas were becoming an increasingly important habitat for juvenile humpback whales and that anthropogenic factors may negatively affect whales in this area. There have also been a number of wintertime humpback sightings in coastal waters of the southeastern U.S. (NMFS unpublished data, New England Aquarium unpublished data, Florida DEP unpublished data). Whether the increased sightings represent a distributional change, or are simply due to an increase in sighting effort and/or whale abundance, is unknown.

Abundance and Status of Stock

Current data suggest that the Gulf of Maine humpback whale stock is steadily increasing in size. This is consistent with an estimated average trend of 3.1% (SE=0.005) in the North Atlantic population overall for the period 1979-1993 (Stevick et al. 2003), although there are no feeding-area-specific estimates. Although these estimates of abundance indicate continued population growth, the size of the humpback whale stock may be below optimum sustainable population in the U.S. Atlantic EEZ (Waring et al. 2007). There are insufficient data to determine current population trends for humpback whales in the North Atlantic overall.

A new large-scale assessment called More of North Atlantic Humpbacks (MoNAH) project is currently underway. This two-year study will attempt to estimate abundance and refine knowledge of population structure with extensive sampling in the Gulf of Maine/Scotian Shelf region and on the primary wintering ground on Silver Bank; additional research will focus on the U.S. mid-Atlantic states (Waring et al. 2007).

Northern Right Whale

Description and Distribution

The right whale, *Eubalaena glacialis*, is a large baleen whale. Adults are generally between 45 ft and 55 ft (13.7-16.8 m) in length and can weigh up to 70 tons (63.5 metric tons). Females are larger than males. The distinguishing features of right whales include a stocky body, generally black coloration (although some individuals have white patches on their undersides), lack of a dorsal fin, large head (about 1/4 of the body length), strongly bowed margin of the lower lip, and callosities on the head region. Two rows of long (up to about eight feet (2.4 m) in length), dark baleen plates hang from the upper jaw, with about 225 plates on each side. The tail is broad, deeply notched, and all black with smooth trailing edge (NMFS 2005).

Individuals of the western Atlantic northern right whale population range from wintering and calving grounds in coastal waters of the southeastern U.S. to summer feeding and nursery grounds in New England waters and northward to the Bay of Fundy and the Scotian Shelf. For much of the year, their distribution is strongly correlated to the distribution of their prey, which appears to be primarily calanoid copepods in the Northern Hemisphere.

Five areas of "high use" were identified in the previous Recovery Plan for the Northern Right Whale (NMFS 1991b), and they are still key habitat areas for right whales: (1) Coastal Florida and Georgia (Sebastian Inlet, Florida to the Altamaha River, Georgia), (2) The Great South Channel (east of Cape Cod), (3) Massachusetts Bay and Cape Cod Bay, (4) The Bay of Fundy, and (5) The Scotian Shelf, including Browns and Baccaro Banks, Roseway Basin and areas to the east. The first three of these areas were designated as Northern right whale critical habitat in June 1994. Right whales occur off New England at various times of the year, with a peak occurrence in winter/spring (Hamilton and Mayo 1990). Peak abundance occurs in the Great South Channel in spring (Kenney et al. 1995, Kenney 2001). In summer and fall, much of the population is found in Canadian waters (i.e., the Bay of Fundy and Scotian Shelf, with the former area being a major summer nursery ground) (Mitchell et al. 1986, Winn et al. 1986, Stone et al. 1990). Whales seen in the Roseway Basin/Browns Bank region were primarily juvenile and adult males (Brown et al. 2001), whereas most of the summer/autumn sightings of mother/calf pairs have been in the Bay of Fundy (Kenney et al. 2001). However, the former area appears to have been largely abandoned in 1993, and the population composition in the Bay of Fundy has recently been much more mixed than it was previously.

Records from the Gulf of Mexico (Moore and Clark 1963; Schmidly et al. 1972) represent either geographic anomalies or a more extensive historic range beyond the sole known calving and wintering ground in the waters of the southeastern U.S. Whatever the case, the location of most of the population is unknown during the winter. Offshore (greater than 30 miles) surveys flown off the coast of northeastern Florida and southeastern Georgia from 1996 to 2001 had 3 sightings in 1996, 1 in 1997, 13 in 1998, 6 in 1999, 11 in 2000 and 6 in 2001 (within each year, some were repeat sightings of previously recorded individuals). The frequency with which right whales occur in offshore waters in the southeastern U.S. remains unclear.

Critical Habitat

As noted above, there are five well-known habitats used annually by western North Atlantic right whales: 1) coastal Florida and Georgia, 2) the Great South Channel, east of Cape Cod, 3) Cape Cod and Massachusetts Bays, 4) the Bay of Fundy, and 5) Browns and Baccaro Banks, south of Nova Scotia. The first three areas occur in U.S. waters and were designated by NMFS as critical habitat in June 1994 (59 FR 28793).

Actions authorized, funded, or carried out by Federal agencies that may have an impact on critical habitat must be consulted upon in accordance with Section 7 of the ESA, regardless of the presence of right whales at the time of impacts. Impacts on these areas that may affect primary constituent elements such as prey availability and the quality of nursery areas must be considered when analyzing whether habitat may be adversely modified.

Reproduction

Females give birth to their first calf at an average age of 9 years (Best et al. 2001, Hamilton et al. 1998). Calves are 18 to 19 ft (5.5 m to 6.0 m) in length at birth (Best 1994). Gestation lasts from 357 to 396 days in southern right whales (Best 1994), and it is likely to be similar in the northern species. Standard reproductive rates for the western North Atlantic population have yet to be calculated.

The calving interval for right whales is between 2 and 7 years, with means ranging from 3.12 (95 percent confidence interval (CI) 3.05–3.17) to 3.67 years (95 percent CI 3.3–4.1) (Knowlton et al. 1994; Best et al. 2001; Burnell 2001; Cooke et al. 2001). In the western North Atlantic, there was a significant increase in the calving interval from 3.67 years for the period 1980 to 1992 (Knowlton et al. 1994) to 5.8 years for the period 1990 to 1998 (Kraus et al. 2001). The increase in the calving interval is of particular concern and, together with other perplexing biological parameters, may suggest the population is under rather unusual biological, energetic, or reproductive stress. Most recently (2001–2005), a dramatic increase in North Atlantic right whale calving (23 calves per year) may have decreased the interval to levels more similar to that of the southern right whale (Kraus et al. in press).

The waters south of Cape Cod and north of the Georgia/Florida winter calving ground are not considered “high use” areas, yet the whales clearly move through these waters, especially waters off New York/New Jersey and the “mid-Atlantic” states, regularly (Reeves et al. 1978, Reeves and Mitchell 1986, Winn et al. 1986, Reeves et al. 1999). Most calving takes place off Georgia and Florida, but limited surveys recently conducted along the mid-Atlantic suggest some mother-calf pairs use the area from Cape Fear, North Carolina, to South Carolina as a wintering/calving area as well.

Ecological Relationships

Diet, Development, and Growth

Weaning seems to be variable, and has been reported as 8 to 17 months in North Atlantic right whales (Hamilton and Marx 1995). In the western North Atlantic, right whales feed primarily on copepods, with *Calanus finmarchicus* believed to be the primary prey (Kraus et al. 1988; Wishner et al. 1988; Murison and Gaskin 1989). However, other zooplankters are also taken, including Pseudocalanus spp., *Centropages* spp., and even cyprids (Mayo and Marx 1990). There is no evidence for consumption of euphausiids although, given the inclusion of this taxon in the diet of right whales elsewhere, it would be surprising if North Atlantic right whales were different in this regard. Unlike balaenopterid whales, right whales are skimmers; they feed by continuously filtering prey through their baleen while moving, mouth agape, through a patch of zooplankton. Feeding occurs from spring through fall, and also in winter in certain areas (e.g., Cape Cod Bay; Mayo and Marx 1990). Oceanographic and bathymetric features, such as relatively cooler water temperatures and 100-200 m depths adjacent to steeply sloping bottom topography, also seem to be related to the utilization of certain areas for feeding (Winn et al. 1986; Clapham 1999).

<u>Migration and Movement</u>
In summer and fall, much of the population is found in Canadian waters (i.e., the Bay of Fundy and Scotian Shelf, with the former area being a major summer nursery ground) (Mitchell et al. 1986, Winn et al. 1986, Stone et al. 1990). Knowlton et al. (1992) reported several long-distance movements as far north as Newfoundland, the Labrador Basin, and southeast of Greenland; in addition, recent resightings of photographically identified individuals have been made off Iceland, arctic Norway and in the old Cape Farewell whaling ground east of Greenland.

Known wintering areas for this population are along the southeastern U.S. coast, where calving occurs from December through March (Winn 1984; Kraus et al. 1986; International Whaling Commission (IWC) 1986), and in Cape Cod Bay where, in 1998, whales were sighted from mid January to mid May (Brown and Marx 1998). However, a majority of the population is unaccounted for in winter (Kraus et al. 1986). Other wintering areas have been suggested, based upon sparse data; these include the Gulf of St. Lawrence (Lien et al. 1989), Newfoundland (Beamish 1981, Lien et al. 1989), New York and New Jersey coastal waters (Mead 1986), Bermuda (Payne and McVay 1971), and the Gulf of Mexico (Mead 1986) (see Reeves 2001 for a review).

Telemetry studies have revealed movement patterns of considerable length and duration (Mate et al. 1997, Slay et al. 1998). They may also feed, at least opportunistically, while migrating. Successful efforts to protect the whales in areas where they linger for long periods and/or aggregate in relatively high densities could be offset if the animals were to be exposed to serious risks, such as collision or entanglement, while in transit between such areas.

Information on residency times of individual whales at specific sites is ambiguous, especially in light of recent satellite transmitter results indicating right whales tagged in the Bay of Fundy may travel long distances in the few days or weeks between sightings (Mate et al. 1997). Schevill et al. (1986) reported individual right whales residing in Cape Cod waters for no more than a few days. In 1976, they observed a cow and calf over a 7-week period, the longest residence time documented during observations between 1955 and 1981. Prior to 1986, Hamilton and Mayo (1990) reported observations of individual whales up to 12 times in a year, with the longest apparent residency being 89 days. Fifty percent of individual right whales sighted by Hamilton and Mayo (1990) were seen in more than one year.

It has been suggested that interspecific competition with either sei whales (*Balaenoptera* *borealis*) or planktivorous fish may limit Northern right whale prey consumption (Mitchell 1975a, Kraus et al. 1988, Payne et al. 1990). In the North Atlantic, sei whales are sympatric with the right whales, and because both species feed on small zooplankton species, they may compete (Mitchell 1975a).

There is also speculation about competition with certain species of fish in the Gulf of Maine, including sand lance (*Ammodytes* spp.), herring (*Clupea* spp.), Atlantic mackerel (*Scomber scombrus*), river herrings (shad, blueback; *Alosa* spp.), menhaden (*Brevoortia tyrannus*), and basking sharks (*Cetorhinus maximus*). However, as noted by Clapham and Brownell (1996), assertions regarding interspecific competition are rarely well defined or ecologically based. While the potential for interference competition exists for right whales, direct evidence is essentially absent.

Abundance and Status of Stock

Based on a census of individual whales identified using photo-identification techniques and an assumption of mortality of whales not seen in seven years, the western North Atlantic stock size was estimated to be 295 individuals in 1992 (Knowlton et al. 1994). An updated analysis using the same method gave an estimate of 299 animals in 1998 (Kraus et al. 2001). A review of the photo-id recapture database in October 2005 indicated that 306 individually recognized whales were known to be alive during 2001. Because this was a nearly complete census, it is assumed that this estimate represents a minimum population size. However, no estimate of abundance with an associated coefficient of variation has been calculated for the population (Warning et al 2007).

The size of this stock is considered to be extremely low relative to optimum sustainable population in the U.S. Atlantic EEZ, and this species is listed as endangered under the ESA. The North Atlantic right whale is considered one of the most critically endangered populations of large whales in the world (Clapham et al. 1999). There has been no apparent sign of recovery in the last 15 years and the species may be rarer and more endangered than previously thought. Because the right whale is a long-lived species, extinction may not occur in the near future, but the possibility of biological extinction in the next century is very real (NMFS 2005).

Sei Whale

Description and Distribution

Sei whales, *Balaenoptera borealis*, are generally 45 to 55 feet in length, though some may reach 65 feet and weigh 14 to 17 tons. Sei whales, like other rorquals species, have slim and streamlined bodies with a blueish-gray body and white undersides. They also possess a single ridge running from the tip of the snout to the blowhole. Sei whales have 32 to 60 throat grooves. They have relativitively short pectoral fins and a tall, falcate dorsal fin. The dorsal fin is located about one-third of the body length anterior from its relatively small fluke (Balcomb and Minasian 1984; Ellis 1980; Leatherwood and Reeves 1983; American Cetacean Society Fact Sheet 2007).

Indications are that, at least during the feeding season, a major portion of the Northwest Atlantic sei whale population is centered in northerly waters, perhaps on the Scotian Shelf (Mitchell and

Chapman 1977). The southern portion of the species' range during spring and summer includes the northern portions of the U.S. Atlantic Exclusive Economic Zone (EEZ) - the Gulf of Maine and Georges Bank. The period of greatest abundance there is in spring, with sightings concentrated along the eastern margin of Georges Bank and into the Northeast Channel area, and along the southwestern edge of Georges Bank in the area of Hydrographer Canyon (CeTAP 1982). NMFS aerial surveys in 1999, 2000, and 2001 found concentrations of sei and right whales along the Northern Edge of Georges Bank in the spring.

The sei whale is often found in the deeper waters characteristic of the continental shelf edge region (Hain et al. 1985), and NMFS aerial surveys found substantial numbers of sei whales in this region, south of Nantucket, in the spring of 2001. Similarly, Mitchell (1975b) reported that sei whales off Nova Scotia were often distributed closer to the 2,000 m depth contour than were fin whales.

Reproduction

Sei whales reach sexual maturity around ten years of age. Males generally reach sexual maturity when they reach 40 ft. in length, while females mature when they reach about 50 ft. The gestation period is between 11.5 and 12 months, with a calving interval of approximately two years. At birth, sei whales range from 14 to 15 ft in length and weigh approximately 2,000 pounds (Balcomb and Minasian 1984, Ellis 1980, Leatherwood and Reeves 1983, American Cetacean Society Fact Sheet 2007).

Ecological Relationships

Diet

Although known to take piscine prey, sei whales (like right whales) are largely planktivorous, feeding primarily on euphausiids and copepods. In years of reduced predation on copepods by other predators, and thus greater abundance of this prey source, sei whales are reported in more inshore locations, such as the Great South Channel (in 1987 and 1989) and Stellwagen Bank (in 1986) areas (R.D. Kenney, pers. comm.; Payne et al. 1990).

Migration and Movement

Based on analysis of records from the Blandford, Nova Scotia, whaling station, where 825 sei whales were taken between 1965 and 1972, Mitchell (1975b) described two "runs" of sei whales, in June-July and in September-October. He speculated that the sei whale population migrates from south of Cape Cod and along the coast of eastern Canada in June and July, and returns on a southward migration again in September and October; however, such a migration remains unverified.

Abundance and Status of Stock

There are insufficient data to determine the population trends for this species and the total number of sei whales in the U.S. Atlantic EEZ is unknown (Waring et al. 2007). However, an abundance of 280 sei whales was estimated from an aerial survey program conducted from 1978 to 1982 on the continental shelf and shelf edge waters between Cape Hatteras, North Carolina and Nova Scotia (CeTAP 1982). Though, this estimate is more than 20 years out of date and almost certainly does not reflect the current true population size; in addition, the estimate has a high degree of uncertainty (i.e., it has a large CV), and it was estimated just after cessation of extensive foreign fishing operations in the region. There are no recent abundance estimates for the sei whale (Waring et al. 2007).

Sperm Whale

Description and Distribution

The sperm whale, *Physeter macrocephalus* (Linnaeus, 1758), is a truly cosmopolitan species, whose distribution is thought to be more extensive than that of any other marine mammal, except the killer whale (*Orcinus orca*) (Rice 1989). Male sperm whales can reach lengths of more than 18 meters (m), while females can reach lengths of up to 12.5 m. They can weigh up to 57 and 24 metric tons, respectively (Rice 1989).

The sperm whale has a disproportionately large head, one quarter to one third of its total body length (Rice 1989). Its rod-shaped lower jaw is narrow and underslung, with 20-26 pairs of well-developed teeth in the mandibles, but the maxillary teeth are vestigial. Its dorsal fin is low in profile, thick, and not pointed or recurved. Sperm whales are generally dark gray in color, with white lips and often white areas on the belly and flanks. Photographs of distinctive markings on the dorsal fins and flukes of sperm whales are used in studies of life history and behavior (Whitehead and Gordon 1986, Whitehead 1990).

The distribution of sperm whales extends to all deep ice-free marine waters from the Equator to the edges of polar pack ice (Rice 1989). Sperm whales are present in many warm-water areas throughout the year, and such areas may have discrete "resident" populations (Watkins et al. 1985; Gordon et al. 1998; Drout 2003; Engelhaupt 2004; Jaquet et al. 2003). While their aggregate distribution is certainly influenced by the patchiness of global marine productivity (Jaquet and Whitehead 1996), no physical barriers, apart from landmasses, appear to obstruct their dispersal (Berzin 1972; Jaquet 1996).

Two of the major 19th century whaling grounds for sperm whales, the Southern Ground and the Charleston Ground, are situated directly off the eastern United States (Townsend 1935). The sperm whalers also visited the northern Gulf of Mexico and the West Indies regularly.

Mitchell (1972) found the highest densities of sperm whales, by far, in the "North Sargasso Sea Region" (30-40°N, 50-70°W) and the "Gulf Stream Region" (two discrete offshore areas between 40°N and 50°N - one over the Grand Banks of Newfoundland and the other over the North Atlantic Ridge). This result is consistent with the observation by Townsend (1935) and Waring et al. (1993), that the Gulf Stream has an important influence on sperm whale distribution.

The overall distribution along the U.S. east coast is centered along the shelf break and over the slope (CETAP 1982, Waring et al. 2005). Very high densities occur in inner slope waters north of Cape Hatteras, North Carolina, seaward of the 1000-m isobath during summer months (Mullin and Fulling 2003; Southeast Fisheries Science Center unpublished data; Waring et al. 2005). Sperm whales are also known to move onto the continental shelf in waters less than 100 m deep on the southern Scotian Shelf and south of New England, particularly between late spring and autumn (Whitehead et al. 1992a-b; Waring et al. 1997; Scott and Sadove 1997).

The sperm whale is the most common large cetacean in the northern Gulf of Mexico, where it occurs in greatest density along and seaward of the 1000 m contour (Mullin et al. 1991, 1994; Jefferson and Schiro 1997; Davis et al. 1998; Weller et al. 2000; Würsig et al. 2000; Mullin and Fulling 2004). They appear to prefer steep rather than shallow depth gradients (Davis et al. 1998). The spatial distribution of sperm whales within the Gulf of Mexico is strongly correlated with mesoscale physical features such as loop current eddies that locally increase primary production and prey availability (Biggs et al. 2005). Several satellite tags used in conjunction with the Sperm Whale Seismic Study (SWSS) indicate sperm whale movements generally along the shelf break (700-1000 m depth) throughout the Gulf of Mexico, with some animals using deeper oceanic waters (Jochens and Biggs 2004).

Reproduction

Sperm whales mature slowly. Females usually begin ovulating at 7-13 years of age. Maturation in males usually begins in this same age interval, but most individuals do not become fully mature until their twenties. Prime bulls, in their late twenties and older, rove among groups of females on the tropical breeding grounds. A male's association with a female group can be as brief as several hours. Since females within a group often come into estrus synchronously, the male need not remain with them for an entire season to achieve maximal breeding success (Best and Butterworth 1980).

The peak breeding season for sperm whales in the North Atlantic occurs during the spring (March/April to May), with some mating activity taking place earlier or later, from December to August. Gestation lasts well over a year, with credible estimates of the normal duration ranging from 15 months to more than a year and a half. Lactation lasts at least two years, and the inter-birth interval is 4-6 years for prime-aged females and apparently, much longer for 40+ year-olds.

Two particular aspects of the sperm whale's reproductive biology are relevant to management. First, the maximal rate of increase in reproduction is very low, perhaps no more than one or two percent per year. Second, selective killing of large males by whalers could have had the residual effect of reducing reproductive rates (Whitehead et al. 1997).

Ecological Relationships

<u>Diet, Development, and Growth</u>

Sperm whales are deep and prolonged divers and can therefore use the entire water column, even in very deep areas. However, they seem to forage mainly on or near the bottom, often ingesting stones, sand, sponges, and other non-food items (Rice 1989; Whitehead et al. 1992a-b). As far as is known, sperm whales feed regularly throughout the year. Lockyer (1981) estimated that they consumed about 3.0-3.5% of their body weight per day.

A large proportion of the sperm whale's diet consists of low-fat, ammoniacal, luminescent squids (Clarke 1980, 1996; Martin and Clarke 1986). In some areas of the North Atlantic, however, males prey heavily on the oil-rich squid *Gonatus fabricii*, a species frequently also eaten by bottlenose whales (*Hyperoodon ampullatus*) (Clarke 1997). A giant squid (*Architeuthis* sp.) as large as 12 m long and weighing 200 kg has been found in a sperm whale's stomach (Berzin 1972). While sperm whales feed primarily on large and medium-sized squids, the list of documented food items is fairly long and diverse. Prey items include other cephalopods, such as octopuses, and medium- and large-sized demersal fishes, such as rays, sharks, and many teleosts (Berzin 1972; Clarke 1977, 1980; Rice 1989). The diet of large males in some areas, especially in high northern latitudes, is dominated by fish (Rice 1989). Lumpsuckers (*Cyclopterus lumpus*), for example, are frequently taken in Denmark Strait (Martin and Clarke 1986).

Stable, long-term associations among related and unrelated females (Christal 1998) form the core units of sperm whale societies (Christal et al. 1998). Up to about a dozen females usually live in such groups, accompanied by their female and young male offspring. Males start leaving these family groups at about six years of age, after which they live in "bachelor schools." The cohesion among males within a bachelor school declines as the animals age. During their breeding prime and old age, male sperm whales are essentially solitary (Christal and Whitehead 1997).

Migration and Movement

A striking feature of the sperm whale's life history is the difference in migratory behavior between adult males and females. Only adult males move into high latitudes, while all age classes and both sexes range throughout tropical and temperate seas. At least some individuals are present year-round in the higher latitudes (Mellinger et al. 2004). A combination of factors, including wide dispersal by males, ontogenetic changes in association patterns, and female pod fidelity and cohesion complicates any evaluation of population structure. An initial examination of global matrilineal population structure suggests that interoceanic dispersal of female lineages is limited (Dillon 1996; Lyrholm and Gyllensten 1998). However, studies of allelic variation in nuclear markers are needed to reveal the extent to which male dispersal might cause genetic mixing between oceanic populations (Lyrholm et al. 1999; Bond 1999).

In a review of the evidence for interspecific competition in baleen whales, Clapham and Brownell (1996) found it to be extremely difficult to prove that inter-specific competition comprises an important factor in the population dynamics of large whales. May et al. (1979) used a relatively simple example, using male sperm whales, squid, and krill in the Antarctic, to show how complex the dynamics could be. According to their model, yield in the krill fishery is a function of both fishing effort on krill and the abundance of sperm whales. Sperm whales prey on cephalopods, which in turn, prey on krill. According to the model, the largest sustainable krill fishery in the Southern Ocean would be attained when sperm whales were not exploited there.

There is no evidence that competition for prey resources is a factor limiting the abundance of sperm whales in the North Atlantic. Adult male sperm whales have been observed to aggregate near trawl nets targeting Greenland halibut (*Reinhardtius hippoglossoides*) in one area of the western North Atlantic, but they are not known to take fish from the nets (Leaper and Karpouzli 1998). Two of the squid species eaten by sperm whales in the North Atlantic - *Gonatus fabricii* and *Todarodes sagittatus* - are known to be important in the diets of northern bottlenose whales (Gonatus only), long-finned pilot whales (*Globicephala melas*, both subspecies recognized in the North Atlantic and Southern Hemisphere), and short-finned pilot whales (*G. macroryhncus*); (Clarke 1997). However, there is no basis for assuming that competition for food among these three cetacean species is a factor in determining their population trend and abundance.

Abundance and Status of Stock

Total numbers of sperm whales off the U.S. or Canadian Atlantic coast are unknown, although several estimates from selected regions of the habitat do exist for select time periods. Currently, the best abundance estimate for sperm whales is the sum of the estimates from the two 2004 U.S. Atlantic surveys, 4,804 (CV =0.38), where the estimate from the northern U.S. Atlantic is 2,607 (CV =0.57), and from the southern U.S. Atlantic is 2,197 (CV =0.47). This joint estimate is considered the best available because together these two surveys have the most complete coverage of the species' habitat (Waring et al. 2007). Because these estimates were not corrected for dive-time, they are likely downwardly biased and an underestimate of actual abundance. The average dive-time of sperm whales is approximately 30 - 60 min (Whitehead et al. 1991, Watkins et al. 1993, Peter Madsen, Woods Hole Oceanographic Institution, pers. comm., in Waring et al. 2007), therefore, the proportion of time that they are at the surface and available to visual observers is assumed to be low. The density of sperm whales along the U.S. east coast (17.04 per 1000 km2) is the highest reported in a recent survey of sperm whale densities worldwide (Whitehead 2002).

The collective 1990- 2004 sperm whale abundance data suggest that, seasonally, at least several thousand sperm whales are occupying the waters of the northeastern U.S. Sperm whale abundance may increase offshore, particularly in association with Gulf Stream and warm-core ring features; however, at present there is no reliable estimate of total sperm whale abundance in the western North Atlantic.

West Indian Manatee

Description and Distribution

West Indian manatees, *Trichechus manatus latirostris*, are massive fusiform-shaped animals with skin that is uniformly dark grey, wrinkled, sparsely haired, and rubber-like. Manatees possess paddle-like forelimbs, no hind limbs, and a spatulate, horizontally flattened tail. Females have two axillary mammae, one at the posterior base of each forelimb. Their bones are massive and heavy with no marrow cavities in the ribs or long bones of the forearms (Odell 1982).

Adults average about 3.0 m (9.8 ft) in length and 1,000 kg (2,200 lbs) in weight, but may reach lengths of up to 4.6 m (15 ft) (Gunter 1941) and weigh as much as 1,620 kg (3,570 lbs) (Rathbun et al. 1990). Newborns average 1.2 to 1.4 m (4 to 4.5 ft) in length and about 30 kg (66 lbs) (Odell 1981). The nostrils, located on the upper snout, open and close by means of muscular valves as the animals surface and dive (Husar 1977; Hartman 1979). A muscular flexible upper lip is used with the forelimbs to manipulate food into the mouth (Odell 1982). Bristles are located on the upper and lower lip pads. Molars designed to crush vegetation form continuously at the back of the jaw and move forward as older ones wear down (Domning and Hayek 1986). The eyes are very small, close with sphincter action, and are equipped with inner membranes that can be drawn across the eyeball for protection. Externally, the ears are minute with no pinnae. Internally, the ear structure suggests that they can hear sound within a relatively narrow low frequency range, that their hearing is not acute, and that they have difficulty in localizing sound (Ketten et al. 1992). Gerstein (1995) suggested that manatees may have a greater low-frequency sensitivity than the other marine mammal species that have been tested.

Manatees are typically found in the temperate and equatorial waters of the southeastern U.S., the Caribbean basin, northern and northeastern South America, and equatorial West Africa. At present, manatees of the genus *Trichechus* are represented by three allopatric species: *T. senegalensis*, the West African manatee, *T. inunguis*, the Amazonian manatee, and *T. manatus*, the West Indian manatee. The West Indian species is subdivided into two subspecies, the Antillean manatee (*Trichechus manatus manatus*) and the Florida manatee (*Trichechus manatus latirostris*) (USFWS 1989).

Historically, the winter range of the Florida manatee (*Trichechus manatus latirostris*) was thought to focus on south Florida, with some animals ranging north of Charlotte Harbor on Florida's west coast and north of Sebastian on Florida's east coast. Extralimital movements occurred and were typically seasonal, with animals traveling north during warmer periods and traveling south as temperatures declined. While most manatees wintered in south Florida, some were known to winter in natural spring areas to the north (Hartman 1974). With the advent of artificial warm water refugia, the spread of exotic submerged aquatic vegetation, and increased protective measures, the manatee's winter range has expanded significantly (Beeler and O'Shea 1988). On the east coast, manatees are now known to winter as far north as southeastern Georgia and, on the west coast, as far north as Crystal River, Florida. Range extremes extend north to Virginia on the Atlantic coast and west to Louisiana on the Gulf coast. The number of sighting reports outside of Florida has increased in recent years.

Reproduction

Breeding takes place when one or more males (ranging from 5 to 22) are attracted to an estrous female to form an ephemeral mating herd (Rathbun et al. 1995). Mating herds can last up to 4 weeks, with different males joining and leaving the herd daily (Hartman 1979; Bengtson 1981; Rathbun et al. 1995 in Rathbun 1999). Permanent bonds between males and females do not form. During peak activity, the males in mating herds compete intensely for access to the female (Hartman 1979). Successive copulations involving different males have been reported. Some observations suggest that larger, presumably older, males dominate access to females early in the formation of mating herds and are responsible for most pregnancies (Rathbun et al. 1995), but males as young as three years old are spermatogenic (Hernandez et al. 1995). Although breeding has been reported in all seasons, Hernandez et al. (1995) reported that histological studies of reproductive organs from carcasses of males found evidence of sperm production in 94% of adult males recovered from March through November. Only 20% of adult males recovered from December through February showed similar production.

The length of the gestation period is uncertain but is thought to be between 11 and 14 months (Odell et al. 1995; Rathbun et al. 1995; Reid et al. 1995). The normal litter size is one, with twins reported rarely (Marmontel 1995; Odell et al. 1995; O'Shea and Hartley 1995; Rathbun et al. 1995). Newborns average 1.2 to 1.4 m (4 to 4.5 ft) in length and about 30 kg (66 lbs) (Odell 1981). Calving intervals vary greatly among individuals. They are probably often less than 2 to 2.5 years, but may be considerably longer depending on age and perhaps other factors (Marmontel 1995; Odell et al. 1995; Rathbun et al. 1995; Reid et al. 1995).

Ecological Relationships

<u>Diet, Development, and Growth</u>

Manatees are herbivores that feed opportunistically on a wide variety of submerged, floating, and emergent vegetation. Because of their broad distribution and migratory patterns, Florida manatees utilize a wider diversity of food items and may be less specialized in their feeding strategies, than manatees in tropical regions (Lefebvre et al. 2000).

Seagrasses appear to be a staple of the manatee diet in coastal areas (Ledder 1986; Provancha and Hall 1991; Kadel and Patton 1992; Koelsch 1997; Lefebvre et al. 2000). Packard (1984) noted two feeding methods in coastal seagrass beds: (1) rooting, where virtually the entire plant is consumed; and (2) grazing, where exposed grass blades are eaten without disturbing the roots or sediment. Manatees may return to specificseagrass beds to graze on new growth (Koelsch 1997; Lefebvre et al. 2000).

In the upper Banana River (located in Brevard County, Florida) Provancha and Hall (1991) found spring concentrations of manatees grazing in beds dominated by manatee grass (*Syringodium filiforme*). They also reported an apparent preference for manatee grass and shoalgrass (*Halodule wrightii*) over the macroalga *Caulerpa* spp. Along the Florida-Georgia border, manatees feed in salt marshes on smooth cordgrass (*Spartina alterniflora*) by timing feeding periods with high tide (Baugh et al. 1989, Zoodsma 1991).

Feeding rates and food preferences depend, in part, on the season and available plant species. Bengtson (1981, 1983) reported that the time manatees spent feeding in the upper St. Johns River was greatest (6 to 7 hrs/day) before winter (August to November), least (3 to 4 hrs/day) in spring and summer (April to July), and intermediate (about 5 hrs/day) in winter (January to March). He estimated annual mean consumptionrates at 33.2 kg/day/manatee or about 4 to 9% of their body weight per day depending on season (Bengtson 1983). At Crystal River, Etheridge et al. (1985) reported cumulative daily winter feeding times from 0 to 6 hrs. 10 min. based on observations of three radio-tagged animals over seven 24-hour periods. The estimated daily consumption rates by adults, juveniles, and calves eating hydrilla (*Hydrilla verticillata*) were 7.1, 9.6, and 15.7% of body weight per day, respectively.

Females appear to reach sexual maturity by about age five but have given birth as early as four (Marmontel 1995, Odell et al. 1995, O'Shea and Hartley 1995, Rathbun et al. 1995), and males may reach sexual maturity at 3 to 4 years of age (Hernandez et al. 1995). Manatees may live in excess of 50 years (Marmontel 1995), and evidence for reproductive senescence is unclear (Marmontel 1995, Rathbun et al. 1995). Catalogued Florida manatee CR 28, a wild manatee that overwinters in Crystal River, was last documented with a calf in 1998, at which time she was estimated to be at least 34 years of age (USGS-Sirenia, unpublished data). A captive animal, MSTm-5801, gave birth to a calf in 1990, at which time she was estimated to be 43 to 48 years of age (FWS, unpublished data).

<u>Migration and Movement</u>
When ambient water temperatures drop below 20° C (68°F) in autumn and winter, manatees aggregate within the confines of natural and artificial warm-water refuges (Lefebvre et al. 2001) or move to the southern tip of Florida (Snow 1991). Most artificial refuges are created by warm-water outfalls from power plants or paper mills. The largest winter aggregations (maximum count of 100 or more animals) are at refuges in Central and Southern Florida. The northernmost

natural warm-water refuge used regularly on the west coast of Florida is at Crystal River and at Blue Springs in the St. Johns River on Florida's east coast. Most manatees return to the same warm-water refuges each year; however, some use different refuges in different years and others use two or more refuges in the same winter (Reid and Rathbun 1984, 1986; Rathbun et al. 1990, Reid et al. 1991, 1995). Many lesser known, minor aggregation sites are used as temporary thermal refuges. Most of these refuges are canals or boat basins where warmer water temperatures persist as temperatures in adjacent bays and rivers decline.

During mild winter periods, manatees at thermal refuges move to nearby grass beds to feed, or even return to a more distant warm season range (Deutsch et al. 2000). For example, manatees using the Riviera Power Plant feed in adjacent Lake Worth and in Jupiter and Hobe Sounds, 19 to 24 km (12 to 15 mi) to the north (Packard 1981). Animals at Blue Spring leave the spring run to feed on freshwater aquatic plants along the St. Johns River and associated waters near the spring (Bengtson 1981, Marine Mammal Commission 1986).

As water temperatures rise manatees disperse from winter aggregation areas. While some remain near their winter refuges, others undertake extensive travels along the coast and far up rivers and canals. On the east coast, summer sightings drop off rapidly north of Georgia (Lefebvre et al. 2001) and are rare north of Cape Hatteras (Rathbun et al. 1982, Schwartz 1995); the northernmost sighting is from Rhode Island (Reid 1996).

Abundance and Status of Stock

The Florida manatee is listed as "endangered" under provisions of the ESA. The manatee is considered a "strategic stock" as defined in Section 12 of the Marine Mammal Protection Act. The basis for this designation is the high level of documented mortality (natural and human-related) relative to the estimated population level and continuing, severe threats to critical manatee habitats in the southeastern U.S.

Despite considerable effort in the early 1980s, scientists have been unable to develop a useful means of estimating or monitoring trends in the size of the overall manatee population in the southeastern U.S. (O'Shea 1988, O'Shea et al. 1992, Lefebvre et al. 1995). Thus, the exact population size for Florida manatees is unknown but the minimum population is estimated at 1,822 animals, based on intensive statewide winter aerial surveys at warm-water refuges coordinated by the Florida Department of Environmental Protection in early February of 1995 (FDEP 1995). Even though most, if not all, warm-water refuges are known, direct counting methods (i.e., by aerial and ground surveys) used to estimate manatee abundance at these refuges have limitations. They are unable to account for uncertainty in the number of animals that may be away from these refuges at any given time, the number of animals not seen because of turbid water, and other factors. The use of mark-resighting techniques to estimate manatee population size based on known animals in the manatee photo identification database has also been impractical, as the proportion of unmarked manatees cannot be estimated.

Manatee population trends are poorly known but, based on the results of a carcass recovery program, deaths have increased by an average of 5.9 percent per year in Florida from 1976 through 1992 (Ackerman et al. in press). Garrott et al.'s (1994) analysis of trends at winter aggregation sites suggest a mean annual increase of 7-12 percent in adjusted counts at sites on the east coast from 1978-1992. Reynolds and Wilcox (1994) reported a decline in the percentage and number of calves seen at power plant aggregation sites during recent winter aerial surveys. It is not clear at this time whether this is related to increases in perinatal mortality or to some other factor.

The health of the population in the Atlantic Region (the east coast of Florida, including all of the Florida Key), which represents almost one-half of the entire population, is unclear. Marmontel (1994) conducted a population viability analysis through computer simulations. This study yielded information on age-related aspects of mortality and reproduction for the Florida manatee population. A scenario, calculated from the data, having an initial population size of 2,000 individuals resulted in a gradually declining population (r = -0.003), a probability of persistence of 44 percent in 1,000 years, and a mean final population size of less than 10 percent of the original value. When adult mortality was reduced by 10 percent in the model, population growth improved considerably, but when adult mortality was increased by 10 percent the population quickly dwindled. These results clearly indicate that the Florida manatee population is still at high risk of extinction in the long term. Any negative change in the population parameters, caused by environmental changes or a catastrophe, might tip the balance towards greater risk of extinction.

Atlantic Spotted Dolphin

Description and Distribution

The Atlantic spotted dolphin, *Stenella frontalis*, occurs in two forms which may be distinct sub-species (Perrin et al. 1987, 1994; Rice 1998): the large, heavily spotted form which inhabits the continental shelf and is usually found inside or near the 200-m isobath; and the smaller, less spotted island and offshore form which occurs in the Atlantic Ocean but is not known to occur in the Gulf of Mexico (Fulling et al. 2003; Mullin and Fulling 2003; Mullin and Fulling 2004). The spotted dolphin's body is covered with spots and becomes more densely spotted with age. The spotted dolphin has a long slim beak containing 35 to 48 small conical teeth in each side of the upper jaw and 34 to 47 small, conical teeth in each side of the lower jaw. The dorsal fin is tall and curved; the flippers are small and pointed as are the flukes with a small median notch. Length averages about 7 ft. (2.1 m) with an average weight of 220 pounds (100 kg). Calves measure 32 to 36 inches (80 to 90 cm) at birth (Balcomb and Minasian 1984, Leatherwood and Reeves 1983, Leatherwood et al. 1982, American Cetacean Society Fact Sheet 2007).

Atlantic spotted dolphins are distributed in tropical and warm temperate waters of the western North Atlantic (Leatherwood et al. 1976). Their distribution is from southern New England, south through the Gulf of Mexico and the Caribbean to Venezuela (Leatherwood et al. 1976, Perrin et al. 1994). The large, heavily spotted form of the Atlantic spotted dolphin along the southeastern and Gulf coasts of the United States, inhabits the continental shelf, usually being found inside or near the 200 m isobath (within 250-350 km of the coast) but sometimes coming into very shallow water adjacent to the beach (Waring et al. 2007). Off the northeast U.S. coast, spotted dolphins are widely distributed on the continental shelf, along the continental shelf edge, and offshore over the deep ocean south of 40° N (CETAP 1982). Atlantic spotted dolphins regularly occur in the inshore waters south of Chesapeake Bay and near the continental shelf edge and continental slope waters north of this region (Payne et al. 1984, Mullin and Fulling

2003). Sightings have also been made along the north wall of the Gulf Stream and warm-core ring features (Waring et al. 1992).

Reproduction

This species reaches maturity between 6 and 8 years of age. Most animals are approximately 6.5 ft (2 m) in length when they reach sexual maturity. Mating and calving take place throughout the year; the calving interval is believed to be about every two years. In stressed populations, mating takes place at an earlier age and the calving intervals are shorter. Gestation is 11 1/2 months and calves are nursed for 11 months (Balcomb et al. 1984, Leatherwood and Reeves 1983, Leatherwood et al. 1982, American Cetacean Society Fact Sheet 2007).

Ecological Relationships

Diet, Development, and Growth

Spotted dolphins feed on many varieties of fish and squid found near the surface of the water. In the eastern Pacific, pregnant females feed more on squid and nursing females tend to feed more on fish. The reason for this is unknown (Balcomb et al. 1984, Leatherwood and Reeves 1983, Leatherwood et al. 1982, American Cetacean Society Fact Sheet 2007).

Migration and Movement

Spotted dolphins consist of tropical and subtropical species and are widely distributed in all tropical and warm-temperate waters of the Atlantic, Pacific, and Indian Oceans (Balcomb et al. 1984, Leatherwood and Reeves 1983, Leatherwood et al. 1982, American Cetacean Society Fact Sheet 2007).

Abundance and Status of Stock

Total numbers of Atlantic spotted dolphins off the U.S. or Canadian Atlantic coast are unknown. The best 2004 abundance estimate for Atlantic spotted dolphins is the sum of the estimates from the two 2004 western U.S. Atlantic surveys, 50,978 (CV=0.42), where the estimate from the northern U.S. Atlantic is 3,578 (CV=0.48), and from the southern U.S. Atlantic is 47,400 (CV=0.45). However, this does not account for the potential for a mixed species herd, as has been recorded for several dolphin assemblages. Pending further genetic studies for clarification of this problem, a single species abundance estimate is considered the best estimate of abundance. This combines species-specific data from the northern as well as southern portions of the species' ranges. There are insufficient data to determine the population trends for this species, given that surveys prior to 1998 did not differentiate between species of spotted dolphins (Waring et al. 2007).

Bottlenose Dolphin (coastal stock)

Description and Distribution

This is a relatively robust dolphin with a usually short and stubby beak - hence the name "bottlenose." The bottlenose dolphin, *Tursiops truncatus*, has more flexibility in its neck than other oceanic dolphins, because five of the seven neck vertebrae are not fused together as in the other oceanic dolphins. There are 18-26 pairs of sharp, conical teeth in each side of its jaw. The color of the bottlenose dolphin varies considerably, but generally this dolphin is light gray to slate gray on the upper part of the body shading to lighter sides and pale, pinkish gray on the belly. The dorsal fin is high and falcate (curved) and located near the middle of the back. The flukes are broad and curved with a deep median notch. The flippers are of moderate length and pointed. Adult length is from 8-12 feet (2.5-3.8 m). These dolphins may weigh as much as 1,430 pounds (650 kg) off Great Britain, though most are much smaller in other parts of the world. Males are significantly larger than females (Wells and Scott 2000, 2002; Reynolds et al. 2000, Connor et al. 2000, American Cetacean Society Fact Sheet 2007).

The coastal morphotype of bottlenose dolphin is continuously distributed along the Atlantic coast south of Long Island, around the Florida peninsula and along the Gulf of Mexico coast. Based on differences in mitochondrial DNA haplotype frequencies, nearshore animals in the northern Gulf of Mexico and the western North Atlantic represent separate stocks (Curry 1997; Duffield and Wells 2002). Recent genetic analyses of samples from northern Florida, Georgia, central South Carolina (primarily the estuaries around Charleston), southern North Carolina, and coastal Virginia, using both mitochondrial DNA and nuclear microsatellite markers, indicate that a significant amount of the overall genetic variation can be explained by differences between these areas (NMFS 2001). These results indicate a minimum of five stocks of coastal bottlenose dolphins along the U.S. Atlantic coast (Waring et al. 2007). Photo-identification studies also support the existence of multiple stocks (NMFS 2001).

The movement patterns of animals outfitted with satellite-linked radio transmitters off Virginia Beach, VA, Beaufort, NC, Charleston, SC, and New Jersey, along with photo-identification of freeze-branded animals, indicate that a significant number of dolphins reside in North Carolina in summer and do not migrate. A dolphin tagged in Virginia Beach, VA, spent the winter between Cape Hatteras and Cape Lookout, NC, indicating seasonal migration between North Carolina and areas further north (NMFS 2001).

In summary, several stock identification techniques (i.e., genetic sampling, photo-identification, satellite telemetry, etc.) confirm a complex mosaic of coastal bottlenose dolphin stocks. Therefore, seven management units exist within the range of the coastal morphotype of western North Atlantic bottlenose dolphin (Figure 4.3-1).

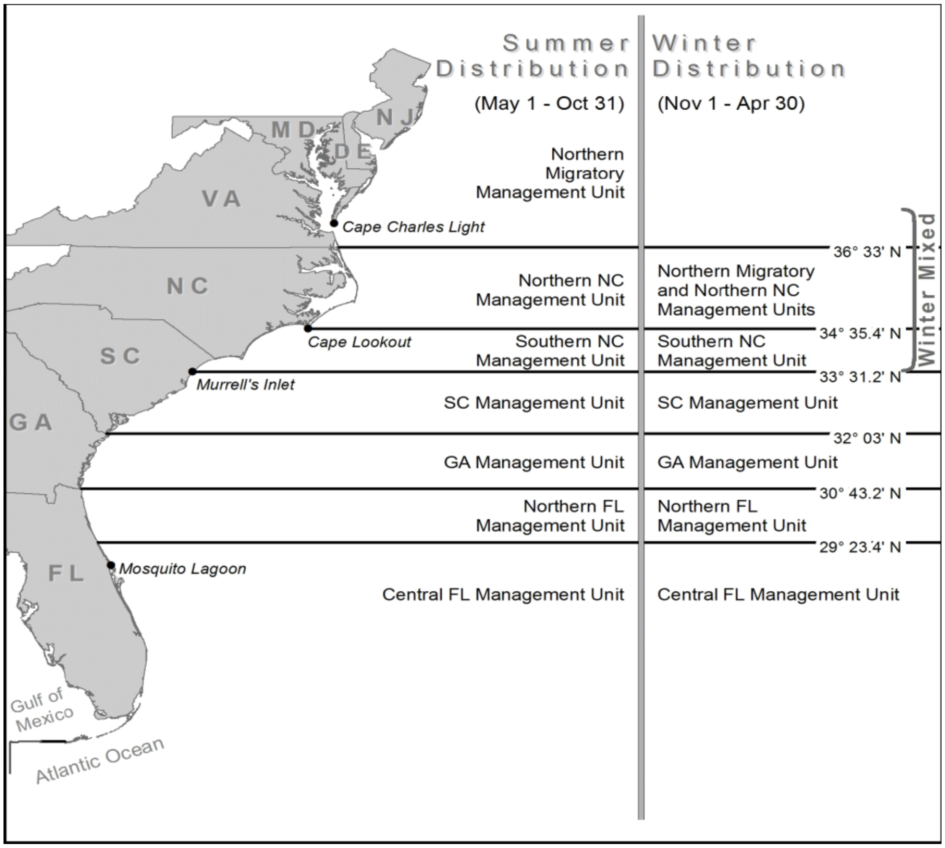


Figure 4.3-1. Management units of the coastal morphotype of bottlenose dolphin along the Atlantic coast of the U.S. as defined from genetic, stable isotope ratio, photo-identification, and telemetry studies (NMFS 2001).

Aerial surveys conducted between 1978 and 1982 (CeTAP 1982) north of Cape Hatteras, North Carolina identified two concentrations of bottlenose dolphins, one inshore of the 25 m isobath and the other offshore of the 50m isobath. The lowest density of bottlenose dolphins was observed over the continental shelf, with higher densities along the coast and near the continental shelf edge. It was suggested, therefore, that the coastal morphotype is restricted to waters < 25 m deep north of Cape Hatteras (Kenney 1990).

Genetic analysis of tissue samples collected during large vessel surveys the summers of 1998 and 1999 indicated that bottlenose dolphins within 7.5 km from shore were most likely of the coastal morphotype. These samples also suggested an area of extensive overlap between the coastal and offshore morphotypes located 7.5 and 34 km from shore south of Cape Hatteras, North Carolina (Torres et al. 2003).

Reproduction

Males reach sexual maturity at about 10 years. Females reach sexual maturity at about 5-10 years. The gestation period is 12 months. Calving can take place year-round with peaks in some areas during spring and fall. Calves nurse for over a year (12-18 months), and stay with their mothers for 3-6 years learning how to catch fish and other important tasks (Wells and Scott

2000, 2002; Reynolds et al. 2000, Connor et al. 2000, American Cetacean Society Fact Sheet 2007).

Ecological Relationships

Diet, Development, and Growth

Feeding behaviors are diverse, primarily involving individual prey capture, but sometimes involving coordinated efforts to catch food, feeding in association with human fishing, and chasing fish into mudbanks. An adult bottlenose dolphin may consume 15-30 pounds (8-15 kg) of food each day. Bottlenose dolphins eat a wide variety of food, including primarily fishes, and sometimes squid, and crustaceans (Wells and Scott 2000, 2002; Reynolds et al. 2000, Connor et al. 2000, American Cetacean Society Fact Sheet 2007).

Abundance and Status of Stock

There are insufficient data to determine the population trend for these stocks. However, the coastal migratory stock was designated as depleted under the MMPA. Table 4.3-2 outlines abundance estimates for each management unit. NMFS conducted abundance surveys during the summer and winter of 2002 in order to update previous abundance estimates from 1995. Current estimates are confounded somewhat by an overlap in distribution between the coastal and offshore bottlenose dolphin stocks, and the difficulty of distinguishing between the two stocks while surveying. However, these estimates are considered more robust than previous abundance estimates conducted in 1995 due to improved experimental design.

Bottlenose Dolphin (offshore stock)

The bottlenose dolphin, *Tursiops truncatus*, offshore stock is distributed primarily along the outer continental shelf and continental slope in the Northwest Atlantic Ocean. North of Cape Hatteras, North Carolina, during summer months, there is a clear distinction between the coastal and offshore stocks of bottlenose dolphins across bathymetry (Waring et al. 2007). Torres et al. (2003) found a statistically significant break in the distribution of the coastal and offshore stocks at 34 km from shore based upon the genetic analysis. The offshore morphotype was found exclusively seaward of 34 km and in waters deeper than 34 m. Biopsy samples of the offshore morphotype have been collected as close as 7.3 km from shore in water depths of 13 m (Garrison et al. 2003).

Seasonally, bottlenose dolphins occur over the outer continental shelf and inner slope waters as far north as Georges Bank (CeTAP 1982, Kenney 1990). Sightings occurred along the continental shelf break from Georges Bank to Cape Hatteras during spring and summer (CeTAP 1982, Kenney 1990). Information from Wells et al. (1999) indicates that the range of the offshore bottlenose dolphin may include waters beyond the continental slope and that offshore bottlenose dolphins may move between the Gulf of Mexico and the Atlantic. Offshore morphotype bottlenose dolphins have stranded as far south as the Florida Keys (Waring et al. 2007).

Table 4.3-2. Estimates of abundance and the associated CV, N_{min}, and PBR for each stock of WNA coastal bottlenose dolphins (Garrison et al. 2003 in Waring et al. 2007). The PBR for the Northern Migratory, Northern NC, and Southern NC management units are applied semi-annually. South of NC, the PBR is applied annually. Except where noted, abundance estimates and PBR values do not include estuarine animals. The recovery factor (Fr) used to calculate PBR for each stock is based upon the CV of the abundance estimate based on the guidelines in Wade and Angliss (1997).

Unit		Best Abundance		N_{min}	Recovery Factor (Fr)	PBR	
		Estimate	CV			Annual	½ Yr
SUMMER (May - October)							
Northern migratory		17,466	0.19	14,621	0.50	(146.2)	73.1
Northern NC							
	oceanic	6,160	0.52	3,255	0.48	(31.2)	15.6
	Estuary[d]	919	0.13	828	0.50	(8.2)	4.2
	BOTH	7,079	0.45	4,083	0.48	(39.2)	19.6
Southern NC							
	oceanic	3,645	1.11	1,863	0.40	(14.9)	7.5
	Estuary[d]	141	0.15	124	0.50	(1.2)	0.6
	BOTH	3,786	1.07	1,987	0.40	(15.9)	7.9
WINTER (November - April)							
NC mixed[a]		16,913	0.23	13,558	0.50	(135.6)	67.8
ALL YEAR							
South Carolina		2,325	0.20	1,963	0.50	19.6	unk
Georgia		2,195	0.30	1,716	0.50	17.2	unk
Northern Florida[b,c]		448	0.38	unk	unk	unk	unk
Central Florida[c]		10,652	0.46	unk	unk	unk	unk

a. NC mixed = northern migratory, Northern NC, and Southern NC
b. Northern Florida estimates are a weighted mean of abundance estimates from the winter 1995 survey and the summer 2002 survey. Due to the age of the winter abundance estimate, PBR cannot be calculated for this stock.
c. Northern and Central Florida estimates include data from the winter 1995 survey and cannot be used to determine PBR due to their age.
d. Read et al. 2003

Reproduction

Males reach sexual maturity at about 10 years. Females reach sexual maturity at about 5-10 years. The gestation period is 12 months. Calving can take place year-round with peaks in some areas during spring and fall. Calves nurse for over a year (12-18 months), and stay with their mothers for 3-6 years learning how to catch fish and other important tasks (Wells and Scott 2000, 2002; Reynolds et al. 2000, Connor et al. 2000, American Cetacean Society Fact Sheet 2007).

Ecological Relationships

Diet, Development, and Growth

Feeding behaviors are diverse, primarily involving individual prey capture, but sometimes involving coordinated efforts to catch food, feeding in association with human fishing, and chasing fish into mudbanks. An adult bottlenose dolphin may consume 15-30 pounds (8-15 kg) of food each day. Bottlenose dolphins eat a wide variety of food, including primarily fishes, and sometimes squid, and crustaceans (Wells and Scott 2000, 2002; Reynolds et al. 2000, Connor et al. 2000, American Cetacean Society Fact Sheet 2007).

Abundance and Status of Stock

During the summer (June - July) of 2002, aerial surveys were conducted along the U.S. Atlantic coast between Florida and New Jersey. The resulting coastwide abundance estimate for the offshore morphotype in waters < 40 m depth was 26,849 (CV = 0.193)(Buckland et al. 2001, Palka 1995, Garrison et al. 2003, Waring et al. 2007).

Another abundance estimate of 9,786 (CV = 0.56) for offshore morphotype bottlenose dolphins was derived from a June 12 to August 4, 2004 ship and plane survey. The survey covered 10,761 km of track line in waters north of 38° N (Palka unpubl.; Palka 1995; Palka and Hammond 2001; Hiby 1999; Waring et al. 2007).

An additional survey of the U.S. Atlantic outer continental shelf and continental slope (water depths > 50m) between 27.5 – 38ºN latitude was conducted during June-August, 2004. Survey effort was stratified to include increased effort along the continental shelf break and Gulf Stream front in the Mid-Atlantic. The survey included 5,659 km of trackline; there were 473 cetacean sightings. Sightings were most frequent in waters North of Cape Hatteras, North Carolina along the shelf break (Palka 1995, Buckland et al. 2001). The resulting abundance estimate for offshore morphotype bottlenose dolphins between Florida and Maryland was 44,953 (CV = 0.26) (Waring et al. 2007).

The best available estimate for offshore morphotype bottlenose dolphins is the sum of the estimates from the summer 2002 aerial survey covering the continental shelf, the summer 2004 vessel survey south of Maryland, and the summer 2004 vessel and aircraft surveys north of Maryland. This joint estimate provides complete coverage of the offshore morphotype habitat from Florida to Georges Bank during summer months. The combined abundance estimate from these surveys is 81,588 (CV = 0.17) (Waring et al. 2007).

The status of this stock relative to its optimum sustainable population in the U.S. Atlantic EEZ is unknown. The western North Atlantic offshore bottlenose dolphin is not listed as threatened or endangered under the ESA. There are insufficient data to determine the population trends for this species. Average 1999-2003 annual fishery-related mortality and serious injury does not exceed the PBR therefore this is not a strategic stock. The total fishery-related mortality and serious injury for this stock is less than 10% of the calculated PBR and, therefore, can be considered to be insignificant and approaching zero mortality and serious injury rate.

Minke Whale

Description and Distribution

The minke whale, *Balaenoptera acutorostrata*, is the smallest member of the rorqual family of whales. One of its most distinctive features is the narrow, triangular rostrum (upper jaw), which is proportionally shorter than in other rorquals. A single ridge extends from the tip of the rostrum to the blowhole. Its body is slender and streamlined. Like all rorquals, the minke has a series of 50 to 70 ventral grooves, or pleats, that expand during feeding. The minke is counter-shaded-black to dark gray on top, white below. Some minkes have a light-colored chevron on the back behind the head. Two areas of lighter gray appear on each side: one behind the flippers and another below and forward of the dorsal fin. Distinctive to minke whales outside of the Antarctic is a white band on each flipper. The dorsal fin of the minke is tall and falcate (curved), and is located two-thirds of the way back on the body. Its flippers are slender and pointed at the tips. Flukes are broad, up to one-fourth of the body length, pointed at the tips, and notched in the center. Adult males average about 26 ft (8 m) with a maximum length of 31 ft (9.4 m), while adult females average 27 ft (8.2 m) with a maximum length of 33 ft (10.2 m). Both males and females weigh about 10 tons. Both sexes are slightly larger in the southern hemisphere (Balcomb and Minasian 1984, Ellis 1980, Leatherwood and Reeves 1983, American Cetacean Society Fact Sheet 2007).

Minke whales have a cosmopolitan distribution, being distributed in polar, temperate and tropical waters. In the North Atlantic, there are four recognized populations — Canadian East Coast, west Greenland, central North Atlantic, and northeastern North Atlantic (Donovan 1991). Minke whales off the eastern coast of the U.S. are considered to be part of the Canadian East Coast stock, which inhabits the area from the eastern half of the Davis Strait (45ºW) to the Gulf of Mexico. The relationship between this stock and the other three stocks is uncertain. It is also uncertain if there are separate stocks within the Canadian East Coast stock (Waring et al. 2007).

The minke whale is common and widely distributed within the U.S. Atlantic Exclusive Economic Zone (EEZ) (CeTAP 1982). There appears to be a strong seasonal component to minke whale distribution. Spring and summer are times of relatively widespread and common occurrence, and when the whales are most abundant in New England waters. During fall in New England waters, there are fewer whales, while during winter, the species appears to be largely absent. Like most other baleen whales, minke whales generally occupy the continental shelf proper, rather than the continental shelf edge region. Records summarized by Mitchell (1991) hint at a possible winter distribution in the West Indies, and in the mid-ocean south and east of Bermuda. As with several other cetacean species, the possibility of a deep-ocean component to the distribution of minke whales exists but remains unconfirmed (Waring et al. 2007).

Reproduction

Sexual maturity is reached at 7 or 8 years in the northern hemisphere. Breeding peaks in summer months. The gestation period is 10 to 11 months, and calving is thought to occur once every two years on average. Calves are 10 ft (3 m) at birth and weigh 1000 pounds (450 kg). Minke calves nurse for approximately 6 months (Balcomb and Minasian 1984, Ellis 1980, Leatherwood and Reeves 1983, American Cetacean Society Fact Sheet 2007).

Ecological Relationships

<u>Diet, Development, and Growth</u>

Minke whales feed primarily on krill in the southern hemisphere and on small schooling fish (capelin, cod, herring, pollock) or krill in the northern hemisphere. They will also eat copepods in certain areas (Balcomb and Minasian 1984, Ellis 1980, Leatherwood and Reeves 1983, American Cetacean Society Fact Sheet 2007).

Migration and Movement

Minkes tend to be solitary animals, though sometimes they are seen traveling in pairs or in small groups of 4 to 6. They are found in all oceans, though they are rarely observed in the tropics. They seem to prefer icy waters, and are found right up to the edge of the icepack in polar regions, and have actually become entrapped in the ice fields on occasion (Balcomb and Minasian 1984, Ellis 1980, Leatherwood and Reeves 1983, American Cetacean Society Fact Sheet 2007).

Abundance and Status of Stock

The total number of minke whales in the Canadian East Coast population is unknown (Waring et al 2007). The best available current abundance estimate for minke whales is 2,998 animals (CV=0.19). This estimate obtained from a July to August 1999 sighting survey conducted by a ship and airplane covering waters from Georges Bank to the mouth of the Gulf of St. Lawrence (NMFS unpublished data, Palka 2006). The status of minke whales, relative to optimum sustainable population, in the U.S. Atlantic EEZ is unknown. However, the minke whale is not listed under the Endangered Species Act (ESA) (Waring et al. 2007).

4.3.2 Sea Turtles

Description and distribution

(from draft SNG Amendment 14)

The following section offers a brief overview of the general life history characteristics of the sea turtles found in the South Atlantic region. Several volumes exist that cover more thoroughly the biology and ecology of these species (i.e., Lutz and Musick (eds.) 1997; Lutz et al. (eds.), 2002).

The ESA status of sea turtles in the South Atlantic was recently evaluated in a section 7 consultation on the continued authorization of snapper grouper fishing under the South Atlantic Snapper Grouper Fishery Management Plan and Amendment 13C (NMFS 2006).

Green sea turtle, *Chelonia mydas*, hatchlings are thought to occupy pelagic areas of the open ocean and are often associated with Sargassum rafts (Carr, 1987; Walker, 1994). Pelagic stage green sea turtles are thought to be carnivorous. Stomach samples of these animals found ctenophores and pelagic snails (Frick 1976, Hughes 1974). At approximately 20 to 25 cm carapace length, juveniles migrate from pelagic habitats to benthic foraging areas (Bjorndal 1997). As juveniles move into benthic foraging areas a diet shift towards herbivory occurs. They consume primarily seagrasses and algae, but are also know to consume jellyfish, salps, and sponges (Bjorndal 1980, 1997; Paredes 1969; Mortimer 1981, 1982). The diving abilities of all sea turtles species vary by life stage. The maximum diving depth of green sea turtles is estimated at 110 m (360 ft) (Frick 1976), but they frequently make dives of less than 20 m (65 ft.)(Walker

1994). The time of these dives also varies by life stage. The maximum dive length is estimated at 66 minutes with most dives lasting from 9 to 23 minutes (Walker 1994).

The hawksbill's, *Eretmochelys imbricata*, pelagic stage lasts from the time they leave the nesting beach as hatchlings until they are approximately 22-25 cm in straight carapace length (Meylan 1988, Meylan and Donnelly 1999). The pelagic stage is followed by residency in developmental habitats (foraging areas where juveniles reside and grow) in coastal waters. Little is known about the diet of pelagic stage hawksbills. Adult foraging typically occurs over coral reefs, although other hardbottom communities and mangrove-fringed are occupied occasionally. Hawksbills show fidelity to their foraging areas over several years (van Dam and Diéz 1998). The hawksbill's diet is highly specialized and consists primarily of sponges (Meylan 1988). Gravid females have been noted ingesting coralline substrate (Meylan 1984) and calcareous algae (Anderes Alvarez and Uchida 1994), which are believed to be possible sources of calcium to aid in eggshell production. The maximum diving depths of these animals are not known, but the maximum length of dives is estimated at 73.5 minutes. More routinely dives last about 56 minutes (Hughes 1974).

Leatherbacks, *Dermochelys coriacea*, are the most pelagic of all ESA-listed sea turtles and spend most of their time in the open ocean; although they will enter coastal waters and are seen over the continental shelf on a seasonal basis to feed in areas where jellyfish are concentrated.

Leatherbacks feed primarily on cnidarians (medusae, siphonophores) and tunicates.
Unlike other sea turtle species, leatherbacks' diets do not shift during their life cycles. Because leatherbacks' ability to capture and eat jellyfish is not constrained by size or age, they continue to feed on these species regardless of life stage (Bjorndal 1997). Leatherbacks are the deepest diving of all sea turtles. It is estimated that this species can dive in excess of 1000 m (Eckert et al. 1989) but more frequently dive to depths of 50 m to 84 m (Eckert et al.. 1986). Dive times range from a maximum of 37 minutes to more routines dives of 4 to 14.5 minutes (Standora et al. 1984, Eckert et al. 1986; Eckert et al. 1989; Keinath and Musick 1993). Leatherbacks may spend 74% to 91% of their time submerged (Standora et al. 1984).

Loggerhead, *Caretta caretta*, hatchlings forage in the open ocean and are often associated with Sargassum rafts (Hughes 1974; Carr 1987; Walker 1994; Bolten and Balazs 1995). The pelagic stage of these turtles are known to eat a wide range of prey including salps, jellyfish, amphipods, crabs, sygnathid fish, squid, and pelagic snails (Brongersma 1972).

Stranding records indicate that when pelagic immature loggerheads reach 40-60 cm straight-line carapace length they begin to live in coastal inshore and nearshore waters of the continental shelf throughout the U. S. Atlantic (Witzell 2002) where they forage over hard- and soft-bottom habitats (Carr 1986). Benthic foraging loggerheads eat a variety of invertebrates with crabs and mollusks being important prey sources (Burke et al. 1993).

Estimates of the maximum diving depths of loggerheads range from 211 m to 233 m (692-764ft) (Thayer et al.,1984; Limpus and Nichols, 1988). The lengths of loggerhead dives are frequently between 17 and 30 minutes (Thayer et al. 1984; Limpus and Nichols 1988; Limpus and Nichols 1994; Lanyan et al. 1989) and they may spend anywhere from

80 to 94% of their time submerged (Limpus and Nichols 1994; Lanyan et al. 1989).

Kemp's ridley, *Lepidochelys kempii*, hatchlings are also pelagic during the early stages of life and feed in surface waters (Carr, 1987; Ogren 1989). Once the juveniles reach approximately 20 cm carapace length they move to relatively shallow (less than 50m) benthic foraging habitat over unconsolidated substrates (Márquez-M. 1994). They have also been observed transiting long distances between foraging habitats (Ogren 1989).

Kemp's ridleys feeding in these nearshore areas primarily prey on crabs, though they are also known to ingest mollusks, fish, marine vegetation and shrimp (Shaver 1991). The fish and shrimp Kemp's ridleys ingest may be scavenged opportunistically from bycatch discards and from discarded bait, and are not thought to be a primary prey item (Shaver 1991). Given their predilection for shallower water, Kemp's ridleys most routinely make dives of 50 m or less (Soma 1985; Byles 1988). Their maximum diving range is unknown. Depending on the life stage a Kemp's ridleys may be able to stay submerged anywhere from 167 minutes to 300 minutes, though dives of 12.7minutes to 16.7 minutes are much more common (Soma 1985; Mendonca and Pritchard 1986; Byles 1988). Kemp's ridleys may also spend as much as 96% of their time underwater (Soma 1985, Byles 1988).

Development, growth and movement patterns

Growth in all species of sea turtles is a relative unknown because direct measurements are not practical given the relatively long life span, specialized habitat requirements, and large spatial scale at which individuals operate, all of which precludes maintaining them in the laboratory or making direct observations in the field. Growth has been inferred from tagging studies (cites), and some bone histology (cites). In general growth rates in all species of sea turtles are hypothesized to be relatively slow. Maturity is thought to be reached in as little as 6 years in Kemps or Leatherbacks, 10-15 years for greens and hawksbills, and 21 to 35 years for loggerheads. Considerable uncertainty exists in all of these estimates, in particular leatherbacks have been hypothesized to reach maturity in as little as 3 years (Pritchard 19xx) and as many as 30 years (Avens pers. comm.).

Most green turtles (*C. mydas*) exhibit particularly slow growth rates, which has been described as a consequence of their largely herbivorous (i.e., low net energy) diet (Bjorndal 1982). Growth rates of juveniles vary substantially among populations, ranging from <1 cm/year (Green 1993) to >5 cm/year (McDonald-Dutton and Dutton 1998), likely due to differences in diet quality, duration of foraging season (Chaloupka et al. 2004b), and density of turtles in foraging areas (Bjorndal et al. 2000; Seminoff et al. 2002c; Balazs and Chaloupka 2004b). Consistent with slow growth, age-to-maturity for the green turtles appears to be the longest of any sea turtle species (Chaloupka and Musick 1997; Hirth 1997).

A variety of studies have addressed growth rates and age to various life stages in Kemp's ridleys. Based on mark-recapture data, skeletal chronological analysis, and growth rates in captivity, it has been estimated that Kemp's ridleys require approximately 1.5 to 2 years to grow from a hatchling to a size of approximately 20 cm straight carapace length (SCL), at which size they are capable of making a transition to a benthic immature stage (B. Higgins, NMFS, personal communication, 2007; Caillouet et al. 1995; Schmid and Witzell 1997; Zug et al. 1997; Schmid 1998; Snover et al. 2007). However, variability in growth rates suggests that the actual time necessary to achieve a 20 cm SCL could range from approximately 1 to 4 years or more (Turtle Expert Working Group (TEWG) 2000).

The state of knowledge of sea turtles movements is increasing rapidly due to a number of factors which include the development and availability of telemetry equipment, and the cooperation and communication between various entities of tagging information. A growing body of literature is available documenting individual movements for many of the species, and some synthetic studies are becoming available that link turtle movements to environmental conditions. Recent examples include, for leatherbacks, the work of Hayes and colleagues (Hayes et al, 2006), and James and colleagues (James, 2006).

Green turtles are highly mobile and they undertake complex movements through geographically disparate habitats during their lifetimes (Musick and Limpus 1997; Plotkin 2003). While offshore, and sometimes while in coastal habitats, green turtles are not obligate herbivores as widely believed, and instead consume invertebrates such as jellyfish, sponges, sea pens, and pelagic prey (i.e., prey that occupy the water column) (Godley et al. 1998; Heithaus et al. 2002; Seminoff et al. 2002b; Hatase et al. 2006; Parker and Balazs in press).

Green turtles spend the majority of their lives in coastal foraging grounds. These areas include both open coastline and protected bays and lagoons. In addition to coastal foraging areas, oceanic habitats are used by oceanic-stage juveniles, migrating adults, and, on some occasions, by green turtles that reside in the oceanic zone for foraging. At nesting beaches, green turtles rely on safe and healthy beaches with intact dune structures, native vegetation, and normal beach temperatures for nesting (Ackerman 1997). Coastal areas denuded of vegetation or with coastal construction can impact thermal regimes on beaches and thus affect the incubation and resulting sex ratio of hatchling turtles.

For leatherback turtles, important nesting areas in the western Atlantic Ocean occur in Florida (USA); St. Croix, U.S. Virgin Islands; Puerto Rico; Costa Rica; Panama; Colombia; Trinidad and Tobago; Guyana; Suriname; French Guiana; and southern Brazil (Marquez 1990; Spotila et al. 1996; Bräutigam and Eckert 2006).

Four leatherbacks tagged on the beaches of Costa Rica and Panama were later found nesting in Cuba, Florida, St. Croix, and Grenada, thereby weakening the concept of a distinct Western Caribbean leatherback population. Among leatherbacks fitted with transmitters in Florida, most remained along the North American continental shelf for three seasons and in winter moved off the shelf. In February 2008, scientists tracked a leatherback turtle that swam from Indonesia to the U.S. coast, an estimated 13,000 mile journey (Associated Press, 2008. Avaialble at www.seaturtle.org).

Ecological relationships

All sea turtles species in the Atlantic impact nearshore terrestrial beach habitats (supralittoral) and a variety of neritic and oceanic habitats. Some stages of nearly all sea turtle species inhabit neritic zones, including benthic and pelagic use, while oceanic zone use is typically epipelagic but some stages of some species (e.g., leatherbacks) are pelagic oceanic for nearly their entire lives (see Bolten 2003). Energy exchange between habitats, and the impact of species specific foraging ecology within habitats may have been substantial historically but due to the hypothesized massive declines in sea turtle populations the impact and potential alterations to these ecosystems could be, in part, responsible for large shifts in ecosystem function (Bjorndal and Jackson, 2003). Unfortunately many of the ecological relationships for most species and stages of sea turtles are based on inference and anecdotal information, thus most of this section is conjecture.

All species of sea turtles come ashore to nest, typically depositing large numbers of eggs. The total biomass deposited into these terrestrial habitats can be large, both from adult female mortality and eggs. Nest failure and partial hatching can leave large quantities of biomass in nutrient poor ecosystems that make up most beach habitat, in addition to transfer of biomass through direct predation on eggs and hatchlings by a variety of terrestrial predators.

After emergence from nests and entering the ocean, all species of sea turtle hatchlings are thought to be pelagic. Little is known about the habitats and foraging ecology, and thus the ecological relationships, of hatchlings after the first few days since entering the sea, and much of this was reviewed above. Most are thought to remain pelagic, passively drifting with some active swimming and inhabiting weed lines or *Sargassum* for many years (Bolten 2003). After this stage leatherbacks become oceanic pelagic, likely eating gelatinous organisms until adult females return to the terrestrial zone for nesting and use the neritic zone as internesting habitat. The remaining species in the Atlantic are thought to move to the oceanic zone and remain pelagic until they reach the large juvenile stage when they return to the neritic zone. Loggerheads are thought to become benthic at this point, inhabiting a wide range of benthic habitat and feeding primarily on hard shelled invertebrates.

<u>Coral reef ecosystems and sea turtles</u>

Sea turtles, particularly Hawksbill and Green sea turtles, impact coral reef ecosystems through selective grazing and predation, and direct disturbance to corals. Loggerheads, and possibly some Kemp's ridleys are known to use coral reefs as resting or hiding spots.

Hawksbill turtles affect the evolution and maintenance of reef structure and dynamics because they prey upon sponges that compete with coral for space on reefs (León and Bjorndal 2002; Meylan 1988). Green turtles primarily forage on seagrass beds (nursery grounds for many reef species) and occasionally on sponges. Green turtles are also known to use coral reefs as 'scratching posts' causing erosions, breaks, and larger scale structural shears and collapses (Bennet and Balaz 2002). Both green turtles and hawksbills use their flippers to pry corals out of the way to access sponges, with green turtles foraging on the periphery of reefs, and hawksbills foraging throughout the reef system. Both of these species can have substantial impacts on the habitats they exploit (see Bjorndal 1997 for review).

Hawksbill turtles diet of demosponges and corallimorpharians, aggressive competitors for space on reefs, makes them important predators, which play a significant role in reef structure and dynamics (León and Bjorndal 2002; Meylan 1988). In spongivore exclusion experiments, Hill (1998) found that the demosponge *Chondrilla nucula* would rapidly overgrow the majority of corals with which it interacts and caused >70% of all coral overgrowths in his Florida Keys study. Similar results have been found with *Ricodea florida*, a corallimorpharians (Vicente 1990). Hawksbills have been reported to positively select both of these species as forage (León and Bjorndal 2002).

Large juvenile and adult green turtles are primarily associated with seagrass beds, their primary forage, and may repeatedly graze patches of seagrass over time. Grazing has been found to substantially increase biomass and productivity without reducing growth rates of *Thalassia testudinum* seagrass beds (Moran et al. 2002). In addition, new growth of *T. testudinum* after grazing has a higher energy and nutrient content than seagrass that did not experience grazing. Grazing activity also has a significant effect on the physical structure of seagrass by decreasing blade length and width, detrital layer, blades/shoot, and above ground biomass (Moran et al. 2002).

While both green and hawksbills turtles are clearly integral components of the dynamics of seagrass and coral habitats, at current population sizes it seems unlikely that they are adequately fulfilling their ecological role in many habitats around the world. Since the arrival of Europeans in the Caribbean, sea turtles have declined drastically. Prior to Columbus' arrival, the population of green turtles may have numbered in the hundreds of millions with hawksbills in the tens of millions (Jackson 1997). Today, it is believed that these populations are at most 5 to 10% of historic levels. Clearly, the absence of these ecosystem engineers from seagrass and coral habitats could have a profound effect on the biodiversity, dynamics, function, and recovery of those habitats. This reduction in sea turtle abundance in seagrass and coral habitats could have a profound effect on the function and recovery of those habitats. Effective management of protected reef areas will require understanding sea turtle distribution and use of coral reefs and other marine habitats.

Abundance and status of stocks

All populations of all species of sea turtles in the North Atlantic are thought to be at fractions of their historic population sizes (Bjorndal and Jackson, 2003). No reliable historic or current estimates are available for any species, although a number of authors have made guestimates. For example Jackson (1997) argued that historical populations of green turtles may have numbered in the hundreds of millions with hawksbills in the tens of millions, and each is now thought to be at only 5 to 10% of previous levels.

By calculating populations based on the annual nests from 2001 to 2005, the abundance of Green turtles in Florida is approximately 5,055 (Meylan et al. 2006). The green turtle nesting population of Florida appears to be increasing based on 18 years (1989-2006) of index nesting data from throughout the state. Although in the last four years there are three 'low' years, this may be due to lesser reproductive effort as a result of environmental variability at foraging grounds rather than a decrease in the number of nesting females.

The most recent population size estimate for leatherbacks in the North Atlantic alone ranges between 34,000 and 94,000 adults (Turtle Expert Working Group 2007). In Florida, a Statewide Nesting Beach Survey (SNBS) program has documented an increase in leatherback nesting numbers from 98 nests in 1988 to between 800 and 900 nests per season in the early 2000s (Florida Fish and Wildlife Conservation Commission, unpublished data; Stewart and Johnson 2006). The estimated annual growth rate was approximately 1.17 with estimated confidence intervals of approximately 1.1-1.21 (Turtle Expert Working Group 2007).

There are increasing impacts to the nesting and marine environment that affect leatherback turtles. Leatherback nesting beaches are affected by development and tourism in several countries (e.g., Maison 2006; Hamann et al. 2006a; Santidrian-Tomillo et al. 2007; Hernandez et al. 2007). In addition, coastal development is usually accompanied by artificial lighting. The presence of lights on or adjacent to nesting beaches alters the behavior of nesting adults and is often fatal to emerging hatchlings as they are attracted to light sources and drawn away from the water (Witherington and Bjorndal 1991; Witherington 1992; Cowan et al. 2002; Deem et al. 2007).

In 2000, the Turtle Expert Working Group (TEWG), convened by the U.S. National Marine Fisheries Service, estimated between 53,000 and 92,000 loggerhead nests per year in the southeastern United States and the Gulf of Mexico, and estimated the total number of nesting females as 32,000-56,000. The Northern Nesting Subpopulation (occurring from North Carolina through northeastern Florida) had an average of 5,151 nests per year from 1989-2005 (Georgia Department of Natural Resources (GDNR), unpublished data; North Carolina Wildlife Resources Commission (NCWRC), unpublished data; South Carolina Department of Natural Resources (SCDNR), unpublished data).

The loggerhead turtle South Florida Nesting Subpopulation occurs from northeastern Florida through Pinellas County, Florida. A near complete census of this nesting subpopulation, undertaken from 1989 to 2006 reveals a mean of 65,460 loggerhead nests per year (approximately 15,966 females nesting per year) (Florida Fish and Wildlife Conservation Commission (FFWCC), unpublished data). During the majority of the 1990's, the South Florida Nesting Subpopulation showed an increase in numbers of nests of 3.6% annually from 1989-1998 (TEWG 2000) and the nesting assemblage was considered "stable or increasing" at that time (Witherington and Koeppel 2000).

However, the most recent and longer time series data from the Florida Index Nesting Beach Survey Program, administered by FFWCC, show a significant decline in nesting of loggerhead turtles. There has been a 22.3% decrease in the annual number of nests over the 17-year period from 1989-2005. In the past decade a decline of 39.5% has been reported (McRae 2006).

Approximately 60% of Kemp's ridley nesting occurs along an approximate 40-km stretch of beach near Rancho Nuevo, Tamaulipas, Mexico (FWS 2006). The Kemp's ridley, like the olive ridley, tends to nest in large aggregations or *arribadas* (Bernardo and Plotkin 2007). It has been speculated that the *arribada* phenomenon may be advantageous for a variety of reasons, including mate finding and enhancing the survival of eggs and hatchlings due to predator swamping (Bernardo and Plotkin 2007). The biological or physical factors that initiate an *arribada* are not clear, but a variety of potential cues have been suggested, including strong onshore wind, lunar and tidal cycles, social facilitation, and olfactory signals (Bernardo and Plotkin 2007).

Data suggest that in adult female Kemp's ridleys, approximately 20% nest every year, approximately 60% nest every 2 years, 15% nest every 3 years, and 5% nest every 4 years (Marquez Millan et al. 1989, TEWG 2000). These data indicate a remigration rate of female Kemp's ridleys from 1.8 (Rostal 2007) to 2.0 years (Marquez Millan et al. 1989, TEWG 2000), suggesting that the total number of adult females in the Kemp's ridley population during 2006 was approximately 7,000 to 8,000 turtles.

The Kemp's ridley occurs in the Gulf of Mexico and along the Atlantic coast of the U.S. There are documented cases of Kemp's ridleys captured in the Atlantic that migrated back to the nesting beach at Rancho Nuevo (Schmid and Witzell 1997, Schmid 1998, Witzell 1998). It is not known what proportion of the Kemp's ridley population migrates to U.S. Atlantic coastal waters.

Listing designations

(from Atlantic Croaker FMP Update 2005)
All sea turtles that occur in U.S. waters are listed as either endangered or threatened under the ESA. The Kemp's ridley (*Lepidochelys kempii*), leatherback (*Dermochelys coriacea*), and hawksbill (*Eretmochelys imbricata*) are listed as endangered. The loggerhead (*Caretta caretta*) and green turtle (*Chelonia mydas*) are listed as threatened, except for breeding populations of green turtles in Florida and on the Pacific coast of Mexico, which are listed as endangered. All five of these species inhabit the waters of the U.S. Atlantic and Gulf of Mexico.

NOAA Fisheries recognizes five loggerhead subgroups within the western Atlantic including two primary subpopulations: (1) a northern nesting subpopulation that occurs from North Carolina to northeast Florida, about 29EN (approximately 7,500 nests in 1998); (2) a south Florida nesting subpopulation, occurring from 29EN on the east coast to Sarasota, Florida on the west coast (mean of 73,751 nests each year). The status of the northern population based on the number of loggerhead nests has been classified as stable or declining (TEWG 2000). Data from all beaches within the south Florida subpopulation where nesting activity has been recorded indicate substantial increases when data are compared over the last 25 years. However, an analysis limited to nesting data from the statewide sea turtle Index Nesting Beach Survey program from 1989 to 2002, a period encompassing index surveys that are more consistent and more accurate than surveys in previous years, has shown no detectable trend (Blair Witherington, Florida Fish and Wildlife Conservation Commission (FFWCC), pers. comm., 2002).

The Kemp's ridley is one of the most endangered of the world's sea turtle species. The only major nesting site for ridleys is a single stretch of beach near Rancho Nuevo,

Tamaulipas, Mexico. Estimates of the adult female nesting population reached a low of 300 in 1985. Conservation efforts by Mexican and U.S. agencies have aided this species by eliminating egg harvest, protecting eggs and hatchlings, and reducing at-sea mortality through fishing regulations. From 1985 to 1999, the number of nests observed at Rancho Nuevo, and nearby beaches increased at a mean rate of 11.3% per year (TEWG, 1998).
Current totals exceed 8,000 nests per year, allowing cautious optimism that the population is on its way to recovery.

Critical Habitat Designations

4.3.3 Birds

Birds are a part of the coastal and oceanic ecosystem of the southeastern United States, occupying roles from grazing herbivores to top predators on many types and sizes of aquatic life. This section on protected species addresses listed bird species occupying habitat from the open ocean and outer continental shelf to coastal wetlands in the Southeast Region of the United States from the Virginia-North Carolina border south to the Dry Tortugas, Florida (Table 4.3-3). These species do not necessarily breed within the area as some breed in Bermuda, the Bahamas, or the West Indies and others breed as far north as the Arctic or as far south as the Falklands.

Bird species are listed for protection in the Migratory Bird Treaty Act (MBTA), the Endangered Species Act (ESA), and the special provisions of state governments. The National Marine Fisheries Service, through the authority of the Magnuson-Stevens Fishery Conservation and Management Act and the High Seas Fishing Compliance Act, has a role in bird conservation. Federal and State governments and non-governmental organizations have joined in bird conservation partnerships and developed bird conservation plans. Those that cover coastal and oceanic birds of the Southeast Region of the U.S. include the North American Waterbird Conservation Plan (Kushlan et al. 2002), the Draft Southeastern United States Regional Waterbird Conservation Plan (Hunter et al. 2005), the North American Waterfowl Management Plan, the U.S. Shorebird Conservation Plan, the South Atlantic Migratory Bird Initiative Implementation Plan (Watson and McWilliams 2005). These plans were sources of information for this description. The U.S. Fish and Wildlife publication, Birds of Conservation Concern 2002, was another source of information. Publications by Lee (1999, 2000) and his recent report in progress (Lee, in prep.) are other major sources. Collier, N. J. and P. Andrew. 1988. Birds to watch: The ICBP World Checklist of Threatened Birds (Collier and Andrew 1988) is another potential information source.

Somewhere near 200 birds occupy habitats extending from the coastal wetlands to the ocean pelagic environment of the South Atlantic Council region. These birds are in 12 orders and 33 families. They fit into eight functional groups of the South Atlantic Council's ECOPATH model and occupy the following habitats: Open Ocean, Coastal Shelf, Beach and Dune, Estuaries, and Coastal Wetlands (marshes and mangroves). In this report, "open ocean" refers to the area at and beyond the shelf break, whereas coastal shelf refers to the area landward of the shelf break. The discussion of birds is organized by habitat, although some bird groups and even bird species occur in more than one habitat. Some species groups that we discuss fit into more than one habitat.

Many oceanic and coastal bird populations of the Southeast Region have declined and are listed as endangered, threatened, or species of concern. Species listed in Table 4.3-3 fit into the above groups. Their highest (most protected) Federal status, State status, and status in the South Atlantic Migratory initiative Implementation Plan (SAMBI) is shown (Table 4.3-3). Only three species, the Bermuda petrel, the roseate tern, and the piping plover, are federally listed as threatened or endangered (the Bermuda petrel listed by Bermuda and Canada, not U.S.), however SAMBI lists 27 of these species as highest priority requiring immediate management attention and another 57 as high priority needing management attention. All birds in Table 4.3-3 are listed by MBTA, and many of these are included on State lists of species of concern.

Table 4.3-3. Selected Bird Species with Protected Status in the Coastal Waters of the Southern United States Atlantic States.

Birds				
Open Ocean	Scientific Name	*Federal Status**	*State Status*	*SAMBI***
Bermuda petrel	*Pterodrama cahow*	E	NC-extremely high conservation concern	HSP
Black-capped petrel	*Pterodroma hasitata*	MBTA	NC-extremely high conservation concern	HP
Fea's petrel	*Pterodroma feae*	MBTA	NC-extremely high conservation concern	
Herald (Trinidade) petrel	*Pterodroma arminjoniana*	MBTA	NC-extremely high conservation concern	
Band-rumped storm-petrel	*Oceanodroma castro*	MBTA		HP
Audubon's shearwater	*Puffinus lherminieri*	MBTA	NC-high conservation concern	HSP
Greater shearwater	*Puffinus gravis*	MBTA		HP
Manx shearwater	*Puffinus puffinus*	MBTA		HP
Cory's shearwater	*Calonectris diomedea*	MBTA	NC-high conservation concern	HP
Sooty shearwater	*Puffinus griseus*	MBTA		H
Masked booby	*Sula dactylatra*	MBTA	FL-conservation concern	
Brown booby	*Sula leucogaster*	MBTA		
Northern gannet	*Morus bassanus*	MBTA		HP
White-tailed tropicbird	*Phaethon lepturus*	MBTA		HP
Red-tailed tropicbird	*Phaethon aethereus*	MBTA		
Razorbill	*Alca torda*	MBTA		HP
Bridled tern	*Sterna anaethetus*	MBTA	FL-conservation concern	HP
Sooty tern	*Sterna fuscata*	MBTA		
Red phalarope	*Phalaropus fulicaria*	MBTA		HP
Red-necked phalarope	*Phalaropus lobatus.*	MBTA		

Waterfowl	Scientific Name	*Federal Status**	*State Status*	*SAMBI***
Common loon	*Gavia immer*	MBTA	NC-moderate conservation concern; SC-conservation concern; FL-conservation concern	HP
Red-throated loon	*Gavia stellata*	MBTA		HP
Horned grebe	*Podiceps auritus*	MBTA	SC-conservation concern; FL-conservation concern	HP
Black scoter	*Melanitta nigra*	MBTA	SC-conservation concern	HSP
Tundra swan	*Cygnus colunbianus*	MBTA	SC-conservation concern	
Snow goose	*Chen caerulescens*	MBTA		HSP
Brant	*Branta bernicla*	MBTA		HSP
Wood duck	*Aix sponsa*	MBTA	SC-conservation concern	
Mallard	*Anas platyrhynchos*	MBTA	SC-conservation concern	HSP
American black duck	*Anas rubripes*	MBTA	SC-conservation concern	HSP
Gadwall	*Anas strepera*	MBTA		
Green-winged teal	*Anas crecca*	MBTA		
American wigeon	*Anas americana*	MBTA		HP
Northern pintail	*Anas acuta*	MBTA	SC-conservation concern; FL-conservation concern	HSP
Blue-winged teal	*Anas discors*	MBTA	SC-conservation concern	HP
Canvasback	*Aythya valisineria*	MBTA	SC-conservation concern	HSP
Redhead	*Aythya americana*	MBTA	SC-conservation concern	HSP
Ring-necked duck	*Aythya collaris*	MBTA	SC-conservation concern	
Greater scaup	*Aythya marila*	MBTA	SC-conservation concern	
Lesser scaup	*Aythya affinis*	MBTA	SC-conservation concern; FL-conservation concern	HSP
White-winged scoter	*Melanitta deglandi*	MBTA	SC-conservation concern	HP
Surf scoter	*Melanitta perspicillata*	MBTA	SC-conservation concern	
Common goldeneye	*Bucephala clangula*	MBTA		HP
Coastal/shorebirds	Scientific Name	*Federal Status**	*State Status*	*SAMBI***
Black skimmer	*Rynchops niger*	MBTA	NC-special concern; SC-conservation concern; FL-special concern	HP
Roseate tern	*Sterna dougalli*	E/T***; MBTA	NC-threatened; SC-endangered; GA-special concern; FL-threatened	HP
Least tern	*Sterna antillarum*	MBTA	NC-special concern; SC-conservation concern; GA-rare; FL-threatened	HP
Royal tern	*Sterna maxima*	MBTA	SC-conservation concern; FL-conservation concern	M
Common tern	*Sterna hirundo*	MBTA	NC-special concern; SC-conservation concern	HSP
Gull-billed tern	*Sterna nilotica*	MBTA	NC-threatened; SC-conservation concern; GA-threatened; FL-conservation concern	HP

Forster's tern	*Sterna forsteri*	MBTA	SC-conservation concern	M
Sandwich tern	*Sterna sandvicensis*	MBTA	SC-conservation concern; FL-conservation concern	HP
Black tern	*Chlidonias niger*	MBTA		HP
Bonaparte's gull	*Larus philadelphia*	MBTA		M
Laughing gull	*Larus atricilla*	MBTA	SC-conservation concern	N/D (where threatening stability of other waterbirds)
Brown pelican	*Pelecanus occidentalis*	MBTA	SC-conservation concern; FL-special concern	HP
American white pelican	*Pelecanus erythrorhynchos*	MBTA		HP
Double-crested cormorant	*Phalacrocorax auritus*	MBTA	SC-conservation concern (breeding populations)	N/D (non-breeding)
Magnificent frigatebird	*Fregata magnificens*	MBTA	FL-conservation concern	
Osprey	*Pandion haliaetus*	MBTA		
Bald eagle	*Haliaeetus leucocephalus*	MBTA	NC-threatened; SC-threatened; GA-endangered; FL-threatened	M
Willet	*Catoptrophorus semipalmatus*	MBTA	SC-conservation concern	HP
Black-necked stilt	*Himantopus mexicanus*	MBTA	SC-conservation concern	
American oystercatcher	*Haematopus palliatus*	MBTA	SC-conservation concern; GA-rare; FL-special concern	HP
Piping plover	*Charadrius melodus*	MBTA	NC-threatened; SC-threatened; GA-threatened; FL-threatened	HSP
Semipalmated plover	*Chardrius semipalmatus*	MBTA	SC-conservation concern	M
black-bellied piper	*Pluvialis squatarola*	MBTA	SC-conservation concern	M
American golden plover	*Pluvialis dominica*	MBTA	SC-conservation concern	HP
Wilson's plover	*Charadrius wilsonia*	MBTA	SC-conservation concern; GA-rare; FL-conservation concern	HP
Snowy plover	*Charadrius alexandrinus*	MBTA	FL-threatened	HSP
Spotted sandpiper	*Actitis macularia*	MBTA	SC-conservation concern	M
Buff-breasted sandpiper	*Tryngites subruficallis*	MBTA	SC-conservation concern	HSP
Upland sandpiper	*Bartramia longicauda*	MBTA	SC-conservation concern	HP
Semipalmated sandpiper	*Calidris pusilla*	MBTA	SC-conservation concern; FL-conservation concern	HP
Solitary sandpiper	*Tringa solitaria*	MBTA	SC-conservation concern	HP
Stilt sandpiper	*Calidris himantopus*	MBTA	SC-conservation concern	HP
Western sandpiper	*Calidris mauri*	MBTA	SC-conservation concern; FL-conservation concern	HP
Pectoral sandpiper	*Calidris melanotos*	MBTA	SC-conservation concern	M
Least sandpiper	*Calidris minutilla*	MBTA	SC-conservation concern	HP
White-rumped sandpiper	*Calidris fuscicollis*	MBTA	SC-conservation concern	
Purple sandpiper	*Calidris maritime*	MBTA	SC-conservation concern	
sanderling	*Calidris alba*	MBTA	SC-conservation concern; FL-conservation concern	HP

Red knot	*Calidris canutus*	MBTA	SC-conservation concern; GA-special concern; FL-conservation concern	HP
Ruddy turnstone	*Arenaria interpres*	MBTA		HP
American avocet	*Recurvirostra americana*	MBTA	SC-conservation concern; FL-conservation concern	HP
Lesser yellowlegs	*Tringa flavipes*	MBTA	SC-conservation concern	HP
Greater yellowlegs	*Tringa melanoleuca*	MBTA	SC-conservation concern	
Dunlin	*Calidris alpina*	MBTA	SC-conservation concern	HP
Short-billed dowitcher	*Limnodromus griseus*	MBTA	SC-conservation concern	HP
Long-billed dowitcher	*Limnodromus scolopaceus*	MBTA	SC-conservation concern	
Whimbrel	*Numenius phaeopus*	MBTA	SC-conservation concern; FL-conservation concern	HSP
Long-billed curlew	*Numenius americanus*	MBTA	SC-conservation concern	HSP
Marbled godwit	*Limosa fedoa*	MBTA	SC-conservation concern; FL-conservation concern	HP
Waders	Scientific Name	*Federal Status**	*State Status*	*SAMBI***
Anhinga	*Anhinga anhinga*	MBTA	SC-conservation concern	
Great blue heron	*Ardea herodias*	MBTA	SC-conservation concern	
Great white heron	*Ardea herodias occidentalis*	MBTA		HSP
Glossy ibis	*Plegadis falcinellus*	MBTA	NC-special concern; SC-conservation concern; GA-special concern; FL-conservation concern	HP
Snowy egret	*Egretta thula*	MBTA	NC-special concern; SC-conservation concern; FL-special concern	HP
Reddish egret	*Egretta rufescens*	MBTA	FL-special concern	HSP
Great egret	*Ardea alba*	MBTA	SC-conservation concern	M
Cattle egret	*Bubulcus ibis*	MBTA	SC-conservation concern	N/D (where replacing other species)
White ibis	*Eudocimus albus*	MBTA	SC-conservation concern; FL-special concern	HP
Little blue heron	*Egretta caerulea*	MBTA	NC-special concern; SC-conservation concern; GA-special concern; FL-special concern	HP
Tri-colored heron	*Egretta tricolor*	MBTA	NC-special concern; SC-conservation concern; FL-special concern	HP
Green heron	*Butorides virescens*	MBTA	SC-conservation concern	
Black-crowned night heron	*Nycticorax nycticorax*	MBTA	SC-conservation concern; FL-conservation concern	HP
Yellow-crowned night heron	*Nyctanassa violacea*	MBTA	SC-conservation concern; FL-conservation concern	HP
Roseate spoonbill	*Ajaia ajaja*	MBTA		M
Wood stork	*Mycteria americana*	MBTA	NC-endangered; SC-endangered; GA-endangered; FL-endangered	HSP
Sandhill crane	*Grus canadensis*	MBTA		HSP
Whooping crane	*Grus americana*	MBTA	FL-special concern	HSP

Marsh/Wetlands	Scientific Name	*Federal Status**	*State Status*	*SAMBI***
American woodcock	*Scolopax minor*	MBTA	SC-conservation concern	HSP
Clapper rail	*Rallus longirostris*	MBTA		M
Yellow rail	*Coturnicops noveboracensis*	MBTA	SC-conservation concern; FL-conservation concern	HP
King rail	*Rallus elegans*	MBTA	SC-conservation concern; FL-conservation concern	HP
Black rail	*Laterallus jamaicensis*	MBTA	SC-conservation concern; FL-conservation concern	HP
American bittern	*Botaurus lentiginosus*	MBTA	SC-conservation concern; FL-conservation concern	HP
Least bittern	*Ixobrychus exilis*	MBTA	SC-conservation concern; FL-conservation concern	HP
Pied-billed grebe	*Podilymbus podiceps*	MBTA	SC-conservation concern (breeding populations)	
American coot	*Fulica americana*	MBTA	SC-conservation concern (breeding populations)	HSP
Wilson's snipe	*Gallinago gallinagodelicate*	MBTA	SC-conservation concern	HP
Purple gallinule	*Porphyrula martinica*	MBTA	SC-conservation concern	HSP
Limpkin	*Aramus guarauna*	MBTA	FL-special concern	HSP
Saltmarsh sharp-tailed sparrow	*Ammodramus caudacutus*	MBTA	GA-special concern	HSP
Seaside sparrow	*Ammodramus maritimus*	MBTA	GA-special concern	HP
Coastal plain swamp sparrow	*Melospiza georgiana*	MBTA		M
Nelson's sharp-tailed sparrow	*Ammodramus nelsoni*	MBTA	GA-special concern	HP

Lee (1999) listed 17 birds of conservation concern with documented occurrences on the Outer Continental Shelf off North Carolina (Table 4.3-4). He divided them into two categories, critical species and species of concern. Most are oceanic pelagic species, but a few occur primarily in coastal shelf waters.

The present status of Southeast Region oceanic and coastal birds listed for special protection or management attention is a result of a variety of factors, including fishing effort, habitat loss, disturbance at nesting sites, pollution, marine debris, disease, and change in food availability. Habitat loss has been a major cause of decline in population number. Introduction and expanding exotic or feral species (e.g., house cats and black rats on nesting islands) is another. In addition, certain native species such as Greater Black-backed, Herring, and Laughing Gulls that prey on the eggs and young of other bird species have greatly increased in number recently and pose a threat to other waterbird species, especially shorebirds. Many seabirds found in the southeast region nest outside the region, where substantial decreases in nesting number have occurred due to human disturbance and predation by both humans and introduced species (e.g., see Schreiber and Lee [2000]). Oil spills are one source of pollution damaging to seabirds. Direct or indirect interactions with fisheries also affects some population groups (i.e., open ocean and coastal shelf species), although these interactions are not well documented or understood in the Southeast Region, and the direct impacts (i.e., capture or entanglement in fishing gear) may be small. Climate change and over fishing, by changing the availability of food supplies may also affect coastal and oceanic bird populations of the Southeast Region.

Table 4.3-4. Seabird species of conservation concern occurring at or near proposed oil exploration sites on the Outer Continental Shelf of North Carolina (from Lee 1999).

Critical Species
Black-capped Petrel
Bermuda Petrel
Herald Petrel
Madeiran or Fea's Petrel ('mollis' group)
Roseate Tern
Species of Concern
Common Loon
Bulwer's Petrel
Greater Shearwater
Sooty Shearwater
Audubon's Shearwater
Band-rumped Storm-Petrel
White-tailed Tropicbird
Red-billed Tropicbird
Masked Booby
Northern Gannet
Bridled Tern
Atlantic Puffin

This presentation will include a brief description and information on distribution, reproduction, development, growth, abundance, movement patterns, population dynamics, and ecological relationships of selected species or species groups. The following discussion starts with birds of the open ocean, followed by birds of coastal waters, then shorebirds, waterfowl, and wading birds, and finally other marsh and coastal wetland birds. Detailed descriptions are given only for a few seabirds, both oceanic and coastal.

Open Ocean Species

Many species of oceanic seabirds breed in the Southeast region or occur in the area regularly. These include boobies, fulmars, petrels, shearwaters, storm-petrels, skuas, jaguars, dovekies, and some species of terns. The Northern Gannet, more coastal than oceanic, is also included with this group in order to be discussed with its relatives, the boobies. The gannet is a boreal breeder. Others, such as the black-capped petrel, the boobies, and the tropicbirds, nest in Caribbean and Gulf of Mexico waters. In addition, some nest in the eastern Atlantic, and others nest in the South Atlantic. Island nesting is the norm. Population numbers range from several million Greater Shearwaters and Wilson's Storm Petrels to less than 100 Bermuda Petrels. This group is characterized by long-lived species in which several years are required to reach maturity and breeding. Movements of juveniles and sexes may be distinct from adults. Age or sex differences in migration routes and destinations may make these populations more vulnerable to disturbances such as oil spills or pollution than they would be if the segments of the population were mixed. The species of this group range in size from the tiny storm petrels (15-22 cm in total length) to the Northern Fulmar (45-51 cm in total length)

Seabirds are a special concern in managing marine fisheries because of their interactions with fishing gear and vessels in both coastal and distant fisheries. Mortalities resulting from fishing gear could complicate efforts to conserve seabird populations threatened with habitat loss or other human caused mortality.

The United States has developed a national plan of action for reducing the incidental catch of seabirds in U.S. longline fisheries (NPOA-S 2005) as a voluntary response to resolution 02-14 of the International Commission for the Conservation of Atlantic Tuna (ICCAT), of which it is a member. Development of the NPOA-S was a collaborative effort between the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (FWS). Action items for continued cooperative effort between the two agencies include a detailed assessment of longline fisheries for seabird bycatch, annual reports on the status of seabird mortality for each longline fishery (in consultation with the appropriate Councils), and measures to reduce seabird bycatch if any problems are found. Such measures include data collection, prescription of mitigation measures, research and development of mitigation measures and methods, and outreach, education, and training about seabird bycatch.

Longline fisheries pose a significant threat to some seabird populations in some parts of the world. The seabird bycatch of U.S. Western North Atlantic (USWNA) longline fisheries is small by comparison. The seabird bycatch of USWNA pelagic longline fisheries has recently been estimated based on data from the observer program, which covers about 6% of the longline effort. From 2002 through 2004, observers recorded two northern gannet (live), one laughing gull (live), and 12 unidentified seabirds (all dead) caught in the South Atlantic Bight (SAB) region. Based on the observer bycatch and longline effort, Hata (2005) estimated an average annual bird bycatch of 27.39 per year in the SAB. Only six taxa have been identified in the USWNA longline bycatch. Besides the northern gannet and the laughing gull, these are the greater and Cory's shearwaters, the herring and great black-backed gulls, and an unknown species of storm petrel. The high percentage of unidentified birds in the bycatch and low observer coverage make estimation of impacts on seabird populations problematic. Population levels are so low for some species that they might be impacted even if catch rates were extremely low. Most seabirds are long-lived (e.g., 10 to >30 yrs) and have low reproductive potential, thus their populations are more sensitive and less resilient to increased mortality than short-lived species.

Eighteen species of open ocean seabird appear in Table 4.3-3. Sixteen of these are included in Lee's (1999) list of seabirds of concern occurring regularly on the Outer Continental Shelf off North Carolina (Table 4.3-4). A set of species profiles by Lee (in prep) is a further source of information on this group. The major component of this group is characterized by long-winged strong fliers that spend months of the year at sea out of sight of land. Most of these species nest outside of the Southeast Region and are in the regional waters during their non-nesting period, winter for northern-nesting species and summer for those that nest in the southern hemisphere.

Others range as far north as North Carolina to feed during their nesting season in tropical latitudes, and they occur in the Southeast Region during the summer. Still others migrate through the region during the spring and fall. These birds are characteristically long-lived with extended adolescence, and they usually raise only one chick per season. This makes their populations especially vulnerable to increased mortality rates of nestlings, fledglings, or adults. Many of these species nest in colonies on islands, where they are especially vulnerable to human harvests and depredation by exploding populations of introduced predator species (e.g., rats, mongooses, and feral cats and pigs).

A set of taxonomic families aptly nicknamed "tubenoses" makes up the largest taxonomic group of open ocean seabirds listed in Table 4.3-3. Of these, the four petrels are of the highest conservation concern (Lee1999). Other tubenoses in Table 4.3-3 include Audubon, Cory, sooty, and greater shearwaters. The smallest tubenoses are the storm-petrels. Lee (1999) suggested that the Wilson's storm-petrel, common in waters of the Southeast Region, may be the most populous bird in the world's open oceans. The band-rumped storm-petrel, Leach's storm-petrel, and white-faced storm petrel also are found in the Western North Atlantic and are included on the MBTA list of protected birds. All four WNA storm-petrels occur on the Outer Continental Shelf off North Carolina (Lee 1999), but only one--the band-rumped storm-petrel--is included on Lee's (1999) list of species of concern.

Petrels nest in burrows on islands and have been subjected not only to predation by humans and introduced animals but also to disturbance of nesting sites by lights, lumbering, forest fires, and other habitat alteration. One egg is laid, and the time from hatching to maturity is 7 yrs and longer for many species. The vulnerability of petrels at their nesting sites has already caused at least three petrel species in the Western Atlantic to become extinct. The remaining four species are in severe jeopardy.

Bermuda Petrel, *Pterodroma cahow*

When first discovered in Bermuda in the 16th century, nesting Bermuda Petrels numbered in the hundreds of thousands. They do not nest anywhere else and were presumed extinct by 1620 as a result of human exploitation and introduced predators. After being considered extinct for over 300 years, 18 pairs were discovered in 1951 on five small islets off Bermuda (Lee, in prep.). Lee (1999) reported 53 pairs but hurricanes in the last decade have destroyed a number of nesting burrows. The Bermuda Government reported 29 pairs actively nesting in 2005 (Lee, in prep.). The only published records of at sea occurrence are for waters around Bermuda and from the Gulf Stream over the Outer Continental Shelf of North Carolina, which appears to be an important foraging area for this rare species. This is a federally listed endangered species and one of the most endangered birds in the world.

Black-capped Petrel, *Pterodroma hasitata*

This highly pelagic species is endemic to the Western North Atlantic. It breeds in the West Indies, where nesting is now confined to the mountains of southern Hispaniola, and forages regularly off the southeastern coast of Cuba and in the deep Gulf Stream waters off the southeastern United States, mostly from Cape Canaveral north to Cape Hatteras (Lee 2000). Nesting occurs in the winter (Lee 2000). This petrel was thought to be extinct until nesting colonies were discovered in Haiti in 1961, when population estimates were made of 2,000 to

20,000 pairs, the latter likely an overestimate. Subsequent habitat destruction may have reduced the population to a current 1,000 to 2,000 pairs (Lee, in prep.). Material in caves from Haiti suggest the birds were once much more abundant and widespread in Hispaniola than they are today, and human consumption and habitat alternation had probably already reduced their number by the time the Haitian colonies were discovered by Wingate (1964). This is one of the most threatened species in America.

Herald Petrel, *Pterodroma arminjoniana*

This is a rare, highly pelagic tropical petrel confined in the Atlantic to two breeding sites, South Trinidade Island and Martin Vas Rocks off Brazil (Lee in prep.). This petrel disperses great distances from its breeding sites. Of several hundred sighting reports in the Western North Atlantic, most are from off Cape Hatteras, but the species has also been reported from Virginia, Puerto Rico, and the mid Atlantic. Most records are from summer along the Outer Continental Shelf and well within the Gulf Stream. This species is highly endangered in the Atlantic basin because of human disturbance and introduced house cats affecting nesting, and the population appears to continue to decline (Lee 2000). Evidence suggests that the Atlantic population is specifically different from ones nesting in the Indian Ocean and tropical Pacific, and the two color morphs nesting on South Trinidade Island may actually represent two different species (Lee 2000).

Fea's Petrel, *Pterodroma feae*

The Fea's petrel breeds in the Cape Verde Islands and Bugio, Desertas Islands off Maderia. A sister species Maderian petrel, *P. maderia*, breeds in remote high elevation sites on Maderia. These two species, known as soft-plumaged petrels, both occur in the North Atlantic and are so similar that even experts cannot agree on how to tell them apart. The population of Fea's petrels is only a few hundred pairs while the Madeira population is less than 50 pairs, possibly only 20 pairs. Both are extremely rare, declining, globally endangered species.

Shearwaters

The shearwaters are another group of tubenoses. In the Western North Atlantic, these include Audubon's, Greater, Manx, Cory's, and Sooty shearwaters. The shearwater species of greatest concern is Audubon's Shearwater, *Puffinus iherminieri*, a tropical species that occurs in the Atlantic as two subspecies. The current nominate population, *P. I. iherminieri*, consists of 3,000 to 5,000 pairs (Lee 2000), and the western Caribbean subspecies, *P. I. loyemilleri*, is close to extinction (van Halewyn and Norton 1984). Nesting site disturbance by rats and feral cats on islands is the greatest threat to this species.

The other shearwaters in Table 1 are obligate trans-equatorial migrants. In the western Atlantic, the sooty shearwater, *Puffinus griseus*, is limited to 1,000-10,000 pairs, although it also occurs in the Pacific. The greater shearwater, *Puffinus gravis*, is of conservation concern not because of low population numbers in the Atlantic basin (populations are estimated at over 5 million breeding pairs in Tristan de Cunha, Gough Island, and a single island in the Falklands [Williams 1984]) but because they aggregate for both nesting and feeding. The Cory's shearwater, *Calonectris diomedea*, is endemic to the Atlantic, where three subspecies exist, none of which are considered imperiled. Young disperse to the Western Atlantic, and two subspecies have been found in the area from Cape Hatteras south. Two shearwaters, the greater and Cory's, have been identified in the observed catch of the U.S. WNA longline fleet, where they usually are found dead on the line rather than being released alive. The greater shearwater is the most frequently identified species in the observed catch. The greater shearwater also is caught in gillnets in New England fisheries. Unexplained greater shearwater mortalities were observed along the Atlantic coast in June 2007, particularly in Florida. The strongest hypothesis for this mortality event is that these were young-of-the-year birds starving to death on their first migration (Lee, pers. comm.).

Gannets and Boobies

Gannets and boobies form another taxonomic group (Sulidae) included in Table 4.3-3. In all members of this group, different plumages are exhibited at different stages of maturity, at least four immature plumages and an adult plumage. The northern gannet and NWA boobies have similar physical characteristics; however the gannet is a boreal breeder whereas the boobies breed tropically.

The northern gannet, *Sula bassana*, is the most coastal of the WNA sulid species and, although it winters at sea, is rarely out of sight of land. In the NWA, the gannet breeds in Newfoundland, Labrador, and Quebec. Canadian waterbird sites list about 194,000 breeders as of 2005 (from data compiled by D. Forsell from Canadian wet sites (see note at end of this section). This estimate does not include Iceland. Since numbers are increasing, there may now be 200,000 breeders and maybe 50,000 -100,000 immatures and fledglings. The northern gannet is seen regularly off North Carolina and might be found anywhere along the South Atlantic coast. Adults winter from the Carolinas to Maryland and northward. The youngest birds winter further south (Florida, Cuba, and Upper Gulf of Mexico). New tracking data also shows some adults now going to the Florida Gulf coast. Gannets often concentrate around fishing vessels and may be vulnerable to various fishing gear. The northern gannet is an observed bycatch species of the WNA longline fishery, but usually is retrieved alive and released. This species has also been observed caught in both anchored and drift gillnets of several coastal and offshore fisheries and also is caught in paired trawls in the Gulf of Maine (D. Forsell, pers. comm). Large numbers of gannets have been found dead and dying off the Atlantic coast on several occasions (e.g., thousands died during the winter of 2002-2003). “Emaciation syndrome” is suggested by autopsies, implicating stress or starvation. Drowning in deep-set gill nets and disease have also been proposed as possible factors in the large mortalities. Despite the die-offs, population numbers are increasing (D. Forsell, pers. comm.).

The masked booby, *Sula dactylatra dactylatra*, is the least common booby species in the WNA, but it is the one most likely to be encountered away from nesting sites because individuals disperse great distances from their breeding grounds. Nesting is on remote islands lacking mammalian predators, often with other boobies. This is a deepwater, pelagic species occurring northward in the Gulf Stream to the Carolinas, where it is usually associated with *Sargassum*. Its diet is flying fish, jacks, and squid. The current NWA population consists of 550-650 pairs in eight known colonies in the West Indies, another 4,000 to 5,200 pairs nesting on islands off Venezuela and Mexico (Schreiber 2000), and a few pairs nesting in the Dry Tortugas. Although the species is pan tropical, it is rare everywhere, and the Atlantic population is considered endangered in the West Indies where over half the breeding stock occurs on a single island off Jamaica. Other WNA boobies are less likely to occur in the waters off the Southeast Region.

Oceanic Terns
The sooty tern, *Sterna fuscata*, and the bridled tern, *Sterna anaethetus melanoptera*, are more oceanic than coastal and so are included in this section on oceanic birds. Both species are found far at sea. Neither species is a plunge diver. Both feed by dipping prey from near the water surface.

The sooty tern is a common high-flying circum-tropical oceanic species. It does not dive nor land on the water, but scoops small fish from the surface of the water while in flight. It often occurs in large flocks; sometimes thousands are in a single flock. Feeding flocks form over foraging schools of surface feeding fishes. Flocks of Sooty Terns have been seen in association with schools of tuna that drive concentrations of small forage fish to the ocean surface where they are accessible to capture by the terns (A. Sprunt IV, pers. comm.). This species has a substantial nesting colony in the Dry Tortugas National Park off the Florida Keys, where carangids and clupeid fish, as well as squid make up the major part of the diet (Browder et al. 1996), and also breeds in the Bahamas and off Central and South America. Small groups occasionally nest along the Gulf coast and north to the Outer Banks. Young WNA sooty terns live primarily off the west coast of Africa after dispersing from their natal areas. Adults occur in tropical seas and, in summer, wander north in the Gulf Stream. This species is the most abundant seabird breeding in the tropical Atlantic. The total Greater Caribbean population is estimated at 230,000-500,000+ pairs (Lee, in prep.). This species occurs throughout the world's tropical seas.

The bridled tern is a pelagic tropical and subtropical species. This tern often is seen resting on boards, the backs of sea turtles, and other floating material far at sea, distinguishing them from sooty terns, which do not have this habit (Sibley 2003). Much of its foraging is in Sargassum, so it is frequently associated with large Sargassum mats. It occurs singly or in small flocks. The bridled tern is distributed throughout the Caribbean, but it is not a common species. Non-breeding birds occur in the Gulf of Mexico and regularly in the Gulf Stream north to the Carolinas. It nests in widely scattered, mostly unprotected sites. Several subspecies collectively form a composite circum-equatorial distribution. Nesting occurs primarily in the West Indies, but also on islands off the northern South American coast, and, minimally, in the Florida Keys. The total WNA population is estimated at 7,000 pairs (Lee, in prep.). This species is not of conservation concern globally or regionally, but individual breeding populations for some countries are quite small (Lee, in prep.), as is the WNA total.

Coastal, Shelf, Beach and Dune Species

Birds of these habitats form three groups: gulls and terns; loons, ducks, geese, and other waterfowl; and shorebirds. These species are listed in their three groups in Table 1. Many species in these groups also occur in estuaries and wetlands, but will be described only in this section. Most gulls and terns listed in Table 1 are in this coastal group. The sooty and bridled terns are discussed in the previous section with other oceanic birds. Other tern species are found far at sea occasionally. The northern gannet, although more coastal than oceanic, was included in the previous section to be discussed with its close relative, the masked booby.

Coastal avian species have a variety of feeding habits and food items, and the diets and feeding modes of some are more varied than others. Gulls are found along beaches and on mudflats of river mouths and estuaries where they may feed on mollusks and benthic infauna (small organisms that live in the sediment) as well as fish and the eggs of other waterbirds. Most gulls (in winter) are roosting along inlets because they are following fishing boats to feed on offal or discarded bait or bycatch or scavenging on beaches. The food of most tern species, cormorants, and brown pelicans is more confined to fish and squid. Most tern species feed on the wing by dipping prey from the water surface, however a few terns plunge dive.

These avian species also are varied in the degree of concern expressed for them and protection they are afforded. The roseate tern is the only coastal pelagic bird species Federally listed as endangered. Some other members of this group listed in Table 1—black skimmer and least, common, sandwich, Forester's, and gull-billed terns—are listed as "species of concern" in one or more of the southern east coast states where they nest. The black tern, although not listed anywhere as a species of concern, probably should be listed because it has been declining since the 1960s. Two other, primarily tropical, terns that nest in the southeast coastal region also are included in Table 1 and in the below discussion, although they are not listed as species of concern either by states or Federally. SAMBI classified three gull species—great-black-backed, herring, and laughing gulls—as "nuisance or depredating" (N/D) species because their expanding populations pose a threat to other birds, especially shorebirds. While the herring gull may be in the N/D category and expanding in the southern states, its population may be declining at about the same rate that the great- black-backed gull is increasing in the New England and Mid-Atlantic states (D. Forsell, pers. comm.) The laughing gull has been listed as a species of concern in South Carolina and, for this reason, is listed in Table 1. Observers have reported all three above-mentioned gull species in the bycatch of the WNA U.S. longline fishery. The Bonaparte gull is the only gull species listed by SAMBI as a priority species for conservation and also is listed in Table 1.

Roseate Tern, *Sterna dougalli dougalli*

The Roseate Tern is Federally listed as "endangered" in North Carolina and the Northeast Region and federally listed as "threatened" from South Carolina to Florida, as well as in Puerto Rico and the U.S. Virgin Islands. It also occurs in—and is listed as "endangered" by the governments of Bermuda and Canada (Newfoundland, Nova Scotia, and Quebec). Breeding areas are disjunct from Nova Scotia to the West Indies. This tern feeds over breaking surf, particularly over the backwash of outgoing tides of estuaries, and roosts on rocks rather than sand or mudflats. It dives on shoals of fish. In Massachusetts, where the principal food of both species is sand lance, the roseate tern feeds with common terns and captures food mainly by plunge-diving (diving from heights of 1-12 m above the surface and often submerging to ≥ 50 cm) (Mostello 2002). The breeding ecology of the roseate tern is closely linked with that of the common tern in Massachusetts; roseate tern nests form clusters inside larger common tern colonies, where the more aggressive species may reduce the overall level of predation (Mostello 2002). The total WNA population presently is probably less than 8,000 pairs (Lee, in prep.). The nominate subspecies, endemic to the North Atlantic, is in sharp decline. A population of the subspecies also exists in Europe.

Common Tern, *Sterna hirundo*
The common tern is a common and widespread tern found in both the eastern and western hemispheres. Nesting in the western hemisphere occurs on inland lakes and rivers and along the Atlantic seaboard from Canada to islands off the Gulf coast states and also in Bermuda, the Bahamas, the Virgin Islands, and islands off Venezuela (Harrison 1983). The common tern feeds by plunge diving (Harrison 1983). This species is found at sea in small to modest-sized flocks often associated with other tern species during migration and when wintering (Lee, in prep.). Off Massachusetts, it feeds closer to shore than the roseate tern (Mostello 2002). Based on independent estimates from the various regions of nesting, the population estimate for the WNA from Lee (in prep.) is 129,473 pairs.

Gull-billed Tern, *Sterna nilotica*
The gull-billed tern is another near-cosmopolitan species that breeds along the eastern seaboard, nesting locally from Long Island south through the Gulf coast states to Cuba and the West Indies. This species' feeding habits differ from that of other terns. According to Sibley (2003), it feeds mainly on insects and crabs, acquired by swooping to the surface, never plunge diving and almost never foraging in water. According to Harrison (1983), it usually obtains prey by hawking over exposed mud flats, but it occasionally plunges into the water, although not from great height. It feeds along coasts, over marshes, lakes, mudflats and even fields, dipping swiftly to pluck prey from the surface or seize insects in mid air (Harrison 1983). Lee (in prep.) estimates the total Western North Atlantic population at: 3,100-3,500 pairs.

Forster's Tern, *Sterna forsteri*
The Forster's tern breeds only in North America and mostly at inland sites in the middle and western portion of the continent, but it also nests in marshes along south eastern Atlantic states north to New Jersey and upper Gulf coasts. These terns migrate and winter primarily inland and along the coast of the southeastern states, Mexico, the California coast, and in the upper Gulf of Mexico. Birds are found in the West Indies in winter indicating some at-sea migration, but this species is only rarely found at sea in the western North Atlantic. The WNA population, including Inland Canada, consists of about 30,000 pairs, most of which occur on the Gulf coast. This is listed as a species of conservation concern in South Carolina.

Sandwich Tern, *Sterna sandvicensis*
This species breeds in North America, Eurasia, and northern South America. Nesting occurs from Virginia southward and along the Gulf coast and also in the West Indies, islands off Central America, and on the coasts of northern and northeastern South America. This is a coastal foraging species and, excluding migration periods, it is almost never seen more than 12 miles from land. A subspecies, the Cayenne tern (*Sterna s. eurygnata*), is recognized that occurs along the South American coast and in the Caribbean. This is not a species of concern except for the Cayenne subspecies. The total WNA population of *Sterna s. sandvicensis* is estimated at 48,000 pairs, and the Cayenne tern population is estimated at 12,000 pairs (Lee, in prep.).

Least Tern, *Sterna antillarum*
The least tern is a cosmopolitan species. The subspecies *S. a. antillarum*, breeds along the eastern seaboard to the Gulf of Mexico and the Caribbean. This tern is coastal species and rarely

seen out of sight of land even during migration. It nests on sand dunes just above the high-tide line among grass and debris, as well as on flat rooftops near water. Its habits are similar to common and other terns, and it mixes freely with other terns at roosting and foraging sites. Wintering birds are found along the South American coast south to Northern Brazil. It also occurs inland. Other subspecies breed in other parts of the Western Hemisphere and the world, however not in the South Atlantic. Protection in the United States has greatly increased the number of viable breeding colonies in the last several decades, and population estimates of 32,000+ pairs for the eastern seaboard group may not reflect the recent increase (Lee, in prep.).

Black Tern, *Chilidonias niger*
Black terns breed in inland freshwater marshes and feeds on insects. They migrate over land, along the coast, and out at sea. The terns nesting in North America winter primarily along the Pacific coast of Central and South America and in the Atlantic along the north coast of South America. The eastern Atlantic subspecies winters primarily along the coast of West Africa. Although not listed as a species of concern at this time, it probably should be; populations have been in sharp decline since the 1960s, and North American breeding bird survey data shows a sharp and significant decline, perhaps as much as 60%, between the 1970s and the late 1990s (Lee, in prep.). Kushlan et al. (2002) estimate the total North American population at 500 to 2,500 adult pair.

Royal Tern, *Sterna maxima*
The royal tern is a large, crested, orange-billed tern second only in size to the Caspian tern, *Sterna caspia*, the largest tern in the world, which also has an orange bill. In the Western Hemisphere, the royal tern breeds on the Atlantic coast from Virginia to Texas and also in the West Indies, Central America, and on the Pacific coast. It also breeds in northern West Africa. This tern usually is found along ocean beaches. It forages by flying over the water to scout out prey and then diving below the water surface (Sibley 2003). It makes its nest scrape on the ground on low-lying natural islands or shoals or dredged-material islands. Royal terns nest in large colonies ranging from a few hundred to over 5,000 nesting pairs (NC Audubon Chapter 1998, (http://www.audubon.org/chapter/nc/nc/wb_07.html). Within a day of hatching, chicks leave the nest to become part of a group that can consist of thousands of chicks from 2 to 35 days old (Cornell Lab of Ornithology website http://www.birds.cornell.edu/AllAboutBirds/BirdGuide). Parent chicks feed only their own chick, which they are able to locate in the crowd (op. cit.). The North Carolina population consists of about 11,000 pairs and is declining (NC Audubon 1998). SAMBI (2005) estimates 5,500 in South Carolina, 8,000 in Georgia, and 2,500 in Florida. The major threats are human disturbances at nesting sites, loss of nesting habitat, fish kills, and discarded monofilament fishing line (op. cit.).

Black Skimmer, *Rynochops niger*
The black skimmer is a strictly coastal species in North America, although it lives along rivers in South America. Skimmers feed by skimming the water surface with their knife-like bills. They rest on mudflats and sandy beaches. They breed along the Atlantic coast from Massachusetts south through the Gulf of Mexico to northern Brazil (but not the Bahamas or West Indies). In winter northern populations migrate southward to Florida and the Gulf of Mexico. Several states with small numbers of colonies and declining populations (NC, SC, and FL) list this as a species

of concern. Lee (in prep.) estimates that the total Atlantic population is in excess of 27,500 pairs.

Laughing Gull, *Larus atricilla*
The laughing gull is a small gull that breeds in the WNA from Maine south to Florida (including Florida Bay), throughout the Bahamas and West Indies, Gulf of Mexico, Mexico and the northern South American coast. It winters in coastal areas within its breeding range and at sea from the Carolinas southward. During the summer the species is restricted to coastal areas, but during the winter it often occurs in flocks in open ocean environments. Laughing gulls follow ships and form feeding flocks around fishing operations. There may at present be about 270,000 pairs of laughing gulls in the Southeast Region (Lee, in prep.).

Great Black-backed Gull, *Larus marinus*
The great black-backed gull is the largest gull in the world (total length 71-79 cm, with a wing span of 152-167 cm). It is confined to the North Atlantic and breeds in North America along coastal areas from Labrador and Quebec south to New York, with individual nesting as far south as North Carolina. Birds from North America and Greenland winter in marine environments from Labrador south to Florida. It is found mostly in coastal areas but can occur far at sea. This species currently is expanding in both distribution and numbers and is viewed (Hunter et al. 2005) as a species that may need to be controlled because of its predation on other beach-nesting bird species. Lee (in prep.) estimates abundance for the WNA is at least 40,000 pairs.

Herring Gull, *Larus argentatus*
The Herring Gull is another large gull of the WNA. It is common and widespread and is known to hybridize on a regular basis with greater black-backed gulls. Most of the breeding range is inland, but nesting occurs from southeastern Alaska east to Greenland and south along the coast to North Carolina. Wintering individuals are found along the coast to southern Florida. In some areas, immatures are more likely to be found far at sea than adults. Kushlan et al. (2002) estimate the North American breeding population at 132,000 pairs. More than 1,000 pairs nested along the NC coast by 1988 (Lee 1995), expanding south into areas where they had not nested prior to 1970. The population is increasing partly because of this gull’s use of landfills as winter-feeding sites. In some areas this gull needs to be controlled because it is detrimental to breeding populations of roseate terns and other species of conservation concern (Hunter et al. 2005, Lee, in prep.). Although the herring gull may be expanding south, the herring gull population may be decreasing in New England and the Mid-Atlantic coast, where the great-black-backed gull is increasing (D. Forsell, pers. comm.).

Loons
Two loon species occur in coastal and inland waters of the south Atlantic states, the common loon (*Gavia immer*) and the red-throated loon (*Gavia stellata*). The common loon is the larger, and more oceanic, of the two. The Atlantic populations of common loon breeds in inland lakes of the mid-west and New England States to arctic Canada. According to Lee (in prep.), common loons winter primarily at sea, and some migrate as far south as Florida. Once on wintering grounds they completely molt their flight feathers and are flightless for an extended period. They are typically seen floating on the water surface and are more likely to dive to avoid approaching ships than to fly. They feed on fish that they capture on extended deep dives. Oil spills are a

major problem for the birds at sea, but mortalities from oil spills are localized. Mass mortalities with loons washing up on coastal beaches all along the coast may result from drowning in nearshore gillnets D. Forsell, pers. comm.), although mercury-contamination picked up on their breeding lakes is another possible reason for these deaths (Lee, in prep.). Populations reportedly are declining, but currently still high overall. Haney (1990) estimated up to 200,000 (a significant portion of the total population) wintering off the Atlantic coast of North America between Latitudes 29° and 35°N. Common loons are the second most abundant North American breeding bird captured in gillnets in the Atlantic offshore waters (Forsell 1999).

The red-throated loon breeds in the northern hemisphere only in the High Arctic and winters in estuaries and coastal waters of the Atlantic coastal states. Nests are reportedly not only in Alaska but also in Canada, Greenland, and Russia. Canada and Greenland are the most likely sources of those that winter along the Atlantic coast., which Lee (in prep.) conservatively estimates at 50,000+. The actual population size may be much larger as the New Jersey (Avalon) Seawatch reported 51,645 seen at Cape May in 2004, http://www.njaudubon.org/Research/PDF/Avalon_totals.pdf , and many migrate overland to the coast south of there (D. Forsell, pers. comm.). This species is the most abundant North American breeding bird caught in mid-Atlantic coastal gillnet fisheries in both coastal and estuarine waters (Forsell 1999).

Shorebirds

Shorebirds, by number, form a major component of the WNA marine bird fauna. All but a few of the shorebirds listed in Table 4.3-3 are of conservation concern in one or more of the southeastern states. There is much concern for these species because of loss and disturbance of habitat and predation by feral animals, raccoons, and certain gulls with expanding populations. Besides development, recreational activities on beaches and dunes have affected both breeding and feeding habitat. High quality breeding habitat is viewed as the key to protecting shorebird populations. An immediate SAMBI objective is to maintain the habitat supporting the present breeding populations of 900 pairs of American oystercatchers, 45 pairs of snowy plovers, 850 pairs of Wilson's plovers, and 55 pairs of piping plovers. The piping plover is now Federally listed as an endangered species. The SAMBI goal is to double the breeding population size for each of these shorebird species in the southern coastal plain states or, through population analyses, to determine the population levels needed to ensure the long-term viability of breeding populations. Another immediate SAMBI objective is to provide high quality managed habitat to support successful migration through, and over-wintering within, the southern coastal states, particularly during fall migration. This means maintaining wash-overs, sand flats, and mudflats, especially on barrier islands created by hurricanes. Another emphasis is on reducing the populations of great black-backed gulls, which prey on shorebirds.

Waterfowl

Ducks, geese, and swans make up the other major component of the coastal avifauna. Most members of this group migrate, following various migration pathways. Some reach only to the northern part of North Carolina and others reach the southern tip of Florida and even into the Caribbean. There are three major groups of ducks: dabbling ducks, bay ducks, and sea ducks. Both the bay ducks and the sea ducks are divers.

Of all the waterfowl groups, the greatest conservation concern is for the sea ducks and greater and lesser scaup. Included in this group called sea ducks are scoters, eiders, harlequin ducks, mergansers, long-tailed ducks, goldeneyes and buffleheads (Bellrose 1976), not all of which occur along the southeastern seaboard. The 15 species of sea ducks constitute 42% of the ducks breeding in North America, yet these are the least known waterfowl (Sea Duck Joint Venture, SDJV). Our knowledge of most sea ducks was very limited until the past decade when new emphasis on estuaries and declining sea duck populations began to focus interest of scientists and managers. Unfortunately most studies have been conducted on breeding grounds or in Canada or waters north of the Carolinas. Little is known about their distribution and habitat requirements during their winter at sea off the southeastern states. There are few reliable population estimates or indices. They breed in low densities in remote parts of the continent, making population surveys logistically difficult, and discouraging the accumulation of even basic natural history information, much less information on life-history, population dynamics, and ecology. Sea ducks may represent no more than 5% of the continental waterfowl harvest, however surveys are not designed to accurately estimate the harvests of these species. Sea ducks have long life spans and, consistent with this, low reproductive rates. Unlike other ducks, most sea duck species are not sexually mature until they are 2 or 3 years old.

Population declines in 10 of the 15 sea duck species have been reported based on surveys conducted in the 1990s (SDJV). The eastern population of harlequin ducks has been listed as endangered in Canada (SDJV). Causes of population losses are unknown. Sea ducks spend about nine months in marine environments, where they occupy a range of habitats—bays, lagoons, estuaries, and coastal shelf waters. They often occur in large aggregations, making them more vulnerable to catastrophic events. Contaminants have been found in tissues of some sea duck species at concentrations known to affect survival and reproduction in other birds (SDJV). Their long life spans make them vulnerable to bioaccumulation of persistent pesticides and heavy metals. Direct mortality from lead poisoning has been documented on Alaskan breeding grounds. Offshore oil production, oil spills, and chronic exposure to low levels of petroleum contamination from bilge dumping are potential threats to the future well being of sea duck populations. In addition, they are exposed to loss of breeding habitat, and their wintering areas have been changed by urban and industrial development.

Commercial gillnet fisheries encountered along their migration routes and on their wintering grounds are an under-recognized threat to diving waterfowl and may be partly responsible for the unexplained declines in populations of scaup and other divers, including the sea ducks. A recent unpublished report by Doug Forsell (U.S. Fish and Wildlife Service, Annapolis) summarizes both published and antidotal information to determine the species affected by gillnetting in both fresh and salt water. The Forsell report and two recent reports by Price and Van Salisbury (2007) and Price (2007) indicate the following avian bycatch in commercial gillnet fisheries: brown pelican, canvasback, common loon, cormorant, diving ducks, double-crested cormorant, great black-backed gull, grebes, pied-billed grebe, red-breasted mergansers, red-throated loon, ruddy duck, scaup, and surf scoter.

Snow geese, Canada geese, and mute and tundra swans, along with numerous species of dabbling ducks and bay ducks, make up the remaining component of the waterfowl of coastal waters in the Southeast. Based on Sibley (2003), ducks notable for occurrence in southeastern coastal waters are the mallard, gadwall, American wigeon, canvasback, greater and lesser scaup, redhead, bufflehead, and hooded, red-breasted, and common mergansers. The American black duck and Florida duck inhabit salt marshes. In the coastal environment, dabbling ducks and bay ducks feed on stems of aquatic vegetation and seeds of marsh grasses. Some species also feed on small crustaceans and mollusks. Sea ducks such as long-tailed ducks feed predominately on animals, including crustaceans and fish, but plant foods make up about 10% of their diet. Mollusks are more important than crustaceans in the diets of black scoter, which also consume plants—frequently eelgrass.

Almost all waterfowl species that use the Atlantic flyway have been affected by the loss of coastal wetland and changes in the flow of fresh water to the coast, brought about by dams, levees, canals, roads, and other structures. While changes in the timing, volume, or distribution of freshwater flow may not affect the birds directly, it affects their aquatic habitat and their food supply, made up of species of plants and animals that benefit from natural estuarine gradients of salinity and river-influenced estuarine circulation. The largest threats to diving ducks are changing habitats, over fishing, sand mining, loss of benthic reef habitats, sedimentation, disturbance, and many other anthropogenic effects of coastal development. Hunting is, of course, a major cause of mortality to those species sought after in this sport.

Estuarine and Coastal Wetland Species

Pelicans and cormorants, wading birds, certain raptors, shorebirds, and waterfowl are major avian groups inhabiting bays, lagoons, and wetlands. They feed on shallow mud flats and along tidal creeks and shorelines. Shorebirds and waterfowl have already been discussed in the previous section. The pelican group, wading birds, and marsh birds will be discussed in this section.

Pelicans and Their Relatives

Brown pelicans, double-crested cormorants, and magnificent frigate birds are characteristic species of coastal waters and estuaries, catching prey by various methods. They congregate around fishing boats and docks where they often find a free meal. Prey acquisition is facilitated by the expandable lower bill of these species, which belong to the taxonomic order Pelicaniformes, along with the boobies and gannets. The principal threats to populations of these species are loss or degradation of nesting or feeding habitat, blooms of toxic algae, and contaminants such as chlorinated hydrocarbons and heavy metals that accumulate in aquatic food chains. They are potentially vulnerable to inshore trawl, seine, gillnet fisheries, and hook and line fisheries. Entanglement in monofilament line is a common source of death or disablement of pelicans and cormorants. Bycatch of both brown pelicans and double-crested cormorants has been documented in North Carolina gillnet fisheries. Pound nets are a big attractant for cormorants and increasingly, pelicans, both for foraging and roosting, thus increasing conflicts with fishers (D. Forsell, pers. comm.).

The brown pelican, *Pelecanus occidentalis*, is confined to coastal regions of North and South America. Plunge diving is this bird's primary mode of fishing, although juveniles sometimes feed by dipping bills while floating on the water surface. Widespread use of DDT led to a serious decline of Brown Pelican populations, however population numbers stabilized and began increasing in the 1980s, and the range of this tropical to southern temperate species has been increasing northward (i.e., from North Carolina to Maryland). Surveys conducted in Atlantic states in the 1980s suggested the WNA population of Brown Pelicans was 18,000 pairs; but present numbers likely are considerably higher (Lee, in prep.). Kushlan et al. (2002) estimate there are 95,800-96,850 adult pairs in North America, not distinguishing Atlantic, Gulf of Mexico-Caribbean, and Pacific coasts.

The double-crested cormorant, *Phalacrocorax auritus*, is the most common and widespread WNA cormorant. Like the pelican and other cormorants, it resides in marine habitats only in coastal areas, feeding in bays and sounds and near inlets and nesting on cliffs, islands, and in trees. Only rarely is it seen at sea out of sight of land. This species occurs throughout much of North America, with northern freshwater populations migrating to ice-free coastal marine and estuarine habitats outside the breeding season. Cormorants often are seen in small groups and occasionally in flocks of thousands around inlets and other areas where fish concentrate. This cormorant forages by diving from the water surface and swimming underwater to catch prey, propelled by its webbed feet. There are three subspecies in the WNA; the most widespread Florida race (*P. a. floridanus*) nests from the Carolinas south into the Northern Bahamas and Cuba. Lee (2007) provides a total WNA population estimate of about 55,000 pairs, based primarily on surveys from the 1980s, however the population has been growing. The Kushlan et al. (2002) estimate for North America is 370,000 breeder pairs.

The magnificent frigatebird, *Fregata magnificens*, is primarily a tropical species of both the Atlantic and Pacific oceans. Nesting is mainly in the West Indies region, but also in the Marquesas and Dry Tortugas (off the Florida Keys), off Brazil, and in the Cape Verde Islands. Birds spend much of their time soaring over waters of the Caribbean and the Bahamas and off the southern and eastern coast of Florida, occasionally wandering north along the Atlantic coast to the Carolinas. This is a large, graceful, highly aerial seabird with long, forked tail streamers. It feeds in nearshore waters, snatching food from the water surface while in flight and pirating food from other seabirds. It can neither walk nor swim. Frigate birds cannot land on water and resume flight. Lee's (in prep.) population estimate for the North Atlantic region is 9,900-10,700 pairs.

Wading Birds

Wading birds form a major portion of the avifauna of coastal wetlands and estuaries, serving the important role of higher trophic level consumers. Wading birds are prominent members of estuarine ecosystems, notable for their graceful flight, beautiful plumage, stately appearance on the water, and interesting feeding behavior, which differs in detail from species to species. From the Outerbanks to Florida Bay and the Florida Keys, wading birds are characteristic wetland species. They form nesting colonies in both inland and coastal wetlands of the southeastern seaboard states and other places. The largest colonies may once have been in south Florida, but this has changed over time, following the drainage of large parts of the Everglades. Substantial population declines are thought to have occurred but are generally not well documented. Loss and degradation of wetland habitat are thought to be a major factor for declines.

Found coastally and in our region, there are many species of wading birds, which can be simply thought of as organized taxonomically into three main groups: the herons and egrets, the ibis and spoonbills, and the wood stork. Best-known species in this group that nest and/or forage in coastal wetlands are the great blue heron, great white Heron, common egret, snowy egret, little blue heron, white ibis, glossy ibis, roseate spoonbill, and wood stork. The great white heron occurs primarily in south Florida (i.e., mainly the southern Everglades, Florida Bay, and the Florida Keys), and not in the other southeastern states, but appears genetically to be a color morph of the great blue heron, whose range extends into Canada. . Most wading birds nest in colonies and forage within a multi-mile radius of their nesting sites. Some, such as the white ibis, feed in salt marshes but depend on freshwater wetlands for crustacean prey to raise young. Expanding and contracting water areas and consistent dry-downs to concentrate prey are important to the nesting success of some, especially the wood stork. Several wading birds are listed as of special conservation concern (Table 4.3-3). The wood stork is a Federally listed endangered species. Populations in south Florida have declined substantially since the 1960s, although new colonies have formed further north to other southeastern states. The new colonies all are small by comparison to the colonies that once existed in south Florida. Another species needing special mention is the reddish egret, which has recently raised concern because of limited known nesting sites and population numbers that are thought to be very low Great blue herons in the Chesapeake Bay utilize pound nets to forage for small fish. One study found half of the foraging flights from a colony were to pound nets.

Marsh Birds

Birds that live among the reed beds, lakes, ponds, and mudflats of the coastal wetlands form another group of Atlantic coast birds defined by habitat. In particular, these include, the American coot, the pied-billed grebe, the American woodcock, the limpkin, the Wilson's snipe, the purple gallinule, the American and least bitterns, several species of rails, and several species of sparrows—all listed in Table 4.3-3. Some, e.g., the limpkin, which feeds on apple snails, will be found primarily in freshwater areas of the coastal wetlands. Four sparrow species are listed as priority species for conservation by SAMBI, and three are of special concern in Georgia. South Carolina and Florida lists of species of conservation concern contain most of the other species. The limpkin is a species of special concern in Florida.

Abundance and status of stocks

(from Atlantic Croaker FMP Update 2005)

The population status and trend data on many species of seabirds are limited especially for small portions of the coast such as the mid-Atlantic. Of the species likely to interact with the croaker fishery the status of the red-throated loon is the least known, but it thought to be declining in the Pacific and probably on the East Coast. The common loon is listed by the Fish and Wildlife Service as a species of concern. Common loons breed on lakes where they face a number of hazards including mercury and lead poisoning, poaching, disturbance, loss of habitat and gillnet fishing. In their migration, molting, and wintering habitat along coastal Atlantic waters the major threat to both loons is from gillnets and oil spills. Northern gannets, brown pelicans, and double-crested cormorants have increasing populations. Of the ducks likely to interact with the fishery, the redbreasted merganser, bufflehead, common goldeneye, ruddy duck, and hooded merganser have populations that are increasing or stable, while the black, surf, and white winged scoters, long-tailed duck, and greater and lesser scaup have populations that are declining or thought to be declining.

4.3.4 Marine Fish

4.3.4.1 Smalltooth sawfish

Description and distribution

The smalltooth sawfish is a tropical marine and estuarine elasmobranch (sharks, skates, and rays) that have a circumtropical distribution. In the western Atlantic Ocean, the smalltooth sawfish has been reported from Brazil through the Caribbean Sea and, the Gulf of Mexico, and the Atlantic coast of the United States (Bigelow and Schroeder, 1953). Historic capture records within the U.S. range from Texas to New York. Water temperatures no lower than 16-18 °C and the availability of appropriate coastal habitat appear to serve as the major environmental constraints limiting the northern movements of smalltooth sawfish in the western North Atlantic Ocean. As a result, most records of this species from areas north of Florida occur during spring and summer periods (May to August) when inshore waters reach warmer temperatures. These larger individuals (> 3.0 m) captured along the Atlantic coast north of Florida represent seasonal migrants from a core population in southern states rather than being members of a continuous, uniform-density population (Bigelow and Schroeder, 1953). It is likely that these individuals migrated southward toward Florida as water temperatures declined in the fall, as there is only one winter record from the Atlantic coast north of Florida.

Reproduction

Fertilization in smalltooth sawfish is internal. Development in sawfish is believed to be ovoviviparous. The embryos of smalltooth sawfish, while still bearing the large yolk sac, already resemble adults relative to the position of their fins and absence of the lower caudal lobe. During embryonic development the rostral blade is soft and flexible. The rostral teeth are also encapsulated or enclosed in a sheath until birth. Shortly after birth, the teeth become exposed and attain their full size proportionate to the size of the saw. The size at birth is approximately 80 cm, with the smallest free-living specimens reported during field studies in Florida being 77 - 84 cm (Simpfendorfer, unpublished data). Bigelow and Schroeder (1953) reported gravid females carry 15-20 embryos. Simpfendorfer (2000) estimated age at maturity between 10 and 20 years. Studies of largetooth sawfish in Lake Nicaragua (Thorson 1976) report brood sizes of 1-13 individuals, with a mean of 7.3 individuals. The gestation period for largetooth sawfish is approximately 5 months and females likely produce litters every second year. Although there are no such studies on smalltooth sawfish, its similarity in size and habitat to the largetooth sawfish implies that their reproductive biology may be similar.

Development, growth and movement patterns

To date, no formal studies on the age and growth of wild smalltooth sawfish have been conducted. Individuals have been maintained in public aquaria for up to 20 years (Cerkleski, pers. comm., 2000) which can provide some information on growth. For example, Bohoroquez (2001) reported three specimens in Columbia grew at an average rate of 19.6 cm/year (one animal grew from 84 cm to 320 cm in 12 years). In a more comprehensive study, Clark et al. (2004) reported an average growth rate of 13.9 cm/year for16 captive smalltooth sawfish (size from 80 cm to 412 cm) in North American. Based on their growth parameters Clark et al. (2004) estimated an age at maturity of 19 yr for males and 33 yr for females while Simpfendorfer (2000) estimated age at maturity between 10 and 20 years, and a maximum age of 30 to 60 yr.

Sawfish in general inhabit the shallow coastal waters but recent data suggests adults can be found to much greater depths. Simpfendorfer and Wiley (2005) reported close associations between encounters and mangroves, seagrasses, and the shoreline than expected at random. Encounter data have also demonstrated that smaller smalltooth sawfish occur in shallower water and larger sawfish occur regularly at depths greater than 10 meters. Poulakis and Seitz (2004) reported that almost half of all sawfish < 3 meters in length were found in water less than 10 meters deep and 46% of encounters with adult sawfish (> 3 meters) in Florida bay and the Florida Keys occurred at depths between 70 to 122 meters. Simpfendorfer and Wiley (2005) also reported a substantial number of larger sawfish in depths greater than 10 meters. Encounter data bases have also identified river mouths as areas where many people observe sawfish. Seitz and Poulakis (2002) noted that many of the encounters occurred at or near river mouths in southwest Florida. Simpfendorfer and Wiley (2005) reported a similar pattern of distribution along the entire west coast of Florida. It is unclear whether this observation represents a preference for river mouths because of physical characteristics. Acoustic tracking results for very small smalltooth sawfish indicate depth and red mangrove root systems are potentially important in helping them avoid predators (Simpfendorfer 2003). Small juveniles have many of the same habitat use characteristics seen in the very small sawfish. However, their association with very shallow water (< 1 ft deep) is weaker, possibly because they are better suited to predator avoidance due to their larger size and greater experience. They do, however, still have a preference for shallow water, remaining in depths mostly less than three feet (90 cm). Information on the habitat use of adult smalltooth sawfish suggests that adult sawfish occur from shallow coastal waters to deeper shelf waters.

Abundance and status of stocks

There are few long-term abundance data sets that include smalltooth sawfish. Catch data from shrimp trawlers off Louisiana from the late 1940's to the 1970's suggests a rapid decline in the species from the period 1950-1964. However, this data set has not been validated nor subjected to statistical analysis to correct for factors unrelated to abundance. The Everglades National Park has established a fisheries monitoring program based on sport fisher dock-side interviews since 1972 (Schmidt et al. 2000). Analysis of these data using a lognormal generalized linear model to correct for factors unrelated to abundance (e.g., change in fishing practices) indicate a slight increasing trend in abundance for smalltooth sawfish in the park (Carlson et al. 2007). From 1989-2002, smalltooth sawfish relative abundance has increased by about 5% per year.

Using a demographic approach and life history data for smalltooth sawfish and similar species from the literature, Simpfendorfer (2000) estimated intrinsic rates of natural population increase as 8-13% per year and population doubling times from 5.4 years to 8.5 years. Musick (1999) and Musick et al. (2000) noted that intrinsic rates of increase less than ten percent were low, and are particularly vulnerable to excessive mortalities and rapid population declines, after which recovery may take decades. As such, smalltooth sawfish populations will recover slowly from depletion, confounding recovery efforts. Simpfendorfer (2000) concluded that recovery was likely to take decades or longer depending on how effectively sawfish could be protected.

Ecological relationships

Unknown.

Listing Designations

The National Marine Fisheries Service (NMFS) added the smalltooth sawfish to its list of candidate species in 1991 (56 FR 26797). Smalltooth sawfish were removed from the list in 1997 (62 FR 37561), but returned on a revised list published June 23, 1999 (64 FR 33466). On November 30, 1999, NMFS received a petition from the Center for Marine Conservation requesting listing of the North American population of smalltooth sawfish as endangered under the Endangered Species Act. Subsequently, NMFS announced the initiation of a smalltooth sawfish formal status review (65 FR 12959) and published a proposed rule (66 FR 19414) to list the U.S. population of smalltooth sawfish as endangered under the Endangered Species Act. On April 1, 2003, NMFS listed the U.S. population of smalltooth sawfish as an endangered species (50 CFR 224). A recent proposal by the United States of America to list all sawfish under Appendix 1 of the Convention on International Trade in Endangered Species of Wild Fauna and Flora banning international trade was approved. The convention made an exception for one species of sawfish, listing them on Appendix II, allowing Australia to continue trade in live animals if it does not hinder the conservation of the species.

4.3.4.2 Shortnose sturgeon

Description and Distribution

The shortnose sturgeon (*Acipenser brevirostrum*) is a federally-listed endangered species, for which a Recovery Plan has been prepared (NMFS 1998). The species occurs in South Atlantic rivers, and on occasion in marine waters. There are apparently no documented records from the EEZ in the South Atlantic (Mark Collins, SC Department of Natural Resources, personal communication to R.W. Laney); however, the species is included here since the Council also must consider the impacts of its plans on federally listed protected species. It is an anadromous species which historically, with the Atlantic sturgeon, formed the basis for a valuable commercial fishery. Information in this account is taken largely from the December 1998 Final Recovery Plan for the species (NMFS 1998), with supplementation from other sources as cited.

The shortnose sturgeon occurs in large coastal rivers of eastern North America, historically from the St. John River in New Brunswick, Canada to the Indian River, Florida (NMFS 1998). NMFS currently recognizes 19 distinct population segments of shortnose sturgeon inhabiting 25 river systems ranging from the Saint John River in New Brunswick, Canada, to the St. Johns River, Florida. Genetic analysis of 11 of these population segments indicate most rivers and estuaries currently harboring shortnose sturgeon and identified as population segments in the NMFS 1998 Recovery Plan contain genetically distinct populations. Of the 11 population segments tested, at least 9 genetically distinct population segments of shortnose sturgeon were identified. Most comparisons among collections in the southeast showed significant genetic discontinuities between adjoining rivers, despite geographic proximity of their river mouths (20-100 km) (Wirgin et al. 2006).

Shortnose sturgeon historically occurred in most rivers of the four South Atlantic states from the Albemarle Sound system in NC through the Indian River system in FL. One relatively recent capture (1998) of a shortnose sturgeon in the Albemarle Sound system has been documented (Wayne Starnes, North Carolina Museum of Natural Sciences, personal communication). There have been no recent documented captures in the Pamlico Sound and its tributaries (Tar, Neuse Rivers). However, there are two recent reports of sturgeon from the Pamlico Sound identified by commercial fishery observers that were allegedly shortnose, but no photographs or tissue were taken for confirmation by professional fishery biologists or geneticists (Wilson Laney, USFWS, personal communication). There is currently a small population of shortnose in the Cape Fear River, North Carolina. At least one population presently exists in the Winyah Bay system (Waccamaw, Pee Dee and Black Rivers), as well as the Santee River, the Cooper River, the ACE Basin (Ashepoo, Combahee and Edisto Rivers) and the Savannah River. Georgia populations occur in the Savannah, Ogeechee, Altamaha, St. Marys and Satilla Rivers. Florida has shortnose presently only in the St. Johns River.

The shortnose is a small species of sturgeon, reaching maturity at fork lengths of 45-50 cm (18-20 in) and maximum size of approximately 120 cm (47 in) (Dadswell et al. 1984). It differs from juvenile Atlantic sturgeon in having a shorter nose, wider mouth, and no enlarged bony plates between the base of the anal fin and the lateral row of scutes (Gilbert 1989). Shortnose sturgeon are found in rivers, estuaries and the sea, but populations spend most of their time in their natal rivers and estuaries (NMFS 1998). In the southeast, the species is estuarine anadromous (i.e., spends most of the year in estuaries and ascends the freshwater portions of rivers to spawn in the spring). Adults in rivers in the south Atlantic forage at the interface of fresh tidal water and saline estuaries and migrate to the upper reaches of rivers to spawn during early spring (Savannah River: Hall et al. 1991; Altamaha River: Heidt and Gilbert 1979; Flouronoy et al. 1992, Rogers and Weber 1995a; Ogeechee River: Weber 1996).

Reproduction

Length and age at maturity

Length at maturity (45-55 cm FL) is similar throughout the shortnose sturgeon's range, but because fish in southern rivers grow faster than those in northern rivers, southern fish mature at younger ages. Males spawn first at 2-3 years in Georgia and 3-5 years in South Carolina, whereas females first spawn at 6 years or less in the Savannah River (Dadswell et al. 1984). Most shortnose sturgeon probably survive spawning, although there is some post-spawning mortality (B. Kynard, United States Geological Survey, personal observation).

Spawning periodicity

Spawning periodicity is poorly understood, but males seem to spawn more frequently than females. At least some males and females in the Savannah River may spawn in consecutive years, but most apparently do not (Collins and Smith 1993). Males may spawn every 1-2 years, but the minimum duration between spawning events for females is generally 3 years (Dadswell 1979, Cooke et al. 2002).

Fecundity and sex ratio

Gonadal maturity and fecundity of females were characterized by Dadswell (1979) for the Saint John River, Canada. Just prior to spawning, egg diameter was 3.1 mm and the ovaries composed 25 percent of the body weight. The number of eggs released ranged from 27,000 to 208,000 (11,568 eggs/kg body weight). Males were most abundant in the sex ratio estimate for the Savannah River (3.5:1, Collins and Smith 1997).

Spawning behavior

The shortnose sturgeon spawning period is estimated to last from a few days to multiple weeks. Sturgeon in the Savannah River remained on the spawning grounds for 2-3 weeks (Hall et al. 1991). Altamaha River fish remained on suspected spawning grounds for as long as nine weeks (Rogers and Weber 1995a). Cooper River fish residenced the spawning site for 89 days, longer than reports from other populations. It is hypothesized that these individuals were actively searching for an upstream route past Pinopolis Dam, but to no avail (Cooke and Leach, 2004a). Males fertilize the female's eggs as the eggs are released close to the substrate. In captivity, males nuzzle the anal and head areas of females, suggesting that females attract males with a chemical attractant (B. Kynard, personal observation).

Spawning habitat

In populations that have free access to the total length of a river, (e.g., no dam within the species' range in the river) spawning areas are located at the most upstream reach of the river used by sturgeon (Saint John, Kennebec, and Altamaha rivers: Dadswell et al. 1984, Rogers and Weber 1995a; Savannah River: Hall et al. 1991). Characteristic channel spawning habitats vary slightly among rivers: in curves with gravel/sand/log substrate in the Savannah River (Hall et al. 1991) and areas near limestone bluffs with gravel to boulder substrate in the Altamaha River (Rogers and Weber 1995a).

Timing of spawning and river conditions

Spawning begins in freshwater from late winter/early spring in southern rivers when water temperatures increase to 8-9°C. Spawning usually ceases when water temperatures reach 12-15° C (Dadswell et al. 1984; Buckley and Kynard 1985b; Hall et al. 1991; O'Herron et al 1993; Squiers et al. 1993; Kynard 1997). However, shortnose sturgeon may spawn at higher temperatures. For example, when high river flow conditions delayed spawning in the Connecticut River, shortnose sturgeon had the physiological flexibility to spawn successfully at 18° C (Kynard 1997). Spawning was detected from 11.5-19°C in the Cooper River, SC (Cooke and Leach, 2004a). In general, spawning occurs earlier in the year in southern rivers and at moderate river discharge levels (relative to northern rivers). For example, spawning occurs in early-February to mid-March in the Savannah River (Hall et al. 1991) and has been documented in late February to late March in the Cooper River (Cooke and Leach, 2004a). Shortnose spawning generally occurs earlier and at lower temperatures than Atlantic sturgeon. Dadswell et al. (1984) report that most shortnose spawn between 9 and 12°C.

Physical factors affecting spawning success

As observed in the Connecticut River, high river flows during the normal spawning period can cause unacceptably fast bottom water velocities and prevent females from spawning (Buckley and Kynard 1985b; Kynard 1997). Buckley and Kynard (1985b) speculated that the reproductive rhythm of females may be under endogenous control and suitable river conditions must be available or endogenous factors prevent females from spawning. Thus, reproductive success depends on suitable river conditions during the spawning season.

Development, growth and movement patterns

Habitat and Environmental Requirements

Shortnose sturgeon in the South Atlantic portion of the range require the use of large coastal rivers from the estuarine portions to upstream spawning areas. Habitat and environmental requirements of shortnose sturgeon are reviewed in Gilbert (1989). Shortnose require large rivers unobstructed by dams, or in which the dams are above their preferred spawning areas, or at which fish passage has been provided. Shortnose are apparently able to maintain completely freshwater populations, such as in the Santee-Cooper system (Collins et al. 2003). Preferred temperature ranges and upper and lower lethal temperatures for shortnose are not currently known. Shortnose sturgeon are seldom found in shallow water where water temperatures exceed 22°C; however, in the Altamaha they were found at temperatures as high as 34°C. Temperatures at wintering sites ranged from 5-10°C in Winyah Bay.

Shortnose sturgeon prefer waters of lower salinity than Atlantic sturgeon. The maximum salinity at which shortnose were found is 30-31 ppt, slightly less than sea water. In areas where shortnose sturgeon and Atlantic sturgeon co-occur, shortnose are typically found in waters less than 3 ppt. Adult sturgeon are typically found in areas with little or no current throughout their lives, especially when they are present in the lower portions of rivers and in the estuaries. Shortnose have been reported from shallower waters in the summer (2-10 m; 6.5-33 ft) and deeper water in the winter (10-30 m; 33-99 ft). They have been observed feeding in heavily vegetated, muddy backwater areas; however, in general submerged aquatic vegetation does not appear to be an important factor in their life history.

Early life stages

At hatching, shortnose sturgeon larvae are blackish-colored, 7-11 mm (0.3-0.4 in) long and resemble tadpoles (Dadswell et al. 1984). Larvae have a large yolk-sac, poorly developed eyes, mouth and fins, and are capable of only limited swimming. In laboratory experiments, 1 to 8-day–old shortnose sturgeon were photonegative, actively sought cover under any available material, and swam along the bottom until cover was found (Richmond and Kynard 1995). It is likely that they hide under available cover at spawning sites. The yolk-sac is absorbed in 9-12 days, and larvae resemble miniature adults by about 20 mm (0.8 in) in length. They likely begin swimming downstream at this size. Larvae collected in the wild were in the deepest waters of the channel. Laboratory studies suggest that there is a two-stage downstream migration: a 2-day migration by larvae, followed by a residency period of young-of-the-year fish, then a resumption of migration by yearlings the second summer of life.

Juveniles

Juveniles occur in or at the saltwater/freshwater interface in most rivers (Savannah: Hall et al. 1991; Altamaha: Flournoy et al. 1992; Ogeechee River: Weber 1996). Juveniles in the Ogeechee River moved into more saline areas (0-16 ppt) and were most active when water temperature dropped below 16°C (Weber 1996). In the Savannah River, juveniles use sand/mud substrate in depths of 10-14 m (33-46 ft) (Hall et al. 1991). Warm summer temperatures above 28 degrees F may severely limit available juvenile nursery habitat in some southern rivers. Summering habitat in the Altamaha River was limited mainly to one cool, deepwater refuge (Flournoy et al. 1992). Likewise, a similar distribution was observed in the Ogeechee River (Rogers and Weber 1994; Rogers and Weber 1995b, Weber 1996).

<u>Adults</u>
Adults that occur in freshwater or tidal fresh reaches of rivers in summer and winter often occupy only a few short reaches of the total river length (Savannah River: Hall et al. 1991; Altamaha River: Flouronoy et al. 1992). In the Connecticut and Merrimack Rivers, the "concentration areas" used by fish were reaches where natural or artificial features cause a decrease in river flow, possibly creating suitable substrate conditions for freshwater mussels (Keiffer and Kynard 1993), a major prey item for adult sturgeon (Dadswell et al. 1984). Summer concentration areas in southern rivers are cool, deep, thermal refugia, where adults and juveniles congregate (Flouronoy et al. 1992; Rogers and Weber 1994; Rogers and Weber 1995b; Weber 1996).

<u>Growth</u>
Growth of juvenile shortnose sturgeon is fast throughout the species' range (Dadswell et al. 1984). YOY are 14-30 cm TL after the first year. Fish reach 50 cm after only 2-4 years in the southern part of the range. Fish grow faster in the South, but do not attain the large sizes of northern fish (Dadswell et al. 1984).

<u>Survival and Recruitment</u>
There is no information on survival of eggs or early life stages in the wild. Many eggs reared in captivity die of fungus infections (Dadswell et al. 1984). Richmond and Kynard (1995) maintain that the availability of spawning substrate with crevices is critical to survival of eggs and embryos. Year class strength of shortnose sturgeon populations is probably established early in life, perhaps in the initial few weeks. Although there is no commercial fishery for shortnose sturgeon (and thus, no fisheries recruitment information), some fisheries incidentally catch adult sturgeon and poaching impacts all populations to an unknown degree.

Incidental capture of shortnose sturgeon also occurs in gill net fisheries in the southern portion of the shortnose sturgeon's range. Gill net fisheries for American shad (Alosa sapidissima) and trawl fisheries for shrimp (Penaeus spp.) in Georgia and South Carolina captured about 2% of a tagged sample of shortnose sturgeon (Collins et al. 1996). The gill net fishery was responsible for 83% of the total shortnose sturgeon captures. Moser and Ross (1993) reported that 4 of 7 telemetered adult sturgeon in the Cape Fear River were captured in the gill net fishery for American shad or striped bass (Morone saxatilis). In addition, apprehension of poachers operating in South Carolina indicates that illegal directed take of shortnose sturgeon in southern rivers may be a significant source of mortality (D. Cooke, personal communication).

<u>Natural mortality</u>
Estimates of total instantaneous mortality rates (Z) are available for several river systems, albeit mainly northern populations. Total mortality for the Pee Dee-Winyah River in South Carolina

was estimated at 0.08 to 0.12 (Dadswell et al. 1984). This estimate and the estimates for the other populations were based on catch curves which were adjusted for gill net selectivity and effort.

Annual egg production

Annual egg production is determined by the fecundity of females and the number of spawning females. Estimates of egg production from the Saint John River indicated mean fecundity per female was 94,000 eggs (Dadswell 1979). Monitoring of spawner abundance in the Connecticut River indicated that abundance varies greatly from year to year (Kieffer and Kynard unpublished data). Smith et al. (1992) also suggested that spawner abundance in the Savannah River can fluctuate greatly from year to year. This information indicates that the number of eggs spawned annually varies greatly (possibly by several magnitudes) over the species' range and complicates estimation of annual egg production.

Migration and Movements

Movement patterns in shortnose sturgeon vary with fish size and home river location. Juvenile shortnose sturgeon generally move upstream in spring and summer and move back downstream in fall and winter; however, these movements usually occur in the region above the saltwater/freshwater interface (Dadswell et al. 1984; Hall et al. 1991). Adult shortnose sturgeon are generally estuarine anadromous in southern rivers (Keiffer and Kynard 1993).

Spawning migrations are apparently triggered when water temperatures warm above 8°C (Dadswell et al. 1984). Consequently, spring spawning migrations occur earlier in southern systems than in northern ones: January-March (Altamaha River: Gilbert and Heidt 1979, Rogers and Weber 1995a; Savannah River: Hall et al. 1991; Pee-Dee/Waccamaw Rivers: Dadswell et al. 1984; Cape Fear River: Moser and Ross 1993). In the Altamaha River, Rogers and Weber (1995a) also documented upstream movement of most adults to suspected spawning grounds in autumn (late November-early December). A second spawning migration occurred in that system during mid-winter (late January-early February).

A shortnose sturgeon spawning migration is characterized by rapid, directed and often extensive upstream movement. Hall et al. (1991) tracked adults during pre-spawning upstream migrations of up to 200 km in the Savannah River and Dadswell et al. (1984) noted that a migration of 193 km occurred in the Altamaha River. Telemetry studies have documented maximum ground speeds of 20-33 km d-1, although mean ground speeds during riverine spawning migrations were around 16 km d-1 (Buckley and Kynard 1985a; Hall et al. 1991; Moser and Ross 1993). Both Hall et al. (1991) and Moser and Ross (1993) observed that spawning migrations are easily interrupted by capture and handling or by dams. Non-spawning movements include rapid, directed post-spawning movements to downstream feeding areas in spring and localized, wandering movements in summer and winter (Dadswell et al. 1984; Buckley and Kynard 1985a; O'Herron et al. 1993). Shortnose sturgeon usually leave the spawning grounds soon after spawning. Keiffer and Kynard (1993) reported that post-spawning migrations were correlated with increasing spring water temperature and river discharge. Post-spawning migration rates range from 3.5-36 km d-1 (Buckley and Kynard 1985a; Hall et al. 1991; Kieffer and Kynard 1993). During these movements shortnose sturgeon apparently move singly and "home" to very specific sites (Dadswell et al. 1984; Kieffer and Kynard 1993; Savoy and Shake 1992).

Continuous tracking of shortnose sturgeon provides detailed information on their migratory behavior. Moser and Ross (1994) demonstrated that, in the Cape Fear River estuary, upstream spawning migration in saltwater was slower (10 km d-1) than migration in freshwater (15 km d-1). This was due to the saltatory nature of movement in the estuary and faster swimming (0.8 body lengths (BL) s-1) in freshwater than in the estuary (0.6 BL s-1). Estimated swimming speed during summer, 0.07-0.37 BL s-1, is considerably slower than during spawning migrations (McCleave et al. 1977), while shortnose sturgeon are even less active in winter (Seibel 1993). Moser and Ross (1994) and McCleave et al. (1977) estimated swimming speed to be greatest when sturgeon oriented against rapid ebbing currents. Moser and Ross (1994) and McCleave et al. (1977) reported that shortnose sturgeon do not display any diel activity pattern, traveled in the upper part of the water column (within 2 m of the surface), and that their movement was apparently unaffected by temperature and salinity.

Abundance and status of stocks

As stated earlier, shortnose sturgeon historically occurred in most rivers of the four South Atlantic states from the Albemarle Sound system in NC through the Indian River system in FL. One relatively recent capture (1998) of a shortnose sturgeon in the Albemarle Sound system has been documented (Wayne Starnes, North Carolina Museum of Natural Sciences, personal communication). There have been no recent documented captures in the Pamlico Sound and its tributaries (Tar, Neuse Rivers). However, there are two recent reports of sturgeon from the Pamlico Sound identified by commercial fishery observers that were allegedly shortnose, but no photographs or tissue were taken for confirmation by professional fishery biologists or geneticists (Wilson Laney, USFWS, personal communication). There is currently a small population of shortnose in the Cape Fear River, North Carolina. At least one population presently exists in the Winyah Bay system (Waccamaw, Pee Dee and Black Rivers), as well as the Santee River, the Cooper River, the ACE Basin (Ashepoo, Combahee and Edisto Rivers) and the Savannah River. Georgia populations occur in the Savannah, Ogeechee, Altamaha, St. Marys and Satilla Rivers. Within the State of Florida, shortnose sturgeon are known only in the St. Johns River.

Total population estimates are not available for the Cape Fear, Winyah Bay, Santee, Cooper, ACE Basin, Savannah, Satilla, St. Marys and St. Johns Rivers. For the Ogeechee River, the total population estimate using Modified Schnabel methodology was 361 (95% CI= 326-400) in 1993 and 147 (95% CI= 104-249) in 2000 (Rogers and Weber 1994; Fleming et al. 2003). For the Altamaha River, the total population estimate using Modified Schnabel methodology was 2,862 (95% CI= 1,069-4,226) in 1988, 798 (95% CI= 645-1,045) in 1990, and 468 (95% CI= 316-903) in 1993 (Rogers unpublished data). A more recent study conducted in the Altamaha system from 2004-2006 resulted in a Schnabel population estimate of 6048 (95% CI= 4526-9110) (Peterson unpublished data).

Analysis of data for 1996, 1997, and 1998 resulted in estimates of 87 (95% CL 56-170), 193 (95% CL 123-319), and 301 (95% CL 150-659) adult fish, respectively residing in the Pinopolis Dam tailrace area during the spawning season (Cooke and Leach, 2004c). The population in the Cape Fear River is thought to be less than 50 fish (Moser and Ross 1995). Some of these population estimates should be viewed with caution as sampling biases may have violated the assumptions of the abundance models, effort may be limited therefore biasing data, or sampling periodicity may have been inadequate (NMFS 1998).

Albemarle Sound/Roanoke and Chowan Rivers
A historic record of a shortnose sturgeon in this area, confirmed by a museum specimen, was from Salmon Creek in the lower Chowan River, April, 1881 (USNM 64330, Vladykov and Greeley, 1963). More recently, an individual was caught in the north Batchelor Bay portion of Albemarle Sound (i.e., ca. mouth of Roanoke River) on 18 April 1998. It died in a net, was brought to the North Carolina Museum of Natural Sciences by Jim Armstrong of United States Fish and Wildlife Service, and is vouchered at the museum (NCSM 27062, Wayne Starnes, North Carolina Museum of Natural Sciences, personal communication). Additionally, an unconfirmed record from Oregon Inlet (Holland and Yelverton 1973) was also reported in Gruchy and Parker (1980), Dadswell et al. (1984), and Gilbert (1989).

Pamlico Sound/Pamlico and Neuse River
Yarrow (1877) reported that shortnose sturgeon were abundant in the North, New, and Neuse Rivers, but these records are doubtful due to their apparent basis in hearsay (Ross et al. 1988). Shortnose sturgeon were also reported from the Beaufort (Jordan 1886) and Neuse Rivers by Fowler (1945). Nearshore records of shortnose sturgeon in this area (Holland and Yelverton 1973) may be misidentifications (Ross et al. 1988). There are two recent reports of sturgeon from the Pamlico Sound identified by commercial fishery observers that were allegedly shortnose, but no photographs or tissue were taken for confirmation by professional fishery biologists or geneticists (Wilson Laney, USFWS, personal communication).

Cape Fear River
Since the first confirmed capture of shortnose sturgeon in the Cape Fear River (January 1987, Ross et al. 1988), an extensive sampling program has produced eight additional specimens (Moser and Ross 1993). All nine specimens captured were adults; no juveniles were collected. The river is dammed in the coastal plain, a short distance upstream of Wilmington, North Carolina. The river channel near the coast is channelized and heavy industries exist near the port. At least two additional records have been reported from fishermen (Fritz Rohde, North Carolina Division of Marine Fisheries, personal communication).

Winyah Bay Drainages
Shortnose sturgeon were documented in the Winyah Bay system during the late 1970's and early 1980's (Dadswell et al. 1984). Fed by the Waccamaw, Pee Dee, and Black Rivers, this coastal plain watershed produced over 100 collections of juveniles and adults during the study period. Within North Carolina, a vouchered specimen was collected from the North Carolina portion of the Pee Dee River in 1984 (Wayne Starnes, North Carolina Museum of Natural Sciences, personal communication), most likely the same individual that was collected below Blewett Falls Dam (Mark Collins, SCDNR-MRD, personal communication). In South Carolina, shortnose sturgeon have been located in the Waccamaw River, although it is possible that they were seasonal migrants from the Pee Dee River. Shortnose sturgeon from the Winyah Bay/Pee Dee River population are able to migrate upstream to the base of Lake Waccamaw (within North Carolina) if so inclined; however, there are currently no evidence/data to support the existence of

a separate Waccamaw River shortnose sturgeon population. Shortnose sturgeon spawning has been verified in the Pee Dee River, South Carolina via egg collection (Mark Collins, SCDNR-MRD, personal communication).

Santee River

Seven shortnose sturgeon were recorded from the Santee River drainage in 1978, and one fish was captured in a gillnet in 1992 (Collins and Smith 1997). In addition, 20 specimens were recovered from a fishkill in the Lower Rediversion Canal, St. Stephen Dam tailrace that occurred during a low dissolved oxygen event below the dam. During the period from 1979-1991, shortnose sturgeon were also recorded from Lake Marion, and in the Congaree and Wateree rivers above the dam (Collins and Smith 1997). These fish may represent an essentially landlocked population (Collins et al. 2003). However, during a very high water year, 15 of 16 (94%) Cooper River adult transmittered shortnose sturgeon that were released in Lake Moultrie were able to exit the Santee-Cooper Lakes (Lakes) (1 possible mortality within the Lakes), primarily to the Santee River, although one individual appears to have exited through the lock at Pinopolis Dam on the Cooper River. At least 14 of the 15 (93%) shortnose sturgeon that exited the Lakes are thought to have survived downstream passage (Cooke and Leach 2004b, Cooke and Leach 2004d). Of the 13 shortnose sturgeon that successfully survived downstream passage specifically into the Santee River, all appear to have exited the Santee River system. Eight were relocated in the Winyah Bay system, two in the Cooper River, two in the Intracoastal Waterway, and one disappeared altogether. This behavior appears to be similar to four shortnose sturgeon that were implanted with transmitters in the Santee River. Albeit a small sample size, one was relocated in the Savannah River, the other seemed to disappear from the Santee River only to reappear approximately a year and a half later, and two disappeared altogether (Cooke and Leach 2004d).

Cooper River

Shortnose sturgeon were documented in what is now the metro Charleston area during the late 1800's (Jordan and Evermann 1896). Shortnose sturgeon were collected in this heavily altered (dammed and urbanized) drainage in the 1980's during research on the American shad (*Alosa sapidissima*) fishery. A functionally landlocked segment may exist in Lake Marion (Collins et al. 2003) above the dam that blocks the system in the lower coastal plain (Pinopolis Dam). However, during a very high water year, 15 of 16 (94%) Cooper River adult transmittered shortnose sturgeon that were released in Lake Moultrie were able to exit the Santee-Cooper Lakes (1 possible mortality within the Lakes), primarily to the Santee River, although one individual appears to have exited through the lock at Pinopolis Dam on the Cooper River. At least 14 of the 15 (93%) shortnose sturgeon that exited the Lakes are thought to have survived downstream passage (Cooke and Leach 2004b, Cooke and Leach 2004d). 14 of 15 (93%) Cooper River adult transmittered shortnose sturgeon that were placed in Pinopolis Lock did not pass upstream into the Santee-Cooper Lakes (Lakes), indicating that upstream passage in the Cooper River into the Lakes is extremely limited (Cooke and Leach 2004b). Below Pinopolis Dam, the lowermost dam on the Cooper River, eleven sturgeon were taken in gillnets in the tailrace in February 1995 (Collins et al. 1996). Cooke and Leach (1999) found that shortnose sturgeon congregate and spawn below Pinopolis Dam. Successful egg fertilization and development is occurring, but only one newly hatched yolk sac larva and no juveniles have been documented (Duncan et al. 2004).). Analysis of data for 1996, 1997, and 1998 resulted in estimates of 87 (95% CL 56-170), 193 (95% CL 123-319), and 301 (95% CL 150-659) adult fish, respectively residing in the Pinopolis Dam tailrace area during the spawning season (Cooke and Leach 2004c). Limited gillnet sampling in 2003 in the spawning area resulted in 8 of the 12 adults (67%) as recaptured fish from previous years (Cooke and Leach 2004a).

Ashepoo, Combahee and Edisto Rivers (The "ACE" Basin)

The Ashepoo, Combahee, and Edisto drainages form one of the most pristine coastal plain watersheds in the southeastern United States. Shortnose sturgeon were incidentally collected during American shad studies in the Ashepoo and Edisto Rivers in the 1970's and early 1980's (Collins and Smith 1997). Ripe adults, as well as YOY/age-1 fish, have been more recently collected by the South Carolina Department of Natural Resources-Marine Resources Division (SCDNR-MRD) from the Edisto River. It is possible that these are actually Savannah River fish that were stocked into the Savannah River and then strayed to colonize the Edisto River (Mark Collins, SCDNR-MRD, personal communication).

Savannah River

The Savannah River is a heavily industrialized and channelized drainage that forms the South Carolina/Georgia border. The river is dammed, but not below the fall line. Shortnose sturgeon were first documented in the system in the mid-1970's (Dadswell et al. 1984). During 1984-1992, over 600 adults were collected by shad fishermen and researchers using gillnets and trammel nets (Collins and Smith 1993). The ratio of adults to juveniles in this study was very high, indicating that recruitment is low in this river (Smith et al. 1992). Adult population estimates were calculated using Jolly Seber (96-1075) and Schnabel (1676) techniques, but were deemed unreliable as not all basic assumptions were met (M. Collins, South Carolina Department of Natural Resources, personal communication). During 1984-1992, approximately 97,000 shortnose sturgeon (19% tagged) of various sizes were stocked in the Savannah River to evaluate the potential for shortnose sturgeon stock enhancement (Smith and Jenkins 1991). Subsequent investigation showed that stocked fish were at large for an average of 416 days and comprised 41% of all juvenile sturgeon collected (Smith et al. 1995). It is thought that the Savannah River population and the Altamaha River population are the two largest populations in the Southeast (Wirgin et al. 2006).

Ogeechee River

The Ogeechee is primarily a coastal plain drainage with 5% of its watershed in the piedmont. The river is undammed, but water quality has changed (eutrophied) during the last 30 years (Weber 1996). Shortnose sturgeon were first documented in the system during the early 1970's (Dadswell et al. 1984). A survey of shortnose sturgeon occurrence, distribution, and abundance, including a 1994-1995 mark/recapture experiment, was conducted from 1993 to 1995 and then from 1999 to 2004 in the tidal portion of the drainage (Rogers and Weber 1994; Weber 1996). The size distribution of shortnose sturgeon sampled indicated that, as in the Cape Fear and Savannah Rivers, the Ogeechee population is dominated by adults. Mark/recapture analysis indicated that abundance is low and possibly declining in the Ogeechee system; the highest point estimate yielded less than 400 individuals from all age classes in 1993 (Weber 1996) and less than 200 individuals from all age classes in 2000 (Fleming et al. 2003). Size frequency, abundance, and catch rate data indicate that natural recruitment does occur in the Ogeechee River system but shortnose sturgeon may be experiencing higher juvenile mortality rates in this system than in the Altamaha (below), with evidence of total recruitment failure in some years. A portion of the shortnose sturgeon that were stocked in the Savannah system have migrated to the Ogeechee River and have contributed substantially to some year-classes in this system (Fleming et al. 2003). Coalescence-based migration estimates suggest that populations south of the Pee Dee River exchange between 1-9.8 individuals per generation, with the highest rate occurring between the Ogeechee and the Altamaha Rivers (Wirgin et al. 2005).

Altamaha River

The Altamaha River system drains the largest watershed east of the Mississippi River and comprises the confluence of the Ocmulgee and Oconee Rivers plus additional, smaller piedmont and coastal plain drainages. The system is moderately industrialized including two kraft process paper mills and a nuclear generating plant. The watershed landscape has been heavily altered by urbanization, suburban development, agriculture, and silviculture. The system is also dammed, but not below the fall line. Shortnose sturgeon were first documented in the Altamaha in the early 1970's (Dadswell et al. 1984), and, later, in a cursory study of spawning movements conducted in the late 1970's (Heidt and Gilbert 1979).

A two-year study of population structure and dynamics was conducted during the early 1990's (Flournoy et al. 1992), building on three additional years of survey data from the late 1980's (B. T-A.Woodward, Georgia Department of Natural Resources, unpublished data). Over 650 individuals were collected during the five years of study, with samples heavily dominated by juveniles (90%). Subsequent analysis of tag/recapture data indicated that, during the two-year study period in the 1990's, abundance did not exceed 6,055 individuals for all size and age classes. However, under the more rigorous constraints imposed by the assumptions of the recapture model and (probably) met under the conditions experienced during the summer of 1990, the point estimate is 798 individuals with a 95% confidence interval (CI) of 645-1,045 fish. The next time that those conditions were met (during the late summer of 1993), a similar 95% CI of 316-903 individuals was generated with a point estimate of 468 fish. An estimate generated from 1988 data, which met the same criteria, yielded 2,862 fish (95% CI 1,069-4,226). A more recent study conducted in the Altamaha system from 2004-2006 resulted in a Schnabel population estimate of 6048 (95% CI=4526-9110) (Peterson unpublished data). Based on these data, the Altamaha population segment is likely the largest and most viable one south of Cape Hatteras, NC (Joel Fleming, GDNR, personal communication). Similarly, Wirgin et al. (2006) suggested that the Savannah River population and the Altamaha River population are the two largest populations in the Southeast (Wirgin et al. 2006).

Satilla and St. Marys

The Satilla and St. Marys Rivers are relatively small coastal plain drainages emptying into the Atlantic Ocean between the Altamaha River, GA and St. Johns River, FL. There are no dams and few human impacts beyond agriculture and timber management along the Satilla system. The St. Marys system (draining the eastern portion of the Okefenokee Swamp and forming a portion of the GA/FL border) is likewise undammed, but is heavily channelized in its estuary to support a small port and military installation. The estuary also receives effluents from three major forest product plants. Collections of shortnose sturgeon were made in the estuaries of both systems during the late 1980's and early 1990's during crustacean monitoring (G. Rogers, Georgia Department of Natural Resources, personal communication). Surveys for sturgeon in the St. Marys (1994 and 1995, 117 net hours) and in the Satilla (1995, 74 net hours) failed to yield any shortnose sturgeon (Rogers and Weber 1995b).

St. Johns River

The St. Johns River in FL is a heavily altered system flowing northward from the east-central portion of the state and emptying into the Atlantic Ocean near Jacksonville, FL. The system is dammed by Rodman Dam in the headwaters (although currently scheduled for removal), heavily industrialized and channelized near the sea, and affected by urbanization, suburban development, agriculture, and silviculture throughout portions of the basin. Shortnose sturgeon have been reported from the system since 1949 (Kilby et al. 1959). Five shortnose sturgeon were collected in the St. Johns in the late 1970's (Dadswell et al. 1984) and, in 1981, three sturgeon were collected and released by the Florida Game and Freshwater Fish Commission. A shortnose sturgeon tagged in Georgia by Georgia Department of Natural Resources near St. Simons Island in March 1996 was captured from the St. Johns River in August 2000 (Jay Holder, FLFWC, personal communication).

Most recently, a shortnose sturgeon was collected by Florida Fish and Wildlife Commission personnel in 2002 on the south side of Federal Point near Palatka, Florida during a 2002-2003 study to determine presence/absence of shortnose sturgeon in the St. Johns River. This single shortnose sturgeon was collected in 4,493 hours of 100-m gillnet sets. Preliminary analysis by Joe Quattro at the University of South Carolina indicated that the sample was genetically similar to other shortnose sturgeon populations found in the southern United States (FLFWC 2005). Historically, few shortnose sturgeon in the St. John's River have been positively identified by biologists and commercial landings were relatively low compared to other southern states. However, there have been several verified incidental captures off the coast of Daytona Beach (Allan Brown, United States Fish and Wildlife Service, personal communication). No sturgeon reproduction has ever been documented in the St. Johns River and the spawning habitat that is currently accessible seems to be marginal (FLFWC 2005).

Ecological relationships

Feeding

Shortnose sturgeon are benthic omnivores but have also been observed feeding off plant surfaces (Dadswell et al. 1984). Based on the high incidence of non-food items in juvenile shortnose sturgeon, Dadswell et al. (1984) concluded that juveniles randomly vacuum the bottom while adults are more selective feeders. Dadswell (1979) determined that adult shortnose sturgeon in the Saint John River, Canada are not opportunists and only switch to other prey when preferred food are unavailable. The presence of food in the gut during all times of day indicated that shortnose sturgeon are continuous feeders (Dadswell 1979).

Shortnose sturgeon feed on crustaceans, insect larvae, worms, and mollusks; however, they apparently undergo ontogenetic shifts in preferred foods. Insect larvae (*Hexagenia* sp., *Chaoborus* sp., *Chironomous* sp.) and small crustaceans (*Gammarus* sp., *Asellus* sp., *Cyathura polita*) predominate in the diet of juveniles (Dadswell et al. 1984; Carlson and Simpson 1987) while adults feed primarily on small mollusks (Dadswell 1984; Hastings 1983). Molluscs ingested by adults captured in freshwater include *Physa* sp., *Heliosoma* sp., *Corbicula* *manilensis*, *Amnicola limnosa*, *Valvata* sp., *Pisidium* sp., and small *Elliptio complanata* (Dadswell et al. 1984). In saline areas molluscan prey include small *Mya arenaria*, and *Macoma balthica* (Dadswell 1979).

Probable foraging activity in southern rivers has been described at the saltwater/freshwater interface during fall and winter in the Pee Dee and Savannah rivers (Dadswell et al. 1984; Hall et al. 1991) and just downstream of the saltwater/freshwater interface in the Altamaha and Ogeechee rivers (Rogers and Weber 1995a; Weber 1996). During summer, shortnose sturgeon in these southern systems appear to reduce activity, fast, and lose weight (Dadswell et al. 1984; Rogers et al. 1994).

Predators, Parasites, and Diseases

There is very little documentation of predation on any life stage of shortnose sturgeon. Young-of-the-year shortnose sturgeon (approximately 5 cm FL) were found in the stomachs of yellow perch (*Perca flavescens*) in the Androscoggin River, Maine (Dadswell et al. 1984). It is likely that sharks and seals may occasionally prey on shortnose sturgeon based on the occasional specimen lacking a tail (Dadswell et al. 1984).

Parasites recorded from shortnose sturgeon (all data from northern populations) include Coelenterata (*Polypodium* sp.), Platyhelminthes (*Diclybothrium armatum*, *Spirochis* sp., *Nitzschia sturionis*), Nematoda (*Capillospirura pseudoargumentosus*), Acanthocephala (*Fessesentis friedi*, *Echinorhynchus attenuatus*), Hirudinea (*Calliobdella vivida*, *Piscicola milneri*, *Piscicola punctata*), Arthropoda (*Argulus alosa*), and Pisces (*Petromyzon marinus*). The degree of infestation has been reported as being quite low with the exception of *Capillospirura* sp. (Dadswell et al. 1984). Sturgeon do not appear to be harmed by these parasites. There have been no reported incidences of disease for shortnose sturgeon in the wild, although an epizootic of *Columnaris* sp. occurred at the FWS' Orangeburg Hatchery in South Carolina (Willie Booker, FWS, South Carolina, personal communication).

Listing designations

4.3.5 Marine Plants

(material from the 2002 Recovery Team Status Review)

Description and distribution

Description

After many years of confusion over identification, Johnson's seagrass (*Halophila johnsonii*) was formally proposed as a separate species by Eiseman and McMillan (1980). *Halophila johnsonii* was previously referred to either as *H. decipiens* or *H. baillonis* Ascherson, but it most closely resembles *H. ovalis* (R. Brown) Hooker f., an Indo-Pacific species, both morphologically and genetically (McMillan and Williams 1980). Plant classification schemes based on anatomical (den Hartog 1970) and molecular phylogenetic (Les et al. 1997) methods both place the seagrass genus *Halophila* in the angiosperm family Hydrocharitaceae, along with two other seagrass genera, *Thalassia* and *Enhalus*. Morphologically, Johnson's seagrass is recognized by the presence of pairs of linearly shaped foliage leaves, each with a petiole formed on the node of a horizontally creeping rhizome (Figure 4.3-2)(NMFS 2001).

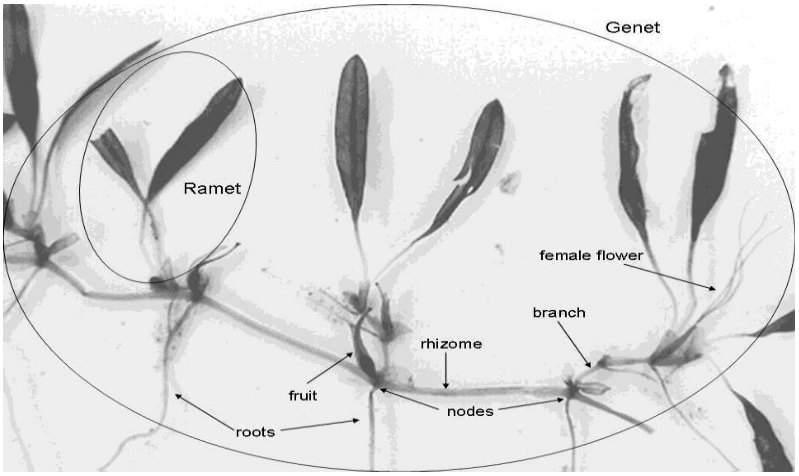
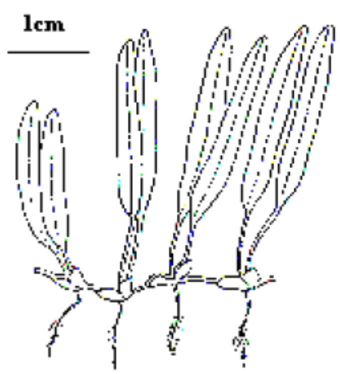
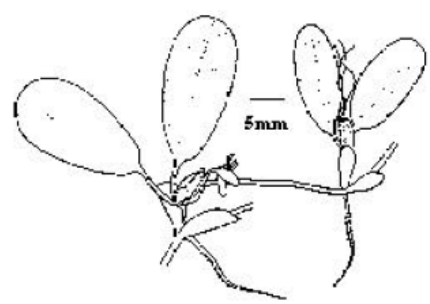


Figure 4.3-2. Photograph of *Halophila johnsonii* showing the genet and individual ramets, the rhizome, a female flower, fruit, nodes, and lateral branching of rhizome

The rhizome is located at or just below the sediment surface and is anchored to unconsolidated substrate by unbranched roots. The leaves are generally 2-5 cm long (including the petioles), and the rhizome internodes rarely exceed 3-5 cm in length, making this species appear diminutive relative to the larger seagrasses. *Halophila johnsonii* differs from *H. decipiens* in a number of morphological, reproductive, and genetic characteristics (Table 4.3-5). The diagnostic characteristics of *H. johnsonii* remain relatively unchanged when plants are cultured in artificial conditions; thus, differences between the two species are not due to phenoplasticity (NMFS 2001).

Table 4.3-5. Morphological, reproductive, and genetic characteristics of *H. johnsonii* and *H. decipiens.* Illustrations adapted from Phillips and Menez, 1988.

H. johnsonii	***H. decipiens***
Linear leaves with entire (smooth) margins.	Oblong-elliptical leaves with serrate margins.
No hairs on blade surface.	Unicellular prickle hairs on both surfaces (unique to *H. decipiens*).
Leaf cross veins diverge at ca. 45° angles.	Leaf cross veins at ca. 60° angles.
Only pistillate (female) flowers are known so it is possibly dioecious (male and female plants) or apomictic (produces seeds without pollination or meiosis so seeds are clones of female parent).	Monoecious (both sexes on one plant).
Populations of *H. johnsonii* collected in the Indian River Lagoon (IRL) differed from *H. decipiens* in five isozymes of the seven isozyme systems tested, with major differences in three of the enzymes (Jewett-Smith et al. 1997).	See box at left.
	

Distribution

Johnson's seagrass is found only in southeastern Florida from near Sebastian Inlet (27.85°, -80.45°) to Virginia Key (27.74°, -80.14°) (Figure 4.3-3). Recently, however, the St. Johns River Water Management District (SJRWMD) observed *H. johnsonii* 3 km north of the Sebastian River mouth on the western shore of the lagoon (27.88°, -80.50°) – a discovery that slightly extends the species known northern range. Where it does occur, its distribution is patchy, both spatially and temporally (Virnstein and Morris 2007).

Halophila johnsonii is a perennial species showing no consistent seasonal or year-to-year pattern in surveys of the Indian River Lagoon (IRL). Although perennial, it exhibited some winter decline. However, during exceptionally mild winters, as in the winter of 2004, *H. johnsonii* can maintain or even increase its abundance from summer to winter (Virnstein et al. 1997, Virnstein and Morris 2007).

Depth of occurrence ranged from 0.03 to 2.5 m within transects monitored in the IRL (Virnstein et al. 1997, Virnstein and Morris 2007). When data from all transects were combined, there was no correlation of *H. johnsonii* abundance with depth. However, the deep edge at some transects was only 0.1 m; at other transects, it was 2.5 m. When all depths of occurrence were standardized (as percent of maximum depth of a transect), *H. johnsonii* was more abundant in the deeper parts of the transects. Most (78% or 574 out of 733) occurrences of *H. johnsonii* were at >70% of maximum transect depth; half were at >90% of maximum depth (Virnstein et al. 1997, Virnstein and Morris 2007).

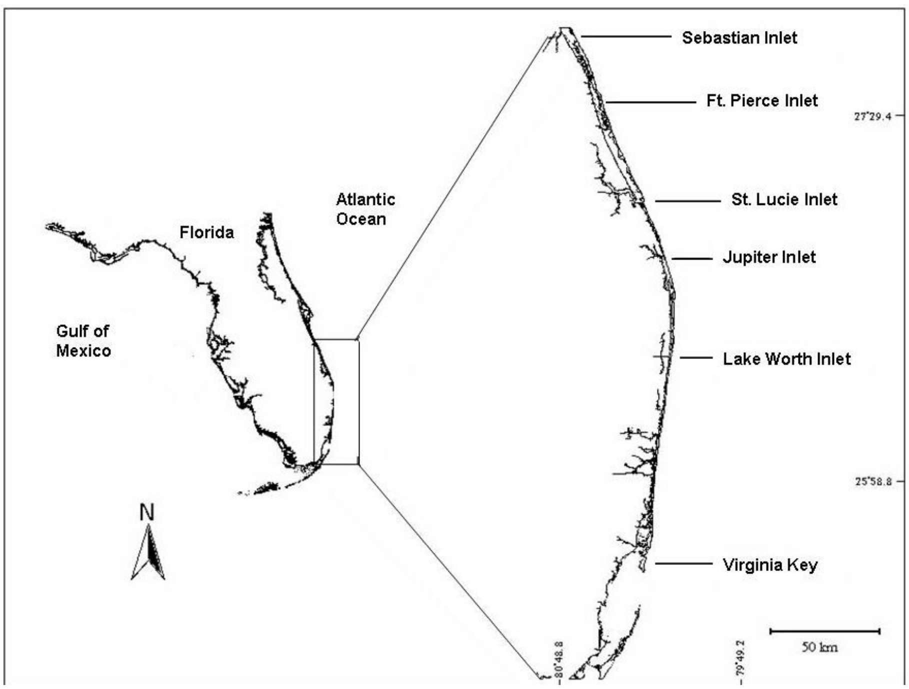


Figure 4.3-3. Geographic range of *Halophila johnsonii*: Sebastian Inlet to northern Virginia Key (Kenworthy 1997).

Observations of its distribution and the results of limited experimental work suggest that *H. johnsonii* has a wider tolerance range for salinity, temperature, and optical water quality conditions than *H. decipiens* (Dawes et al. 1989; Gallegos and Kenworthy 1996; Durako et al. 2003; Kunzelman et al. 2005; Torquemada et al. 2005). *Halophila johnsonii* has been observed growing perennially near the mouths of freshwater discharge canals (Gallegos and Kenworthy 1996), in deeper turbid waters of the interior portion of the Indian River Lagoon (Kenworthy 2000; Virnstein and Morris 2007), and in clear water associated with the high energy environments and flood deltas inside ocean inlets (Kenworthy 1993, 1997; Virnstein et al. 1997; Heidelbaugh et al. 2000; Virnstein and Morris 2007).

While *H. johnsonii* is negatively affected by both extreme hypo- and hyper-salinity conditions, it does tolerate hypersaline conditions better than hyposaline conditions. Most other seagrasses, conversely, are thought to be more sensitive to increased salinity (Ogata and Matsui 1965; Biebl and McRoy 1971; Zieman 1975; Adams and Bate 1994; Doering and Chamberlain 1998). Torquemada et al. (2005) and Dawes et al. (1989) concluded that *H. johnsonii* could be seriously affected by salinity variations produced by human activities, such as freshwater discharges through water management practices or brine discharges from seawater desalination plants. Interestingly, salinity changes do not seem to alter the tolerance of this species to other environmental factors, such as temperature or pH (Torquemada et al. 2005).

Reproduction

Like all other seagrasses, *H. johnsonii* is clonal, which refers to plants that have many semi-independent units (ramets) acting together as a single organism (Cook 1983). Reproduction is achieved primarily by asexual means. While all other species of seagrass reproduce sexually, there is still no evidence of sexual reproduction in *H. johnsonii*. All attempts to find seeds and seedlings have failed to detect any evidence of their occurrence (Jewitt-Smith et al. 1997; Hammerstom and Kenworthy 2003). Likewise, despite widespread sampling and surveys throughout the entire range of the species, no male flowers have ever been reported and confirmed. Female flowers, however, have been documented in both culture and nature (Eiseman and McMillan 1980; Heidelbaugh et al. 2000). They are common and often very abundant (Heidelbaugh et al. 2000). They have been observed throughout the entire range of the species during all times of the year, but no consistent patterns of spatial or temporal distribution have been observed or reported.

Although male flowers have never been observed, it is not possible to completely rule out their existence and the potential for sexual reproduction. They may occur cryptically in isolation or in the vicinity of females. They may be extremely rare, or they may express themselves only at night, as was the case in a related species, *Halophila hawaiiana* (Herbert 1986).

While sexual reproduction of *H. johnsonii* remains somewhat of a mystery, reproduction by asexual means and clonal growth is well understood. Asexual reproduction occurs when rhizome apical meristems divide and form new leaf pairs, flowers, or rhizome apices (Posluszny and Tomlinson 1990) (Figure 4.3-2). The divisions and subsequent differentiation of meristems (meristem dependence) into the various attributes of the ramets are the foundation of growth and productivity in all seagrasses (Tomlinson 1974). *Halophila johnsonii* grows by division of apical meristems on horizontal rhizomes which branch, forming leaf pairs, female flowers and new lateral branches (Figure 4.3-4). On average, new meristems are formed on rhizomes every 2 to 4 days (Kenworthy 1997, Bolen 1997) and meristem densities can reach hundreds to thousands per square meter (Kenworthy 1997, Heidelbaugh et al. 2000).

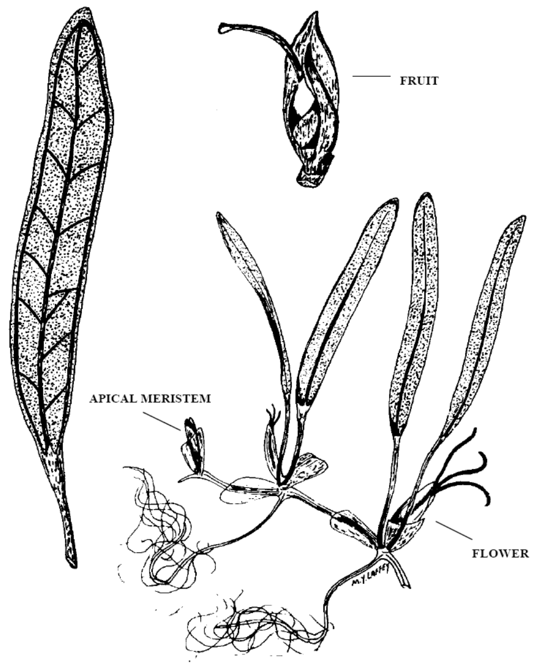


Figure 4.3-4. Johnson's seagrass, *Halophila johnsonii*. Leaves are generally 2-5 cm long. Adapted from Eiseman and McMillan (1980).

Development and growth

The species spreads as clones expand in local space by rhizome extension and leaf pair formation, eventually forming high density "patches." Rhizomes can elongate at rates approaching 0.5 cm per day (Bolen 1997, Kenworthy 1997), and when combined with prolific branching, individual patches (clones) can expand at extraordinary rates, ranging from 0.3 to 1.0 m^{-2} per month (Kenworthy 1997, 2003; Greening and Holland 2003). This expansion can lead to coalescence of adjacent patches and the formation of larger meadows. Widely spaced patches, usually on the order of 1-20 square meters in size, are the most commonly encountered feature of *H. johnsonii* meadows (Virnstein et al. 1997, Kenworthy 1997, 2000; Virnstein and Morris 2007; Kenworthy 2003). Although it is more commonly found in monotypic patches, *H. johnsonii* can also grow among low to moderate densities of *Halodule wrightii* and *Syringodium filiforme*, and in deeper water mixed with *H. decipiens* (Kenworthy 1993, 1997, 2000; Virnstein et al. 1997, Virnstein and Morris 2007).

Patches can also disappear rapidly. Sometimes they will disappear for several years and then re-establish: a process referred to as "pulsating patches" (Heidelbaugh et al. 2000, Virnstein and Morris 2007). Mortality, or the disappearance of patches, can be caused by a number of processes, including burial from bioturbation and sediment deposition, erosion, herbivory, desiccation, and turbidity. *Halophila johnsonii*'s canopy is only 2-5 cm tall and may be easily covered by sediments transported during storms or redistributed by macrofaunal bioturbation during the feeding activities of benthic organisms (Heidelbaugh et al. 2000).

In the absence of sexual reproduction, one possible explanation for the pulsating patches is dispersal and re-establishment of vegetative fragments, a process which commonly occurs in aquatic plants and has been demonstrated in other seagrasses (DiCarlo et al.; 2005). While *H. johnsonii* is vulnerable to uprooting by wind waves, storm events, tidal currents, bioturbation, and motor vessels, these are also mechanisms capable of disturbing patches and creating clonal fragments for dispersal. Hall et al. (2006) showed that drifting fragments of *H. johnsonii* can remain viable for 4 to 8 days, after which time they can settle, root, and grow.

Ecological relationships

Seagrasses have recently received increasing attention from scientists and managers because of the valuable functional roles they play in coastal ecosystems (Costanza et al. 1997; Larkum et al. 2006). Seagrass beds are one of the primary nursery habitats because of their abundance of prey items as well as the protection they provide from predators (Zieman and Zieman 1989; Heck et al. 2003). Other functions associated with seagrasses include nutrient recycling, detrital production and export, and sediment stabilization. Very little work has been done on the functional value of *H. johnsonii*, therefore, the functional roles of its closest relative, *H. ovalis*, and other *Halophila* spp. are used a proxy in this discussion.

The most well-known function of seagrasses is their role as habitat for numerous fishes and invertebrates. Some species spend their entire lives within seagrass beds and others utilize it only during certain stages of their life cycle (usually the postlarval and juvenile stages). Heidelbaugh (1999) conducted one of the only studies that examined benthic fauna associated with *H. johnsonii*. In this study, differences in benthic fauna among *H. johnsonii*, *H. wrightii*, and bare sand were compared on the flood tidal delta just inside Sebastian Inlet, Fl. *Halophila johnsonii* beds yielded a total of 126 species (69 epifauna and 57 infauna), while 117 species were collected from *H. wrightii* beds and 99 species from bare sand. The most abundant infaunal organisms belonged to Nematoda while the most abundant epifaunal species were amphipods and tanaids. The majority of macrofaunal organisms consisted of decapod crustaceans (*Callinectes sapidus*), fishes (*Eucinostomus* sp.), and some gastropods (especially *Bursatella leachii*). Three hundred and twenty macrofaunal organisms were collected from *H. johnsonii* beds compared to 690 from *H. wrightii* beds and 78 from bare sand.

Rapid growth, high turnover rates, and labile tissues make *Halophila* spp. a good source of nutrition for several marine herbivores (Kenworthy et al. 1989, Lanyon 1991, Preen 1995, Bolen 1997). The Florida manatee (*Trichechus manatus latirostris*) has been observed grazing on *H. johnsonii* near a power plant in Palm Beach, Florida (J. Reid, Sirennia Project, U.S.G.S., Gainesville, FL, personal observation). Green turtles (*Chelonia mydas*) are known to eat several species of *Halophila* (Hasbun et al. 2000; Kannan and Rajagopalan 2004; Russell et al. 2003; Whiting and Miller 1998). *Halophila* species also provides nutrition for herbivorous fish. Through consumption, the stareye parrotfish (*Calotomus carolinus*) has the ability to control the abundance and distribution of short lived seagrass species such as *H. stipulacea* in Kenya (Mariani and Alcoverro 1999). Even invertebrates such as the queen conch (*Strombus gigas*) (Thayer et al. 1984) and various species of harpacticoid copepods (Shimode and Shirayama 2006) have been observed feeding on *Halophila* species.

Seagrasses play an important role in nutrient cycling within systems and can act as both a source and sink for nutrients. Processes that lead to a loss of nutrients from the system include: exudation/leaching from living and dead plant material, export of sloughed leaves and leaf fragments, nutrient transfer by foraging animals, denitrification, and diffusion from sediment. Processes that result in an increase of nutrients include: nitrogen-fixation, sedimentation, and nutrient uptake by leaves. It is the fluctuation of these processes that leads to interannual variations in net losses or net gains of nutrients, and therefore, fluctuations in the productivity of seagrass meadows (Hemminga et al., 1991).

Bacteria mediate the recycling of nutrients and may be important in regulating the flow of energy from seagrass detritus to consumer organisms (Robertson et al. 1982). Studies in the Salt River Submarine Canyon at St. Croix, US Virgin Islands show that *H. decipiens* is an important source of organic matter and detritus for the Canyon (Josselyn et al. 1983; Josselyn et al. 1986; Kenworthy et al. 1989). Despite its production being less than other seagrasses, *H. decipiens* has a fast turnover time and is a major source of primary production on the floor of the Canyon (Kenworthy et al. 1989). Disturbance and burial of plant material are important mechanisms influencing the disposition of organic matter (Williams et al. 1985; Josselyn et al. 1986). Burial of *H. decipiens* through wave action and animal activities increases the rate of detrital input and retains the detritus within the Canyon (Kenworthy et al. 1989).

Seagrasses have long been recognized for their ability to stabilize sediments. It was once assumed, however, that due to its small size and sparse biomass, *Halophila* spp. were not capable of stabilization (den Hartog 1970). Fonseca (1989) proved this assumption incorrect using a surface-supplied, inverted seawater flume. He found the cumulative effect of *H. decipiens* in reducing sediment erosion was significantly greater than adjacent, unvegetated sand.

Abundance and status

Johnson's seagrass has only relatively recently been identified as a distinct species (Eiseman and McMillan 1980) and no historical information on the species' distribution is available. However, since 1994, the St. Johns River Water Management District has monitored 73 permanent transects in the Indian River Lagoon (IRL) in both summer (June-July) and winter (January-February) (Virnstein et al. 1997, Virnstein and Morris 2007). Despite extensive ground-truthing since 1986 and monitoring all 73 transects throughout the IRL beginning in the summer of 1994 (a total of about 25,000 quadrats), *H. johnsonii* has never been found more than 3 km north of the Sebastian Inlet area. Where it does occur, its distribution is patchy, both spatially and temporally.

Halophila jonsonii is a perennial plant with no strong seasonal pattern, although it generally exhibits some winter decline. Monitoring in the IRL indicates that there is spatial and temporal variation in the abundance of *H. johnsonii* patches (Virnstein et al. 1997). Although the monitoring data are limited, no large distributional gaps have been detected in the IRL, and there has been no overall increase or decrease in abundance or geographic range over the period from summer 1994 to summer 1999.

Halophila. johnsonii was listed as threatened under the Endangered Species Act on September 14, 1998 (63 FR 49035). NMFS concluded that Johnson's seagrass is rare, has a limited reproductive capacity, and is vulnerable to a number of anthropogenic and natural disturbances. It also exhibits the most limited geographic distribution of any seagrass. Within its small geographic range (lagoons on the east coast of Florida from Sebastian Inlet to central Biscayne Bay), it is one of the least abundant species. Because of its limited reproductive capacity and energy storage capacity, it is less likely to survive environmental perturbations and to be able to repopulate an area when lost. Finally, environmental degradation and habitat loss have continued despite existing federal and state conservation efforts. Completion of a report reviewing the current status of *H. johnsonii* is anticipated in the fall of 2007.

Critical Habitat

Ten areas in the geographic range of Johnson's seagrass were designated as critical habitat on April 5, 2000 (65 FR 17768). These areas and their approximate acreage include: a portion of the Indian River Lagoon, north of the Sebastian Inlet Channel (5.7); a portion of the Indian River Lagoon, south of the Sebastian Inlet Channel (2.0); a portion of the Indian River Lagoon near the Fort Pierce Inlet (4.3); a portion of the Indian River Lagoon, north of the St. Lucie Inlet (2770); a portion of Hobe Sound (900); a site on the south side of Jupiter Inlet (4.3); a site in central Lake Worth Lagoon (15.0); a site in Lake Worth Lagoon, Boynton Beach (95.5); a site in Lake Wyman, Boca Raton (20.0); and a portion of Biscayne Bay (18,757). This designated area accounts for approximately 22,574 acres or 9,139 hectares.

4.3.6 Marine Invertebrates

(all information below from *Acropora* Status review)

Description

All Atlantic *Acropora* spp. are considered to be environmentally sensitive, requiring relatively clear, well-circulated water (Jaap et al. 1989). Atlantic *Acropora* spp. are almost entirely dependent upon sunlight for nourishment compared to massive, boulder-shaped species in the region (Porter 1976; Lewis 1977), with these latter types of corals more dependent on zooplankton. Thus, Atlantic *Acropora* spp. are much more susceptible to increases in water turbidity than some other coral species. Dredging or pollution activities that reduce long-term water clarity can also reduce the coral photosynthetic to respiration ratio (P/R ratio) below unity. Therefore, *Acropora* spp. may not be able to compensate with an alternate food source, such as zooplankton and suspended particulate matter, like other corals.

Optimal water temperatures for *A. palmata* range from 25 to 29°C, although colonies in the U.S.V.I. have been known to tolerate short-term temperatures around 30°C without obvious bleaching (loss of zooxanthellae). Jaap (1979) and Roberts et al. (1982) note an upper temperature tolerance of 35.8°C for *A. palmata*. All Atlantic acroporids are susceptible to bleaching due to adverse environmental conditions (Ghiold and Smith 1990; Williams and Bunkley-Williams 1990). Major mortality of *A. palmata* and *A. cervicornis* occurred in the Dry Tortugas, Florida, in 1977 due to a winter cold front that depressed surface water temperatures to 14 to 16°C. Some reduction in growth rates of

A. cervicornis was reported in Florida when temperatures dropped to less than 26°C (Shinn 1966). All *Acropora* spp. require near oceanic salinities (34 to 37 ppt).

Staghorn Coral

Historically, *A. cervicornis* (Figure 4.3-5) was reported from depths ranging from <1 to 60 m (Goreau and Goreau 1973). It is believed that 60 m is an extreme situation and that the coral is relatively rare below 20 m depth. The common depth range is currently observed at 5 to 15 m. In southeastern Florida, this species historically occurred on the outer reef platform (16 to 20 m) (Goldberg 1973), on spur and groove bank reefs and transitional reefs (Jaap 1984; Wheaton and Jaap 1988), and on octocoral-dominated hardbottom (Davis 1982). In the Florida Keys *A. cervicornis* can occur from 1 to 34 m depths (Wells 1933; Davis 1982; Jaap 1984; Jaap and Wheaton 1988; Jaap et al. 1989). Colonies may also be common in back- and patch-reef habitats (Gilmore and Hall 1976; Cairns 1982).

Although *A. cervicornis* colonies are sometimes found interspersed among colonies of *A. palmata*, they are generally in more protected, deeper water or seaward of the *A. palmata* zone and hence, protected from waves. Historically, *A. cervicornis* was the primary constructor of mid-depth (10 to 15 m) reef terraces in the western Caribbean, including Jamaica, the Cayman Islands, Belize, and some reefs along the eastern Yucatan peninsula (Adey 1978).

Figure 4.3-5a. Staghorn coral, *Acropora cervicornis* (Source: Walt Jaap).

As depth increases, *A. cervicornis* colonies tend to be less compacted, have longer branches, and branching tends to be at greater intervals. Gladfelter (1982) demonstrated that infilling occurs as the branch elongates. Thus, at the tip, the porosity of the axial calyx is >90% and the wall is 60%, while at 60 cm from the tip, the porosity of the axial calyx is dead and the porosity of the wall is about 20%. This strengthens the branch as it elongates and the momentum of the branch increases. At depths of 20 to 40 m, where currents and wave force are minimal, branch diameter is thinner, being approximately half the diameter of a colony in the shallow surge zone. The porosity of the skeletons of *A. cervicornis* ranges from 35 to 65% by volume, with the mechanical strength of the skeleton proportional to the porosity (Schumacher and Plewka 1981). Because the skeleton is quite porous, it breaks readily in strong wave forces.

Elkhorn Coral
The maximum range in depth reported for *A. palmata* Figure 4.3-5b is <1 m to 30 m, but the optimal depth range for this coral is considered to be 1 to 5 m depth (Goreau and Wells 1967).

Figure 4.3-5b. Elkhorn coral, *Acropora palmata* (Source: W. Jaap).

Currently, the deepest known colonies of *A. palmata* occur at 21 m in the Flower Garden Banks National Marine Sanctuary (Hickerson, pers. comm.) and at Navassa National Wildlife Refuge (Miller, pers. comm.). The preferred habitat of *A. palmata* is the seaward face of a reef (turbulent shallow water), including the reef crest, and shallow spur and groove zone (Shinn 1963; Cairns 1982; Rogers et al. 1982). At low tide, colonies are sometimes exposed. Colonies of *A. palmata* often grow in nearly mono-specific, dense stands and form interlocking framework known as thickets in fringing and barrier reefs (Jaap 1984; Tomascik and Sander 1987; Wheaton and Jaap 1988). Storm-generated fragments are often found occupying back reef areas immediately landward of the reef flat/reef crest, while colonies are rare on lagoonal patch reefs (Dunne 1979). *Acropora palmata* formed extensive barrier-reef structures in Belize (Cairns 1982), the greater and lesser Corn Islands, Nicaragua (Gladfelter 1982; Lighty et al. 1982), and Roatan, Honduras, and built extensive fringing reef structures throughout much of the Caribbean (Adey 1978). Colonies generally do not form a thicket below 5 m depth, with maximum water depths of framework construction ranging from 3 m to 12 m (see Table 1 in Lighty et al. 1982).

Distribution and Abundance

When discussing historic distribution and abundance, it is important to briefly mention the environmental setting of the wider Caribbean region (tropical western Atlantic, Caribbean-

Atlantic province), insofar as environmental differences across the region influence the extent to which *Acropora* spp. have been able to build extensive reef structures. Specifically, although both *A. cervicornis* and *A. palmtata* are found throughout the Caribbean Sea, their historical abundance patterns are not necessarily similar and there is ample evidence to suggest that many reef systems were constructed without significant contributions by acroporids. Early reviews of western Atlantic reefs and coral species, as well as discussions of reef geomorphology in the western Atlantic, are provided elsewhere (e.g., Glynn 1973, Milliman 1973, Adey 1977; 1978), but provide context to the historical patterns of these corals.

The entire Caribbean-Atlantic province is characterized as microtidal and is impacted by largely unidirectional trade winds and waves subject, in part, to strong ocean flows. The most northern reefs in the province (i.e. Florida, northwestern Bahamas, and Bermuda) are cyclically stressed by the occasional effect of polar air during winter months and thus have limited reef development by *Acropora* spp. or lack these species altogether (Bermuda). Throughout the Caribbean, wave energy influences the degree to which crustose coralline algae and *Acropora* spp. dominate as reef-building elements (Adey 1977; Geister 1977). For example, large swells from the Atlantic Ocean limit acroporid reef development in the Windward Islands (eastern Caribbean) and the eastern flanks of the Bahamas (Roberts et al. 1992). In the Lesser Antilles, neither *A. cervicornis* nor *A. palmata* are significant agents of reef framework construction, due principally to higher wind strength, easterly consistencies, and longer fetch; this area is also subjected to longperiod swells or rollers during the winter months that further limits shallow and middepth reef construction (Adey 1977). In the southwestern Caribbean (e.g., Panama), reef terraces are present that are potentially conducive to acroporid-reef development, but seasonally rough seas batter the area resulting in wave-swept pavements (Glynn 1973).

In contrast, the northwestern Caribbean (e.g. Cuba, Cayman Islands, Jamaica, eastern Yucatan, Belize) is characterized by relatively low winds of medium to high easterly consistencies, that allows extensive acroporid growth at shallow and mid-depth (10 to 25 m). For example, the Belize Barrier Reef, the largest barrier reef in the province, appears to be based upon an *A. cervicornis* framework (Adey 1977).

The current range for both *A. cervicornis* and *A. palmata* remains unchanged from the historical (Figure 4.3-6) as far as data are available; there is a paucity of quantitative data for many locations throughout the wider Caribbean. Historically most data collected has been from a few specific reef sites that may or may not represent the regional condition of the acroporids or coral reefs in general. In contrast, there are many qualitative data/observations indicating drastic declines in abundance of both *A. palmata* and *A. cervicornis* throughout their geographic range (e.g., Aronson and Precht 2001a).

Figure 4.3-6. Approximate range of *Acropora* spp. (highlighted), including the Gulf of Mexico, Atlantic Ocean and Caribbean Sea. The highlighted areas are not specific locations of the corals, rather reflect general distribution.

Recently, there have been two publications that have summarized status (abundance and distribution) of *A. cervicornis* and *A. palmata*. The Status of Coral Reefs in the western Atlantic: Results of initial Surveys, Atlantic and Gulf Rapid Reef Assessment (AGRRA) Program (Lang 2003) provides results (1997–2004) of a regional systematic survey of corals, including *Acropora* spp., from many locations throughout the Caribbean. While data from this survey represent a snapshot in time of the reef, the geographic scope of the survey is great; targeted areas are visited by data collectors of varying expertise, and data represent a single survey. AGRRA data (1997-2004) indicate that the historic range of both species remains intact, that *A. cervicornis* is rarely found throughout the range (including areas of previously known occurrence) and a moderate occurrence of *A. palmata*.

An AGRRA bio-area index for *A. palmata* was recently developed to summarize data for nearly 300 sites throughout the wider Caribbean (Garza-Perez and Ginsburg pers. comm.). This bio-area index utilizes maximum diameter and partial mortality values of *A. palmata* colonies per site (total area of living tissue/10 transects) and is presented in Figures 4.3-7a and 4.3-7b. Results from the spatial analysis are as follows:

1. most (n=61) bio-areas (Figure 4.3-7a) ranked as moderate to high (100 to 500 m^2/10 transects) are concentrated in Andros Barrier Reef (Bahamas) and the northern Caribbean (Cuba and Belize);
2. 195 sites (Figure 4.3-7b) distributed throughout the geographic area were ranked as low bio-areas (from 0.01 to 100 m^2/10 transects)

3. standing dead colonies of *A. palmata* were found throughout the geographic range (Figure 4.3-7b).

It is important to note that the data for the Andros Barrier Reef AGRRA surveys were conducted prior to the Caribbean-wide 1998 coral die-off and the site has not been resurveyed since 1997. Furthermore, status of *A. palmata* has not been updated following the 2004 hurricane season where Hurricanes Charley passed over Cuba, and Hurricanes Frances and Jeanne passed over the Bahamas.

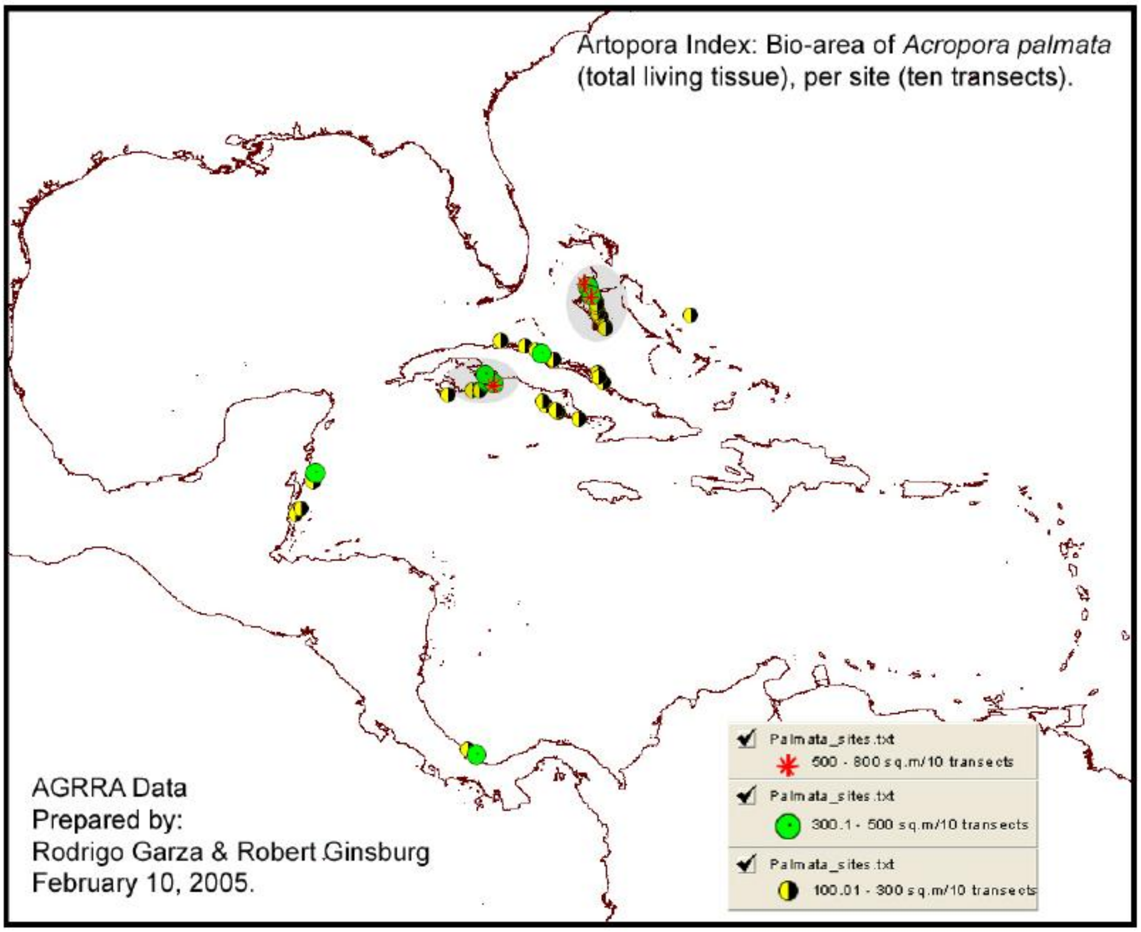


Figure 4.3-7a. Locations of reefs indexed with moderate or high (circles) *Acropora palmata* bio-area as reported from 1997- 2004 AGRRA surveys. Map provided courtesy Garza-Perez and Ginsburg.

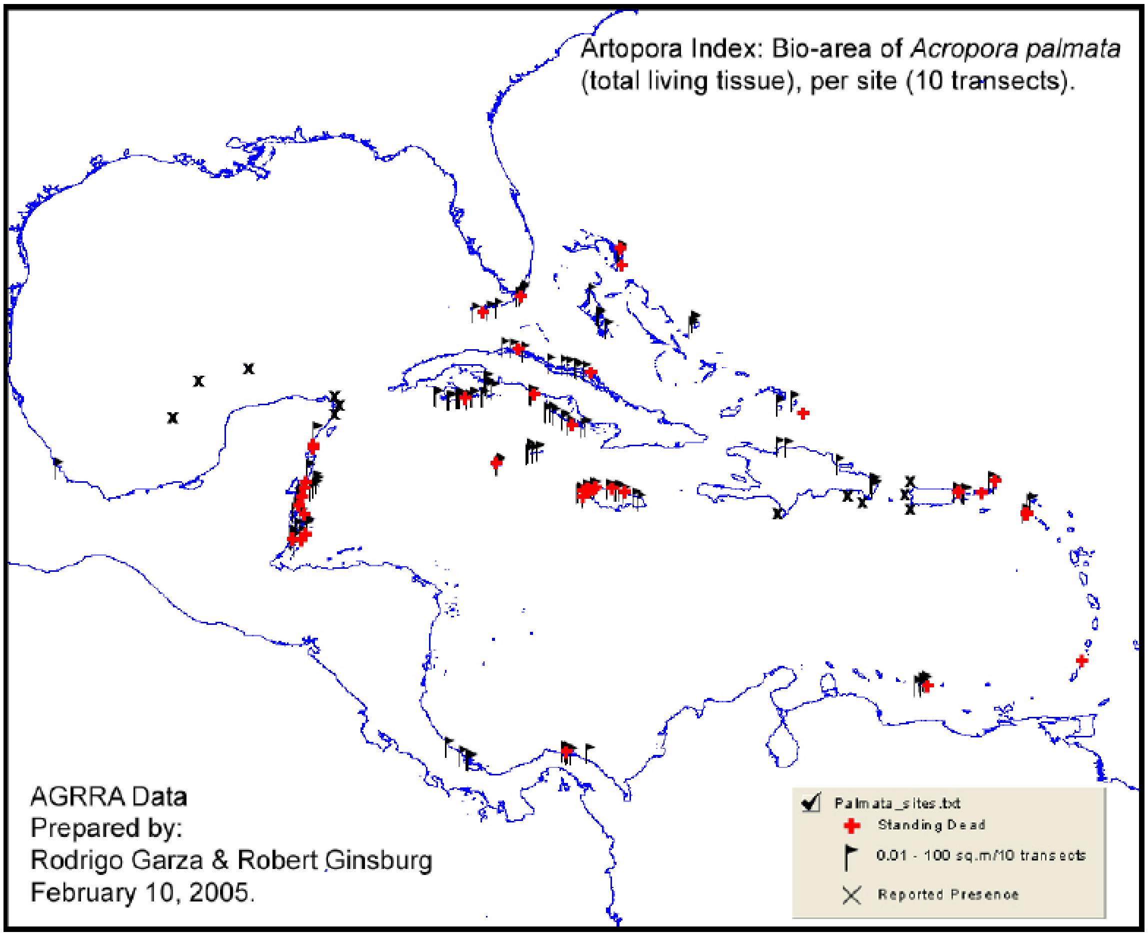


Figure 4.3-7b. Locations of reefs indexed with low (flag) *Acropora palmata* bio-areas as reported from 1997-2004 AGRRA surveys. Locations of standing-dead *A. palmata* colonies are indicated by a cross. Map provided courtesy Garza-Perez and Ginsburg.

Prior to the AGRRA summary, Bruckner (2002) provided a comprehensive summary of the best-known quantitative and qualitative data on the status of the Atlantic acroporids resulting from a NOAA-sponsored workshop wherein participants compiled data and summarized conditions throughout the range. Much of the data from the Bruckner (2002) report are summarized below, and some are updated and included in the case studies at the end of this section.

Abundance and distribution (historic and current) of *Acropora cervicornis*

Historically, *A. cervicornis* so dominated the reef within the 7 to 15 m depth that the area became known as the staghorn zone (Figure 4.3-8) throughout much of the Caribbean. In many other reef systems in the wider Caribbean, most notably the western Caribbean areas of Jamaica, Cayman Islands, Belize and eastern Yucatan (Adey 1977), *A. cervicornis* was a major mid-depth (10 to 25 m) reef-builder. Principally due to wind conditions and rough seas, *A. cervicornis* has not been known to build extensive reef structures in the Lesser Antilles and southwestern Caribbean.

Acropora cervicornis has also been documented in deeper water (16 to 30 m) (Goldberg 1973) and as far north as Palm Beach, Florida (26° 3'N). It is also distributed further south and west throughout the coral and hardbottom habitats of the Florida Keys (Antonius et al. 1978; Burns 1985; Dustan 1988; Dustan and Halas 1987; Glynn et al. 1989; Jaap 1984; Jaap and Wheaton 1975; Jaap et al. 1988; Wheaton and Jaap 1988), and Dry Tortugas (Vaughan 1915; Davis 1982; Dustan 1985, 1988; Jaap et al. 1989). In Biscayne National Park (upper Florida Keys), *A. cervicornis* was more abundant on reefs further from tidal passes (e.g., Ajax and Long Reefs) than those nearby, with historical coverage ranging from 0.1% to 2.7% in the 1980s (Burns 1985).

Because Florida is one of the few areas where multi-year quantitative data are available for *A. cervicornis* at more than a single location (Carysfort Reef; Dustan and Halas 1987, Looe Key Reef; Wheaton and Jaap 1988, Dry Tortugas; Davis 1982 and Porter et al. 1982) (Figure 4.3-9), those data are further analyzed and presented as a case study in section 4.5.3 of the *Acropora* Status Review document.

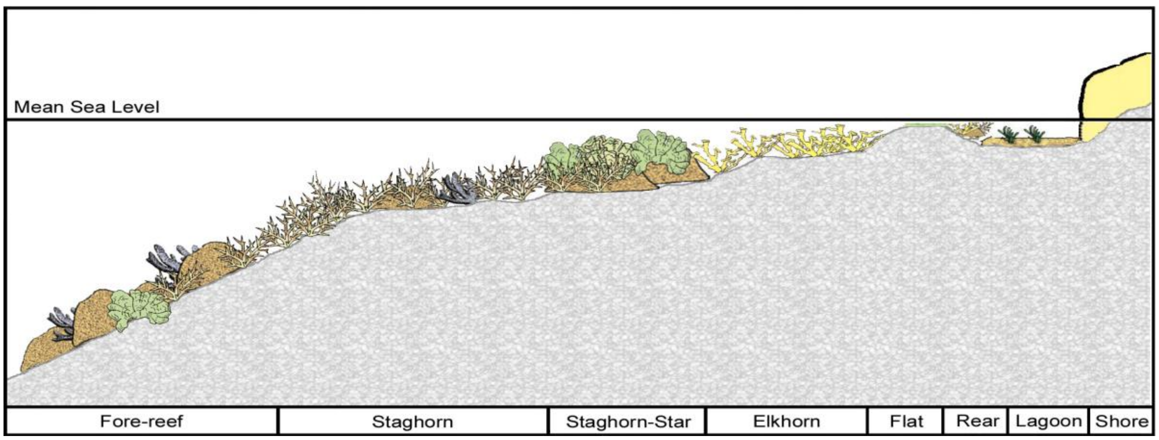


Figure 4.3-8. Reef zonation schematic example modified from several reef zonation-descriptive studies (Goreau 1959; Kinzie 1973; Bak 1977).

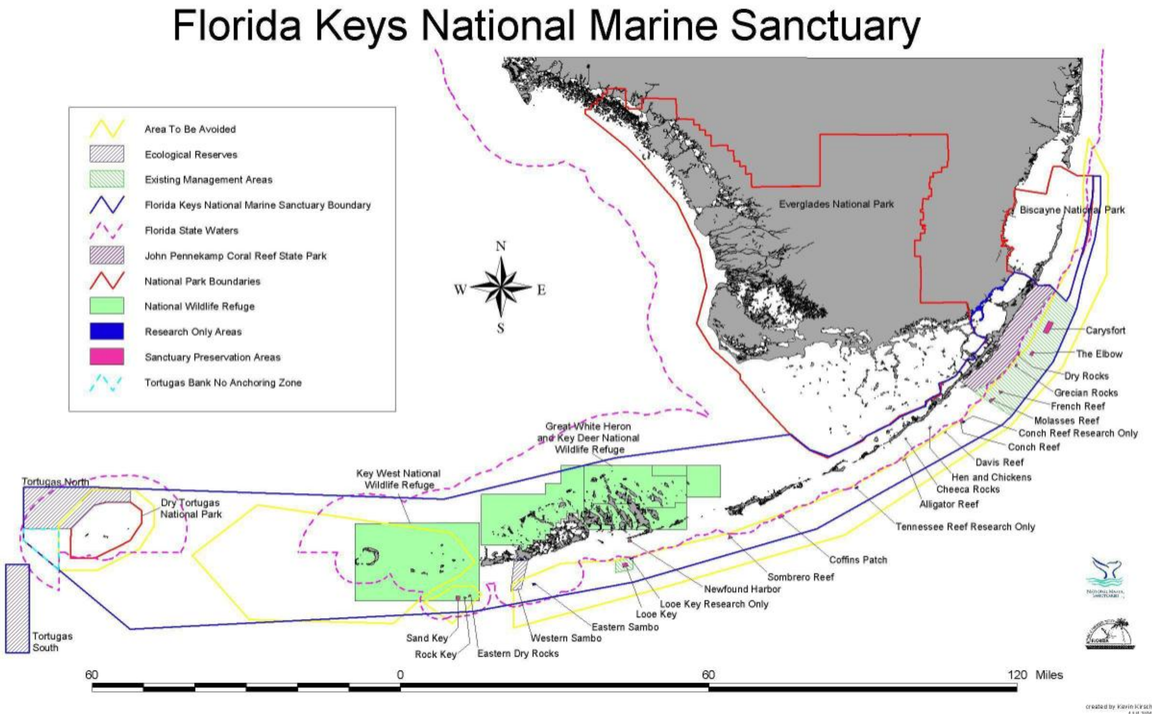


Figure 4.3-9. Map of the Florida Keys National Marine Sanctuary and reefs of the Florida Keys.

<u>Historical and current distribution and abundance of *Acropora palmata*</u>

Throughout much of the Caribbean, *A. palmata* historically occupied the 1 to 8 m depth range (reef flat, wave zone, reef crest) known as the 'elkhorn zone' (Figure 4.3-8). *Acropora palmata* occupied this zone in Jamaica (Goreau 1959), Alacran Reef, Yucatan peninsula (Kornicker and Boyd 1962), Abaco Island, Bahamas (Storr 1964), the southwestern Gulf of Mexico, Bonaire (Scatterday 1974), and the Florida Keys (Jaap 1984; Dustan and Halas 1987).

The predominance of *A. palmata* in shallow reef zones is related to the degree of wave energy. In areas with strong wave energy conditions only isolated colonies may occur, while thickets may develop in areas of intermediate wave energy (Geister 1977). Although considered a turbulent water species, *A. palmata* is sensitive to breakage by wave action, and is often replaced by coralline algae in heavy surf zones throughout the province (Adey 1977).

While *A. cervicornis* has been documented further north along the Florida east coast, the northern extension of *A. palmata* is at Fowey Rocks offshore the Miami area (25° 37' N) (Porter 1987). This area technically begins the Florida Reef Tract where all of the major reef-building corals appear in shallow water in the southeastern U.S. (Burns 1985).

Surveys in the early 1970s north of Miami (e.g., Palm Beach) did not note the occurrence of *A. palmata* (Goldberg 1973). Between Fowey Rocks and Carysfort Reef, *A. palmata* has been historically rare as the significant reef development or framework construction by *A. palmata* begins further south at Carysfort Reef (25° 20'N), extending discontinuously southwestward to the Dry Tortugas (Jaap 1984). Notably, recent surveys have reported a few colonies of *A.*

palmata off Pompano Beach, Broward County, FL (Figure 4.3-10). The status of these few northern-most colonies presently is unknown.

Figure 4.3-10. *Acropora palmata* off of Pompano Beach, Broward County, Florida, in 2003; (Photo credit: J. Sprung).

Distribution records of *A. palmata* for the southeast Florida coast include: upper Florida Keys (Burns 1985; Dustan 1985, 1988; Dustan and Halas 1987; Jaap et al. 1988), lower Florida Keys (Jaap and Wheaton 1975; Antonius et al. 1978; Jaap 1979; Wheaton and Jaap 1988), and Dry Tortugas (Davis 1982; Jaap et al. 1989). Offshore reefs built primarily by *A. palmata* are situated along the outer margin of an arc-shaped limestone plateau (south Florida shelf). "Flourishing" *A. palmata* reefs (i.e., those with a shallow or emergent reef flat) are limited to the northern seaward half of Key Largo where an *Acropora* zone (reef flat/reef crest) was present. At Molasses Reef (see Figure 4.3-9) living *A. palmata* was almost absent in 1959-60 (Shinn 1963) and it was later suggested that conditions necessary for the growth of this coral changed since the coralline spurs were originally accreted (Shinn et al. 1981).

Numerous other studies describing *A. palmata* abundance and distribution in the Florida Keys are available. When possible, data (e.g., Chiappone and Sullivan 1997) were further analyzed and presented as a case study in section 4.5.3 of the *Acropora* Status Review document. Other data from short-term projects throughout the Florida Keys are summarized below:

- From 1984 to 1991, a decline in *A. palmata* abundance at shallow depths (4 to 6 m) but not deeper were noted in coral communities on six reefs (including sites in both the upper Keys and lower Keys) (Porter and Meier 1992). These changes were attributed to disease and the demise of the long-spined sea urchin (*Diadema antillarum*).
- Living and dead assemblages of corals on two offshore sites and two patch reefs were compared and significant differences in taxonomic composition between live and dead

coral assemblages were found between reef types (Greenstein and Pandolfi 1997). While both the patch and offshore reefs historically had more *A. cervicornis* and *A. palmata*, they were now dominated by other corals (*Porites astreoides* and *Siderastrea siderea*). Interestingly, massive growth forms were under-represented in the dead assemblage, while branching growth forms (*Acropora* spp.) were underrepresented in the live coral assemblage.

Reproduction

The distribution and abundance of Atlantic *Acropora* spp., like other coral species, reflects patterns of larval recruitment, asexual reproduction via fragmentation, mortality, regenerative capabilities, and aggressive interactions (Richmond and Hunter 1990). Interspecific differences in the mechanisms of recruitment, dispersal, and mortality are likely important in determining the species composition of reef corals in different environments. These differences reflect the differential allocation of energy to the basic life history functions of growth (rate and rigidity of the skeleton), reproduction (fecundity, mode of larval dispersal, recruitment success), and colony maintenance (intra- and interspecific interactions, competitive ability, regeneration) (Connell 1973; Lang 1973; Bak and Engel 1979; Szmant 1986). Populations of Atlantic *Acropora* spp. are dependent upon sexual recruits for recovery after catastrophic disturbance, but can locally dominate hardbottom and coral reef habitats when colonies fragment and propagate across the bottom.

Extensive research has been conducted on the diverse reproductive strategies employed by scleractinian corals (Fadlallah 1983; Szmant 1986; Richmond and Hunter 1990). Atlantic *Acropora* spp., like many stony coral species, employ both sexual and asexual reproductive propagation. Sexual reproduction in corals includes gametogenesis (i.e., development of gametes) within the polyps near the base of the mesenteries. Some coral species have separate sexes, while others such as the Atlantic *Acropora* spp., are hermaphroditic. *Acropora cervicornis* and *A. palmata* in particular do not differ substantially in their sexual reproductive biology. Both species are spawners, meaning that coral larvae develop externally to the parental colonies (Szmant 1986) and both species are simultaneous hermaphrodites, meaning that a given colony will contain both female and male reproductive parts during the spawning season. Gametes (eggs and sperm) are located in different mesenteries of the same polyp (Soong 1991). The development period is longer for eggs than sperm, lasting approximately 10 months (Szmant 1986).

The spawning season for *A. cervicornis* and *A. palmata* is relatively short; with gametes released only a few nights during July, August, and/or September. In some populations, spawning is synchronous after the full moon during any of these three months. Annual egg production in *A. cervicornis* and *A. palmata* populations studied in Puerto Rico was estimated to be 600 to 800 eggs per cm^2 of living coral tissue (Szmant 1986). Eggs from both corals are ~300 µm in diameter. Colonies of *A. cervicornis* studied on the Caribbean coast of Panama during 1987-88 produced eggs 0.3 to 1.0 mm in length along the long axis that were elliptical in shape (Soong 1991). Spermaries were present during July and August and not during other times of the year. In the same study, *A. palmata* eggs were 0.2 to 1.0 mm in length along the long axis and shaped as irregular ellipses.

Spermaries were present during July, August, and September. In a subsequent study, Soong and Lang (1992) observed that large axial polyps and basal tissues (1.0 to 4.5 cm from the colony base) in *A. cervicornis* were infertile, whereas gonads located within 2 to 6 cm of the branch tips always had smaller eggs than those in the mid-region of the branches. In *A. palmata*, small eggs were found in the whole colony, while infertile areas were observed in the encrusting base and along the growing edges of branches (Soong and Lang 1992). Upper surfaces of *A. palmata* colonies had significantly greater fecundity (more fertile polyps per unit surface area) and larger numbers of eggs within fertile polyps.

Colonies of *A. cervicornis* and *A. palmata* studied on the Caribbean coast of Panama indicated that larger colonies of both species (as measured by surface area of the live colony) have higher fertility rates (Soong and Lang 1992). For *A. palmata*, no colonies with a surface area between 4 and 15 cm^2 (n=4) or between 15 to 60 cm^2 (n=9) were fertile, while 7% of those 60 to 250 cm^2 in tissue surface area were fertile (n=14). Over 30% of the colonies between 250 and 1000 cm^2 in tissue surface area were fertile (n=16), 43% of colonies between 1000 and 4000 cm^2 (n=7), and 88% of colonies larger than 4000 cm^2 (n=33). In the same study, only colonies of *A. cervicornis* with a branch length larger than 9 cm were fertile, with 38% fertility for those 9 to 13 cm in branch length (n=13), 59% for 13 to 17 cm (n=17), and 89% for colonies with branches longer than 17 cm (n=18). Estimated size at puberty for *A. palmata* was 1600 cm^2 (n=84 colonies sampled) and for *A. cervicornis* was 17 cm in branch length (n=52 colonies sampled). The smallest reproductive colony of *A. palmata* was 16 x 8 cm^2 and for *A. cervicornis* was 9 cm in branch length (Soong and Lang 1992).

In corals, fertilization can occur internally or externally, but in Atlantic *Acropora* spp., fertilization and development are exclusively external. Embryonic development culminates with the development of planktonic larvae called planulae. Little is known concerning the settlement patterns of planula larvae of Atlantic *Acropora* spp. (Bak et al. 1977 ; Sammarco 1980 ; Rylaarsdam 1983). In general, upon proper stimulation, coral larvae, whether released from parental colonies or developed in the water column external to the parental colonies, settle and metamorphose on appropriate substrates. Unlike most other coral larvae, *A. palmata* planulae appear to prefer to settle on upper, exposed surfaces, rather than in dark or cryptic ones (Szmant and Miller, accepted), at least in a laboratory setting. Initial calcification ensues with the forming of the basal plate and the initial protosepta, followed by the theca or polyp wall and axial skeletal members. Buds that form on the initial corallite develop into daughter corallites. Both externally and internally produced coral planula larvae presumably experience considerable mortality (up to 90% or more) from predation or other factors prior to settlement and metamorphosis (Goreau et al. 1981). Once larvae are able to settle onto appropriate hard substrates, metabolic energy is diverted to colony growth and maintenance. Because newly settled corals barely protrude above the substrate, juveniles need to reach a certain size to reduce damage or mortality from impacts such as grazing, sediment burial, and algal overgrowth (Bak and Elgershuizen 1976; Birkeland 1977; Sammarco 1985). Recent studies examining early survivorship of lab cultured *A. palmata* settled onto experimental limestone plates and placed in the field indicate that survivorship is substantially higher than for *Montastraea faveolata*, another spawner, and similar to brooding species over the first nine months after settlement (Szmant and Miller, accepted).

This pattern corresponds to the size of planulae; *A. palmata* eggs and larvae are much larger than those of *Montastraea* spp. Overall, older recruits (i.e., after they have survived to a size they are visible to the human eye, probably 1 to 2 yrs after settlement (Figure 4.3-11) appear to have similar growth and post-settlement mortality rates across species (Van Moorsel 1988).

Figure 4.3-11. *Acropora palmata* sexual recruit, St. John, U.S.V.I. Photo credit: C. Rogers.

Spatial and temporal patterns of coral recruitment have been intensively studied on Caribbean reefs (Birkeland 1977; Bak and Engel 1979; Rogers et al. 1984; Baggett and Bright 1985; Chiappone and Sullivan 1996). Biological and physical factors that have been shown to affect spatial and temporal patterns of coral recruitment include substrate availability and community structure (Birkeland 1977), grazing pressure (Rogers et al. 1984; Sammarco 1985), fecundity, mode and timing of reproduction (Harriot 1985; Richmond and Hunter 1990), behavior of larvae (Lewis 1974; Goreau et al. 1981), hurricane disturbance (Hughes and Jackson 1985), physical oceanography (Baggett and Bright 1985; Fisk and Harriot 1990), the structure of established coral assemblages (Lewis 1974; Harriot 1985), and chemical cues (Morse et al. 1988).

Relatively few studies, however, have examined variation in Caribbean coral recruitment over larger spatial scales (10 to 100 km) or among different structural types of reefs (Wallace and Bull 1981; Harriot and Fisk 1987; Fisk and Harriot 1990). Many studies of Caribbean reefs have used the quantification of juvenile coral densities as a proxy to measure recruitment success, with juvenile corals defined as metamorphosed corals visible underwater to the unaided eye ranging up to 4 cm in maximum diameter (Bak and Engel 1979). Newly settled corals are visible in the field at approximately 5 to 10 mm in diameter, and colonies approaching 4 cm in diameter are approximately 1 to 3 years old (Van Moorsel 1988).

Studies of *Acropora* spp. from across the Caribbean confirm two overall patterns of sexual recruitment: (1) Low juvenile densities relative to other coral species and (2) low juvenile densities relative to the commonness of adults (Porter 1987). This pattern suggests that the composition of the adult population is dependent upon variable recruitment. It also likely reflects the dominance of asexual reproduction by fragmentation for these species (for example, surviving fragments are usually larger than 4 cm and thus never undergo a "juvenile" stage by this definition). In both Curaçao and Bonaire in the 1970s, densities of juvenile *A. palmata* reached 0.13 per m^2, while no *A. cervicornis* juveniles were found (Bak and Engel 1979). On the north coast of Jamaica, juvenile *A. cervicornis* densities were as high as 4.3 per m^2 at 11 m depth on barren substrate (Rylaarsdam 1983). However, phototransects revealed no *Acropora* spp. recruitment in 1976 or 1980 at <20 m depth, with smaller colonies presumably originated from the larger colonies via fragmentation (Porter et al. 1981). In Salt River, St. Croix, *A. palmata* juveniles occurred at densities of 0.1 to 0.3 per m^2 at 3 to 9 m depth, while densities of juvenile *A. cervicornis* ranged from 0.01 to 0.30 per m^2 at 9 m depth (Rogers et al. 1984). Similar results were obtained in the Florida Keys (Dustan 1977; Porter and Meier 1992; Chiappone and Sullivan 1996). Surveys of nine sites representing three different offshore reef types from 3 to 15 m depth yielded no juveniles of *Acropora* spp. from 450, 1-m^2 quadrats (Chiappone and Sullivan 1996). To date, however, the settlement rates (number of larvae settling per unit area) of Atlantic *Acropora* spp. have still not been quantified; the juvenile density measurements cited above represent larvae that have not only settled, but metamorphosed (i.e., excreted a calcium carbonate skeleton) and survived to a specific size visible to surveyors underwater. Anecdotal evidence and observations in the Caribbean indicate that both *A. cervicornis* and *A. palmata* sexually recruit onto reefs, and in several instances, populations that have experienced major declines (>90%) are showing signs of recovery in terms of newly settled sexual recruits (Bruckner 2002).

Besides sexual reproduction, most coral species, including Atlantic acroporids, also reproduce asexually. Asexual reproduction involves fragmentation, wherein colony pieces or fragments are dislodged from larger colonies to form new colonies (Highsmith 1982). The budding of new polyps within a colony can also be considered asexual reproduction. Fragmentation can occur during storms (Porter et al. 1981; Tunnicliffe 1981; Highsmith 1982), with susceptibility to mechanical breakage of colony branches influenced by the boring activities of sponges and lithophagus bivalves. Fragmentation is a common means of propagation in many species of branching corals and historically has been considered to be the most common means of forming new colonies in Atlantic *Acropora* spp. (Gilmore and Hall 1976; Davis 1977; Tunnicliffe 1981; Bak and Criens 1982; Hughes 1985). The perception of the dominance of fragmentation as a reproductive mode for *A. palmata* and *A. cervicornis* implies that colonies derived from fragmentation can be distinguished from those derived from larvae. However, this may not always be the case. Recently developed genetic tools can detect colonies with the same genotype (implying one was fragmented from the other). Application of these tools in the field to a population of *A. palmata* (where individual small colonies were scored by field experts as larval or asexual recruits) indicated very poor correlation (Miller et al. in review). It appears that the reliability of assessing the contribution of sexual versus asexual reproduction in *Acropora* populations by field survey is limited, but is an area of study that warrants further investigation.

Asexual reproduction can play a major role in maintaining local populations when sexual recruitment is very limited. Fragmentation, followed by stabilization, survivorship, and growth can provide a mechanism for maintaining and expanding Atlantic *Acropora* spp. populations.

However, region-wide declines have increased the reliance of *Acropora* spp. on sexual recruitment as a means of establishing and sustaining populations (Bruckner 2002). Atlantic *Acropora* spp. may require a certain storm frequency to maintain and expand populations through asexual reproduction, principally by fragmentation, when sexual recruitment is limited (Bruckner 2002). Frequent occurrence of storms or a single intense storm, however, may negatively impact colony survival, since a fragment may become abraded during the storm or may not encounter suitable substrate to reattach after the storm passes.

Development and growth

Staghorn Coral

The growth rate for *A. cervicornis* has been reported to range from 3 to 11.5 cm/yr (Table 4.3-6). This growth rate is relatively fast in comparison to that of other corals and historically enabled the species to construct significant bioherms (reef structures) in several locations throughout the Caribbean (Adey 1978).

Table 4.3-6. The annual growth rate for *Acropora cervicornis* as reported from several sources.

Growth rate (cm/yr)	Location	Record
4	Dry Tortugas	Vaughan (1915)
10.9	Key Largo, Florida	Shinn (1966)
11.5	Eastern Sambo, Florida	Jaap (1974)
10	Key Largo, Florida	Shinn (1976)
7.1	U.S. Virgin Islands	Gladfelter et al. (1978)
3 to 4	Exuma, Bahamas	Becker and Muller (2001)

Gladfelter (1982, 1983a) used a scanning electron microscope to describe the growth process in *A. cervicornis*. She reported that crystals are initially deposited randomly on the distal margin of the axial corallite. Subsequently, needle-like crystals attach and grow outward from the surface of the crystals. The needle-like crystals in contact with the calicoblastic epithelial cells grow and fuse together generating the skeletal foundation or septotheca. During daylight, calcium carbonate accretion occurs on all of the skeletal elements; at night the activity is limited to fusiform crystal formation. Gladfelter (1983b) reported daily tissue growth of 300 μm in the region of the axial polyp. "*A. cervicornis* exhibits a daily rhythm in calcification capacity, with daily maxima at sunrise and sunset. Daily minima occur shortly after sunrise and sunset" (Chalker 1977; Chalker and Taylor 1978; Gladfelter 1983b). Contrasting growth of in situ and laboratory-reared specimens revealed differences in the basal extension; however, other measurements (e.g., $CaCO_3$ accretion and vertical extension) were equivalent (Becker and Mueller 2001).

Growth in *A. cervicornis* is also expressed in expansion, occurring as a result of fragmenting and forming new centers of growth (Bak and Criens 1982; Tunnicliffe 1981). A broken off branch may be carried by waves and currents to a distant location or may land in close proximity to the original colony. If the location is favorable, branches grow into a new colony, expanding and occupying additional area. Fragmenting and expansion, coupled with a relatively fast growth rate, facilitates potential spatial competitive superiority for *A. cervicornis* relative to other corals and other benthic organisms (Shinn 1976; Neigel and Advise 1983; Jaap et al. 1989). Fragments that contained the axial corallite were found to have lower mortality than fragments that came from the inner portions of a colony and did not have axial corallites (Bowden-Kerby 2001a). There was up to a six-fold difference in growth rate over 12 months based on the fragment's origin (Bowden-Kerby 2001b).

Elkhorn Coral
The growth rate of *A. palmata*, expressed as the linear extension of branches, is reported to range from 4 to 11 cm annually (Table 4.3-7) (Vaughan 1915, Jaap 1974). The 4-cm annual growth rate cited by Vaughan (1915) undoubtedly underestimates growth. Annual linear extension was estimated to be 8.8 cm; basal extension was 2.3 mm/month, and tissue growth was 200 cm^2 per month at Quintana Roo, Puerto Morelos, Mexico (Padilla and Lara 1996). A colony two meters in height could theoretically be 20 to 29 years old based on a 7- to 10-cm annual growth rate. The theoretical age of a much larger colony(4 m) is 40 to 57 years old. Linear extension and tissue growth were dependent on the size of the colony; however, basal extension was independent of colony size (Padilla and Lara 1996). Colonies of *A. palmata* in the field had a greater calcification rate and rate of extension relative to specimens grown in an experimental tank (Becker and Mueller 2001). Wells (1933) reported from observations in 1932 that colonies of *A. palmata* were eight feet high (2.4 m) and 15 feet (4.5 m) in diameter at Bird Key Reef, Dry Tortugas; this is probably the maximum size that this species can attain.

Settled larvae typically create a small crust or patch with tubular corallites oriented at approximately 90 degrees from the plane of attachment. One or more protuberances develop and grow outward to form proto-branches.

Table 4.3-7. *Acropora palmata* growth rates reported from several sources.

Growth rate (cm/yr)	Location	Record
4	Dry Tortugas, Florida	Vaughan (1915)
10	Florida Keys	Jaap (1974)
4.7 to 9.9	U.S. Virgin Islands	Gladfelter, et al. (1978)
5.2	Colombia	Garcia et al. (1996)
2 to 11	Exuma, Bahamas	Becker and Mueller (2001)

The range of growth forms in *A. palmata* includes the iconic broad frond, with symmetrical colonies that are two or more meters across. Branches are up to 50 cm across and range in thickness from 4 to 5 cm, tapering toward the branch terminal; these colonies are most typical of the spur and groove formations where water circulation is omni-directional. In areas where wind and waves are predominantly from a single direction, the branches tend to grow in to the direction of the waves. The series of branches look like a medieval fortification (palisade); this growth form is typical of the barrier reef habitat. As depth increases, the branches are oriented in a more vertical orientation (Wainwright 1976; Graus et al. 1977). This compensates for hydraulic bending forces, but the thickening of the base also helps to counteract the hydrodynamic forces (Schumacher and Plewka 1981). *Acropora palmata* porosity ranges from approximately 35 to 45% by volume (Schumacher and Plewka 1981).

Acropora palmata can rapidly monopolize large areas by fragment propagation. A branch of *A. palmata* may be carried by waves and currents away from the mother colony to distances that range from 0.1 to 100 m, but usually less than 30 m (Baums et al., unpublished data). Fragments cleaved from the colony may grow into new colonies (Highsmith et al. 1980; Bak and Criens 1982; Highsmith 1982; Rogers et al. 1982).

Fragmentation during storm events is a significant means of generating new colonies, as documented during several storms: Hurricanes Hattie (Stoddart 1962, 1969), Edith (Glynn et al. 1964), Gerta (Highsmith et al. 1980), Allen (Woodley et al. 1981), David and Frederic (Rogers et al. 1982), Hugo (Bythell et al. 1991), Joan (Geister 1992, Zea et al. 1998), Gilbert (Kobluk and Lysenko 1992; Jordan-Dahlgren and Rodriguez-Martinez 1998), Andrew (Lirman and Fong 1996, 1997, Jaap pers. observ.), Georges and Charley (2004) (Jaap pers. observ.), as well as after Storms Bret (Van Veghel and Hoetjes 1995) and Gordon (Lirman and Fong 1997). Lirman and Fong (1997) reported that *A. palmata* fragment wounds healed rapidly (1.59 cm of linear growth/month). Nine months after Tropical Storm Gordon, 157 of 218 fragments had fused to the sea floor, and protobranches on the fragments grew rapidly.

Population dynamics

Atlantic *Acropora* spp. are generally considered intermediate along the continuum from r-selected (rapid colonizers, fast growth, early maturation, but small maximum size and thus limited contribution to reef growth; generally brooding corals) to k-selected (slow growing, generally spawning, but attaining large colony size via indeterminate growth) life history strategies. *Acropora palmata* and *A. cervicornis* tend to be fast growing, have rapid wound healing, high rates of survival of asexually produced fragments, and the ability of broken branches to grow into new colonies (Gladfelter et al. 1978; Bak and Criens 1982; Highsmith 1982). Their level of aggression (i.e., ability to extend their mesenterial digestive filaments onto neighboring species and digest away living tissue) is relatively low compared to many other Caribbean corals (Lang 1973). However, Atlantic *Acropora* spp. have superior overgrowth capabilities. These life history characteristics, supported by documentation of recent trends in populations across the Caribbean, illustrate that once *Acropora* spp. experience local (reef-scale) reductions in colony numbers and size, recovery may not occur for decades.

There are several implications of the current low population sizes of *Acropora* spp. throughout much of the Caribbean. First, the number of sexual recruits to a population will be most influenced by larval availability, recruitment, and early juvenile mortality. Because corals cannot move and are dependent upon external fertilization in order to produce larvae, fertilization success declines greatly as adult density declines; this is termed an Allee effect (Levitan 1991). To compound the impact, *Acropora* spp., although hermaphroditic, do not effectively self-fertilize; gametes must be outcrossed with a different genotype to form viable offspring. Thus, in populations where fragmentation is prevalent, the effective density (of genetically distinct

adults) will be even lower than colony density. It is highly likely that this type of recruitment limitation
(Allee effect) is occurring in some local *A. palmata* and *A. cervicornis* populations, given their state of drastically reduced abundance/density. Simultaneously, when adult abundances of *A. palmata* and *A. cervicornis* are reduced, the source for fragments (to provide for asexual recruitment) is also compromised. These conditions imply that once a threshold level of population decline has been reached (i.e., a density where fertilization success becomes negligible) the chances for recovery are low.

Population Genetics
Understanding the population structure of *A. cervicornis* and *A. palmata* is complicated by the fact that both corals undergo both sexual and asexual (clonal) reproduction (see Reproduction section above) and the relative contribution of each is not readily discernable in the field (Miller et al. in review). Two aspects of population structure are of critical importance in assessing extinction risk in widespread clonal species: (1) The degree of genotypic diversity (within populations and overall); and (2) the degree of genetic exchange between populations. The levels of genotypic diversity in *A. palmata* and *A. cervicornis* are of particular concern given their presumed dominant asexual reproductive mode (Highsmith 1982) and rapid range-wide decline (see Description and Distribution section above). That is, while quantitative field surveys may provide abundance estimates based on number of colonies or percent cover, it is conceivable that the genotypic diversity in either species might be drastically lower. The degree of genetic connectivity among populations is important in understanding the potential adaptation of local populations to specific environmental conditions and the potential for re-colonization from neighboring or distant reefs in areas of extirpation.

Immunological self-recognition (fusion versus rejection response when two individuals are placed in contact) was used in an early study to investigate clonal structure in *A. cervicornis* (Neigel and Avise 1983). This approach indicated that ramets of individual genets occurred at up to 20 m distance and individual genets occupied up to 10 m^2 in Jamaica and St. Croix, U.S.V.I. (Neigel and Avise 1983). However, there has been subsequent questioning of the genetic basis of the self-recognition response, as electrophoretically distinct individuals have been shown to fuse (e.g., Heyward and Stoddart 1985). Molecular genetic analysis seems to be necessary to reliably evaluate clonal structure.

Common molecular approaches to study genetic population structure such as mitochondrial DNA markers have yielded low levels of intraspecific variation in anthozoans in general and corals in particular and, hence, are of limited use in coral population genetic studies (Shearer et al. 2002). The presence of intracellular symbionts in coral tissue greatly complicates the application of highly polymorphic, anonymous DNA markers since it is difficult to distinguish between coral and symbiont DNA.

Previous efforts at developing coral-specific microsatellite markers for *Acropora* spp. also met with little success (Marquez et al. 2000). Nonetheless, molecular genetic tools have recently become available to address questions of population genetic structure and gene flow in *A. cervicornis* (Vollmer and Palumbi in prep) and *A. palmata* (Baums et al. in press a). These tools are summarized below, based upon manuscripts in development or under scientific review.

A recent study examined genetic exchange and clonal population structure in *A. palmata* by sampling and genotyping colonies from eleven locations throughout its geographic range using microsatellite markers (Baums et al. in press a). Results (Baums et al. in press b) indicate that populations in the eastern Caribbean (St. Vincent and the Grenadines, U.S.V.I., Curaçao, and Bonaire) have experienced little or no genetic exchange with populations in the western Caribbean (Bahamas, Florida, Mexico,Panama, Navassa, and Mona Island). Puerto Rico is an area of mixing where populations show genetic contribution from both regions, though it is more closely connected with the western Caribbean. Within these regions, the degree of larval exchange appears to be asymmetrical with some locations being entirely self-recruiting and some receiving immigrants from other locations within their region (Baums et al. in press b).

The clonal structure of individual *A. palmata* populations was found to be highly variable, ranging from completely sexual where each colony represents a different genet to completely asexual, where all colonies comprise a single genet (Baums et al. in prep). The overall range-wide average, expressed as Ng/N (the number of genotypes found divided by the total number of colonies sampled) was about 0.5. Interestingly, clonal structure appeared to vary between the eastern and western Caribbean, with eastern populations being denser and more genotypically diverse (i.e., greater contribution by sexual recruitment) than western populations (Baums et al. in prep). In fact, four out of five populations sampled in the Florida Keys were monoclonal, indicating they were derived from fragmentation of a single larval recruit (Baums et al. in press (a) and unpublished data). This lack of genotypic diversity in several *A. palmata* populations implies that sexual reproduction may be completely lost and is thus a basis for concern for the long-term persistence of this species. Measures of genetic diversity such as heterozygosity are unknown for either species and are not likely to be revealed from the current genetic approaches.

Vollmer and Palumbi (in prep.) used DNA sequences of specific nuclear and mitochondrial genes, to analyze connectivity of *A. cervicornis* populations on a Caribbean-wide scale. Their results indicate a much finer scale of geographic differentiation (i.e., less connectivity across large areas) than the microsatellite results for *A. palmata* (Baums et al. in press b). They report that larval exchange between *A. cervicornis* populations as close as 2 to 15 km is extremely limited, implying that larval sources need to be conserved on a very small spatial scale. Little is known regarding clonal structure of *A. cervicornis* populations throughout their geographic range, although Vollmer and Palumbi (in prep.) indicate that approximately 60% of the colonies they sampled (purposely sampling colonies distant from each other) from areas throughout the Caribbean represented distinct genotypes. As in *A. palmata*, populations of *A. cervicornis* in southeast Florida (Broward County, probably the most abundant extant stands anywhere) appear to have low genotypic diversity as each of the large thickets sampled to date is monoclonal (Baums and Vargas unpubl. data).

Ecological relationships

Coral reefs serve a number of functional roles in subtropical and tropical environments of the Caribbean, including, but not limited to primary production, recycling of nutrients in relatively oligotrophic seas, calcium carbonate deposition yielding reef construction, refuge and foraging base for other organisms, and modification of near-field or local water circulation patterns (De Freese 1991). Coral reefs also protect shorelines, serving to buffer inshore subtidal (e.g., seagrass) and intertidal (e.g., mangroves) communities from otherwise high wave energy conditions in certain localities. Coral reefs are host to a multitude of species of algae, invertebrates, and fishes. Reef environments are characterized by an incredible diversity of species packed into a relatively small spatial dimension (m^2 to km^2) defined by high benthic diversity (Connell 1978; Richards and Lindeman 1987). Organisms essential in the construction of tropical reefs are hermatypic (reef-building) corals and coralline algae. Through reef construction, these organisms provide habitat for sedentary and mobile species (Lewis 1981).

The functional roles discussed below are presented for *Acropora* spp. where information specific to acroporids are available, and otherwise for coral reefs in general. This generalization to function in coral reef systems as a whole is appropriate in evaluating the role of *Acropora* spp. given their status as constructional or "foundation" species in Caribbean coral reef ecosystems as described below.

Acropora spp. were important shallow and mid-depth reef builders in the wider Caribbean

Acropora palmata and *A. cervicornis* are two of the major reef-building corals in the wider Caribbean. Historically, both of these species formed dense thickets at shallow (<5 m) and intermediate (10 to 15 m) depths in many reef systems, including some locations in the Florida Keys, western Caribbean (e.g., Jamaica, Cayman Islands, Caribbean Mexico, Belize), and eastern Caribbean. In the Florida Keys, for example, *A. palmata* was the primary builder of constructional spur and groove reefs along much of the Florida reef tract, with coralline spurs up to several meters in height and up to 15 m in length (Shinn 1963; Shinn et al. 1981). Early descriptions of Florida Keys reefs referred to reef zones, of which the elkhorn (*A. palmata*) zone was described for many shallow-water reefs (Figure 4.3-8) (Jaap 1984; Dustan 1985; Dustan and Halas 1987).

Interestingly, Shinn et al. (1977) noted that in southeastern Florida, some reefs were able to form and keep pace with sea level rise without the "help" of reef construction of *A. palmata*. As summarized in Bruckner (2002), however, the structural and ecological roles of Atlantic *Acropora* spp. in the Caribbean are unique and cannot be filled by other reef-building corals in terms of accretion rates and the formation of structurally complex reefs.

Coral reefs influence water circulation patterns

An important characteristic of coral reefs is their ability to modify the surrounding physicalchemical environment (Ginsburg and Lowenstam 1958). The reef framework controls the accumulation of sediments on and adjacent to the reef, as well as local circulation patterns (Jaap 1984). Barrier reefs are the best example of the ability of organic communities to affect circulation patterns that in turn influence benthic community distribution and sedimentation. Barrier reefs provide shelter for the back reef lagoon, allowing for benthic communities adapted to low-wave energy conditions, such as seagrass beds, to persist and flourish. Several studies have noted the differences in sediment and habitat characteristics between inshore and offshore environments (Enos 1977; Szmant and Forrester 1996) and associated differences in sediment nutrient characteristics. Sediments in the back reef (inner shelf margin) consist of finer grain particles with greater nutrient pools relative to sediments directly associated with reefs, such as large skeletal fragments. Benthic community distribution also differs considerably between nearshore and offshore. Seagrasses and other soft-sediment communities dominate the inner shelf margin, while reefs and bare sand slope areas dominate the outer shelf margin.

Coral reefs serve important refuge and foraging functions

Coral reefs, including hard substrate and associated sediments, afford organisms an incredible array of refuges (Jaap 1984). Epifauna are organisms living on the reef surface, and include mobile epifauna (crustaceans, echinoderms, mollusks, and fishes) and sessile epifauna (e.g., sponges, corals, gorgonians, and bryozoans). Infauna are those animals which burrow into hard substrate, such as polychaete and sipunculid worms, sponges, and mollusks, while minute meiofauna are associated with reef sediments. Holes and crevices in the reef structure provide shelter for echinoderms, mollusks, polychaetes, crustaceans, other invertebrate groups, and fishes. In a single coral colony, for example, Grassle (1973) counted 1,441 polychaetes representing 103 species. In several coral colonies, McClosky (1970) counted 1,517 individuals representing 37 different invertebrate species. Gastropods, crustaceans, echinoderms, and fishes consume benthic algae associated with the reef structure (i.e., coral-produced substrate); these herbivores, in turn, fuel the production of higher trophic levels such as invertivores and carnivores.

While no comprehensive quantitative inventories have been made of all of the flora and fauna associated with coral reefs (Lewis 1981), probably the best information illustrating the diversity associated with these structures is for fishes. In western Atlantic reef environments, the number of fish species directly or indirectly associated with the reef system can exceed 400 species (Starck and Davis 1967; Jones and Thompson 1978; Bohnsack et al. 1987). The high taxonomic diversity of reef fishes indicates that many species are highly evolved, with several families entirely restricted to the reef environment, among them: Chaetodontidae (butterflyfishes), Scaridae (parrotfishes), Acanthuridae (surgeonfishes), Labridae (wrasses), Holocentridae (squirrelfishes), Balistidae (triggerfishes), and Pomacentridae (damselfishes) (Sale 1977; Longhurst and Pauly 1987). Many reef fishes are highly sedentary, with some species (e.g., damselfishes) actively defending territories. Even the spatial distribution of larger predatory species tends to be very reef-specific, with individuals rarely traveling more than 5 km from a home site after post-settlement, except for spawning purposes (Longhurst and Pauly 1987).

In addition to the important functions of reef building and reef maintenance provided by Atlantic *Acropora* spp., these species serve as fish habitat (Ogden and Ehrlich 1977; Appeldoorn et al. 1996), including essential fish habitat (CFMC 1998), for species of economic and ecologic importance. Loss of *Acropora* spp. from the Caribbean would have substantial impacts on many coral reef species and by extension on the composition of reef communities.

Assessments of reef fish abundances and diversity have been conducted in the Caribbean and the Florida Keys over the last four to five decades. Invariably, these studies have quantified fish populations relative to geomorphic strata or reef zonation (Ehrlich 1975; Sale 1980; McGehee 1994; Lindeman 1997; Kendall at al. 2003), or relative to substrate characteristics such as rugosity (Luckhurst and Luckhurst 1978), complexity (Nunez Lara and Arias Gonzalez 1998), or refuge (hole) size (Hixon and Beets 1989, 1993). A number of long-term sampling efforts may have data that can be used to infer habitat use or value, but these analyses have either not been published or are limited in spatial scope.

However in St. Croix, U.S.V.I., heterotypic schools of juvenile French and white grunts (*Haemulon flavolineatum* and *H. plumieri*) were found to transfer substantial amounts of nitrogen and phosphorous in the nutrient-poor waters of a coral reef; water nearby *A. palmata* with grunts had ammonia (NH^{4+}) concentrations up to 0.7 µM (micromolar) greater compared to a nearby colony without fish (Meyer et al. 1983). While direct connections between reef fishes and Atlantic *Acropora* spp. have not been well reported (with the exceptions below), several studies have found a positive relationship between substrate complexity and fish densities and diversity. Unfortunately, few of these studies provide data on the use of certain coral species or growth forms by particular fish species.

One exception to this pattern is the study by Lirman (1999) who reported significantly higher abundances of grunts (Haemulidae), snappers (Lutjanidae), and sweepers (Pempheridae) in high-topography areas with coverage by *A. palmata* compared to lower topography or lower coral cover sites. Comparisons between sites where *A. palmata* was absent and present suggested that fish schools, comprised primarily of grunts and snappers, use *A. palmata* colonies preferentially.

Settlement habitats of the white grunt, *Haemulon plumieri*, in another study were examined in southwest Puerto Rico in a *Thalassia*-*Acropora cervicornis* back-reef lagoon (Hill 2001). Although this site might nominally be classed as a seagrass bed, *A. cervicornis* was the primary focus of newly settling grunts. Neither the *Thalassia* (seagrass) nor other available coral sites (boulder or brain corals, gorgonians, algal covered corals) attracted or maintained significant numbers of juveniles during the study.

Hill (2001) indicated that *A. cervicornis* thickets were the preferred settlement habitat for grunts that became saturated during high recruitment seasons, yielding greater usage of supposed sub-optimal habitats nearby (e.g., seagrass or gorgonians). Numerous reef studies have described the relationship between increased habitat complexity, and increased species richness, abundance and diversity of fishes. Habitat selection is viewed as a trade-off between refuge from predation and access to feeding resources (Werner and Gillliam 1984). Settlement and juvenile habitats typically are thought to reduce exposure to predators (Shulman 1984). Hixon and Beets (1989, 1993) showed that appropriately sized refuges could moderate predation effects and thus alter reef fish distribution patterns. At a larger scale, complete absence of particular habitats has been shown to affect fish assemblage composition if species are not able to use alternate habitats (Nagelkerken et al. 2000). Loss of the complex habitats provided by *A. cervicornis* and *A. palmata* could result in increased rates of predation on juvenile snappers and grunts, with likely reductions of habitat-specifics like *H. plumieri*. It is important to note that *A. palmata* and *A. cervicornis* are the only large, branching coral species in Caribbean reef systems capable of creating large amounts of complex reef habitat. Though "standing dead" coral skeletons (especially *A. palmata*, as *A. cervicornis* tends to crumble into rubble) can still serve as habitat for fishes, subsequent storms and bioerosion will eventually destroy this habitat if none is being constructed to replace it.

In the current situation, with low abundance of *Acropora* spp. on most Caribbean reefs, very little new complex reef habitat is being created and, hence, its availability to ecologically and economically important reef fishes is likely to continue to decline in the coming years.

Competition

Coral reefs are described as space-limited systems and thus it is believed that competition for space is an important structuring factor. Because of their fast growth rates and canopy-forming morphology, *A. palmata* and *A. cervicornis* are known to be competitive dominants within coral communities, in terms of their ability to overgrow other stony and soft corals. However, other types of reef benthic organisms (i.e., algae) have higher growth rates and, hence, expected greater competitive ability than *Acropora* spp. Since the 1980s, many Caribbean reef areas have undergone a shift in benthic community structure involving reduced cover by stony corals and increased coverage by macroalgae. This shift is generally attributed to the greater persistence of macroalgae under reduced grazing regimes due to human overexploitation of herbivorous fishes (Hughes 1994) and the regional mass mortality of the long-spined sea urchin in 1983-84. Impacts to water quality (principally nutrient input) are also believed to enhance macroalgal productivity.

Aronson and Precht (2001) emphasize, however, that these Caribbean-wide changes in benthic assemblages were precipitated by massive coral mortality events (namely the loss of *Acropora* spp. from White Band Disease) as macroalgae are generally unable to actively overgrow and kill live corals. In other words, the coral-dominated Caribbean reef system was resistant to reduced herbivory regimes for a period of time as long as corals maintained their occupation of space. However, when coral mortality occurred, macroalgae were able to pre-empt that space (especially following the loss of grazing by *Diadema*) and were subsequently resistant to coral re-colonization (Hughes and Connell 1999). Thus the described shifts have been persistent on a decadal scale. The noted exception is in areas where the grazing sea urchins (*Diadema antillarum*) have recently recovered and removed the macroalgal dominants, thereby clearing space to allow enhanced coral recruitment (Edmunds and Carpenter 2001).

In summary, macroalgae are now the major space-occupiers on many Caribbean reefs. Their dominant occupation of reef surfaces impedes the recruitment of new corals (McCook et al. 2001) and hence, recovery by sexual recruits of *Acropora* spp. It is unlikely, however, that macroalgae have major impacts as direct competitors with healthy adult colonies. Other encrusting invertebrates may also pose a direct overgrowth threat to small colonies or bases of *Acropora* spp., but the extent of such interactions is not well documented.

Predation

Acropora spp. are subject to invertebrate (e.g., polychaete, mollusk, echinoderm) and vertebrate (fish) predation, but “plagues” of coral predators such as the Indo-Pacific crown-of-thorns outbreaks (*Acanthaster planci*) have not been described in the Atlantic.
Predation may directly cause mortality or injuries that lead to invasion of other biota (e.g., algae, boring sponges).

The most important predators on Atlantic *Acropora* spp. are the fireworm, *Hermodice carunculata*, and the muricid snail, *Coralliophila abbreviata*. Both these predators will feed on a wide range of cnidarian prey, but may prefer *Acropora* spp. *Hermodice* are commonly found enveloping the long branch tips of *A. cervicornis* that are subsequently left devoid of tissue (Marsden 1962; Lizama and Blanquet 1975; Dustan 1977). *Hermodice* also feeds on branch tips or protuberances of *A. palmata*, where the predation scars appear as white patches (Porter 1987). Vargas-Angel et al. (2003) report a density between 86 and ~618 *Hermodice* ha^{-1} in *A. cervicornis* thickets in southeast Florida with predation scars affecting <0.2% of the *A. cervicornis* cover. There are few other data on the prevalence or impact of *Hermodice* on *Acropora* spp. populations.

Although these predators rarely kill entire colonies, there are several possible mechanisms of indirect impact. Because they prey on the growing tips (including the apical polyps), especially of *A. cervicornis*, growth of the colony may be arrested for prolonged periods of time. Additionally, *Hermodice carunculata* from the Mediterranean
Sea has been shown to serve as a vector for a bacterial bleaching pathogen in laboratory experiments (Sussman et al. 2003).

The other important predator of Atlantic *Acropora* spp. is the gastropod, *Coralliophila abbreviata*. This predator also feeds on a wide range of corals, but seems to be particularly damaging to *Acropora* spp. (Baums et al. 2003b). Prevalence data from throughout the Caribbean indicates that approximately 10% to 20% of *Acropora* spp. colonies harbor snails (Baums et al. 2003a). The rate of consumption by *Coralliophila* is highly variable, but may reach 6.5 cm^2 of coral tissue per snail per day (Bruckner et al. 1997) and probably averages ~1.5 cm^2 of coral tissue per snail per day (Baums et al. 2003b). Given that the mean snail density on infested *A. palmata* colonies is reported at over three snails per colony (Bruckner et al. 1997; Baums et al. 2003a) with a maximum of at least 23 snails per colony (Baums et al. 2003a), snail predation clearly represents a significant potential source of tissue loss. There is evidence that these predators concentrate on remnant *Acropora* populations following host coral decline (Knowlton et al. 1990; Baums et al. 2003a). For example, after Hurricane Allen struck the north coast of Jamaica in 1980 and greatly reduced the acroporid population, *C. abbreviata* continued to feed on remnant *A. cervicornis* colonies, reducing the population further (Knowlton et al. 1981). It should be noted, however, that *Coralliophila* seem to be extremely rare or absent on *Acropora* spp. in certain areas (e.g., Bocas del Toro, Panama, Baums pers. comm.; Dry Tortugas, Miller pers. observ.).

The three-spot damselfish (*Pomacentrus planifrons*) and other species in the genus establish algal nursery gardens within branching *Acropora* spp. when available and on other coral species when acroporids are rare (Thresher 1976; Brawley and Adey 1977; Kaufman 1977; Itzkowitz 1978; Williams 1978; Sammarco and Carleton 1982). Although not predators in the strict sense, the damselfishes nip off living coral tissue, thus denuding the skeleton to make a place for their algal gardens. Again, it is likely that *P. planifrons* impacts are proportionally greater when the abundance of *Acropora* is reduced. Observations in several areas (e.g., Dry Tortugas, Navassa) suggest that isolated small colonies, particularly of *A. cervicornis*, have a very high prevalence of damselfish occupation.

Other predators also consume *Acropora* tissue to a lesser degree. Although not widely documented, the Caribbean long-spined sea urchin (*Diadema antillarum*) is known to feed upon live *Acropora* coral tissue (Bak and van Eys 1975, Sammarco 1980). Laboratory experiments confirmed that this sea urchin will feed on coral tissue when starved, but may also do so when feeding on turf algae when sea urchin population numbers are relatively high (e.g., >4 individuals/m^2) (Porter 1987). More recent studies indicate that besides damselfishes, parrotfishes, such as the stoplight parrotfish (*Sparisoma viride*), may also incidentally feed upon *Acropora* tissue. Very little is known concerning the extent of parrotfish grazing on Atlantic *Acropora* spp., but monitoring in the Florida Keys indicates that these scars usually heal in a matter of weeks to months (Williams pers. comm.).

Overall, predators can have important direct and indirect impacts on *A. palmata* and *A. cervicornis*. Predation impacts are greater in the current scenario of low coral abundance as coral predators have not been subject to the same degrees of disturbance mortality and their broad diet breadth has allowed them to persist at high levels despite decreases in acroporid prey. However, predation impacts on *Acropora* spp. appear to be much lower in certain geographic areas.

4.4 State Comprehensive Wildlife Conservation Strategies

(excerpted from the State Wildlife Action Plans Summary Report (August 2006): http://www.teaming.com/pdf/StateWildlifeActionPlansReportwithStateSummaries.pdf)

The wildlife action plans represent a collective vision for the future of conservation. For the first time, states have had the opportunity to assess the full range of challenges and actions that are vital to keeping wildlife from becoming endangered.

The impetus for the historic planning effort comes from the Teaming with Wildlife coalition, representing more than 3,500 agencies, conservation groups, and businesses who for more than a decade have tirelessly championed the cause for funding to keep wildlife from becoming endangered. The coalition's work led to passage of the Wildlife Conservation and Restoration Program and the State Wildlife Grants Program in 2000. As a requirement of these programs, Congress asked each state wildlife agency to develop a "comprehensive wildlife conservation strategy"—a wildlife action plan—that evaluates wildlife conservation needs and outlines the necessary action steps.

While the wildlife action plans share a common framework of the eight required elements, they are tailored to reflect each state's unique wildlife, habitat, and conservation needs. States worked closely through the Association of Fish and Wildlife Agencies and the U.S. Fish and Wildlife Service on the development of the wildlife action plans. By combining the best scientific information available with extensive public participation, states developed effective action plans that will work for wildlife and for people.

The wildlife action plans focus on practical, proactive measures to conserve and restore important lands and waters, curb establishment of invasive species and address other pressing conservation needs. The tools for conservation employed in the action plans emphasize incentives, partnerships and collaborative management, rather than top-down regulations. The action plans also stress the importance of gaining the knowledge necessary to effectively conserve a broad range of wildlife species. In addition, every state wildlife action plan incorporates continued monitoring and evaluation in order to measure the success of the proposed actions in conserving wildlife.

Taken as a whole, the wildlife action plans present a national action agenda for the conservation of wildlife species that is focused on those that have not benefited from conservation attention due to lack of dedicated funding. The results are already apparent in improved relationships at all levels—across public and private ownerships, across state boundaries, and in the growing list of new groups and individuals working together for wildlife. Taking the timely next steps to adequately fund these wildlife action plans is crucial in order to achieve the goal of preventing wildlife from becoming endangered.

Below are the Executive Summaries for each of the South Atlantic states' Comprehensive Wildlife Conservation Strategies. For detailed information contained in each Plan, please refer to each document. The documents can be downloaded in pdf format at http://www.teaming.com/state_pages.htm.

North Carolina

For more than fifty years, state fish and wildlife agencies have benefited from funds accumulated through the Federal Aid in Wildlife Restoration Act (Pittman-Robertson), the Federal Aid in Sport Fisheries Restoration Act (Dingell-Johnson), and the Aquatic Resources Trust Fund (Wallop- Breaux), to support the conservation and management of game fish and wildlife species. These funds have been critical to the establishment of long-term state agency planning related to game species. Yet conservation efforts for the majority of fish and wildlife species, those that are not hunted or fished, have in large part been opportunistic and crisis-driven, limited by the availability of funding, and by a lack of strategic approaches to species and habitat conservation. With more than 1,000 species now listed on the Federal Endangered and Threatened species list, the need has never been greater for funding and planning to support the conservation, protection, and restoration of the full array of wildlife species, especially those not covered under traditional funding sources.

In 2001 Congress, recognizing this need, began providing annual funding allocations to supplement existing state fish and wildlife conservation programs. Along with this new funding came the responsibility of each state and territory to develop a Wildlife Action Plan. The North Carolina Wildlife Action Plan was submitted to meet that obligation, and in the process, provide a conservation blueprint for agencies, organizations, industries, and academics across the state to advance the sound management of our fish and wildlife resources into the future. Within the document, we identify critical fish and wildlife resources and priority conservation needs associated with those resources. Our Plan is strengthened by all of the local, state, and regional conservation planning efforts that have preceded it; these efforts provided us a foundation upon which to build.
Our Plan promotes proactive conservation measures to ensure cost-effective solutions ("keeping common species common") instead of reactive measures enacted in the face of imminent losses.

Five goals form the core of the Plan: 1) to improve understanding of the species diversity in North Carolina and enhance our ability to make conservation or management decisions for all species, 2) to conserve and enhance habitats and the communities they support, 3) to foster partnerships and cooperative efforts among natural resource agencies, organizations, academia and private industry, 4) to support educational efforts to improve understanding of wildlife resources among the general public and conservation stakeholders, and 5) to support and improve existing regulations and programs aimed at conserving habitats and communities.

In order to meet these goals, we engaged hundreds of people across a broad spectrum of agencies and organizations. We continue to seek the feedback and input of conservation stakeholders.

Key themes that are perpetuated through the document include:

- The need to strengthen partnerships among natural resource agencies, organizations, academics, and individuals in order to meet shared goals and visions,
- The need to impact the landscape in a large-scale fashion, and to consider all components of a sustainable community of plants and animals,
- The need to gather additional information and fill knowledge gaps in order to advance our understanding of species and their habitats,
- The need to work cooperatively with private landowners to influence the conservation of natural resources across the majority of the state, and
- The need to educate and engage local governments, planning commissions, and urban public about the importance of fish and wildlife conservation as a key component of successful land use planning.

The sections of the Plan build on one another in similar fashion to its development. Within the **Approach** section are summaries of key processes and exercises that were carried out in order to develop the Plan, including organizational frameworks, partnerships and stakeholder involvement, and the species prioritization process. Next, in the **State of the State** we provide an overview of the condition of the state's natural resources, threats affecting species and habitats in the state, key conservation partners, and challenges faced in program administration and efficacy. In **Statewide Conservation Strategies** we address four broad-scale conservation issues, including strategies on urban wildlife issues, private lands wildlife management, land conservation priorities, and education and outreach. Following is the most detailed chapter of the report, entitled **Species and Habitat Assessments & Conservation Strategies**. In this chapter, we feature the conservation needs of terrestrial resources within habitats across the three ecoregions of the state (the Southern Blue Ridge, Piedmont, and Mid-Atlantic Coastal Plain), aquatic resources within the 17 river basins in the state, and marine resources at our coast (this section is largely based on the North Carolina Division of Marine Fisheries Coastal Habitat Protection Plan). Next, we address cross-cutting conservation needs among habitats and basins within **Synthesis of Conservation Priorities**. In **Status and Trends Monitoring** we discuss species and habitat monitoring needs. We outline ways to monitor the implementation of conservation activities, adapt to new information, and revise future iterations of the Plan in our final chapter, **Implementation Monitoring, Adaptive Management, & Review and Revision Procedures**. Last, we present **Acknowledgements**, a comprehensive **Glossary**, a **Key to Abbreviations and Acronyms**, and multiple **Appendices**.

This document was developed at the strategic level, meaning that the implementation of activities identified in the Plan must go one step farther to consider the operational details of involving partners, setting explicit objectives and targets, detailing monitoring protocols, etc. We have organized the format and content of the Plan to provide maximum utility as a resource to set conservation priorities. The Plan is designed to flow from beginning to end, but individual chapters and sections can also be used independently, as stand-alone documents. For example, users may turn to a particular habitat or basin section to review priority needs and recommendations pertaining specifically to their region or expertise area (e.g., the Catawba River basin, maritime forest habitat).

We hope that the information provided within each chapter and section translates into clear and objective conservation planning at that level.

Our Plan has been nearly three years in development. The development process was strengthened by the input, feedback, and participation of hundreds of stakeholders across the state (stakeholder representation extended across more than 15 state and federal agencies, 12 non-governmental organizations, five universities, and four private companies). But the completion of this first edition is just the beginning. The Plan is a work in progress, and will continue to evolve during implementation and through future revisions. Though the funding that initiated development of the state Plan continues to be allocated on an annual basis (making long-term planning difficult), there is hope across the nation that our state Strategies will clearly demonstrate to Congress the need for increased and permanent Federal fish and wildlife conservation funding in the future. Regardless of funding sources, the partnerships and collaborative efforts that this Plan fosters should lead to significant accomplishments in the conservation of North Carolina's wildlife resources.

South Carolina

In May of 2002, the South Carolina Department of Natural Resources (SCDNR) began a process to develop the Comprehensive Wildlife Conservation Strategy (CWCS) that was funded through the State Wildlife Grants (SWG) program. The SCDNR committed to developing the Strategy and begin implementing the conservation actions by October 1, 2005. The goal of the Strategy is to emphasize a cooperative, proactive approach to conservation while working with federal, state and local governments; local businesses; and conservation-minded individuals to join in the effort of maintaining the fish and wildlife resources of South Carolina.

In order to sustain South Carolina's diverse wildlife resources in the future, the following actions are critical: (1) increase baseline biological inventories with emphasis on natural history, distribution and status of native species; (2) increase commitment by natural resource agencies, conservation organizations and academia toward establishing effective conservation strategies; (3) increase financial support and technological resources for planning and implementation of these strategies; and (4) create public-private partnerships and educational outreach programs for broad-scale conservation efforts. South Carolina's CWCS is a first step toward instituting these actions.

The diversity of animals in South Carolina is vast. Habitats in this state range from the mountains to the ocean and include many different taxonomic animal groups. SCDNR wanted to address as many of those groups as possible for inclusion in the list of priority species for the CWCS; as such, twelve taxonomic groups are included in the Strategy: mammals, birds, reptiles, amphibians, freshwater fishes, diadromous fishes, marine fishes, marine invertebrates, crayfish, freshwater mussels, freshwater snails, and insects (both freshwater and terrestrial).

The SCDNR identified 1,240 species to include on the state's Priority Species List. Reports were prepared for each species, guild or indicator; in these reports, authors described the species, their status, population and abundance, habitat needs, challenges, conservation accomplishments and conservation actions. This approach allows for identification of both general conservation strategies for wildlife and habitats in South Carolina, as well as development of species-based conservation strategies. The latter allows for management of particular species within a given habitat. A separate volume, **Supplemental Volume: Species and Habitat Accounts**, contains these reports in their entirety. The SCDNR also identified habitats critical for the priority species considered in the CWCS. Both terrestrial and aquatic habitats were considered and reports were prepared for 38 habitats (terrestrial and marine) organized within five ecoregions, as well as 13 ecobasins, which characterize the freshwater aquatic habitats of the state. These reports are also presented in the Supplemental Volume.

As conservation strategies were developed for each species, it became evident that they could be separated into eight categories, which we have designated as Conservation Action Areas (CAAs). These eight CAAs are: Education and Outreach; Habitat Protection; Invasive and Nonnative Species; Private Land Cooperation; Public Land Management; Regulatory Actions; Survey and Research Needs; and Urban and Developing Lands. Within each CAA, conservation actions were condensed from the recommendations prepared for each animal on South Carolina's Priority Species List. Some of the actions identified will affect all species included in the CWCS; others may affect only a few species. Each of these actions was prioritized and measures that indicate success of implementing the action were identified.

It is also critical that we monitor priority species, their habitats and the effectiveness of the actions that are implemented to conserve them. With the information gathered in this program, project leaders will be required to produce annual progress reports for review by a steering committee and the CWCS coordination team. These reports will be evaluated for insight into adaptive management needs and reassessments of the CWCS.

From the beginning of the CWCS effort, SCDNR and the planning team sought to realize successful partnerships and public involvement in the development of the strategy. It is understood that successful conservation is furthered by the existence of a strong collaborative involvement between all resource stakeholders, private or public, governmental or nongovernmental. Task forces were convened to assist in determining important natural resource issues in South Carolina. Taxa teams were assembled to determine challenges to species and conservation actions to address those challenges. Public meetings were held to gather input from the citizens of the state. Prior to submission of the CWCS, the SCDNR began creating Conservation Action Committees around the CAAs identified above; two of these committees have convened and have begun working toward identifying statewide strategies for species and habitat conservation. Partnerships will continue to be critical in implementing the actions identified in South Carolina's CWCS.

Georgia

In December 2002 the Wildlife Resources Division (WRD) of the Georgia Department of Natural Resources (DNR) began a process to develop a comprehensive wildlife conservation strategy. Through the Wildlife Conservation and Reinvestment Program, WRD made a commitment to develop and begin implementation of this comprehensive wildlife conservation strategy (CWCS) by October 1, 2005. Funding for this planning effort came from a federal grant to WRD through the State Wildlife Grant program; matching funds were provided through Georgia's Nongame Wildlife Conservation Fund.

The goal of the strategy is to conserve Georgia's animals, plants, and natural habitats through proactive measures emphasizing voluntary and incentive-based programs on private lands, habitat restoration and management by public agencies and private conservation organizations, rare species survey and recovery efforts, and environmental education and public outreach activities.

The best available wildlife data were used to develop this CWCS. The strategy included an assessment of habitats required by these species, as well as problems affecting these habitats. Further, this strategy addressed research and survey needs, habitat restoration needs, and monitoring needs. It also included an evaluation of existing programs and policies for wildlife conservation in Georgia and recommendations for improvements in these areas. Coordination with other organizations that manage land or administer conservation programs in Georgia was a key component of this effort.

The planning process involved staff within DNR, representatives of private and public conservation organizations and land managers and owners in Georgia. A Steering Committee composed of representatives of various agencies, organizations, and land management groups provided project oversight. Technical teams addressed specific components of the conservation strategy; these teams included WRD staff and representatives of other agencies and organizations. Input from the Steering Committee, stakeholders, representatives of other conservation organizations, consulting biologists, academic researchers, and the public was used in the development of the conservation strategy. Educational materials were developed to inform the public about the project's goals and milestones; these materials were posted on a website developed specifically for this project and distributed at public meetings.

Components of this planning effort included: 1) development of databases on rare species and natural communities; 2) identification of high priority species and habitats; 3) identification of high priority research and biological inventory needs; 4) surveys for rare species on public and private lands; 5) development of databases of conservation lands and high priority watersheds and landscapes; 6) prioritization of conservation, education, and habitat protection needs; 7) collaboration with state and federal agencies on habitat protection/restoration plans; 8) technical assistance to private conservation organizations and local governments; 9) review of existing conservation laws, rules, and policies; and 10) public input and educational outreach.

Three technical teams focused on biodiversity database development and use, GIS/mapping support and land cover assessments, and environmental education, respectively. The GIS support team developed and distributed a survey to WRD staff to determine priority needs for geographically based dataset needs. Team members also reviewed the land cover database produced by the Georgia Gap Analysis Program, continued development of a statewide conservation lands database, and produced land cover and vegetation maps. The database support/enhancements team discussed uses of biological diversity data. This team developed specific recommendations for exchange and application of biodiversity information, including improved Web-based access to rare species/natural community information, region-specific rare species datasets for WRD law enforcement personnel, and watershed-based datasets. The environmental education team developed recommendations for improvements in wildlife-related education programs, and was assisted by the Environmental Education Alliance of Georgia.

Six technical teams focused on the following groups of species: birds, amphibians and reptiles, mammals, fishes and aquatic invertebrates, terrestrial invertebrates, and plants.
Although conservation efforts for plants could not be addressed under this grant, a parallel conservation planning process was undertaken, funded in part through a federal grant to the Wildlife Resources Division, with matching funds provided from the Nongame Wildlife Conservation Fund. These technical teams consulted numerous data sources and used a variety of criteria to identify high priority species for Georgia; these included critically imperiled species, habitat indicator species known to be in decline, species endemic to Georgia, and rare or uncommon species in need of further research to determine conservation objectives.

Results of the various biological and ecological assessments undertaken in this planning effort are presented in this document. Many of the details of these analyses can be found in the appendices that follow the main report. Ranges of distribution, habitat associations, conservation needs, and research priorities for 296 species of high priority animals and 323 species of high priority plants are outlined in Section IV and in appendices A and B. Similarly, high priority habitats are defined for each ecoregion and management needs for these habitats are discussed in Section IV and Appendix C.

In this document, conservation goals are defined broadly, while discussions of strategies and partnerships more specifically address the objectives that must be met to achieve these goals. Conservation goals, strategies and partnerships are identified for each of the five ecological regions of the state in Section IV of this report. In addition, statewide wildlife conservation themes and strategies are addressed in Section V. Lists of specific high priority conservation actions were also developed. These conservation actions were first identified by the technical teams, Steering Committee, and other stakeholders and included specific programs for improvements in habitat protection, conservation of high priority habitats and species, research and surveys, and environmental education and public outreach. These identified conservation actions were then evaluated by the Steering Committee using a set of seven ranking criteria. The complete set of 78 prioritized conservation actions can be found in Appendix L of this report. Summaries of existing programs and resources for habitat protection and recommendations to increase capacity for wildlife conservation in Georgia are provided in Section V of this document.

The following goals represent important conservation themes in this document:

- Maintain known viable populations of all high-priority species and functional examples of all high priority habitats through voluntary land protection and incentive-based habitat management programs on private lands and habitat restoration and management on public lands.
- Increase public awareness of high priority species and habitats by developing educational messages and lesson plans for use in environmental education facilities, local schools, and other facilities.
- Facilitate restoration of important wildlife habitats through reintroduction of prescribed fire, hydrologic enhancements, and vegetation restoration.
- Conduct statewide assessments of rare natural communities and habitats that support species of conservation concern.
- Improve efforts to protect vulnerable and ecologically important habitats such as isolated wetlands, headwater streams, and caves.
- Combat the spread of invasive/noxious species in high priority natural habitats by identifying problem areas, providing technical and financial assistance, developing specific educational messages, and managing exotic species populations on public lands.
- Minimize impacts from development and other activities on high-priority species and habitats by improving environmental review procedures and facilitating training for and compliance with best management practices.
- Update the state protected species list and work with conservation partners to improve management of these species and their habitats.
- Conduct targeted field inventories of neglected taxonomic groups, including invertebrates and nonvascular plants.
- Continue efforts to recover federally listed species through implementation of recovery plans, and restore populations of other high priority species.
- Establish a consistent source of state funding for land protection to support wildlife conservation, and increase availability and use of federal funds for land acquisition and management.
- Continue efforts to monitor land use changes statewide and in each ecoregion, and use predictive models to assess impacts to high priority species and habitats.

Monitoring needs for species, habitats, and conservation programs are also addressed in Sections IV and V of this document. Monitoring programs are acknowledged as critical components of adaptive management efforts in wildlife conservation, and specific recommendations are provided to improve existing monitoring programs. In addition, partnerships with other organizations involved in monitoring efforts are recommended.
Specific high priority monitoring projects are mentioned in the body of the report and in Appendix L. The approach taken in this planning effort was to identify the types of data to be collected and relevant performance indicators for every high priority conservation action as a first step to development of monitoring programs.

Several projects undertaken as components of this planning project represent efforts to develop new analytical tools and methods that can inform future conservation plans at various geographic scales. A pilot project to develop historic vegetation maps was completed by researchers at the University of Georgia. Using land lot survey data from the 1800s, researchers developed historic vegetation maps for three state-owned wildlife management areas. This pilot project produced analytical tools and data that will facilitate development of habitat management plans for public lands. A second pilot project utilized land cover data from the Georgia Gap Analysis Program and occurrence data for rare and declining species to identify regions of the state that may represent important areas for conservation work in the future. These two projects are described in appendices J and K, respectively.

Project staff began development of a new natural community classification system that will serve as a standard for habitat mapping on public lands. The new classification system is based on ecosystems and vegetation alliances described by NatureServe and the Natural Heritage Network. WRD staff also collaborated with a group of volunteers working on a detailed guide to Georgia's natural environments. This document will be based on the NatureServe ecosystem classification and written for a broad audience including teachers, science students, and practicing biologists. Development of this document will facilitate mapping and tracking of natural communities consistently across the state and increase public awareness of Georgia's ecosystems.

Public involvement in the development, review and revision of this document was facilitated by a series of fourteen public meetings undertaken over the project period.
These included regional stakeholder meetings as well as traditional public meetings. In addition, public input was solicited through materials posted on the CWCS website, news releases, brochures, fact sheets, and presentations given to various groups and organizations around the state. These public outreach efforts will continue as we begin to implement the conservation strategy.

The CWCS reflects an assessment of wildlife conservation needs and programs to address those needs based on data available in 2003-2005. Our understanding of the conservation needs of Georgia's species and habitats is likely to change based on the result of additional surveys, results of monitoring efforts associated with management efforts, or new trends in land uses. In addition, the development of new analytical techniques, funding programs, or legislative mandates may result in a need to reassess some of the conservation priorities described in this document.

The intent of the Wildlife Resources Division is to begin a formal process of reviewing the current wildlife conservation strategy within the next five years and to adopt revisions to the strategy as deemed necessary based on this review. In order to do this, we propose to reconvene the technical teams and Steering Committee and hold public meetings to assess and address changing conservation needs for species and habitats in Georgia. The proposed procedure for this review is outlined in Section VI of this document.

The first piece of legislation to be approved by the 2005 session of Georgia General Assembly was the Georgia Land Conservation Act and on April 14, 2005, Governor Perdue signed into law this important piece of legislation. The bill enjoyed overwhelming public and legislative support and was generally lauded throughout the state. The intent of the Act is to provide funding options and a flexible administrative framework to conserve land resources, recognize the values of the State's natural and cultural resources, and promote land conservation partnerships.

The Wildlife Resources Division of the Georgia Department of Natural Resources views this new state land conservation program as an important and timely component of the Comprehensive Wildlife Conservation Strategy that will aid significantly in its implementation. This Act directs some $100 million for land conservation efforts in the state of Georgia and makes available $45 million in state and private funding that can and will be used to match and leverage various federal wildlife conservation grants consistent with the strategies and priorities included in this document.

The changes that are occurring in the Georgia landscape as a result of population growth and increasing development pressures present daunting challenges to those involved in wildlife conservation. The trend of increasing fragmentation and degradation of natural habitats is likely to continue in the coming decades, driven by local, national, and global economic and demographic factors. Many scientists believe that the next fifty years will be a critical period in the struggle to protect our remaining biological resources.

The following elements are critical for conservation of Georgia's natural heritage: (1) increased emphasis on field research focused on the identification and assessment of species, biotic communities, and ecosystems; (2) greater commitment of resources to identify and protect those habitats that contribute most significantly to biodiversity; (3) further development and funding of conservation programs that emphasize public-private partnerships for broad-scale conservation of "working landscapes"; (4) greater emphasis on land use planning to minimize impacts of future developments on natural habitats; and (5) increased collaboration between researchers and educators to heighten public awareness of the magnitude and significance of biodiversity decline in the state. The Department of Natural Resources will continue to work with a wide array of public agencies, private conservation organizations, research institutions, sportsmen's groups, educators, local governments, and landowners in the coming years to address these critical elements of wildlife conservation.

Florida

The primary support and focus for wildlife conservation and management within the United States historically has come from state hunting and fishing interests and Federal Assistance programs for game species under the Pittman–Robertson, Dingle–Johnson, and Wallop–Breaux Acts. Additionally, the Endangered Species Act has provided support to recover federally threatened and endangered species. Although these programs have been successful, the majority of wildlife species have unmet conservation needs and many are at risk of becoming imperiled.

Waiting until a species is on the verge of extinction and then trying to recover it is costly and results in the inevitable loss of some species. To encourage a new conservation paradigm and work towards managing species before they become imperiled, the U. S. Congress created the State Wildlife Grants Program. This program is dedicated to a holistic approach that includes all species, but is centered on conservation of species that have not fallen under historical efforts.

As a requirement of participating in the State Wildlife Grants Program, the Florida Fish and Wildlife Conservation Commission (FWC) has joined the other 55 states, territories, and district by committing to develop a Comprehensive Wildlife Conservation Strategy (Strategy) for the state.

To meet the intent of the State Wildlife Grants Program, the FWC has created Florida's Wildlife Legacy Initiative (Initiative). The goal of the Initiative is to develop a strategic vision for conserving all of Florida's wildlife. The three main objectives of the Initiative are: (1) to create partnerships for wildlife conservation across the State of Florida; (2) to support partnership building and use of the Strategy by making funding available through Florida's State Wildlife Grants Program; and (3) to develop and implement Florida's Strategy. Thousands of experts and stakeholders have participated and provided input to meet these objectives. These partners, including representatives from other state and federal agencies, organizations, businesses, and individuals, have been integral throughout the Strategy development process.

As discussions and work have progressed on planning, development, and implementation of Florida's Wildlife Legacy Initiative, several major premises have been employed and incorporated throughout the Strategy:

- The goal of Florida's Strategy is to build a blueprint and action plan for conserving the vast array of wildlife that makes Florida such a unique place to live and visit. This blueprint should be compatible with human needs and not preclude recreational or other use of wildlife resources and landscapes.
- Florida already has developed and implemented significant wildlife resource management tools and programs. The Strategy has been designed to build upon these efforts in a cumulative manner, identify gaps and further needs, and create a comprehensive vision for coordinating efforts across the state.
- Florida's Strategy uses a habitat category approach to arrange wildlife species and habitats, and the conservation threats and actions needed to conserve them, into meaningful and manageable categories. By taking actions that sustain the health and integrity of the habitat categories, the broad array of wildlife that lives within each will be conserved and maintained.
- The Strategy encompasses the entire state and therefore is too broad for any one individual, group, or agency to develop and implement. Coordination and cooperation among federal and state agencies, local governments, Native American tribes, non-governmental organizations, private entities, and individuals is essential.
- A non-regulatory approach is paramount to create partnerships for implementation of actions needed to conserve wildlife. The Strategy focuses on voluntary and cooperative efforts providing a starting point to develop non-regulatory mechanisms. The Strategy is not regulatory in nature and is not intended to be used in a regulatory manner.
- Meeting the needs of wildlife will mean a healthier environment for future generations of Floridians. Florida faces a huge challenge to meet the needs of an expanding human population while conserving wildlife resources.
- Education has played a vital role in conservation of Florida's wildlife and other natural resources. Support for conservation education is needed to promote awareness, responsible action and behavior.

- The Strategy should clearly meet or exceed the eight elements required under the State Wildlife Grants Program and federal guidance.

The Strategy is organized in chapters, which follow a progression of thought and content development. The **Introduction**, **Approach**, and **State of the State** form the beginning section of the Strategy. The **Introduction** briefly outlines what the effort is and provides context for how it has been undertaken in Florida. The **Approach** summarizes the processes that were carried out in order to develop the Strategy, including organizational structure and methods specific to each Strategy requirement. The **State of the State** provides a discussion of Florida's natural resources, including economics, wildlife species, and conservation resources.

Florida's Strategic Vision forms the central section of the Strategy and synthesizes a strategic view for wildlife conservation at the statewide-level. Priority conservation issues are addressed in this chapter, including species, habitats, threats, actions, data gaps, monitoring tools, and conservation challenges. Species form the basis for Florida's entire endeavor and focus should continually be placed back upon them as the Strategy is implemented and reviewed. Several habitats have been highlighted for their importance and generally were associated with coastal, wetland, upland pine, reef, and submerged aquatic vegetation areas. Major statewide threats identified include: habitat loss and fragmentation, degradation of water resources, incompatible fire management, invasive plants and animals, and management of the physical environment (e.g., dams, shoreline hardening, dredging, etc.). Major statewide actions developed to abate these threats include: development of incentive-based programs for conservation, acquisition of important lands and waters, coordination of conservation efforts, public education, and development of a cooperative conservation effort. Priority data gaps to be filled focus on improved habitat mapping capability, filling species information needs, improving understanding and methodology for marine systems, and initiation of more efforts related to genetic diversity issues. Monitoring and adaptive management are focused on species, habitat, threat, and overall Strategy levels and will be critical to documenting success and refining efforts. Lastly, key conservation challenges such as partnership development, information management, and public awareness must be met and overcome for efforts to be successful.

The chapters on **Species of Greatest Conservation Need** (SGCN), **Habitats**, and **Multiple Habitat Threats and Conservation Actions** form the final and most extensive section of the Strategy. The SGCN chapter identifies 974 species of interest and lists their status and trends. The Habitats chapter describes 45 terrestrial, freshwater, and marine habitat categories that comprise the state of Florida. These habitat category descriptions include information on their status and trends, associated SGCN, related threats, and conservation measures needed. Additionally, the chapter **Multiple Habitat Threats and Conservation Actions** lists threats that apply to greater than five habitats and the suite of actions to abate each threat. Last, the Strategy contains **Acknowledgements**, **References/Literature Cited**, a **Glossary of Acronyms**, a **Glossary of Terms**, and four **Appendices**.

Florida's Strategy is a strategic vision of the integrated conservation efforts needed to sustain the broad array of wildlife in the state. More detailed operation-level plans will be needed to complete many of the actions identified in the Strategy. Such plans should be developed by the appropriate entities whose interest, authority, or responsibility encompass each action. Although the Strategy is not intended to be a work or management plan for the FWC or any other organization, support provided by the State Wildlife Grants Program will enable coordination and implementation of many projects through Florida's Wildlife Legacy Initiative. The Strategy is a work in progress that will continually be updated, revised, and improved based on the input and deliberations of all those interested in wildlife conservation. Working together, Floridians can shape a future that is filled with the wonderful wildlife resources that define this great state and provide for the enjoyment, recreation, sustenance, and livelihood of its citizens and visitors.

Acropora Status

(Source: http://www.nmfs.noaa.gov/pr/species/invertebrates/elkhorncoral.htm)

ESA Threatened - throughout its range

Taxonomy
Kingdom: Animalia
Phylum: Cnidaria
Class: Anthozoa
Order: Scleractinia
Family: Acroporidae
Genus: *Acropora*
Species: *palmata*

Species Description
Elkhorn coral is a large, branching coral with thick and sturdy antler-like branches.

The dominant mode of reproduction for elkhorn coral is asexual, with new colonies forming when branches break off of a colony and reattach to the substrate. Sexual reproduction occurs via broadcast spawning of gametes into the water column once each year in August or September. Individual colonies are both male and female (simultaneous hermaphrodites) and will typically release millions of "gametes".

The coral larvae (planula) live in the plankton for several days until finding a suitable area to settle, but very few larvae survive to settle and metamorphose into new colonies. The preponderance of asexual reproduction in this species raises the possibility that genetic diversity may be very low in the remnant populations.

Colonies are fast growing: branches increase in length by 2-4 inches (5-10 cm) per year, with colonies reaching their maximum size in approximately 10-12 years. Over the last 10,000 years, elkhorn coral has been one of the three most important Caribbean corals contributing to reef growth and development and providing essential fish habitat.

Habitat
Elkhorn coral was formerly the dominant species in shallow water (3 ft-16 ft (1-5 m) deep) throughout the Caribbean and on the Florida Reef Tract, forming extensive, densely aggregated thickets (stands) in areas of heavy surf. Coral colonies prefer exposed reef crest and fore reef environments in depths of less than 20 feet (6 m), although isolated corals may occur to 65 feet (20 m).


Elkhorn Coral Critical Habitat

NMFS designated critical habitat for elkhorn and staghorn corals in November 2008 in four areas: Florida, Puerto Rico, St. John/St. Thomas, and St. Croix.


Elkhorn Coral with White Band Disease
(Acropora palmata)

Photo: Andy Bruckner, NOAA

Distribution

Elkhorn coral is found on coral reefs in southern Florida, the Bahamas, and throughout the Caribbean. Its northern limit is Biscayne National Park, Florida, and it extends south to Venezuela; it is not found in Bermuda. Once found in continuous stands that extended along the front side of most coral reefs, the characteristic "*Acropora palmata* zone" supported a diverse assemblage of other invertebrates and fish. These zones have been largely transformed into rubble fields with few, isolated living colonies.

Population Trends

In areas where loss has been quantified, estimates are in the range of 90-95% reduction in abundance since 1980. Additional drastic reductions (e.g., 75-90%) were recently observed in some areas such as the Florida Keys in 1998 due to bleaching and hurricane damage.

Threats

Since 1980, populations have collapsed throughout their range from disease outbreaks with losses compounded locally by hurricanes, increased predation, bleaching, elevated temperatures, and other factors. This species is also particularly susceptible to damage from sedimentation.

The dominant mode of reproduction for elkhorn coral is asexual fragmentation; this life history trait allows rapid population recovery from physical disturbances such as storms. However, this mode of reproduction makes recovery from disease or bleaching episodes (in which entire colonies or even entire stands are killed) very difficult. The large role of asexual reproduction for this species increases the likelihood that genetic diversity in the remnant populations may be very low. Scientists are becoming increasingly concerned for this species based on its demographic paramaters; specifically, how species recruitment and genetic diversity affect recovery potential.

Conservation Efforts

Elkhorn Coral
(Acropora palmata)
Photo: Andy Bruckner, NOAA

Elkhorn Coral
(Acropora palmata)
Photo: Jordan T. Wilkerson

Florida Keys National Marine Sanctuary (FKNMS), the largest coral reef management entity in the region, has developed a management plan for the Sanctuary's corals that includes protective activities, such as zoning, channel markings, and restoration efforts.

Restoration activities have included efforts to re-attach *Acropora* fragments generated by ship groundings and hurricane events; these efforts have had mixed success. Similar efforts to re-attach coral fragments have also been made in Puerto Rico and the U.S. Virgin Islands.

Other restoration efforts have included attempts to culture and settle coral larvae with very limited success. New techniques for restoring *Acropora* are currently being pursued. Such new techniques involve enhancing sexual recruitment, reestablishing ecological roles within reef systems (e.g. herbivorous urchins), and other methods for controlling predators and disease.

In 1998, the United States Coral Reef Task Force was established by Presidential Executive Order 13089 to coordinate and strengthen efforts for protecting coral reef ecosystems. The Task Force is co-chaired by the Departments of Commerce and Interior, and includes leaders of 12 federal agencies, seven U.S. states and territories, and three freely associated states. In 2002, the Task Force adopted a resolution calling for the development of Local Action Strategies, which are locally-driven plans for collaborative and cooperative action among federal, state, territory, and non-governmental partners to reduce key threats on valuable coral reef resources. Three Local Action Strategies have been developed within the range of elkhorn coral for Florida, Puerto Rico, and the U.S. Virgin Islands. These strategies are underway and will be implemented over a three-year period (FY2005-2007).

Regulatory Overview

On March 4, 2004, the Center for Biological Diversity petitioned NOAA's National Marine Fisheries Service (NMFS) to list elkhorn (*Acropora palmata*), staghorn (*A. cervicornis*), and fused-staghorn (*A. prolifera*) coral under the Endangered Species Act (ESA). On June 23, 2004, NMFS found that listing these species may be warranted [pdf] and initiated a formal review of their biological status. NMFS convened the Atlantic *Acropora* Biological Review Team (BRT) to summarize the best available scientific and commercial data available for these species in the status review report.

The BRT completed the status review [pdf] [4.9 MB] on March 3, 2005. On March 18, 2005, NMFS determined that elkhorn and staghorn corals warrant listing [pdf] as "threatened" species under the ESA. However, NMFS also concluded that listing fused-staghorn coral is not warranted, as it is a hybrid and does not constitute a species as defined under the ESA. On May 9, 2005, NMFS proposed adding elkhorn and staghorn coral to the Endangered Species list [pdf].

NMFS finalized the ESA listing of elkhorn and staghorn coral on May 4, 2006 (71 FR 26852 [pdf]). More information can be found in the press release [pdf] of the final listing.

NMFS designated critical habitat for elkhorn and staghorn corals in November 2008..

NOAA Fisheries

General fact sheet
Atlantic *Acropora* corals

What is a coral?

Staghorn coral (*A. cervicornis*)

Corals are colonial invertebrates that excrete a calcium carbonate skeleton. There are two main types of corals: hermatypic, which produce reefs and are only found in tropical regions, and ahermatypic, which do not produce reefs and are found worldwide.

Most hermatypic corals host symbiotic (living together) algae, which live inside their tissue. The algae are called zooxanthellae. Zooxanthellae give corals their color and need sunlight for photosynthesis. They provide food to the coral and remove some of the corals waste products. In return the coral provides protection and access to light.

What do corals do?

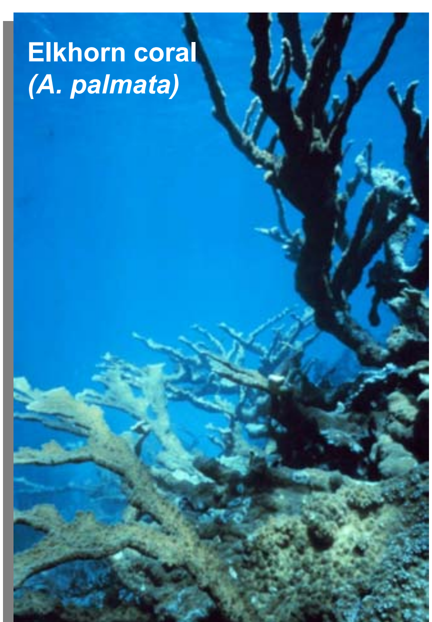
Corals provide habitat for reef fish and invertebrates. They also increase biological diversity. Corals reefs form a barrier along coasts and around islands offering shoreline protection from storms. Coral reefs support fishing, scuba diving, boating, and other recreational activities, as well as subsistence and commercial extraction that generate billions of dollars per year worldwide.

What is *Acropora*?

The *Acropora* genus is the most abundant and species-rich group of corals in the world. Only three species exist in the Atlantic/Caribbean region, Staghorn coral (*Acropora cervicornis)*, Elkhorn coral (*A. palmata)*, and Fused staghorn (*A. prolifera)*, a hybrid of the two. Acroporids are branching corals. These three coral species were the dominant reef building species throughout Florida and Caribbean.

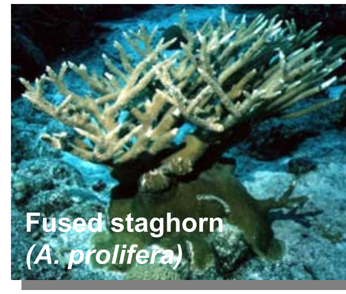
Where are the Atlantic Acroporids found?

Atlantic acroporids are found typically in shallow water on reefs throughout the Bahamas, Florida and the Caribbean. Acroporids live in high-energy zones, with a lot of wave action. Too much wave action (major storms) can cause branching corals to break. However, fragmentation via branch breakage is one method of reproduction for acroporids.



Elkhorn coral (*A. palmata*)

NOAA Fisheries


Fused staghorn (*A. prolifera*)

What salinity do *Acroporids* require?

Although some corals can tolerate extremes, most acroporids require normal marine salinity (33-37‰).

What temperatures do *Acroporids* need to survive?

Acroporids are typically found in water temperatures from 66°F to 86°F. Some degree of stress is experienced at water temperatures greater than 2-3°F cooler or warmer than normal for an extended period.

Do *Acroporids* need sunlight?

Corals depend on the symbiotic zooxanthellae for food. Zooxanthellae need sunlight to photosynthesize. Runoff from land deposits nutrients, which trigger algal blooms, and sediments onto the reef that cloud water. Without sufficient light, the photosynthetic rate is reduced and with it the amount of nutrition produced by the zooxanthellae and the ability of corals to secrete calcium carbonate and build reefs. For branching corals, the optimum range is 60-100 percent of tropical sunlight. Corals grow best in clear water free from excess nutrients, runoff, or algal blooms. Acroporids are particularly sensitive to sediment, as they are among the least effective of the reef-building corals at trapping and removing sediment from their surface. On the other hand, excessive ultraviolet (UV) light may lead to bleaching.

What is coral bleaching and what causes it?

Bleaching is the temporary or permanent loss of zooxanthellae (symbiotic algae) from the coral. Many types of physiological stress can cause coral bleaching (e.g., UV, excessively warm or cold water temperatures, in some cases bacterial infection, etc.). However, the recent mass bleaching events are caused by warm water temperatures and have caused widespread coral mortality on coral reefs throughout the world,

What things negatively affect *Acroporids*?

There are many stresses affecting acroporids, both natural and human-induced. Land based sources of pollution, such as runoff, sewage discharge, dredging and coastal development can increase nutrient levels, sediment loading and turbidity. Runoff can also reduce oxygen levels and possibly introduce pathogens. Excess nutrients allow large fleshy algae (macroalgae) to proliferate and overgrow corals. Pathogens may cause diseases in corals such as white-band disease and white pox/patchy necrosis, which are thought to be two of the most significant causes of mortality to Atlantic acroporids. Climate change, associated with increased water temperature and elevated light levels, may cause bleaching, reduced coral growth rates and deposition rate of their calcium carbonate skeleton. Overfishing and disease have caused a reduction in number of important predatory fishes such as groupers and herbivores (plant eaters) such as parrotfish. Reduction in number to predatory fishes can possibly lead to an increase in organisms that prey on acroporids, such as the short coral snail, fireworm, and damselfish. Furthermore, without a healthy herbivorous fish population, macroalgae growth limits the recovery of stressed corals and the settlement of new baby corals to replace those that have been lost from disease, bleaching, predation and overgrowth.

NOAA Partners in *Acropora* Research, Monitoring, and Conservation

Atlantic and Gulf Rapid Reef Assessment (AGRRA)
Caribbean Coastal Marine Productivity Network (CARICOMP)
Coral Disease and Health Consortium (CDHC)
Florida Marine Research Institute (FMRI)
Louisiana State University (LSU)
National Center for Caribbean Coral Reef Research (NCORE)
National Coral Reef Institute (NCRI)
National Park Service (NPS)
U.S. Geological Survey – Biological Resources Division (USGS–BRD)
University of Miami
University of Puerto Rico
University of the Virgin Islands

FISHERY ECOSYSTEM PLAN OF THE SOUTH ATLANTIC REGION
VOLUME III: SOUTH ATLANTIC HUMAN AND INSTITUTIONAL ENVIRONMENT

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ABBREVIATIONS AND ACRONYMS

ABC	Acceptable Biological Catch
ACCSP	Atlantic Coastal Cooperative Statistics Program
ACE	Ashepoo-Combahee-Edisto Basin National Estuarine Research Reserve
APA	Administrative Procedures Act
AUV	Autonomous Underwater Vehicle
B	A measure of stock biomass either in weight or other appropriate unit
B_{MSY}	The stock biomass expected to exist under equilibrium conditions when fishing at F_{MSY}
B_{OY}	The stock biomass expected to exist under equilibrium conditions when fishing at F_{OY}
B_{CURR}	The current stock biomass
CEA	Cumulative Effects Analysis
CEQ	Council on Environmental Quality
CFMC	Caribbean Fishery Management Council
CPUE	Catch per unit effort
CRP	Cooperative Research Program
CZMA	Coastal Zone Management Act
DEIS	Draft Environmental Impact Statement
EA	Environmental Assessment
EBM	Ecosystem-Based Management
EEZ	Exclusive Economic Zone
EFH	Essential Fish Habitat
EFH-HAPC	Essential Fish Habitat - Habitat Area of Particular Concern
EIS	Environmental Impact Statement
EPAP	Ecosystem Principles Advisory Panel
ESA	Endangered Species Act of 1973
F	A measure of the instantaneous rate of fishing mortality
$F_{30\%SPR}$	Fishing mortality that will produce a static SPR = 30%.
$F_{45\%SPR}$	Fishing mortality that will produce a static SPR = 45%.
F_{CURR}	The current instantaneous rate of fishing mortality
FMP	Fishery Management Plan
F_{MSY}	The rate of fishing mortality expected to achieve MSY under equilibrium conditions and a corresponding biomass of B_{MSY}
F_{OY}	The rate of fishing mortality expected to achieve OY under equilibrium conditions and a corresponding biomass of B_{OY}
FEIS	Final Environmental Impact Statement
FMU	Fishery Management Unit
FONSI	Finding Of No Significant Impact
GOOS	Global Ocean Observing System
GFMC	Gulf of Mexico Fishery Management Council
IFQ	Individual fishing quota
IMS	Internet Mapping Server
IOOS	Integrated Ocean Observing System
M	Natural mortality rate

MARMAP	Marine Resources Monitoring Assessment and Prediction Program
MARFIN	Marine Fisheries Initiative
MBTA	Migratory Bird Treaty Act
MFMT	Maximum Fishing Mortality Threshold
MMPA	Marine Mammal Protection Act of 1973
MRFSS	Marine Recreational Fisheries Statistics Survey
MSA	Magnuson-Stevens Act
MSST	Minimum Stock Size Threshold
MSY	Maximum Sustainable Yield
NEPA	National Environmental Policy Act of 1969
NMFS	National Marine Fisheries Service
NMSA	National Marine Sanctuary Act
NOAA	National Oceanic and Atmospheric Administration
NRC	National Research Council
OY	Optimum Yield
POC	Pew Oceans Commission
R	Recruitment
RFA	Regulatory Flexibility Act
RIR	Regulatory Impact Review
SAFE	Stock Assessment and Fishery Evaluation Report
SAFMC	South Atlantic Fishery Management Council
SEDAR	Southeast Data, Assessment, and Review
SEFSC	Southeast Fisheries Science Center
SERO	Southeast Regional Office
SDDP	Supplementary Discard Data Program
SFA	Sustainable Fisheries Act
SIA	Social Impact Assessment
SSC	Scientific and Statistical Committee
TAC	Total allowable catch
T_{MIN}	The length of time in which a stock could rebuild to B_{MSY} in the absence of fishing mortality
USCG	U.S. Coast Guard
USCOP	U.S. Commission on Ocean Policy
VMS	Vessel Monitoring System

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5.0 The Human Environment in the South Atlantic

5.1 Coastal Communities in the South Atlantic

This description of potential fishing communities for the U.S. South Atlantic coast includes a compilation of various social indicators that are relevant to fishing, fishermen and fishing communities. These indicators provide baseline information from which assumptions about social impacts might be made regarding future regulatory actions. A number of data sources were used to assemble community profiles, including: the U.S. Census Bureau Decennial census and zip code business patterns; the federal permit system and state permit system. These profiles were bolstered by field visits in many of these communities to confirm the presence of fishing related activity and to interview key informants about the interconnectedness of that activity to the larger economy and culture of the community. This was accomplished using what is called rapid assessment. While this methodology is no substitute for the more in-depth ethnographic methods commonly used by anthropologists in community studies, it was all that was possible under the budgetary constraints of this research. In addition, these data were compiled into a Geographic Information System (GIS) to facilitate data mapping and amalgamation with other GIS data.

5.1.1 Methodology for Defining Fishing Communities

Previous descriptions of fishing communities tied to particular management actions have provided an indication of the difficulties in defining community and a community's relation to fishing dependence (Aguirre International 1996; Impact Assessment, Inc. 1991; NPFMC 1994; Johnson and Orbach 1996). Griffith and Dyer (Aguirre International 1996) developed a typology of fishing community dependence for the Northeast Multi-species Groundfish Fishery (MGF). In that typology, the authors identified indicators of dependence which included specific physical-cultural and general social-geographic indicators, i.e., number of repair/supply facilities; number of fish dealers/ processors; presence of religious art/architecture dedicated to fishing; presence of secular art/architecture to fishing; number of MGF permits; and the number of MGF vessels. Using previous results and rapid appraisal they developed a fishery dependence index score for the five primary ports in the MGF. As a result they were able to document five variables that best predicted dependence upon the MGF: (1) relative isolation or integration of fishers into alternative economic sectors, including political participation; (2) vessel types within the port's fishery; (3) degree of specialization; (4) percentage of population involved in fishery or fishery-related industries; and (5) competition and conflict within the port, between different components of the MGF (Aguirre International 1996).

McCay and Cieri (2000) recently compiled a social and economic profile of the fishing ports and coastal counties of the Mid-Atlantic region. In their study they used a variety of sources for information: (1) federal census and employment data, analyzed for the counties associated with the commercial fisheries of each state; (2) NMFS weigh-out data on 1998 landings, by species, gear-type, and port, together with similar data, by county, from the state of North Carolina; and (3) field visits and interviews. Their approach was to identify fishing communities recognized as "ports" by the port agents of the NMFS.

Detailed community profiles have been conducted in Alaska to understand the impacts of harvest allocation on communities and on fisheries (Impact Assessment, Inc. 1991; NPFMC 1994). These profiles utilized census data, permit data, and other available reports supplemented by ethnographic data collection for each community. The profiles provided baseline data to facilitate social impact assessment for license limitation management of the ground fish and crab fisheries.

Johnson and Orbach (1996) combined several counties into management areas, which reflected many sociological, ecological and environmental differences and the types of fishing found in the various fishing communities. Although they did not attempt to define dependence or specify specific fishing communities, they did contend that management of fisheries would be enhanced if it were to take into consideration the broader social and ecological realities of fishermen's behavior.

More recent research to identify fishing communities has been undertaken in both the Northeast and the Southeast. Hall-Arber et al. (2002) used several approaches in assessing a community's dependence upon fishing. One was a regional model of fishing-related employment compared to alternative employment. Another focused on fishing structure complexity and the degrees of individual communities' gentrification and the third approach used community profiles with detailed port characteristics and stakeholder views on community, way of life, institutions and fisheries management. They conclude that a regional analysis reflects the incorporation of a fishing component into economy of contemporary coastal communities.

In their study of Florida fishing communities, Jacob et al. (2001) used a protocol based on central place theory which combined federal and state fishing permit data and census employment data aggregated at the zip code level to sort population centers and their surrounding hinterlands into central places for the entire state of Florida. Zip code was used for the basic unit of aggregation because it is a geographic identifier for many forms of commercial and recreational fishing data, it is also a relatively small unit of measure, and its boundaries form a service delivery area. To account for the embedded nature of economic linkages in fishing communities, regional economic multipliers for employment were used to estimate the number of jobs that were directly and indirectly related to fishing in each community. Based upon their measure of dependency a small number of coastal communities were determined to be dependent upon fishing. However, using such a dependency measure is not without its drawbacks as concerns about the undercounting of certain occupations within the census data and the inability to satisfactorily measure the recreational sector in terms of its contribution to the local economy are noted.

Because there has been little or no research to document fishing communities in the South Atlantic, this description of communities will use a modified approach similar to that used by Jacob et al. (2002). Although a regional approach is sometimes warranted, it is apparent that in their Florida research (Jacob et al. 2002) some fishing communities became subsumed within the larger service sector economy of Florida's coastal regions, which have been fueled by the rapidly growing tourism and recreation sectors. While it is true that most Floridians do participate in an economy that extends beyond their community, it is likely that the majority of their needs are met within the confines of that place they consider their home or what we are referring to as a community. It is improbable that the same boundary serves as community for all individuals. Therefore we have to assume that based upon certain criteria a pre-determined boundary will encompass an area that captures a sense of community for most of those who live within that boundary. Without extensive ethnographic research into social networks and sense of place, it is impractical to assume that we know the exact boundary around a fishing community. For that reason, in this description there will be no definite boundary assumed, however the fishing community will be understood to exist within a range of boundaries.

Data at the census designated place level (CDP) are used for describing the demographic character of most communities. Where zip code level data only are available (permits, NAIC employment figures), data are compiled for the all zip codes associated with the area identified. A map, which shows the zip code boundary for each CDP, is provided along with the outline of the CDP.

One of the difficulties in using CDP data is that it has been shown that fishermen will often live outside the boundaries of the CDP where their vessel is home ported (Jacob et al. 2001). Data at the CDP level will not always have a direct one to one correspondence with other data such as the fisherman's home zip code or zip code business patterns for fishing employment locations. Therefore data that correspond to one level of place may not correspond to another. Consequently, it is important to understand these differences when undertaking any assessment of impacts to a community. Furthermore, it has been noted that census data often underreport certain groups of people. Recent research (Kitner 2001) has identified coastal communities and fishing communities as being part of those groups who may not be fully represented by census data.

Because at this time there are no standard guidelines for delineating the boundaries of a fishing community, this description will combine data from different levels and concepts of place (zip code, homeport and Census Designated Place). Each, in its own way, may represent some part of a fishing community, but none will represent the community in its entirety. Such boundaries cannot be determined without extensive research, as mentioned before. The data presented here will highlight the differences in the types of data used in determining the boundaries of a community and any such impacts that might ensue.

5.1.2 Census Demographic and Employment Data Caveats

When using census data it is important that certain caveats be made clear. As mentioned previously, census data has been notorious for underreporting certain groups of people who are difficult to locate and therefore are often not reported in the census. Commercial fishermen are part of that group as outlined in recent research by Kitner (2001). For that reason, it must be assumed that census data as it relates to fishing communities underreports employment and participation in work related to commercial fishing. As was pointed out in earlier research (Jacob et. al. 2001) any attempt at quantifying employment or income from commercial or recreational fishing becomes problematic. Data may be suppressed or grossly underreported and therefore any description will miss important economic and social contributions of fishing related businesses.

At the same time, census data is the only demographic data that can be applied over large geographic areas and population ranges. It is easily available and represents the most affordable alternative for describing any community at this time. Although these data are suspect, it can only be assumed that any underreporting is consistent across geographic area and population range. Although this situation is not ideal, by combining several different data from various sources, a general description of community and the fishing activity associated with it may be attained. Until more detailed ethnographic research that can examine the social and economic networks that exist in fishing communities can be undertaken, this general and often broad description of community will have to suffice.

Census demographic data were collected for communities and appear under each community description. Those data include the following variables for each community: total population by age; educational attainment; race; industry; occupation; average wage or salary; poverty status. These data were collected for census years 1970, 1980, 1990, and 2000. Census data for the first three decades were compiled using the MARFIN Socioeconomic Database created by the Louisiana Population Data Center. The census data for the year 2000 were compiled from the U.S. Census Bureau's American Factfinder Webpage. In using data from the 2000 census there are several caveats that must be noted. The 2000 census was the first year that individuals were allowed more than one choice when deciding race. Therefore, when comparing the category race to the previous three decades, the association will not be consistent. In order to lessen misunderstanding for this description only those categories where one race alone was chosen were used. In other words, those who chose more than one race were not included. This will result in some underreporting for the year 2000 in the tables presented.

Other significant changes in the 2000 census were made to the industry and occupation categories. This was the first decennial census to use the North American Industry Classification Code (NAIC) in replacement of the Standard Industry Code (SIC). In the transition from SIC to the NAIC, many industry and occupation categories were reclassified making it difficult to compare any previous census and the most recent. For the purposes of comparison here, certain industry categories were reclassified and compiled to reflect the best representation of the previous classification used in the preceding census (See Appendix 1 in Jepson et al. 2006). This recoding was done after comparing certain industry classifications which were moved into other categories with the switch to the NAIC from SIC. While admittedly not perfect, this reclassification was necessary to make comparisons of industry changes over time. The task of reclassifying the occupation category was deemed too onerous and therefore the only category reported for 2000 is the Farm, Fish and Forestry category, which did not change and most likely contains the majority of fishing related employment.

Employment data collected by the Census Bureau were also used at the zip code level for the community descriptions. Again, it must be assumed for reasons stated earlier that these data are likely to underreport actual fishing employment. In addition, the category of fishing that is reported in the economic census does not include those individuals who report themselves as self-employed, of which most commercial fishermen consider themselves to be. Therefore, employment figures again grossly distort the actual employment from commercial and recreational fishing. In addition, like Jacob et al. (2001), employment for the recreational sector was difficult to quantify and the marinas sector is once again used to provide some indication of community employment for the recreational sector. It is recognized that this measure is inadequate and is one component of a much larger employment sector.

At the end of each state's community profiles, two tables have been provided to categorize both the attendant fishing infrastructure in those communities, but to also begin a process of determining which of the following communities might warrant further consideration as a fishing community. The information provided in these tables is considered highly subjective based upon the presence or absence of certain criteria and an assessment of other information provided through interviews or historical data. It is therefore suggested that any future determination of fishing community status use these tables cautiously and be judicious in attempting to incorporate any other information that might be available to categorize any of the communities included in this document. It must also be noted that during field research and as part of the management process, other communities have been mentioned for inclusion to be considered as fishing communities and therefore those communities included in this document do not constitute an exhaustive listing of potential fishing communities.

5.1.3 North Carolina Communities with Substantial Fishing Activity

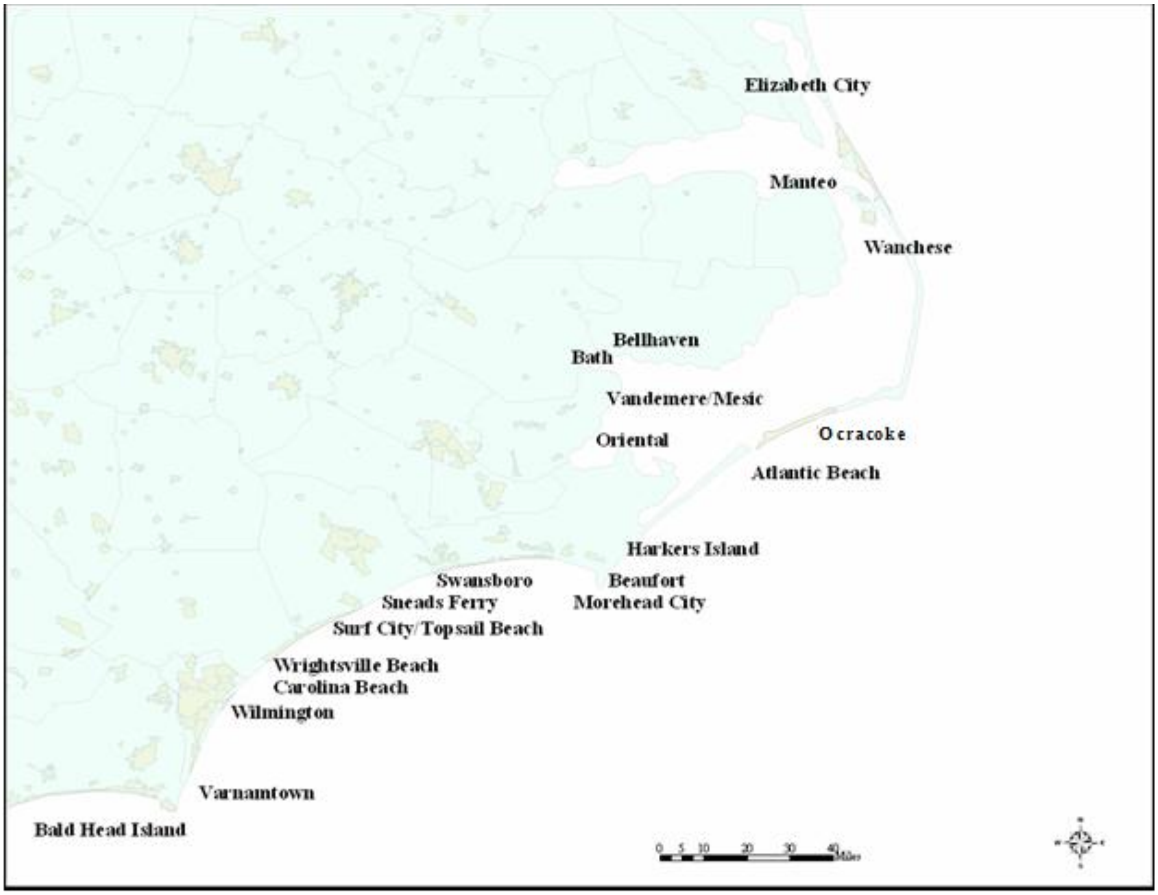

Figure 5.1.3-1. North Carolina Potential Fishing Communities.

According to the National Marine Fisheries Service, North Carolina has landed close to 140 and 160 million pounds of seafood in 2001 and 2002 respectively. Two ports, Wanchese-Stumpy Point, and Beaufort-Morehead City, both rank within the top 50 ports in terms of landings and value for those same years. In 2008, North Carolina vessels with federal permits predominantly held Atlantic dolphin/wahoo commercial (452) , Atlantic dolphin/wahoo charter (330), Atlantic king mackerel (313) or Spanish mackerel (202), or snapper grouper charter/headboat for snapper grouper (287) permits. Figure 5.1.3-1 shows potential fishing communities in North Carolina.

Table 5.1.3-1. Numbers of Federal Permits (October 2008) by Type for North Carolina (Source: NMFS 2008)

Type	Permits
ATLANTIC DOLPHIN/WAHOO COMMERCIAL	452
ATLANTIC DOLPHIN/WAHOO CHARTER/ HEADBOAT	330
S. ATLANTIC CHARTER/HEADBOAT FOR PELAGIC FISH	314
KING MACKEREL	313
SPINY LOBSTER & TAILING	15,23
ROCK SHRIMP & ENDORSEMENTS	76,-16
S. ATL. CHARTER/HEADBOAT FOR SNAPPER-GROUPER	287
SWORDFISH & SHARKS	-,-
S. ATLANTIC SNAPPER-GROUPER (UNLIMITED)	127
S. ATLANTIC SNAPPER-GROUPER (225)	10
SPANISH MACKEREL	202
SOUTH ATLANTIC SHRIMP	168
DEALER	91

There were over 8,600 state licenses sold with capability of sale and over 3,900 reported sales in 2006 (Table 5.1.3-2). The overall number of licenses sold has been decreasing since 2001. The number of licenses reporting sales has been decreasing while the number of licenses without sales has been increasing.

Table 5.1.3-2. Number of licenses sold by the North Carolina Division each license year. The number of licenses with selling privileges that potentially can report catch on trip tickets by license year, and the number of licenses actually used to report catches. Individuals may hold more than one license with selling privileges (**Data Source: NCDMF 2007 Annual Report (Big Book), pp. II-89.)**

License Year	Number of licenses sold*	Number of licenses reporting sales	Number of licenses sold, but did not report sales
1994	6,779	4,820	1959
1994/1995	7,534	6,545	989
1995/1996	7,801	7,148	653
1996/1997	8,175	6,716	1459
1997/1998	8,317	7,009	1308
1998/1999	8,438	6,528	1910
1999/2000	9,711	5,892	3819
2000/2001	9,677	5,802	3875
2001/2002	9,712	5,352	4360
2002/2003	9,494	5,014	4480
2003/2004	9,146	4,717	4429
2004/2005	8,875	4,458	4417
2005/2006	8,645	3,925	4720

*Licenses from 1994 to June 1999 are Endorsement to Sell licenses. Licenses from 1999 to the present include number of SCFL, RSCFL, Shellfish, Menhaden License for Non-Residents without SCFL, Recreational Fishing Tournament License to Sell Fish, and Land or Sell licenses. License year is July to June. Source: 1994-1997/98 license year sales were derived from historical reports. 1998/99-2001/2002 from FIN license sales reports.
**1998/99 was a transition year and not all dBase licenses were migrated to FIN. The numbers provided were from FIN.
***1999/00 to 2001/02 include licenses sold that were subsequently surrendered without a refund.
+1999/2000 license counts were stated as much higher in other documents. This was due to the grace period when switching from ETS to SCFL. The number above is correct.

The majority of license sales are for commercial fishing vessels, with over 8,846permits or 37.5 percent in 2008 (Table 5.1.3-3). Standard commercial fishing license is the next most frequent with 25.2 and recreational commercial gear third at 21.7 percent. There were 737 dealer licenses sold for the year 2008 in North Carolina.

Table 5.1.3-3. Number of State Permits by Type for North Carolina (Source: NCDMF 2008).

Type	Permits	Percent
Commercial Fishing Vessel Registration	8,846	37.5
Fish Dealer License	737	3.1
Land or Sell License	104	.4
License to Land Flounder from the Atlantic Ocean	147	,6
Menhaden License for Non-Resident without SCFL	10	.04
NC Shellfish License without SCFL	1,706	0
Ocean Pier License	20	.1
Recreational Commercial Gear License	5,110	
Recreational Fishing Tournament to Sell License	32	.1
Spotter Plane License	9	0
Retired Standard Commercial Fishing License	912	3.9
Standard Commercial Fishing License	5,948	25.2
Total	23,581	100.0

There has been considerable research conducted with North Carolina fishermen and their communities over time. Johnson and Orbach's research (1996) combined several counties into management areas which reflected many sociological, ecological and environmental differences. Those differences were related to the different types of fishing found in the various communities. Although they did not attempt to specify specific fishing communities, they did contend that management of fisheries would be enhanced if it were to take into consideration the broader social and ecological realities of fishermen's behavior. Griffith (1999) has written extensively about North Carolina fishermen and their communities and Garrity-Blake (1994) has also provided an in-depth look at the menhaden fishery. Numerous journal articles and gray papers have also contributed to an understanding of North Carolina and its fisheries. But to date there has been no systematic attempt to identify fishing communities and begin baseline data collection. The communities described here were selected from a list of fishing communities identified by various advisory panel members who are knowledgeable about North Carolina fisheries and their communities. The list was modified after conducting rapid assessment in some of those communities. These descriptions are not a definitive list of fishing communities in North Carolina, but represent the first phase of assembling both the data and descriptions to begin identifying those communities which may indeed be classified as a "fishing community."

A map for each community is provided which displays federal dealers and a symbol indicating the number of federal permits by zip code. The zip code area name is displayed in light blue while the CDP name is in black. The symbol for permits is centered within the zip code area and does not represent the precise location of any permit holder. Dealer permits are displayed near their physical location.

5.1.3.1 Varnamtown

Varnamtown (Figure 5.1.3-2) has seen a slight population increase from 1990 to 2000. The majority of housing is owner occupied (Table 5.1.3-5) and residence is fairly stable with most living in the same house within the last five years for both the 1990 and 2000 census (Table 5.1.3-6). Just over fifty percent of the population is in the labor force for the last two decennial censuses, but the percent unemployed has declined from 8.2 percent in 1990 to 5.1 percent in 2000. The population is almost entirely White with a few Latinos according to Table 5.1.3-8. The poverty rate has declined from 17.2 percent in 1990 to 11.2 percent in 2000 (Table 5.1.3-10). Employment in the retail and wholesale industry leads with construction and transportation next (Table 5.1.3-11). There has been a slight decline in both the categories of Agriculture, Fishing and Mining (Table 5.1.3-11) and Farm, Fish, Forest (Table 5.1.3-12) from 1990 to 2000.

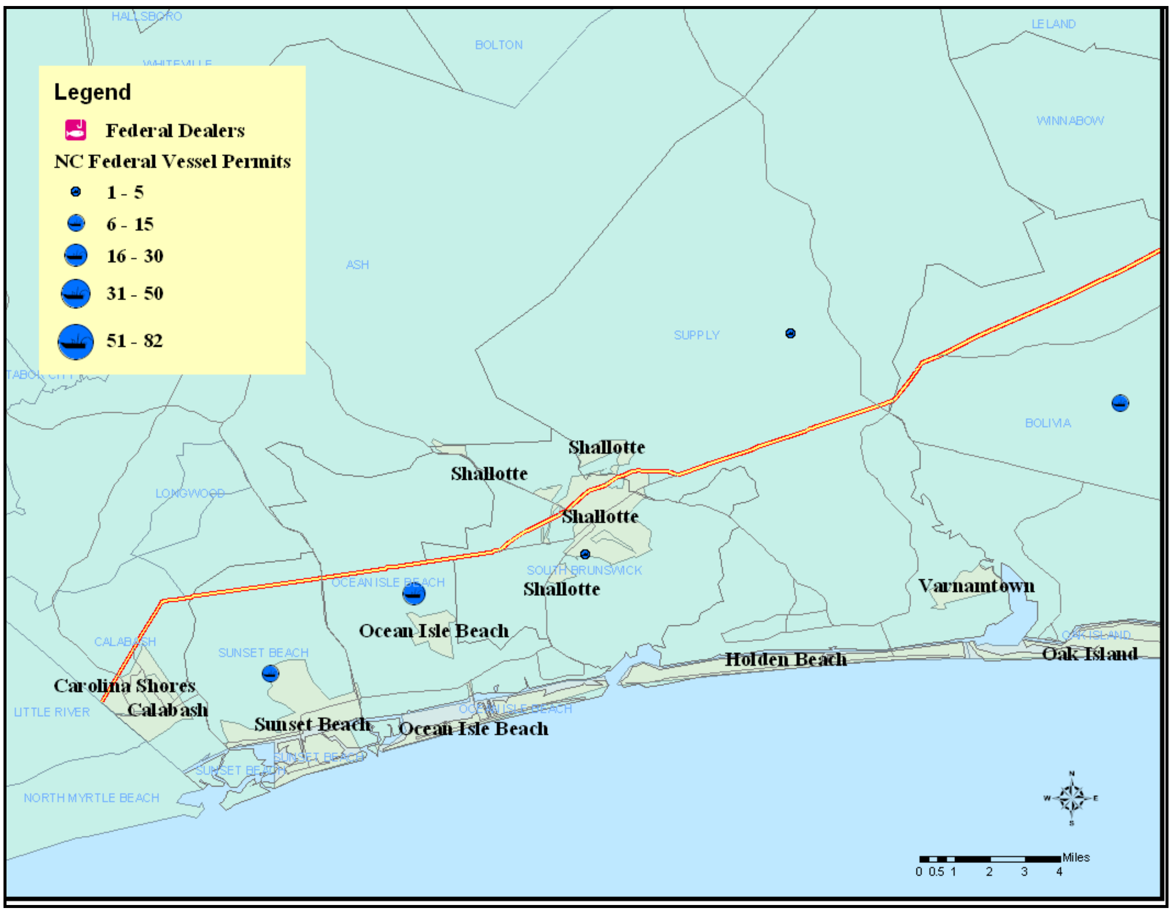

Figure 5.1.3-2. Varnamtown, NC.

Varnamtown is supposedly the fishing hub for this region, although as evidenced by the above map (Figure 5.1.3-2) and Tables 5.1.3-4 and 5.1.3-5, many fishermen list Supply as their residence for some reason, which may be where the post office is located. A sign at the town entrance prominently displays a shrimp trawler welcoming you to the community. Varnamtown is relatively rural and surrounded by farmland. There are at least five fish houses and a marina which services non-commercial boats. One of the fish houses does have charter operations and a jet-ski business that operate under the same roof.

One fish house owner commented that they struggle with their seafood business because shrimpers are having difficulty making ends meet. Most fishermen who dock and sell at local fish houses live near the town itself. A large percentage of locals make some kind of a living off the water – harvesting fish, clams, or oysters according to those interviewed. Some fish year-round, but many have other jobs such as carpentry and work on dredge boats. Development has changed the community; outsiders are a more common sight now, according to one individual, whereas in the past it was primarily locals living in the community.

Sunset Beach / Seaside

Sunset Beach is really two communities – one on the creek side and the other on the ocean side. The creek side with its strip malls and mobile homes is where the locals live year-round. It appears to be much more working-class than its ocean side counterpart. The beach side is developed with expensive homes, gift shops, and beach wear stores. On the creek side and a little more inland is the town of Seaside, where there is limited fishing. The Pelican Point Marina in nearby Shallotte is primarily a recreational marina with no commercial boats. A few small trawlers dock at a seafood restaurant near a steel and aluminum welding shop that caters to the fishing population.

Holden Beach, North Carolina

Developed much like Sunset Beach, Holden Beach has one marina but no charter operations. It is tourist centered, with beach wear marts and a couple of seafood restaurants.

Supply, North Carolina

Supply is an unincorporated area, yet the zip code area is named after this small community. Viewing the permit tables and the zip code related employment table it is obvious there is considerable fishing activity within the zip code area that does not appear in federal permit tables (Table 5.1.3-13) nor the state permit table (Table 5.1.3-15) for Varnamtown. Supply has over 600 licenses issued in 2002 with 167 shellfishing licenses and over 130 standard commercial fishing licenses. There are 22 dealers licensed in Supply and over 260 commercial vessels according to Table 5.1.3-16. In 2008 only 2 federal permits were issued, those being for south Atlantic shrimp (Table 5.1.3-13).

Varnamtown Census Demographics

Population

Table 5.1.3-4. Total Persons and Persons by Age category for Varnamtown, North Carolina 1970-2000 (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Total Persons and Age Category	1970	1980	1990	2000
Total Persons	.	.	434	492
Persons Age 0-5	.	.	24	37
Persons Age 6-15	.	.	50	45
Persons Age 16-17	.	.	21	11
Persons Age 18-24	.	.	61	30
Persons Age 25-34	.	.	44	59
Persons Age 35-44	.	.	60	80
Persons Age 45-54	.	.	57	57
Persons Age 55-64	.	.	59	93
Persons Age 65+	.	.	58	80

Housing Tenure

Table 5.1.3-5. Housing Tenure for Varnamtown, North Carolina 1990-2000 (Source: U.S. Census Bureau).

Percent Renter Occupied	1990	2000
	15.1	14.2
Percent Owner Occupied	**1990**	**2000**
	84.9	85.8

Residence in 1985 and 1995

Table 5.1.3-6. Residence in 1985 and 1995 for Varnamtown, North Carolina 1990-2000 (Source: U.S. Census Bureau).

Different House Same County	1990	2000
	72	67
Same House	**1990**	**2000**
	296	333

Employment/Unemployment

Table 5.1.3-7. Employment and Unemployment for Varnamtown, North Carolina 1990 2000 (Source: U.S. Census Bureau).

Persons 16 yrs and over	1990	2000
Percent in labor force	51.4	52.9
Percent unemployed	8.2	5.1

Race

Table 5.1.3-8. Race for Varnamtown, North Carolina 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Race	**1970**	**1980**	**1990**	**2000**
Black Persons	.	.	0	0
Latino Black Persons	.	.	0	0
Latino Persons	.	.	0	3
White Persons	.	.	432	475
Latino White Persons	.	.	0	2

Education

Table 5.1.3-9. Years of Education by Category for those 25 Years and Older for Varnamtown, North Carolina 1970-2000 (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Education	**1970**	**1980**	**1990**	**2000**
25+ w/ 0-8 years education	.	.	68	46
25+ w/ 9-11 years education	.	.	59	48
25+ w/ HS diploma	.	.	90	126
25+ w/ 13-15 years. education	.	.	43	74
25+ w/ College Degree	.	.	11	71
Drop outs	.	.	10	4

Income and Poverty

Table 5.1.3-10. Average Household Wage/Salary and Persons Below the Poverty Level for Varnamtown, North Carolina 1970-2000 (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Wage or Salary	**1970**	**1980**	**1990**	**2000**
Average Household Wage/Salary Income (dollars)	.	.	$26590	$33750
Poverty Level				
Persons Below Poverty Level	.	.	75	55
Age 65+ Below Poverty Level	.	.	24	14
Households with Public Assistance	.	.	19	4

Industry

Table 5.1.3-11. Employment by Industry for Varnamtown, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Industry	**1970**	**1980**	**1990**	**2000**
Agriculture, Fishing, Mining	.	.	16	15
Construction	.	.	37	40
Business Services	.	.	21	6
Communication/Utilities	.	.	0	10
Manufacturing	.	.	8	1
Financial, Insurance & Real Estate	.	.	4	9
Services	.	.	2	76
Wholesale/Retail Trade	.	.	55	42
Transportation	.	.	42	2

Occupation

Table 5.1.3-12. Employment by Occupation for Varnamtown, North Carolina 1970-2000 (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Occupation	**1970**	**1980**	**1990**	**2000**
Sales	.	.	35	-
Clerical	.	.	12	-
Craft	.	.	23	-
Exec/Managerial	.	.	10	-
Farm/Fish/Forest	.	.	18	15
Household Services	.	.	4	-
Laborer/Handler	.	.	10	-
Operative/Transport	.	.	12	-
Service, except Household	.	.	20	-
Technical	.	.	0	-

Varnamtown Fishing Demographics

Table 5.1.3-13. Number of Federal Permit by Type for Varnamtown, North Carolina (Source: NMFS 2008).

Type	Permits
ATLANTIC DOLPHIN/WAHOO COMMERCIAL	-
ATLANTIC DOLPHIN/WAHOO CHARTER/ HEADBOAT	-
S. ATLANTIC CHARTER/HEADBOAT FOR PELAGIC FISH	-
KING MACKEREL	-
SPINY LOBSTER & TAILING	- -
ROCK SHRIMP & ENDORSEMENTS	

S. ATL. CHARTER/HEADBOAT FOR SNAPPER-GROUPER	-	
SWORDFISH & SHARKS	-	-
S. ATLANTIC SNAPPER-GROUPER (UNLIMITED)	-	
S. ATLANTIC SNAPPER-GROUPER (225)	-	
SPANISH MACKEREL	-	
SOUTH ATLANTIC SHRIMP	2	
Total		

Table 5.1.3-14. Employment in Fishing Related Industry for Varnamtown, North Carolina (Zip code Business Patterns, U.S. Census Bureau 1998).

Category	NAIC Code	Number Employed
Fishing	114100	16
Seafood Canning	311711	0
Seafood Processing	311712	0
Boat Building	336612	0
Fish and Seafoods	422460	36
Fish and Seafood Markets	445220	8
Marinas	713930	8
Total Fishing Employment		52

Table 5.1.3-15. Number of State Permit by Type for Varnamtown, North Carolina (Source: NCDMF 2008).

Type	Permits
Commercial Fishing Vessel Registration	0
Dealer License	1
Flounder License	0
Land or Sell License	0
Non-resident Menhaden License	0
Ocean Fishing Pier License	0
Spotter Plane License	0
Retired Standard Commercial Fishing License	0
Standard Commercial Fishing License	0
Shellfish License	0
Recreational Fishing Tournament to Sell License	0
Total	0

Table 5.1.3-16. Number of State Permit by Type for Supply, North Carolina (Source: NCDMF 2002).

Type	Permits
Commercial Fishing Vessel Registration	264
Dealer License	22
Flounder License	0
Land or Sell License	0
Non-resident Menhaden License	0
Ocean Fishing Pier License	0
Spotter Plane License	0
Retired Standard Commercial Fishing License	21

Standard Commercial Fishing License	131
Shellfish License	167
Recreational Fishing Tournament to Sell License	0
Total	605

5.1.3.2 Southport/ Bald Head Island (28461)

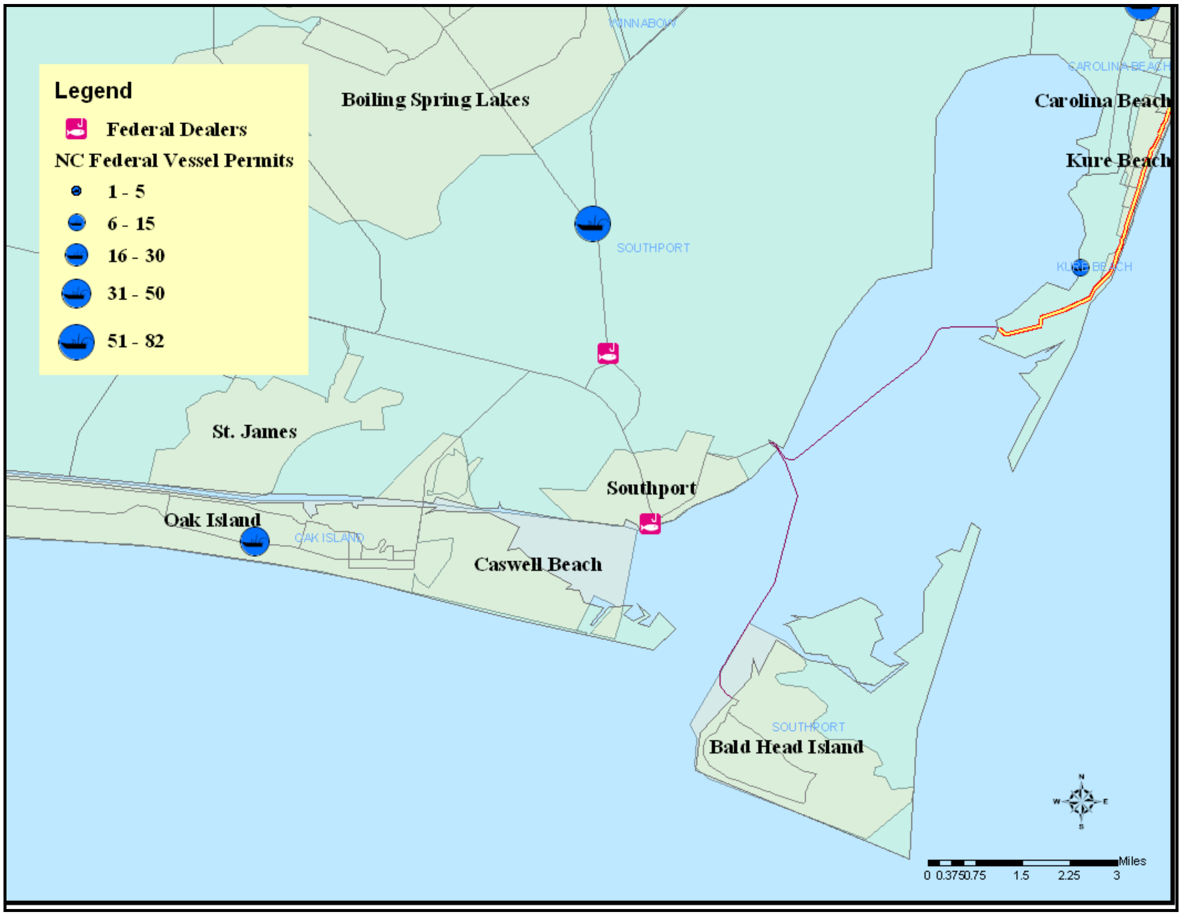

Figure 5.1.3-3. Southport/Bald Head Island, North Carolina.

Southport

Southport (Figure 5.1.3-3) is a quaint fishing community located at the mouth of the Cape Fear River, originally incorporated in 1792; this community caters to both tourists and locals. The downtown marina has restaurants, gift shops and several inns. There are at least three marinas in the area, with several seafood restaurants nearby. There is a dredging company and a nearby boat yard and a welding company that provide marine repairs. The North Carolina State Ports Authority has a small boat harbor located here and the NC Maritime Museum has a branch in Southport.

There are several recreational fishing tournaments held in Southport including the US Open King Mackerel Fishing Tournament held in October which attracts more than 500 boats annually. Other tournaments include the Lady Anglers King Mackerel Tournament in August and the Wildlife Bait and Tackle Flounder Tournament held in September.

Southport has some seafood employment with most in seafood processing and fish and seafoods as shown in Table 5.1.3-37. There are over 200 state permits with the majority being commercial vessel registrations and the next being standard commercial fishing licenses at 76. There were 14 dealer permits listed also.

Southport has seen a decrease in its population since 1980 from 2835 to 2386 in 2000. Approximately 70 percent of the housing was owner occupied in 1990 and 2000 and a large majority of the population has remained stable, living in the same home as five years before for both censuses. The percentage of people in the work force has increased while the percentage of unemployed has dropped according to Table 5.1.3-20. The majority of the population is White (76%) with 22% Black and less than 2% Latino (Table 5.1.3-21). The poverty rate in 2000 was 12.5 percent which is up from 10 percent in 1980 (Table 5.1.3-23). There has been a decline in both the Agriculture, Fishing and Mining industry category and the Farm, Fish, and Forestry occupation category since 1990 (Tables 5.1.3-24 and 5.1.3-25).

Bald Head Island

Bald Head Island is an exclusive community with a private ferry operated by the island. Many Southport residents work on the island or for the ferry system. There are a few restaurants, an inn, and gift shops located around a marina on the island. The marina is a full service marina with electrical service which will accommodate vessels up to 90 feet in length. There is a charter fishing operation at the marina, but no commercial vessels dock there. People can fish from shore and there is an annual fishing rodeo in May.

The population on Bald Head Island has doubled since 1990 to 165 persons. Housing tenure has shifted somewhat with the percent renter occupied growing from 8.3 percent in 1990 to 37.9 percent in 2000 (Table 5.1.3-27). Residence is beginning to show some stability with the percentage of people living in the same house as five years ago in 2000 more than in 1990 according to Table 5.1.3-28. A greater percentage of people are now in the labor force and unemployment has risen also as shown in Table 5.1.3-29. The population is predominately White according to Table 5.1.3-30, but there has been a recent increase in the category for Blacks although relatively slight in terms of overall population. According to Table 5.1.3-23 the average wage or salary has dropped considerably since 1990 and the number of persons in poverty has also risen. These dramatic changes reflect the total persons identified in the census for this island which has a relatively small population.

Southport Census Demographics

Population

Table 5.1.3-17. Total Persons and Persons by Age category for Southport, North Carolina 1970-2000 (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Total Persons and Age Category	1970	1980	1990	2000
Total Persons	.	2835	2359	2386
Persons Age 0-5	.	125	89	156
Persons Age 6-15	.	133	113	277
Persons Age 16-17	.	514	297	46
Persons Age 18-24	.	96	67	107
Persons Age 25-34	.	216	162	212
Persons Age 35-44	.	385	298	309
Persons Age 45-54	.	343	322	375
Persons Age 55-64	.	302	236	325
Persons Age 65+	.	304	279	579

Housing Tenure

Table 5.1.3-18. Housing Tenure for Southport, North Carolina 1990-2000 (Source: U.S. Census Bureau).

Percent Renter Occupied	1990	2000
	29.9	31.8
Percent Owner Occupied	**1990**	**2000**
	70.1	68.2

Residence in 1985 and 1995

Table 5.1.3-19. Residence in 1985 and 1995 for Southport, North Carolina 1990-2000 (Source: U.S. Census Bureau).

Different House Same County	1990	2000
	238	182
Same House	**1990**	**2000**
	1388	1331

Employment/Unemployment

Table 5.1.3-20. Employment and Unemployment for Southport, North Carolina 1990-2000 (Source: U.S. Census Bureau).

Persons 16 yrs and over	1990	2000
Percent in labor force	48.7	56.3
Percent unemployed	8.9	5

Race

Table 5.1.3-21. Race for Southport, North Carolina 1970-2000 (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Race	1970	1980	1990	2000
Black Persons	.	785	622	512
Latino Black Persons	.	19	0	0
Latino Persons	.	51	8	34
White Persons	.	2044	1737	1777
Latino White Persons	.	32	8	24

Education

Table 5.1.3-22. Years of Education by Category for those 25 Years and Older for Southport, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Education	1970	1980	1990	2000
25+ w/ 0-8 years education	.	275	192	73
25+ w/ 9-11 years education	.	365	220	195
25+ w/ HS diploma	.	534	476	407
25+ w/ 13-15 years. education	.	363	331	489
25+ w/ College Degree	.	301	340	622
Drop outs	.	7	0	14

Income and Poverty

Table 5.1.3-23. Average Household Wage/Salary and Persons Below the Poverty Level for Southport, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Wage or Salary	1970	1980	1990	2000
Average Household Wage/Salary Income (dollars)	.	$16282	$28062	$33714
Poverty Level				
Persons Below Poverty Level	.	283	281	298
Age 65+ Below Poverty Level	.	44	108	75
Households with Public Assistance	.	138	90	36

Industry

Table 5.1.3-24. Employment by Industry for Southport, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Industry	1970	1980	1990	2000
Agriculture, Fishing, Mining	.	0	16	5
Construction	.	89	4	97
Business Services	.	37	31	75
Communication/Utilities	.	137	126	64
Manufacturing	.	67	54	49
Financial, Insurance & Real Estate	.	0	36	80
Services	.	49	65	429
Wholesale/Retail Trade	.	196	307	159
Transportation	.	186	157	37

Occupation

Table 5.1.3-25. Employment by Occupation for Southport, North Carolina 1970-2000 (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Occupation	1970	1980	1990	2000
Sales	.	64	128	-
Clerical	.	1680	120	-
Craft	.	170	47	-
Exec/Managerial	.	100	104	-
Farm/Fish/Forest	.	0	22	2
Household Services	.	21	9	-
Laborer/Handler	.	54	39	-
Operative/Transport	.	27	35	-
Service, except Household	.	174	144	-
Technical	.	38	54	-

Bald Head Census Demographics

Population

Table 5.1.3-26. Total Persons and Persons by Age category for Bald Head Island, North Carolina 1970-2000 (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Total Persons and Age Category	1970	1980	1990	2000
Total Persons	.	.	78	165
Persons Age 0-5	.	.	6	9
Persons Age 6-15	.	.	0	6
Persons Age 16-17	.	.	0	0
Persons Age 18-24	.	.	0	0
Persons Age 25-34	.	.	4	20
Persons Age 35-44	.	.	8	5
Persons Age 45-54	.	.	19	40
Persons Age 55-64	.	.	22	65
Persons Age 65+	.	.	19	20

Housing Tenure

Table 5.1.3-27. Housing Tenure for Bald Head Island, North Carolina 1990-2000. (Source: U.S. Census Bureau).

Percent Renter Occupied	1990	2000
	8.3	37.9
Percent Owner Occupied	**1990**	**2000**
	91.7	62.1

Residence in 1985 and 1995

Table 5.1.3-28. Residence in 1985 and 1995 for Bald Head Island, North Carolina 1990-2000 (Source: U.S. Census Bureau).

Different House Same County	1990	2000
	12	6
Same House	**1990**	**2000**
	6	56

Employment/Unemployment

Table 5.1.3-29. Employment and Unemployment for Bald Head Island, North Carolina 1990-2000. (Source: U.S. Census Bureau).

Persons 16 yrs and over	1990	2000
Percent in labor force	48.6	56.7
Percent unemployed	0.0	5.9

Race

Table 5.1.3-30. Race for Bald Head Island, North Carolina 1970-2000 (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Race	1970	1980	1990	2000
Black Persons	.	.	0	5
Latino Black Persons	.	.	0	0

Latino Persons	.	.	0	0
White Persons	.	.	78	165
Latino White Persons	.	.	0	0

Education

Table 5.1.3-31. Years of Education by Category for those 25 Years and Older for Bald Head Island, North Carolina 1970-2000 (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Education	1970	1980	1990	2000
25+ w/ 0-8 years education	.	.	0	0
25+ w/ 9-11 years education	.	.	0	0
25+ w/ HS diploma	.	.	6	10
25+ w/ 13-15 years. education	.	.	15	28
25+ w/ College Degree	.	.	47	112
Drop outs	.	.	0	0

Income and Poverty

Table 5.1.3-32. Average Household Wage/Salary and Persons Below the Poverty Level for Bald Head Island, North Carolina 1970-2000 (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Wage or Salary	1970	1980	1990	2000
Average Household Wage/Salary Income (dollars)	.	.	108616	62083
Poverty Level				
Persons Below Poverty Level	.	.	4	17
Age 65+ Below Poverty Level	.	.	0	0
Households with Public Assistance	.	.	0	0

Industry

Table 5.1.3-33. Employment by Industry for Bald Head Island, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Industry	1970	1980	1990	2000
Agriculture, Fishing, Mining	.	.	0	0
Construction	.	.	0	5
Business Services	.	.	0	19
Communication/Utilities	.	.	0	1
Manufacturing	.	.	4	3
Financial, Insurance & Real Estate	.	.	2	24
Services	.	.	17	4

Wholesale/Retail Trade	.	.	6	11
Transportation	.	.	0	2

Occupation

Table 5.1.3-34. Employment by Occupation for Bald Head Island, North Carolina 1970-2000 (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Occupation	**1970**	**1980**	**1990**	**2000**
Sales	.	.	9	-
Clerical	.	.	0	-
Craft	.	.	0	-
Exec/Managerial	.	.	14	-
Farm/Fish/Forest	.	.	0	0
Household Services	.	.	0	-
Laborer/Handler	.	.	0	-
Operative/Transport	.	.	0	-
Service, except Household	.	.	2	-
Technical	.	.	0	-

Southport/Bald Head Island Fishing Demographics

Table 5.1.3-35. Number of Federal Permits (October 2008) by Type for Southport, North Carolina (Source: NMFS 2008).

Type	Permits
ATLANTIC DOLPHIN/WAHOO COMMERCIAL	58
ATLANTIC DOLPHIN/WAHOO CHARTER/ HEADBOAT	23
S. ATLANTIC CHARTER/HEADBOAT FOR PELAGIC FISH	23
KING MACKEREL	51, -
SPINY LOBSTER & TAILING	5, 11
ROCK SHRIMP & ENDORSEMENTS	4, 1
S. ATL. CHARTER/HEADBOAT FOR SNAPPER-GROUPER	24
SWORDFISH & SHARKS	24, 2-
S. ATLANTIC SNAPPER-GROUPER (UNLIMITED)	18
S. ATLANTIC SNAPPER-GROUPER (225)	2
SPANISH MACKEREL	34
SOUTH ATLANTIC SHRIMP	6

Table 5.1.3-36. Number of Federal Permit (October 2008) by Type for Bald Head Island, North Carolina (Source: NMFS 2008).

Type	Permits
ATLANTIC DOLPHIN/WAHOO COMMERCIAL	2
ATLANTIC DOLPHIN/WAHOO CHARTER/ HEADBOAT	2
S. ATLANTIC CHARTER/HEADBOAT FOR PELAGIC FISH	2
KING MACKEREL	4
SPINY LOBSTER & TAILING	2, -
S. ATL. CHARTER/HEADBOAT FOR SNAPPER-GROUPER	2

Table 5.1.3-37. Employment in Fishing Related Industry for Southport/Bald Head Island, North Carolina (Zip code Business Patterns, U.S. Census Bureau 1998).

Category	NAIC Code	Number Employed
Fishing	114100	0
Seafood Canning	311711	0
Seafood Processing	311712	16
Boat Building	336612	0
Fish and Seafoods	422460	12
Fish and Seafood Markets	445220	4
Marinas	713930	12
Total Fishing Employment		28

Table 5.1.3-38. Number of State Permit by Type for Southport/Baldhead, North Carolina (Source: NCDMF 2008).

Type	Permits
Commercial Fishing Vessel Registration	132
Dealer License	9
Flounder License	0
Land or Sell License	0
Non-resident Menhaden License	0
Ocean Fishing Pier License	0
Spotter Plane License	0
Retired Standard Commercial Fishing License	11
Standard Commercial Fishing License	85
Shellfish License	15
Recreational Fishing Tournament to Sell License	1
Total	253

5.1.3.3 Carolina Beach (28428)

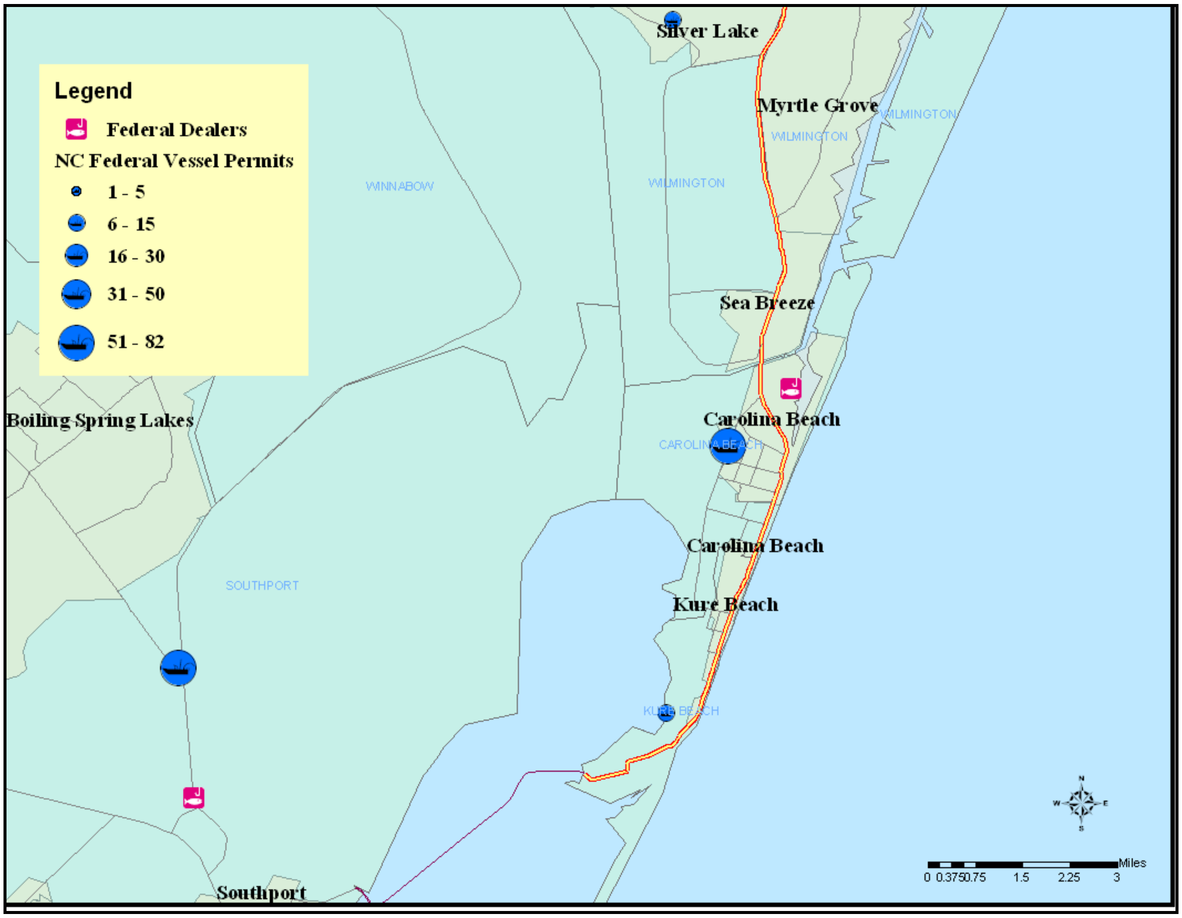

Figure 5.1.3-4. Carolina Beach, North Carolina.

Carolina Beach is situated along what is referred to as the Crystal Coast and has a storied history from Colonial times to the Civil War. Close to Wrightsville Beach, this community is not nearly as crowded or developed, but is still a major tourist destination that relies heavily on the charterboat industry. The municipal marina is where the charter and head boats are docked. Three head boats and three party/cruise boats and approximately 22 charters utilize the municipal marina. There are several bait & tackle shops nearby and there remains one commercial fish house in the community; out of at least five in the past. Five commercial vessels dock at the municipal marina. There are about eight seafood restaurants in the community and most of the hotels are independently owned rather than national chains. The area hosts three fishing tournaments each year: the Atlantic Anglers' Spring Classic Surf Fishing Tournament in May, the East Coast Got-Em-On-Live-Bait Classic King Mackerel Tournament in July, and the Carolina Beach Surf Fishing Tournament in October. The community also hosts the annual Seafood, Blues and Jazz Festival.

Carolina Beach's population has grown steadily since 1980 to over 4,700 people in 2000 (Table 5.1.3-40). Housing tenure has grown in the area of owner occupied since 1990 (Table 5.1.3-41) and more people seem to be living in the same house as they did five years ago (Table 5.1.3-42). The number of persons in the labor force has not changed much while unemployment has dropped from 1990 to 2000 (Table 5.1.3-43). Racial percentages for the population have remained relatively stable with a predominantly White population according to Table 5.1.3-44.

Carolina Beach has over twenty vessels with federal permits and by far the majority of those vessels hold charter permits for both snapper grouper and coastal pelagics (Table 5.1.3-49). Most of the employment for the zip code area is in fish and seafood (Table 5.1.3-50) while the majority of the 131 state permits are for commercial fishing vessels at 84 Table 5.1.3-51. There are another 35 standard commercial fishing licenses and 19 shellfish licenses in Carolina Beach.

Carolina Beach Census Demographics

Population

Table 5.1.3-40. Total Persons and Persons by Age category for Carolina Beach, North Carolina 1970-2000 (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Total Persons and Age Category	1970	1980	1990	2000
Total Persons	.	1992	3631	4729
Persons Age 0-5	.	102	231	210
Persons Age 6-15	.	268	381	402
Persons Age 16-17	.	77	51	66
Persons Age 18-24	.	230	357	317
Persons Age 25-34	.	314	593	660
Persons Age 35-44	.	225	646	778
Persons Age 45-54	.	254	504	943
Persons Age 55-64	.	216	404	771
Persons Age 65+	.	292	464	582

Housing Tenure

Table 5.1.3-41. Housing Tenure for Carolina Beach, North Carolina 1990-2000. (Source: U.S. Census Bureau).

Percent Renter Occupied	1990	2000
	50.4	32.3
Percent Owner Occupied	**1990**	**2000**
	49.6	67.7

Residence in 1985 and 1995

Table 5.1.3-42. Residence in 1985 and 1995 for Carolina Beach, North Carolina 1990-2000. (Source: U.S. Census Bureau).

Different House Same County	**1990**	**2000**
	874	593
Same House	**1990**	**2000**
	1115	2164

Employment/Unemployment

Table 5.1.3-43. Employment and Unemployment for Carolina Beach, North Carolina 1990-2000. (Source: U.S. Census Bureau).

Persons 16 yrs and over	**1990**	**2000**
Percent in labor force	65.8	68.0
Percent unemployed	8.2	3.1

Race

Table 5.1.3-44. Race for Carolina Beach, North Carolina 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Race	**1970**	**1980**	**1990**	**2000**
Black Persons	.	11	31	56
Latino Black Persons	.	0	0	0
Latino Persons	.	26	16	36
White Persons	.	1969	3574	4536
Latino White Persons	.	24	16	21

Education

Table 5.1.3-45. Years of Education by Category for those 25 Years and Older for Carolina Beach, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Education	**1970**	**1980**	**1990**	**2000**
25+ w/ 0-8 years education	.	183	104	38
25+ w/ 9-11 years education	.	299	355	355
25+ w/ HS diploma	.	445	782	1175
25+ w/ 13-15 years. education	.	258	693	1000
25+ w/ College Degree	.	116	492	1157
Drop outs	.	30	31	9

Income and Poverty

Table 5.1.3-46. Average Household Wage/Salary and Persons Below the Poverty Level for Carolina Beach, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Wage or Salary	**1970**	**1980**	**1990**	**2000**
Average Household Wage/Salary Income (dollars)	.	$14147	$28055	$37662
Poverty Level				
Persons Below Poverty Level	.	202	520	439
Age 65+ Below Poverty Level	.	26	33	0
Households with Public Assistance	.	51	61	36

Industry

Table 5.1.3-47. Employment by Industry for Carolina Beach, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Industry	**1970**	**1980**	**1990**	**2000**
Agriculture, Fishing, Mining	.	17	80	19
Construction	.	80	202	419
Business Services	.	38	103	219
Communication/Utilities	.	36	51	61
Manufacturing	.	120	174	138
Financial, Insurance & Real Estate	.	44	92	126
Services	.	41	156	1127
Wholesale/Retail Trade	.	167	575	483
Transportation	.	227	462	78

Occupation

Table 5.1.3-48. Employment by Occupation for Carolina Beach, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Occupation	**1970**	**1980**	**1990**	**2000**
Sales	.	111	191	-
Clerical	.	1180	199	-
Craft	.	162	265	-
Exec/Managerial	.	81	245	-
Farm/Fish/Forest	.	29	92	9
Household Services	.	0	0	-
Laborer/Handler	.	32	81	-
Operative/Transport	.	55	46	-
Service, except Household	.	142	253	-
Technical	.	13	93	-

Carolina Beach Fishing Demographics

Table 5.1.3-49. Number of Federal Permit by Type for Carolina Beach, North Carolina (Source: NMFS 2002).

Table 5.1.3-50. Employment in Fishing Related Industry for Carolina Beach, North Carolina (Zip code Business Patterns, U.S. Census Bureau 1998).

Category	NAIC Code	Number Employed
Fishing	114100	0
Seafood Canning	311711	0
Seafood Processing	311712	0
Boat Building	336612	0
Fish and Seafoods	422460	36
Fish and Seafood Markets	445220	4
Marinas	713930	4
Total Fishing Employment		44

Table 5.1.3-51. Number of State Permit by Type for Carolina Beach, North Carolina (Source: NCDMF 2008).

Type	Permits
Commercial Fishing Vessel Registration	60
Dealer License	9
Flounder License	0
Land or Sell License	0
Non-resident Menhaden License	0
Ocean Fishing Pier License	1
Spotter Plane License	0
Retired Standard Commercial Fishing License	7
Standard Commercial Fishing License	35
Shellfish License	19
Recreational Fishing Tournament to Sell License	0
Total	131

5.1.3.4 Wilmington (28401, 28403, 28405, 28411, 28412)

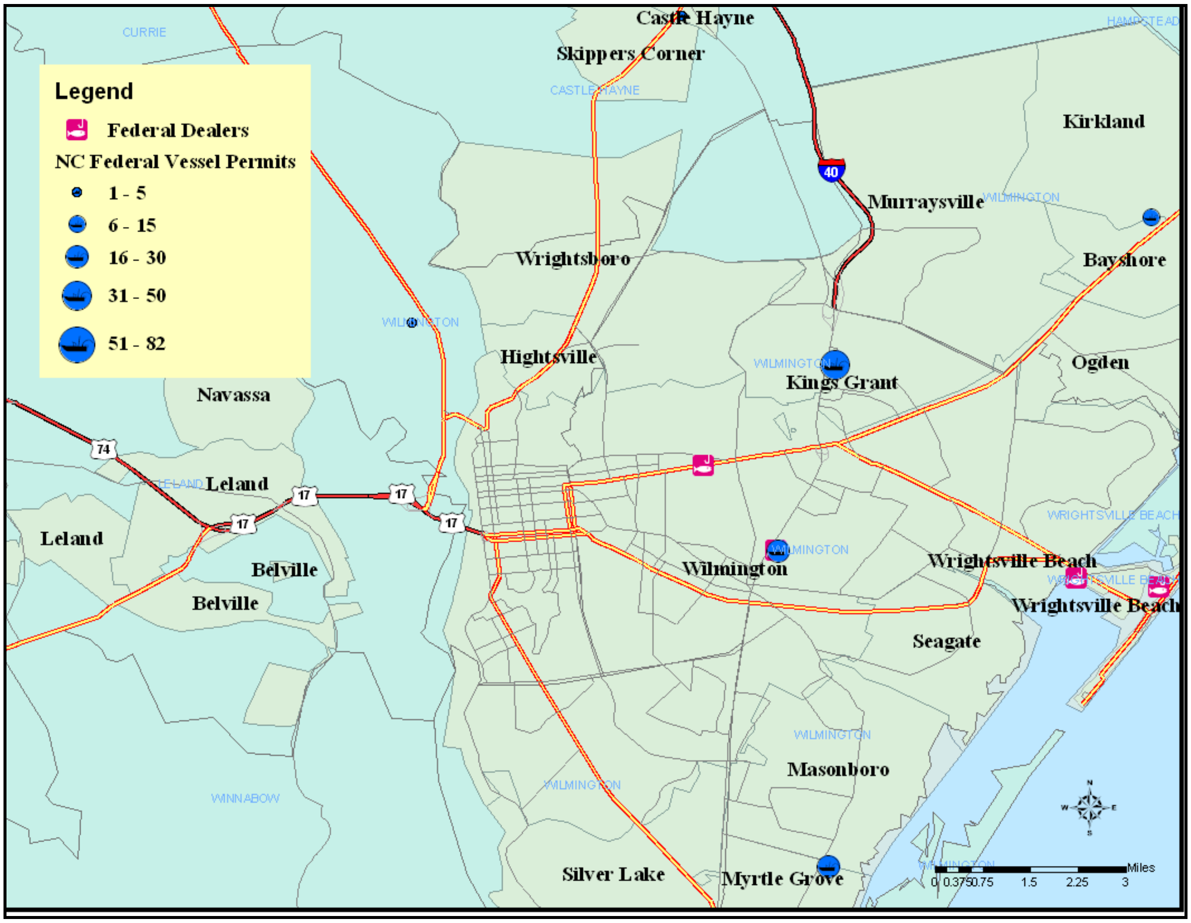

Figure 5.1.3-5. Wilmington, North Carolina.

Wilmington was previously known as New Liverpool, New Town and Newton, and founded by a group of Englishmen, many of whom were maritime businessmen. Located on the Cape Fear River, the town became an important port, but growth was originally slow following the Revolutionary War because of a lack of decent roads and the long distance of the port from the mouth of the river. However, in the mid-1800s, the port began to develop into a center for exports with rice, peanuts, flax, cotton, and naval stores being shipped all over the world. With the advent of the Civil War the export trade in Wilmington halted, however, the town gained prominence as "the lifeline of the Confederacy," involving itself in the blockade running/profiteering business. After the war, cotton exports were still an important commodity shipped from the port, but World War II brought a shift in the economy with more of an emphasis upon ship building. Today, Wilmington continues to be an important port with the State's Port Authority located there.

The total number of persons living in Wilmington has grown steadily since the 1970s according to Table 5.1.3-52. Housing tenure has not changed much with an almost even split between owner and renter occupied housing (Table 5.1.3-53). Residence has changed to some degree with more people living in a different house outside the county, so a new migration from outside the county and state must be taking place (Table 5.1.3-54). The percentage of people in the labor force has not changed much but unemployment has risen since 1990 from 3.8 to 8.6 in the year 2000 (Table 5.1.3-55). The population is still predominantly White, yet there is a substantial Black population that has historically been there (Table 5.1.3-56). The poverty rate has dropped since 1970 when it was 25.2, but still remains at 18.8 percent for the year 2000 ((Table 5.1.3-58). As with most communities there has been a substantial drop in the number of those persons employed in the agriculture, fishing and mining category of industry as well as the category of Farm, Fish and Forestry under occupation for Wilmington (Tables 5.1.3-59 and 5.1.3-60).

Wilmington has had between 30 to 40 vessels with federal permits since 1998 and most of those have had permits to fish coastal pelagics and snapper grouper (Table 5.1.3-61). There is considerable employment in the realm of fish and seafood and seafood markets, but the majority is in marinas and some also in boat building as reported in Table 5.1.3-62. In 2008, there were 970 state permits issued for Wilmington with the majority of those issued for commercial vessels. There were almost 285 standard commercial fishing licenses and 117 shellfish licenses sold for Wilmington residents. Over 42 dealer licenses were issued as were 3 to recreational fishing tournaments in order to sell licenses (Table 5.1.3-63).

Wilmington Census Demographics

Population

Table 5.1.3-52. Total Persons and Persons by Age category for Wilmington, North Carolina 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Total Persons and Age Category	1970	1980	1990	2000
Total Persons	46169	44000	55530	75542
Persons Age 0-5	3858	2805	4157	4838
Persons Age 6-15	8874	6453	6530	7491
Persons Age 16-17	1904	1411	1453	1394
Persons Age 18-24	5496	6816	8393	12985
Persons Age 25-34	5203	6856	9064	38669
Persons Age 35-44	4568	3865	7364	75048
Persons Age 45-54	5679	3966	4901	8952
Persons Age 55-64	5120	4996	4856	6546
Persons Age 65+	4681	6237	8812	11704

Housing Tenure

Table 5.1.3-53. Housing Tenure for Wilmington, North Carolina 1990-2000. (Source: U.S. Census Bureau).

Percent Renter Occupied	**1990**	**2000**
	52.9	51.4
Percent Owner Occupied	**1990**	**2000**
	47.1	48.6

Residence in 1985 and 1995

Table 5.1.3-54. Residence in 1985 and 1995 for Wilmington, North Carolina 1990-2000. (Source: U.S. Census Bureau).

Different House Same County	**1990**	**2000**
	13901	3785
Same House	**1990**	**2000**
	23715	26649

Employment/Unemployment

Table 5.1.3-55. Employment and Unemployment for Wilmington, North Carolina 1990-2000. (Source: U.S. Census Bureau).

Persons 16 yrs and over	**1990**	**2000**
Percent in labor force	61.9	63.7
Percent unemployed	3.8	8.6

Race

Table 5.1.3-56. Race for Wilmington, North Carolina 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Race	**1970**	**1980**	**1990**	**2000**
Black Persons	15823	17357	18785	19342
Latino Black Persons	58	208	48	145
Latino Persons	115	385	393	1991
White Persons	30165	26425	36130	52227
Latino White Persons	57	168	234	831

Education

Table 5.1.3-57. Years of Education by Category for those 25 Years and Older for Wilmington, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Education	**1970**	**1980**	**1990**	**2000**
25+ w/ 0-8 years education	7870	5795	3421	2053
25+ w/ 9-11 years education	5786	5303	6010	5880
25+ w/ HS diploma	6544	6864	9402	11303
25+ w/ 13-15 years. education	2655	3763	6625	10670
25+ w/ College Degree	2396	4195	7258	18570
Drop outs	1121	472	347	358

Income and Poverty

Table 5.1.3-58. Average Household Wage/Salary and Persons Below the Poverty Level for Wilmington, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Wage or Salary	**1970**	**1980**	**1990**	**2000**
Average Household Wage/Salary Income (dollars)	$7151	$15057	$26529	$31099
Poverty Level				
Persons Below Poverty Level	11643	10393	11780	14196
Age 65+ Below Poverty Level	1574	1584	1439	0
Households with Public Assistance	957	2166	2466	201

Industry

Table 5.1.3-59. Employment by Industry for Wilmington, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Industry	**1970**	**1980**	**1990**	**2000**
Agriculture, Fishing, Mining	202	185	275	99
Construction	1234	1091	1935	88
Business Services	492	556	1177	11
Communication/Utilities	554	596	651	3193
Manufacturing	4753	3458	3722	2839
Financial, Insurance & Real Estate	1849	1676	1506	847
Services	710	777	1252	5209
Wholesale/Retail Trade	5093	3377	9061	1410
Transportation	3663	3953	7009	1079

Occupation

Table 5.1.3-60. Employment by Occupation for Wilmington, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Occupation	1970	1980	1990	2000
Sales	1136	1949	3774	-
Clerical	2609	23170	3294	-
Craft	2681	1894	2794	-
Exec/Managerial	1729	1613	2618	-
Farm/Fish/Forest	60	213	262	79
Household Services	855	385	303	-
Laborer/Handler	1065	937	1032	-
Operative/Transport	2753	1803	1868	-
Service, except Household	2924	3484	4700	-
Technical	248	420	835	-

Wilmington Fishing Demographics

Table 5.1.3-61. Number of Federal Permit (October 2008) by Type for Wilmington, North Carolina (Source: NMFS 2008).

Type	Permits
ATLANTIC DOLPHIN/WAHOO COMMERCIAL	33
ATLANTIC DOLPHIN/WAHOO CHARTER/ HEADBOAT	11
S. ATLANTIC CHARTER/HEADBOAT FOR PELAGIC FISH	12
KING MACKEREL	21
SPINY LOBSTER & TAILING	-, -
ROCK SHRIMP & ENDORSEMENTS	-, -
S. ATL. CHARTER/HEADBOAT FOR SNAPPER-GROUPER	12
SWORDFISH & SHARKS	1, 1
S. ATLANTIC SNAPPER-GROUPER (UNLIMITED)	12
S. ATLANTIC SNAPPER-GROUPER (225)	1
SPANISH MACKEREL	11
SOUTH ATLANTIC SHRIMP	1

Table 5.1.3-62. Employment in Fishing Related Industry for Wilmington, North Carolina (Zip code Business Patterns, U.S. Census Bureau 1998).

Category	NAIC Code	Number Employed
Fishing	114100	0
Seafood Canning	311711	0
Seafood Processing	311712	0
Boat Building	336612	12
Fish and Seafoods	422460	42
Fish and Seafood Markets	445220	24
Marinas	713930	64
Total Fishing Employment		142

Table 5.1.3-63. Number of State Permit by Type for Wilmington, North Carolina (Source: NCDMF 2008).

Type	Permits
Commercial Fishing Vessel Registration	472
Dealer License	42
Flounder License	2
Land or Sell License	0
Non-resident Menhaden License	0
Ocean Fishing Pier License	0
Spotter Plane License	0
Retired Standard Commercial Fishing License	49
Standard Commercial Fishing License	285
Shellfish License	117
Recreational Fishing Tournament to Sell License	3
Total	970

5.1.3.5 Wrightsville Beach (28480)

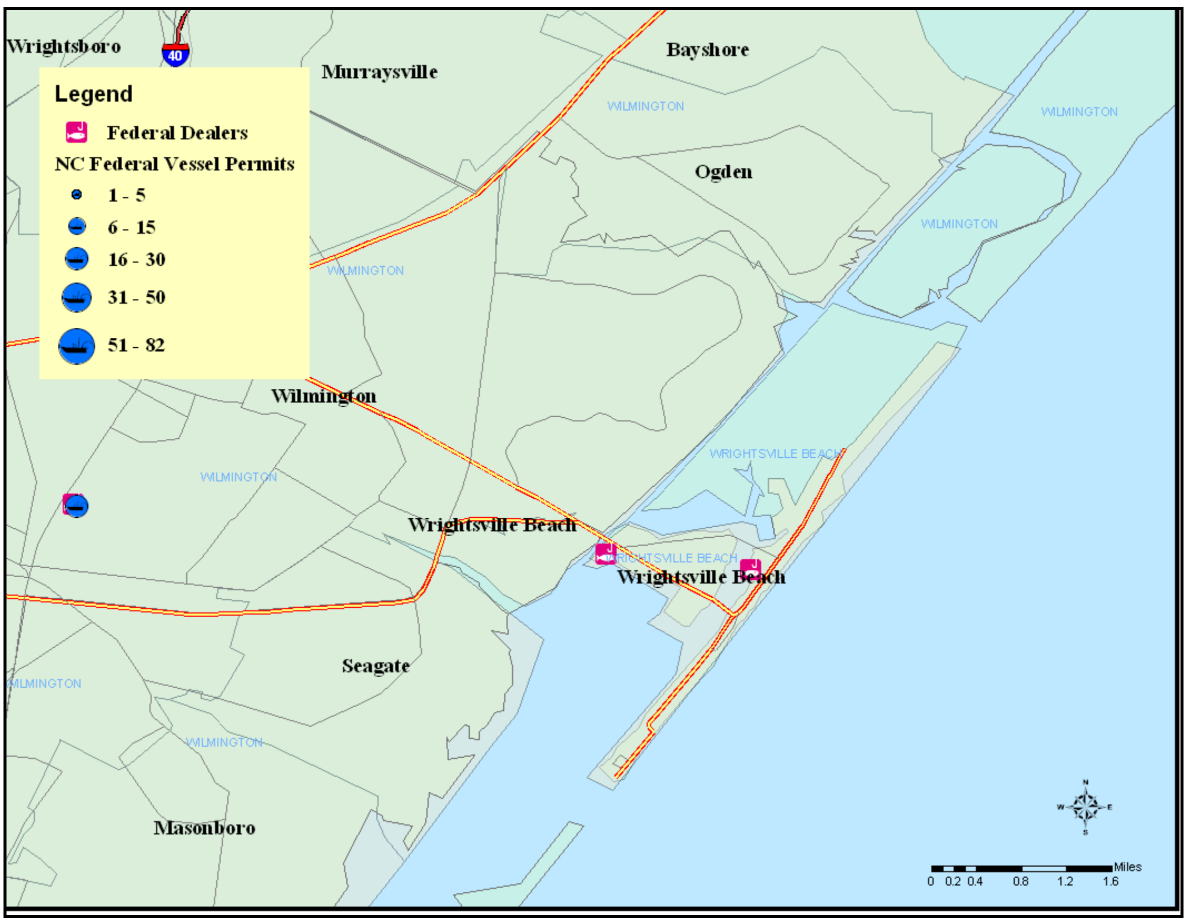

Figure 5.1.3-5. Wrightsville Beach, North Carolina.

The town of Wrightsville Beach occupies one of the barrier islands along North Carolina's southeastern coast. Today, the island is 1,000 to 5,000 feet in width and stretches almost four miles from Masonboro Inlet on the south to Mason Inlet on the north. Originally the island was called New Hanover Banks, a sandy barrier island cut by the shallow Moor's Inlet. The northern part of the island was called Shell Island. Development of the island was slow due to the distance and lack of transportation other than by boat. The island was once owned by the State of North Carolina until it was transferred into private hands in three separate grants between 1791 and 1881. One of the families who owned land was the Wright family, for which the island is named. For a century following, there were no residents on the island. However, hunters and fishermen were drawn to the area for the Spanish mackerel and bluefish. Sailing also became popular around the area and frequent races led to the establishment of the Carolina Yacht Club in 1853. Members of the Carolina Yacht Club erected a clubhouse, which was the first structure built on what would be called Wrightsville Beach. The Club is recognized as the third oldest yacht club in the United States.

A turnpike was completed in 1887, which connected Wilmington to Wrightsville Sound, and increased development and growth on the island. Also, the Wilmington Seacoast Railroad Company extended its track from Wilmington to the island. More yacht clubs were established, along with beach cottages, hotels and local stores, leading the area to become a popular summer vacation spot. On March 6, 1889, the town of Wrightsville Beach was incorporated. A public pavilion was created in 1905 on the end of the rail line. This pavilion included a bowling alley, shooting gallery, movie theatre and snack bar. In 1935, a large two-lane bridge across the Intracoastal Waterway to Harbor Island, then over Bank's Channel to Wrightsville Beach. A population of about 110 year-round residents in 1930 grew to about 1500 in 1945.

There has been a slight decline in the total population for Wrightsville Beach since 1980 (Table 5.1.3-64). Housing tenure has remained approximately the same with a slight increase in the number of owner occupied housing (Table 5.1.3-65). There seems to be increased stability residence with more people living in the same house in 2000 than there were in 1990 in terms of percentage (Table 5.1.3-66). The percentage of individuals in the labor force has remained about the same with a slight decrease and unemployment is relatively unchanged at 2.0 percent since 1990 (Table 5.1.3-67). The majority of the population remains White with slight increases in the number of Latinos and Blacks (Table 5.1.3-68). Average wage or salary saw a significant increase from 1980 to 1990 but a much smaller increase in 2000. The poverty rate has remained around 9.0 percent throughout the last three decades (Table 5.1.3-70).

In 2008, vessels with federal permits predominantly held Atlantic dolphin/wahoo commercial (9), Atlantic dolphin/wahoo charter (10), south Atlantic charter/headboat for pelagic fish(10), or snapper grouper charter/headboat for snapper grouper (7) permits (Table 5.1.3-73). In the community and most of the fishing related employment has been in the marina sector according to Table 5.1.3-74. There were 19 commercial vessels registered with the state and one dealer (Table 5.1.3-75).

Wrightsville Beach Census Demographics

Population

Table 5.1.3-64. Total Persons and Persons by Age category for Wrightsville Beach, North Carolina 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Total Persons and Age Category	**1970**	**1980**	**1990**	**2000**
Total Persons	.	2884	2797	2719
Persons Age 0-5	.	64	75	84
Persons Age 6-15	.	170	165	121
Persons Age 16-17	.	56	37	34
Persons Age 18-24	.	630	465	421
Persons Age 25-34	.	625	650	595
Persons Age 35-44	.	405	456	314
Persons Age 45-54	.	321	349	474
Persons Age 55-64	.	307	241	258
Persons Age 65+	.	291	359	418

Housing Tenure

Table 5.1.3-65. Housing Tenure for Wrightsville Beach, North Carolina 1990-2000. (Source: U.S. Census Bureau).

Percent Renter Occupied	**1990**	**2000**
	47.9	44.8
Percent Owner Occupied	**1990**	**2000**
	52.1	55.2

Residence in 1985 and 1995

Table 5.1.3-66. Residence in 1985 and 1995 for Wrightsville Beach, North Carolina 1990-2000. (Source: U.S. Census Bureau).

Different House Same County	**1990**	**2000**
	692	392
Same House	**1990**	**2000**
	998	1176

Employment/Unemployment

Table 5.1.3-67. Employment and Unemployment for Wrightsville Beach, North Carolina 1990-2000. (Source: U.S. Census Bureau).

Persons 16 yrs and over	**1990**	**2000**
Percent in labor force	71.9	65.6
Percent unemployed	2.9	2.0

Race

Table 5.1.3-68. Race for Wrightsville Beach, North Carolina 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Race	1970	1980	1990	2000
Black Persons	.	0	9	7
Latino Black Persons	.	0	0	0
Latino Persons	.	0	9	17
White Persons	.	2853	2788	2532
Latino White Persons	.	0	9	12

Education

Table 5.1.3-69. Years of Education by Category for those 25 Years and Older for Wrightsville Beach, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Education	1970	1980	1990	2000
25+ w/ 0-8 years education	.	95	23	15
25+ w/ 9-11 years education	.	126	68	10
25+ w/ HS diploma	.	399	327	277
25+ w/ 13-15 years. education	.	553	462	378
25+ w/ College Degree	.	776	1001	1379
Drop outs	.	0	0	0

Income and Poverty

Table 5.1.3-70. Average Household Wage/Salary and Persons Below the Poverty Level for Wrightsville Beach, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Wage or Salary	1970	1980	1990	2000
Average Household Wage/Salary Income (dollars)	.	$22649	$54474	$55903
Poverty Level				
Persons Below Poverty Level	.	275	276	255
Age 65+ Below Poverty Level	.	0	0	9
Households with Public Assistance	.	22	18	14

Industry

Table 5.1.3-71. Employment by Industry for Wrightsville Beach, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Industry	1970	1980	1990	2000
Agriculture, Fishing, Mining	.	17	29	0

Construction	.	55	171	151
Business Services	.	39	54	202
Communication/Utilities	.	98	92	59
Manufacturing	.	184	197	65
Financial, Insurance & Real Estate	.	81	79	174
Services	.	123	119	640
Wholesale/Retail Trade	.	242	558	347
Transportation	.	570	540	31

Occupation

Table 5.1.3-72. Employment by Occupation for Wrightsville Beach, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Occupation	1970	1980	1990	2000
Sales	.	301	404	-
Clerical	.	1890	177	-
Craft	.	139	89	-
Exec/Managerial	.	293	351	-
Farm/Fish/Forest	.	16	0	0
Household Services	.	5	0	-
Laborer/Handler	.	17	54	-
Operative/Transport	.	29	42	-
Service, except Household	.	305	191	-
Technical	.	60	80	-

Wrightsville Beach Fishing Demographics

Table 5.1.3-73. Number of Federal Permit (October 2008) by Type for Wrightsville Beach, North Carolina (Source: NMFS 2008).

Type	Permits
ATLANTIC DOLPHIN/WAHOO COMMERCIAL	9
ATLANTIC DOLPHIN/WAHOO CHARTER/ HEADBOAT	10
S. ATLANTIC CHARTER/HEADBOAT FOR PELAGIC FISH	10
KING MACKEREL	8
SPINY LOBSTER & TAILING	-, -
ROCK SHRIMP & ENDORSEMENTS	-, -
S. ATL. CHARTER/HEADBOAT FOR SNAPPER-GROUPER	7
SWORDFISH & SHARKS	1, -
S. ATLANTIC SNAPPER-GROUPER (UNLIMITED)	2
S. ATLANTIC SNAPPER-GROUPER (225)	-
SPANISH MACKEREL	3
SOUTH ATLANTIC SHRIMP	-

Table 5.1.3-74. Employment in Fishing Related Industry for Wrightsville Beach, North Carolina (Zip code Business Patterns, U.S. Census Bureau 1998).

Category	NAIC Code	Number Employed
Fishing	114100	0

Seafood Canning	311711	0
Seafood Processing	311712	0
Boat Building	336612	0
Fish and Seafoods	422460	4
Fish and Seafood Markets	445220	8
Marinas	713930	32
Total Fishing Employment		44

Table 5.1.3-75. Number of State Permit by Type for Wrightsville Beach, North Carolina (Source: NCDMF 2008).

Type	**Permits**
Commercial Fishing Vessel Registration	19
Dealer License	1
Flounder License	0
Land or Sell License	0
Non-resident Menhaden License	0
Ocean Fishing Pier License	0
Spotter Plane License	0
Retired Standard Commercial Fishing License	3
Standard Commercial Fishing License	10
Shellfish License	0
Recreational Fishing Tournament to Sell License	0
Total	34

5.1.3.6 Surf City/Topsail Beach (28445) and Hampstead (28443)

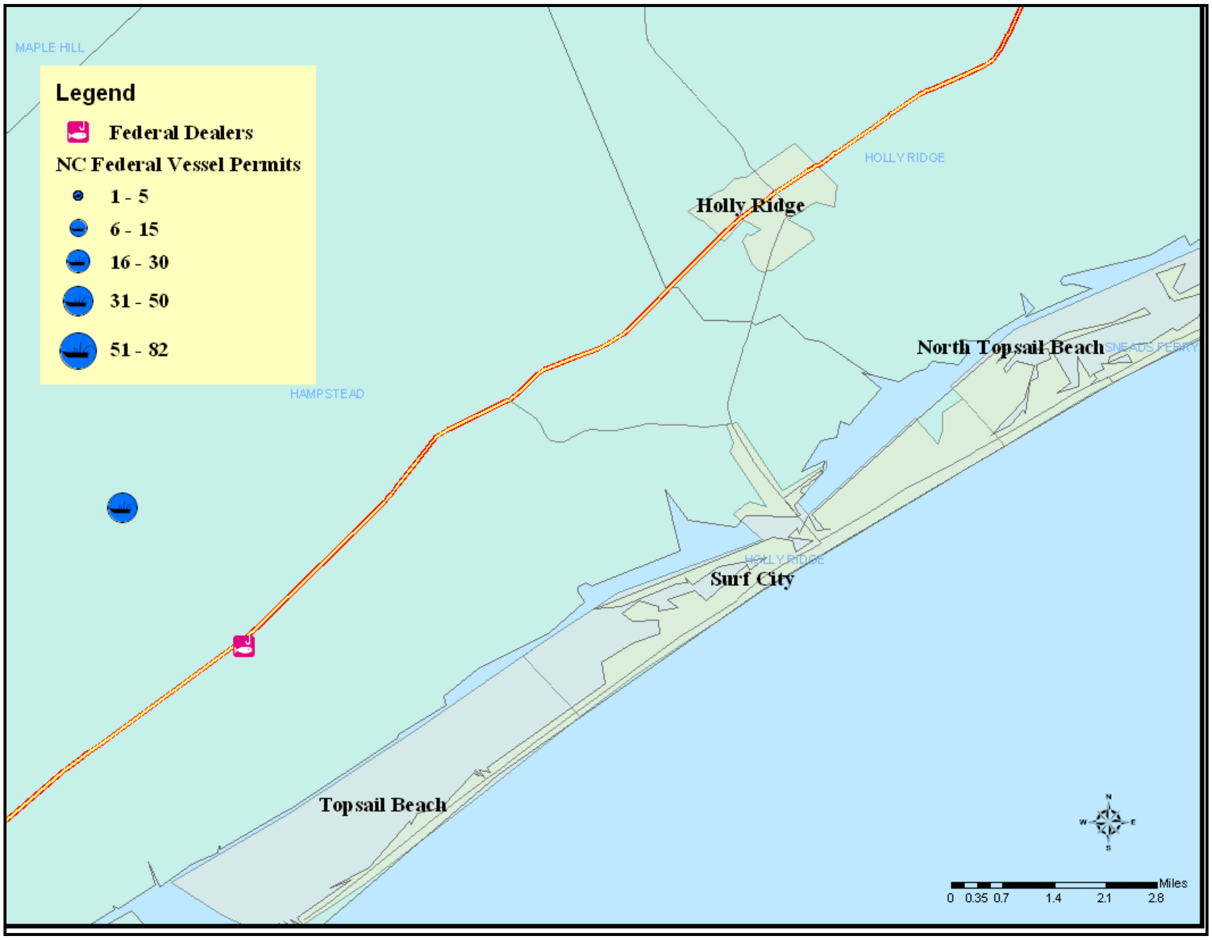

Figure 5.1.3-6. Surf City/Topsail Beach, North Carolina.

Surf City is located in Pender County and had at one time as many as seven long fishing piers. But, like Atlantic Beach and other places, hurricanes reduced that number to two. Fishing is still important but does not contribute as much to the economy as it once used to according to several key informants. There are still a few trawlers that dock here, but they are very small, inlet only trawlers. Most fishermen do not live on the island or in town, but live more inland in places like Hampstead and Holly Ridge. Several respondents commented that it is too expensive for anyone but "northerners" and tourists to live around the beach. Another factor that makes it hard to fish this area is because they are in the middle of the island, and it takes a long time to get out to the sound. It is 13 miles to the inlet from where they are located on the intracoastal waterway.

There is only one fish market in the town today. According to one informant, around 1940 to 1960 this place was a "fisherman's paradise" and there was so much business that the one fish house was open 24 hours a day. With the influx of outsiders, property values have increased making it difficult for fishermen to survive in this area. There are few commercial fishermen and few vessels in the area today that call this community home. Where it once was a commercial fishing village, it has now become more of a tourist/recreational community according to some.

Hampstead is changing from a small fishing village into one of the fastest growing areas in North Carolina. Fishing is still a major piece of the area's identity. There are two wholesale-only fresh fish dealers in the town. One donates approximately 5,000 pounds of fish to the yearly seafood festival which is held in October. The annual Spot Festival celebrates fishing and the fish for which it is named. .

Of the three communities listed, Topsail Beach is the only recognized Census Designated Place and therefore is the only one with census demographics reported. The population has seen a steady increase but remains relatively small with only 404 in the 2000 census (Table 5.1.3-76). Housing tenure has remained relatively the same with three quarters of the housing owner occupied (Table 5.1.3-77). Residence has changed little with slightly more people living in the same house as they did five years ago (Table 5.1.3-78). The percentage of people in the labor force has also remained the same as has the unemployment rate, which is very low at 0.5 percent (Table 5.1.3-79). The population is almost entirely White with a few Latinos appearing in the 2000 census as shown in Table 5.1.3-80.

While Topsail Beach shows few federal or state permits ((Tables 5.1.3-87 and 5.1.3-90, respectively), Hampstead does have more permits listed. Most federal permits that list Hampstead as homeport are either for dolphin/wahoo or snapper grouper (Table 5.1.3-85). The majority of fishing related employment listed for Hampstead is in fish and seafood while both Topsail and Hampstead each show relatively little employment in fishing (Tables 5.1.3-86 and 5.1.3-88). Hampstead has 459 state permits issued with 232 being for commercial vessels and another 121 being standard commercial fishing licenses. There were 58 shellfish licenses issued and 29 dealers in the area (Table 5.1.3-89).

Topsail Beach Census Demographics

Population

Table 5.1.3-76. Total Persons and Persons by Age category for Topsail Beach, North Carolina 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Total Persons and Age Category	1970	1980	1990	2000
Total Persons	.	270	362	404
Persons Age 0-5	.	11	4	4
Persons Age 6-15	.	27	23	11
Persons Age 16-17	.	5	7	11
Persons Age 18-24	.	15	21	18
Persons Age 25-34	.	30	35	57
Persons Age 35-44	.	32	58	26
Persons Age 45-54	.	25	75	69
Persons Age 55-64	.	76	56	97
Persons Age 65+	.	49	83	111

Housing Tenure

Table 5.1.3-77. Housing Tenure for Topsail Beach, North Carolina 1990-2000. (Source: U.S. Census Bureau).

Percent Renter Occupied	**1990**	**2000**
	26.0	25.6
Percent Owner Occupied	**1990**	**2000**
	74.0	74.4

Residence in 1985 and 1995

Table 5.1.3-78. Residence in 1985 and 1995 for Topsail Beach, North Carolina 1990-2000. (Source: U.S. Census Bureau).

Different House Same County	**1990**	**2000**
	33	15
Same House	**1990**	**2000**
	150	208

Employment/Unemployment

Table 5.1.3-79. Employment and Unemployment for Topsail Beach, North Carolina 1990-2000. (Source: U.S. Census Bureau).

Persons 16 yrs and over	**1990**	**2000**
Percent in labor force	56.8	53.7
Percent unemployed	0.0	0.5

Race

Table 5.1.3-80. Race for Topsail Beach, North Carolina 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Race	**1970**	**1980**	**1990**	**2000**
Black Persons	.	0	1	0
Latino Black Persons	.	0	0	0
Latino Persons	.	0	0	2
White Persons	.	268	358	467
Latino White Persons	.	0	0	1

Education

Table 5.1.3-81. Years of Education by Category for those 25 Years and Older for Topsail Beach, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Education	1970	1980	1990	2000
25+ w/ 0-8 years education	.	10	1	2
25+ w/ 9-11 years education	.	30	30	34
25+ w/ HS diploma	.	78	46	59
25+ w/ 13-15 years. education	.	42	85	103
25+ w/ College Degree	.	52	123	162
Drop outs	.	0	4	0

Income and Poverty

Table 5.1.3-82. Average Household Wage/Salary and Persons Below the Poverty Level for Topsail Beach, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Wage or Salary	1970	1980	1990	2000
Average Household Wage/Salary Income (dollars)	.	$12739	$39762	$55750
Poverty Level				
Persons Below Poverty Level	.	40	17	27
Age 65+ Below Poverty Level	.	5	0	0
Households with Public Assistance	.	2	0	6

Industry

Table 5.1.3-83. Employment by Industry for Topsail Beach, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Industry	1970	1980	1990	2000
Agriculture, Fishing, Mining	.	0	10	0
Construction	.	23	14	30
Business Services	.	0	0	22
Communication/Utilities	.	0	0	9
Manufacturing	.	0	9	18
Financial, Insurance & Real Estate	.	0	7	19
Services	.	6	29	50
Wholesale/Retail Trade	.	16	41	48
Transportation	.	39	76	8

Occupation

Table 5.1.3-84. Employment by Occupation for Topsail Beach, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Occupation	1970	1980	1990	2000
Sales	.	15	65	-
Clerical	.	100	23	-
Craft	.	17	4	-
Exec/Managerial	.	27	40	-
Farm/Fish/Forest	.	0	6	0
Household Services	.	0	0	-
Laborer/Handler	.	7	0	-
Operative/Transport	.	0	0	-
Service, except Household	.	25	19	-
Technical	.	0	2	-

Topsail Beach Fishing Demographics

Table 5.1.3-85. Number of Federal Permit by Type for Hampstead, North Carolina (Source: NMFS 2002).

Type of Permit	1998	1999	2000	2001
Total permitted vessels	13	15	15	11
Commercial King Mackerel	12	12	12	9
Commercial Spanish Mackerel	9	6	4	2
Commercial Spiny Lobster	0	0	2	1
Charter/Headboat for Coastal Pelagics	1	0	0	1
Charter/Headboat for Snapper Grouper	1	0	0	1
Snapper Grouper Class 1	10	12	14	10
Snapper Grouper Class 2	0	0	0	0
Swordfish	0	0	0	0
Shark	0	0	0	0
Rock Shrimp	1	1	1	1
Federal Dealers			1	

Table 5.1.3-86. Employment in Fishing Related Industry for Hampstead, North Carolina (Zip code Business Patterns, U.S. Census Bureau 1998).

Category	NAIC Code	Number Employed
Fishing	114100	4
Seafood Canning	311711	0
Seafood Processing	311712	0
Boat Building	336612	4
Fish and Seafoods	422460	52
Fish and Seafood Markets	445220	4
Marinas	713930	0
Total Fishing Employment		64

Table 5.1.3-87. Number of Federal Permit (October 2008) by Type for Topsail Beach, North Carolina (Source: NMFS 2008).

Type	Permits
ATLANTIC DOLPHIN/WAHOO COMMERCIAL	3
ATLANTIC DOLPHIN/WAHOO CHARTER/ HEADBOAT	2
S. ATLANTIC CHARTER/HEADBOAT FOR PELAGIC FISH	2
KING MACKEREL	3
SPINY LOBSTER & TAILING	-, -
ROCK SHRIMP & ENDORSEMENTS	-, -
S. ATL. CHARTER/HEADBOAT FOR SNAPPER-GROUPER	2
SWORDFISH & SHARKS	1, -
S. ATLANTIC SNAPPER-GROUPER (UNLIMITED)	2
S. ATLANTIC SNAPPER-GROUPER (225)	-
SPANISH MACKEREL	1
SOUTH ATLANTIC SHRIMP	-

Table 5.1.3-88. Employment in Fishing Related Industry for Topsail Beach, North Carolina (Zip code Business Patterns, U.S. Census Bureau 1998).

Category	**NAIC Code**	**Number Employed**
Fishing	114100	5
Seafood Canning	311711	0
Seafood Processing	311712	0
Boat Building	336612	0
Fish and Seafoods	422460	0
Fish and Seafood Markets	445220	5
Marinas	713930	0
Total Fishing Employment		10

Table 5.1.3-89. Number of State Permit by Type for Hampstead, North Carolina (Source: NCDMF 2008).

Type	**Permits**
Commercial Fishing Vessel Registration	232
Dealer License	29
Flounder License	0
Land or Sell License	0
Non-resident Menhaden License	0
Ocean Fishing Pier License	0
Spotter Plane License	0
Retired Standard Commercial Fishing License	19
Standard Commercial Fishing License	121
Shellfish License	58
Recreational Fishing Tournament to Sell License	0
Total	459

Table 5.1.3-90. Number of State Permit by Type for Surf City/Topsail Beach, North Carolina (Source: NCDMF 2008).

Type	Permits
Commercial Fishing Vessel Registration	51
Dealer License	9
Flounder License	0
Land or Sell License	1
Non-resident Menhaden License	0
Ocean Fishing Pier License	1
Spotter Plane License	0
Retired Standard Commercial Fishing License	8
Standard Commercial Fishing License	22
Shellfish License	6
Recreational Fishing Tournament to Sell License	0
Total	92

5.1.3.7 Sneads Ferry (28460)

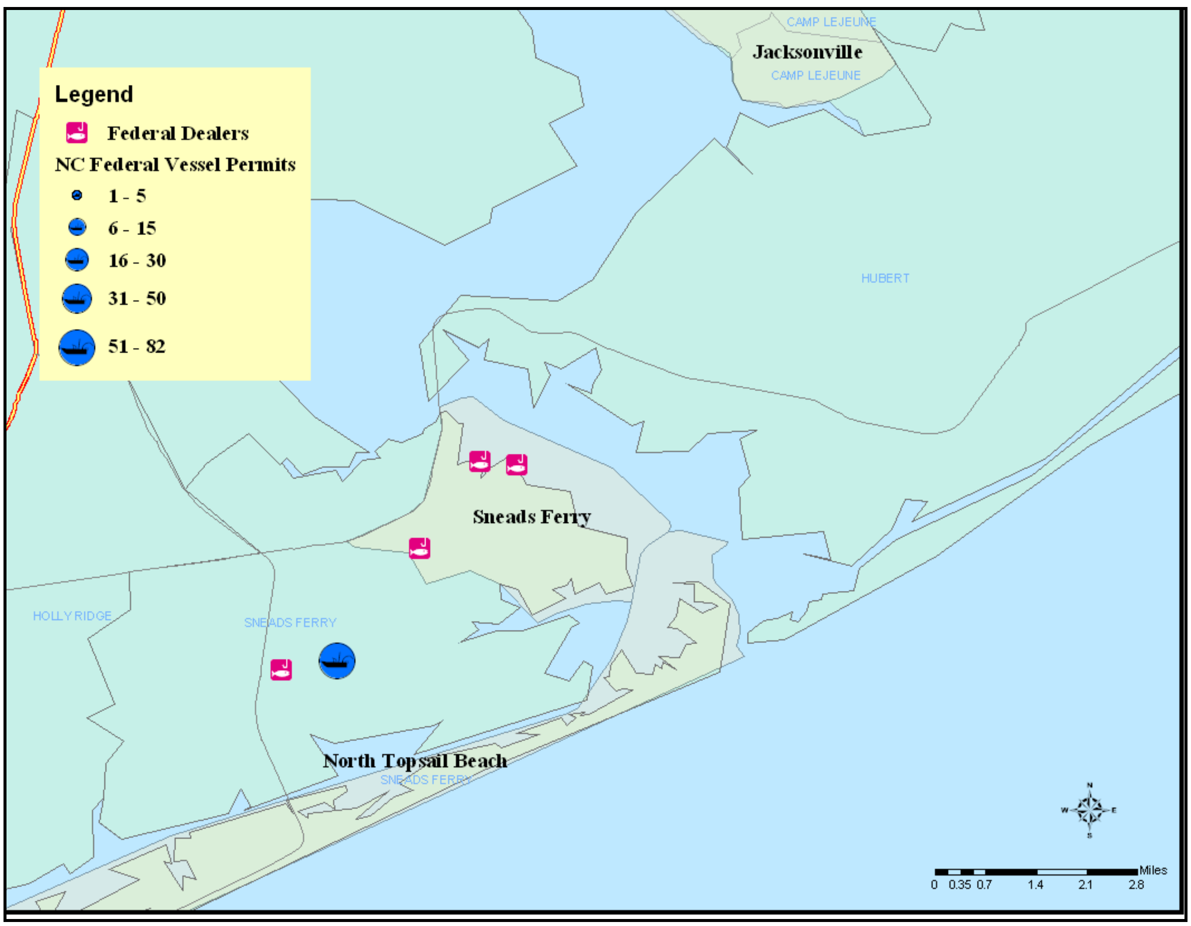

Figure 5.1.3-7. Sneads Ferry, North Carolina.

The white rubber boots worn by commercial fishermen in this community and many other parts of North Carolina are commonly referred to as "Snead's Ferry Sneakers."

With such an icon named after the community it suggests the importance of commercial fishing to the area.

Snead's Ferry is a small town with very little of the large-scale development that is evident elsewhere on the North Carolina coast. However, there are apparently more retirees moving here from places like Atlantic Beach because it is more affordable according to some individuals. Many houses in the community have fishing vessels docked in front of the house or on the lawn. Snead's Ferry's location is an advantage for fishermen, because the channel leads directly to the sound without having to travel through many creeks; this offers larger boats more accessibility. One respondent commented that at least half of the people in the community have something to do with the fishing industry. Others living in Surf City believe that Snead's Ferry is now made up of at least 20% of residents who are either servicemen or who work on the base. Some of these individuals also shrimp at night or on the weekends. This is a source of resentment, because these people are no longer full time fishermen, and have more disposable income with which to purchase better equipment or simply have better standards of living. The community celebrates the Shrimp Festival each second weekend in August.

One fish house owner who has been working in Snead's Ferry for 12 years has 15 boats that sell to him and dock at his place of business. These fishermen do everything, including net fishing, crabbing, clamming, and shrimping. He commented that he doesn't see much of a future in fishing because younger people are not getting involved. This same individual commented that a lot of new people are moving in from other places and he considers it only a matter of years before his place sells. The fish house next door is for sale and he is just waiting for the right price, and he will sell, too. Most of the captains and crew live within two miles of his fish house and there does not seem to be a problem finding crew; primarily because they have worked in the industry for so long and most have been with the same captains for quite some time. He also commented that most of the fishermen in town are shrimpers and net fishermen who go out daily which allows them to be home at night and have a more stable life.

In 2008, vessels with federal permits predominantly held south Atlantic shrimp (30), Atlantic dolphin/wahoo commercial (9), rock shrimp (17), or snapper grouper charter/headboat for snapper grouper (11) permits (Table 5.1.3-100). There were over 705 state commercial fishing vessel registrations for Snead's Ferry and, among those, there were 192 standard commercial fishing licenses (Table 5.1.3-102). The community also had 1 recreational sell license (Table 5.1.3-102). According to Table 5.1.3-101 there was some seafood employment in other areas with 16 persons employed in fish and seafood and 2 in marinas.

Sneads Ferry Census Demographics

<u>Population</u>

Table 5.1.3-91. Total Persons and Persons by Age category for Sneads Ferry, North Carolina 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Total Persons and Age Category	**1970**	**1980**	**1990**	**2000**
Total Persons	.	.	2042	2152
Persons Age 0-5	.	.	179	153
Persons Age 6-15	.	.	276	242
Persons Age 16-17	.	.	27	56
Persons Age 18-24	.	.	229	120
Persons Age 25-34	.	.	330	383
Persons Age 35-44	.	.	252	334
Persons Age 45-54	.	.	241	287
Persons Age 55-64	.	.	283	268
Persons Age 65+	.	.	225	309

Housing Tenure

Table 5.1.3-92. Housing Tenure for Sneads Ferry, North Carolina 1990-2000. (Source: U.S. Census Bureau).

Percent Renter Occupied	**1990**	**2000**
	30.3	28.8
Percent Owner Occupied	**1990**	**2000**
	69.7	71.2

Residence in 1985 and 1995

Table 5.1.3-93. Residence in 1985 and 1995 for Sneads Ferry, North Carolina 1990-2000. (Source: U.S. Census Bureau).

Different House Same County	**1990**	**2000**
	467	203
Same House	**1990**	**2000**
	1035	1199

Employment/Unemployment

Table 5.1.3-94. Employment and Unemployment for Sneads Ferry, North Carolina 1990-2000. (Source: U.S. Census Bureau).

Persons 16 yrs and over	**1990**	**2000**
Percent in labor force	59.3	59.0
Percent unemployed	7.8	2.2

Race

Table 5.1.3-95. Race for Sneads Ferry, North Carolina 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Race	**1970**	**1980**	**1990**	**2000**
Black Persons	.	.	182	113
Latino Black Persons	.	.	0	2
Latino Persons	.	.	10	38
White Persons	.	.	1840	2029
Latino White Persons	.	.	10	16

Education

Table 5.1.3-96. Years of Education by Category for those 25 Years and Older for Sneads Ferry, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Education	**1970**	**1980**	**1990**	**2000**
25+ w/ 0-8 years education	.	.	177	101
25+ w/ 9-11 years education	.	.	221	176
25+ w/ HS diploma	.	.	576	654
25+ w/ 13-15 years. education	.	.	239	367
25+ w/ College Degree	.	.	80	267
Drop outs	.	.	23	16

Income and Poverty

Table 5.1.3-97. Average Household Wage/Salary and Persons Below the Poverty Level for Sneads Ferry, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Wage or Salary	**1970**	**1980**	**1990**	**2000**
Average Household Wage/Salary Income (dollars)	.	.	$21901	$34509
Poverty Level				
Persons Below Poverty Level	.	.	427	290
Age 65+ Below Poverty Level	.	.	56	12
Households with Public Assistance	.	.	43	30

Industry

Table 5.1.3-98. Employment by Industry for Sneads Ferry, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Industry	**1970**	**1980**	**1990**	**2000**
Agriculture, Fishing, Mining	.	.	121	77

Construction	.	.	47	120
Business Services	.	.	73	34
Communication/Utilities	.	.	0	21
Manufacturing	.	.	16	66
Financial, Insurance & Real Estate	.	.	10	63
Services	.	.	49	309
Wholesale/Retail Trade	.	.	243	135
Transportation	.	.	187	64

Occupation

Table 5.1.3-99. Employment by Occupation for Sneads Ferry, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Occupation	1970	1980	1990	2000
Sales	.	.	73	-
Clerical	.	.	58	-
Craft	.	.	77	-
Exec/Managerial	.	.	88	-
Farm/Fish/Forest	.	.	132	83
Household Services	.	.	0	-
Laborer/Handler	.	.	31	-
Operative/Transport	.	.	6	-
Service, except Household	.	.	145	-
Technical	.	.	21	-

Sneads Ferry Fishing Demographics

Table 5.1.3-100. Number of Federal Permit (October 2008) by Type for Sneads Ferry, North Carolina (Source: NMFS 2008).

Type	Permits
ATLANTIC DOLPHIN/WAHOO COMMERCIAL	9
ATLANTIC DOLPHIN/WAHOO CHARTER/ HEADBOAT	3
S. ATLANTIC CHARTER/HEADBOAT FOR PELAGIC FISH	4
KING MACKEREL	9
SPINY LOBSTER & TAILING	2, 1
ROCK SHRIMP & ENDORSEMENTS	17, 2
S. ATL. CHARTER/HEADBOAT FOR SNAPPER-GROUPER	5
SWORDFISH & SHARKS	-, -
S. ATLANTIC SNAPPER-GROUPER (UNLIMITED)	11
S. ATLANTIC SNAPPER-GROUPER (225)	1
SPANISH MACKEREL	4
SOUTH ATLANTIC SHRIMP	30

Table 5.1.3-101. Employment in Fishing Related Industry for Sneads Ferry, North Carolina (Zip code Business Patterns, U.S. Census Bureau 1998).

Category	NAIC Code	Number Employed
Fishing	114100	0

Seafood Canning	311711	0
Seafood Processing	311712	0
Boat Building	336612	0
Fish and Seafoods	422460	12
Fish and Seafood Markets	445220	0
Marinas	713930	4
Total Fishing Employment		16

Table 5.1.3-102. Number of State Permit by Type for Sneads Ferry, North Carolina (Source: NCDMF 2008).

Type	**Permits**
Commercial Fishing Vessel Registration	324
Dealer License	23
Flounder License	2
Land or Sell License	0
Non-resident Menhaden License	0
Ocean Fishing Pier License	0
Spotter Plane License	0
Retired Standard Commercial Fishing License	45
Standard Commercial Fishing License	192
Shellfish License	118
Recreational Fishing Tournament to Sell License	1
Total	705

5.1.3.8 Swansboro (28584)

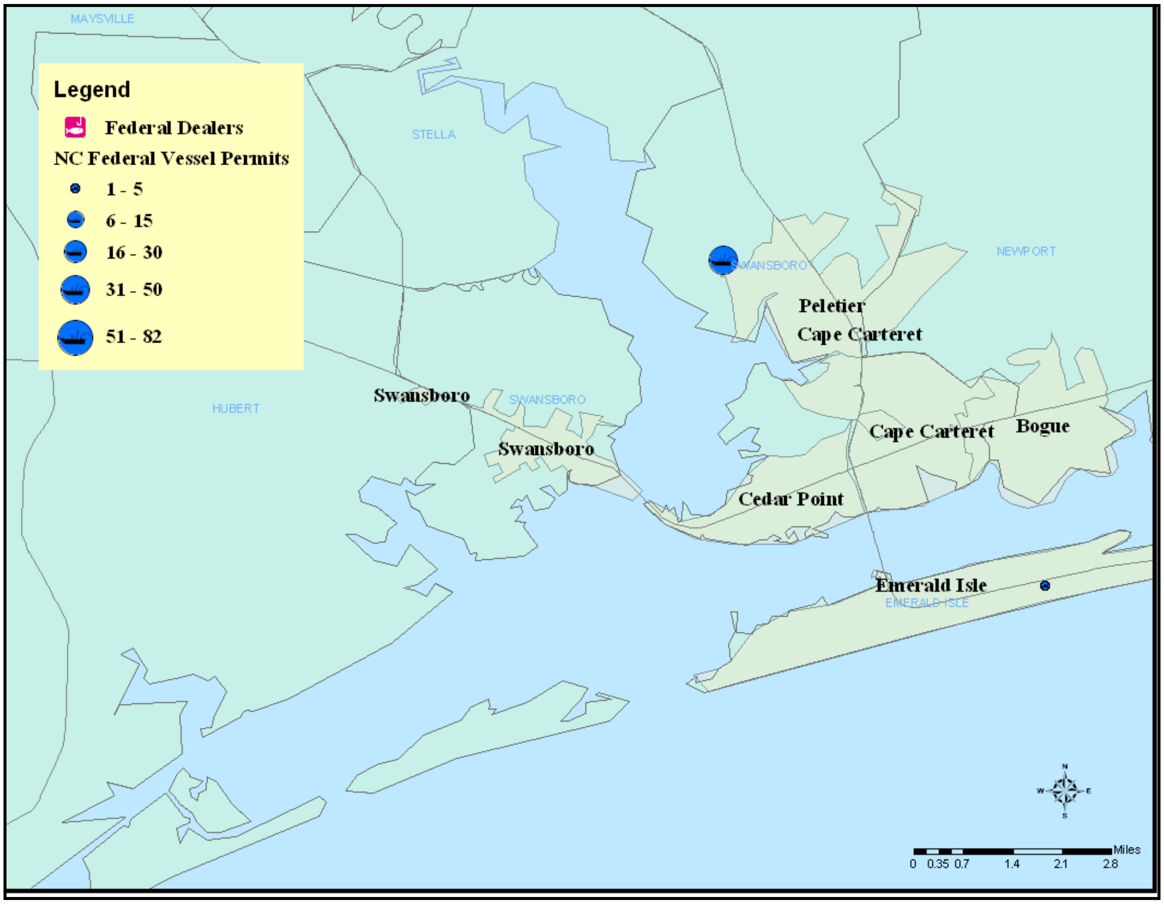

Figure 5.1.3-8. Swansboro, North Carolina.

Swansboro is supposedly the second oldest town in North Carolina. Settlement of the surrounding lands by English colonists probably was influenced by its proximity to Bogue Inlet and the White Oak River. Shipbuilding and the export of naval stores were the mainstays of the local economy. The town was a major port in the late eighteenth century, and relied mainly on ship building. The end of the Civil War brought a close to that prosperity and fishing became important socially and economically.

The community has a small historic section that has been well preserved with many old buildings still intact and restored, now used mostly for tourist shops. There are two fish houses with some small trawlers docked nearby. There are at least five seafood restaurants and two seafood markets. Though Swansboro has all the trappings of a fishing community, according to some, it is more a tourist community now. According to one fisherman, from Swansboro, the community was much more of a fishing town around ten years ago when there was close to double the fleet. Shrimping has experienced a recent downturn because imports with lower prices have affected the market. Because of the costs involved, local shrimp are more expensive and they are not as big, therefore more and more people are buying imports according to one individual. There are two main docks in the community, one has three trawlers and the other has two. Almost all captains and crew live in town, although crew may come from other places, fishing has always been a family business in Swansboro. There are a few charter businesses in town with one in particular that has a seafood market, a head boat and one charter.

In 2008, vessels with federal permits predominantly held Atlantic dolphin/wahoo commercial (12), Atlantic dolphin/wahoo charter (10), south Atlantic charter/headboat for pelagic fish (10), or snapper grouper charter/headboat for snapper grouper (10) permits (Table 5.1.3-112). Much of the employment according to census zip code data is in marinas with a few employed in fish and seafood (Table 5.1.3-113). There were over 126 state-permitted vessels with 69 standard commercial licenses and over 53 shellfish licenses according to Table 5.1.3-114, and 3 recreational tournament sell licenses.

Swansboro Census Demographics

Population

Table 5.1.3-103. Total Persons and Persons by Age category for Swansboro, North Carolina 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Total Persons and Age Category	1970	1980	1990	2000
Total Persons	.	976	1165	1433
Persons Age 0-5	.	30	101	96
Persons Age 6-15	.	141	131	204
Persons Age 16-17	.	32	22	40
Persons Age 18-24	.	88	152	116
Persons Age 25-34	.	96	204	152
Persons Age 35-44	.	120	139	238
Persons Age 45-54	.	156	114	210
Persons Age 55-64	.	147	114	166
Persons Age 65+	.	150	188	211

Housing Tenure

Table 5.1.3-104. Housing Tenure for Swansboro, North Carolina 1990-2000. (Source: U.S. Census Bureau).

Percent Renter Occupied	1990	2000
	43.7	23.5
Percent Owner Occupied	**1990**	**2000**
	56.3	76.5

Residence in 1985 and 1995

Table 5.1.3-105. Residence in 1985 and 1995 for Swansboro, North Carolina 1990-2000. (Source: U.S. Census Bureau).

Different House Same County	1990	2000
	124	148
Same House	**1990**	**2000**
	484	637

Employment/Unemployment

Table 5.1.3-106. Employment and Unemployment for Swansboro, North Carolina 1990-2000. (Source: U.S. Census Bureau).

Persons 16 yrs and over	1990	2000
Percent in labor force	59.5	65.2
Percent unemployed	4.9	2.8

Race

Table 5.1.3-107. Race for Swansboro, North Carolina 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Race	1970	1980	1990	2000
Black Persons	.	0	24	66
Latino Black Persons	.	0	0	0
Latino Persons	.	4	14	40
White Persons	.	972	1115	1274
Latino White Persons	.	4	8	12

Education

Table 5.1.3-108. Years of Education by Category for those 25 Years and Older for Swansboro, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Education	1970	1980	1990	2000
25+ w/ 0-8 years education	.	106	67	25
25+ w/ 9-11 years education	.	131	80	72
25+ w/ HS diploma	.	251	269	289
25+ w/ 13-15 years. education	.	109	157	267
25+ w/ College Degree	.	72	138	324
Drop outs	.	4	0	0

Income and Poverty

Table 5.1.3-109. Average Household Wage/Salary and Persons Below the Poverty Level for Swansboro, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Wage or Salary	**1970**	**1980**	**1990**	**2000**
Average Household Wage/Salary Income (dollars)	.	$17162	$25410	$37740
Poverty Level				
Persons Below Poverty Level	.	86	172	171
Age 65+ Below Poverty Level	.	30	30	16
Households with Public Assistance	.	28	34	11

Industry

Table 5.1.3-110. Employment by Industry for Swansboro, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Industry	**1970**	**1980**	**1990**	**2000**
Agriculture, Fishing, Mining	.	5	8	5
Construction	.	31	36	74
Business Services	.	10	11	28
Communication/Utilities	.	8	6	23
Manufacturing	.	30	34	17
Financial, Insurance & Real Estate	.	8	23	31
Services	.	13	18	266
Wholesale/Retail Trade	.	45	166	141
Transportation	.	86	135	26

Occupation

Table 5.1.3-111. Employment by Occupation for Swansboro, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Occupation	**1970**	**1980**	**1990**	**2000**
Sales	.	42	86	-
Clerical	.	540	60	-
Craft	.	84	48	-
Exec/Managerial	.	39	43	-
Farm/Fish/Forest	.	4	8	5
Household Services	.	2	0	-
Laborer/Handler	.	8	7	-
Operative/Transport	.	22	15	-
Service, except Household	.	58	54	-
Technical	.	11	22	-

Swansboro Fishing Demographics

Table 5.1.3-112. Number of Federal Permit October 2008) by Type for Swansboro, North Carolina (Source: NMFS 2008).

Type	Permits
ATLANTIC DOLPHIN/WAHOO COMMERCIAL	12
ATLANTIC DOLPHIN/WAHOO CHARTER/ HEADBOAT	10
S. ATLANTIC CHARTER/HEADBOAT FOR PELAGIC FISH	10
KING MACKEREL	6
SPINY LOBSTER & TAILING	-, -
ROCK SHRIMP & ENDORSEMENTS	2, -
S. ATL. CHARTER/HEADBOAT FOR SNAPPER-GROUPER	10
SWORDFISH & SHARKS	-, -
S. ATLANTIC SNAPPER-GROUPER (UNLIMITED)	2
S. ATLANTIC SNAPPER-GROUPER (225)	-
SPANISH MACKEREL	4
SOUTH ATLANTIC SHRIMP	4

Table 5.1.3-113. Employment in Fishing Related Industry for Swansboro, North Carolina (Zip code Business Patterns, U.S. Census Bureau 1998).

Category	**NAIC Code**	**Number Employed**
Fishing	114100	0
Seafood Canning	311711	0
Seafood Processing	311712	0
Boat Building	336612	0
Fish and Seafoods	422460	0
Fish and Seafood Markets	445220	4
Marinas	713930	16
Total Fishing Employment		20

Table 5.1.3-114. Number of State Permit by Type for Swansboro, North Carolina (Source: NCDMF 2008).

Type	**Permits**
Commercial Fishing Vessel Registration	126
Dealer License	10
Flounder License	3
Land or Sell License	0
Non-resident Menhaden License	0
Ocean Fishing Pier License	0
Spotter Plane License	0
Retired Standard Commercial Fishing License	10
Standard Commercial Fishing License	69
Shellfish License	53
Recreational Fishing Tournament to Sell License	3
Total	274

5.1.3.9 Atlantic Beach (28512)

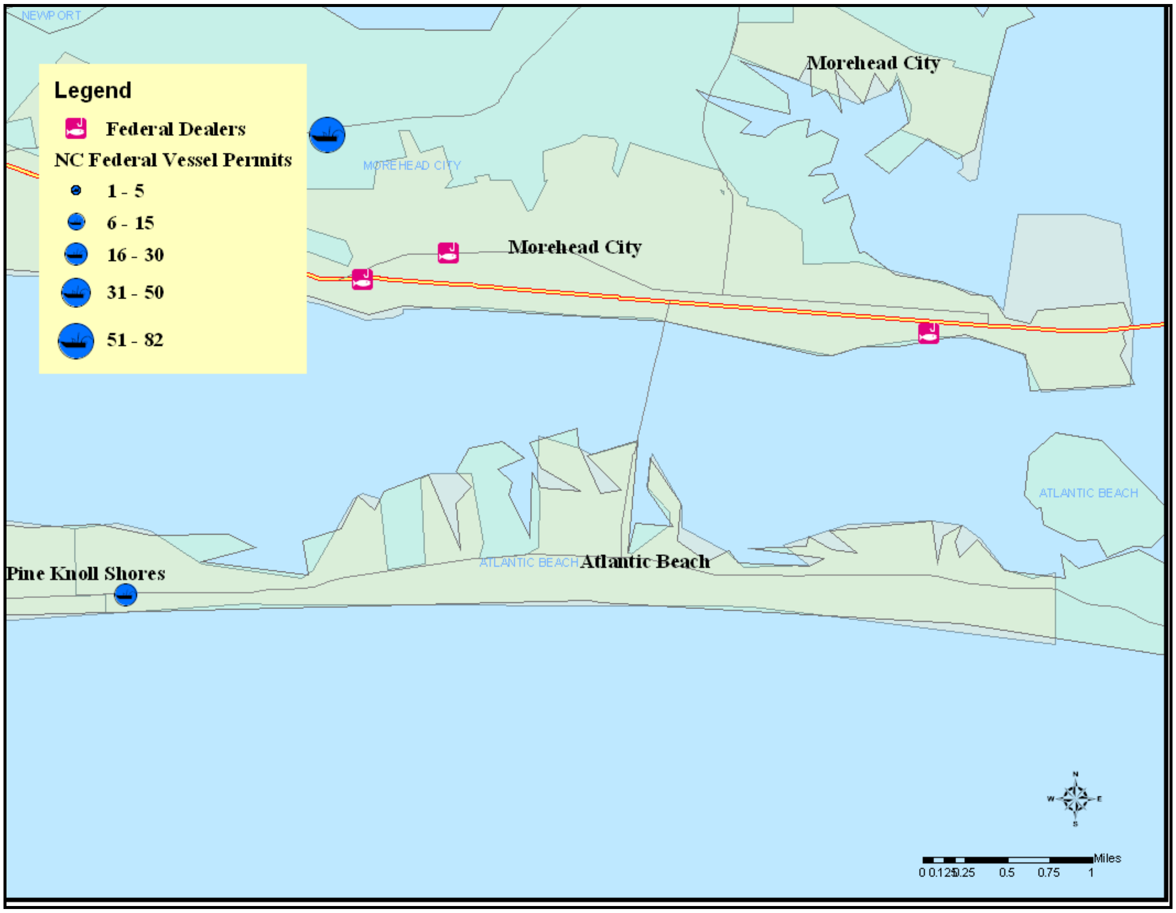

Figure 5.1.3-9. Atlantic Beach, North Carolina.

Atlantic Beach has been a popular resort town since the 1870s. The first bathing pavilion was built on Bogue Banks in 1887. Other resorts and tourism related development occurred over the next century and the area remains today a popular vacation destination. Today there is a boardwalk with rides, a video arcade, shops, restaurants, etc., along the waterfront. The beach is the primary attraction and there is a defined seasonal tourism during the summer months. There is a small marina in the community, with charterboats, but there is no commercial fishing out of Atlantic Beach. There are about 12-14 charterboats total, according to one respondent. Some boats that advertise as being from Atlantic Beach actually dock in Morehead. The charter business is also very seasonal, and there seems to be plenty of competition. During the off season, charter fishermen take on other jobs, like carpentry or anything they can find.

In 2008, vessels with federal permits predominantly held Atlantic dolphin/wahoo commercial (17), Atlantic dolphin/wahoo charter (19), south Atlantic charter/headboat for pelagic fish(15), or snapper grouper charter/headboat for snapper grouper (14) permits (Table 5.1.3-124). There are, however, over 55 state commercially registered vessels and 35 standard commercial fishing licenses (Table 5.1.3-126).

The Salter Path/Indian Beach area is south of Atlantic Beach and may have more fishing related businesses than Atlantic Beach. There are five or more seafood restaurants and several fish houses that sell retail and wholesale seafood. The community has many hotels and also a miniature golf course. A small area along the creek is where most of the fish houses and restaurants are located. One individual commented that most people make their living from seafood here, yet most fishermen have other jobs and their wives work because it is difficult to make a living solely from the fishing industry year round. Another commented that Salter Path used to be a fishing community with shrimp boats, net fishing, clam and scallop, but there is no offshore fishing from the area. Overall, this area has become more dependent upon tourism and the associated service economy.

Salter Path had 73 state registered commercial vessels and 54 standard commercial licenses issued for the year 2002. There were also 9 dealer licenses for the community (Table 5.1.3-127).

Atlantic Beach Census Demographics

Population

Table 5.1.3-115. Total Persons and Persons by Age category for Atlantic Beach, North Carolina 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Total Persons and Age Category	1970	1980	1990	2000
Total Persons	.	930	1938	1811
Persons Age 0-5	.	26	84	51
Persons Age 6-15	.	75	139	89
Persons Age 16-17	.	34	59	27
Persons Age 18-24	.	204	157	125
Persons Age 25-34	.	196	363	222
Persons Age 35-44	.	142	316	251
Persons Age 45-54	.	100	316	389
Persons Age 55-64	.	108	261	323
Persons Age 65+	.	45	243	334

Housing Tenure

Table 5.1.3-116. Housing Tenure for Atlantic Beach, North Carolina 1990-2000. (Source: U.S. Census Bureau).

Percent Rent	1990	2000
	38.6	35.4
Percent Own	**1990**	**2000**
	61.4	66.6

Residence in 1985 and 1995

Table 5.1.3-117. Residence in 1985 and 1995 for Atlantic Beach, North Carolina 1990-2000. (Source: U.S. Census Bureau).

Different House Same County	**1990**	**2000**
	378	163
Same House	**1990**	**2000**
	718	908

Employment/Unemployment

Table 5.1.3-118. Employment and Unemployment for Atlantic Beach, North Carolina 1990-2000. (Source: U.S. Census Bureau).

Persons 16 yrs and over	**1990**	**2000**
Percent in labor force	69.3	63.3
Percent unemployed	3.0	5.4

Race

Table 5.1.3-119. Race for Atlantic Beach, North Carolina 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Race	**1970**	**1980**	**1990**	**2000**
Black Persons	.	10	20	11
Latino Black Persons	.	0	0	0
Latino Persons	.	19	14	12
White Persons	.	902	1882	1735
Latino White Persons	.	19	12	11

Education

Table 5.1.3-120. Years of Education by Category for those 25 Years and Older for Atlantic Beach, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Education	**1970**	**1980**	**1990**	**2000**
25+ w/ 0-8 years education	.	45	45	40
25+ w/ 9-11 years education	.	89	179	109
25+ w/ HS diploma	.	209	398	354
25+ w/ 13-15 years. education	.	121	412	428
25+ w/ College Degree	.	127	362	585
Drop outs	.	5	7	3

Income and Poverty

Table 5.1.3-121. Average Household Wage/Salary and Persons Below the Poverty Level for Atlantic Beach, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Wage or Salary	**1970**	**1980**	**1990**	**2000**
Average Household Wage/Salary Income (dollars)	.	$15156	$30093	$38313
Poverty Level				
Persons Below Poverty Level	.	81	195	131
Age 65+ Below Poverty Level	.	3	17	5
Households with Public Assistance	.	15	23	6

Industry

Table 5.1.3-122. Employment by Industry for Atlantic Beach, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Industry	**1970**	**1980**	**1990**	**2000**
Agriculture, Fishing, Mining	.	12	31	7
Construction	.	26	117	135
Business Services	.	7	26	54
Communication/Utilities	.	10	27	30
Manufacturing	.	39	82	21
Financial, Insurance & Real Estate	.	22	41	104
Services	.	49	110	303
Wholesale/Retail Trade	.	74	288	222
Transportation	.	148	307	31

Occupation

Table 5.1.3-123. Employment by Occupation for Atlantic Beach, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Occupation	**1970**	**1980**	**1990**	**2000**
Sales	.	67	256	-
Clerical	.	710	124	-
Craft	.	53	126	-
Exec/Managerial	.	109	164	-
Farm/Fish/Forest	.	11	28	5
Household Services	.	0	3	-
Laborer/Handler	.	10	35	-
Operative/Transport	.	7	22	-
Service, except Household	.	47	139	-
Technical	.	4	34	-

Atlantic Beach Fishing Demographics

Table 5.1.3-124. Number of Federal Permit (October 2008) by Type for Atlantic Beach, North Carolina (Source: NMFS 2008).

Type	Permits
ATLANTIC DOLPHIN/WAHOO COMMERCIAL	17
ATLANTIC DOLPHIN/WAHOO CHARTER/ HEADBOAT	19
S. ATLANTIC CHARTER/HEADBOAT FOR PELAGIC FISH	15
KING MACKEREL	10
SPINY LOBSTER & TAILING	-, -
ROCK SHRIMP & ENDORSEMENTS	1, 1
S. ATL. CHARTER/HEADBOAT FOR SNAPPER-GROUPER	14
SWORDFISH & SHARKS	-, -
S. ATLANTIC SNAPPER-GROUPER (UNLIMITED)	5
S. ATLANTIC SNAPPER-GROUPER (225)	-
SPANISH MACKEREL	4
SOUTH ATLANTIC SHRIMP	-

Table 5.1.3-125. Employment in Fishing Related Industry for Atlantic Beach, North Carolina (Zip code Business Patterns, U.S. Census Bureau 1998).

Category	NAIC Code	Number Employed
Fishing	114100	0
Seafood Canning	311711	0
Seafood Processing	311712	0
Boat Building	336612	0
Fish and Seafoods	422460	0
Fish and Seafood Markets	445220	4
Marinas	713930	56
Total Fishing Employment		60

Table 5.1.3-126. Number of State Permit by Type for Atlantic Beach, North Carolina (Source: NCDMF 2008).

Type	Permits
Commercial Fishing Vessel Registration	55
Dealer License	12
Flounder License	0
Land or Sell License	0
Non-resident Menhaden License	0
Ocean Fishing Pier License	2
Spotter Plane License	0
Retired Standard Commercial Fishing License	6
Standard Commercial Fishing License	35
Shellfish License	6
Recreational Fishing Tournament to Sell License	3
Total	121

Table 5.1.3-127. Number of State Permit by Type for Salter Path, North Carolina (Source: NCDMF 2002).

Type	Permits

Commercial Fishing Vessel Registration	73
Dealer License	9
Flounder License	1
Land or Sell License	0
Non-resident Menhaden License	0
Ocean Fishing Pier License	0
Spotter Plane License	0
Retired Standard Commercial Fishing License	4
Standard Commercial Fishing License	54
Shellfish License	17
Recreational Fishing Tournament to Sell License	0
Total	158

5.1.3.10 Morehead City (28557)

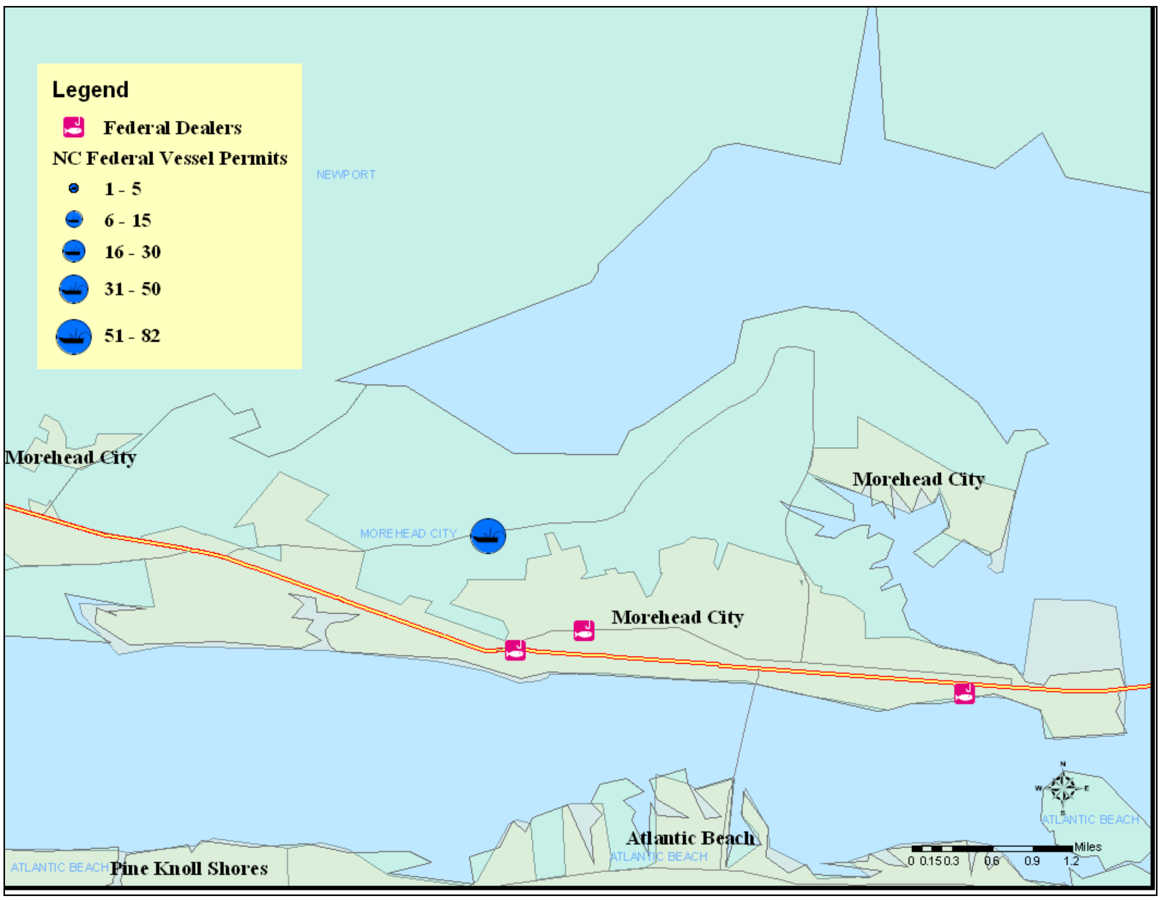

Figure 5.1.3-10. Morehead City, North Carolina.

Morehead City was founded in the 1840s and soon had a railroad line that connected its deep-water harbor with inland markets. Following several severe hurricanes during the 1880s and 1890s, fishermen who had lived on Shackleford Banks moved their houses by boat onto the mainland in the areas between 10th and 15th Streets. They called this area the Promise Land and it became the nucleus of the fishing industry that continues to be an important part of the economy of Morehead City. In recent years, a large charter-fishing fleet has developed, and Morehead City has become widely known as a center for sport and tournament fishing, drawing fishermen from all over the eastern United States. It is the location of one of the major, annual international Blue Marlin tournaments, as well as other fishing tournaments.

Today Morehead City has a community college, several strip malls and commercial enterprises. There is a coastal theme to many of the businesses and art galleries, with a focus on tourism. The waterfront is small but crowded with several tourist attractions and numerous charterboats. According to one captain of a charterboat, the best fishing area on the NC coast is 50-100 miles offshore of here. The Big Rock Blue Marlin tournament held the second week in June is the biggest paying tournament on the East Coast. The tournament brings approximately 200 boats to the area. With an estimated four people per boat plus families, the tournament generates considerable economic benefit to the community. Many of the local charterboats are chartered for this tournament, which has an entry fee of $12,000 per person. There are also several small tournaments held in the community during the mackerel and marlin season. While there are no local fishing clubs, the Raleigh Sport Fishing Alliance is a regional fishing club with many of its members fishing out of Morehead City. One charter crew member said that he commercial fished for 21 years, but tired of weather problems and the “feast or famine” economy of commercial fishing. He said he had seen some commercial fishermen go out by themselves in any kind of weather because they couldn’t find crew members, just to survive. He also mentioned that there are good crews around that migrate up and down the coast according to work.

In 2008, vessels with federal permits predominantly held Atlantic dolphin/wahoo commercial (45), Atlantic dolphin/wahoo charter (26), south Atlantic charter/headboat for pelagic fish(22), or snapper grouper charter/headboat for snapper grouper 22) permits (Table 5.1.3-137). About half held charter permits for both species groups. There are about 100 people employed in fishing related business according to census business figures in Table 5.1.3-138. About half of those are in marinas and 36 are employed in fish and seafood business. 398 state commercial vessel licenses were issued for Morehead City and 124 standard commercial fishing permits. There were 40 shellfish licenses and 18 dealer licenses issued by the state (Table 5.1.3-139).

Morehead City Census Demographics

Population

Table 5.1.3-128. Total Persons and Persons by Age category for Morehead City, North Carolina 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Total Persons and Age Category	1970	1980	1990	2000
Total Persons	5226	4359	6046	7649
Persons Age 0-5	394	256	497	578
Persons Age 6-15	1037	601	744	780
Persons Age 16-17	225	152	109	106
Persons Age 18-24	543	379	528	584
Persons Age 25-34	556	594	1037	1058
Persons Age 35-44	584	478	792	975
Persons Age 45-54	642	434	549	1128
Persons Age 55-64	576	576	535	748
Persons Age 65+	570	854	1255	1692

Housing Tenure

Table 5.1.3-129. Housing Tenure for Morehead City, North Carolina 1990-2000. (Source: U.S. Census Bureau).

Percent Rent	1990	2000
	44.7	44.8
Percent Own	**1990**	**2000**
	55.3	55.2

Residence in 1985 and 1995

Table 5.1.3-130. Residence in 1985 and 1995 for Morehead City, North Carolina 1990-2000. (Source: U.S. Census Bureau).

Different House Same County	1990	2000
	1710	1061
Same House	**1990**	**2000**
	2532	3296

Employment/Unemployment

Table 5.1.3-131. Employment and Unemployment for Morehead City, North Carolina 1990-2000. (Source: U.S. Census Bureau).

Persons 16 yrs and over	1990	2000
Percent in labor force	59.4	60.2
Percent unemployed	4.1	7.8

Race

Table 5.1.3-132. Race for Morehead City, North Carolina 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Race	1970	1980	1990	2000
Black Persons	1009	789	1066	1071
Latino Black Persons	0	5	0	4
Latino Persons	151	50	26	180
White Persons	4170	3563	4941	6213
Latino White Persons	151	45	26	71

Education

Table 5.1.3-133. Years of Education by Category for those 25 Years and Older for Morehead City, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Education	1970	1980	1990	2000
25+ w/ 0-8 years education	884	721	495	401
25+ w/ 9-11 years education	655	724	730	660
25+ w/ HS diploma	717	712	1231	1467
25+ w/ 13-15 years. education	425	453	890	1474
25+ w/ College Degree	247	326	552	1547
Drop outs	84	29	35	52

Income and Poverty

Table 5.1.3-134. Average Household Wage/Salary and Persons Below the Poverty Level for Morehead City, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Wage or Salary	1970	1980	1990	2000
Average Household Wage/Salary Income (dollars)	$6676	$13267	$22827	$28737
Poverty Level				
Persons Below Poverty Level	1008	782	1098	1105
Age 65+ Below Poverty Level	185	125	155	199
Households with Public Assistance	120	152	276	99

Industry

Table 5.1.3-135. Employment by Industry for Morehead City, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Industry	**1970**	**1980**	**1990**	**2000**
Agriculture, Fishing, Mining	51	43	84	37
Construction	114	125	183	394
Business Services	51	39	86	260
Communication/Utilities	50	84	28	87
Manufacturing	151	202	226	252
Financial, Insurance & Real Estate	74	100	120	272
Services	70	112	190	1404
Wholesale/Retail Trade	602	291	727	543
Transportation	543	409	797	62

Occupation

Table 5.1.3-136. Employment by Occupation for Morehead City, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Occupation	**1970**	**1980**	**1990**	**2000**
Sales	114	238	406	-
Clerical	272	2550	285	-
Craft	306	253	391	-
Exec/Managerial	246	188	297	-
Farm/Fish/Forest	5	52	86	37
Household Services	117	41	10	-
Laborer/Handler	116	105	121	-
Operative/Transport	148	92	92	-
Service, except Household	389	289	495	-
Technical	0	33	65	-

Morehead City Fishing Demographics

Table 5.1.3-137. Number of Federal Permit (October 2008) by Type for Morehead City, North Carolina (Source: NMFS 2008).

Type	Permits
ATLANTIC DOLPHIN/WAHOO COMMERCIAL	45
ATLANTIC DOLPHIN/WAHOO CHARTER/ HEADBOAT	26
S. ATLANTIC CHARTER/HEADBOAT FOR PELAGIC FISH	22
KING MACKEREL	18
SPINY LOBSTER & TAILING	-, 2
ROCK SHRIMP & ENDORSEMENTS	1,-
S. ATL. CHARTER/HEADBOAT FOR SNAPPER-GROUPER	22
SWORDFISH & SHARKS	-, 1
S. ATLANTIC SNAPPER-GROUPER (UNLIMITED)	11
S. ATLANTIC SNAPPER-GROUPER (225)	-

SPANISH MACKEREL	19
SOUTH ATLANTIC SHRIMP	-

Table 5.1.3-138. Employment in Fishing Related Industry for Morehead City, North Carolina (Zip code Business Patterns, U.S. Census Bureau 1998).

Category	NAIC Code	Number Employed
Fishing	114100	4
Seafood Canning	311711	0
Seafood Processing	311712	0
Boat Building	336612	16
Fish and Seafoods	422460	36
Fish and Seafood Markets	445220	4
Marinas	713930	40
Total Fishing Employment		100

Table 5.1.3-139. Number of State Permit by Type for Morehead City, North Carolina (Source: NCDMF 2008).

Type	Permits
Commercial Fishing Vessel Registration	193
Dealer License	18
Flounder License	1
Land or Sell License	0
Non-resident Menhaden License	0
Ocean Fishing Pier License	0
Spotter Plane License	0
Retired Standard Commercial Fishing License	21
Standard Commercial Fishing License	124
Shellfish License	40
Recreational Fishing Tournament to Sell License	1
Total	398

5.1.3.11 Beaufort (28516)

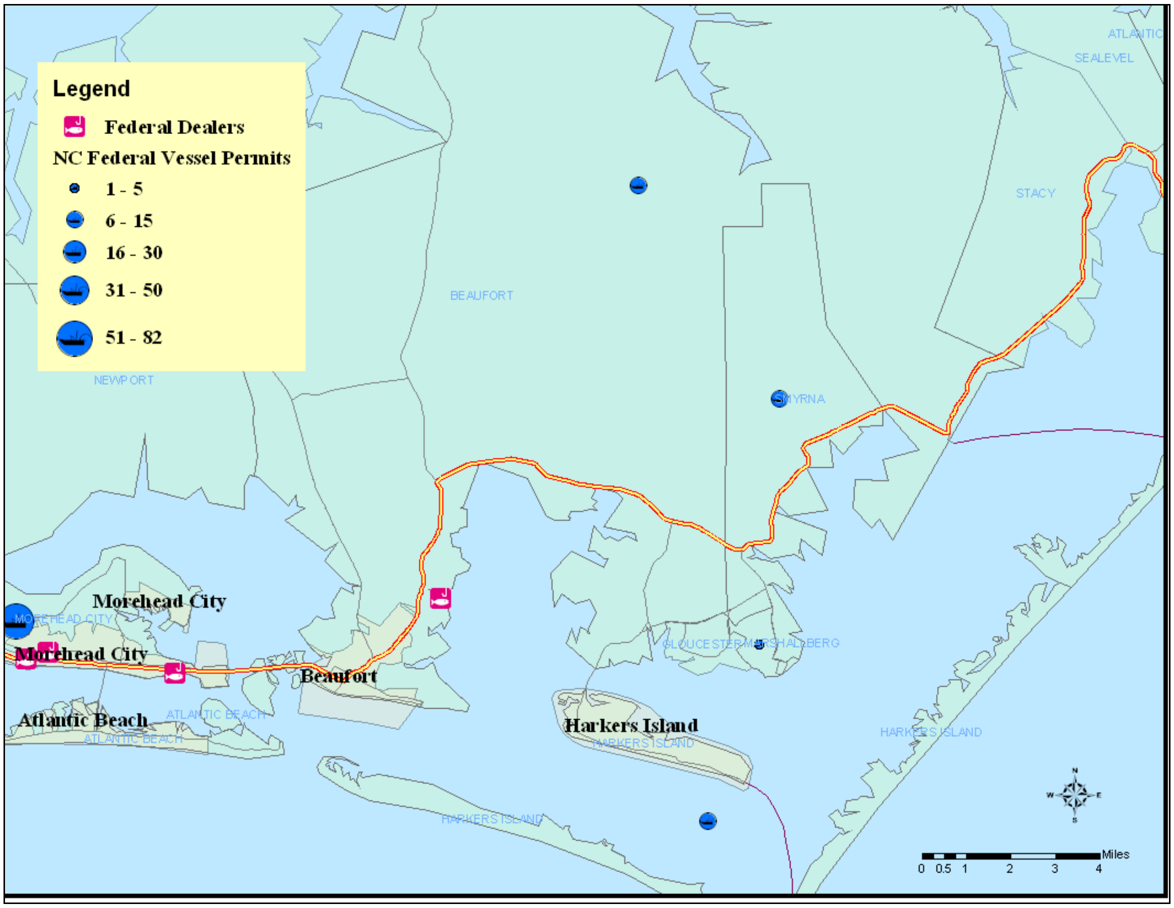

Figure 5.1.3-11. Beaufort, North Carolina.

Beaufort was built on a former Native American village, called Warelock which means "fish town" or "fishing village," near Cape Lookout and borders the southern portion of the Outer Banks. Its deep water harbor is home to vessels of all sizes and its marinas are a favorite stop-over for transient boaters. Originally a fishing village and port of safety, it was known as "Fishtowne" until incorporated in 1722. A whaling community, Diamond City, was located on Shackleford Banks, six miles to the southeast by boat during the eighteenth and nineteenth centuries. Lumber, barrel staves, rum, and molasses comprised some of Beaufort's main exports. However, when the port declined as a trade center, commercial fishing gained greater importance and became the primary economic activity of the town. Beaufort served as home port for a large menhaden fishing fleet and had numerous processing facilities for menhaden products.

Today, tourism, service industries, retail businesses and construction are important mainstays of the area, with many shops and restaurants catering to visitors from outside the area. The community has some exclusive homes along the waterfront but overall most housing is modest. It is home to both the NOAA Center for Coastal Fisheries and Habitat Research and Duke Marine Sciences Center. Directly across the bridge from Morehead city is Radio Island, which is the commercial fishing hub for Beaufort. There are a few private boats along the waterfront in downtown Beaufort, but the commercial enterprises are predominantly located on Radio Island. The waterfront does have two tour/party boats, in addition to private boats, some of which may be smaller charter vessels. There are several marinas in the community and several businesses that provide support services for both the recreational and commercial fishing industries.

According to one individual, Beaufort is a commercial fishing community, although less so now, than in the past. This seems to be largely due to fewer young people getting into the fishing business as it does not seem to pay well. This same individual has seven trawlers and four small snapper/grouper boats as part of his business. During the summer, three longline vessels travel from New York and dock at his facility. The majority of fish they purchase is marketed in Virginia and farther north. Shrimp is a large part of the seafood industry here, but, imports are having an impact on the domestic market lowering prices. His facility is a full service fish house, with processing, ice, fuel, and its own net repair. There was, at one time, an ice plant across the bridge, which has now become a condominium development. The last shad factory in the state is located on Front St. in Beaufort. At the time, there were only two shad vessels left in the state, and they were docked there, too. He said that shad built the fishing industry in Beaufort, but that people are trying to put them (the Shad Company) out of business because their property is valuable. He estimates that on Radio Island there are 20 trawlers that dock there permanently.

Another individual said that his fish house once processed year round, but now only operates seven months of the year due to closures. They had four employees, but now employ only two. He said that in 1987 Beaufort had its best year for shrimp. According to this individual most people involved in the fishery live in Beaufort or Morehead City. There are three fish houses in Beaufort, one of which deals primarily in bait. In 1987 there were about 25 larger commercial vessels (70-90’) in addition to a lot of smaller boats; now there are approximately 11 large commercial vessels in Beaufort.

In 2008, vessels with federal permits predominantly held Atlantic dolphin/wahoo commercial (15), Atlantic dolphin/wahoo charter (12), or south Atlantic shrimp (7) permits (Table 5.1.3-148). Most of the employment that is fishing related according to census business pattern data is related to boat building with 184 persons employed in that business. Others are employed in fish processing and fish and seafood according to Table 5.1.3-149. There are 391 commercial vessels registered with the state from Beaufort with almost 300 standard commercial fishing licenses. There are 119 shellfish licenses and 30 dealer license (Table 5.1.3-150).

Beaufort Census Demographics

Population

Table 5.1.3-140. Total Persons and Persons by Age category for Beaufort, North Carolina 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Total Persons and Age Category	1970	1980	1990	2000
Total Persons	3368	3826	3808	3528

Persons Age 0-5	155	199	305	145
Persons Age 6-15	665	498	393	299
Persons Age 16-17	152	126	76	75
Persons Age 18-24	272	401	376	208
Persons Age 25-34	372	621	597	451
Persons Age 35-44	337	353	511	516
Persons Age 45-54	448	414	399	518
Persons Age 55-64	451	557	423	508
Persons Age 65+	465	616	728	808

Housing Tenure

Table 5.1.3-141. Housing Tenure for Beaufort, North Carolina 1990-2000. (Source: U.S. Census Bureau).

Percent Rent	**1990**	**2000**
	44.3	42.9
Percent Own	**1990**	**2000**
	55.7	57.1

Employment/Unemployment

Table 5.1.3-142. Employment and Unemployment for Beaufort, North Carolina 1990-2000. (Source: U.S. Census Bureau).

Persons 16 yrs and over	**1990**	**2000**
Percent in labor force	61.0	56.3
Percent unemployed	6.8	4.7

Race

Table 5.1.3-143. Race for Beaufort, North Carolina 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Race	**1970**	**1980**	**1990**	**2000**
Black Persons	1042	922	908	751
Latino Black Persons	0	0	0	3
Latino Persons	28	26	71	142
White Persons	2326	2897	2815	2812
Latino White Persons	28	26	0	49

Education

Table 5.1.3-144. Years of Education by Category for those 25 Years and Older for Beaufort, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Education	**1970**	**1980**	**1990**	**2000**

25+ w/ 0-8 years education	697	555	229	151
25+ w/ 9-11 years education	490	562	432	415
25+ w/ HS diploma	506	572	832	747
25+ w/ 13-15 years. education	222	412	542	691
25+ w/ College Degree	158	460	399	773
Drop outs	78	49	26	24

Income and Poverty

Table 5.1.3-145. Average Household Wage/Salary and Persons Below the Poverty Level for Beaufort, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Wage or Salary	**1970**	**1980**	**1990**	**2000**
Average Household Wage/Salary Income (dollars)	$6803	$13988	$23933	$28763
Poverty Level				
Persons Below Poverty Level	774	614	660	568
Age 65+ Below Poverty Level	170	126	120	84
Households with Public Assistance	67	216	163	64

Industry

Table 5.1.3-146. Employment by Industry for Beaufort, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Industry	**1970**	**1980**	**1990**	**2000**
Agriculture, Fishing, Mining	38	153	51	40
Construction	43	27	87	165
Business Services	43	44	39	90
Communication/Utilities	9	18	18	61
Manufacturing	130	171	233	124
Financial, Insurance & Real Estate	46	104	134	52
Services	26	63	68	675
Wholesale/Retail Trade	386	148	440	315
Transportation	358	362	486	66

Occupation

Table 5.1.3-147. Employment by Occupation for Beaufort, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Occupation	**1970**	**1980**	**1990**	**2000**
Sales	114	178	268	-
Clerical	131	1910	282	-
Craft	269	170	177	-
Exec/Managerial	123	169	228	-

Farm/Fish/Forest	0	124	16	20
Household Services	72	12	0	-
Laborer/Handler	63	59	91	-
Operative/Transport	164	68	101	-
Service, except Household	224	196	270	-
Technical	0	40	40	-

Beaufort Fishing Demographics

Table 5.1.3-148. Number of Federal Permit (October 28) by Type for Beaufort, North Carolina (Source: NMFS 2008).

Type	Permits
ATLANTIC DOLPHIN/WAHOO COMMERCIAL	15
ATLANTIC DOLPHIN/WAHOO CHARTER/ HEADBOAT	12
S. ATLANTIC CHARTER/HEADBOAT FOR PELAGIC FISH	6
KING MACKEREL	4
SPINY LOBSTER & TAILING	2,
ROCK SHRIMP & ENDORSEMENTS	8,2
S. ATL. CHARTER/HEADBOAT FOR SNAPPER-GROUPER	4
SWORDFISH & SHARKS	-, 2
S. ATLANTIC SNAPPER-GROUPER (UNLIMITED)	5
S. ATLANTIC SNAPPER-GROUPER (225)	-
SPANISH MACKEREL	4
SOUTH ATLANTIC SHRIMP	16

Table 5.1.3-149. Employment in Fishing Related Industry for Beaufort, North Carolina (Zip code Business Patterns, U.S. Census Bureau 1998).

Category	**NAIC Code**	**Number Employed**
Fishing	114100	8
Seafood Canning	311711	0
Seafood Processing	311712	36
Boat Building	336612	184
Fish and Seafoods	422460	20
Fish and Seafood Markets	445220	4
Marinas	713930	48
Total Fishing Employment		300

Table 5.1.3-150. Number of State Permit by Type for Beaufort, North Carolina (Source: NCDMF 2008).

Type	**Permits**
Commercial Fishing Vessel Registration	391
Dealer License	30
Flounder License	15
Land or Sell License	1
Non-resident Menhaden License	0
Ocean Fishing Pier License	0
Spotter Plane License	0
Retired Standard Commercial Fishing License	45
Standard Commercial Fishing License	265

Shellfish License	119
Recreational Fishing Tournament to Sell License	1
Total	868

5.1.3.12 Harker's Island (28531)

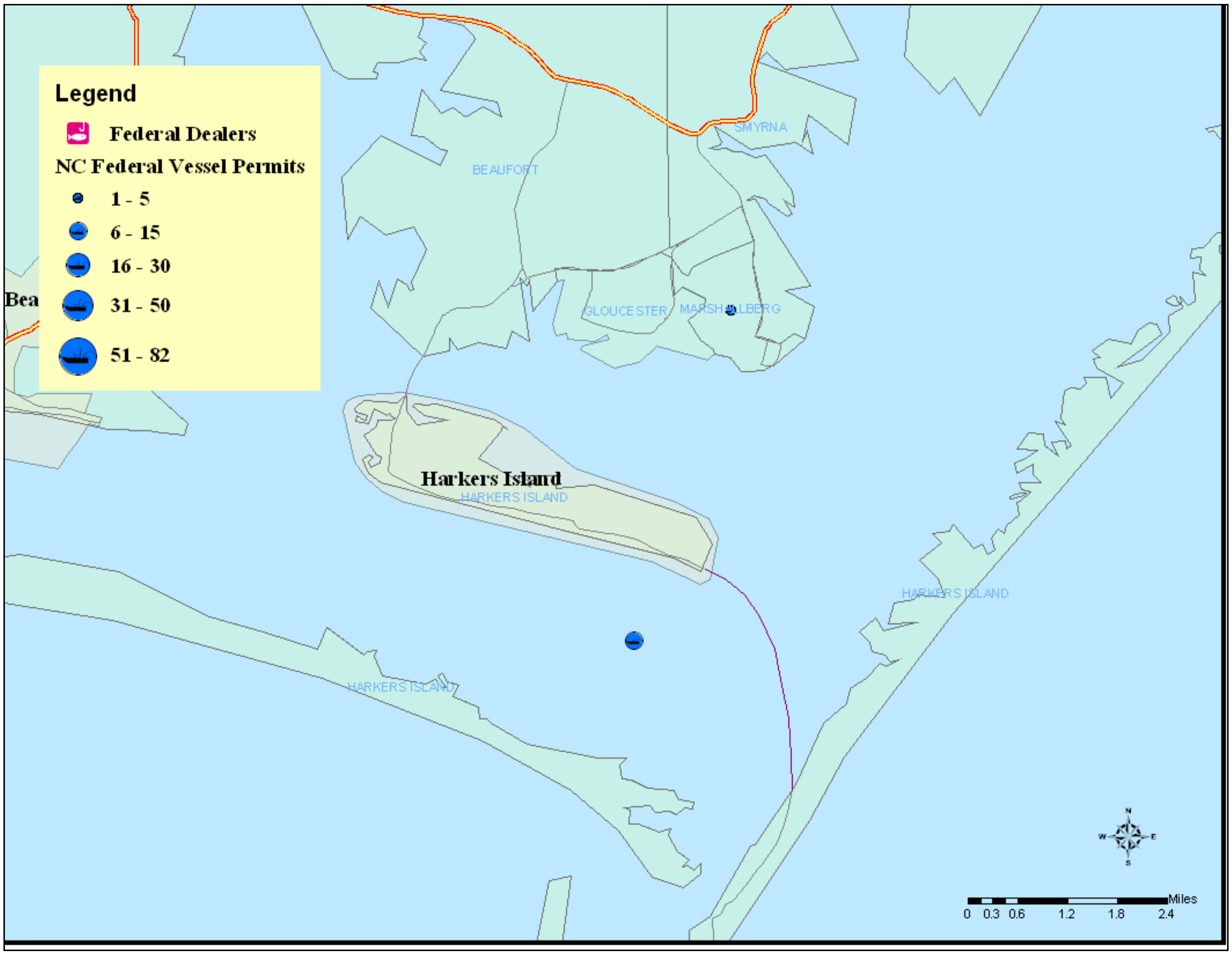

Figure 5.1.3-12. Harker's Island, North Carolina.

Harker's Island has a small marina at the entrance to the island where approximately nine small trawlers dock. The island does not seem to have seen the same residential development that many other coastal communities have, although it has reportedly been discovered by outsiders who are using it as a retirement destination. Fishermen on Cedar Island that were interviewed indicated that many of the locals from Harker's Island have moved to Gloucester because of high property taxes.

A few individuals consider Harker's Island a fishing community, even though landings are not nearly as high as in the past. Increasingly, there are more part-time fishermen, whereas in the past most were full-time. Accordingly, most have other jobs in order to make a living and fishing is to supplement income or solely more of a recreational endeavor. The hardcore old-timers who were the fishing mainstay on the island are too old and can't fish anymore or have passed away. Approximately one quarter of the island residents are full or part-time commercial fishermen according to several individuals. The island is also known for its boat building.

Ten years ago the island's economy was split evenly between fishing and tourism according to one individual, but more recently tourism has become the dominant industry. Rising property values have made it difficult for second and third generation islanders to remain. Recently, some undeveloped lots have been priced at or near $125,000; in addition property taxes seem to double every few years according to that individual. Locals are slowly being pushed from their heritage (commercial fishing), because they cannot afford the higher costs of living associated with the demographic shift when those of a higher socioeconomic class move to the area and are willing to pay higher prices for land and housing. Imports are also taking a toll on the fishing industry as the domestic seafood has to compete with cheaper imports. The majority of the boats built in the past were commercial and made of wood; today there are more, larger sport and head boats that are often built in Florida or other states. It is estimated that there are approximately 25 trawlers in the area today. There is some long hauling that is also done by some, where two boats pull a net with 5-8 men per boat.

In 2008, vessels with federal permits predominantly held Atlantic dolphin/wahoo commercial (7), Atlantic dolphin/wahoo charter (6), south Atlantic charter/headboat for pelagic fish (4), or snapper grouper charter/headboat for snapper grouper (4) permits (Table 5.1.3-160). There are over 156 commercial vessels with state licenses according to Table 5.1.3-162, with 77 standard commercial licenses and 68 shellfish licenses. Most of the fishing related employment according to census zip code business patterns in Table 5.1.3-161 is in the boat building sector.

Harker's Island Census Demographics

Population

Table 5.1.3-151. Total Persons and Persons by Age category for Harker's Island, North Carolina 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Total Persons and Age Category	1970	1980	1990	2000
Total Persons	.	132	117	1588
Persons Age 0-5	.	351	193	17
Persons Age 6-15	.	73	50	165
Persons Age 16-17	.	240	213	52
Persons Age 18-24	.	270	256	126
Persons Age 25-34	.	263	258	160
Persons Age 35-44	.	194	270	258
Persons Age 45-54	.	171	219	256
Persons Age 55-64	.	181	180	237
Persons Age 65+	.	132	117	317

Housing Tenure

Table 5.1.3-152. Housing Tenure for Harker's Island, North Carolina 1990-2000. (Source: U.S. Census Bureau).

Percent Rent	1990	2000
	18.9	81.4
Percent Own	**1990**	**2000**
	81.1	16.6

Residence in 1985 and 1995

Table 5.1.3-153. Residence in 1985 and 1995 for Harker's Island, North Carolina 1990-2000. (Source: U.S. Census Bureau).

Different House Same County	1990	2000
	336	80
Same House	**1990**	**2000**
	1212	1227

Employment/Unemployment

Table 5.1.3-154. Employment and Unemployment for Harker's Island, North Carolina 1990-2000. (Source: U.S. Census Bureau).

Persons 16 yrs and over	1990	2000
Percent in labor force	53.6	47.1
Percent unemployed	2.5	2.9

Race

Table 5.1.3-155. Race for Harker's Island, North Carolina 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Race	1970	1980	1990	2000
Black Persons	.	0	0	0
Latino Black Persons	.	0	0	0
Latino Persons	.	0	0	2
White Persons	.	1868	1751	1502
Latino White Persons	.	0	0	1

Education

Table 5.1.3-156. Years of Education by Category for those 25 Years and Older for Harker's Island, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Education	1970	1980	1990	2000
25+ w/ 0-8 years education	.	381	216	112

25+ w/ 9-11 years education	.	327	295	337
25+ w/ HS diploma	.	301	399	383
25+ w/ 13-15 years. education	.	50	157	246
25+ w/ College Degree	.	20	77	133
Drop outs	.	55	17	17

Income and Poverty

Table 5.1.3-157. Average Household Wage/Salary and Persons Below the Poverty Level for Harker's Island, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Wage or Salary	**1970**	**1980**	**1990**	**2000**
Average Household Wage/Salary Income (dollars)	.	$13099	$22808	$33125
Poverty Level				
Persons Below Poverty Level	.	381	345	245
Age 65+ Below Poverty Level	.	87	41	59
Households with Public Assistance	.	83	34	1

Industry

Table 5.1.3-158. Employment by Industry for Harker's Island, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Industry	**1970**	**1980**	**1990**	**2000**
Agriculture, Fishing, Mining	.	175	62	71
Construction	.	42	48	95
Business Services	.	9	25	17
Communication/Utilities	.	11	26	12
Manufacturing	.	78	111	71
Financial, Insurance & Real Estate	.	65	81	0
Services	.	0	5	255
Wholesale/Retail Trade	.	60	181	50
Transportation	.	67	192	23

Occupation

Table 5.1.3-159. Employment by Occupation for Harker's Island, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Occupation	**1970**	**1980**	**1990**	**2000**
Sales	.	16	54	-
Clerical	.	690	74	-
Craft	.	149	120	-
Exec/Managerial	.	46	50	-
Farm/Fish/Forest	.	174	73	61

Household Services	.	0	0	-
Laborer/Handler	.	20	44	-
Operative/Transport	.	17	82	-
Service, except Household	.	67	89	-
Technical	.	12	33	-

Harker's Island Fishing Demographics

Table 5.1.3-160. Number of Federal Permit (October 2008) by Type for Harker's Island, North Carolina (Source: NMFS 2008).

Type	Permits
ATLANTIC DOLPHIN/WAHOO COMMERCIAL	7
ATLANTIC DOLPHIN/WAHOO CHARTER/ HEADBOAT	6
S. ATLANTIC CHARTER/HEADBOAT FOR PELAGIC FISH	3
KING MACKEREL	4
SPINY LOBSTER & TAILING	-,
ROCK SHRIMP & ENDORSEMENTS	-,-
S. ATL. CHARTER/HEADBOAT FOR SNAPPER-GROUPER	4
SWORDFISH & SHARKS	-,-
S. ATLANTIC SNAPPER-GROUPER (UNLIMITED)	4
S. ATLANTIC SNAPPER-GROUPER (225)	-
SPANISH MACKEREL	2
SOUTH ATLANTIC SHRIMP	2

Table 5.1.3-161. Employment in Fishing Related Industry for Harker's Island, North Carolina (Zip code Business Patterns, U.S. Census Bureau 1998).

Category	**NAIC Code**	**Number Employed**
Fishing	114100	0
Seafood Canning	311711	0
Seafood Processing	311712	0
Boat Building	336612	24
Fish and Seafoods	422460	0
Fish and Seafood Markets	445220	0
Marinas	713930	8
Total Fishing Employment		32

Table 5.1.3-162. Number of State Permit by Type for Harker's Island, North Carolina (Source: NCDMF 2002).

Type	**Permits**
Commercial Fishing Vessel Registration	156
Dealer License	11
Flounder License	0
Land or Sell License	0
Non-resident Menhaden License	0
Ocean Fishing Pier License	0
Spotter Plane License	0
Retired Standard Commercial Fishing License	33
Standard Commercial Fishing License	77

Shellfish License	45
Recreational Fishing Tournament to Sell License	0
Total	312

5.1.3.13 Hatteras (27959)

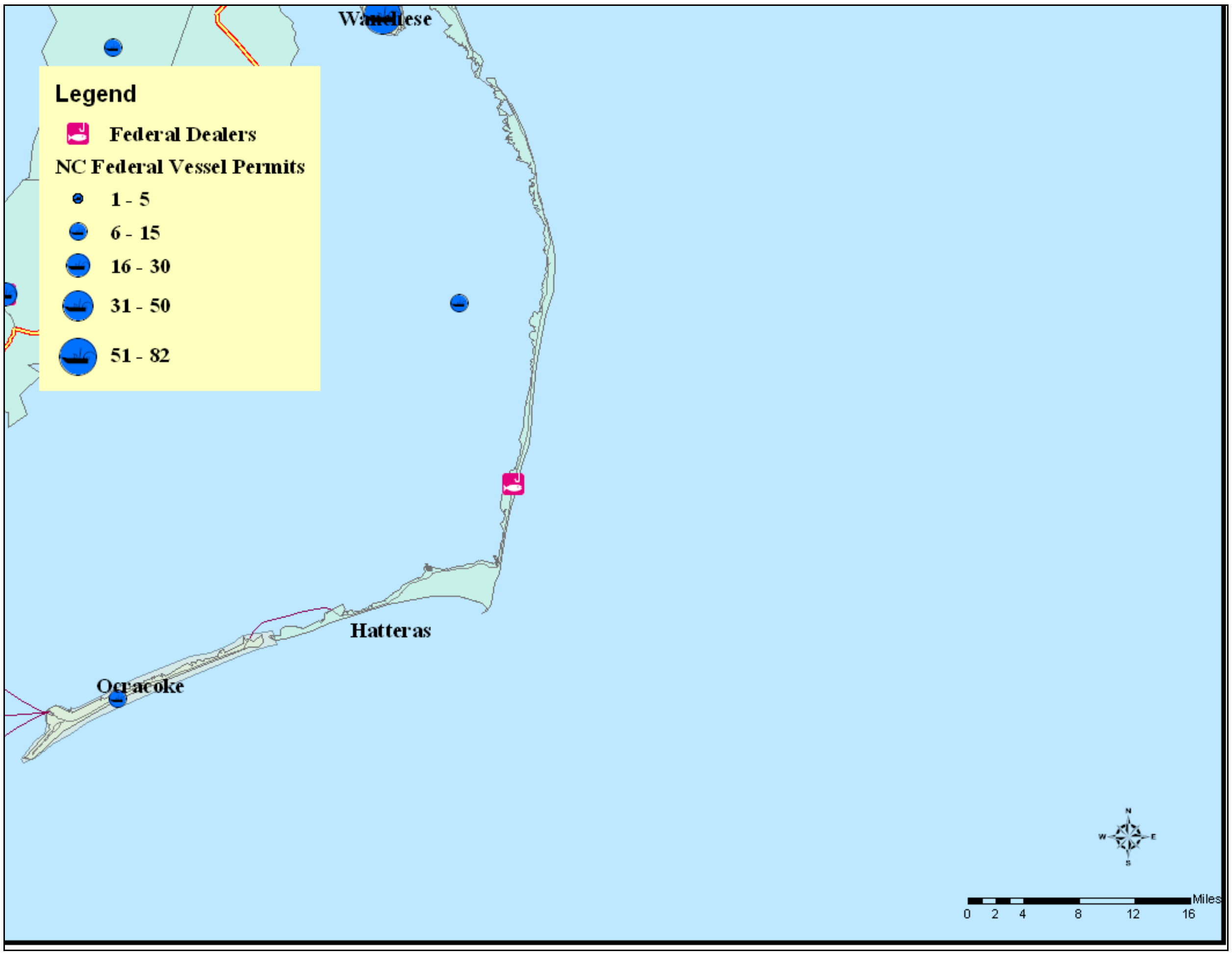

Figure 5.1.3-13. Hatteras, North Carolina.

Hatteras is located on the southern end of Hatteras Island on North Carolina's Outer Banks. The isolation of the community adds to the local character. Hatteras has historically been a seaport community with whaling an important part of the economy in its early history. Since World War II, the economy of the Hatteras community has depended on charter and commercial fishing. More recently, tourism has become an increasingly important economic activity (McCay and Cieri 2000).

The entire north end of Hatteras Island was once known as Chicamacomico, but in 1874, the postal service changed the name to Rodanthe. In earlier times, the Italian explorer Amerigo Vespucci landed in the area in the 16th Century. Centuries later, in 1858, the island became a popular fishing and shipping village and a post office was established. In 1861, Confederates troops landed on the northern end of the island to re-take Fort

Hatteras and Fort Clark, which had fallen to the Union's first naval invasion of the South. After the Civil War, development began to increase on the island and the Durant's lifesaving station was built in 1878. By the turn of the century, a U.S. weather station was established on the island and in the mid-1930s the Army Corps of Engineers had dredged a deep channel which allowed for better access from Pamlico Sound to Hatteras Inlet. Soon after, a sizable fishing fleet was established at Hatteras. During World War II, the area was known as "Torpedo Junction" due to more than 100 ships that were lost due to German submarines.

Hatteras Village is a small and quiet town surrounded by coast on either side. It is located next to a National Seashore with a historic lighthouse. Hatteras is host to several prestigious fishing tournaments and is homeport for the island's famous charter fishing fleet. In addition, there are numerous restaurants that offer fresh caught seafood.

There were as many as 10 or 12 fish houses once and most recently, the largest fish house was sold for condominium development; there are four working fish houses left now. According to one individual, many fishermen are leaving the fishing business as tourism is dominating the economy for the area. This same individual further commented that water quality has changed and that there used to be more shellfish on the shoreline; now it is all gone due to development. He further suggested that the bridges that have recently been built have changed the currents of the inlet and have affected the local ecosystem.

In 2008, vessels with federal permits predominantly held Atlantic dolphin/wahoo commercial (40), Atlantic dolphin/wahoo charter (45), south Atlantic charter/headboat for pelagic fish (39), or snapper grouper charter/headboat for snapper grouper (37) permits (Table 5.1.3-164). Most of the fishing related employment is in the marina sector (Table 5.1.3-165). There are 86 state registered commercial fishing vessels and 75 standard commercial fishing licenses in Hatteras. There are 12 dealer licenses and 10 shellfish licenses in the community (Table 5.1.3-166).

The census demographic table that follows was compiled using census block data for the area. Long term census data from 1970 and 1980 were not available for Hatteras.

Hatteras Census Demographics

Table 5.1.3-163. Hatteras Census Demographics.

Factor	1990	2000
Total population	2675	2797
Gender Ratio M/F (Percent)	51.6/48.4	50.5/49.5
Age (Percent of total population)		
Under 18 years of age	23.9	20.0
18 to 64 years of age	65.0	64.2
65 years and over	11.1	15.1
Ethnicity or Race (Number)		
White	2644	2705
Black or African American	10	0
American Indian and Alaskan Native	0	0
Asian	21	0
Native Hawaiian and other Pacific Islander	0	0

Some other race	0	38
Two or more races	-	54
Hispanic or Latino (any race)	18	98
Educational Attainment (Population 25 and over)		
Percent with less than 9th grade	7.1	6.6
Percent high school graduate or higher	74.4	80.2
Percent with a Bachelor's degree or higher	20.6	17.2
Language Spoken at Home (Population 5 years and over)		
Percent who speak a language other than English at home	1.6	5.1
And Percent who speak English less than very well	0.0	2.6
Household income (Median $)	N/A[1]	N/A[1]
Poverty Status (Percent of population with income below poverty line)	6.0	10.0
Percent female headed household	9.0	6.2
Home Ownership (Percent)		
Owner occupied	72.3	78.1
Renter occupied	27.7	21.9
Value Owner-occupied Housing (Median $)	N/A[2]	N/A[2]
Monthly Contract Rent (Median $)	N/A[3]	N/A[3]
Employment Status (Population 16 yrs and over)		
Percent in the labor force	67.3	68.2
Percent of civilian labor force unemployed	4.2	8.9
Occupation (Percent)		
Management, professional, and related occupations	23.7	24.6
Service occupations	15.4	16.8
Sales and office occupations	17.3	20.4
Farming, fishing, and forestry occupations	6.4	7.8
Construction, extraction, and maintenance occupations	16.4	20.0
Production, transportation, and material moving occupations	13.9	10.5
Industry (Percent)		
Agriculture, forestry, fishing and hunting	11.3	8.4
Manufacturing	3.4	4.4
Percent government workers	21.0	19.3

1 Median Household Income is between $16,799-29,900 for 1990; $33,456-40,718 for 2000
2 Median Value Owner-occupied Housing is between $51,900-127,600 for 1990; $111,300-155,100 for 2000
3 Median Contract Rent is between $325-338 for 1990; $335-421 for 2000

Hatteras Fishing Demographics

Table 5.1.3-164. Number of Federal Permit (October 2008) by Type for Hatteras, North Carolina (Source: NMFS 2008).

Type	Permits
ATLANTIC DOLPHIN/WAHOO COMMERCIAL	40
ATLANTIC DOLPHIN/WAHOO CHARTER/ HEADBOAT	45
S. ATLANTIC CHARTER/HEADBOAT FOR PELAGIC FISH	39
KING MACKEREL	35
SPINY LOBSTER & TAILING	-,
ROCK SHRIMP & ENDORSEMENTS	-,-
S. ATL. CHARTER/HEADBOAT FOR SNAPPER-GROUPER	37
SWORDFISH & SHARKS	1,4
S. ATLANTIC SNAPPER-GROUPER (UNLIMITED)	6
S. ATLANTIC SNAPPER-GROUPER (225)	1
SPANISH MACKEREL	26

Table 5.1.3-165. Employment in Fishing Related Industry for Hatteras, North Carolina (Zip code Business Patterns, U.S. Census Bureau 1998).

Category	NAIC Code	Number Employed
Fishing	114100	0
Seafood Canning	311711	0
Seafood Processing	311712	0
Boat Building	336612	0
Fish and Seafoods	422460	0
Fish and Seafood Markets	445220	4
Marinas	713930	16
Total Fishing Employment		20

Table 5.1.3-166. Number of State Permit by Type for Hatteras, North Carolina (Source: NCDMF 2008).

Type	Permits
Commercial Fishing Vessel Registration	86
Dealer License	12
Flounder License	0
Land or Sell License	0
Non-resident Menhaden License	0
Ocean Fishing Pier License	0
Spotter Plane License	0
Retired Standard Commercial Fishing License	5
Standard Commercial Fishing License	75
Shellfish License	10
Recreational Fishing Tournament to Sell License	0
Total	188

5.1.3.14 Oriental (28571)

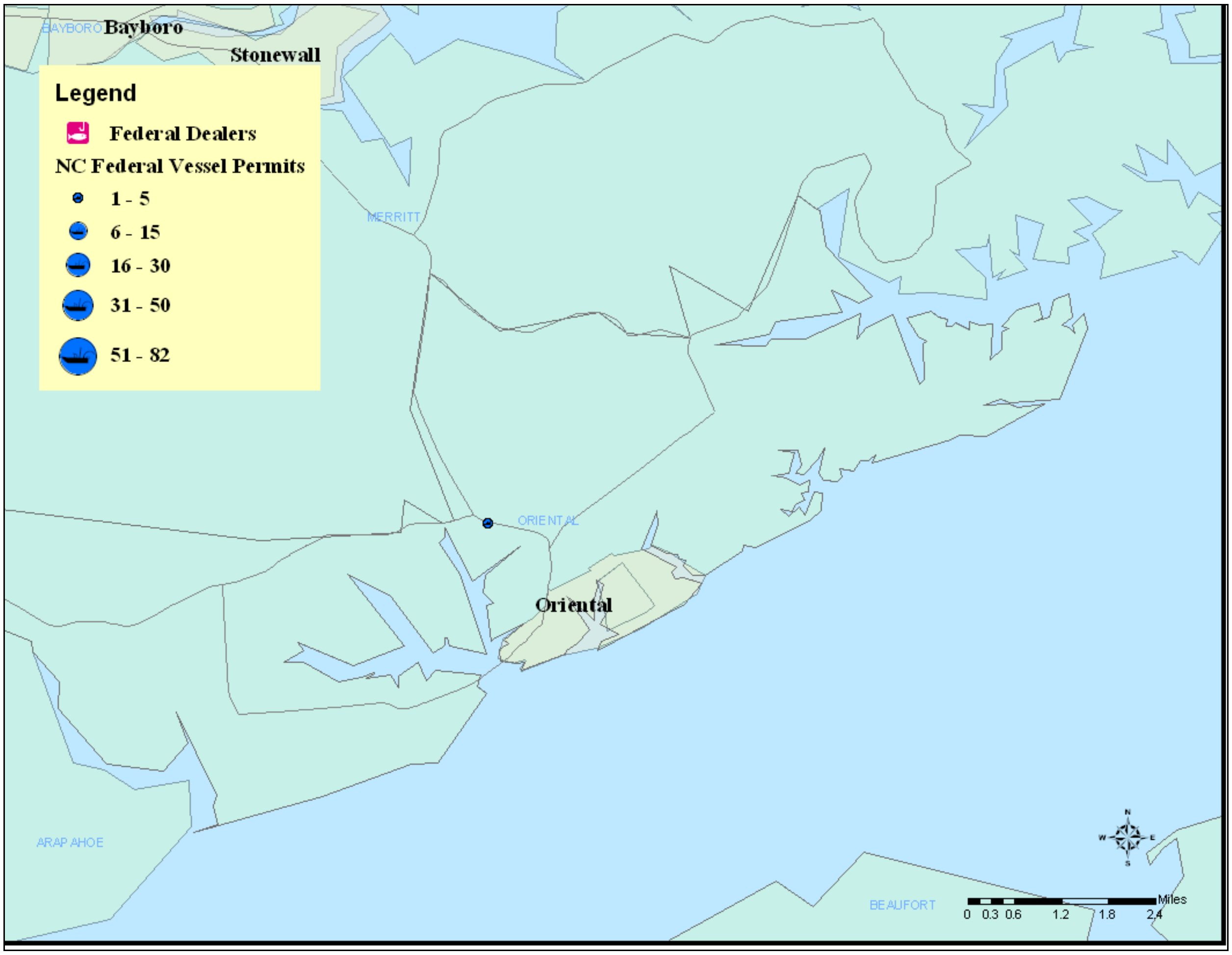

Figure 5.1.3-14. Oriental, North Carolina.

Oriental has seen little population growth over the past few decades and relatively little change in other census demographics. There has been a rise in unemployment from 1990 to 2000 but a drop in the number of individuals who are living below the poverty line for the same decade. There was little change in employment in farm, fish and forestry over that same time period. In fact, the number of federally permitted vessels has remained fairly constant (Table 5.1.3-176). There is considerable employment in fish and seafood with 72 people reported in that sector in Table 5.1.3-177. As far as state permits, there were 63 commercial vessels registered in Oriental and 53 standard commercial fishing licenses. There were also 8 dealer licenses issued within the community (Table 5.1.3-178).

Oriental Census Demographics

<u>Population</u>

Table 5.1.3-167. Total Persons and Persons by Age category for Oriental, North Carolina 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Total Persons and Age Category	1970	1980	1990	2000
Total Persons	.	535	804	878
Persons Age 0-5	.	35	66	24
Persons Age 6-15	.	51	57	57
Persons Age 16-17	.	13	14	11
Persons Age 18-24	.	43	44	34
Persons Age 25-34	.	62	74	48
Persons Age 35-44	.	42	100	84
Persons Age 45-54	.	67	83	142
Persons Age 55-64	.	91	149	161
Persons Age 65+	.	130	217	317

Housing Tenure

Table 5.1.3-168. Housing Tenure for Oriental, North Carolina 1990-2000. (Source: U.S. Census Bureau).

Percent Renter Occupied	1990	2000
	20.7	19.7
Percent Owner Occupied	**1990**	**2000**
	79.3	80.3

Residence in 1985 and 1995

Table 5.1.3-169. Residence in 1985 and 1995 for Oriental, North Carolina 1990-2000. (Source: U.S. Census Bureau).

Different House Same County	1990	2000
	127	40
Same House	**1990**	**2000**
	364	525

Employment/Unemployment

Table 5.1.3-170. Employment and Unemployment for Oriental, North Carolina 1990-2000. (Source: U.S. Census Bureau).

Persons 16 yrs and over	1990	2000
Percent in labor force	44.5	37.0
Percent unemployed	1.1	6.8

Race

Table 5.1.3-171. Race for Oriental, North Carolina 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Race	1970	1980	1990	2000
Black Persons	.	51	103	64
Latino Black Persons	.	3	0	0
Latino Persons	.	3	0	12
White Persons	.	477	701	792
Latino White Persons	.	0	0	2

Education

Table 5.1.3-172. Years of Education by Category for those 25 Years and Older for Oriental, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Education	1970	1980	1990	2000
25+ w/ 0-8 years education	.	68	27	11
25+ w/ 9-11 years education	.	84	57	69
25+ w/ HS diploma	.	69	155	158
25+ w/ 13-15 years. education	.	97	141	195
25+ w/ College Degree	.	74	192	317
Drop outs	.	4	2	2

Income and Poverty

Table 5.1.3-173. Average Household Wage/Salary and Persons Below the Poverty Level for Oriental, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Wage or Salary	1970	1980	1990	2000
Average Household Wage/Salary Income (dollars)	.	$12303	$27660	$37794
Poverty Level				
Persons Below Poverty Level	.	87	138	74
Age 65+ Below Poverty Level	.	37	27	29
Households with Public Assistance	.	21	28	2

Industry

Table 5.1.3-174. Employment by Industry for Oriental, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Industry	1970	1980	1990	2000
Agriculture, Fishing, Mining	.	25	9	9
Construction	.	8	23	15
Business Services	.	3	6	19
Communication/Utilities	.	5	5	12
Manufacturing	.	12	46	32
Financial, Insurance & Real Estate	.	3	27	11

Services	.	10	16	100
Wholesale/Retail Trade	.	19	105	55
Transportation	.	86	69	2

Occupation

Table 5.1.3-175. Employment by Occupation for Oriental, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Occupation	**1970**	**1980**	**1990**	**2000**
Sales	.	25	37	-
Clerical	.	300	35	-
Craft	.	29	28	-
Exec/Managerial	.	28	54	-
Farm/Fish/Forest	.	10	9	7
Household Services	.	0	0	-
Laborer/Handler	.	9	15	-
Operative/Transport	.	8	20	-
Service, except Household	.	33	35	-
Technical	.	8	0	-

Oriental Fishing Demographics

Table 5.1.3-176. Number of Federal Permit (October 2008) by Type for Oriental, North Carolina (Source: NMFS 2008).

Type	Permits
ATLANTIC DOLPHIN/WAHOO COMMERCIAL	-
ATLANTIC DOLPHIN/WAHOO CHARTER/ HEADBOAT	-
S. ATLANTIC CHARTER/HEADBOAT FOR PELAGIC FISH	-
KING MACKEREL	-
SPINY LOBSTER & TAILING	-,
ROCK SHRIMP & ENDORSEMENTS	2,-
S. ATL. CHARTER/HEADBOAT FOR SNAPPER-GROUPER	-
SWORDFISH & SHARKS	-,-
S. ATLANTIC SNAPPER-GROUPER (UNLIMITED)	-
S. ATLANTIC SNAPPER-GROUPER (225)	-
SPANISH MACKEREL	-
SOUTH ATLANTIC SHRIMP	9

Table 5.1.3-177. Employment in Fishing Related Industry for Oriental, North Carolina (Zip code Business Patterns, U.S. Census Bureau 1998).

Category	**NAIC Code**	**Number Employed**
Fishing	114100	4
Seafood Canning	311711	0
Seafood Processing	311712	4
Boat Building	336612	0
Fish and Seafoods	422460	72
Fish and Seafood Markets	445220	0
Marinas	713930	28

Total Fishing Employment	108

Table 5.1.3-178. Number of State Permit by Type for Oriental, North Carolina (Source: NCDMF 2008).

Type	Permits
Commercial Fishing Vessel Registration	63
Dealer License	8
Flounder License	17
Land or Sell License	0
Non-resident Menhaden License	0
Ocean Fishing Pier License	0
Spotter Plane License	0
Retired Standard Commercial Fishing License	5
Standard Commercial Fishing License	53
Shellfish License	2
Recreational Fishing Tournament to Sell License	0
Total	150

5.1.3.15 Vandemere/Mesic (28587)

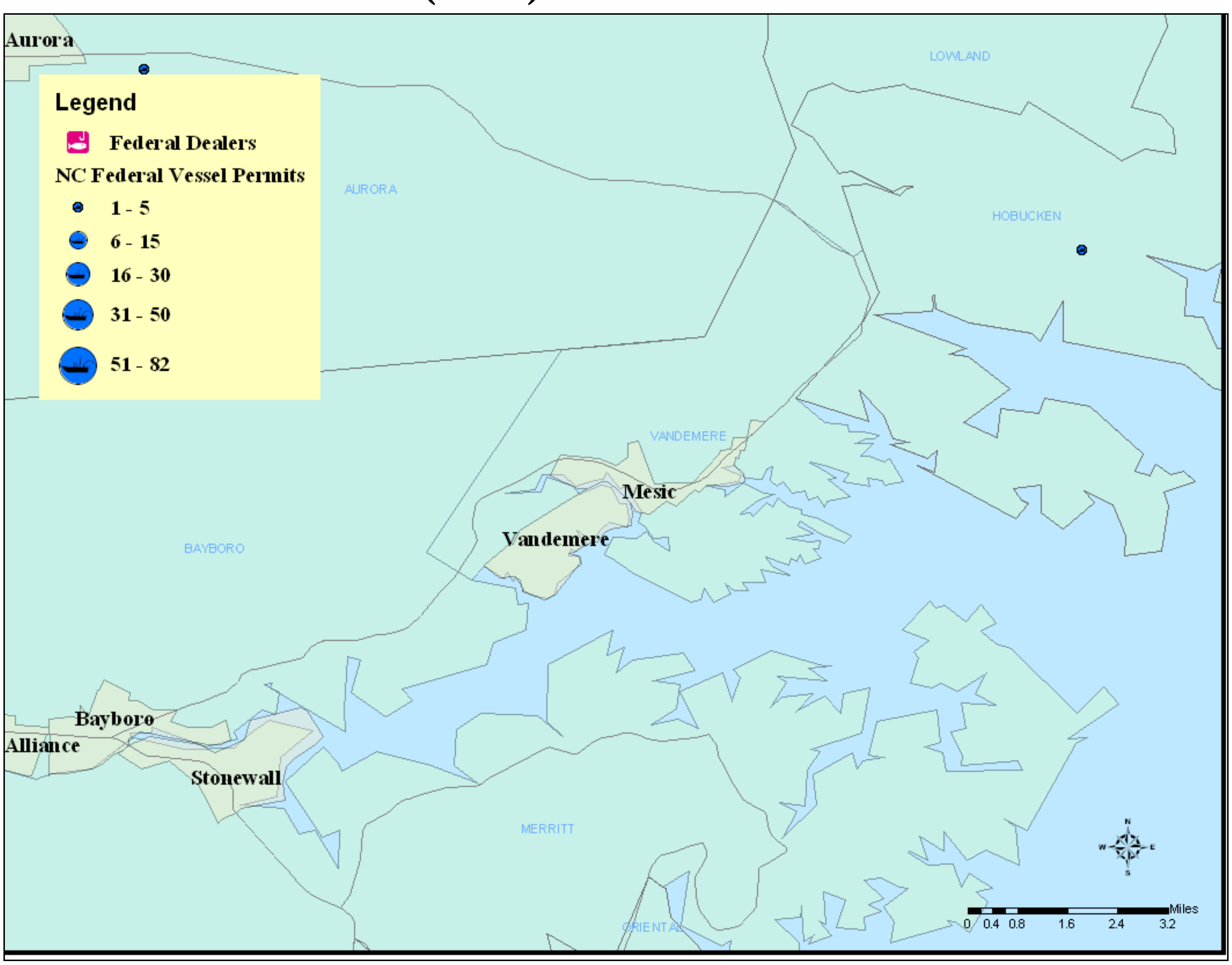

Figure 5.1.3-15. Vandemere/Mesic, North Carolina.

Vandemere and Mesic have both seen a slight population decline over the past decade. Both communities are predominately African-American. Vandemere has about 60% of the population in the labor force while Mesic has 45%. Vandemere has seen a decrease in the percentage of unemployed to 9.4 percent while Mesic has seen an increase to 5.6 percent. Both communities have seen a reduction in the number of people who live below the poverty line and an increase in the average wage or salary. Both communities have also seen a steady decline in the number of people who work in farm, fishing and forestry for both occupation and industry. There are very few federal permits in Vandemere (Table 5.1.3-197) and none listed for Mesic. There are 36 people employed in seafood processing according to Table 5.1.3-198 and 4 in fishing and fish and seafood. A total of 14 commercial vessels are registered with the state according to Table 5.1.3-199 and 12 standard commercial fishing licenses.

Vandemere Census Demographics

Population

Table 5.1.3-179. Total Persons and Persons by Age category for Vandemere, North Carolina 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Total Persons and Age Category	1970	1980	1990	2000
Total Persons	.	354	338	320
Persons Age 0-5	.	19	38	26
Persons Age 6-15	.	61	19	47
Persons Age 16-17	.	17	16	8
Persons Age 18-24	.	51	44	22
Persons Age 25-34	.	34	46	29
Persons Age 35-44	.	43	32	53
Persons Age 45-54	.	35	42	40
Persons Age 55-64	.	36	44	41
Persons Age 65+	.	58	57	54

Housing Tenure

Table 5.1.3-180. Housing Tenure for Vandemere, North Carolina 1990-2000. (Source: U.S. Census Bureau).

Percent Renter Occupied	1990	2000
	25.5	15.5
Percent Owner Occupied	**1990**	**2000**
	75.0	85.5

Residence in 1985 and 1995

Table 5.1.3-181. Residence in 1985 and 1995 for Vandemere, North Carolina 1990-2000. (Source: U.S. Census Bureau).

Different House Same County	1990	2000
	49	20
Same House	**1990**	**2000**
	228	223

Employment/Unemployment

Table 5.1.3-182. Employment and Unemployment for Vandemere, North Carolina 1990-2000. (Source: U.S. Census Bureau).

Persons 16 yrs and over	1990	2000
Percent in labor force	63.4	60.3
Percent unemployed	11.8	9.4

Race

Table 5.1.3-183. Race for Vandemere, North Carolina 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Race	1970	1980	1990	2000
Black Persons	.	218	177	153
Latino Black Persons	.	0	0	0
Latino Persons	.	0	0	6
White Persons	.	136	161	128
Latino White Persons	.	0	0	6

Education

Table 5.1.3-184. Years of Education by Category for those 25 Years and Older for Vandemere, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Education	1970	1980	1990	2000
25+ w/ 0-8 years education	.	60	45	20
25+ w/ 9-11 years education	.	67	65	47
25+ w/ HS diploma	.	59	67	64
25+ w/ 13-15 years. education	.	14	25	48
25+ w/ College Degree	.	6	10	38
Drop outs	.	2	6	0

Income and Poverty

Table 5.1.3-185. Average Household Wage/Salary and Persons Below the Poverty Level for Vandemere, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN

Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Wage or Salary	**1970**	**1980**	**1990**	**2000**
Average Household Wage/Salary Income (dollars)	.	$13,243	$19,713	$32,917
Poverty Level				
Persons Below Poverty Level	.	92	118	69
Age 65+ Below Poverty Level	.	24	26	19
Households with Public Assistance	.	27	16	2

Industry

Table 5.1.3-186. Employment by Industry for Vandemere, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Industry	**1970**	**1980**	**1990**	**2000**
Agriculture, Fishing, Mining	.	22	32	19
Construction	.	8	2	7
Business Services	.	0	11	5
Communication/Utilities	.	5	5	0
Manufacturing	.	35	33	27
Financial, Insurance & Real Estate	.	2	7	6
Services	.	5	5	30
Wholesale/Retail Trade	.	5	29	19
Transportation	.	32	20	13

Occupation

Table 5.1.3-187. Employment by Occupation for Vandemere, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Occupation	**1970**	**1980**	**1990**	**2000**
Sales	.	11	7	-
Clerical	.	180	14	-
Craft	.	12	14	-
Exec/Managerial	.	5	9	-
Farm/Fish/Forest	.	16	35	1
Household Services	.	3	0	-
Laborer/Handler	.	35	13	-
Operative/Transport	.	0	17	-
Service, except Household	.	15	16	-
Technical	.	0	2	-

Mesic Census Demographics

Population

Table 5.1.3-188. Total Persons and Persons by Age category for Mesic, North Carolina 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Total Persons and Age Category	**1970**	**1980**	**1990**	**2000**
Total Persons	.	400	297	251
Persons Age 0-5	.	33	12	10
Persons Age 6-15	.	64	48	45
Persons Age 16-17	.	23	6	13
Persons Age 18-24	.	66	30	5
Persons Age 25-34	.	39	41	13
Persons Age 35-44	.	29	29	32
Persons Age 45-54	.	58	39	34
Persons Age 55-64	.	51	39	32
Persons Age 65+	.	34	53	67

Housing Tenure

Table 5.1.3-189. Housing Tenure for Mesic, North Carolina 1990-2000. (Source: U.S. Census Bureau).

Percent Renter Occupied	**1990**	**2000**
	25.0	10.4
Percent Owner Occupied	**1990**	**2000**
	75.0	89.6

Residence in 1985 and 1995

Table 5.1.3-190. Residence in 1985 and 1995 for Mesic, North Carolina 1990-2000. (Source: U.S. Census Bureau).

Different House Same County	**1990**	**2000**
	35	18
Same House	**1990**	**2000**
	228	162

Employment/Unemployment

Table 5.1.3-191. Employment and Unemployment for Mesic, North Carolina 1990-2000. (Source: U.S. Census Bureau).

Persons 16 yrs and over	**1990**	**2000**
Percent in labor force	47.1	45.9
Percent unemployed	3.1	5.6

Race

Table 5.1.3-192. Race for Mesic, North Carolina 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Race	1970	1980	1990	2000
Black Persons	.	288	205	176
Latino Black Persons	.	3	0	0
Latino Persons	.	3	3	0
White Persons	.	112	90	76
Latino White Persons	.	0	1	0

Education

Table 5.1.3-193. Years of Education by Category for those 25 Years and Older for Mesic, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Education	1970	1980	1990	2000
25+ w/ 0-8 years education	.	60	40	23
25+ w/ 9-11 years education	.	70	46	55
25+ w/ HS diploma	.	60	64	52
25+ w/ 13-15 years. education	.	15	32	29
25+ w/ College Degree	.	6	15	15
Drop outs	.	5	0	4

Income and Poverty

Table 5.1.3-194. Average Household Wage/Salary and Persons Below the Poverty Level for Mesic, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Wage or Salary	1970	1980	1990	2000
Average Household Wage/Salary Income (dollars)	.	13536	16607	27188
Poverty Level				
Persons Below Poverty Level	.	90	77	68
Age 65+ Below Poverty Level	.	17	18	10
Households with Public Assistance	.	21	13	4

Industry

Table 5.1.3-195. Employment by Industry for Mesic, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Industry	1970	1980	1990	2000
Agriculture, Fishing, Mining	.	15	27	4
Construction	.	8	2	10
Business Services	.	3	0	0
Communication/Utilities	.	3	2	6
Manufacturing	.	42	10	5
Financial, Insurance & Real Estate	.	13	4	9

Services	.	0	2	35
Wholesale/Retail Trade	.	6	34	6
Transportation	.	19	18	7

Occupation

Table 5.1.3-196. Employment by Occupation for Mesic, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Occupation	1970	1980	1990	2000
Sales	.	6	2	-
Clerical	.	120	12	-
Craft	.	35	5	-
Exec/Managerial	.	2	2	-
Farm/Fish/Forest	.	15	32	0
Household Services	.	0	3	-
Laborer/Handler	.	32	7	-
Operative/Transport	.	6	9	-
Service, except Household	.	10	23	-
Technical	.	2	5	-

Vandemere Fishing Demographics

Table 5.1.3-197. Number of Federal Permit (October 2008) by Type for Vandemere, North Carolina (Source: NMFS 2008).

Type	Permits
ATLANTIC DOLPHIN/WAHOO COMMERCIAL	-
ATLANTIC DOLPHIN/WAHOO CHARTER/ HEADBOAT	-
S. ATLANTIC CHARTER/HEADBOAT FOR PELAGIC FISH	-
KING MACKEREL	-
SPINY LOBSTER & TAILING	-,
ROCK SHRIMP & ENDORSEMENTS	-,-
S. ATL. CHARTER/HEADBOAT FOR SNAPPER-GROUPER	-
SWORDFISH & SHARKS	-,-
S. ATLANTIC SNAPPER-GROUPER (UNLIMITED)	-
S. ATLANTIC SNAPPER-GROUPER (225)	-
SPANISH MACKEREL	-
SOUTH ATLANTIC SHRIMP	9

Table 5.1.3-198. Employment in Fishing Related Industry for Vandemere, North Carolina (Zip code Business Patterns, U.S. Census Bureau 1998).

Category	NAIC Code	Number Employed
Fishing	114100	4
Seafood Canning	311711	0
Seafood Processing	311712	36
Boat Building	336612	0
Fish and Seafoods	422460	4
Fish and Seafood Markets	445220	0

Marinas	713930	0
Total Fishing Employment		44

Table 5.1.3-199. Number of State Permit by Type for Vandemere, North Carolina (Source: NCDMF 2008).

Type	**Permits**
Commercial Fishing Vessel Registration	14
Dealer License	3
Flounder License	0
Land or Sell License	0
Non-resident Menhaden License	0
Ocean Fishing Pier License	0
Spotter Plane License	0
Retired Standard Commercial Fishing License	4
Standard Commercial Fishing License	12
Shellfish License	0
Recreational Fishing Tournament to Sell License	0
Total	33

5.1.3.16 Bath (27808)

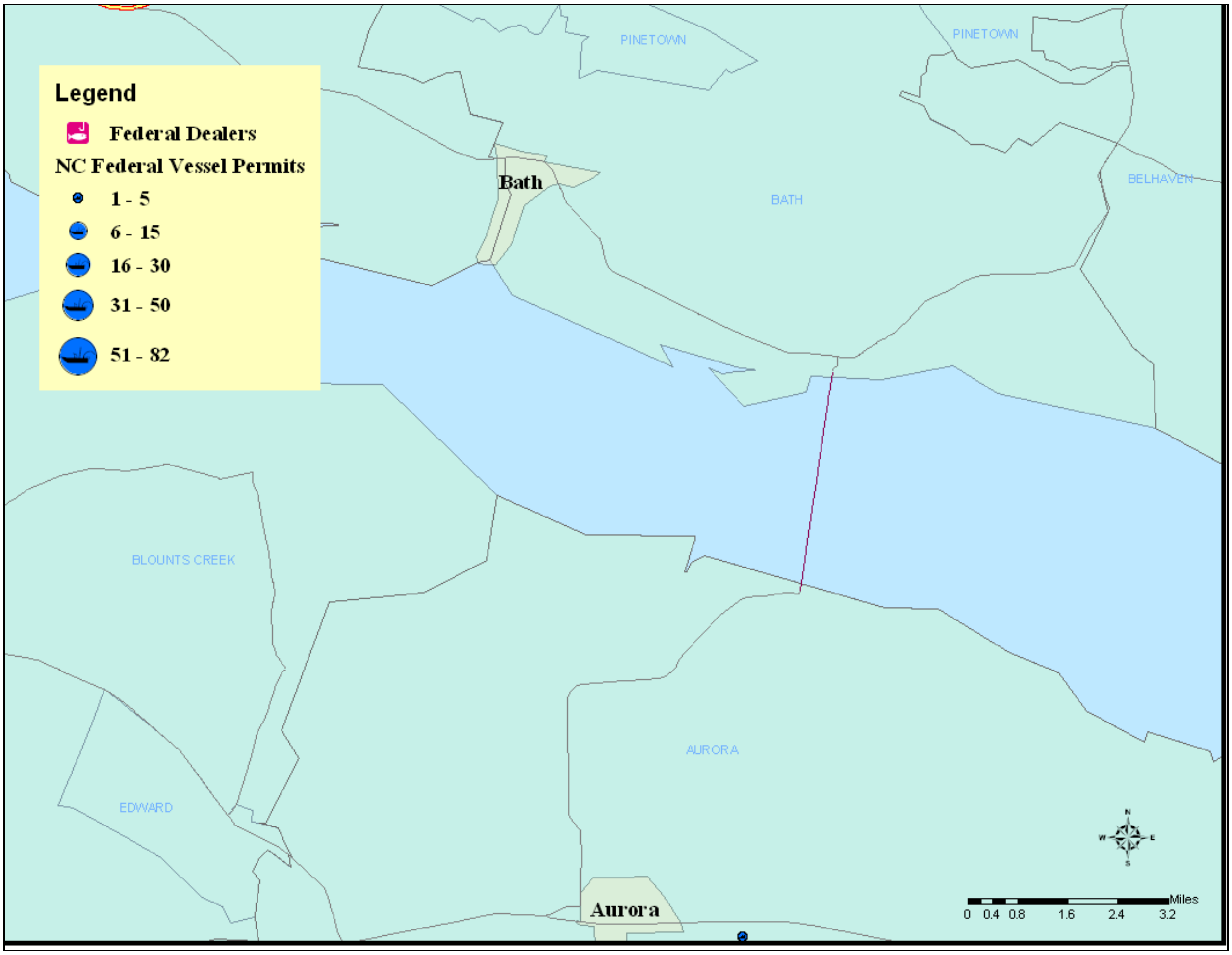

Figure 5.1.3-16. Bath, North Carolina.

There has been a slight population increase for Bath in the past ten years (Table 5.1.3-200) and an increase in the percentage of the population in the labor force (Table 5.1.3-203). Unemployment is 4.5% with a slight increase in the number of persons living below the poverty level (Table 5.1.3-206). There were very few people employed in the farm, fish and forestry category for either industry or occupation (Tables 5.1.3-207 and 5.1.3-208). According to Table 5.1.3-209 there were only 9 federal permits issued in 2008 and those were for south Atlantic shrimp. Employment in fishing related businesses reported in Table 5.1.3-210 shows only 4 people employed in fish and seafood. There are over 84 commercial vessels registered by the state in Bath and over 77 standard commercial fishing licenses according to Table 5.1.3-211.

Bath Census Demographics

<u>Population</u>

Table 5.1.3-200. Total Persons and Persons by Age category for Bath, North Carolina 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Total Persons and Age Category	**1970**	**1980**	**1990**	**2000**
Total Persons	.	213	138	268
Persons Age 0-5	.	6	9	12
Persons Age 6-15	.	17	4	51
Persons Age 16-17	.	6	0	2
Persons Age 18-24	.	15	7	5
Persons Age 25-34	.	17	20	26
Persons Age 35-44	.	12	7	20
Persons Age 45-54	.	12	14	66
Persons Age 55-64	.	37	34	24
Persons Age 65+	.	91	43	62

Housing Tenure

Table 5.1.3-201. Housing Tenure for Bath, North Carolina 1990-2000. (Source: U.S. Census Bureau).

Percent Renter Occupied	**1990**	**2000**
	26.7	11.0
Percent Owner Occupied	**1990**	**2000**
	73.3	89.0

Residence in 1985 and 1995

Table 5.1.3-202. Residence in 1985 and 1995 for Bath, North Carolina 1990-2000. (Source: U.S. Census Bureau).

Different House Same County	**1990**	**2000**
	29	29
Same House	**1990**	**2000**
	72	157

Employment/Unemployment

Table 5.1.3-203. Employment and Unemployment for Bath, North Carolina 1990-2000. (Source: U.S. Census Bureau).

Persons 16 yrs and over	**1990**	**2000**
Percent in labor force	42.6	56.1
Percent unemployed	0.0	4.5

Race

Table 5.1.3-204. Race for Bath, North Carolina 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Race	1970	1980	1990	2000
Black Persons	.	31	10	8
Latino Black Persons	.	0	0	0
Latino Persons	.	0	0	5
White Persons	.	182	128	259
Latino White Persons	.	0	0	4

Education

Table 5.1.3-205. Years of Education by Category for those 25 Years and Older for Bath, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Education	1970	1980	1990	2000
25+ w/ 0-8 years education	.	67	14	3
25+ w/ 9-11 years education	.	41	20	24
25+ w/ HS diploma	.	35	34	60
25+ w/ 13-15 years. education	.	11	21	45
25+ w/ College Degree	.	15	27	64
Drop outs	.	0	0	2

Income and Poverty

Table 5.1.3-206. Average Household Wage/Salary and Persons Below the Poverty Level for Bath, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Wage or Salary	1970	1980	1990	2000
Average Household Wage/Salary Income (dollars)	.	11844	18284	50625
Poverty Level				
Persons Below Poverty Level	.	68	19	22
Age 65+ Below Poverty Level	.	39	12	7
Households with Public Assistance	.	17	11	3

Industry

Table 5.1.3-207. Employment by Industry for Bath, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Industry	1970	1980	1990	2000
Agriculture, Fishing, Mining	.	8	3	5
Construction	.	5	0	5
Business Services	.	2	3	1

Communication/Utilities	.	0	0	4
Manufacturing	.	18	13	23
Financial, Insurance & Real Estate	.	5	8	6
Services	.	0	0	55
Wholesale/Retail Trade	.	2	29	9
Transportation	.	17	6	0

Occupation

Table 5.1.3-208. Employment by Occupation for Bath, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Occupation	1970	1980	1990	2000
Sales	.	5	3	-
Clerical	.	160	5	-
Craft	.	12	6	-
Exec/Managerial	.	11	8	-
Farm/Fish/Forest	.	5	3	3
Household Services	.	0	0	-
Laborer/Handler	.	0	0	-
Operative/Transport	.	13	8	-
Service, except Household	.	5	10	-
Technical	.	0	0	-

Bath Fishing Demographics

Table 5.1.3-209. Number of Federal Permit (October 2008) by Type for Bath, North Carolina (Source: NMFS 2008).

Type	Permits
ATLANTIC DOLPHIN/WAHOO COMMERCIAL	-
ATLANTIC DOLPHIN/WAHOO CHARTER/ HEADBOAT	-
S. ATLANTIC CHARTER/HEADBOAT FOR PELAGIC FISH	-
KING MACKEREL	-
SPINY LOBSTER & TAILING	-,
ROCK SHRIMP & ENDORSEMENTS	-,-
S. ATL. CHARTER/HEADBOAT FOR SNAPPER-GROUPER	-
SWORDFISH & SHARKS	-,-
S. ATLANTIC SNAPPER-GROUPER (UNLIMITED)	-
S. ATLANTIC SNAPPER-GROUPER (225)	-
SPANISH MACKEREL	-
SOUTH ATLANTIC SHRIMP	9

Table 5.1.3-210. Employment in Fishing Related Industry for Bath, North Carolina (Zip code Business Patterns, U.S. Census Bureau 1998).

Category	NAIC Code	Number Employed
Fishing	114100	0
Seafood Canning	311711	0
Seafood Processing	311712	0

Boat Building	336612	0
Fish and Seafoods	422460	4
Fish and Seafood Markets	445220	0
Marinas	713930	0
Total Fishing Employment		4

Table 5.1.3-211. Number of State Permit by Type for Bath, North Carolina (Source: NCDMF 2008).

Type	**Permits**
Commercial Fishing Vessel Registration	84
Dealer License	9
Flounder License	0
Land or Sell License	0
Non-resident Menhaden License	0
Ocean Fishing Pier License	0
Spotter Plane License	0
Retired Standard Commercial Fishing License	18
Standard Commercial Fishing License	77
Shellfish License	9
Recreational Fishing Tournament to Sell License	0
Total	207

5.1.3.17 Belhaven (2781

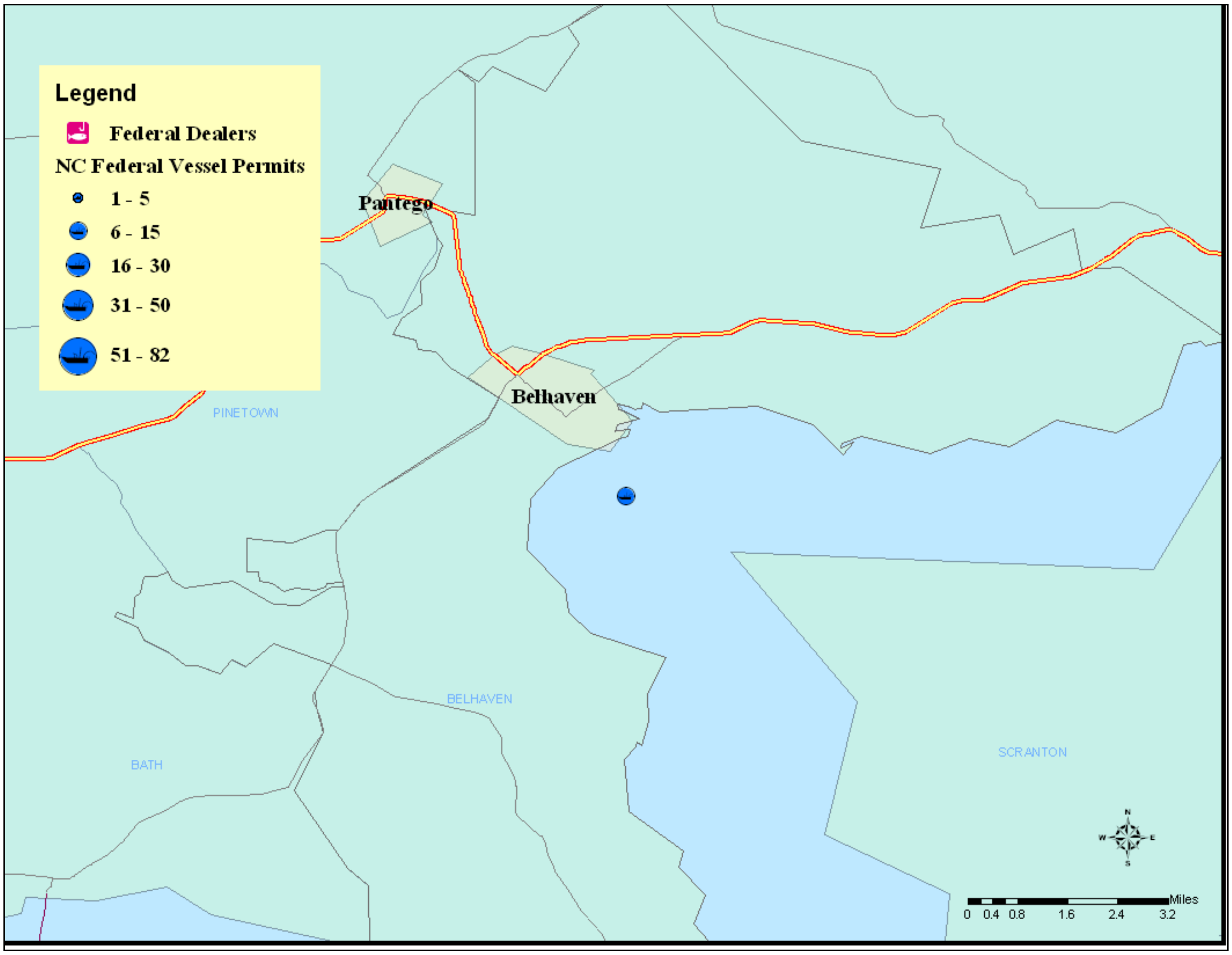

Figure 5.1.3-17. Bellhaven, North Carolina.

Belhaven is a predominantly African-American community (Table 5.1.3-216) which has seen a decline in population over the past decade (Table 5.1.3-212). The community has also experienced an increase in the unemployment rate and a decrease in the percentage of the population that is in the labor force (Table 5.1.3-215). Average household wage and salary has decreased while there has been a decline in the number of people who live below the poverty line (Table 5.1.3-218). There has been a decrease in the number of people who work in farm, fishing and forestry sector for both industry and occupation (Tables 5.1.3-219 and 5.1.3-220). While there are very few federally permitted vessels homeported in Belhaven (Table 5.1.3-221) there were over 100 people employed in fishing related businesses according to Table 5.1.3-222. There were over 188 commercial fishing vessels registered with the state from Belhaven and 163 standard commercial fishing licenses (Table 5.1.3-223).

Belhaven Census Demographics

Population

Table 5.1.3-212. Total Persons and Persons by Age category for Belhaven, North Carolina 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Total Persons and Age Category	**1970**	**1980**	**1990**	**2000**
Total Persons	.	2430	2269	1951
Persons Age 0-5	.	214	228	161
Persons Age 6-15	.	465	374	313
Persons Age 16-17	.	97	72	41
Persons Age 18-24	.	279	211	125
Persons Age 25-34	.	318	334	262
Persons Age 35-44	.	214	295	266
Persons Age 45-54	.	214	178	229
Persons Age 55-64	.	230	228	200
Persons Age 65+	.	368	349	354

Housing Tenure

Table 5.1.3-213. Housing Tenure for Belhaven, North Carolina 1990-2000. (Source: U.S. Census Bureau).

Percent Renter Occupied	**1990**	**2000**
	31.3	38.0
Percent Owner Occupied	**1990**	**2000**
	68.7	62.0

Residence in 1985 and 1995

Table 5.1.3-214. Residence in 1985 and 1995 for Belhaven, North Carolina 1990-2000. (Source: U.S. Census Bureau).

Different House Same County	**1990**	**2000**
	548	122
Same House	**1990**	**2000**
	1305	1072

Employment/Unemployment

Table 5.1.3-215. Employment and Unemployment for Belhaven, North Carolina 1990-2000. (Source: U.S. Census Bureau).

Persons 16 yrs and over	**1990**	**2000**
Percent in labor force	57.1	45.1
Percent unemployed	5.6	10.1

Race

Table 5.1.3-216. Race for Belhaven, North Carolina 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Race	1970	1980	1990	2000
Black Persons	.	1429	1421	1192
Latino Black Persons	.	39	0	2
Latino Persons	.	39	0	53
White Persons	.	994	841	699
Latino White Persons	.	0	0	35

Education

Table 5.1.3-217. Years of Education by Category for those 25 Years and Older for Belhaven, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Education	1970	1980	1990	2000
25+ w/ 0-8 years education	.	473	292	130
25+ w/ 9-11 years education	.	253	343	283
25+ w/ HS diploma	.	361	438	536
25+ w/ 13-15 years. education	.	142	156	185
25+ w/ College Degree	.	115	89	148
Drop outs	.	17	24	29

Income and Poverty

Table 5.1.3-218. Average Household Wage/Salary and Persons Below the Poverty Level for Belhaven, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Wage or Salary	1970	1980	1990	2000
Average Household Wage/Salary Income (dollars)	.	11428	18331	16674
Poverty Level				
Persons Below Poverty Level	.	804	811	688
Age 65+ Below Poverty Level	.	151	103	130
Households with Public Assistance	.	152	168	45

Industry

Table 5.1.3-219. Employment by Industry for Belhaven, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Industry	1970	1980	1990	2000
Agriculture, Fishing, Mining	.	59	52	44
Construction	.	41	43	80
Business Services	.	14	18	30
Communication/Utilities	.	28	27	8
Manufacturing	.	244	188	74
Financial, Insurance & Real Estate	.	78	89	4
Services	.	29	13	212
Wholesale/Retail Trade	.	117	246	99
Transportation	.	240	175	10

Occupation

Table 5.1.3-220. Employment by Occupation for Belhaven, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Occupation	1970	1980	1990	2000
Sales	.	97	56	-
Clerical	.	920	89	-
Craft	.	124	90	-
Exec/Managerial	.	52	65	-
Farm/Fish/Forest	.	47	46	28
Household Services	.	11	9	-
Laborer/Handler	.	145	71	-
Operative/Transport	.	91	70	-
Service, except Household	.	121	147	-
Technical	.	6	12	-

Belhaven Fishing Demographics

Table 5.1.3-221. Number of Federal Permit by Type for Belhaven, North Carolina (Source: NMFS 2002).

Type of Permit	1998	1999	2000	2001
Total permitted vessels	3	3	4	4
Commercial King Mackerel	1	1	1	1
Commercial Spanish Mackerel	1	1	2	2
Commercial Spiny Lobster	0	0	0	0
Charter/Headboat for Coastal Pelagics	0	0	0	0
Charter/Headboat for Snapper Grouper	0	0	0	0
Snapper Grouper Class 1	0	0	0	0
Snapper Grouper Class 2	0	0	0	0
Swordfish	0	0	0	0
Shark	0	0	0	0
Rock Shrimp	2	2	2	2
Federal Dealers	0	0	0	0

Table 5.1.3-222. Employment in Fishing Related Industry for Belhaven, North Carolina (Zip code Business Patterns, U.S. Census Bureau 1998).

Category	NAIC Code	Number Employed
Fishing	114100	0
Seafood Canning	311711	0
Seafood Processing	311712	88
Boat Building	336612	0
Fish and Seafoods	422460	12
Fish and Seafood Markets	445220	0
Marinas	713930	4
Total Fishing Employment		104

Table 5.1.3-223. Number of State Permit by Type for Belhaven, North Carolina (Source: NCDMF 2008).

Type	Permits
Commercial Fishing Vessel Registration	188
Dealer License	13
Flounder License	7
Land or Sell License	0
Non-resident Menhaden License	0
Ocean Fishing Pier License	0
Spotter Plane License	0
Retired Standard Commercial Fishing License	33
Standard Commercial Fishing License	163
Shellfish License	20
Recreational Fishing Tournament to Sell License	0
Total	424

5.1.3.18 Wanchese (27981)

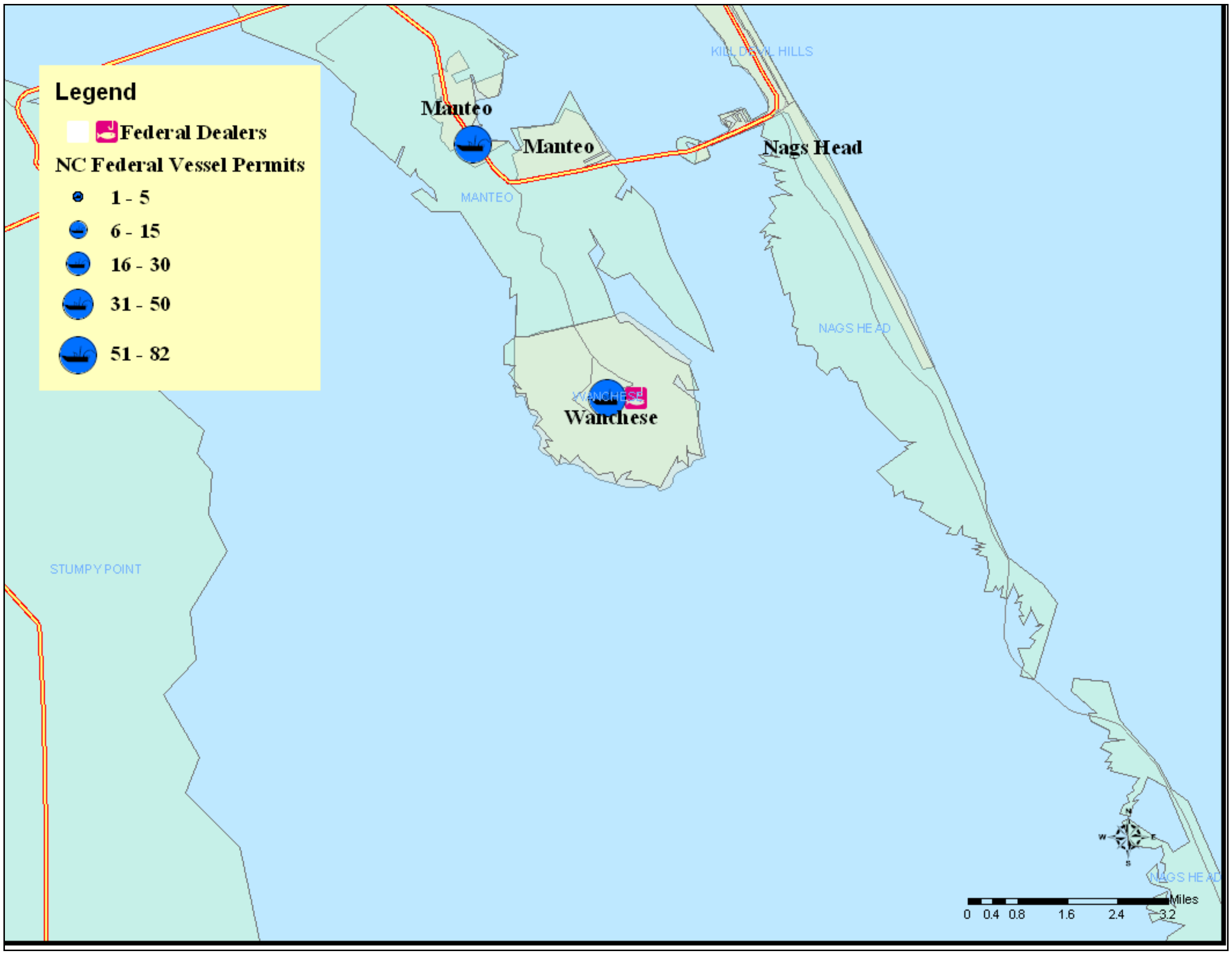

Figure 5.1.3-18. Wanchese, North Carolina.

Roanoke Island has a mix of tall, green, piney woods and miles of sheltered shoreline on the sound side providing a contrast to the open dunes of the outer islands. Wanchese, one of the island's two villages and is located at the southern end. It is a small, unincorporated fishing community with docks that provide services to many types of local and non-local commercial and recreational fishermen. Throughout the nineteenth century, the commercial industry was able to expanded owing in part to the first local postmaster, who owned or financed most of the commercial fishing boats in Wanchese. That individual established a system of credit for local fishermen at his store where debts were paid off when fishermen brought in their catches. It was said that at that time all residents were commercial fishermen (Wilson and McCay 1998).

Wanchese's first fish house was established in 1936 by ER (Zeke) Daniels, the grandfather of the current generation of two fish house owners. Zeke's son was the first to fish a trawler in Wanchese in the 1950s. He converted a 65' wooden boat which was primarily used to fish for species like flounder during the winter time. As mentioned most of their fishing occurred in the Pamlico and Albemarle Sounds, however there was a certain amount beach fishing that occurred, targeting species such as sea mollusks, trout, croaker, spots, striped bass (rock fish) and bluefish. The sounds provided croakers, butterfish, Spanish mackerel, spots and pig fishes. At that time, sea bass was the primary species targeted in the ocean during the winter months of the year. Later, a WWI subchaser was purchased and converted for scalloping (Wilson and McCay 1998).

The largest industrial area in Wanchese is centered round the Wanchese Seafood Industrial Park. The Park was built to enhance business opportunities in the seafood and marine trades. It encourages outside as well as local development in an effort to create a "new day for seafood and marine commerce." Between 1978 and 1985 it was reported that there were nine fish houses in operation in Wanchese. Today, there are six packing houses all operational and all dealing in many of the same species, with each house having a slightly different specialty. In the past all of the houses packed basically the same type of fish, with flounder being one of the most prominent species. However, over time this has changed as each house has had to specialize in order to remain in business.

Charterboat fishing has become increasing popular in Wanchese over the last 10 years. The number of charterboats has increased and facilities have been created to handle the increased presence of the for-hire industry. Currently, there are 27 charterboats and 2 head boats working out of Wanchese. Many of these individuals are from outside the Wanchese area; however, there are a few local fishermen who have decided to try recreational fishing instead of commercial.

Wanchese has seen an increase in its population over the past decade (Table 5.1.3-224) but a reduction in the percentage of people in the labor force (Table 5.1.3-227). Percent of unemployed has dropped from 8.9 in 1990 to 2.8 in 2000. While average wage and salary has increased, the number of people below the poverty level has remained constant (Table 5.1.3-230). However, the number of households with public assistance has gone from a high of 35 in 1990 to none in 2000 (Table 5.1.3-230). Employment in farm, fishing and forestry rose from 1980 to 1990 but has seen a decline in the year 2000 (Table 5.1.3-231 and 5.1.3-232). In 2008, vessels with federal permits predominantly held Atlantic dolphin/wahoo commercial (41),Spanish mackerel (29), king mackerel (25) Atlantic dolphin/wahoo charter (18), and south Atlantic charter/headboat for pelagic fish permits (Table 5.1.3-233). Employment in fishing related activities reported in Table 5.1.3-234 indicates 120 people employed in several categories with 56 in fish and seafood, 40 in boatbuilding, 16 in fishing and 8 in seafood processing. There were 247 commercial vessels registered and over 193 standard commercial fishing licenses in the community according to Table 5.1.3-235. There were also 12 dealer licenses and 20 flounder licenses for Wanchese (Table 5.1.3-235).

Wanchese Census Demographics

Population

Table 5.1.3-224. Total Persons and Persons by Age category for Wanchese, North Carolina 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Total Persons and Age Category	1970	1980	1990	2000
Total Persons	.	1020	1374	1544
Persons Age 0-5	.	74	141	100
Persons Age 6-15	.	168	249	244
Persons Age 16-17	.	39	48	43
Persons Age 18-24	.	92	149	80
Persons Age 25-34	.	195	253	273
Persons Age 35-44	.	115	157	276
Persons Age 45-54	.	136	186	262
Persons Age 55-64	.	99	92	106
Persons Age 65+	.	73	99	160

Housing Tenure

Table 5.1.3-225. Housing Tenure for Wanchese, North Carolina 1990-2000. (Source: U.S. Census Bureau).

Percent Renter Occupied	1990	2000
	27.9	27.7
Percent Owner Occupied	**1990**	**2000**
	72.1	72.3

Residence in 1985 and 1995

Table 5.1.3-226. Residence in 1985 and 1995 for Wanchese, North Carolina 1990-2000. (Source: U.S. Census Bureau).

Different House Same County	1990	2000
	342	118
Same House	**1990**	**2000**
	672	1100

Employment/Unemployment

Table 5.1.3-227. Employment and Unemployment for Wanchese, North Carolina 1990-2000. (Source: U.S. Census Bureau).

Persons 16 yrs and over	1990	2000
Percent in labor force	78.1	66.6
Percent unemployed	8.9	2.8

Race

Table 5.1.3-228. Race for Wanchese, North Carolina 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Race	1970	1980	1990	2000
Black Persons	.	0	0	5
Latino Black Persons	.	0	0	0
Latino Persons	.	0	0	28
White Persons	.	1020	1354	1477
Latino White Persons	.	0	0	21

Education

Table 5.1.3-229. Years of Education by Category for those 25 Years and Older for Wanchese, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Education	1970	1980	1990	2000
25+ w/ 0-8 years education	.	120	85	48
25+ w/ 9-11 years education	.	168	172	205
25+ w/ HS diploma	.	205	259	388
25+ w/ 13-15 years. education	.	94	170	221
25+ w/ College Degree	.	31	61	215
Drop outs	.	13	14	0

Income and Poverty

Table 5.1.3-230. Average Household Wage/Salary and Persons Below the Poverty Level for Wanchese, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Wage or Salary	1970	1980	1990	2000
Average Household Wage/Salary Income (dollars)	.	13702	25574	39250
Poverty Level				
Persons Below Poverty Level	.	135	127	125
Age 65+ Below Poverty Level	.	13	12	26
Households with Public Assistance	.	18	35	0

Industry

Table 5.1.3-231. Employment by Industry for Wanchese, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Industry	**1970**	**1980**	**1990**	**2000**
Agriculture, Fishing, Mining	.	86	137	64
Construction	.	41	35	77
Business Services	.	0	25	8
Communication/Utilities	.	21	9	10
Manufacturing	.	26	66	102
Financial, Insurance & Real Estate	.	16	57	15
Services	.	10	23	302
Wholesale/Retail Trade	.	32	184	143
Transportation	.	134	179	26

Occupation

Table 5.1.3-232. Employment by Occupation for Wanchese, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Occupation	**1970**	**1980**	**1990**	**2000**
Sales	.	62	82	-
Clerical	.	670	70	-
Craft	.	48	88	-
Exec/Managerial	.	41	65	-
Farm/Fish/Forest	.	80	131	74
Household Services	.	0	0	-
Laborer/Handler	.	24	23	-
Operative/Transport	.	0	35	-
Service, except Household	.	54	97	-
Technical	.	7	19	-

Wanchese Fishing Demographics

Table 5.1.3-233. Number of Federal Permit (October 2008)by Type for Wanchese, North Carolina (Source: NMFS 2008).

Type	Permits
ATLANTIC DOLPHIN/WAHOO COMMERCIAL	41
ATLANTIC DOLPHIN/WAHOO CHARTER/ HEADBOAT	18
S. ATLANTIC CHARTER/HEADBOAT FOR PELAGIC FISH	17
KING MACKEREL	25
SPINY LOBSTER & TAILING	1, 1
ROCK SHRIMP & ENDORSEMENTS	6,-
S. ATL. CHARTER/HEADBOAT FOR SNAPPER-GROUPER	18
SWORDFISH & SHARKS	12,15
S. ATLANTIC SNAPPER-GROUPER (UNLIMITED)	7
S. ATLANTIC SNAPPER-GROUPER (225)	1
SPANISH MACKEREL	29
SOUTH ATLANTIC SHRIMP	10

Table 5.1.3-234. Employment in Fishing Related Industry for Wanchese, North Carolina (Zip code Business Patterns, U.S. Census Bureau 1998).

Category	NAIC Code	Number Employed
Fishing	114100	16
Seafood Canning	311711	0
Seafood Processing	311712	8
Boat Building	336612	40
Fish and Seafoods	422460	56
Fish and Seafood Markets	445220	0
Marinas	713930	0
Total Fishing Employment		120

Table 5.1.3-235. Number of State Permit by Type for Wanchese, North Carolina (Source: NCDMF 2008).

Type	Permits
Commercial Fishing Vessel Registration	247
Dealer License	12
Flounder License	20
Land or Sell License	0
Non-resident Menhaden License	0
Ocean Fishing Pier License	0
Spotter Plane License	0
Retired Standard Commercial Fishing License	15
Standard Commercial Fishing License	193
Shellfish License	6
Recreational Fishing Tournament to Sell License	0
Total	293

5.1.3.19 Manteo (27954)

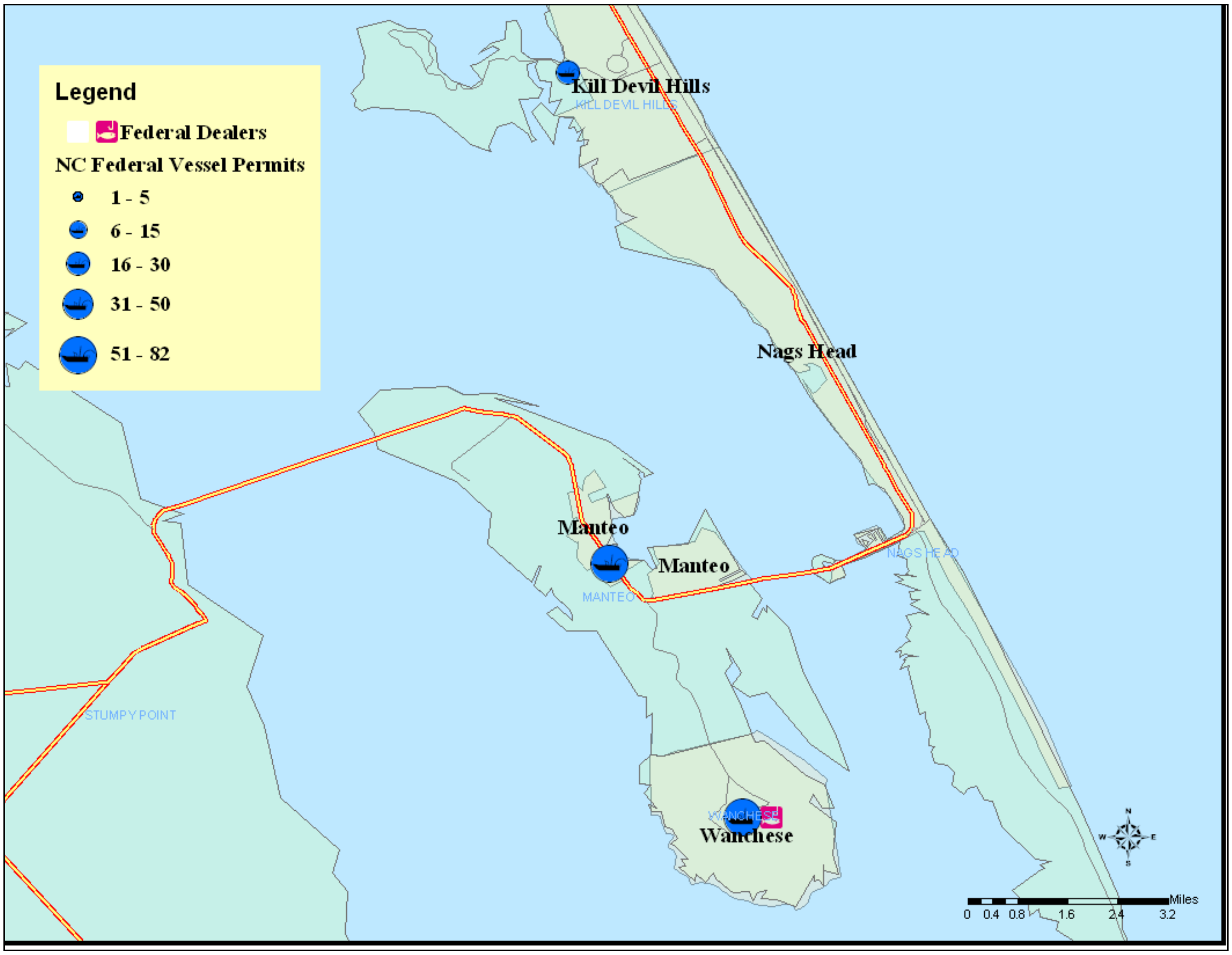

Figure 5.1.3-19. Manteo, North Carolina.

Manteo has seen steady population growth (Table 5.1.3- 236) with a decline in its African-American population (Table 5.1.3-240). The percent of the population that is unemployed has risen over the past ten years while the percent of people in the labor force has also declined slightly (Table 5.1.3-239). Average wage and salary has raised some but, the number of persons living below the poverty line has increased (Table 5.1.3-242). There has been a steady decline in the number of individuals working in the farm, fish and forestry sectors also over the past three decades (Tables 5.1.3-243 and 5.1.3-244). In 2008, vessels with federal permits predominantly held Atlantic dolphin/wahoo charter (37), south Atlantic charter/headboat for pelagic fish (35), or snapper grouper charter/headboat for snapper grouper (25), or Atlantic dolphin/wahoo commercial (14), permits (Table 5.1.3-245). Fishing related employment is highest among the fish and seafood sector according to Table 5.1.3-246 with 176 persons employed in that sector and 16 in marinas. The state reports over 170 commercially registered vessels and 142 standard commercial fishing licenses for Wanchese (Table 5.1.3-247).

Manteo Census Demographics

Population

Table 5.1.3-236. Total Persons and Persons by Age category for Manteo, North Carolina 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Total Persons and Age Category	1970	1980	1990	2000
Total Persons	.	951	997	1045
Persons Age 0-5	.	51	73	104
Persons Age 6-15	.	128	88	123
Persons Age 16-17	.	24	10	23
Persons Age 18-24	.	132	76	66
Persons Age 25-34	.	147	215	478
Persons Age 35-44	.	75	137	924
Persons Age 45-54	.	86	88	125
Persons Age 55-64	.	75	94	128
Persons Age 65+	.	222	216	184

Housing Tenure

Table 5.1.3-237. Housing Tenure for Manteo, North Carolina 1990-2000. (Source: U.S. Census Bureau).

Percent Renter Occupied	1990	2000
	39.6	46.4
Percent Owner Occupied	**1990**	**2000**
	60.4	53.6

Residence in 1985 and 1995

Table 5.1.3-238. Residence in 1985 and 1995 for Manteo, North Carolina 1990-2000. (Source: U.S. Census Bureau).

Different House Same County	1990	2000
	153	115
Same House	**1990**	**2000**
	493	422

Employment/Unemployment

Table 5.1.3-239. Employment and Unemployment for Manteo, North Carolina 1990-2000. (Source: U.S. Census Bureau).

Persons 16 yrs and over	1990	2000
Percent in labor force	64.6	61.0
Percent unemployed	2.4	5.5

Race

Table 5.1.3-240. Race for Manteo, North Carolina 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Race	**1970**	**1980**	**1990**	**2000**
Black Persons	.	221	133	106
Latino Black Persons	.	0	0	0
Latino Persons	.	1	10	27
White Persons	.	730	854	899
Latino White Persons	.	1	0	9

Education

Table 5.1.3-241. Years of Education by Category for those 25 Years and Older for Manteo, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Education	**1970**	**1980**	**1990**	**2000**
25+ w/ 0-8 years education	.	142	52	25
25+ w/ 9-11 years education	.	112	127	55
25+ w/ HS diploma	.	181	200	217
25+ w/ 13-15 years. education	.	83	200	225
25+ w/ College Degree	.	87	119	207
Drop outs	.	4	10	0

Income and Poverty

Table 5.1.3-242. Average Household Wage/Salary and Persons Below the Poverty Level for Manteo, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Wage or Salary	**1970**	**1980**	**1990**	**2000**
Average Household Wage/Salary Income (dollars)	.	$14919	$25666	$29803
Poverty Level				
Persons Below Poverty Level	.	103	104	202
Age 65+ Below Poverty Level	.	34	26	0
Households with Public Assistance	.	55	17	2

Industry

Table 5.1.3-243. Employment by Industry for Manteo, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Industry	**1970**	**1980**	**1990**	**2000**
Agriculture, Fishing, Mining	.	25	20	14
Construction	.	35	48	14
Business Services	.	9	27	0
Communication/Utilities	.	4	21	42
Manufacturing	.	18	36	32
Financial, Insurance & Real Estate	.	17	15	7
Services	.	28	26	58
Wholesale/Retail Trade	.	55	195	14
Transportation	.	75	139	10

Occupation

Table 5.1.3-244. Employment by Occupation for Manteo, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Occupation	**1970**	**1980**	**1990**	**2000**
Sales	.	43	73	-
Clerical	.	560	71	-
Craft	.	39	59	-
Exec/Managerial	.	28	71	-
Farm/Fish/Forest	.	27	21	17
Household Services	.	7	2	-
Laborer/Handler	.	16	23	-
Operative/Transport	.	19	14	-
Service, except Household	.	57	90	-
Technical	.	12	4	-

Manteo Fishing Demographics

Table 5.1.3-245. Number of Federal Permit (October 2008) by Type for Manteo, North Carolina (Source: NMFS 2008).

Type	Permits
ATLANTIC DOLPHIN/WAHOO COMMERCIAL	14
ATLANTIC DOLPHIN/WAHOO CHARTER/ HEADBOAT	37
S. ATLANTIC CHARTER/HEADBOAT FOR PELAGIC FISH	35
KING MACKEREL	6
SPINY LOBSTER & TAILING	-,
ROCK SHRIMP & ENDORSEMENTS	-,-
S. ATL. CHARTER/HEADBOAT FOR SNAPPER-GROUPER	25
SWORDFISH & SHARKS	1,1
S. ATLANTIC SNAPPER-GROUPER (UNLIMITED)	-
S. ATLANTIC SNAPPER-GROUPER (225)	-
SPANISH MACKEREL	5
SOUTH ATLANTIC SHRIMP	-

Table 5.1.3-246. Employment in Fishing Related Industry for Manteo, North Carolina (Zip code Business Patterns, U.S. Census Bureau 1998).

Category	**NAIC Code**	**Number Employed**
Fishing	114100	8
Seafood Canning	311711	0
Seafood Processing	311712	0
Boat Building	336612	0
Fish and Seafoods	422460	176
Fish and Seafood Markets	445220	0
Marinas	713930	16
Total Fishing Employment		200

Table 5.1.3-247. Number of State Permit by Type for Manteo, North Carolina (Source: NCDMF 2008).

Type	**Permits**
Commercial Fishing Vessel Registration	148
Dealer License	4
Flounder License	0
Land or Sell License	0
Non-resident Menhaden License	0
Ocean Fishing Pier License	0
Spotter Plane License	0
Retired Standard Commercial Fishing License	8
Standard Commercial Fishing License	132
Shellfish License	7
Recreational Fishing Tournament to Sell License	0
Total	300

5.1.3.20 Ocracoke (27960)

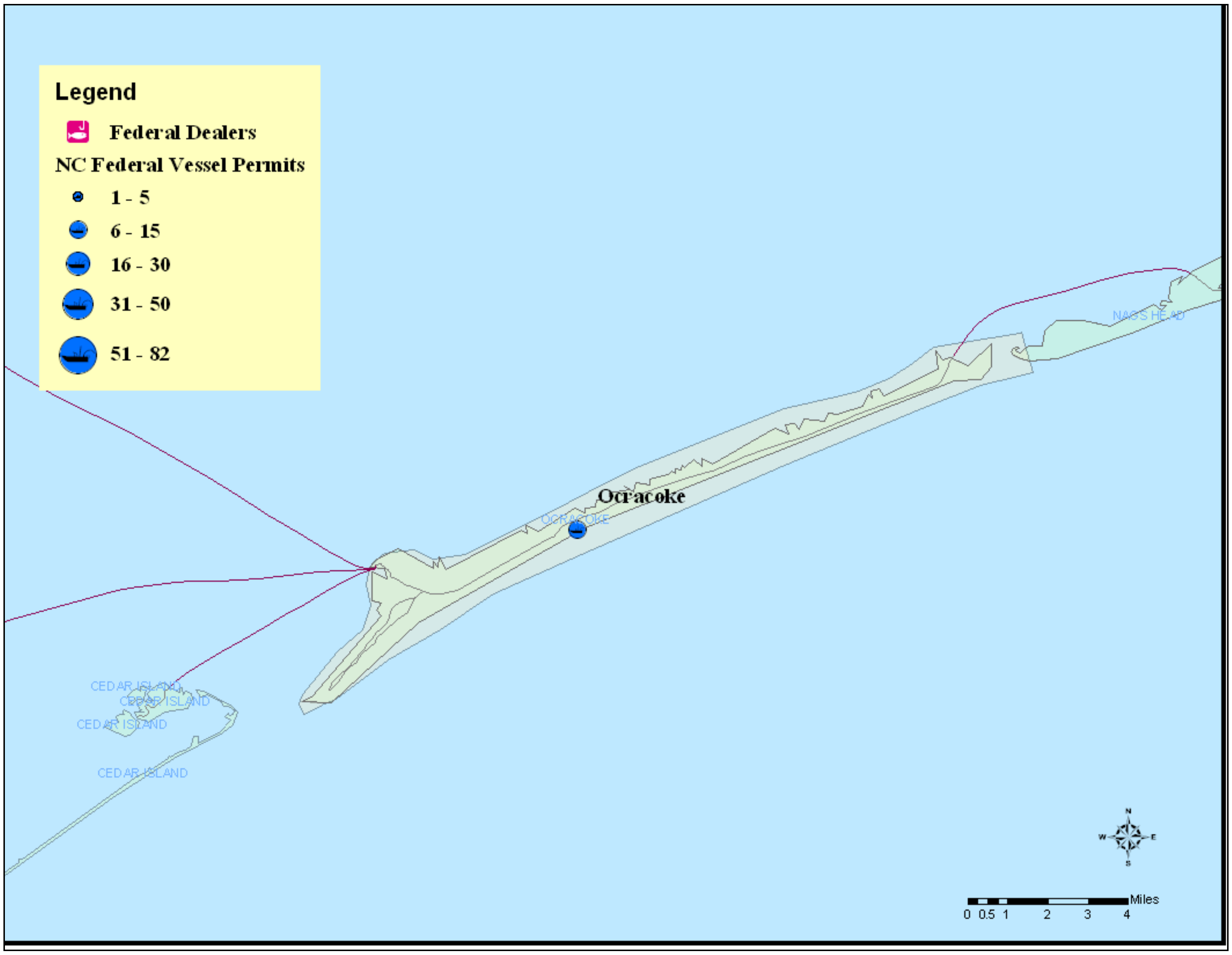

Figure 5.1.3-19. Ocracoke, North Carolina.

Ocracoke is the first island on the southern part of the outer banks. It is only accessible by ferry. Despite it being so isolated, it is rather progressive according to some, yet mostly undeveloped; much of the island consists of the National Park/Seashore. Most residents are year-round and there seems to be a strong sense of community among the locals. The commercial fishing industry has disappeared, though there is one small fish house with two inshore and one offshore fisherman working there. Tourism has been growing, as has the charter industry. There are three to four offshore charterboats, four or five inshore charters and one head boat. About three offshore commercial boats homeport there, with about 20 people claiming to be commercial fishermen on the island; although many of the fishermen have two or three different jobs. The major development boom started about six years ago and since then property values have skyrocketed. There are 12 to 15 seafood restaurants in and around the community.

Many individuals in this region and along the sound fish on the beach with nets or harvest shellfish; there is one shrimp trawler on the island. Ocracoke was never considered a full-fledged commercial fishing community according to some. There was no way to get the harvest off the island other than making the long trip to the mainland. The island has always been mostly tourist oriented.

Cedar Island has historically been a fishing community according those interviewed. There are three small fish houses in the community and most vessels are small as most fish inshore primarily for shrimp, crab and flounder. Pound netting is a historic method of fishing that is still practiced here. Territory now leased from the state was once claimed by local families who would fish specific locations. Today, many fishermen also work on the ferry or dredges to supplement their income.

Ocracoke was only recently designated a census place so comparison of previous census data cannot be made. There are few vessels that claim Ocracoke as homeport holding federal permits (Table 5.1.3-257). Fishing related employment is also very sparse as only 12 persons are reported as working in various sectors of fishing, fish and seafood, and marinas according to 5.1.3-258. There were however 81 commercial vessels registered by the state on the island and 61 standard commercial fishing licenses (Table 5.1.3-259).

Ocracoke Census Demographics

Population

Table 5.1.3-248. Total Persons and Persons by Age category for Ocracoke, North Carolina 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Total Persons and Age Category	1970	1980	1990	2000
Total Persons	.	.		730
Persons Age 0-5	.	.		26
Persons Age 6-15	.	.		49
Persons Age 16-17	.	.		12
Persons Age 18-24	.	.		58
Persons Age 25-34	.	.		73
Persons Age 35-44	.	.		122
Persons Age 45-54	.	.		122
Persons Age 55-64	.	.		134
Persons Age 65+	.	.		134

Housing Tenure

Table 5.1.3-249. Housing Tenure for Ocracoke, North Carolina 1990-2000. (Source: U.S. Census Bureau).

Percent Renter Occupied	1990	2000
	-	18.1
Percent Owner Occupied	**1990**	**2000**
	-	81.9

Residence in 1985 and 1995

Table 5.1.3-250. Residence in 1985 and 1995 for Ocracoke, North Carolina 1990-2000. (Source: U.S. Census Bureau).

Different House Same County	1990	2000
	-	18
Same House	**1990**	**2000**
	-	492

Employment/Unemployment

Table 5.1.3-251. Employment and Unemployment for Ocracoke, North Carolina 1990-2000. (Source: U.S. Census Bureau).

Persons 16 yrs and over	1990	2000
Percent in labor force	-	54.7
Percent unemployed	-	2.0

Race

Table 5.1.3-252. Race for Ocracoke, North Carolina 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Race	1970	1980	1990	2000
Black Persons	.	.		13
Latino Black Persons	.	.		0
Latino Persons	.	.		15
White Persons	.	.		732
Latino White Persons	.	.		7

Education

Table 5.1.3-253. Years of Education by Category for those 25 Years and Older for Ocracoke, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Education	1970	1980	1990	2000
25+ w/ 0-8 years education	.	.		21
25+ w/ 9-11 years education	.	.		62
25+ w/ HS diploma	.	.		208
25+ w/ 13-15 years. education	.	.		108
25+ w/ College Degree	.	.		186
Drop outs	.	.		0

Income and Poverty

Table 5.1.3-254. Average Household Wage/Salary and Persons Below the Poverty Level for Ocracoke, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Wage or Salary	**1970**	**1980**	**1990**	**2000**
Average Household Wage/Salary Income (dollars)	.	.		34315
Poverty Level				
Persons Below Poverty Level	.	.		68
Age 65+ Below Poverty Level	.	.		14
Households with Public Assistance	.	.		20

Industry

Table 5.1.3-255. Employment by Industry for Ocracoke, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Industry	**1970**	**1980**	**1990**	**2000**
Agriculture, Fishing, Mining	.	.		13
Construction	.	.		14
Business Services	.	.		16
Communication/Utilities	.	.		7
Manufacturing	.	.		33
Financial, Insurance & Real Estate	.	.		10
Services	.	.		102
Wholesale/Retail Trade	.	.		116
Transportation		.		37

Occupation

Table 5.1.3-256. Employment by Occupation for Ocracoke, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Occupation	**1970**	**1980**	**1990**	**2000**
Sales	.	.		-
Clerical	.	.		-
Craft	.	.		-
Exec/Managerial	.	.		-
Farm/Fish/Forest	.	.		13
Household Services	.	.		-
Laborer/Handler	.	.		-
Operative/Transport	.	.		-
Service, except Household	.	.		-
Technical	.	.		-

Ocracoke Fishing Demographics

Table 5.1.3-257. Number of Federal Permit (October 2008) by Type for Ocracoke, North Carolina (Source: NMFS 2008).

Type	Permits
ATLANTIC DOLPHIN/WAHOO COMMERCIAL	4
ATLANTIC DOLPHIN/WAHOO CHARTER/ HEADBOAT	3
S. ATLANTIC CHARTER/HEADBOAT FOR PELAGIC FISH	3
KING MACKEREL	3
SPINY LOBSTER & TAILING	-,
ROCK SHRIMP & ENDORSEMENTS	-,-
S. ATL. CHARTER/HEADBOAT FOR SNAPPER-GROUPER	3
SWORDFISH & SHARKS	1,1
S. ATLANTIC SNAPPER-GROUPER (UNLIMITED)	-
S. ATLANTIC SNAPPER-GROUPER (225)	1
SPANISH MACKEREL	2
SOUTH ATLANTIC SHRIMP	-

Table 5.1.3-258. Employment in Fishing Related Industry for Ocracoke, North Carolina (Zip code Business Patterns, U.S. Census Bureau 1998).

Category	NAIC Code	Number Employed
Fishing	114100	4
Seafood Canning	311711	0
Seafood Processing	311712	0
Boat Building	336612	0
Fish and Seafoods	422460	4
Fish and Seafood Markets	445220	0
Marinas	713930	4
Total Fishing Employment		12

Table 5.1.3-259. Number of State Permit by Type for Ocracoke, North Carolina (Source: NCDMF 2008).

Type	Permits
Commercial Fishing Vessel Registration	81
Dealer License	13
Flounder License	0
Land or Sell License	0
Non-resident Menhaden License	0
Ocean Fishing Pier License	0
Spotter Plane License	0
Retired Standard Commercial Fishing License	4
Standard Commercial Fishing License	61
Shellfish License	8
Recreational Fishing Tournament to Sell License	0
Total	167

5.1.3.21 Elizabeth City (27909)

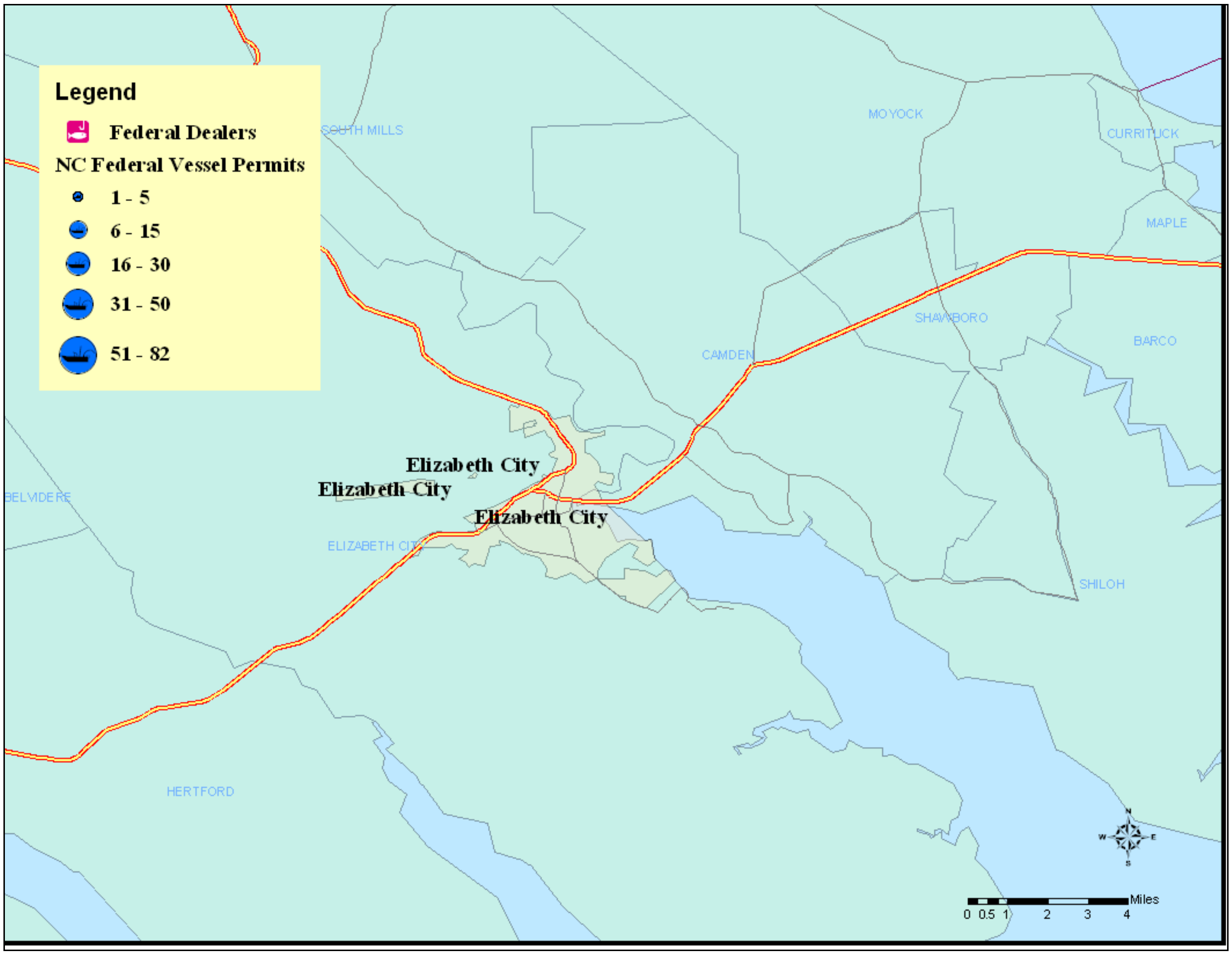

Figure 5.1.3-20. Elizabeth City, North Carolina.

Elizabeth City has seen substantial population growth in the past decade (Table 5.1.3-260) with most of the growth among African-Americans (Table 5.1.3-264), but has also experienced a significant rise in unemployment (Table 5.1.3-263). The percentage of population in the work force has risen slightly as has the number of people living below the poverty line (Table 5.1.3-266). In 2008, only 4 federal permits were issue to vessels that claim Elizabeth City as homeport (Table 5.1.3-269). However, there are 56 persons employed in the fish and seafood sector of fishing related employment reported in Table 5.1.3-270. There were 88 commercial vessels registered with the state and 193 standard commercial licenses reported in Table 5.1.3-271.

Elizabeth City Census Demographics

<u>Population</u>

Table 5.1.3-260. Total Persons and Persons by Age category for Elizabeth City, North Carolina 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Total Persons and Age Category	1970	1980	1990	2000
Total Persons	13903	14004	14279	17285
Persons Age 0-5	967	880	1316	1428
Persons Age 6-15	2769	1880	1919	2474
Persons Age 16-17	608	417	416	513
Persons Age 18-24	1488	2628	2056	2739
Persons Age 25-34	1314	1891	2165	2049
Persons Age 35-44	1451	1141	1622	2371
Persons Age 45-54	1776	1362	1082	1761
Persons Age 55-64	1505	1484	1196	1287
Persons Age 65+	1786	2131	2507	2663

Housing Tenure

Table 5.1.3-261. Housing Tenure for Elizabeth City, North Carolina 1990-2000. (Source: U.S. Census Bureau).

Percent Renter Occupied	1990	2000
	50.5	50.3
Percent Owner Occupied	**1990**	**2000**
	49.5	49.7

Residence in 1985 and 1995

Table 5.1.3-262. Residence in 1985 and 1995 for Elizabeth City, North Carolina 1990-2000. (Source: U.S. Census Bureau).

Different House Same County	1990	2000
	3021	842
Same House	**1990**	**2000**
	6487	7755

Employment/Unemployment

Table 5.1.3-263. Employment and Unemployment for Elizabeth City, North Carolina 1990-2000. (Source: U.S. Census Bureau).

Persons 16 yrs and over	1990	2000
Percent in labor force	53.0	58.2
Percent unemployed	2.9	15.4

Race

Table 5.1.3-264. Race for Elizabeth City, North Carolina 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Race	**1970**	**1980**	**1990**	**2000**
Black Persons	5274	6446	7500	9692
Latino Black Persons	21	95	5	37
Latino Persons	21	144	71	258
White Persons	8546	7448	6739	6813
Latino White Persons	0	41	61	104

Education

Table 5.1.3-265. Years of Education by Category for those 25 Years and Older for Elizabeth City, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Education	**1970**	**1980**	**1990**	**2000**
25+ w/ 0-8 years education	2919	2301	1534	896
25+ w/ 9-11 years education	1896	1555	1541	1568
25+ w/ HS diploma	1348	1634	2109	2877
25+ w/ 13-15 years. education	760	1208	1645	2240
25+ w/ College Degree	909	1311	1273	2388
Drop outs	246	142	94	162

Income and Poverty

Table 5.1.3-266. Average Household Wage/Salary and Persons Below the Poverty Level for Elizabeth City, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Wage or Salary	**1970**	**1980**	**1990**	**2000**
Average Household Wage/Salary Income (dollars)	$6494	$13816	$21638	$24193
Poverty Level				
Persons Below Poverty Level	3600	2721	3643	4318
Age 65+ Below Poverty Level	681	505	484	570
Households with Public Assistance	273	536	777	559

Industry

Table 5.1.3-267. Employment by Industry for Elizabeth City, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Industry	1970	1980	1990	2000
Agriculture, Fishing, Mining	81	88	96	136
Construction	261	351	353	425
Business Services	71	105	134	251
Communication/Utilities	197	218	155	222
Manufacturing	892	655	616	579
Financial, Insurance & Real Estate	498	455	347	229
Services	140	196	190	3085
Wholesale/Retail Trade	1821	869	1880	1294
Transportation	1148	1046	1229	141

Occupation

Table 5.1.3-268. Employment by Occupation for Elizabeth City, North Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Occupation	1970	1980	1990	2000
Sales	402	432	611	-
Clerical	656	6650	614	-
Craft	731	629	675	-
Exec/Managerial	333	518	466	-
Farm/Fish/Forest	54	95	73	65
Household Services	321	69	43	-
Laborer/Handler	270	376	294	-
Operative/Transport	644	328	302	-
Service, except Household	967	920	962	-
Technical	44	117	143	-

Elizabeth City Fishing Demographics

Table 5.1.3-269. Number of Federal Permit (October 2008) by Type for Elizabeth City, North Carolina (Source: NMFS 2008).

Type	Permits
ATLANTIC DOLPHIN/WAHOO COMMERCIAL	1
ATLANTIC DOLPHIN/WAHOO CHARTER/ HEADBOAT	1
S. ATLANTIC CHARTER/HEADBOAT FOR PELAGIC FISH	1
KING MACKEREL	-
SPINY LOBSTER & TAILING	-,
ROCK SHRIMP & ENDORSEMENTS	-,-
S. ATL. CHARTER/HEADBOAT FOR SNAPPER-GROUPER	-
SWORDFISH & SHARKS	-,
S. ATLANTIC SNAPPER-GROUPER (UNLIMITED)	-
S. ATLANTIC SNAPPER-GROUPER (225)	1

SPANISH MACKEREL	-
SOUTH ATLANTIC SHRIMP	-

Table 5.1.3-270. Employment in Fishing Related Industry for Elizabeth City, North Carolina (Zip code Business Patterns, U.S. Census Bureau 1998).

Category	NAIC Code	Number Employed
Fishing	114100	8
Seafood Canning	311711	0
Seafood Processing	311712	0
Boat Building	336612	0
Fish and Seafoods	422460	56
Fish and Seafood Markets	445220	0
Marinas	713930	8
Total Fishing Employment		72

Table 5.1.3-271. Number of State Permit by Type for Elizabeth City, North Carolina (Source: NCDMF 2008).

Type	Permits
Commercial Fishing Vessel Registration	88
Dealer License	10
Flounder License	0
Land or Sell License	0
Non-resident Menhaden License	0
Ocean Fishing Pier License	0
Spotter Plane License	0
Retired Standard Commercial Fishing License	16
Standard Commercial Fishing License	77
Shellfish License	2
Recreational Fishing Tournament to Sell License	0
Total	193

5.1.3.22 North Carolina Fishing Infrastructure and Community Characterization

The following tables provide a general view of the presence or absence of fishing infrastructure located within the coastal communities of North Carolina with substantial fishing activity. It should be noted that there are many other attributes that might have been included in this table, however, because of inconsistency in rapid appraisal for all communities, these items were selected as the most consistently reported or had secondary data available to determine presence or absence. It should also be noted that in some cases certain infrastructure may exist within a community but was not readily apparent or could not be ascertained through secondary data. Table 5.1.3-272 offers an overview of the presence of the selected infrastructure items and provides an overall total score which is merely the total of infrastructure present.

Table 5.1.3-272. Fishing Infrastructure Table for North Carolina Potential Fishing Communities.

Community	Federal Commercial Permits (5+)	State Commercial Licenses (10+)	Federal Charter Permits (5+)	Seafood Landings	Seafood retail markets	Fish processors, Wholesale fish house	Recreational docks / marinas	Recreational Fishing Tournaments	Total
Varnamtown	-	-	-	-	+	+	+	-	3
Southport	+	+	+	+	+	+	+	+	8
Bald Head Island	-	-	-	-	-	-	+	+	2
Carolina Beach	+	+	+	+	+	-	+	+	7
Wilmington	+	+	-	+	+	+	+	+	7
Wrightsville Beach	+	+	-	+	+	+	+	+	7
Topsail Beach/Surf City	-	-	-	+	-	-	+	+	3
Sneads Ferry	+	+	-	+	+	+	+	+	7
Swansboro	+	+	+	+	+	-	+	+	7
Atlantic Beach	+	+	-	-	-	-	+	+	4
Morehead City	+	+	+	+	+	+	+	+	8
Beaufort	+	+	+	+	+	+	+	+	8
Harker's Island	+	+	-	-	-	-	+	-	3
Hatteras	+	+	+	+	+	-	+	+	7
Oriental	+	+	-	+	-	-	+	+	5
Vandemere/Mesic	-	+	-	-	+	+	+	-	4
Bath	-	+	-	-	-	-	+	-	2
Belhaven	-	+	-	-	-	+	+	-	3
Wanchese	+	+	-	+	+	+	+	-	6
Manteo	+	+	+	+	+	+	+	+	8
Ocracoke	-	+	-	-	+	+	+	-	4
Elizabeth City	-	+	-	-	+	+	+	-	4

In providing a preliminary characterization of potential fishing communities in Table 5.1.3-273 we have provided a grouping of communities that seem to have more involvement in various fishing enterprises and therefore are classified as primarily involved. These communities seem to have considerable fishing infrastructure, but also appear to have a history and culture surrounding both commercial and recreational fishing that contributes to an appearance and perception of being a fishing community in the mind of residents and others. The communities of Wilmington and Wrightsville Beach, which have considerable fishing infrastructure but are listed in secondarily involved are placed in that category largely because these two communities are located in a more metropolitan area that has a very diversified economy and while there seems to be an emphasis upon fishing, it is most likely that fishing has a small role in the overall economy and culture of the area. Others, like Elizabeth City, have a large processor located in the community, but may lack other components that are considered part of fishing culture or history. Many of these communities are in transition due to various social and demographic changes from coastal development, growing populations, changing regulations, etc. This preliminary characterization is just that and should not be considered a definite designation as fishing community, but a general guide for locating communities that may warrant consideration as a potential fishing community. Furthermore communities are not ranked in any particular order, this is merely a categorization.

Table 5.1.3-273. Preliminary Characterization of Potential Fishing Communities in North Carolina.

Primarily-Involved	Secondarily-Involved
Southport	Varnamtown
Carolina Beach	Bald Head Island
Sneads Ferry	Wilmington
Swansboro	Wrightsville Beach
Morehead City	Topsail Beach/Surf City
Beaufort	Atlantic Beach
Hatteras	Oriental
Wanchese	Vandemere/Mesic
Manteo	Bath
Harker's Island	Belhaven
	Ocracoke
	Elizabeth City

5.1.4 South Carolina Communities with Substantial Fishing Activity

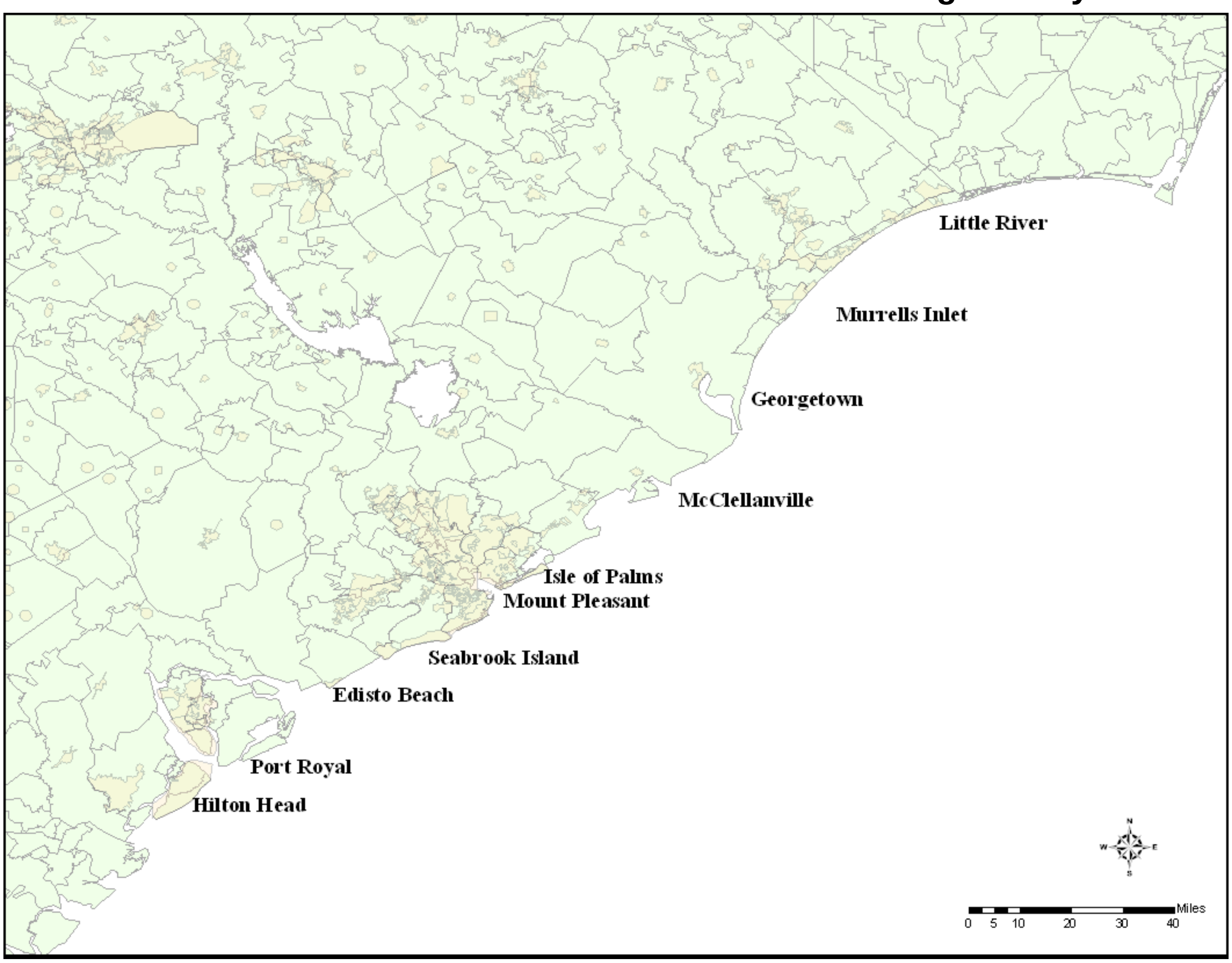

Figure 5.1.4-1. Potential Fishing Communities of South Carolina.

South Carolina landed over 14 million pounds of seafood in 2001 and over 13 million in 2002. The value of those landings was over 23 million dollars in 2001 and over 20 million dollars in 2002. No South Carolina port was listed in the top 50 U.S. ports in terms of pounds landed or in terms of value of landings. According to NMFS (2002) South Carolina recreational fishermen landed over 3 million pounds of finfish in 2001 and in 2002 that number dropped to just less than 2 million pounds. There were three processors in South Carolina during 2001 with a total of 28 employees. The number of wholesale dealers was not listed in the report under South Carolina, but was combined under Inland States. In the years 2001 and 2002, South Carolina had approximately 520 and 556 registered vessels respectively.

In 2008, South Carolina vessels with federal permits predominantly held south Atlantic charter/headboat pelagic, south Atlantic dolphin/wahoo charter, or South Atlantic shrimp permits.

Table 5.1.4-1. Number of Federal Permit (October 2008) by Type for South Carolina (Source: NMFS 2008).

Type	Permits
ATLANTIC DOLPHIN/WAHOO COMMERCIAL	75
ATLANTIC DOLPHIN/WAHOO CHARTER/ HEADBOAT	115
S. ATLANTIC CHARTER/HEADBOAT FOR PELAGIC FISH	123
KING MACKEREL	29
SPINY LOBSTER & TAILING	1, 4
ROCK SHRIMP & ENDORSEMENTS	6,-
S. ATL. CHARTER/HEADBOAT FOR SNAPPER-GROUPER	3
SWORDFISH & SHARKS	1,1
S. ATLANTIC SNAPPER-GROUPER (UNLIMITED)	-
S. ATLANTIC SNAPPER-GROUPER (225)	1
SPANISH MACKEREL	11
SOUTH ATLANTIC SHRIMP	52
DEALER	54

South Carolina requires licenses for both recreational and commercial fishing, including the sale of seafood and other marine products. The table below lists commercial licenses only (Table 5.1.4-2). The majority of South Carolina state permits are saltwater licenses and trawler licenses. The next most common are crab pots, bait dealer and shellfish licenses.

Table 5.1.4-2. Number of State Permits (Res. & Non-Res.) by Type for South Carolina. (Source: South Carolina Division of Marine Fisheries, 2008).

Type	Permits
Bait Dealer	90
Channel Net	49
Crab Pots	351
Drag Dredge	3
Gill Net	205
Hand Held Equipment	233
Herring Net	57

Mechanical Equipment	4
Minnow Traps	27
Miscellaneous Pots/Traps	2
Other Equipment	146
Peeler Crab Permit	27
Saltwater License	1397
Seine Net	14
Shad Gill Net	490
Shellfish Dealer	67
Shellfish License	197
Trawler License	436
Trotlines	36
Wholesale Dealer	267
Total	4098

Figure 5.1.4-1 shows potential fishing communities in South Carolina. A map for each community is provided which displays federal dealers and a symbol indicating the number of federal permits by zip code. The zip code area name is displayed in light blue while the CDP name is in black. The symbol for permits is centered within the zip code area and does not represent the precise location of any permit holder. Dealer permits are displayed near their physical location.

5.1.4.1 Hilton Head Island (29926, 29928)

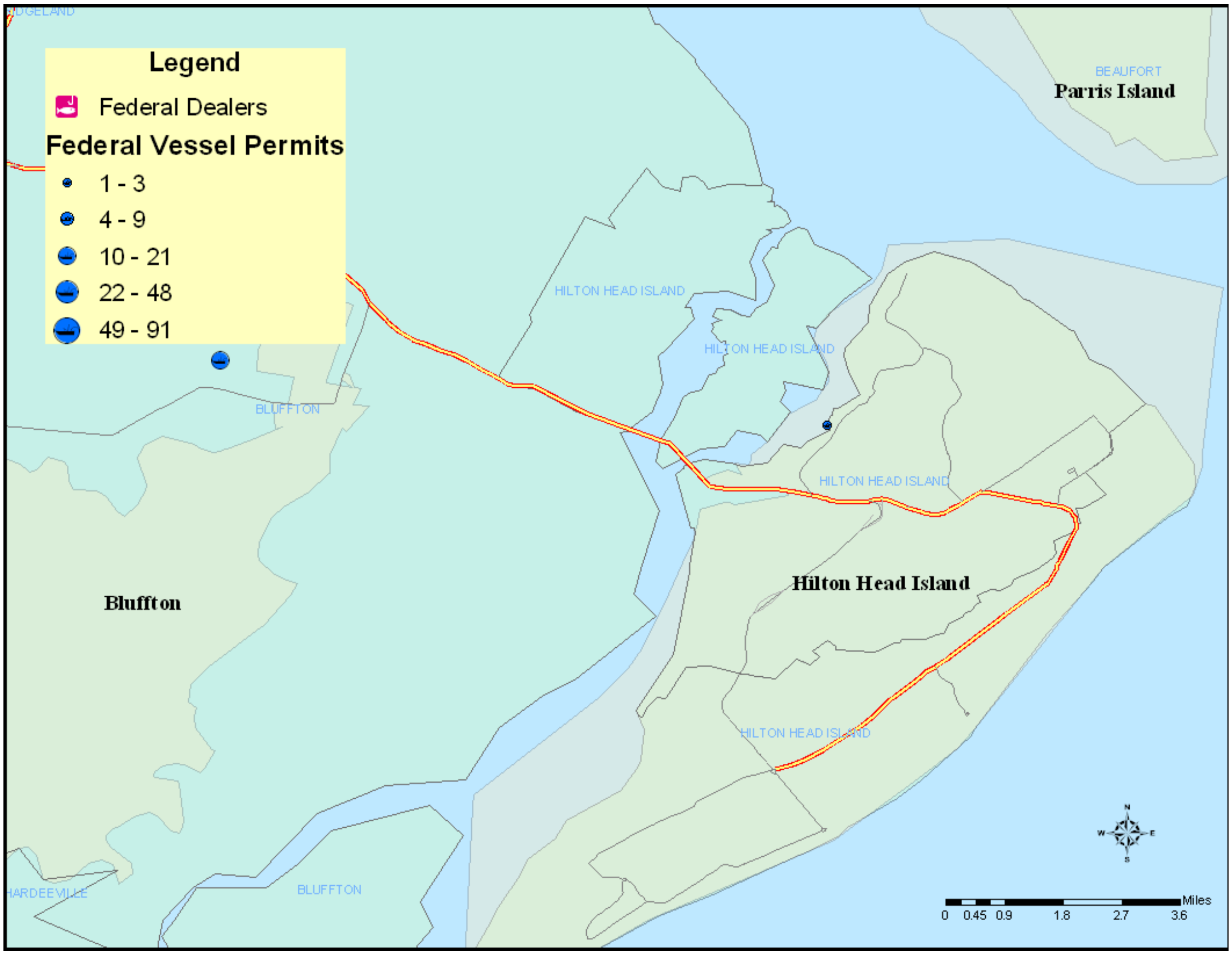

Figure 5.1.4-2. Hilton Head Island, South Carolina.

Hilton Head has seen steady population growth since 1980 and has tripled in size in 2000 (Table 5.1.4-3). While average wage and salary have also tripled over that time period and unemployment has remained low (Table 5.1.4-6), the number of people living under the poverty level has also risen noticeably (Table 5.1.4-9). There were at one time hundreds of persons employed in the farm, fish and forestry categories for occupation and industry. Recently, however, those numbers have dropped significantly (Tables 5.1.4-10 and 5.1.3-11). There are relatively few federally permitted vessels homeported at Hilton Head (Table 5.1.4-12) and most employment in fishing related business is in marinas sector according to Table 5.1.4-13. There were 108 total state permits for Hilton Head and 45 of those were Saltwater licenses and 11 trawler licenses (Table 5.1.4-13). Nearby Bluffton had 104 state permits with 44 of those being saltwater licenses and16 trawler licenses and 11 wholesale dealers (Table 5.1.4-15).

Hilton Head Census Demographics

<u>Population</u>

Table 5.1.4-3. Total Persons and Persons by Age category for Hilton Head Island, South Carolina 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Total Persons and Age Category	1970	1980	1990	2000
Total Persons	.	11344	23694	33,775
Persons Age 0-5	.	619	1636	1843
Persons Age 6-15	.	1287	2191	3328
Persons Age 16-17	.	323	419	595
Persons Age 18-24	.	1191	1845	2370
Persons Age 25-34	.	1968	4032	3986
Persons Age 35-44	.	1209	3288	2231
Persons Age 45-54	.	962	2428	4540
Persons Age 55-64	.	1885	3061	4558
Persons Age 65+	.	1782	4794	8098

Housing Tenure

Table 5.1.4-4. Housing Tenure for Hilton Head, South Carolina 1990-2000. (Source: U.S. Census Bureau).

Percent Renter Occupied	1990	2000
	35.3	22.3
Percent Owner Occupied	**1990**	**2000**
	64.7	77.7

Residence in 1985 and 1995

Table 5.1.4-5. Residence in 1985 and 1995 for Hilton Head, South Carolina 1990-2000. (Source: U.S. Census Bureau).

Different House Same County	1990	2000
	4996	5864
Same House	**1990**	**2000**
	7662	14712

Employment/Unemployment

Table 5.1.4-6. Employment and Unemployment for Hilton Head, South Carolina 1990-2000. (Source: U.S. Census Bureau).

Persons 16 yrs and over	1990	2000
Percent in labor force	61.0	55.5
Percent unemployed	2.8	1.8

Race

Table 5.1.4-7. Race for Hilton Head Island, South Carolina 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Race	**1970**	**1980**	**1990**	**2000**
Black Persons	.	1647	2318	2758
Latino Black Persons	.	10	11	39
Latino Persons	.	86	246	3886
White Persons	.	9659	21207	26752
Latino White Persons	.	76	174	2141

Education

Table 5.1.4-8. Years of Education by Category for those 25 Years and Older for Hilton Head Island, South Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Education	**1970**	**1980**	**1990**	**2000**
25+ w/ 0-8 years education	.	441	291	594
25+ w/ 9-11 years education	.	361	792	1252
25+ w/ HS diploma	.	1855	3394	4651
25+ w/ 13-15 years. education	.	1815	4533	5590
25+ w/ College Degree	.	3334	7485	13464
Drop outs	.	60	78	88

Income and Poverty

Table 5.1.4-9. Average Household Wage/Salary and Persons Below the Poverty Level for Hilton Head Island, 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Wage or Salary	**1970**	**1980**	**1990**	**2000**
Average Household Wage/Salary Income (dollars)	.	$20858	$42896	$60438
Poverty Level				
Persons Below Poverty Level	.	758	1662	2442
Age 65+ Below Poverty Level	.	79	279	215
Households with Public Assistance	.	165	228	176

Industry

Table 5.1.4-10. Employment by Industry for Hilton Head Island, South Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Industry	1970	1980	1990	2000
Agriculture, Fishing, Mining	.	158	216	41
Construction	.	607	923	2459
Business Services	.	293	644	994
Communication/Utilities	.	104	236	548
Manufacturing	.	290	621	593
Financial, Insurance & Real Estate	.	85	240	1606
Services	.	681	1693	5914
Wholesale/Retail Trade	.	1139	4676	4309
Transportation	.	1335	2993	226

Occupation

Table 5.1.4-11. Employment by Occupation for Hilton Head Island, South Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Occupation	1970	1980	1990	2000
Sales	.	728	2477	-
Clerical	.	7870	1366	-
Craft	.	462	1076	-
Exec/Managerial	.	965	2148	-
Farm/Fish/Forest	.	114	165	58
Household Services	.	59	70	-
Laborer/Handler	.	174	216	-
Operative/Transport	.	49	200	-
Service, except Household	.	947	1921	-
Technical	.	119	295	-

Hilton Head Fishing Demographics

Table 5.1.4-12. Number of Federal Permit (October 2008) by Type for Hilton Head Island, South Carolina (Source: NMFS 2008).

Type	Permits
ATLANTIC DOLPHIN/WAHOO COMMERCIAL	-
ATLANTIC DOLPHIN/WAHOO CHARTER/ HEADBOAT	2
S. ATLANTIC CHARTER/HEADBOAT FOR PELAGIC FISH	4
KING MACKEREL	-
SPINY LOBSTER & TAILING	-,
ROCK SHRIMP & ENDORSEMENTS	-,-
S. ATL. CHARTER/HEADBOAT FOR SNAPPER-GROUPER	4
SWORDFISH & SHARKS	-,
S. ATLANTIC SNAPPER-GROUPER (UNLIMITED)	1
S. ATLANTIC SNAPPER-GROUPER (225)	1
SPANISH MACKEREL	-

Table 5.1.4-13. Employment in Fishing Related Industry for Hilton Head Island, South Carolina (Zip code Business Patterns, U.S. Census Bureau 1998).

Category	**NAIC Code**	**Number Employed**
Fishing	114100	0
Seafood Canning	311711	0
Seafood Processing	311712	0
Boat Building	336612	3
Fish and Seafoods	422460	3
Fish and Seafood Markets	445220	0
Marinas	713930	13
Total Fishing Employment		19

Table 5.1.4-14. Number of State Permits by Type for Hilton Head, South Carolina. (Source South Carolina Division of Marine Fisheries, 2008).

Type	Permits
Bait Dealer	1
Channel Net	0
Crab Pots	4
Drag Dredge	0
Gill Net	2
Hand Held Equipment	10
Herring Net	0
Mechanical Equipment	0
Minnow Traps	0
Miscellaneous Pots/Traps	0
Other Equipment	5
Peeler Crab Permit	0
Saltwater License	45
Seine Net	0
Shad Gill Net	0
Shellfish Dealer	5
Shellfish License	9
Trawler License	11
Trotlines	0
Wholesale Dealer	16
Total	108

Table 5.1.4-15. Number of State Permits by Type for Bluffton, South Carolina. (Source South Carolina Division of Marine Fisheries, 2008).

Type	Permits
Bait Dealer	2
Channel Net	0
Crab Pots	7
Drag Dredge	0
Gill Net	1
Hand Held Equipment	9
Herring Net	0
Mechanical Equipment	0
Minnow Traps	1
Miscellaneous Pots/Traps	0
Other Equipment	3
Peeler Crab Permit	1
Saltwater License	44
Seine Net	0
Shad Gill Net	0
Shellfish Dealer	4
Shellfish License	5
Trawler License	16
Trotlines	0
Wholesale Dealer	11
Total	104

5.1.4.2 Beaufort/Port Royal (29935)

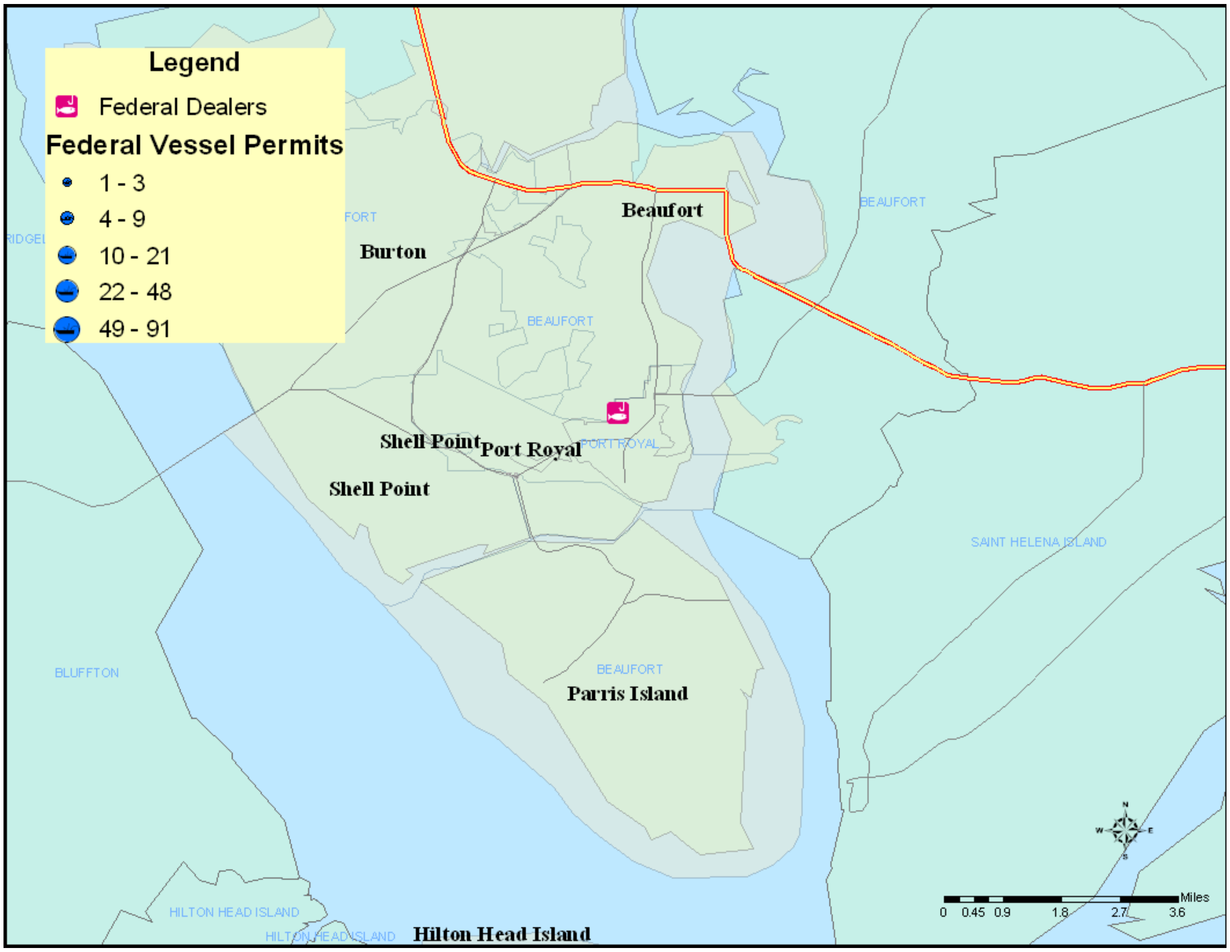

Figure 5.1.4-3. Beaufort/Port Royal, South Carolina.

Beaufort

The town of Beaufort was incorporated in 1711 and is the second oldest town in South Carolina. Both Beaufort County and the town of Beaufort were named for Henry Somerset, Duke of Beaufort (1684-1714), who was one of the Lords Proprietors of Carolina. Beaufort County was incorporated in 1785 and about 1800, it began to enter more prosperous times when rice, cotton and indigo plantations were abundant. Beaufort is the county seat and located on Port Royal Island. In 1874, the town of Port Royal was incorporated and is one of the large Sea Islands along the southeast Atlantic coast of the United States. The seaport of Beaufort is located at the head of one of the largest natural harbors on the Atlantic coast. Shrimping, fishing and crabbing are of major importance to these areas. They have been a part of their history since their settlement and the local economies continue to be dependent on them. Today, the entire area of downtown Beaufort is designated as a historic district. Every October in Port Royal there is an annual Shrimp Festival where the local maritime history is intertwined with the tourism industry. Local shrimpers share their history and recipes with tourists.

Port Royal

Port Royal has seen its population fluctuate over the past three decades and reached a high of 4,022 in 2000 (Table 5.1.4-16). The percent of unemployed persons had risen in the last decade to 9.0% (Table 5.1.4-19). Average wage and salary have also grown but persons below the poverty level has remained about the same (Table 5.1.4-22). Persons employed in farm, fish and forestry has also fluctuated over the years. Two federal permits were issued to vessels claiming it as homeport (Table 5.1.4-25). There are a 15 persons employed in the fish and seafood sector according to Table 5.1.4-26. There are only 13 state permits in Port Royal (Table 5.1.4-27), while in nearby St. Helena there are 197 with 73saltwater licenses, 25 trawler licenses and 14 wholesale dealers (Table 5.1.4-28). Beaufort which is also nearby had 198 total state licenses with 69 saltwater licenses and 23 trawler licenses (Table 5.1.5-29).

Port Royal Census Demographics

Population

Table 5.1.4-16. Total Persons and Persons by Age category for Port Royal, South Carolina 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Total Persons and Age Category	1970	1980	1990	2000
Total Persons	2865	3004	2985	4022
Persons Age 0-5	333	270	369	452
Persons Age 6-15	582	431	394	487
Persons Age 16-17	122	102	107	71
Persons Age 18-24	625	686	423	684
Persons Age 25-34	428	651	696	840
Persons Age 35-44	233	228	390	243
Persons Age 45-54	230	196	164	399
Persons Age 55-64	154	224	170	249
Persons Age 65+	143	185	272	370

Housing Tenure

Table 5.1.4-17. Housing Tenure for Port Royal, South Carolina 1990-2000. (Source: U.S. Census Bureau).

Percent Renter Occupied	1990	2000
	58.3	54.5
Percent Owner Occupied	**1990**	**2000**
	41.7	45.5

Residence in 1985 and 1995

Table 5.1.4-18. Residence in 1985 and 1995 for Port Royal, South Carolina 1990-2000. (Source: U.S. Census Bureau).

Different House Same County	**1990**	**2000**
	485	794
Same House	**1990**	**2000**
	968	1,285

Employment/Unemployment

Table 5.1.4-19. Employment and Unemployment for Port Royal, South Carolina 1990-2000. (Source: U.S. Census Bureau).

Persons 16 yrs and over	**1990**	**2000**
Percent in labor force	70.6	73.1
Percent unemployed	6.6	9.0

Race

Table 5.1.4-20. Race for Port Royal, South Carolina 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Race	**1970**	**1980**	**1990**	**2000**
Black Persons	611	860	1012	1140
Latino Black Persons	0	0	33	12
Latino Persons	21	48	111	169
White Persons	2229	2055	1899	2475
Latino White Persons	21	44	66	60

Education

Table 5.1.4-21. Years of Education by Category for those 25 Years and Older for Port Royal, South Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Education	**1970**	**1980**	**1990**	**2000**
25+ w/ 0-8 years education	328	215	114	120
25+ w/ 9-11 years education	306	153	237	152
25+ w/ HS diploma	353	540	594	606
25+ w/ 13-15 years. education	97	249	335	679
25+ w/ College Degree	104	327	272	736
Drop outs	114	22	38	35

Income and Poverty

Table 5.1.4-22. Average Household Wage/Salary and Persons Below the Poverty Level for Port Royal, South Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Wage or Salary	**1970**	**1980**	**1990**	**2000**
Average Household Wage/Salary Income (dollars)	6132	13607	26346	36599
Poverty Level				
Persons Below Poverty Level	568	396	402	391
Age 65+ Below Poverty Level	46	54	31	69
Households with Public Assistance	20	52	123	6

Industry

Table 5.1.4-23. Employment by Industry for Port Royal, South Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Industry	**1970**	**1980**	**1990**	**2000**
Agriculture, Fishing, Mining	26	35	18	31
Construction	21	113	64	189
Business Services	39	9	48	73
Communication/Utilities	9	39	35	50
Manufacturing	84	57	123	60
Financial, Insurance & Real Estate	18	12	76	159
Services	23	71	84	865
Wholesale/Retail Trade	234	125	414	402
Transportation	182	188	321	13

Occupation

Table 5.1.4-24. Employment by Occupation for Port Royal, South Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Occupation	**1970**	**1980**	**1990**	**2000**
Sales	33	106	122	-
Clerical	113	1710	161	-
Craft	114	137	162	-
Exec/Managerial	60	95	161	-
Farm/Fish/Forest	0	33	10	24
Household Services	34	0	0	-
Laborer/Handler	57	45	45	-
Operative/Transport	124	14	50	-
Service, except Household	124	161	261	-
Technical	0	12	39	-

Port Royal Fishing Demographics

Table 5.1.3-25. Number of Federal Permit (October 2008) by Type for Port Royal, South Carolina (Source: NMFS 2008).

Type	Permits
ATLANTIC DOLPHIN/WAHOO COMMERCIAL	-
ATLANTIC DOLPHIN/WAHOO CHARTER/ HEADBOAT	1
S. ATLANTIC CHARTER/HEADBOAT FOR PELAGIC FISH	1
KING MACKEREL	-
SPINY LOBSTER & TAILING	-,
ROCK SHRIMP & ENDORSEMENTS	-,-
S. ATL. CHARTER/HEADBOAT FOR SNAPPER-GROUPER	-
SWORDFISH & SHARKS	-,
S. ATLANTIC SNAPPER-GROUPER (UNLIMITED)	-
S. ATLANTIC SNAPPER-GROUPER (225)	-
SPANISH MACKEREL	-
SOUTH ATLANTIC SHRIMP	-

Table 5.1.4-26. Employment in Fishing Related Industry for Port Royal, South Carolina (Zip code Business Patterns, U.S. Census Bureau 1998).

Category	**NAIC Code**	**Number Employed**
Fishing	114100	0
Seafood Canning	311711	0
Seafood Processing	311712	0
Boat Building	336612	0
Fish and Seafoods	422460	15
Fish and Seafood Markets	445220	0
Marinas	713930	3
Total Fishing Employment		18

Table 5.1.4-27. Number of State Permits by Type for Port Royal, South Carolina. (Source South Carolina Division of Marine Fisheries, 2008).

Type	Permits

Bait Dealer	2
Channel Net	0
Crab Pots	1
Drag Dredge	0
Gill Net	0
Hand Held Equipment	0
Herring Net	0
Mechanical Equipment	0
Minnow Traps	0
Miscellaneous Pots/Traps	0
Other Equipment	0
Peeler Crab Permit	1
Saltwater License	5
Seine Net	0
Shad Gill Net	0
Shellfish Dealer	1
Shellfish License	0
Trawler License	2
Trotlines	0
Wholesale Dealer	1
Total	13

Table 5.1.4-28. Number of State Permits by Type for St. Helena Island, South Carolina. (Source South Carolina Division of Marine Fisheries, 2008).

Type	Permits
Bait Dealer	2
Channel Net	0
Crab Pots	19
Drag Dredge	0
Gill Net	2
Hand Held Equipment	27
Herring Net	0
Mechanical Equipment	0
Minnow Traps	1
Miscellaneous Pots/Traps	0
Other Equipment	10
Peeler Crab Permit	1
Saltwater License	73
Seine Net	0
Shad Gill Net	0
Shellfish Dealer	4
Shellfish License	18
Trawler License	25
Trotlines	1
Wholesale Dealer	14
Total	197

Table 5.1.4-29. Number of State Permits by Type for Beaufort, South Carolina. (Source South Carolina Division of Marine Fisheries, 2008).

Type	Permits
Bait Dealer	6
Channel Net	0
Crab Pots	19
Drag Dredge	0
Gill Net	0
Hand Held Equipment	25
Herring Net	0
Mechanical Equipment	0
Minnow Traps	1
Miscellaneous Pots/Traps	0
Other Equipment	13
Peeler Crab Permit	1
Saltwater License	69
Seine Net	0
Shad Gill Net	0
Shellfish Dealer	5
Shellfish License	19
Trawler License	23
Trotlines	2
Wholesale Dealer	15
Total	198

5.1.4.3 Edisto Beach (29438)

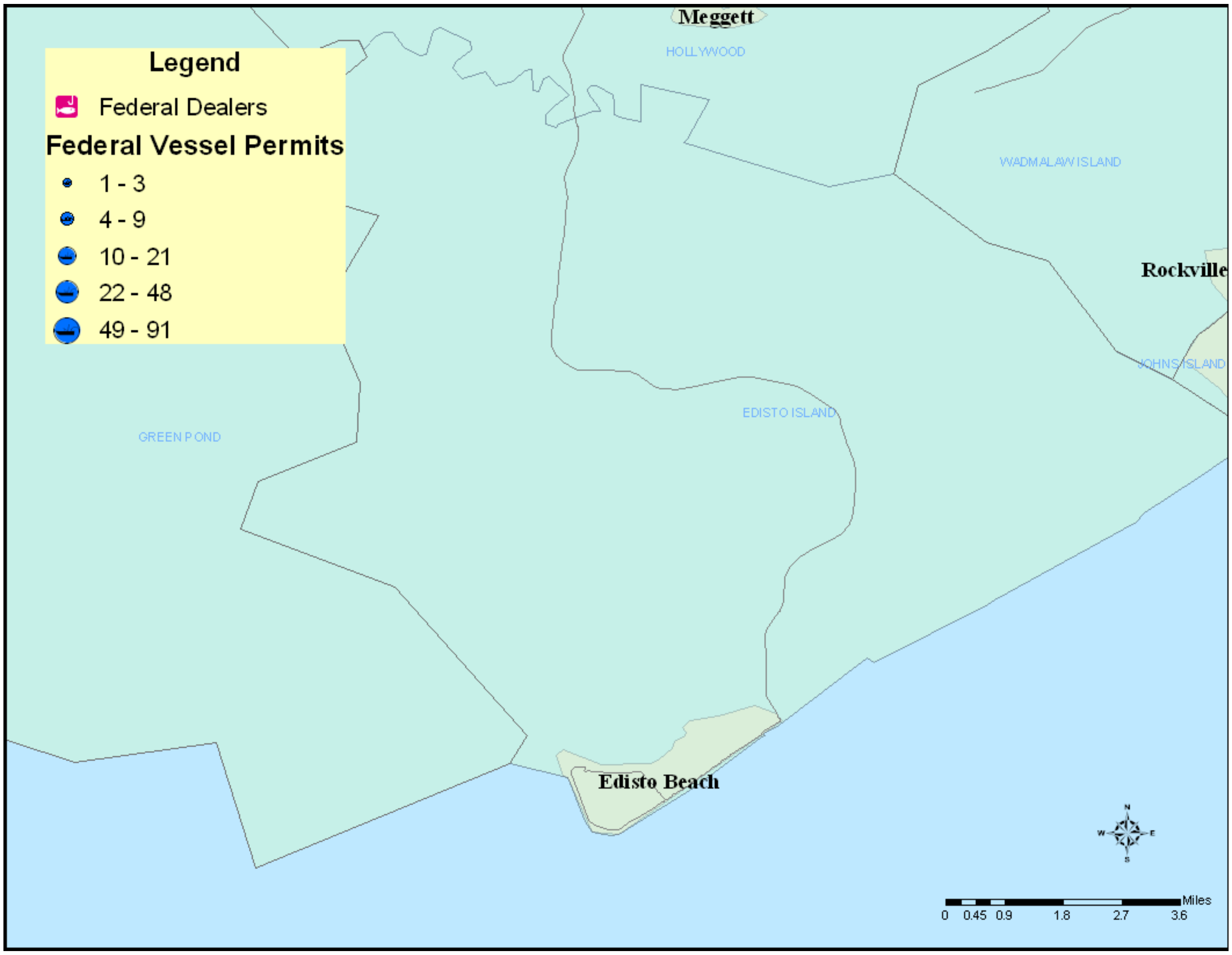

Figure 5.1.4-4. Edisto Beach, South Carolina.

Edisto Beach is a small beach community that has seen steady population growth over the past thirty years (Table 5.1.4-30). It has only about half of its population in the work force and unemployment has been and remains low (Table 5.1.4-33). Average wage and salary have jumped significantly in the last decade and the number of persons below the poverty level has risen only slightly. The number of persons employed in farm, fish and forestry has been few, but fluctuates over time. Two federal permits for south Atlantic shrimp were issued to vessels homeported in Edisto Beach (Table 5.1.4-39) and only 3 persons employed in fish and seafood according to Table 5.1.3-40. There are 44 state permits in the community with 20 of those being saltwater licenses and 8 trawler licenses (Table 5.1.4-51).

Edisto Beach Census Demographics

Population

Table 5.1.4-30. Total Persons and Persons by Age category for Edisto Beach, South Carolina 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Total Persons and Age Category	1970	1980	1990	2000
Total Persons	.	182	342	649
Persons Age 0-5	.	0	4	8
Persons Age 6-15	.	17	25	28
Persons Age 16-17	.	7	3	3
Persons Age 18-24	.	16	10	38
Persons Age 25-34	.	23	26	44
Persons Age 35-44	.	20	33	28
Persons Age 45-54	.	18	27	123
Persons Age 55-64	.	39	91	144
Persons Age 65+	.	42	123	214

Housing Tenure

Table 5.1.4-31. Housing Tenure for Edisto Beach, South Carolina 1990-2000. (Source: U.S. Census Bureau).

Percent Renter Occupied	1990	2000
	15.5	14.9
Percent Owner Occupied	**1990**	**2000**
	84.5	85.1

Residence in 1985 and 1995

Table 5.1.4-32. Residence in 1985 and 1995 for Edisto Beach, South Carolina 1990-2000. (Source: U.S. Census Bureau).

Different House Same County	1990	2000
	9	67
Same House	**1990**	**2000**
	190	290

Employment/Unemployment

Table 5.1.4-33. Employment and Unemployment for Edisto Beach, North Carolina 1990-2000. (Source: U.S. Census Bureau).

Persons 16 yrs and over	1990	2000
Percent in labor force	40.3	47.5
Percent unemployed	0.0	2.4

Race

Table 5.1.4-34. Race for Edisto Beach, South Carolina 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Race	1970	1980	1990	2000
Black Persons	.	0	0	17
Latino Black Persons	.	0	0	1
Latino Persons	.	0	0	2
White Persons	.	182	342	613
Latino White Persons	.	0	0	0

Education

Table 5.1.4-35. Years of Education by Category for those 25 Years and Older for Edisto Beach, South Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Education	**1970**	**1980**	**1990**	**2000**
25+ w/ 0-8 years education	.	6	0	15
25+ w/ 9-11 years education	.	17	33	24
25+ w/ HS diploma	.	37	79	118
25+ w/ 13-15 years. education	.	40	67	122
25+ w/ College Degree	.	42	102	293
Drop outs	.	0	0	0

Income and Poverty

Table 5.1.4-36. Average Household Wage/Salary and Persons Below the Poverty Level for Edisto Beach, South Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Wage or Salary	**1970**	**1980**	**1990**	**2000**
Average Household Wage/Salary Income (dollars)	.	$25443	$27617	$54444
Poverty Level				
Persons Below Poverty Level	.	0	15	23
Age 65+ Below Poverty Level	.	0	3	6
Households with Public Assistance	.	3	3	1

Industry

Table 5.1.4-37. Employment by Industry for Edisto Beach, South Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Industry	**1970**	**1980**	**1990**	**2000**
Agriculture, Fishing, Mining	.	8	2	4
Construction	.	3	4	13
Business Services	.	13	5	13
Communication/Utilities	.	3	0	6
Manufacturing	.	5	3	21
Financial, Insurance & Real Estate	.	5	0	39
Services	.	25	18	132
Wholesale/Retail Trade	.	30	51	64
Transportation	.	11	33	12

Occupation

Table 5.1.4-38. Employment by Occupation for Edisto Island, South Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Occupation	**1970**	**1980**	**1990**	**2000**
Sales	.	33	30	-
Clerical	.	190	23	-
Craft	.	11	10	-
Exec/Managerial	.	8	31	-
Farm/Fish/Forest	.	3	0	9
Household Services	.	0	0	-
Laborer/Handler	.	3	0	-
Operative/Transport	.	0	3	-
Service, except Household	.	11	9	-
Technical	.	0	4	-

Edisto Island Fishing Demographics

Table 5.1.4-39. Number of Federal Permit (October 2008) by Type for Edisto Island, South Carolina (Source: NMFS 2008).

Type	Permits
ATLANTIC DOLPHIN/WAHOO COMMERCIAL	-
ATLANTIC DOLPHIN/WAHOO CHARTER/ HEADBOAT	-
S. ATLANTIC CHARTER/HEADBOAT FOR PELAGIC FISH	-
KING MACKEREL	-
SPINY LOBSTER & TAILING	-,
ROCK SHRIMP & ENDORSEMENTS	-,-
S. ATL. CHARTER/HEADBOAT FOR SNAPPER-GROUPER	-
SWORDFISH & SHARKS	-,
S. ATLANTIC SNAPPER-GROUPER (UNLIMITED)	-
S. ATLANTIC SNAPPER-GROUPER (225)	-
SPANISH MACKEREL	-
SOUTH ATLANTIC SHRIMP	2

Table 5.1.4-40. Employment in Fishing Related Industry for Edisto Island, South Carolina (Zip code Business Patterns, U.S. Census Bureau 1998).

Category	NAIC Code	Number Employed
Fishing	114100	0
Seafood Canning	311711	0
Seafood Processing	311712	0
Boat Building	336612	0
Fish and Seafoods	422460	3
Fish and Seafood Markets	445220	0
Marinas	713930	0
Total Fishing Employment		3

Table 5.1.4-41. Number of State Permits by Type for Edisto Island, South Carolina. (Source South Carolina Division of Marine Fisheries, 2008).

Type	Permits
Bait Dealer	1
Channel Net	0
Crab Pots	7
Drag Dredge	0
Gill Net	1
Hand Held Equipment	0
Herring Net	0
Mechanical Equipment	0
Minnow Traps	0
Miscellaneous Pots/Traps	0
Other Equipment	1
Peeler Crab Permit	1
Saltwater License	20
Seine Net	0
Shad Gill Net	0
Shellfish Dealer	2
Shellfish License	0
Trawler License	8
Trotlines	0
Wholesale Dealer	3
Total	44

5.1.4.4 Seabrook Island

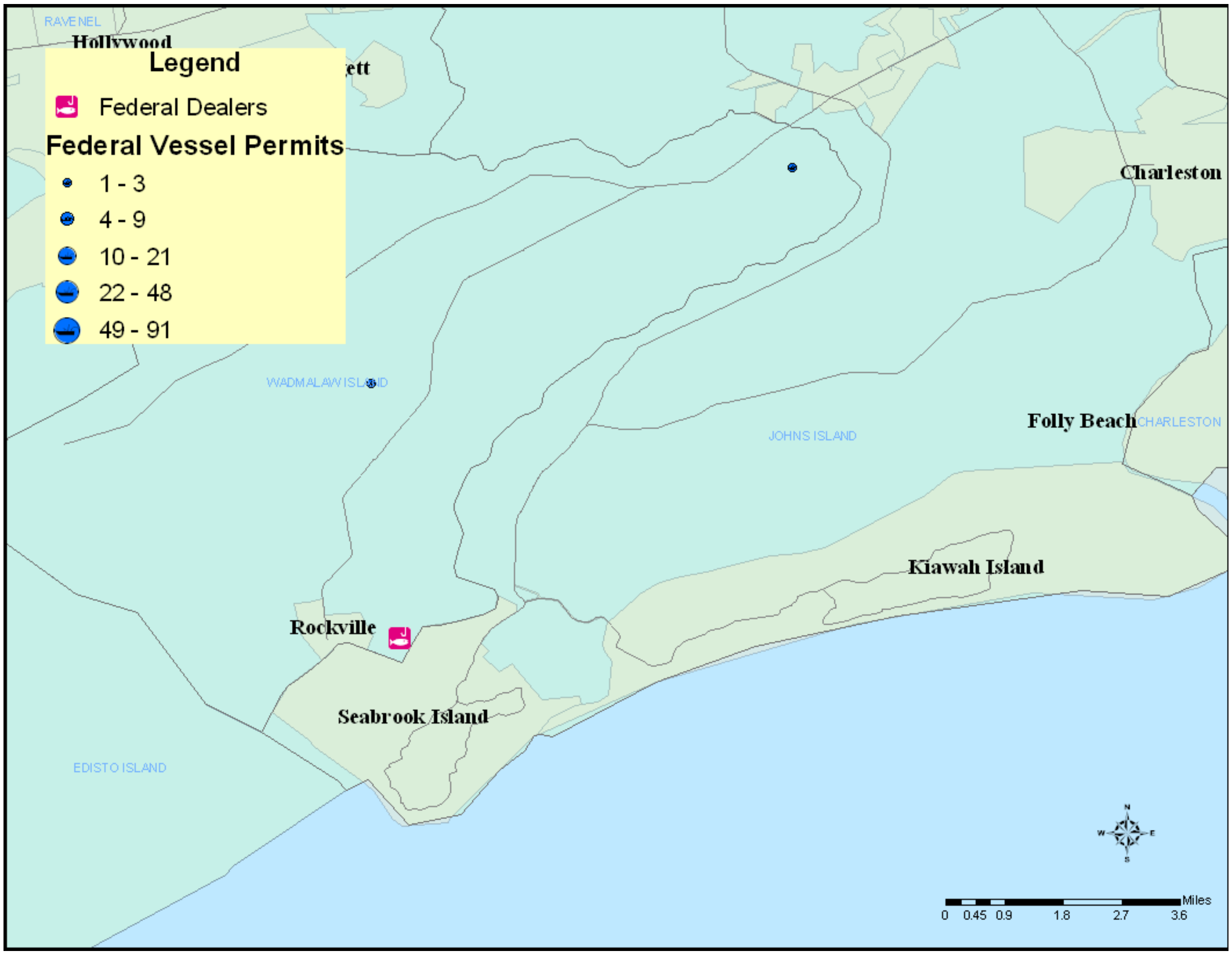

Figure 5.1.4-5. Seabrook Island, South Carolina.

Seabrook has seen some population growth since 1990 with a total population of 1203 in 2000. Most of households are owner occupied which has increased over the past ten years. Unemployment has decreased to 2.3 percent in 200 while the percent of the population in the labor force has dropped from 46.9 percent in 1990 to 40.6 percent in 2000. Average wage and salary has risen slightly while number of persons living under the poverty line has decreased. Employment in farm, fish and forestry occupation and industry has dropped over the past ten years to only 3 persons in the industry category. There is only five federal permits issued to vessels that claims Seabrook as a homeport (Table 5.1.4-51). All of the employment in fishing related sectors is in marinas according to (Table 5.1.4-52). There were 30 state permits for the community of Seabrook, but the nearby community of Wadmalaw Island did have 29 permits with 11 being saltwater licenses and 0 wholesale dealers (Table 5.1.4-53).

Seabrook Census Demographics

<u>Population</u>

Table 5.1.4-42. Total Persons and Persons by Age category for Seabrook Island, South Carolina 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Total Persons and Age Category	1970	1980	1990	2000
Total Persons	.	.	931	1203
Persons Age 0-5	.	.	26	24
Persons Age 6-15	.	.	77	20
Persons Age 16-17	.	.	23	13
Persons Age 18-24	.	.	43	36
Persons Age 25-34	.	.	42	80
Persons Age 35-44	.	.	79	48
Persons Age 45-54	.	.	132	197
Persons Age 55-64	.	.	189	310
Persons Age 65+	.	.	320	437

Housing Tenure

Table 5.1.4-43. Housing Tenure for Seabrook Island, South Carolina 1990-2000. (Source: U.S. Census Bureau).

Percent Renter Occupied	1990	2000
	21.5	7.9
Percent Owner Occupied	**1990**	**2000**
	78.5	92.1

Residence in 1985 and 1995

Table 5.1.4-44. Residence in 1985 and 1995 for Seabrook Island, South Carolina 1990-2000. (Source: U.S. Census Bureau).

Different House Same County	1990	2000
	112	224
Same House	**1990**	**2000**
	307	472

Employment/Unemployment

Table 5.1.4-45. Employment and Unemployment for Seabrook Island, South Carolina 1990-2000. (Source: U.S. Census Bureau).

Persons 16 yrs and over	1990	2000
Percent in labor force	46.9	40.6
Percent unemployed	6.2	2.3

Race

Table 5.1.4-46. Race for Seabrook Island, South Carolina 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Race	**1970**	**1980**	**1990**	**2000**
Black Persons	.	.	0	18
Latino Black Persons	.	.	0	0
Latino Persons	.	.	2	11
White Persons	.	.	928	1203
Latino White Persons	.	.	2	10

Education

Table 5.1.4-47. Years of Education by Category for those 25 Years and Older for Seabrook Island, South Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Education	**1970**	**1980**	**1990**	**2000**
25+ w/ 0-8 years education	.	.	8	0
25+ w/ 9-11 years education	.	.	5	6
25+ w/ HS diploma	.	.	91	137
25+ w/ 13-15 years. education	.	.	159	153
25+ w/ College Degree	.	.	432	810
Drop outs	.	.	0	4

Income and Poverty

Table 5.1.4-48. Average Household Wage/Salary and Persons Below the Poverty Level for Seabrook Island, South Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Wage or Salary	**1970**	**1980**	**1990**	**2000**
Average Household Wage/Salary Income (dollars)	.	.	62628	66548
Poverty Level				
Persons Below Poverty Level	.	.	31	46
Age 65+ Below Poverty Level	.	.	6	20
Households with Public Assistance	.	.	6	0

Industry

Table 5.1.4-49. Employment by Industry for Seabrook Island, South Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Industry	1970	1980	1990	2000
Agriculture, Fishing, Mining	.	.	9	3
Construction	.	.	16	21
Business Services	.	.	13	55
Communication/Utilities	.	.	6	10
Manufacturing	.	.	14	6
Financial, Insurance & Real Estate	.	.	7	80
Services	.	.	78	209
Wholesale/Retail Trade	.	.	107	129
Transportation	.	.	70	7

Occupation

Table 5.1.4-50. Employment by Occupation for Seabrook Island, South Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Occupation	1970	1980	1990	2000
Sales	.	.	90	-
Clerical	.	.	43	-
Craft	.	.	8	-
Exec/Managerial	.	.	99	-
Farm/Fish/Forest	.	.	14	0
Household Services	.	.	0	-
Laborer/Handler	.	.	0	-
Operative/Transport	.	.	0	-
Service, except Household	.	.	21	-
Technical	.	.	5	-

Seabrook Fishing Demographics

Table 5.1.4-51. Number of Federal Permit (October 2008) by Type for Seabrook Island, South Carolina (Source: NMFS 2008).

Type	Permits
ATLANTIC DOLPHIN/WAHOO COMMERCIAL	-
ATLANTIC DOLPHIN/WAHOO CHARTER/ HEADBOAT	1
S. ATLANTIC CHARTER/HEADBOAT FOR PELAGIC FISH	1
KING MACKEREL	-
SPINY LOBSTER & TAILING	-,
ROCK SHRIMP & ENDORSEMENTS	-,-
S. ATL. CHARTER/HEADBOAT FOR SNAPPER-GROUPER	1
SWORDFISH & SHARKS	-,
S. ATLANTIC SNAPPER-GROUPER (UNLIMITED)	-
S. ATLANTIC SNAPPER-GROUPER (225)	-
SPANISH MACKEREL	-

Table 5.1.4-52. Employment in Fishing Related Industry for Seabrook Island, South Carolina (Zip code Business Patterns, U.S. Census Bureau 1998).

Category	NAIC Code	Number Employed
Fishing	114100	0
Seafood Canning	311711	0
Seafood Processing	311712	0
Boat Building	336612	0
Fish and Seafoods	422460	0
Fish and Seafood Markets	445220	0
Marinas	713930	31
Total Fishing Employment		31

Table 5.1.4-53. Number of State Permits by Type for Seabrook Island, South Carolina. (Source South Carolina Division of Marine Fisheries, 2008).

Type	Permits
Bait Dealer	2
Channel Net	0
Crab Pots	5
Drag Dredge	0
Gill Net	0
Hand Held Equipment	1
Herring Net	0
Mechanical Equipment	0
Minnow Traps	1
Miscellaneous Pots/Traps	0
Other Equipment	3
Peeler Crab Permit	0
Saltwater License	11
Seine Net	0
Shad Gill Net	0
Shellfish Dealer	0
Shellfish License	1
Trawler License	4
Trotlines	2
Wholesale Dealer	0
Total	30

Table 5.1.4-54. Number of State Permits by Type for Wadmalaw Island, South Carolina. (Source South Carolina Division of Marine Fisheries, 2008).

Type	Permits
Bait Dealer	1
Channel Net	0
Crab Pots	4
Drag Dredge	0
Gill Net	0
Hand Held Equipment	2
Herring Net	0
Mechanical Equipment	0
Minnow Traps	0
Miscellaneous Pots/Traps	0
Other Equipment	0
Peeler Crab Permit	0
Saltwater License	12
Seine Net	0
Shad Gill Net	0
Shellfish Dealer	1
Shellfish License	2
Trawler License	4
Trotlines	0
Wholesale Dealer	3
Total	29

5.1.4.5 Mt. Pleasant (29464)

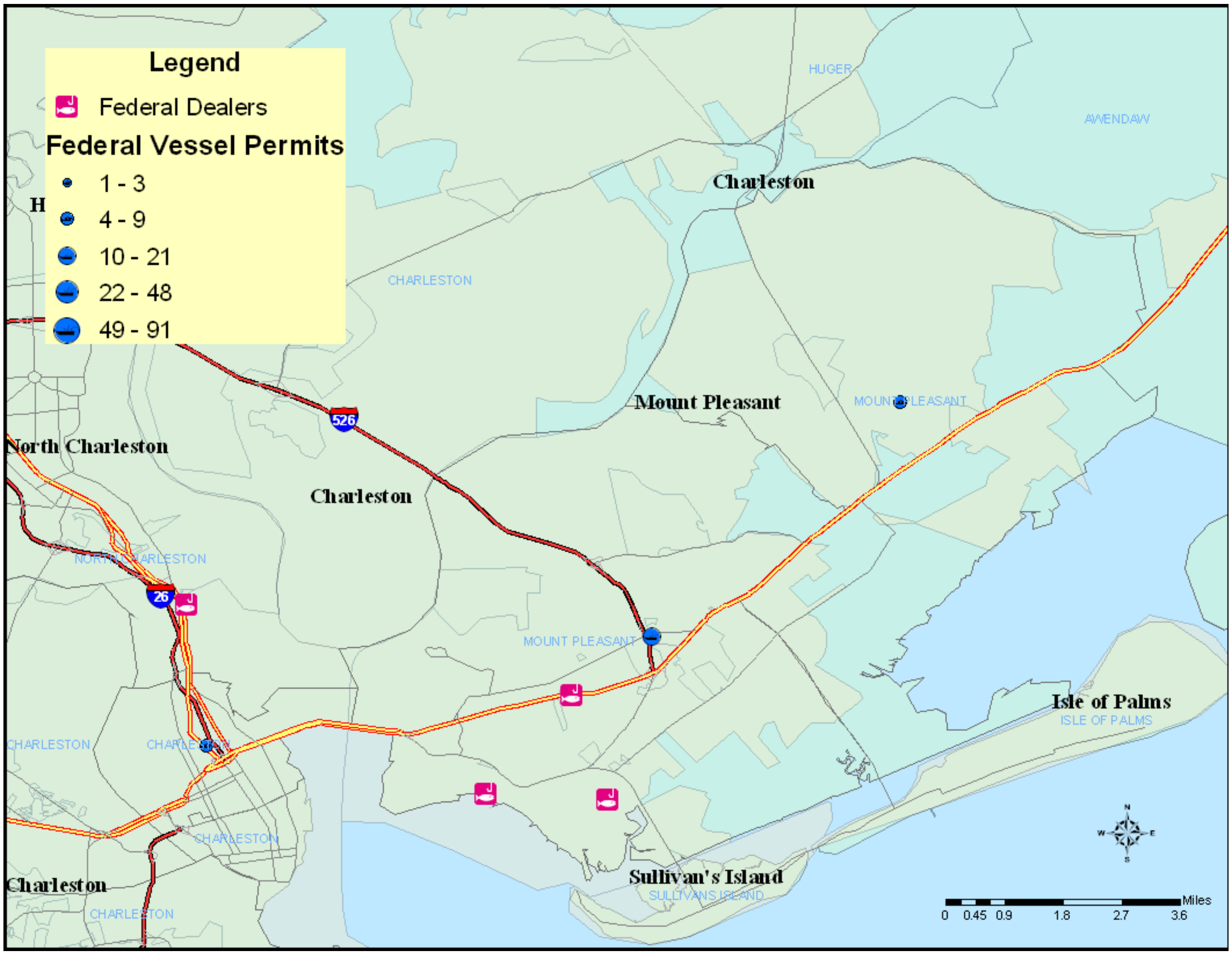

Figure 5.1.4-6. Mt. Pleasant, South Carolina.

The first inhabitants of the Mount Pleasant area were the Sewee Indians. The first English settlers arrived around 1680 under the leadership of Captain Florentia O' Sullivan. He had been granted 2,340 acres and each time a new family arrived, they were allotted several hundred acres. The first small settlement of the area was the village of Greenwich, which was adjacent to Jacob Motte's "Mount Pleasant" estate. Motte's estate was purchased in 1803 and divided into 35 large lots. In 1837, the village of Greenwich was merged with Mount Pleasant. Many of the families in this area had timber concerns and some maintained the ferries.

Mount Pleasant also played a leading role in the first major military engagement of the Revolutionary War in 1775. After the war, the area was known as a resort town with many stores and rentals available. The area is still widely known as a vacation area and "model town" in South Carolina.

Mount Pleasant has seen its population double every ten years from 1970 to 1990 and now has reached a high of 47,386 in 2000. The number of persons in the labor force has dropped slightly to 69.9 percent while percent unemployed has remained fairly low at 2.2

percent. Average wage and salary has risen substantially but so has the number of persons living below the poverty level. While there was a significant jump in the number of persons working in farm, fish and forestry in 1990, that number dropped significantly in 2000. While there are only 5 federal permits issued to vessels homeported in Mount Pleasant (Table 5.1.4-63), there are 12 persons listed as fishing and 28 persons employed in fish and seafood and markets (Table 5.1.4-64). There are 131 state permits in Mt. Pleasant with 53 saltwater licenses (Table 5.1.4-65). There were 10 trawler licenses and 14 wholesale dealer licenses.

Mount Pleasant Census Demographics

Population

Table 5.1.4-54. Total Persons and Persons by Age category for Mount Pleasant, South Carolina 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Total Persons and Age Category	1970	1980	1990	2000
Total Persons	6172	13838	30108	47386
Persons Age 0-5	513	1089	2706	4309
Persons Age 6-15	1473	2183	4060	6499
Persons Age 16-17	266	489	571	1061
Persons Age 18-24	594	1479	2704	3087
Persons Age 25-34	809	3267	6690	7757
Persons Age 35-44	805	1862	5872	4676
Persons Age 45-54	771	1179	2690	7122
Persons Age 55-64	447	1241	2039	3935
Persons Age 65+	384	861	2776	4773

Housing Tenure

Table 5.1.4-55. Housing Tenure for Mount Pleasant, South Carolina 1990-2000. (Source: U.S. Census Bureau).

Percent Renter Occupied	1990	2000
	37.9	26.0
Percent Owner Occupied	**1990**	**2000**
	62.1	74.0

Residence in 1985 and 1995

Table 5.1.4-56. Residence in 1985 and 1995 for Mount Pleasant, South Carolina 1990-2000. (Source: U.S. Census Bureau).

Different House Same County	1990	2000
	8729	11501
Same House	**1990**	**2000**
	10092	18087

Employment/Unemployment

Table 5.1.4-57. Employment and Unemployment for Mount Pleasant, South Carolina 1990-2000. (Source: U.S. Census Bureau).

Persons 16 yrs and over	1990	2000
Percent in labor force	74.5	69.9
Percent unemployed	2.0	2.2

Race

Table 5.1.4-58. Race for Mount Pleasant, South Carolina 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Race	1970	1980	1990	2000
Black Persons	779	991	2754	3445
Latino Black Persons	0	0	17	8
Latino Persons	40	124	373	635
White Persons	5389	12723	27096	42515
Latino White Persons	40	124	335	413

Education

Table 5.1.4-59. Years of Education by Category for those 25 Years and Older for Mount Pleasant, South Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Education	1970	1980	1990	2000
25+ w/ 0-8 years education	494	611	630	453
25+ w/ 9-11 years education	555	865	1325	1408
25+ w/ HS diploma	1181	2037	3549	4571
25+ w/ 13-15 years. education	545	1923	4596	6386
25+ w/ College Degree	441	2974	8378	19537
Drop outs	98	60	69	75

Income and Poverty

Table 5.1.4-60. Average Household Wage/Salary and Persons Below the Poverty Level for Mount Pleasant, South Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Wage or Salary	1970	1980	1990	2000
Average Household Wage/Salary Income (dollars)	$10501	$22344	$41109	$61054
Poverty Level				
Persons Below Poverty Level	660	925	1724	2335
Age 65+ Below Poverty Level	73	116	207	277
Households with Public Assistance	66	143	330	154

Industry

Table 5.1.4-61. Employment by Industry for Mount Pleasant, South Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Industry	**1970**	**1980**	**1990**	**2000**
Agriculture, Fishing, Mining	14	60	245	81
Construction	187	418	1400	1565
Business Services	21	187	607	2189
Communication/Utilities	159	244	394	681
Manufacturing	468	933	1549	1816
Financial, Insurance & Real Estate	372	569	932	2025
Services	138	507	1436	15121
Wholesale/Retail Trade	526	1350	6669	5534
Transportation	509	1383	3208	1008

Occupation

Table 5.1.4-62. Employment by Occupation for Mount Pleasant, South Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Occupation	**1970**	**1980**	**1990**	**2000**
Sales	213	843	2703	-
Clerical	452	12500	2043	-
Craft	449	659	1543	-
Exec/Managerial	284	1006	2910	-
Farm/Fish/Forest	0	81	162	72
Household Services	36	105	54	-
Laborer/Handler	40	187	351	-
Operative/Transport	182	235	323	-
Service, except Household	186	600	1394	-
Technical	19	400	853	-

Mount Pleasant Fishing Demographics

Table 5.1.4-63. Number of Federal Permit (October 2008) by Type for Mount Pleasant, South Carolina (Source: NMFS 2008).

Type	Permits
ATLANTIC DOLPHIN/WAHOO COMMERCIAL	-
ATLANTIC DOLPHIN/WAHOO CHARTER/ HEADBOAT	1
S. ATLANTIC CHARTER/HEADBOAT FOR PELAGIC FISH	1
KING MACKEREL	-
SPINY LOBSTER & TAILING	-,
ROCK SHRIMP & ENDORSEMENTS	-,-
S. ATL. CHARTER/HEADBOAT FOR SNAPPER-GROUPER	1
SWORDFISH & SHARKS	-,
S. ATLANTIC SNAPPER-GROUPER (UNLIMITED)	1
S. ATLANTIC SNAPPER-GROUPER (225)	1

SPANISH MACKEREL	-
SOUTH ATLANTIC SHRIMP	2

Table 5.1.4-64. Employment in Fishing Related Industry for Mount Pleasant, South Carolina (Zip code Business Patterns, U.S. Census Bureau 1998).

Category	NAIC Code	Number Employed
Fishing	114100	12
Seafood Canning	311711	0
Seafood Processing	311712	0
Boat Building	336612	7
Fish and Seafoods	422460	10
Fish and Seafood Markets	445220	18
Marinas	713930	17
Total Fishing Employment		64

Table 5.1.4-65. Number of State Permits by Type for Mount Pleasant, South Carolina. (Source South Carolina Division of Marine Fisheries, 2008).

Type	Permits
Bait Dealer	3
Channel Net	0
Crab Pots	15
Drag Dredge	0
Gill Net	1
Hand Held Equipment	12
Herring Net	1
Mechanical Equipment	0
Minnow Traps	0
Miscellaneous Pots/Traps	0
Other Equipment	5
Peeler Crab Permit	1
Saltwater License	53
Seine Net	0
Shad Gill Net	2
Shellfish Dealer	2
Shellfish License	11
Trawler License	10
Trotlines	1
Wholesale Dealer	14
Totals	131

5.1.4.6 Isle of Palms (29451)

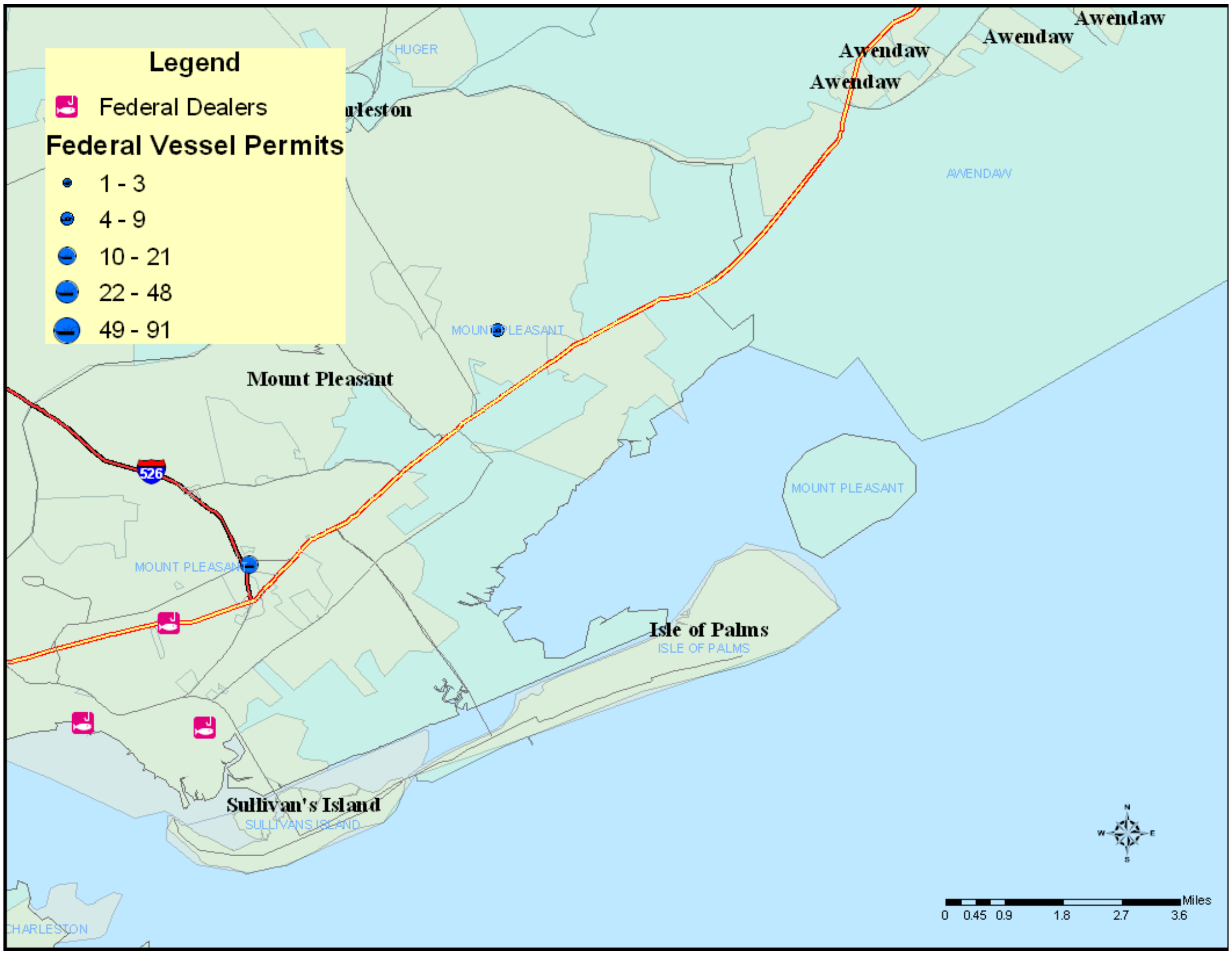

Figure 5.1.4-7. Isle of Palms, South Carolina.

Isle of Palms has seen little population growth over the past several decades. The percent of the population in the labor force has dropped slightly to 63.1 percent and unemployment is down to 1.3 percent in 2000. Average wage and salary has almost doubled every ten years since 1970 to a high of $76,170 in 2000. The number of persons below the poverty level dropped dramatically in 1990 but has since risen to 156. The number of persons in farm, fish, and forestry occupations and the industry has dropped steadily over the years. There are 6 federal permits issued to vessels that call Isle of Palms homeport (Table 5.1.4-75) most all employment in fishing related businesses is in marinas with 18 and 3 persons in fish and seafood markets. There were a total of 6 state permits according to (Table 5.1.4-77) and 3 of those were saltwater licenses and 0 were shellfish.

Isle of Palms Census Demographics

<u>Population</u>

Table 5.1.4-66. Total Persons and Persons by Age category for Isle of Palms, South Carolina 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Total Persons and Age Category	1970	1980	1990	2000
Total Persons	2657	3421	3682	4583
Persons Age 0-5	268	165	203	264
Persons Age 6-15	653	489	450	499
Persons Age 16-17	57	118	102	114
Persons Age 18-24	270	419	223	231
Persons Age 25-34	547	765	476	489
Persons Age 35-44	263	466	735	364
Persons Age 45-54	337	339	572	907
Persons Age 55-64	122	382	468	696
Persons Age 65+	82	244	453	698

Housing Tenure

Table 5.1.4-67. Housing Tenure for Isle of Palms, South Carolina 1990-2000. (Source: U.S. Census Bureau).

Percent Renter Occupied	1990	2000
	20.9	19.3
Percent Owner Occupied	**1990**	**2000**
	70.6	80.7

Residence in 1985 and 1995

Table 5.1.4-68. Residence in 1985 and 1995 for Isle of Palms, South Carolina 1990-2000. (Source: U.S. Census Bureau).

Different House Same County	1990	2000
	802	809
Same House	**1990**	**2000**
	1520	2214

Employment/Unemployment

Table 5.1.4-69. Employment and Unemployment for Isle of Palms, South Carolina 1990-2000. (Source: U.S. Census Bureau).

Persons 16 yrs and over	1990	2000
Percent in labor force	72.2	63.1
Percent unemployed	4.6	1.3

Race

Table 5.1.4-70. Race for Isle of Palms, South Carolina 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Race	**1970**	**1980**	**1990**	**2000**
Black Persons	0	0	0	16
Latino Black Persons	0	0	0	0
Latino Persons	0	24	11	55
White Persons	2657	3416	3671	4458
Latino White Persons	0	19	11	44

Education

Table 5.1.4-71. Years of Education by Category for those 25 Years and Older for Isle of Palms, South Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Education	**1970**	**1980**	**1990**	**2000**
25+ w/ 0-8 years education	95	72	38	17
25+ w/ 9-11 years education	231	155	178	91
25+ w/ HS diploma	454	594	479	363
25+ w/ 13-15 years. education	311	547	656	720
25+ w/ College Degree	260	828	1155	2284
Drop outs	43	7	0	0

Income and Poverty

Table 5.1.4-72. Average Household Wage/Salary and Persons Below the Poverty Level for Isle of Palms, South Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Wage or Salary	**1970**	**1980**	**1990**	**2000**
Average Household Wage/Salary Income (dollars)	$10772	$21527	$40083	$76170
Poverty Level				
Persons Below Poverty Level	199	250	76	156
Age 65+ Below Poverty Level	20	18	0	7
Households with Public Assistance	12	16	12	17

Industry

Table 5.1.4-73. Employment by Industry for Isle of Palms, South Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Industry	**1970**	**1980**	**1990**	**2000**
Agriculture, Fishing, Mining	8	11	8	2
Construction	80	137	254	195
Business Services	43	61	95	208
Communication/Utilities	66	82	127	73
Manufacturing	282	209	170	161
Financial, Insurance & Real Estate	212	144	131	259
Services	63	108	188	1350
Wholesale/Retail Trade	307	324	762	507
Transportation	185	343	359	54

Occupation

Table 5.1.4-74. Employment by Occupation for Isle of Palms, South Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Occupation	**1970**	**1980**	**1990**	**2000**
Sales	111	228	413	-
Clerical	244	2800	210	-
Craft	155	220	239	-
Exec/Managerial	135	232	432	-
Farm/Fish/Forest	4	11	26	0
Household Services	0	0	0	-
Laborer/Handler	11	45	54	-
Operative/Transport	50	18	10	-
Service, except Household	81	151	132	-
Technical	42	72	66	-

Isle of Palms Fishing Demographics

Table 5.1.4-75. Number of Federal Permit (October 2008) by Type for Isle of Palms, South Carolina (Source: NMFS 2008).

Type	Permits
ATLANTIC DOLPHIN/WAHOO COMMERCIAL	1
ATLANTIC DOLPHIN/WAHOO CHARTER/ HEADBOAT	1
S. ATLANTIC CHARTER/HEADBOAT FOR PELAGIC FISH	1
KING MACKEREL	-
SPINY LOBSTER & TAILING	-,
ROCK SHRIMP & ENDORSEMENTS	-,-
S. ATL. CHARTER/HEADBOAT FOR SNAPPER-GROUPER	1
SWORDFISH & SHARKS	-,
S. ATLANTIC SNAPPER-GROUPER (UNLIMITED)	-
S. ATLANTIC SNAPPER-GROUPER (225)	-
SPANISH MACKEREL	-
SOUTH ATLANTIC SHRIMP	2

Table 5.1.4-76. Employment in Fishing Related Industry for Isle of Palms, South Carolina (Zip code Business Patterns, U.S. Census Bureau 1998).

Category	NAIC Code	Number Employed
Fishing	114100	0
Seafood Canning	311711	0
Seafood Processing	311712	0
Boat Building	336612	0
Fish and Seafoods	422460	0
Fish and Seafood Markets	445220	3
Marinas	713930	18
Total Fishing Employment		21

Table 5.1.4-77. Number of State Permits by Type for Isle of Palms, South Carolina. (Source South Carolina Division of Marine Fisheries, 2008).

Type	Permits
Bait Dealer	0
Channel Net	0
Crab Pots	1
Drag Dredge	0
Gill Net	0
Hand Held Equipment	0
Herring Net	0
Mechanical Equipment	0
Minnow Traps	0
Miscellaneous Pots/Traps	0
Other Equipment	0
Peeler Crab Permit	0
Saltwater License	3
Seine Net	0
Shad Gill Net	0
Shellfish Dealer	0
Shellfish License	0
Trawler License	1
Trotlines	0
Wholesale Dealer	1
Total	6

5.1.4.7 McClellanville (29458)

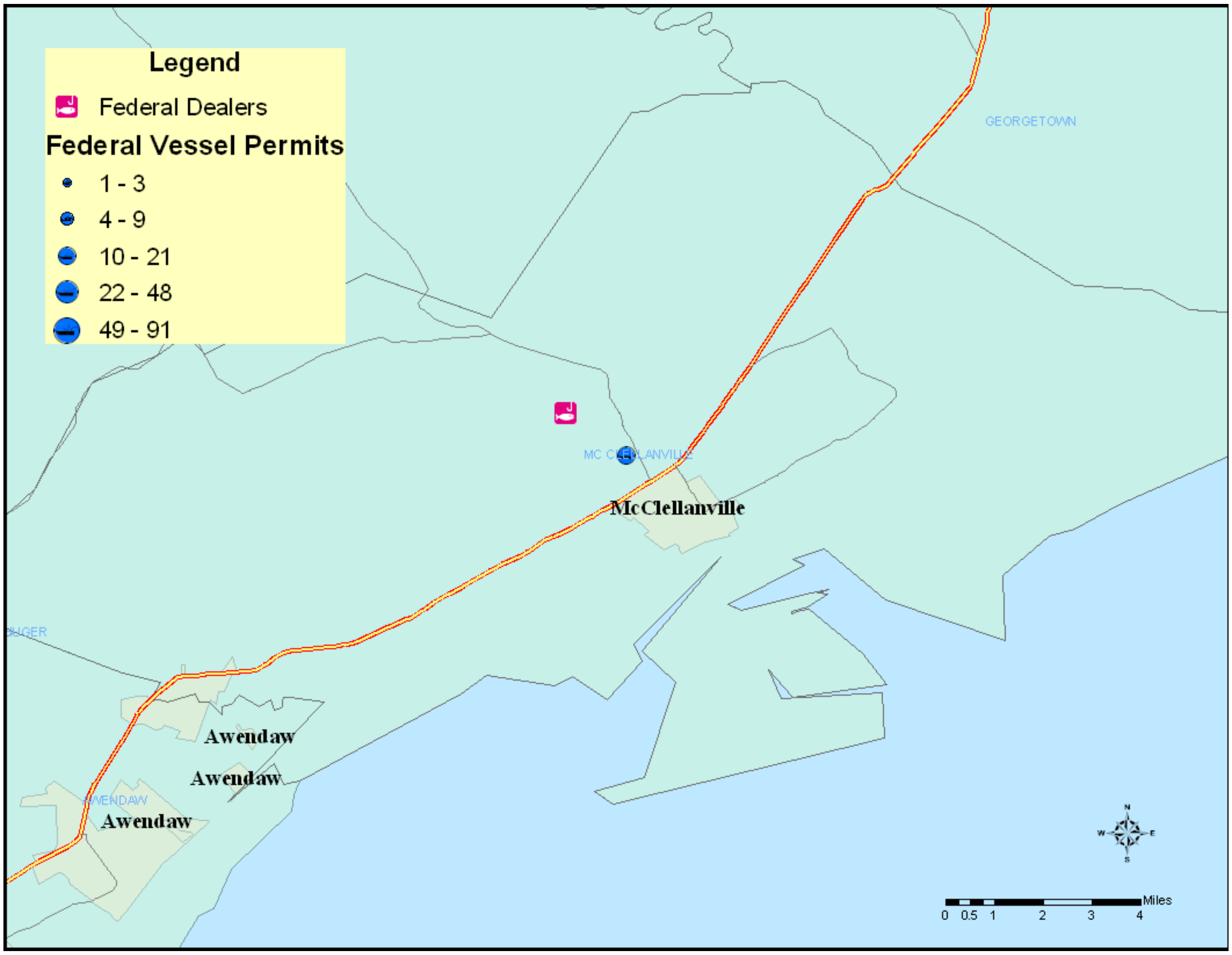

Figure 5.1.4-8. McClellanville, South Carolina.

The population of McClellanville dropped in the 1990 census but has since increased again in 2000 to 459. The percent of the population that is unemployed has remained very low while the percent of population in the work force has dropped from 64.3 percent to 56.9. Average wage and salary have grown, but so has the number of persons living below the poverty level. The number of persons employed in farm, fish, and forestry occupations has remained fairly constant over the past three decades. In 2008, there were 6 south Atlantic shrimp and 6 other federal permits issued to vessels homeported in McClellanville (Table 5.1.4-87). All employment in fishing related business is in fish and seafood (Table 5.1.4-88). There are 153 state permits in McClellanville, with 52 of those being saltwater licenses (Table 5.1.4-89). There are 16 trawler licenses, 23 handheld equipment licenses and 8 wholesale dealer licenses.

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McClellanville Census Demographics

<u>Population</u>

Table 5.1.4-78. Total Persons and Persons by Age category for McClellanville, South Carolina 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Total Persons and Age Category	1970	1980	1990	2000
Total Persons	.	441	364	459
Persons Age 0-5	.	55	17	21
Persons Age 6-15	.	54	81	55
Persons Age 16-17	.	11	11	13
Persons Age 18-24	.	25	15	29
Persons Age 25-34	.	83	54	43
Persons Age 35-44	.	52	74	22
Persons Age 45-54	.	34	23	119
Persons Age 55-64	.	56	34	64
Persons Age 65+	.	70	55	70

Housing Tenure

Table 5.1.4-79. Housing Tenure for McClellanville, South Carolina 1990-2000. (Source: U.S. Census Bureau).

Percent Renter Occupied	1990	2000
	12.2	19.9
Percent Owner Occupied	**1990**	**2000**
	87.8	80.1

Residence in 1985 and 1995

Table 5.1.4-80. Residence in 1985 and 1995 for McClellanville, South Carolina 1990-2000. (Source: U.S. Census Bureau).

Different House Same County	1990	2000
	62	65
Same House	**1990**	**2000**
	258	309

Employment/Unemployment

Table 5.1.4-81. Employment and Unemployment for McClellanville, South Carolina 1990-2000. (Source: U.S. Census Bureau).

Persons 16 yrs and over	1990	2000
Percent in labor force	64.3	56.9
Percent unemployed	1.8	0.9

Race

Table 5.1.4-82. Race for McClellanville, South Carolina 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Race	**1970**	**1980**	**1990**	**2000**
Black Persons	.	60	26	34
Latino Black Persons	.	0	0	0
Latino Persons	.	3	0	10
White Persons	.	381	338	415
Latino White Persons	.	3	0	10

Education

Table 5.1.4-83. Years of Education by Category for those 25 Years and Older for McClellanville, South Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Education	**1970**	**1980**	**1990**	**2000**
25+ w/ 0-8 years education	.	37	16	19
25+ w/ 9-11 years education	.	32	26	32
25+ w/ HS diploma	.	69	53	59
25+ w/ 13-15 years. education	.	68	44	92
25+ w/ College Degree	.	89	81	139
Drop outs	.	2	3	0

Income and Poverty

Table 5.1.4-84. Average Household Wage/Salary and Persons Below the Poverty Level for McClellanville, South Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Wage or Salary	**1970**	**1980**	**1990**	**2000**
Average Household Wage/Salary Income (dollars)	.	$17490	$26388	$42500
Poverty Level				
Persons Below Poverty Level	.	32	45	54
Age 65+ Below Poverty Level	.	12	6	6
Households with Public Assistance	.	5	7	4

Industry

Table 5.1.4-85. Employment by Industry for McClellanville, South Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Industry	1970	1980	1990	2000
Agriculture, Fishing, Mining	.	34	30	27
Construction	.	27	22	33
Business Services	.	0	2	13
Communication/Utilities	.	8	5	1
Manufacturing	.	11	6	8
Financial, Insurance & Real Estate	.	7	3	7
Services	.	0	4	135
Wholesale/Retail Trade	.	12	51	28
Transportation	.	35	29	6

Occupation

Table 5.1.4-86. Employment by Occupation for McClellanville, South Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Occupation	1970	1980	1990	2000
Sales	.	7	15	-
Clerical	.	190	23	-
Craft	.	33	24	-
Exec/Managerial	.	23	9	-
Farm/Fish/Forest	.	26	24	24
Household Services	.	0	0	-
Laborer/Handler	.	9	7	-
Operative/Transport	.	0	8	-
Service, except Household	.	17	4	-
Technical	.	3	2	-

McClellanville Fishing Demographics

Table 5.1.4-87. Number of Federal Permit (October 2008) by Type for McClellanville, South Carolina (Source: NMFS 2008).

Type	Permits
ATLANTIC DOLPHIN/WAHOO COMMERCIAL	1
ATLANTIC DOLPHIN/WAHOO CHARTER/ HEADBOAT	-
S. ATLANTIC CHARTER/HEADBOAT FOR PELAGIC FISH	-
KING MACKEREL	-
SPINY LOBSTER & TAILING	-,
ROCK SHRIMP & ENDORSEMENTS	1,-
S. ATL. CHARTER/HEADBOAT FOR SNAPPER-GROUPER	1
SWORDFISH & SHARKS	-,1
S. ATLANTIC SNAPPER-GROUPER (UNLIMITED)	2
S. ATLANTIC SNAPPER-GROUPER (225)	-
SPANISH MACKEREL	-
SOUTH ATLANTIC SHRIMP	6

Table 5.1.4-88. Employment in Fishing Related Industry for McClellanville, South Carolina (Zip code Business Patterns, U.S. Census Bureau 1998).

Category	NAIC Code	Number Employed
Fishing	114100	0
Seafood Canning	311711	0
Seafood Processing	311712	0
Boat Building	336612	0
Fish and Seafoods	422460	50
Fish and Seafood Markets	445220	0
Marinas	713930	0
Total Fishing Employment		50

Table 5.1.4-89. Number of State Permits by Type for McClellanville, South Carolina. (Source South Carolina Division of Marine Fisheries, 2008).

Type	Permits
Bait Dealer	2
Channel Net	1
Crab Pots	10
Drag Dredge	1
Gill Net	0
Hand Held Equipment	23
Herring Net	0
Mechanical Equipment	2
Minnow Traps	2
Miscellaneous Pots/Traps	0
Other Equipment	5
Peeler Crab Permit	2
Saltwater License	53
Seine Net	0
Shad Gill Net	1
Shellfish Dealer	3
Shellfish License	24
Trawler License	16
Trotlines	0
Wholesale Dealer	8
Total	153

5.1.4.8 Georgetown (29440)

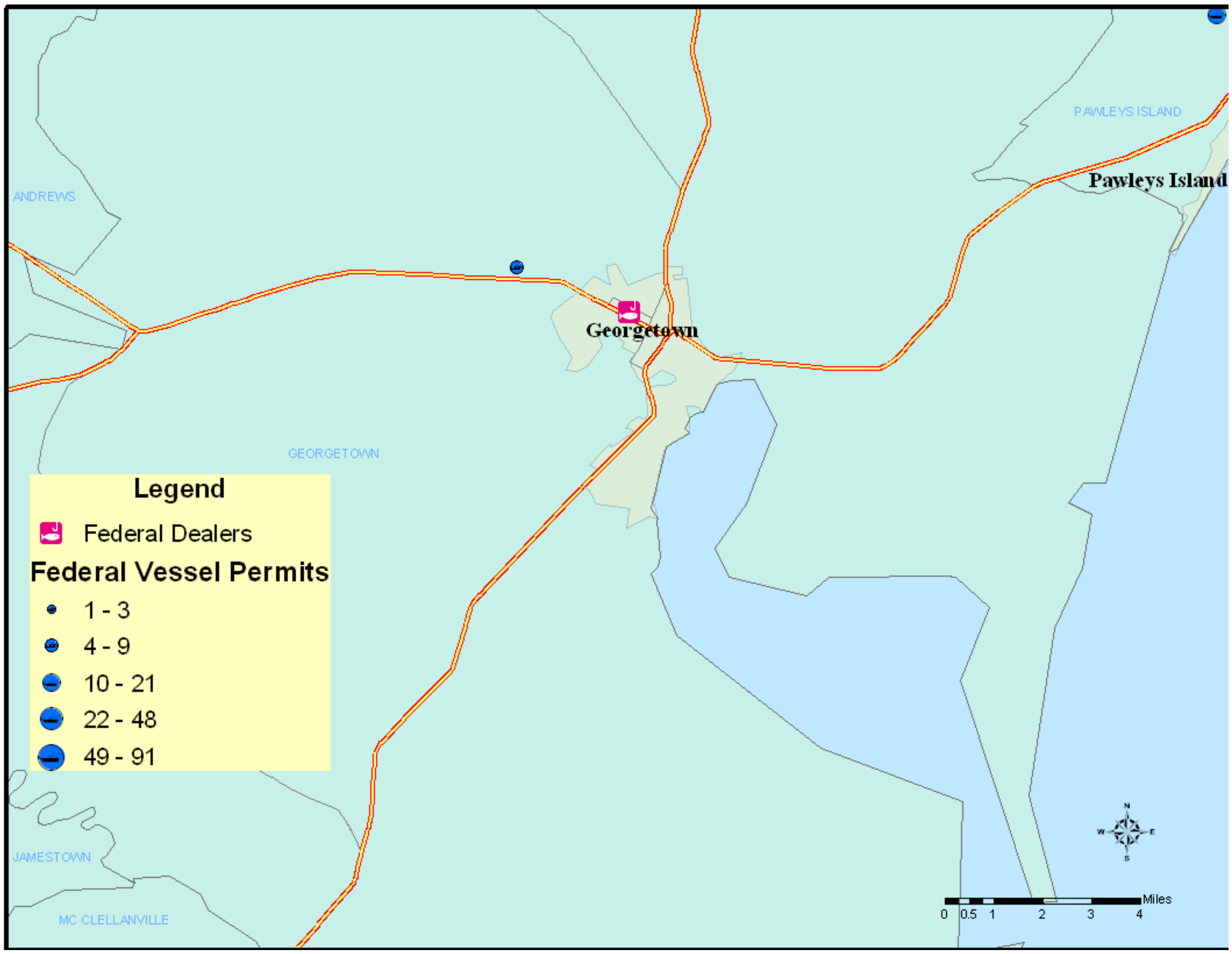

Figure 5.1.4-9. Georgetown, South Carolina.

Georgetown is South Carolina's third oldest city, following Charleston and Beaufort. The town became a busy seaport by 1729 as the import and export of cargo created wealth for the town, as well as targets for the pirates who were hiding out in the bays of the barrier islands. Many of the local stores in the area sold naval materials and uniforms. The indigo plant, of which the blue dye was derived from, grew along the coastal plains. An aristocratic society of plantation owners was established and they formed the "Winyah Indigo Society". However as the price of the dye fell from overseas markets, local planters began cultivating rice instead. The original rice seeds were brought in from Madagascar to the port of Charleston around 1680. Grocers in England were said to praise the "Carolina Gold" rice above all other rice. Rice even was used as a replacement for money, being accepted as payment for taxes. However with the Emancipation Proclamation and destructive hurricanes, the last commercial rice harvest in Georgetown County was in 1919. The area then turned to lumber production. In 1936, the International Paper Company built a plant in Georgetown. By 1942, this plant became the largest craft paper mill in the world. Commercial fishing and tourism are now significant industries in the area that contribute greatly to its economic well-being.

Georgetown's population has been declining from 1980 when it was 10,144 until 2000 where it dropped to 8,934. Georgetown's population is predominantly African-American and has approximately 56 percent of its population in the labor force. The unemployment rate has gone down since 1990 to 7.8 percent. Average wage and salary have grown slightly over the past 30 years, but the number of people living below the poverty level has dropped little. As is the case for most communities the number of persons employed in farm, fish and forestry has seen a steady decline. In 2008, vessels with federal permits predominantly held Atlantic dolphin/wahoo commercial (11), Atlantic dolphin/wahoo charter (10), or snapper grouper unlimited (9) permits (Table 5.1.4-99) and most fishing related employment is in boat building (Table 5.1.4-100). There are 8 persons reported as working in fish and seafood and markets also. With little fishing employment evident elsewhere, it is surprising to see over 502 state permits issued for Georgetown residents. Over 122 of those permits were for saltwater licenses and 22 were trawler permits. There are 19 wholesale dealer licenses in the community as well as 49 crab pot permits and 45 channel net (Table 5.1.4-101).

Georgetown Census Demographics

Population

Table 5.1.4-90. Total Persons and Persons by Age category for Georgetown, South Carolina 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Total Persons and Age Category	1970	1980	1990	2000
Total Persons	.	10144	9517	8934
Persons Age 0-5	.	812	909	735
Persons Age 6-15	.	1763	1652	1496
Persons Age 16-17	.	362	358	299
Persons Age 18-24	.	1162	810	745
Persons Age 25-34	.	1458	1374	1101
Persons Age 35-44	.	940	1289	646
Persons Age 45-54	.	1052	753	1151
Persons Age 55-64	.	1058	816	701
Persons Age 65+	.	1362	1556	1515

Housing Tenure

Table 5.1.4-91. Housing Tenure for Georgetown, South Carolina 1990-2000. (Source: U.S. Census Bureau).

Percent Renter Occupied	1990	2000
	37.5	38.3
Percent Owner Occupied	**1990**	**2000**
	62.5	61.7

Residence in 1985 and 1995

Table 5.1.4-92. Residence in 1985 and 1995 for Georgetown, South Carolina 1990-2000. (Source: U.S. Census Bureau).

Different House Same County	1990	2000
	2,174	2,129
Same House	**1990**	**2000**
	5,222	4,900

Employment/Unemployment

Table 5.1.4-93. Employment and Unemployment for Georgetown, South Carolina 1990-2000. (Source: U.S. Census Bureau).

Persons 16 yrs and over	1990	2000
Percent in labor force	57.6	56.3
Percent unemployed	9.4	7.8

Race

Table 5.1.4-94. Race for Georgetown, South Carolina 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Race	1970	1980	1990	2000
Black Persons	.	4729	5111	5078
Latino Black Persons	.	85	23	26
Latino Persons	.	96	49	168
White Persons	.	5386	4307	3611
Latino White Persons	.	11	8	58

Education

Table 5.1.4-95. Years of Education by Category for those 25 Years and Older for Georgetown, South Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Education	1970	1980	1990	2000
25+ w/ 0-8 years education	.	1489	917	534
25+ w/ 9-11 years education	.	1303	1188	1077
25+ w/ HS diploma	.	1495	1596	1676
25+ w/ 13-15 years. education	.	809	853	1062
25+ w/ College Degree	.	774	907	1178
Drop outs	.	85	118	132

Income and Poverty

Table 5.1.4-96. Average Household Wage/Salary and Persons Below the Poverty Level for Georgetown, South Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Wage or Salary	1970	1980	1990	2000
Average Household Wage/Salary Income (dollars)	.	$14727	$26608	$29424
Poverty Level				
Persons Below Poverty Level	.	2644	2756	2087
Age 65+ Below Poverty Level	.	359	388	223
Households with Public Assistance	.	445	465	124

Industry

Table 5.1.4-97. Employment by Industry for Georgetown, South Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Industry	1970	1980	1990	2000
Agriculture, Fishing, Mining	.	141	117	61
Construction	.	337	242	251
Business Services	.	61	106	98
Communication/Utilities	.	62	86	80
Manufacturing	.	794	760	669
Financial, Insurance & Real Estate	.	295	371	216
Services	.	161	148	1431
Wholesale/Retail Trade	.	739	1144	973
Transportation	.	707	846	90

Occupation

Table 5.1.4-98. Employment by Occupation for Georgetown, South Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Occupation	1970	1980	1990	2000
Sales	.	317	510	-
Clerical	.	6230	380	-
Craft	.	436	360	-
Exec/Managerial	.	319	315	-
Farm/Fish/Forest	.	55	65	53
Household Services	.	48	25	-
Laborer/Handler	.	255	178	-
Operative/Transport	.	343	458	-
Service, except Household	.	759	681	-
Technical	.	128	77	-

Georgetown Fishing Demographics

Table 5.1.4-99. Number of Federal Permit by Type (October 2008) for Georgetown, South Carolina (Source: NMFS 2008).

Type	Permits
ATLANTIC DOLPHIN/WAHOO COMMERCIAL	11
ATLANTIC DOLPHIN/WAHOO CHARTER/ HEADBOAT	10
S. ATLANTIC CHARTER/HEADBOAT FOR PELAGIC FISH	10
KING MACKEREL	4
SPINY LOBSTER & TAILING	-,
ROCK SHRIMP & ENDORSEMENTS	1,-
S. ATL. CHARTER/HEADBOAT FOR SNAPPER-GROUPER	9
SWORDFISH & SHARKS	1,4
S. ATLANTIC SNAPPER-GROUPER (UNLIMITED)	9
S. ATLANTIC SNAPPER-GROUPER (225)	-
SPANISH MACKEREL	1
SOUTH ATLANTIC SHRIMP	3

Table 5.1.4-100. Employment in Fishing Related Industry for Georgetown, South Carolina (Zip code Business Patterns, U.S. Census Bureau 1998).

Category	**NAIC Code**	**Number Employed**
Fishing	114100	0
Seafood Canning	311711	0
Seafood Processing	311712	0
Boat Building	336612	16
Fish and Seafoods	422460	4
Fish and Seafood Markets	445220	4
Marinas	713930	16
Total Fishing Employment		40

Table 5.1.4-101. Number of State Permits by Type for Georgetown, South Carolina. (Source South Carolina Division of Marine Fisheries, 2008).

Type	Permits
Bait Dealer	2
Channel Net	45
Crab Pots	49
Drag Dredge	2
Gill Net	10
Hand Held Equipment	10
Herring Net	1
Mechanical Equipment	1
Minnow Traps	0
Miscellaneous Pots/Traps	0
Other Equipment	5
Peeler Crab Permit	4
Saltwater License	122
Seine Net	0
Shad Gill Net	195
Shellfish Dealer	3
Shellfish License	9
Trawler License	22
Trotlines	3
Wholesale Dealer	19
Total	502

5.1.4.9 Murrells Inlet (29576)

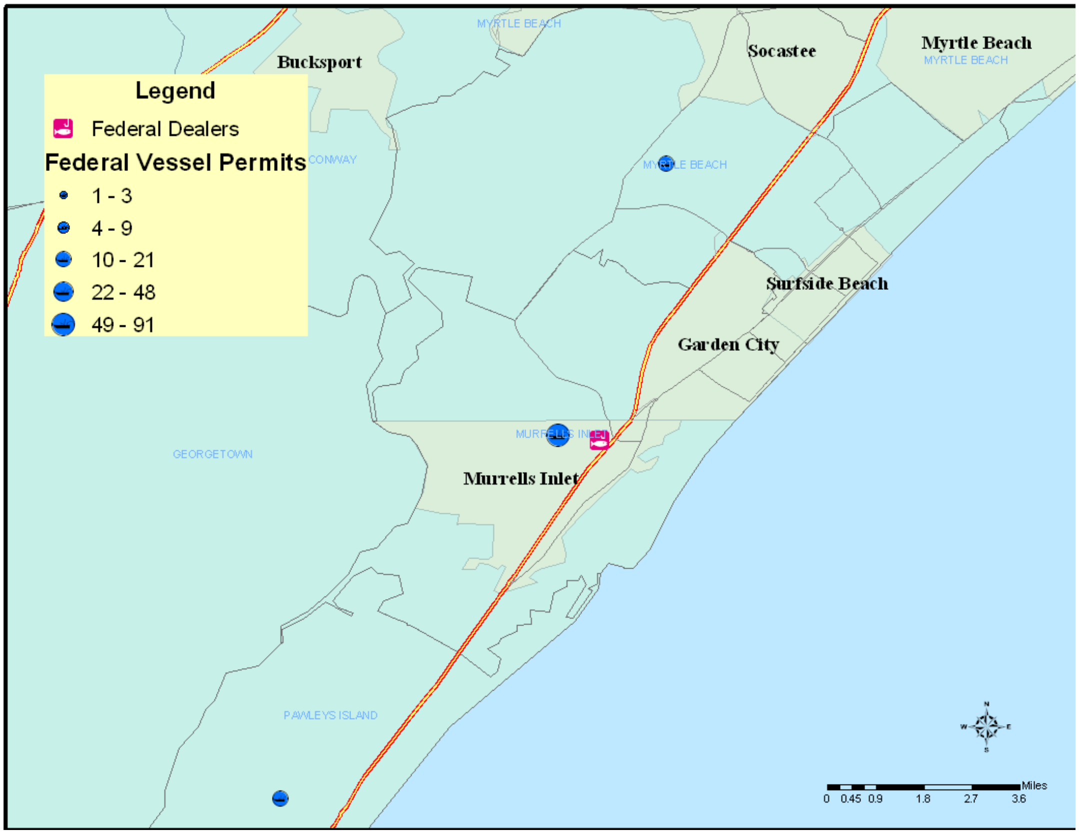

Figure 5.1.4-10. Murrells Inlet, South Carolina.

Murrells Inlet is known as the Seafood Capital of South Carolina. The origin of its name remains a mystery. However Murrells Inlet was officially named by the post office in 1913. The first settlers of the area were Native American Tribes. However beginning in the 16th and 17th centuries, Spanish and English colonists arrived in the area. Pirates also utilized the Inlet's winding creeks for refuge and a hiding place. Large tracts of land were cultivated into successful rice plantations. By 1850, almost 47 million pounds of rice were produced in this area. Murrells Inlet was used as a port during the Civil War to sneak cotton and other products to England in exchange for war supplies, such as food and medicine. The Civil War led to the decline of the rice culture and in 1916, the last remaining commercial rice grower was out of business.

By this time, commercial and recreational fishing became a popular industry. By 1914, captain-led fishing excursions cost $5 per person for a day trip out of the Inlet on a 20-foot skiff. Today, charter, recreational and commercial fishing are still popular in Murrells Inlet.

Murrells Inlet has seen its population increase to a high of 5,492 in 2000. The percentage of owner occupied housing has also increased to 85 percent. The percent of the population in the labor force has remained practically the same while unemployment has risen from 3 percent in 1990 to 5.2 percent in 2000. Average wage and salary has risen over the past few decades while the number of persons living below the poverty level has fluctuated and now is 435 in 2000. The number of persons working in farm, fish and forestry occupations has seen a decline like most communities.

In 2008, vessels with federal permits predominantly held south Atlantic charter/headboat for pelagic fish (29), Atlantic dolphin/wahoo commercial (22), Atlantic dolphin/wahoo charter/headboat (28), snapper grouper charter/headboat for snapper grouper (29), or snapper grouper unlimited (19) permits (Table 5.1.4-111). There are four federal dealers in the community. Most of the fishing employment is in fish and seafood markets with 10 persons employed in that sector out of the 16 total (Table 5.1.4-112). There are 135 state permits issued to residents of Murrells Inlet. Sixty-four of those permits are for saltwater licenses. Another 8 are for handheld equipment and 12 are for crab pots. There are 15 wholesale dealer licenses held by Murrells Inlet residents (Table 5.1.4-113).

Murrells Inlet Census Demographics

Population

Table 5.1.4-102. Total Persons and Persons by Age category for Murrells Inlet, South Carolina 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Total Persons and Age Category	1970	1980	1990	2000
Total Persons	.	2394	3277	5492
Persons Age 0-5	.	145	218	213
Persons Age 6-15	.	388	281	541
Persons Age 16-17	.	102	12	98
Persons Age 18-24	.	264	292	249
Persons Age 25-34	.	291	602	629
Persons Age 35-44	.	329	480	408
Persons Age 45-54	.	182	370	860
Persons Age 55-64	.	333	527	859
Persons Age 65+	.	337	495	1189

Housing Tenure

Table 5.1.4-103. Housing Tenure for Murrells Inlet, South Carolina 1990-2000. (Source: U.S. Census Bureau).

Percent Renter Occupied	1990	2000
	20.1	14.7
Percent Owner Occupied	**1990**	**2000**
	79.9	85.3

Residence in 1985 and 1995

Table 5.1.4-104. Residence in 1985 and 1995 for Murrells Inlet, South Carolina 1990-2000. (Source: U.S. Census Bureau).

Different House Same County	**1990**	**2000**
	615	495
Same House	**1990**	**2000**
	1194	2857

Employment/Unemployment

Table 5.1.4-105. Employment and Unemployment for Murrells Inlet, South Carolina 1990-2000. (Source: U.S. Census Bureau).

Persons 16 yrs and over	**1990**	**2000**
Percent in labor force	60.7	61.6
Percent unemployed	3.0	5.2

Race

Table 5.1.4-106. Race for Murrells Inlet, South Carolina 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Race	**1970**	**1980**	**1990**	**2000**
Black Persons	.	516	410	389
Latino Black Persons	.	2	0	4
Latino Persons	.	7	0	34
White Persons	.	1867	2827	5035
Latino White Persons	.	0	0	20

Education

Table 5.1.4-107. Years of Education by Category for those 25 Years and Older for Murrell's Inlet, South Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Education	**1970**	**1980**	**1990**	**2000**
25+ w/ 0-8 years education	.	323	156	110
25+ w/ 9-11 years education	.	364	477	572
25+ w/ HS diploma	.	445	784	1285
25+ w/ 13-15 years. education	.	205	426	969
25+ w/ College Degree	.	135	456	1427
Drop outs	.	26	21	28

Income and Poverty

Table 5.1.4-108. Average Household Wage/Salary and Persons Below the Poverty Level for Murrells Inlet, South Carolina 1970-2000 (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Wage or Salary	**1970**	**1980**	**1990**	**2000**
Average Household Wage/Salary Income (dollars)	.	$13233	$30776	$39877
Poverty Level				
Persons Below Poverty Level	.	350	501	435
Age 65+ Below Poverty Level	.	59	20	74
Households with Public Assistance	.	70	26	42

Industry

Table 5.1.4-109. Employment by Industry for Murrells Inlet, South Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Industry	**1970**	**1980**	**1990**	**2000**
Agriculture, Fishing, Mining	.	58	39	15
Construction	.	57	168	361
Business Services	.	13	162	149
Communication/Utilities	.	25	59	84
Manufacturing	.	123	97	140
Financial, Insurance & Real Estate	.	75	55	243
Services	.	38	98	1077
Wholesale/Retail Trade	.	161	646	861
Transportation	.	424	476	69

Occupation

Table 5.1.4-110. Employment by Occupation for Murrells Inlet, South Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Occupation	**1970**	**1980**	**1990**	**2000**
Sales	.	189	231	-
Clerical	.	1300	141	-
Craft	.	98	172	-
Exec/Managerial	.	132	339	-
Farm/Fish/Forest	.	39	39	11
Household Services	.	10	11	-
Laborer/Handler	.	42	68	-
Operative/Transport	.	53	100	-
Service, except Household	.	216	297	-
Technical	.	30	15	-

Murrells Inlet Fishing Demographics

Table 5.1.4-111. Number of Federal Permit by Type (October 2008) for Murrells Inlet, South Carolina (Source: NMFS 2008).

Type	Permits
ATLANTIC DOLPHIN/WAHOO COMMERCIAL	22
ATLANTIC DOLPHIN/WAHOO CHARTER/ HEADBOAT	28
S. ATLANTIC CHARTER/HEADBOAT FOR PELAGIC FISH	29
KING MACKEREL	9
SPINY LOBSTER & TAILING	-,2
ROCK SHRIMP & ENDORSEMENTS	1,-
S. ATL. CHARTER/HEADBOAT FOR SNAPPER-GROUPER	29
SWORDFISH & SHARKS	1,4
S. ATLANTIC SNAPPER-GROUPER (UNLIMITED)	19
S. ATLANTIC SNAPPER-GROUPER (225)	-
SPANISH MACKEREL	4
SOUTH ATLANTIC SHRIMP	1

Table 5.1.4-112. Employment in Fishing Related Industry for Murrells Inlet, South Carolina (Zip code Business Patterns, U.S. Census Bureau 1998).

Category	**NAIC Code**	**Number Employed**
Fishing	114100	0
Seafood Canning	311711	3
Seafood Processing	311712	0
Boat Building	336612	0
Fish and Seafoods	422460	3
Fish and Seafood Markets	445220	10
Marinas	713930	0
Total Fishing Employment		16

Table 5.1.4-113. Number of State Permits by Type for Murrells Inlet, South Carolina. (Source South Carolina Division of Marine Fisheries, 2008).

Type	Permits
Bait Dealer	6
Channel Net	0
Crab Pots	12
Drag Dredge	0
Gill Net	1
Hand Held Equipment	8
Herring Net	0
Mechanical Equipment	0
Minnow Traps	2
Miscellaneous Pots/Traps	0
Other Equipment	3
Peeler Crab Permit	0
Saltwater License	64
Seine Net	0
Shad Gill Net	5
Shellfish Dealer	7
Shellfish License	6
Trawler License	6
Trotlines	0
Wholesale Dealer	15
Total	135

5.1.4.10 Little River (29566)

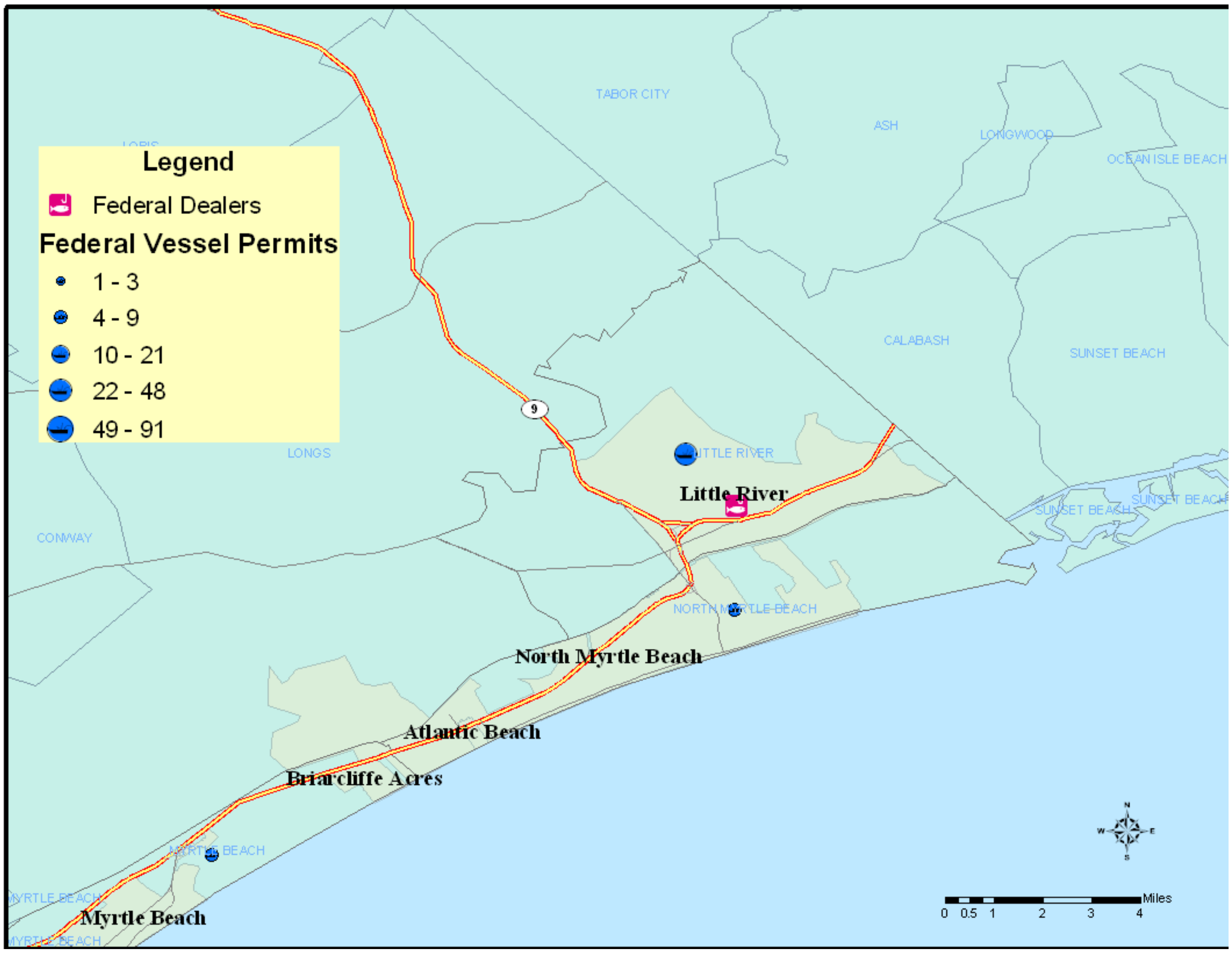

Figure 5.1.4-11. Little River, South Carolina.

Native American tribes who settled this area called the stream "Mineola," which means "Little River." Little River is one of the oldest settlements along the South Carolina coast. Fishermen and farmers began settling the area in the late 1600s and 1700s. The small, protected harbor was a refuge for shipwreck survivors and pirates, who needed a place to repair their boats and rest. It is still common to see treasure maps attempting to locate buried treasure on the placemats of the local restaurants.

For a time, Little River became known as "Yankee Town" by the rest of Horry County because of the settlers from New England. The area became a thriving port town in the 1850s. The shipments included fine lumber and naval supplies to Northern markets. The town had a few stores, sawmill, water house, school, churches and a bank. However the Civil War halted much of the town's developments. Today, Little River is widely known for its charterboats, deep-sea and commercial fishing.

Little River's population has nearly doubled in the last decade. The percent of owner occupied housing has risen from 61 percent in 1990 to over 80 percent in 2000. The percent of the population in the labor force has remained unchanged while unemployment has dropped. Average wage and salary have increased and so has the number of persons living below the poverty level. The number of persons working in the agriculture, fishing and mining sector has grown to 87 over the past ten years, while those in the occupation of farm, fishing and forestry has dropped. There are 17 vessels with federal permits homeported in Little River and the majority of them have either snapper grouper class 1 or snapper grouper charter permits (Table 5.1.4-123). Fishing related employment reported in Table 5.1.4-124 is mostly in the marinas sector with 31 persons and 7 more are in fish and seafood. Of the 87 state permits listed in Table 5.1.4-125, twenty-eight were for saltwater licenses.

Little River Census Demographics

Population

Table 5.1.4-114. Total Persons and Persons by Age category for Little River, South Carolina 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Total Persons and Age Category	1970	1980	1990	2000
Total Persons	.	.	3682	6904
Persons Age 0-5	.	.	244	337
Persons Age 6-15	.	.	325	682
Persons Age 16-17	.	.	81	100
Persons Age 18-24	.	.	270	258
Persons Age 25-34	.	.	601	723
Persons Age 35-44	.	.	539	487
Persons Age 45-54	.	.	356	1017
Persons Age 55-64	.	.	618	1206
Persons Age 65+	.	.	648	1842

Housing Tenure

Table 5.1.4-115. Housing Tenure for Little River, South Carolina 1990-2000. (Source: U.S. Census Bureau).

Percent Renter Occupied	1990	2000
	32.3	18.2
Percent Owner Occupied	**1990**	**2000**
	67.7	81.8

Residence in 1985 and 1995

Table 5.1.4-116. Residence in 1985 and 1995 for Little River, South Carolina 1990-2000. (Source: U.S. Census Bureau).

Different House Same County	1990	2000

	589	1408
Same House	**1990**	**2000**
	1568	2748

Employment/Unemployment

Table 5.1.4-117. Employment and Unemployment for Little River, South Carolina 1990-2000. (Source: U.S. Census Bureau).

Persons 16 yrs and over	**1990**	**2000**
Percent in labor force	56.6	58.0
Percent unemployed	6.5	3.4

Race

Table 5.1.4-118. Race for Little River, South Carolina 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Race	**1970**	**1980**	**1990**	**2000**
Black Persons	.	.	487	466
Latino Black Persons	.	.	0	12
Latino Persons	.	.	22	72
White Persons	.	.	3186	6385
Latino White Persons	.	.	13	38

Education

Table 5.1.4-119. Years of Education by Category for those 25 Years and Older for Little River, South Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Education	**1970**	**1980**	**1990**	**2000**
25+ w/ 0-8 years education	.	.	94	72
25+ w/ 9-11 years education	.	.	335	503
25+ w/ HS diploma	.	.	937	2119
25+ w/ 13-15 years. education	.	.	672	1277
25+ w/ College Degree	.	.	565	1533
Drop outs	.	.	22	23

Income and Poverty

Table 5.1.4-120. Average Household Wage/Salary and Persons Below the Poverty Level for Little River, South Carolina 1970-2000 (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Wage or Salary	**1970**	**1980**	**1990**	**2000**
Average Household Wage/Salary Income (dollars)	.	.	$30023	$40427
Poverty Level				

Persons Below Poverty Level	.	.	496	517
Age 65+ Below Poverty Level	.	.	63	32
Households with Public Assistance	.	.	45	24

Industry

Table 5.1.4-121. Employment by Industry for Little River, South Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Industry	**1970**	**1980**	**1990**	**2000**
Agriculture, Fishing, Mining	.	.	68	87
Construction	.	.	163	354
Business Services	.	.	50	156
Communication/Utilities	.	.	83	153
Manufacturing	.	.	54	156
Financial, Insurance & Real Estate	.	.	54	463
Services	.	.	73	1340
Wholesale/Retail Trade	.	.	605	925
Transportation	.	.	465	31

Occupation

Table 5.1.4.122. Employment by Occupation for Little River, South Carolina 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Occupation	**1970**	**1980**	**1990**	**2000**
Sales	.	.	260	-
Clerical	.	.	241	-
Craft	.	.	180	-
Exec/Managerial	.	.	244	-
Farm/Fish/Forest	.	.	58	31
Household Services	.	.	10	-
Laborer/Handler	.	.	64	-
Operative/Transport	.	.	39	-
Service, except Household	.	.	278	-
Technical	.	.	28	-

Little River Fishing Demographics

Table 5.1.4-123. Number of Federal Permit (October 2008) by Type for Little River, South Carolina (Source: NMFS 2008).

Type	Permits
ATLANTIC DOLPHIN/WAHOO COMMERCIAL	24
ATLANTIC DOLPHIN/WAHOO CHARTER/ HEADBOAT	20
S. ATLANTIC CHARTER/HEADBOAT FOR PELAGIC FISH	20
KING MACKEREL	8
SPINY LOBSTER & TAILING	1,3
ROCK SHRIMP & ENDORSEMENTS	-,-
S. ATL. CHARTER/HEADBOAT FOR SNAPPER-GROUPER	20

SWORDFISH & SHARKS	-,4
S. ATLANTIC SNAPPER-GROUPER (UNLIMITED)	23
S. ATLANTIC SNAPPER-GROUPER (225)	1
SPANISH MACKEREL	4
SOUTH ATLANTIC SHRIMP	-

Table 5.1.4-124. Employment in Fishing Related Industry for Little River, South Carolina (Zip code Business Patterns, U.S. Census Bureau 1998).

Category	NAIC Code	Number Employed
Fishing	114100	0
Seafood Canning	311711	0
Seafood Processing	311712	0
Boat Building	336612	0
Fish and Seafoods	422460	7
Fish and Seafood Markets	445220	0
Marinas	713930	31
Total Fishing Employment		38

Table 5.1.4-125. Number of State Permits by Type for Little River, South Carolina. (Source South Carolina Division of Marine Fisheries, 2003).

Type	Permits
Bait Dealer	0
Channel Net	0
Crab Pots	2
Drag Dredge	0
Gill Net	2
Hand Held Equipment	2
Herring Net	0
Mechanical Equipment	0
Miscellaneous Pots/Traps	1
Other Equipment	0
Peeler Crab Permit	0
Saltwater License	8
Seine Net	0
Shad Net	0
Shellfish Dealer	0
Shellfish License	1
Trawler License	5
Trotlines	0
Wholesale Dealer	3
Total	24

5.1.4.11 South Carolina Fishing Infrastructure and Community Characterization

The following tables provide a general view of the presence or absence of fishing infrastructure located within the coastal communities of South Carolina with substantial fishing activity. It should be noted that there are many other attributes that might have been included in this table, however, because of inconsistency in rapid appraisal for all communities, these items were selected as the most consistently reported or had secondary data available to determine presence or absence. It should also be noted that in some cases certain infrastructure may exist within a community but was not readily apparent or could not be ascertained through secondary data. Table 5.1.4-126 offers an overview of the presence of the selected infrastructure items and provides an overall total score which is merely the total of infrastructure present.

Table 5.1.4-126. Fishing Infrastructure Table for South Carolina Potential Fishing Communities.

Community	Federal Commercial Permits (5+)	State Commercial Licenses (10+)	Federal Charter Permits (5+)	Seafood Landings	Fish processors, Wholesale fish house	Recreational docks / marinas	Recreational Fishing Tournaments	Total
Hilton Head Island	-	+	-	+	+	+	+	5
Port Royal	-	-	-	+	+	+	-	3
Edisto Beach	-	+	-	-	+	-	-	2
Seabrook Island	-	+	-	-	-	-	-	1
Mt. Pleasant	+	+	-	+	+	+	-	5
Isle of Palms	-	-	-	-	-	+	-	1
McClellanville	-	+	-	+	+	+	-	3
Georgetown	+	+	-	+	+	+	+	6
Murrells Inlet	+	+	+	+	+	+	-	6
Little River	+	+	+	+	+	+	-	6

In attempting a preliminary characterization of potential fishing communities in Table 5.1.4-127, we have provided a grouping of communities that appear to have more involvement in various fishing enterprises and therefore are classified as primarily involved. These communities have considerable fishing infrastructure, but also have a history and culture surrounding both commercial and recreational fishing that contributes to an appearance and perception of being a fishing community in the mind of residents and others. The communities are not ranked in any particular order, this is merely a categorization.

Table 5.1.4-127. Preliminary Characterization of Potential Fishing Communities in South Carolina.

Primarily-Involved	Secondarily-Involved
Mt. Pleasant	Edisto Beach
McClellanville	Seabrook Island
Georgetown	Isle of Palms
Murrells Inlet	
Little River	
Hilton Head Island	

Charleston, while having many commercial and charter permits is a large enough metropolitan area that fishing is rather small when compared to the larger economy and although historically may have played a role in the community culture is likely not a major focus historically or does it play a large role in the economy at this time. It is likely that the fishing community of Charleston has become ensconced in other parts of the metropolitan area, such as Shem Creek (Mt. Pleasant) and has become a component of that community's history and culture. Many of these communities are in transition due to various social and demographic changes from coastal development, growing populations, increasing tourism, changing regulations, etc. This preliminary characterization is just that and should not be considered a definite designation as fishing community, but a general guide for locating communities that may warrant consideration as a potential fishing community.

Table 5.1.4-128. Number of State Permits by Type for Charleston, South Carolina. (Source South Carolina Division of Marine Fisheries, 2008).

Type	Permits
Bait Dealer	11
Channel Net	1
Crab Pots	33
Drag Dredge	0
Gill Net	2
Hand Held Equipment	32
Herring Net	0
Mechanical Equipment	0
Minnow Traps	3
Miscellaneous Pots/Traps	1
Other Equipment	9
Peeler Crab Permit	3
Saltwater License	75
Seine Net	3
Shad Gill Net	0
Shellfish Dealer	8
Shellfish License	28
Trawler License	10
Trotlines	13
Wholesale Dealer	23
Total	255

5.1.5 Georgia Communities with Substantial Fishing Activity

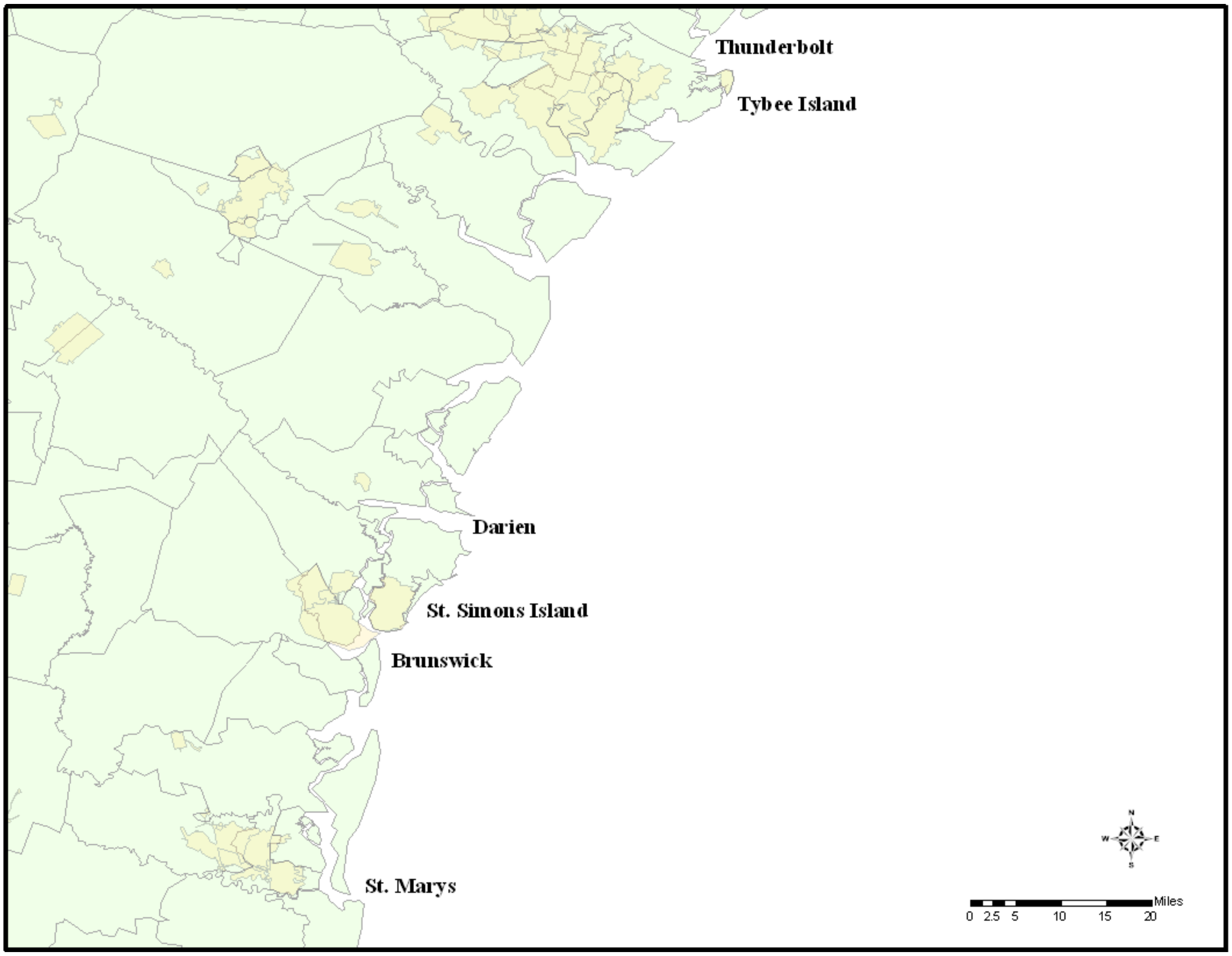

Figure 5.1.5-1. Potential Fishing Communities of Georgia.

Georgia landed over 9 million pounds of seafood in both 2001 and 2002. The value of those landings was over 14 million dollars in 2001 and over 15 million dollars in 2002. No Georgia port was listed in the top 50 U.S. ports in terms of pounds landed or in terms of value of landings. According to NMFS (2002) Georgia recreational fishermen landed over 2 million pounds of finfish in 2001 and in 2002 that number dropped to just over more than 1 million pounds. There were 5 processors in Georgia for 2001 with a total of 1,119 employees and 30 wholesale dealers employing 432 persons. In 2008, Georgia permitted 531 commercial vessels and 254 with trawl gear.

In 2008, Georgia vessels with federal permits held predominantly south Atlantic shrimp (102), Atlantic dolphin/wahoo charter (25), south Atlantic charter/headboat pelagic (28), south Atlantic charter/headboat for snapper grouper (28), and snapper grouper unlimited (23) permits. Figure 5.1.5-1 shows potential fishing communities in Georgia.

Table 5.1.5-1. Number of Federal Permit (October 2008) by Type for Georgia (Source: NMFS 2008).

Type	Permits
ATLANTIC DOLPHIN/WAHOO COMMERCIAL	11
ATLANTIC DOLPHIN/WAHOO CHARTER/ HEADBOAT	25
S. ATLANTIC CHARTER/HEADBOAT FOR PELAGIC FISH	28
KING MACKEREL	10
SPINY LOBSTER & TAILING	3,4
ROCK SHRIMP & ENDORSEMENTS	12,-
S. ATL. CHARTER/HEADBOAT FOR SNAPPER-GROUPER	28
SWORDFISH & SHARKS	-,4
S. ATLANTIC SNAPPER-GROUPER (UNLIMITED)	23
S. ATLANTIC SNAPPER-GROUPER (225)	1
SPANISH MACKEREL	7
SOUTH ATLANTIC SHRIMP	102
DEALER	9

Table 5.1.5-2. Number of State Permit by Type for Georgia (Source: GADNR 2008).

Type	**Number**
Commercial Fishing Vessel Registration	531
Vessels with trawl gear	254

Georgia requires commercial fishermen to be licensed and also requires a license for commercial crabbing and commercial cast netting. A commercial trawling license is required to use power drawn nets in the state waters. In addition, the state requires a dealer license for retail and wholesale fish to be sold, soft-shell crab and bait dealers. Figure 5.1.5-1 shows potential fishing communities in Georgia.

5.1.5.1 Tybee Island (31328)

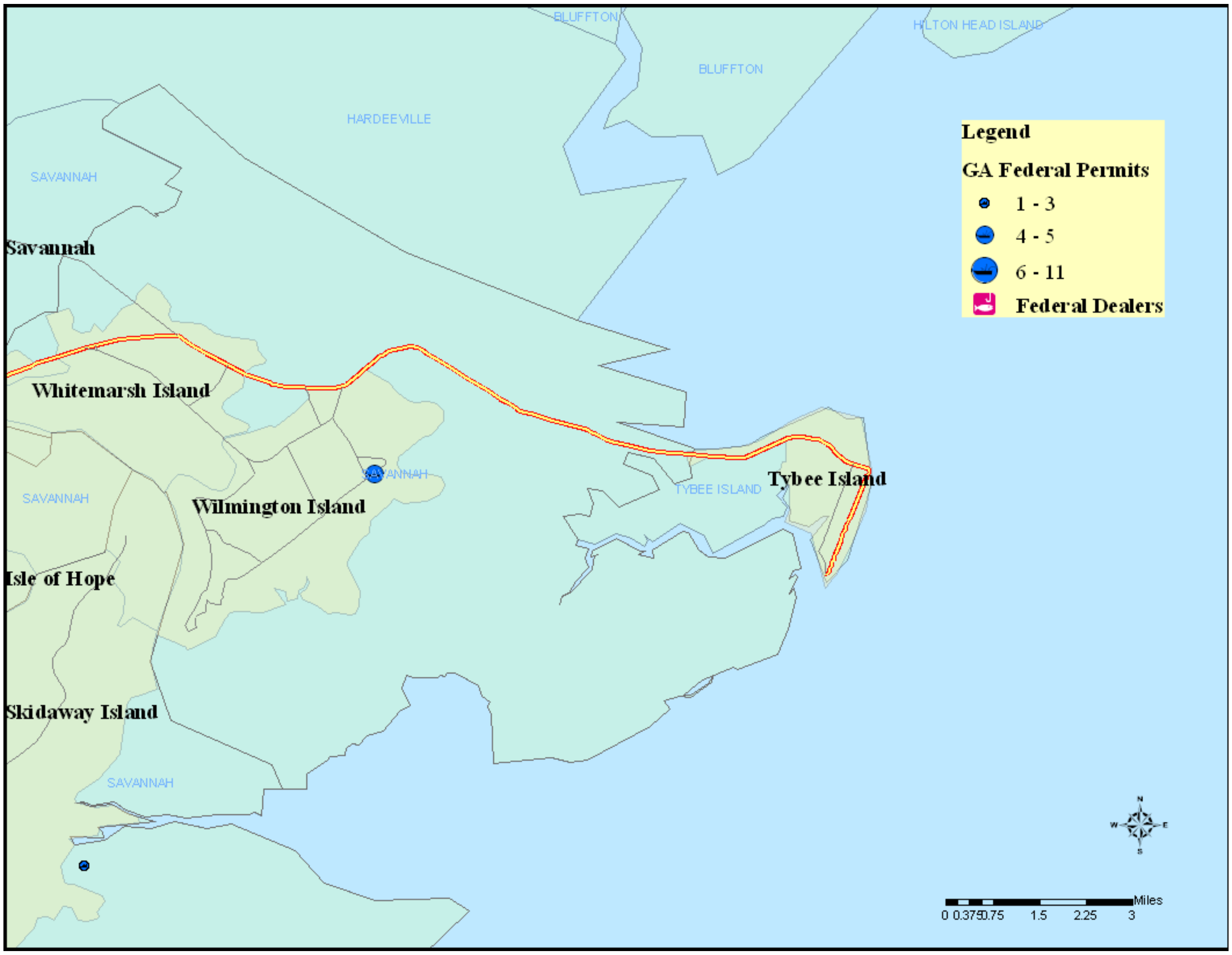

Figure 5.1.5-2. Tybee Island, Georgia.

Tybee Island stands at the mouth of the Savannah River. In 1736, a 90 foot lighthouse was built to help aid navigation in the area. At this time in America, this structure was the tallest. This lighthouse had to be rebuilt three times, lastly in 1773, due to storms. It currently stands at 154 feet tall and is Georgia's oldest lighthouse. After the Civil War, Tybee began to grow into a resort area. Before 1870 there were very few full time residents, but by the 1890s, there were over 400 beach cottages and local business for the summer residents. Tybee is still an attractive tourist destination with seven miles of beaches, with many options for both inshore and offshore fishing.

The population of Tybee Island has grown steadily over the past 20 years. The percent of the population in the labor force has also remained stable at around 61 percent and the percent of unemployed around 4.5 percent. Average wage and salary has increased to a high of $49,741 in 2000 while the number of persons living below the poverty level has remained around 330. The number of persons employed in the farm, fish, and forestry sectors of industry and occupation has slowly declined to where there were none reported in 2000. This is consistent with Table 5.1.5-12 where there are no vessels listed with federal permits for 2000 or 2001. Furthermore, Table 5.1.5-13 lists 3 persons employed in boat building as the only fishing related employment. There are however, 9 commercial vessels registered with the state from Tybee Island and all seven have full time fishermen as owners (Table 5.1.5-14).

Tybee Island Census Demographics

Population

Table 5.1.5-3. Total Persons and Persons by Age category for Tybee Island, Georgia 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Total Persons and Age Category	1970	1980	1990	2000
Total Persons	.	2240	2689	3432
Persons Age 0-5	.	126	192	104
Persons Age 6-15	.	264	273	350
Persons Age 16-17	.	63	91	50
Persons Age 18-24	.	234	239	192
Persons Age 25-34	.	381	381	326
Persons Age 35-44	.	222	391	528
Persons Age 45-54	.	212	323	738
Persons Age 55-64	.	281	258	510
Persons Age 65+	.	430	541	634

Housing Tenure

Table 5.1.5-4. Housing Tenure for Tybee Island, Georgia 1990-2000. (Source: U.S. Census Bureau).

Percent Renter Occupied	1990	2000
	35.1	31.3
Percent Owner Occupied	**1990**	**2000**
	64.9	68.8

Residence in 1985 and 1995

Table 5.1.5-5. Residence in 1985 and 1995 for Tybee Island, Georgia 1990-2000. (Source: U.S. Census Bureau).

Different House Same County	1990	2000
	802	736
Same House	**1990**	**2000**
	1,134	1,589

Employment/Unemployment

Table 5.1.5-6. Employment and Unemployment for Tybee Island, Georgia 1990-2000. (Source: U.S. Census Bureau).

Persons 16 yrs and over	1990	2000
Percent in labor force	59.3	61.9
Percent unemployed	4.8	4.5

Race

Table 5.1.5-7. Race for Tybee Island, Georgia 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Race	1970	1980	1990	2000
Black Persons	.	35	13	64
Latino Black Persons	.	0	0	0
Latino Persons	.	20	76	43
White Persons	.	2160	2625	3219
Latino White Persons	.	18	63	35

Education

Table 5.1.5-8. Years of Education by Category for those 25 Years and Older for Tybee Island, Georgia 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Education	1970	1980	1990	2000
25+ w/ 0-8 years education	.	187	114	74
25+ w/ 9-11 years education	.	257	205	208
25+ w/ HS diploma	.	476	661	649
25+ w/ 13-15 years. education	.	292	401	404
25+ w/ College Degree	.	314	342	1063
Drop outs	.	11	9	24

Income and Poverty

Table 5.1.5-9. Average Household Wage/Salary and Persons Below the Poverty Level for Tybee Island, Georgia 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Wage or Salary	1970	1980	1990	2000
Average Household Wage/Salary Income (dollars)	.	$17558	$33194	$49741
Poverty Level				
Persons Below Poverty Level	.	221	324	332
Age 65+ Below Poverty Level	.	44	35	17
Households with Public Assistance	.	37	15	28

Industry

Table 5.1.5-10. Employment by Industry for Tybee Island, Georgia 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Industry	**1970**	**1980**	**1990**	**2000**
Agriculture, Fishing, Mining	.	10	35	0
Construction	.	96	121	190
Business Services	.	38	49	103
Communication/Utilities	.	43	13	60
Manufacturing	.	110	150	123
Financial, Insurance & Real Estate	.	32	85	96
Services	.	55	63	1094
Wholesale/Retail Trade	.	209	405	415
Transportation	.	214	290	42

Occupation

Table 5.1.5-11. Employment by Occupation for Tybee Island, Georgia 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Occupation	**1970**	**1980**	**1990**	**2000**
Sales	.	140	162	-
Clerical	.	1290	203	-
Craft	.	126	150	-
Exec/Managerial	.	150	223	-
Farm/Fish/Forest	.	10	35	0
Household Services	.	4	13	-
Laborer/Handler	.	36	9	-
Operative/Transport	.	45	50	-
Service, except Household	.	138	208	-
Technical	.	28	0	-

Tybee Island Fishing Demographics

Table 5.1.5-12. Number of Federal Permit (October 2008) by Type for Tybee Island, Georgia (Source: NMFS 2008).

Type	Permits
ATLANTIC DOLPHIN/WAHOO COMMERCIAL	-
ATLANTIC DOLPHIN/WAHOO CHARTER/ HEADBOAT	3
S. ATLANTIC CHARTER/HEADBOAT FOR PELAGIC FISH	3
KING MACKEREL	-
SPINY LOBSTER & TAILING	-,-
ROCK SHRIMP & ENDORSEMENTS	-,-
S. ATL. CHARTER/HEADBOAT FOR SNAPPER-GROUPER	3
SWORDFISH & SHARKS	-,-
S. ATLANTIC SNAPPER-GROUPER (UNLIMITED)	1
S. ATLANTIC SNAPPER-GROUPER (225)	-
SPANISH MACKEREL	-
SOUTH ATLANTIC SHRIMP	1

Table 5.1.5-13. Employment in Fishing Related Industry for Tybee Island, Georgia (Zip code Business Patterns, U.S. Census Bureau 1998).

Category	NAIC Code	Number Employed
Fishing	114100	0
Seafood Canning	311711	0
Seafood Processing	311712	0
Boat Building	336612	3
Fish and Seafoods	422460	0
Fish and Seafood Markets	445220	0
Marinas	713930	0
Total Fishing Employment		3

Table 5.1.5-14. Number of State Permit by Type for Tybee Island, Georgia (Source: GADNR 2008).

Type	Number
Commercial Fishing Vessel License & Vessels with trawl gear	9

5.1.5.2 Thunderbolt (31404, 31410)

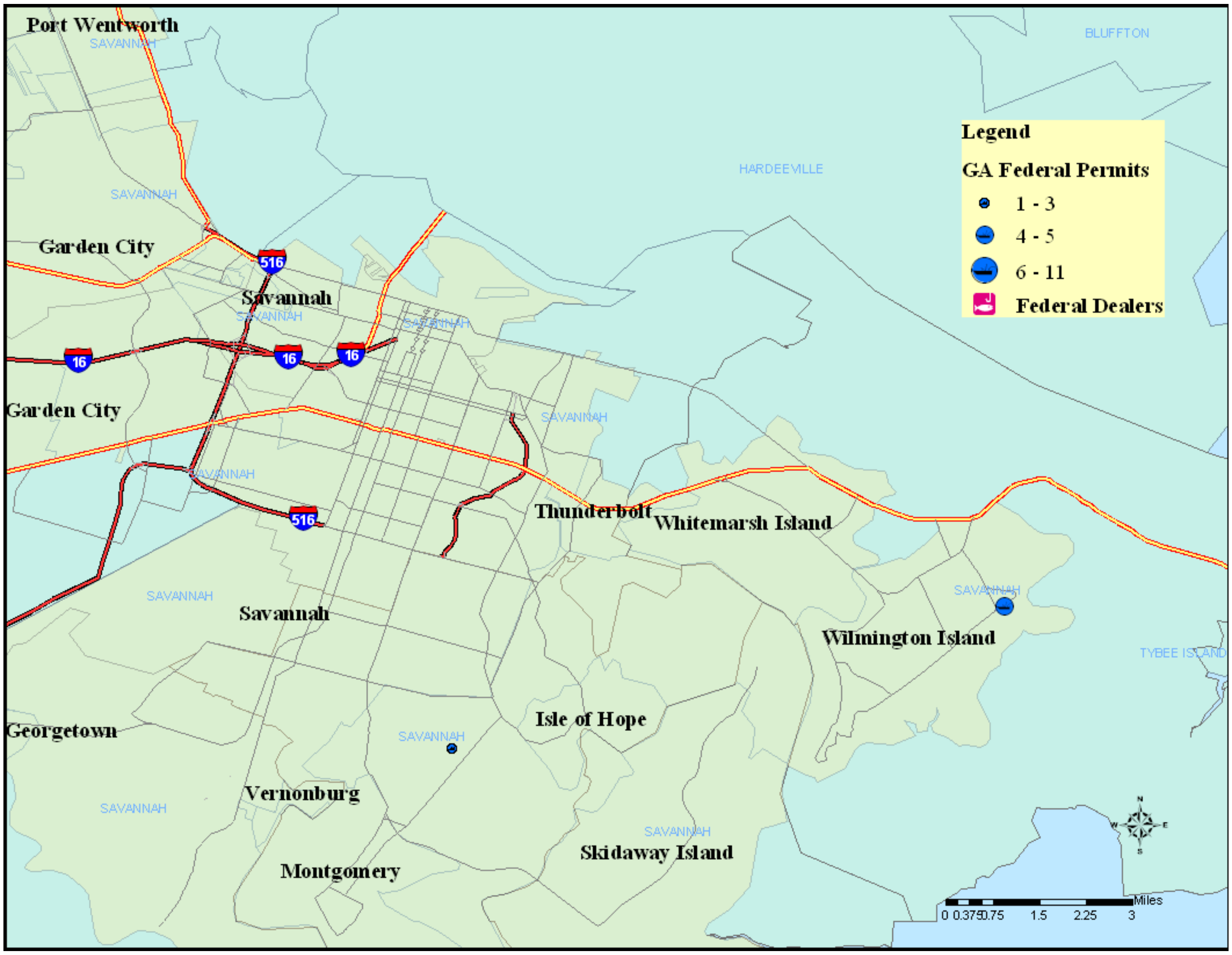

Figure 5.1.5-3. Thunderbolt, Georgia.

Thunderbolt's population has fluctuated over the past three decades and most recently declined during 1990 to 2000 where it stands at 2360. While the percent of population in the labor force has remained fairly stable, unemployment dropped significantly from a high of 17.2 in 1990 to 4.4 percent in 2000. Average wage and salary have risen slowly and the number of persons living below the poverty level has fluctuated some, but remains over 250. The number of persons employed in the farm, fish and forestry sectors under occupation and industry has dropped to zero over the past decade. This is consistent with fishing demographics as there are no vessels with federal permits listing Thunderbolt as homeport. There are at least three vessels registered with the state and three individuals who consider themselves to be full-time commercial fishermen according to Table 5.1.5-26.

Thunderbolt Census Demographics

Population

Table 5.1.5-15. Total Persons and Persons by Age category for Thunderbolt, Georgia 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Total Persons and Age Category	**1970**	**1980**	**1990**	**2000**
Total Persons	2766	2161	2786	2360
Persons Age 0-5	121	136	143	112
Persons Age 6-15	391	268	227	204
Persons Age 16-17	114	103	51	51
Persons Age 18-24	988	272	1011	213
Persons Age 25-34	211	411	393	349
Persons Age 35-44	252	154	243	291
Persons Age 45-54	206	207	181	395
Persons Age 55-64	288	337	208	237
Persons Age 65+	136	257	329	508

Housing Tenure

Table 5.1.5-16. Housing Tenure for Thunderbolt, Georgia 1990-2000. (Source: U.S. Census Bureau).

Percent Renter Occupied	**1990**	**2000**
	44.3	35.7
Percent Owner Occupied	**1990**	**2000**
	55.7	64.3

Residence in 1985 and 1995

Table 5.1.5-17. Residence in 1985 and 1995 for Thunderbolt, Georgia 1990-2000. (Source: U.S. Census Bureau).

Different House Same County	**1990**	**2000**
	567	628
Same House	**1990**	**2000**
	1041	1185

Employment/Unemployment

Table 5.1.5-18. Employment and Unemployment for Thunderbolt, Georgia 1990-2000. (Source: U.S. Census Bureau).

Persons 16 yrs and over	**1990**	**2000**
Percent in labor force	59.9	61.1
Percent unemployed	17.2	4.4

Race

Table 5.1.5-19. Race for Thunderbolt, Georgia 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Race	**1970**	**1980**	**1990**	**2000**
Black Persons	1466	785	1495	758
Latino Black Persons	20	0	0	1
Latino Persons	20	24	11	33
White Persons	1300	1360	1270	1339
Latino White Persons	0	24	11	16

Education

Table 5.1.5-20. Years of Education by Category for those 25 Years and Older for Thunderbolt, Georgia 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Education	**1970**	**1980**	**1990**	**2000**
25+ w/ 0-8 years education	259	176	75	227
25+ w/ 9-11 years education	307	292	180	280
25+ w/ HS diploma	272	387	358	317
25+ w/ 13-15 years. education	100	185	345	245
25+ w/ College Degree	155	326	314	396
Drop outs	134	13	11	14

Income and Poverty

Table 5.1.5-21. Average Household Wage/Salary and Persons Below the Poverty Level for Thunderbolt, Georgia 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Wage or Salary	**1970**	**1980**	**1990**	**2000**
Average Household Wage/Salary Income (dollars)	$9079	$16017	$33591	$35824
Poverty Level				
Persons Below Poverty Level	267	292	143	279
Age 65+ Below Poverty Level	45	10	23	49
Households with Public Assistance	11	33	44	33

Industry

Table 5.1.5-22. Employment by Industry for Thunderbolt, Georgia 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Industry	**1970**	**1980**	**1990**	**2000**
Agriculture, Fishing, Mining	17	22	9	0
Construction	120	71	80	110
Business Services	52	33	34	42
Communication/Utilities	19	27	21	36
Manufacturing	172	80	133	121
Financial, Insurance & Real Estate	46	26	43	14
Services	16	69	44	673
Wholesale/Retail Trade	458	134	452	317
Transportation	171	176	290	78

Occupation

Table 5.1.5-23. Employment by Occupation for Thunderbolt, Georgia 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Occupation	**1970**	**1980**	**1990**	**2000**
Sales	45	68	201	-
Clerical	199	1590	251	-
Craft	227	108	115	-
Exec/Managerial	93	116	161	-
Farm/Fish/Forest	6	37	19	0
Household Services	26	8	0	-
Laborer/Handler	80	22	70	-
Operative/Transport	109	16	22	-
Service, except Household	157	104	123	-
Technical	8	7	31	-

Thunderbolt Fishing Demographics

Table 5.1.5-24. Number of Federal Permit (October 2008) by Type for Thunderbolt, Georgia (Source: NMFS 2008).

Type	Permits
ATLANTIC DOLPHIN/WAHOO COMMERCIAL	-
ATLANTIC DOLPHIN/WAHOO CHARTER/ HEADBOAT	-
S. ATLANTIC CHARTER/HEADBOAT FOR PELAGIC FISH	-
KING MACKEREL	-
SPINY LOBSTER & TAILING	-,-
ROCK SHRIMP & ENDORSEMENTS	-,-
S. ATL. CHARTER/HEADBOAT FOR SNAPPER-GROUPER	-
SWORDFISH & SHARKS	-,-
S. ATLANTIC SNAPPER-GROUPER (UNLIMITED)	-
S. ATLANTIC SNAPPER-GROUPER (225)	-
SPANISH MACKEREL	-
SOUTH ATLANTIC SHRIMP	-

Table 5.1.5-25. Employment in Fishing Related Industry for Thunderbolt, Georgia (Zip code Business Patterns, U.S. Census Bureau 1998).

Category	NAIC Code	Number Employed
Fishing	114100	0
Seafood Canning	311711	0
Seafood Processing	311712	0
Boat Building	336612	0
Fish and Seafoods	422460	3
Fish and Seafood Markets	445220	6
Marinas	713930	60
Total Fishing Employment		69

Table 5.1.5-26. Number of State Permit by Type for Thunderbolt, Georgia (Source: GADNR 2002).

Type	Number
Commercial Fishing Vessel Registration &	0
Vessels with trawl gear	0

5.1.5.3 Darien (31305)

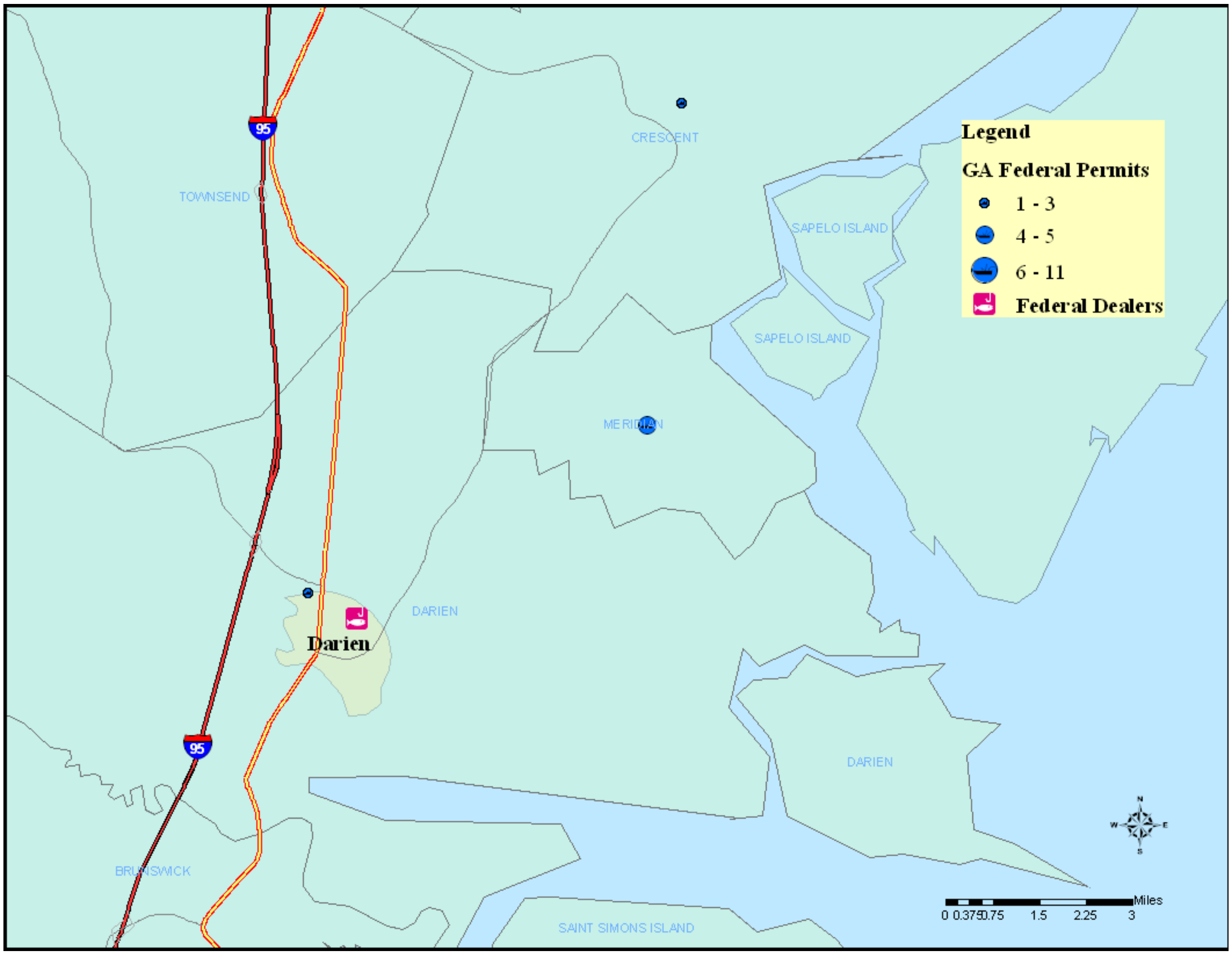

Figure 5.1.5-4. Darien, Georgia.

Darien was settled by Scottish Highlanders in the mid-1700s. During the 1800s, it was a leading seaport on the east coast. Even today, many shrimp fishing boats dock at the waterfront. Darien was named in honor of the unsuccessful colonization led by Darien Scots, at the Isthmus of Panama. After the American Revolution, Darien became an important port due to its position near the mouth of the Altamaha River. In 1816, the town of Darien was incorporated and it became the county seat in 1818.

The area became known as an international shipping port which was frequented by ships from Asia, Europe and South America. In 1900, more than 100 million linear board feet of timber and lumber were shipped from Darien. However, these shipments began to decline and in 1916, the last of Darien's sawmills went bankrupt. By the mid 1920s, the area experienced renewed growth with the commercial seafood industry. Many turned to the productive nearshore waters for their livelihood. By the early 1960s, McIntosh County had the largest shrimping fleet on the Georgia coast, with several oyster and shrimp packing houses along the banks of the Altamaha River. Even though today this area is economically dependent on tourism, commercial fishing is still the livelihood for many members of the community.

Over the past decade Darien's population has remained almost unchanged. Other demographic variables have also remained fairly stable as average wage and salary have also remained practically the same in 1990 and 2000. The number of persons living under the poverty level has also remained stable, while the percent of population in the labor force has gone up slightly; the unemployment percentage has gone down from 9.9 in 1990 to 2.4 in 2000. While there has been a decline in the number of persons reported in farm, fish and forestry occupations and industry there remain about 17 persons in those sectors. In 2008, 21 south Atlantic shrimp permits were issued Table 5.1.5-36 and fishing related employment shows 12 people employed in the sectors of fishing, seafood processing and fish and seafood (Table 5.1.5-37). The state has 56 commercial vessels registered in Darien including those having trawl gear.

Darien Census Demographics

Population

Table 5.1.5-27. Total Persons and Persons by Age category for Darien, Georgia 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Total Persons and Age Category	1970	1980	1990	2000
Total Persons	.	1731	1783	1751
Persons Age 0-5	.	115	150	172
Persons Age 6-15	.	335	302	329
Persons Age 16-17	.	62	46	46
Persons Age 18-24	.	242	157	125
Persons Age 25-34	.	223	263	179
Persons Age 35-44	.	175	234	254
Persons Age 45-54	.	188	199	235
Persons Age 55-64	.	160	164	201
Persons Age 65+	.	214	268	210

Housing Tenure

Table 5.1.5-28. Housing Tenure for Darien, Georgia 1990-2000. (Source: U.S. Census Bureau).

Percent Renter Occupied	1990	2000
	26.5	27.5
Percent Owner Occupied	**1990**	**2000**
	73.5	72.5

Residence in 1985 and 1995

Table 5.1.5-29. Residence in 1985 and 1995 for Darien, Georgia 1990-2000. (Source: U.S. Census Bureau).

Different House Same County	1990	2000
	197	305
Same House	**1990**	**2000**
	1152	897

Employment/Unemployment

Table 5.1.5-30. Employment and Unemployment for Darien, Georgia 1990-2000. (Source: U.S. Census Bureau).

Persons 16 yrs and over	1990	2000
Percent in labor force	56.0	60.4
Percent unemployed	9.9	2.8

Race

Table 5.1.5-31. Race for Darien, Georgia 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Race	1970	1980	1990	2000
Black Persons	.	749	766	751
Latino Black Persons	.	0	3	5
Latino Persons	.	6	5	11
White Persons	.	982	1017	926
Latino White Persons	.	6	2	4

Education

Table 5.1.5-32. Years of Education by Category for those 25 Years and Older for Darien, Georgia 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Education	1970	1980	1990	2000
25+ w/ 0-8 years education	.	268	191	84
25+ w/ 9-11 years education	.	266	266	187
25+ w/ HS diploma	.	236	375	386
25+ w/ 13-15 years. education	.	87	141	151
25+ w/ College Degree	.	103	130	154
Drop outs	.	44	16	27

Income and Poverty

Table 5.1.5-33. Average Household Wage/Salary and Persons Below the Poverty Level for Darien, Georgia 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Wage or Salary	**1970**	**1980**	**1990**	**2000**
Average Household Wage/Salary Income (dollars)	.	$13161	$24025	$24135
Poverty Level				
Persons Below Poverty Level	.	605	416	425
Age 65+ Below Poverty Level	.	98	85	53
Households with Public Assistance	.	60	147	40

Industry

Table 5.1.5-34. Employment by Industry for Darien, Georgia 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Industry	**1970**	**1980**	**1990**	**2000**
Agriculture, Fishing, Mining	.	39	38	20
Construction	.	38	46	68
Business Services	.	17	15	14
Communication/Utilities	.	27	22	21
Manufacturing	.	155	154	67
Financial, Insurance & Real Estate	.	37	57	33
Services	.	21	14	401
Wholesale/Retail Trade	.	92	188	228
Transportation	.	150	150	21

Occupation

Table 5.1.5-35. Employment by Occupation for Darien, Georgia 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Occupation	**1970**	**1980**	**1990**	**2000**
Sales	.	78	62	-
Clerical	.	890	84	-
Craft	.	70	115	-
Exec/Managerial	.	43	55	-
Farm/Fish/Forest	.	35	33	17
Household Services	.	13	11	-
Laborer/Handler	.	39	37	-
Operative/Transport	.	97	62	-
Service, except Household	.	112	118	-
Technical	.	7	17	-

Darien Fishing Demographics

Table 5.1.5-36. Number of Federal Permit (October 2008) by Type for Darien, Georgia (Source: NMFS 2008).

Type	Permits
ATLANTIC DOLPHIN/WAHOO COMMERCIAL	1
ATLANTIC DOLPHIN/WAHOO CHARTER/ HEADBOAT	1
S. ATLANTIC CHARTER/HEADBOAT FOR PELAGIC FISH	1
KING MACKEREL	1
SPINY LOBSTER & TAILING	-,1
ROCK SHRIMP & ENDORSEMENTS	1,-
S. ATL. CHARTER/HEADBOAT FOR SNAPPER-GROUPER	1
SWORDFISH & SHARKS	-,-
S. ATLANTIC SNAPPER-GROUPER (UNLIMITED)	1
S. ATLANTIC SNAPPER-GROUPER (225)	-
SPANISH MACKEREL	1
SOUTH ATLANTIC SHRIMP	21

Table 5.1.5-37. Employment in Fishing Related Industry for Darien, Georgia (Zip code Business Patterns, U.S. Census Bureau 1998).

Category	**NAIC Code**	**Number Employed**
Fishing	114100	6
Seafood Canning	311711	0
Seafood Processing	311712	3
Boat Building	336612	0
Fish and Seafoods	422460	3
Fish and Seafood Markets	445220	0
Marinas	713930	0
Total Fishing Employment		12

Table 5.1.5-38. Number of State Permit by Type for Darien, Georgia (Source: GADNR 2008).

Type	**Number**
Commercial Fishing Vessel Registration & Vessels with Trawl gear	56

5.1.5.4 Brunswick (31520, 31523, 31525)

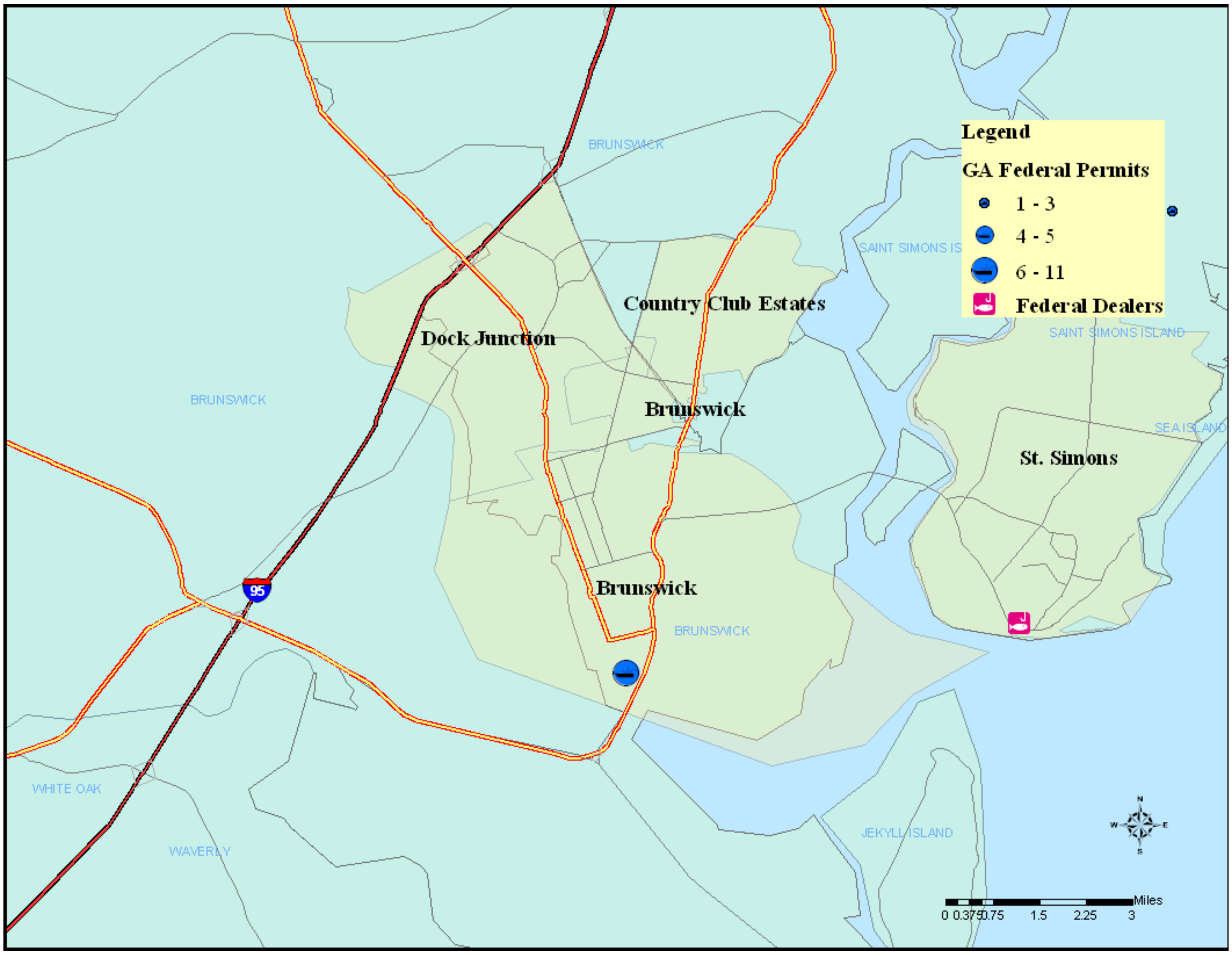

Figure 5.1.5-5. Brunswick, Georgia.

Brunswick's population has seen a steady decline over the past three decades in almost every age category. The percent of the population in the labor force has remained the same since 1990 but unemployment has risen to 10.4 percent in 2000. Average wage and salary has dropped since 1990 and the number of people living under the poverty level has increased. For those working in the sectors of farm, fish and forestry in occupation and industry there has also been a steady decline. Brunswick has 23 vessels holdings south Atlantic shrimp federal permits according to Table 5.1.5-48. There are a substantial number of persons working in fishing related businesses according to Table 5.1.5-49 with over 1500 persons working in the seafood processing sector. The state has 46 vessels registered including those with trawl gear (Table 5.1.5-50).

Brunswick Census Demographics

<u>Population</u>

Table 5.1.5-39. Total Persons and Persons by Age category for Brunswick, Georgia 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Total Persons and Age Category	1970	1980	1990	2000
Total Persons	19585	17605	16433	15424
Persons Age 0-5	1732	1349	1678	1442
Persons Age 6-15	4106	3031	2562	2443
Persons Age 16-17	756	741	491	433
Persons Age 18-24	2311	2126	1509	1563
Persons Age 25-34	2045	2454	2625	1826
Persons Age 35-44	2213	1710	2032	2299
Persons Age 45-54	2338	1604	1482	1836
Persons Age 55-64	1793	1936	1444	1174
Persons Age 65+	1900	2407	2610	2408

Housing Tenure

Table 5.1.5-40. Housing Tenure for Brunswick, Georgia 1990-2000. (Source: U.S. Census Bureau).

Percent Renter Occupied	1990	2000
	50.5	55.4
Percent Owner Occupied	**1990**	**2000**
	49.5	44.6

Residence in 1985 and 1995

Table 5.1.5-41. Residence in 1985 and 1995 for Brunswick, Georgia 1990-2000. (Source: U.S. Census Bureau).

Different House Same County	1990	2000
	4579	2442
Same House	**1990**	**2000**
	7806	7598

Employment/Unemployment

Table 5.1.5-42. Employment and Unemployment for Brunswick, Georgia 1990-2000. (Source: U.S. Census Bureau).

Persons 16 yrs and over	1990	2000
Percent in labor force	58.0	58.7
Percent unemployed	9.4	10.2

Race

Table 5.1.5-43. Race for Brunswick, Georgia 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Race	**1970**	**1980**	**1990**	**2000**
Black Persons	8754	9464	9606	9247
Latino Black Persons	0	140	8	83
Latino Persons	62	275	82	908
White Persons	10803	8020	6734	5162
Latino White Persons	62	110	54	518

Education

Table 5.1.5-44. Years of Education by Category for those 25 Years and Older for Brunswick, Georgia 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Education	**1970**	**1980**	**1990**	**2000**
25+ w/ 0-8 years education	3898	2856	1532	1032
25+ w/ 9-11 years education	2446	2225	2308	1998
25+ w/ HS diploma	2354	2883	3454	2935
25+ w/ 13-15 years. education	838	1186	1490	1062
25+ w/ College Degree	753	961	1056	1516
Drop outs	428	348	142	176

Income and Poverty

Table 5.1.5-45. Average Household Wage/Salary and Persons Below the Poverty Level for Brunswick, Georgia 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Wage or Salary	**1970**	**1980**	**1990**	**2000**
Average Household Wage/Salary Income (dollars)	$6674	$13078	$23510	$22272
Poverty Level				
Persons Below Poverty Level	4879	4737	4142	4508
Age 65+ Below Poverty Level	711	585	475	487
Households with Public Assistance	664	951	985	322

Industry

Table 5.1.5-46. Employment by Industry for Brunswick, Georgia 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Industry	**1970**	**1980**	**1990**	**2000**
Agriculture, Fishing, Mining	96	88	143	93
Construction	433	406	407	425
Business Services	155	152	281	130
Communication/Utilities	188	205	141	84
Manufacturing	1999	1482	874	527
Financial, Insurance & Real Estate	461	472	225	299
Services	310	294	317	3833
Wholesale/Retail Trade	2315	1625	2178	2098
Transportation	1474	1504	1648	136

Occupation

Table 5.1.5-47. Employment by Occupation for Brunswick, Georgia 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Occupation	**1970**	**1980**	**1990**	**2000**
Sales	421	597	852	-
Clerical	966	8780	873	-
Craft	872	834	598	-
Exec/Managerial	572	514	591	-
Farm/Fish/Forest	27	156	129	77
Household Services	432	138	109	-
Laborer/Handler	621	455	308	-
Operative/Transport	1206	679	377	-
Service, except Household	1738	1675	1718	-
Technical	79	207	183	-

Brunswick Fishing Demographics

Table 5.1.5-48. Number of Federal Permit (October 2008) by Type for Brunswick, Georgia (Source: NMFS 2008).

Type	Permits
ATLANTIC DOLPHIN/WAHOO COMMERCIAL	-
ATLANTIC DOLPHIN/WAHOO CHARTER/ HEADBOAT	2
S. ATLANTIC CHARTER/HEADBOAT FOR PELAGIC FISH	2
KING MACKEREL	1
SPINY LOBSTER & TAILING	-,-
ROCK SHRIMP & ENDORSEMENTS	3,1
S. ATL. CHARTER/HEADBOAT FOR SNAPPER-GROUPER	2
SWORDFISH & SHARKS	-,-
S. ATLANTIC SNAPPER-GROUPER (UNLIMITED)	-
S. ATLANTIC SNAPPER-GROUPER (225)	-
SPANISH MACKEREL	-
SOUTH ATLANTIC SHRIMP	23

Table 5.1.5-49. Employment in Fishing Related Industry for Brunswick, Georgia (Zip code Business Patterns, U.S. Census Bureau 1998).

Category	NAIC Code	Number Employed
Fishing	114100	3
Seafood Canning	311711	0
Seafood Processing	311712	1582
Boat Building	336612	0
Fish and Seafoods	422460	25
Fish and Seafood Markets	445220	0
Marinas	713930	53
Total Fishing Employment		1663

Table 5.1.5-50. Number of State Permit by Type for Brunswick, Georgia (Source: GADNR 2002).

Type	Number
Commercial Fishing Vessel Registration	88
Vessels with shrimp gear	56
Full-time commercial fishermen	63
Part-time commercial fishermen	11

5.1.5.5 St. Simons Island (31522)

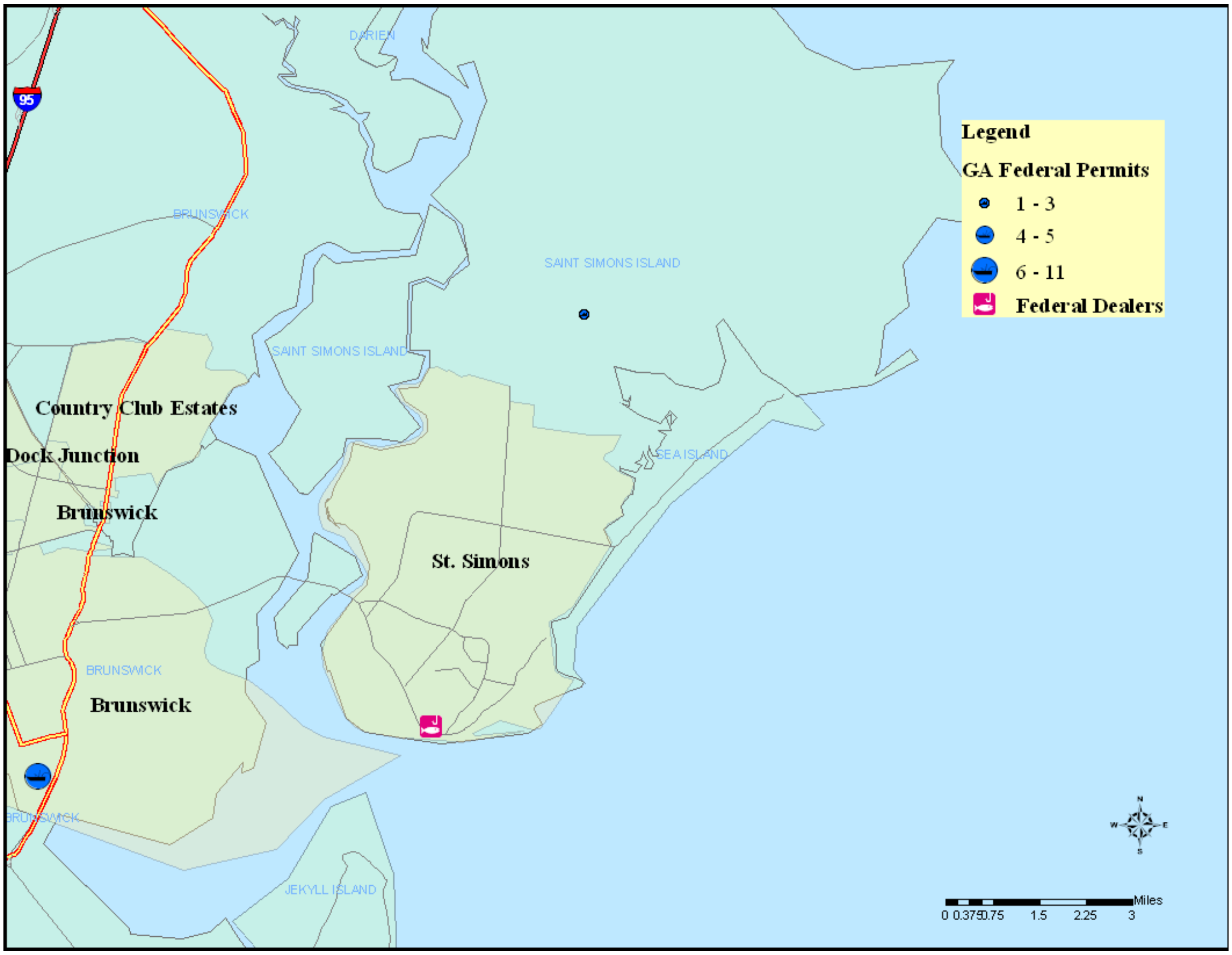

Figure 5.1.5-6. St. Simons Island, Georgia.

St. Simons Island has seen a fairly steady growth in its population. The percent of population in the labor force has remained fairly stable at just above 60 percent and unemployment has remained low at 3.4 percent. Average wage and salary have risen significantly while the number of persons living under the poverty level has remained about the same at over 600. As for most coastal communities, the number of persons employed in farm, fish, and forestry sectors under occupation and industry has declined steadily over the past 30 years for this community. St. Simons Island has little commercial fishing employment as there are no vessels registered with federal permits that homeport there (Table 5.1.5-60). Most all of the fishing related employment is in the marinas sector according to Table 5.1.5-61 and there are only 3 commercial vessels registered with the state (Table 5.1.5-62).

St. Simons Island Census Demographics

Population

Table 5.1.5-51. Total Persons and Persons by Age category for St. Simons Island, Georgia 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Total Persons and Age Category	1970	1980	1990	2000
Total Persons	5191	6566	12026	13448
Persons Age 0-5	383	298	726	661
Persons Age 6-15	992	823	1364	1616
Persons Age 16-17	168	223	241	288
Persons Age 18-24	625	617	798	672
Persons Age 25-34	799	1258	1661	1265
Persons Age 35-44	506	822	2022	1982
Persons Age 45-54	561	660	1466	2307
Persons Age 55-64	593	690	1309	1735
Persons Age 65+	449	1119	2439	2922

Housing Tenure

Table 5.1.5-52. Housing Tenure for St. Simons Island, Georgia 1990-2000. (Source: U.S. Census Bureau).

Percent Renter Occupied	1990	2000
	33.7	26.2
Percent Owner Occupied	**1990**	**2000**
	66.3	73.8

Residence in 1985 and 1995

Table 5.1.5-53. Residence in 1985 and 1995 for St. Simons Island, Georgia 1990-2000. (Source: U.S. Census Bureau).

Different House Same County	1990	2000
	1,429	2,871
Same House	**1990**	**2000**
	4,425	6,138

Employment/Unemployment

Table 5.1.5-54. Employment and Unemployment for St. Simons Island, Georgia 1990-2000. (Source: U.S. Census Bureau).

Persons 16 yrs and over	1990	2000
Percent in labor force	62.3	64.5
Percent unemployed	1.8	3.5

Race

Table 5.1.5-55. Race for St. Simons Island, Georgia 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Race	1970	1980	1990	2000
Black Persons	583	440	631	486
Latino Black Persons	0	6	0	8
Latino Persons	0	96	187	253
White Persons	4602	6092	11362	12426
Latino White Persons	0	90	177	191

Education

Table 5.1.5-56. Years of Education by Category for those 25 Years and Older for St. Simons Island, Georgia 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Education	1970	1980	1990	2000
25+ w/ 0-8 years education	456	346	220	167
25+ w/ 9-11 years education	426	492	516	263
25+ w/ HS diploma	800	1073	1614	1366
25+ w/ 13-15 years. education	544	1129	2133	1532
25+ w/ College Degree	682	1509	3967	5894
Drop outs	43	20	9	-

Income and Poverty

Table 5.1.5-57. Average Household Wage/Salary and Persons Below the Poverty Level for St. Simons Island, Georgia 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Wage or Salary	1970	1980	1990	2000
Average Household Wage/Salary Income (dollars)	$8778	$20621	$42677	$58475
Poverty Level				
Persons Below Poverty Level	683	336	660	602
Age 65+ Below Poverty Level	128	88	130	218
Households with Public Assistance	49	89	217	35

Industry

Table 5.1.5-58. Employment by Industry for St. Simons Island, Georgia 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Industry	**1970**	**1980**	**1990**	**2000**
Agriculture, Fishing, Mining	14	110	134	15
Construction	167	143	289	388
Business Services	60	120	202	503
Communication/Utilities	44	42	108	215
Manufacturing	375	290	597	519
Financial, Insurance & Real Estate	39	78	249	754
Services	86	224	400	4006
Wholesale/Retail Trade	749	795	2712	1673
Transportation	475	876	1234	107

Occupation

Table 5.1.5-59. Employment by Occupation for St. Simons Island, Georgia 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Occupation	**1970**	**1980**	**1990**	**2000**
Sales	226	526	790	-
Clerical	307	4440	646	-
Craft	159	290	310	-
Exec/Managerial	371	455	1155	-
Farm/Fish/Forest	8	83	126	0
Household Services	88	50	42	-
Laborer/Handler	68	44	107	-
Operative/Transport	109	73	97	-
Service, except Household	313	661	753	-
Technical	10	67	148	-

St. Simons Fishing Demographics

Table 5.1.5-60. Number of Federal Permit (October 2008) by Type for St. Simons Island, Georgia (Source: NMFS 2008).

Type	Permits
ATLANTIC DOLPHIN/WAHOO COMMERCIAL	-
ATLANTIC DOLPHIN/WAHOO CHARTER/ HEADBOAT	-
S. ATLANTIC CHARTER/HEADBOAT FOR PELAGIC FISH	-
KING MACKEREL	-
SPINY LOBSTER & TAILING	-,-
ROCK SHRIMP & ENDORSEMENTS	-,-
S. ATL. CHARTER/HEADBOAT FOR SNAPPER-GROUPER	-
SWORDFISH & SHARKS	-,-
S. ATLANTIC SNAPPER-GROUPER (UNLIMITED)	-
S. ATLANTIC SNAPPER-GROUPER (225)	-
SPANISH MACKEREL	-
SOUTH ATLANTIC SHRIMP	-

Table 5.1.5-61. Employment in Fishing Related Industry for St. Simons Island, Georgia (Zip code Business Patterns, U.S. Census Bureau 1998).

Category	NAIC Code	Number Employed
Fishing	114100	0
Seafood Canning	311711	0
Seafood Processing	311712	0
Boat Building	336612	0
Fish and Seafoods	422460	15
Fish and Seafood Markets	445220	0
Marinas	713930	43
Total Fishing Employment		58

Table 5.1.5-62. Number of State Permit by Type for St. Simons, Georgia (Source: GADNR 2002).

Type	Number
Commercial Fishing Vessel Registration	4
Vessels with shrimp gear	4
Full-time commercial fishermen	7
Part-time commercial fishermen	2

5.1.5.6 St. Mary's (31558)

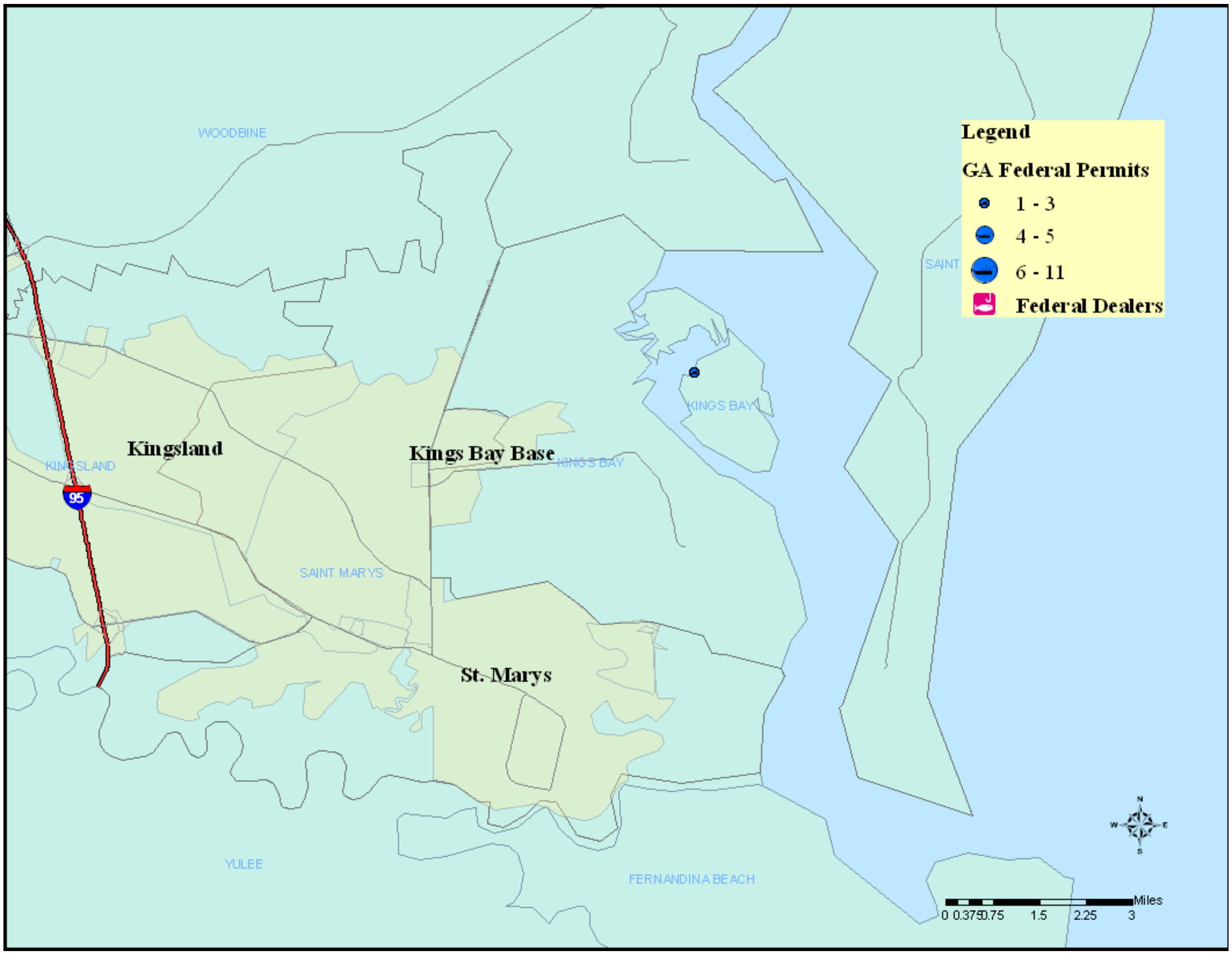

Figure 5.1.5-7. St. Mary's, Georgia.

St. Mary's has seen steady population growth since 1970. The percent of the population in the labor force has remained fairly constant while unemployment has risen to 6.4 percent. Average wage and salary has risen consistently over the years, but the number of persons living under the poverty level took a significant jump in 2000 to over 1400 persons in 2000 from 975 in 1990. Those employed in farm, fish and forestry sector have seen a steady decline in their numbers since 1970 also. There were only no vessels registered with federal permits from the community in Table 5.1.5-72, but there were 42 persons listed in the fishing sector in Table 5.1.5-73. The state has 14 vessels permitted including those having trawl gear (Table 5.1.5-74).

St. Mary's Census Demographics

Table 5.1.5-63. Total Persons and Persons by Age category for St. Mary's, Georgia 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Total Persons and Age Category	1970	1980	1990	2000
Total Persons	3364	3596	8187	13445
Persons Age 0-5	336	296	1070	1408
Persons Age 6-15	904	674	1465	2465
Persons Age 16-17	149	159	252	460
Persons Age 18-24	235	468	879	1677
Persons Age 25-34	536	513	1902	2355
Persons Age 35-44	443	455	1120	2210
Persons Age 45-54	328	474	684	1394
Persons Age 55-64	193	245	399	711
Persons Age 65+	129	260	416	765

Housing Tenure

Table 5.1.5-64. Housing Tenure for St. Mary's, Georgia 1990-2000. (Source: U.S. Census Bureau).

Percent Renter Occupied	1990	2000
	44.5	46.5
Percent Owner Occupied	**1990**	**2000**
	55.5	53.5

Residence in 1985 and 1995

Table 5.1.5-65. Residence in 1985 and 1995 for St. Mary's, Georgia 1990-2000. (Source: U.S. Census Bureau).

Different House Same County	1990	2000
	1,078	5,312
Same House	**1990**	**2000**
	2,161	3,934

Employment/Unemployment

Table 5.1.5-66. Employment and Unemployment for St. Mary's, Georgia 1990-2000. (Source: U.S. Census Bureau).

Persons 16 yrs and over	1990	2000
Percent in labor force	73.4	74.2
Percent unemployed	5.9	6.6

Race

Table 5.1.5-67. Race for St. Mary's, Georgia 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Race	1970	1980	1990	2000
Black Persons	673	753	1405	2710
Latino Black Persons	0	0	0	41
Latino Persons	56	145	346	614
White Persons	2691	2781	6478	9969
Latino White Persons	56	109	192	298

Education

Table 5.1.5-68. Years of Education by Category for those 25 Years and Older for St. Mary's, Georgia 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Education	1970	1980	1990	2000
25+ w/ 0-8 years education	370	344	251	200
25+ w/ 9-11 years education	377	410	545	730
25+ w/ HS diploma	638	657	1606	2328
25+ w/ 13-15 years. education	131	270	1012	998
25+ w/ College Degree	113	266	756	2184
Drop outs	37	30	49	28

Income and Poverty

Table 5.1.5-69. Average Household Wage/Salary and Persons Below the Poverty Level for St. Mary's, Georgia 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Wage or Salary	1970	1980	1990	2000
Average Household Wage/Salary Income (dollars)	9224	19855	31056	42087
Poverty Level				
Persons Below Poverty Level	430	612	975	1488
Age 65+ Below Poverty Level	42	31	59	50
Households with Public Assistance	52	78	152	143

Industry

Table 5.1.5-70. Employment by Industry for St. Mary's, Georgia 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Industry	**1970**	**1980**	**1990**	**2000**
Agriculture, Fishing, Mining	52	21	47	24
Construction	5	75	231	313
Business Services	13	24	138	355
Communication/Utilities	5	31	44	164
Manufacturing	676	618	490	705
Financial, Insurance & Real Estate	28	15	142	313
Services	23	95	186	2787
Wholesale/Retail Trade	217	142	825	1306
Transportation	145	274	558	142

Occupation

Table 5.1.5-71. Employment by Occupation for St. Mary's, Georgia 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Occupation	**1970**	**1980**	**1990**	**2000**
Sales	57	160	366	-
Clerical	132	2570	645	-
Craft	214	217	360	-
Exec/Managerial	72	139	340	-
Farm/Fish/Forest	10	18	34	0
Household Services	45	0	28	-
Laborer/Handler	111	97	150	-
Operative/Transport	254	219	91	-
Service, except Household	116	128	508	-
Technical	48	26	69	-

St. Marys' Fishing Demographics

Table 5.1.5-72. Number of Federal Permit (October 2008) by Type for St. Mary's, Georgia (Source: NMFS 2008).

Type	Permits
ATLANTIC DOLPHIN/WAHOO COMMERCIAL	-
ATLANTIC DOLPHIN/WAHOO CHARTER/ HEADBOAT	-
S. ATLANTIC CHARTER/HEADBOAT FOR PELAGIC FISH	-
KING MACKEREL	-
SPINY LOBSTER & TAILING	-,-
ROCK SHRIMP & ENDORSEMENTS	-,-
S. ATL. CHARTER/HEADBOAT FOR SNAPPER-GROUPER	-
SWORDFISH & SHARKS	-,-
S. ATLANTIC SNAPPER-GROUPER (UNLIMITED)	-
S. ATLANTIC SNAPPER-GROUPER (225)	-
SPANISH MACKEREL	-
SOUTH ATLANTIC SHRIMP	-

Table 5.1.5-73. Employment in Fishing Related Industry for St. Mary's, Georgia (Zip code Business Patterns, U.S. Census Bureau 1998).

Category	NAIC Code	Number Employed
Fishing	114100	42
Seafood Canning	311711	0
Seafood Processing	311712	0
Boat Building	336612	3
Fish and Seafoods	422460	0
Fish and Seafood Markets	445220	0
Marinas	713930	0
Total Fishing Employment		45

Table 5.1.5-74. Number of State Permit by Type for St. Mary's, Georgia (Source: GADNR 2002).

Type	Number
Commercial Fishing Vessel Registration	19
Vessels with shrimp gear	9
Full-time commercial fishermen	13
Part-time commercial fishermen	5

5.1.5.7 Georgia Fishing Infrastructure and Community Characterization

The following tables provide a general view of the presence or absence of fishing infrastructure located within the coastal communities of Georgia with substantial fishing activity. It should be noted that there are many other attributes that might have been included in this table, however, because of inconsistency in rapid appraisal for all communities, these items were selected as the most consistently reported or had secondary data available to determine presence or absence. It should also be noted that in some cases certain infrastructure may exist within a community but was not readily apparent or could not be ascertained through secondary data. Table 5.1.5-75 offers an overview of the presence of the selected infrastructure items and provides an overall total score which is merely the total of infrastructure present.

Table 5.1.5-75. Fishing Infrastructure Table for Georgia Potential Fishing Communities

Community	Federal Commercial Permits (5+)	State Commercial Licenses (10+)	Federal Charter Permits (5+)	Seafood Landings	Seafood retail markets	Fish processors, Wholesale fish house	Recreational docks / marinas	Recreational Fishing Tournaments	Total
Tybee Island	-	-	-	-	+	-	+	-	2
Thunderbolt	-	-	-	-	-	-	+	-	1
Darien	-	+	-	+	+	+	+	-	5
Brunswick	+	+	-	-	+	+	+	+	6
St. Simons Island	-	-	-	-	+	+	+	+	4
St. Mary's	-	+	-	-	+	-	+	+	4

In attempting a preliminary characterization of potential fishing communities in Table 5.1.5-76, we have provided a grouping of communities that appear to have more involvement in various fishing enterprises and therefore are classified as primarily involved. These communities have considerable fishing infrastructure, but also have a history and culture surrounding both commercial and recreational fishing that contributes to an appearance and perception of being a fishing community in the mind of residents and others. The communities are not ranked in any particular order, this is merely a categorization.

Table 5.1.5-76. Preliminary Characterization of Potential Fishing Communities in Georgia

Primarily-Involved	Secondarily-Involved
Darien	Tybee Island
Brunswick	Thunderbolt
St. Mary's	
St. Simons Island	

Many of these communities are in transition due to various social and demographic changes from coastal development, growing populations, increasing tourism, changing regulations, etc. This preliminary characterization is just that and should not be considered a definite designation as fishing community, but a general guide for locating communities that may warrant consideration as a potential fishing community.

5.1.6 Florida Communities with Substantial Fishing Activity

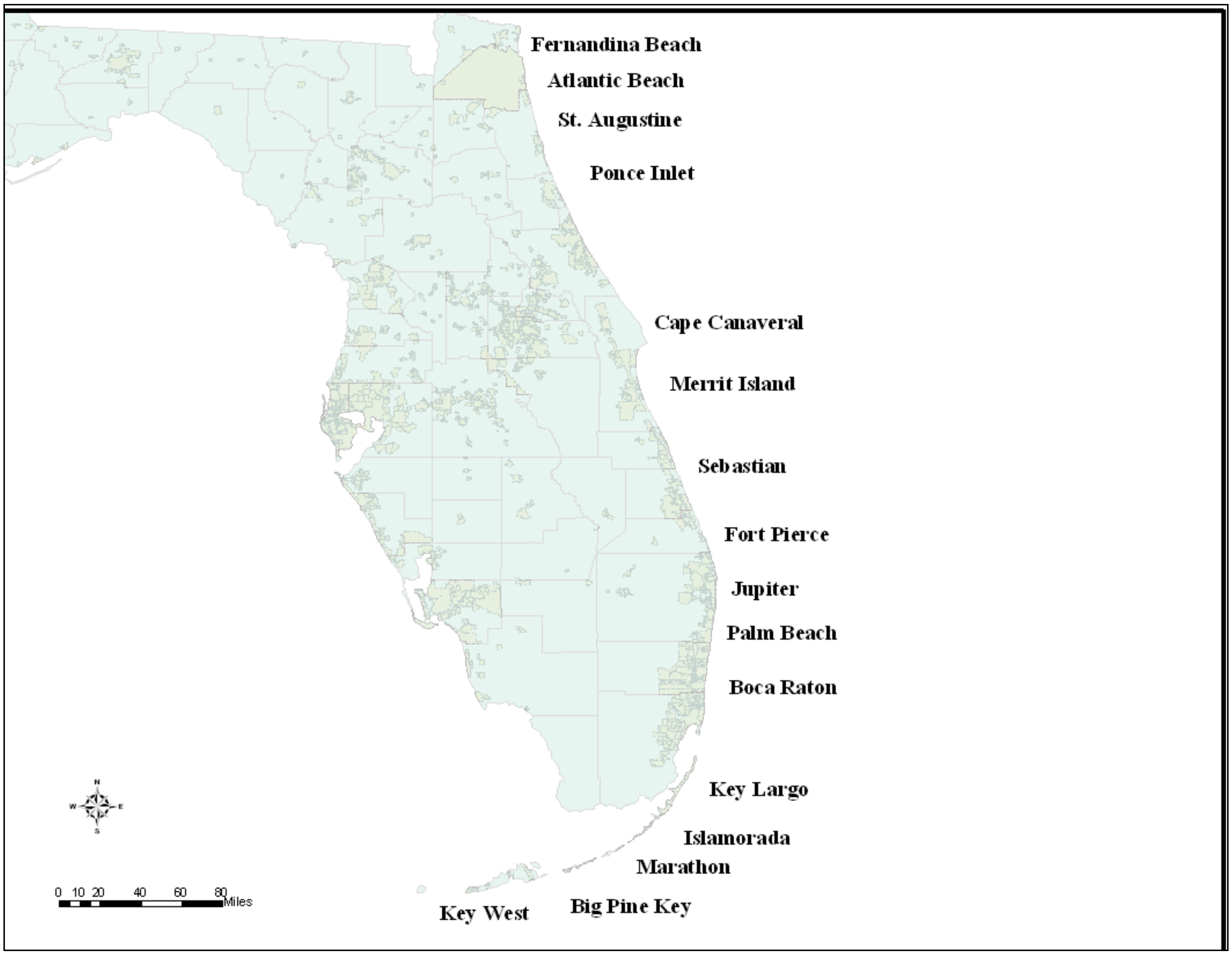

Figure 5.1.6-1. Florida Communities with Substantial Fishing Activity as Identified by South Atlantic Advisory Panels.

Figure 5.1.6-1 illustrates those communities which were identified originally by the advisory panels as communities that might be considered fishing communities. They are included below with brief profiles and census and fishing demographic tables used to describe the communities.

The East coast of Florida landed over 37 million pounds of seafood in 2001 and over 32 million in 2002. The value of those landings was over 48 million dollars in 2001 and over 38 million dollars in 2002. Florida had one port, Key West, listed in the top 50 U.S. ports in terms of pounds landed and in terms of value of landings there were three ports for Florida: Key West, St. Petersburg, and Ft. Myers. According to NMFS (2002) Florida recreational fishermen landed over 68 million pounds of finfish in 2001 and in 2002 that number dropped to just over 59 million pounds for the entire state. There were 93 processors in all of Florida for 2001 with a total of 2,654 employees and 284 wholesale dealers employing 2,485. In the years 2001 and 2002, Florida had approximately 2,136 and 1,934 registered vessels respectively. During those same years there were 5,502 boats registered in 2001 and in 2002 that number was 4,438.

Table 5.1.6-1. Number of Federal Permit (October 2008) by Type for Florida (Source: NMFS 2008).

Type	Permits
ATLANTIC DOLPHIN/WAHOO COMMERCIAL	1,196
ATLANTIC DOLPHIN/WAHOO CHARTER/ HEADBOAT	813
S. ATLANTIC CHARTER/HEADBOAT FOR PELAGIC FISH	875
KING MACKEREL	1,008
SPINY LOBSTER & TAILING	-,-
ROCK SHRIMP & ENDORSEMENTS	69,-
S. ATL. CHARTER/HEADBOAT FOR SNAPPER-GROUPER	919
SWORDFISH & SHARKS	-,-
S. ATLANTIC SNAPPER-GROUPER (UNLIMITED)	-
S. ATLANTIC SNAPPER-GROUPER (225)	-
SPANISH MACKEREL	1,101
SOUTH ATLANTIC SHRIMP	173
DEALER	208

In 2008, Florida vessels with federal permits predominantly held south Atlantic dolphin/wahoo commercial (1,196) , south Atlantic dolphin/wahoo charter (813), Atlantic king mackerel (1,008) or Spanish mackerel (1,101), or snapper grouper charter/headboat (919) permits. Figure 5.1.6-1 shows potential fishing communities in Florida.

5.1.6.1 Fernandina Beach (32034)

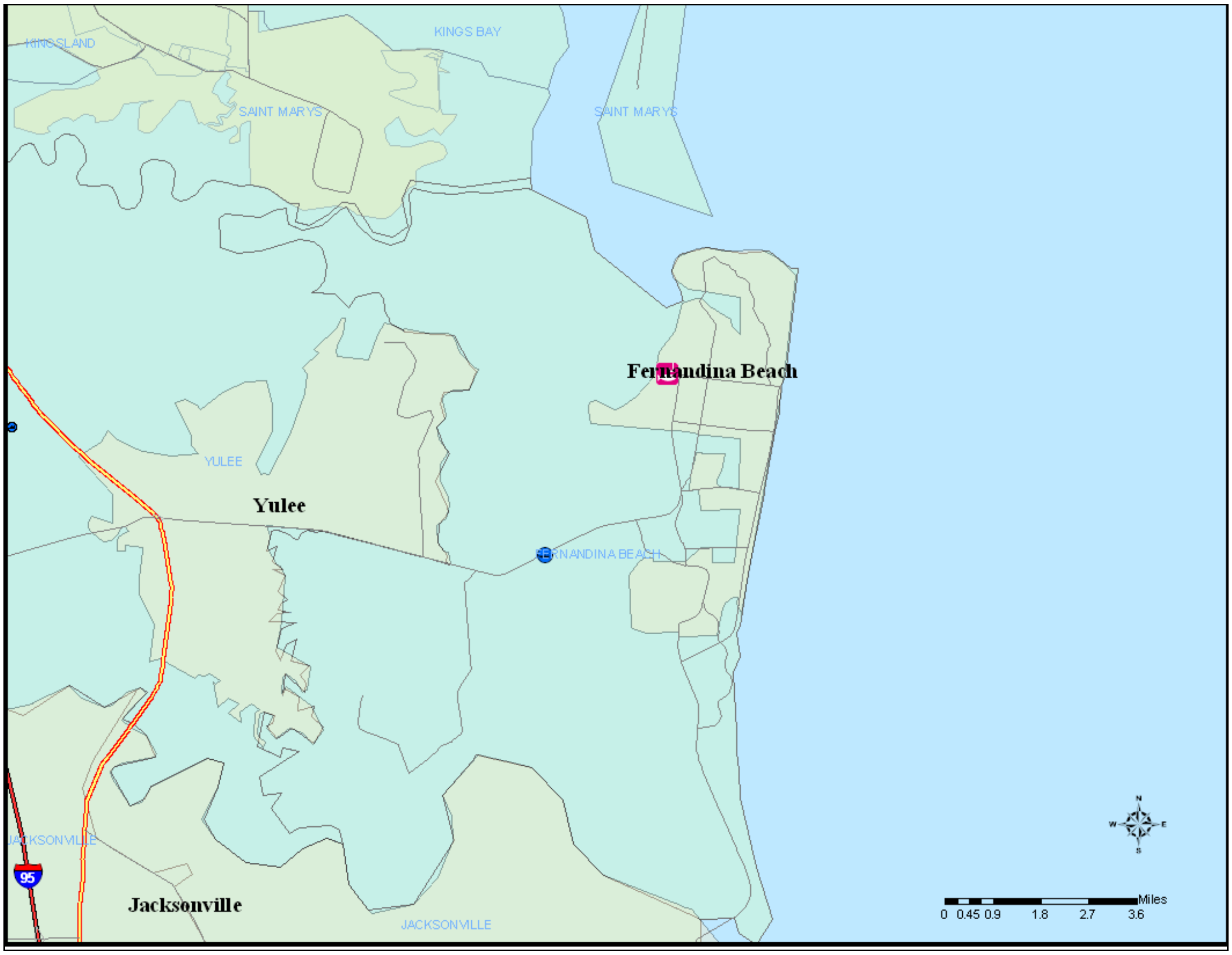

Figure 5.1.6-2. Fernandina Beach, Florida.

Fernandina Beach is located in Nassau County, Florida, on the northernmost barrier island (Amelia Island) of the state's east coast. The island extends from the mouth of the St. Mary's River southward to Nassau Sound and is just over thirteen miles long and two miles wide (Jacob et al. 2002).

Fishing has had a long history in the community as immigrants in the 1700s were net fishermen seeking mullet, sheepshead, crabs, trout, turtles, drum, oysters and "pogies" (menhaden). Agriculture, forestry, fishing, and tourism were the most prominent industries in the Fernandina Beach area during the early 1900's. Shrimp fishing was developed in 1902 by a Sicilian immigrant living in Fernandina Beach who fished with a small diesel engine on his boat to pull a shrimp seine net across the ocean floor. Commercial shrimp fishing grew substantially when a New England fisherman, who was searching the Florida peninsula for bluefish, began harvesting large quantities of shrimp. Shrimp processing and shipment facilities were soon developed in Fernandina Beach. That fishing heritage has been preserved in Old Town Fernandina Beach, which has been designated a National Historic District. Today, Fernandina's harbor is filled with commercial and charter fishing boats, shrimp boats and private vessels. Seafood restaurants contribute to the fishing village theme which continues to resonate throughout the community although tourism has become the primary source of economic revenue (Jacob et al. 2002).

Fernandina Beach Census Demographics

Population

Table 5.1.6-2. Total Persons and Persons by Age category for Fernandina Beach, Florida 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Total Persons and Age Category	1970	1980	1990	2000
Total Persons	6955	7224	8765	10242
Persons Age 0-5	586	468	652	682
Persons Age 6-15	1594	1252	1121	1128
Persons Age 16-17	371	351	252	234
Persons Age 18-24	577	723	805	712
Persons Age 25-34	754	1076	1344	1063
Persons Age 35-44	831	786	1457	1565
Persons Age 45-54	755	816	903	1550
Persons Age 55-64	767	878	923	1337
Persons Age 65+	599	791	1308	1971

Housing Tenure

Table 5.1.6-3. Housing Tenure for Fernandina Beach, Florida 1990-2000. (Source: U.S. Census Bureau).

Percent Renter Occupied	1990	2000
	35.2	31.8
Percent Owner Occupied	**1990**	**2000**
	64.8	68.2

Residence in 1985 and 1995

Table 5.1.6-4. Residence in 1985 and 1995 for Fernandina Beach, Florida 1990-2000. (Source: U.S. Census Bureau).

Different House Same County	1990	2000
	1672	1776
Same House	**1990**	**2000**
	3630	4802

Employment/Unemployment

Table 5.1.6-5. Employment and Unemployment for Fernandina Beach, Florida 1990-2000. (Source: U.S. Census Bureau).

Persons 16 yrs and over	1990	2000
Percent in labor force	63.9	58.9
Percent unemployed	4.5	7.1

Race

Table 5.1.6-6. Race for Fernandina Beach, Florida 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Race	1970	1980	1990	2000
Black Persons	2136	2054	1975	1698
Latino Black Persons	13	61	0	10
Latino Persons	58	248	48	246
White Persons	4819	5158	6739	8434
Latino White Persons	45	187	48	168

Education

Table 5.1.6-7. Years of Education by Category for those 25 Years and Older for Fernandina Beach, Florida 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Education	1970	1980	1990	2000
25+ w/ 0-8 years education	1128	796	556	438
25+ w/ 9-11 years education	767	625	754	713
25+ w/ HS diploma	1159	1493	1869	2019
25+ w/ 13-15 years. education	301	707	1071	2140
25+ w/ College Degree	351	726	1371	3145
Drop outs	127	74	67	80

Income and Poverty

Table 5.1.6-8. Average Household Wage/Salary and Persons Below the Poverty Level for Fernandina Beach, Florida 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Wage or Salary	1970	1980	1990	2000
Average Household Wage/Salary Income (dollars)	$8499	$19526	$35352	$40893
Poverty Level				
Persons Below Poverty Level	1366	897	1211	1026
Age 65+ Below Poverty Level	214	146	189	158
Households with Public Assistance	145	251	215	97

Industry

Table 5.1.6-9. Employment by Industry for Fernandina Beach, Florida 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Industry	**1970**	**1980**	**1990**	**2000**
Agriculture, Fishing, Mining	79	90	71	25
Construction	169	58	305	341
Business Services	60	68	156	304
Communication/Utilities	63	73	59	161
Manufacturing	921	769	686	442
Financial, Insurance & Real Estate	74	199	220	295
Services	106	186	268	2112
Wholesale/Retail Trade	709	556	1389	1230
Transportation	448	537	916	248
Industry	1970	1980	1990	2000
Agriculture, Fishing, Mining	79	90	71	25
Construction	169	58	305	341
Business Services	60	68	156	304
Communication/Utilities	63	73	59	161
Manufacturing	921	769	686	442
Financial, Insurance & Real Estate	74	199	220	295
Services	106	186	268	2112
Wholesale/Retail Trade	709	556	1389	1230
Transportation	448	537	916	248

Occupation

Table 5.1.6-10. Employment by Occupation for Fernandina Beach, Florida 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Occupation	**1970**	**1980**	**1990**	**2000**
Sales	95	197	426	-
Clerical	381	3630	440	-
Craft	319	385	491	-
Exec/Managerial	318	363	636	-
Farm/Fish/Forest	22	74	90	12
Household Services	114	63	35	-
Laborer/Handler	235	133	162	-
Operative/Transport	391	190	155	-
Service, except Household	517	601	773	-
Technical	15	108	189	-

Fernandina Beach Fishing Demographics

Table 5.1.6-11. Number of Federal Permit (October 2008) by Type for Fernandina Beach, Florida (Source: NMFS 2008).

Type	Permits
ATLANTIC DOLPHIN/WAHOO COMMERCIAL	3
ATLANTIC DOLPHIN/WAHOO CHARTER/ HEADBOAT	9
S. ATLANTIC CHARTER/HEADBOAT FOR PELAGIC FISH	9
KING MACKEREL	1,008
SPINY LOBSTER & TAILING	-,1
ROCK SHRIMP & ENDORSEMENTS	7,7
S. ATL. CHARTER/HEADBOAT FOR SNAPPER-GROUPER	10
SWORDFISH & SHARKS	-,-
S. ATLANTIC SNAPPER-GROUPER (UNLIMITED)	1
S. ATLANTIC SNAPPER-GROUPER (225)	-
SPANISH MACKEREL	1
SOUTH ATLANTIC SHRIMP	7

Table 5.1.6-12. Employment in Fishing Related Industry for Fernandina Beach, Florida (Zip code Business Patterns, U.S. Census Bureau 1998).

Category	NAIC Code	Number Employed
Fishing	114100	3
Seafood Canning	311711	0
Seafood Processing	311712	0
Boat Building	336612	7
Fish and Seafoods	422460	0
Fish and Seafood Markets	445220	10
Marinas	713930	10
Total Fishing Employment		30

5.1.6.2 Atlantic Beach (32233)

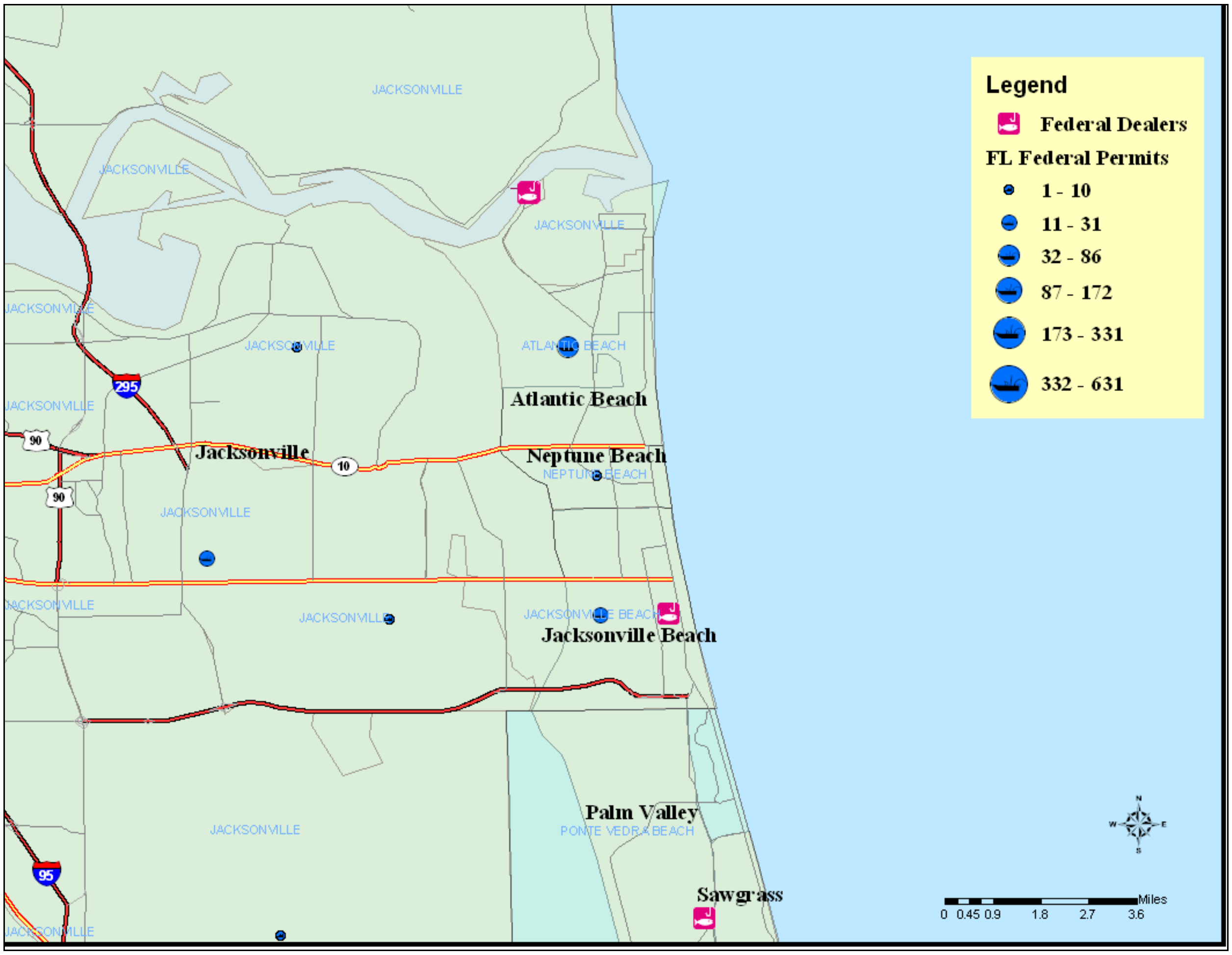

Figure 5.1.6-3. Atlantic Beach, Florida.

The community of Atlantic Beach has remained fairly small throughout its history. The arrival of Henry Flagler's Florida East Coast Railroad in 1900 helped spur development and prominence within this coastal community. However, it was not until the construction of the Mayport Naval Station in the 1940s and the completion of the Matthews Bridge in the 1950s that the area truly became ready for development. Beginning in the 1990s, the Atlantic Beach community embarked on environmental endeavors regarding their aquatic resources. They created the Tideviews Preserve and the Dutton Island Preserve. Among some of the many activities offered in the Dutton Island Preserve, fishing off the pier is a popular activity for park visitors.

Atlantic Beach has seen steady growth in its population. There has been a decline in the percent of the population in the labor force and unemployment has dropped to 3.3 percent in 2000. Average wage and salary rose significantly between 1980 and 1990, but only slightly in 2000. The number of persons living below the poverty level has dropped every decade but still is around 1100 person in 2000. Jobs in the sector of farm, fish and forestry have fluctuated over the past three decades, but dropped to low levels in 2000.

Although there no vessels with federal permits in Atlantic Beach (Table 5.1.6-22) there were 56 persons employed in the fish and seafood sector according to Table 5.1.6-23.

Atlantic Beach Census Demographics

Population

Table 5.1.6-13. Total Persons and Persons by Age category for Atlantic Beach, Florida 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Total Persons and Age Category	1970	1980	1990	2000
Total Persons	.	7847	11636	13474
Persons Age 0-5	.	598	1172	947
Persons Age 6-15	.	1336	1483	1669
Persons Age 16-17	.	351	351	418
Persons Age 18-24	.	1068	1177	945
Persons Age 25-34	.	1421	2236	1727
Persons Age 35-44	.	998	1716	1948
Persons Age 45-54	.	843	1366	2210
Persons Age 55-64	.	580	1131	1040
Persons Age 65+	.	567	1004	1995

Housing Tenure

Table 5.1.6-14. Housing Tenure for Atlantic Beach, Florida 1990-2000. (Source: U.S. Census Bureau).

Percent Renter Occupied	1990	2000
	37.7	35.0
Percent Owner Occupied	**1990**	**2000**
	62.3	65.0

Residence in 1985 and 1995

Table 5.1.6-15. Residence in 1985 and 1995 for Atlantic Beach, Florida 1990-2000. (Source: U.S. Census Bureau).

Different House Same County	1990	2000
	3238	3201
Same House	**1990**	**2000**
	4215	6702

Employment/Unemployment

Table 5.1.6-16. Employment and Unemployment for Atlantic Beach, Florida 1990-2000. (Source: U.S. Census Bureau).

Persons 16 yrs and over	**1990**	**2000**
Percent in labor force	71.8	65.0
Percent unemployed	4.7	3.3

<u>Race</u>

Table 5.1.6-17. Race for Atlantic Beach, Florida 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Race	**1970**	**1980**	**1990**	**2000**
Black Persons	.	1470	1813	1669
Latino Black Persons	.	35	0	28
Latino Persons	.	271	334	559
White Persons	.	5933	9271	10627
Latino White Persons	.	106	164	365

<u>Education</u>

Table 5.1.6-18. Years of Education by Category for those 25 Years and Older for Atlantic Beach, Florida 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Education	**1970**	**1980**	**1990**	**2000**
25+ w/ 0-8 years education	.	343	323	316
25+ w/ 9-11 years education	.	704	896	985
25+ w/ HS diploma	.	1507	1778	2312
25+ w/ 13-15 years. education	.	887	1530	2512
25+ w/ College Degree	.	968	2319	4395
Drop outs	.	78	116	29

<u>Income and Poverty</u>

Table 5.1.6-19. Average Household Wage/Salary and Persons Below the Poverty Level for Atlantic Beach, Florida 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Wage or Salary	**1970**	**1980**	**1990**	**2000**
Average Household Wage/Salary Income (dollars)	.	$18276	$41525	$48353
Poverty Level				
Persons Below Poverty Level	.	1377	1248	1179
Age 65+ Below Poverty Level	.	159	58	110
Households with Public Assistance	.	161	249	128

<u>Industry</u>

Table 5.1.6-20. Employment by Industry for Atlantic Beach, Florida 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Industry	**1970**	**1980**	**1990**	**2000**
Agriculture, Fishing, Mining	.	77	98	24
Construction	.	205	365	521
Business Services	.	104	260	564
Communication/Utilities	.	80	147	219
Manufacturing	.	229	447	462
Financial, Insurance & Real Estate	.	157	230	644
Services	.	320	547	3107
Wholesale/Retail Trade	.	648	2054	1530
Transportation	.	874	1451	293

Occupation

Table 5.1.6-21. Employment by Occupation for Atlantic Beach, Florida 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Occupation	**1970**	**1980**	**1990**	**2000**
Sales	.	462	1064	-
Clerical	.	5250	701	-
Craft	.	379	373	-
Exec/Managerial	.	386	986	-
Farm/Fish/Forest	.	57	86	36
Household Services	.	25	39	-
Laborer/Handler	.	97	165	-
Operative/Transport	.	68	114	-
Service, except Household	.	675	942	-
Technical	.	75	162	-

Atlantic Beach Fishing Demographics

Table 5.1.6-22. Number of Federal Permit by Type for Atlantic Beach, Florida (Source: NMFS 2008).

Type	Permits
ATLANTIC DOLPHIN/WAHOO COMMERCIAL	-
ATLANTIC DOLPHIN/WAHOO CHARTER/ HEADBOAT	-
S. ATLANTIC CHARTER/HEADBOAT FOR PELAGIC FISH	-
KING MACKEREL	-
SPINY LOBSTER & TAILING	-,-
ROCK SHRIMP & ENDORSEMENTS	-,-
S. ATL. CHARTER/HEADBOAT FOR SNAPPER-GROUPER	-
SWORDFISH & SHARKS	-,-
S. ATLANTIC SNAPPER-GROUPER (UNLIMITED)	-
S. ATLANTIC SNAPPER-GROUPER (225)	-
SPANISH MACKEREL	-
SOUTH ATLANTIC SHRIMP	-

Table 5.1.6-23. Employment in Fishing Related Industry for Atlantic Beach, Florida (Zip code Business Patterns, U.S. Census Bureau 1998).

Category	NAIC Code	Number Employed
Fishing	114100	3
Seafood Canning	311711	0
Seafood Processing	311712	0
Boat Building	336612	0
Fish and Seafoods	422460	56
Fish and Seafood Markets	445220	0
Marinas	713930	3
Total Fishing Employment		62

5.1.6.3 St. Augustine (32084, 32085, 32086, 32092)

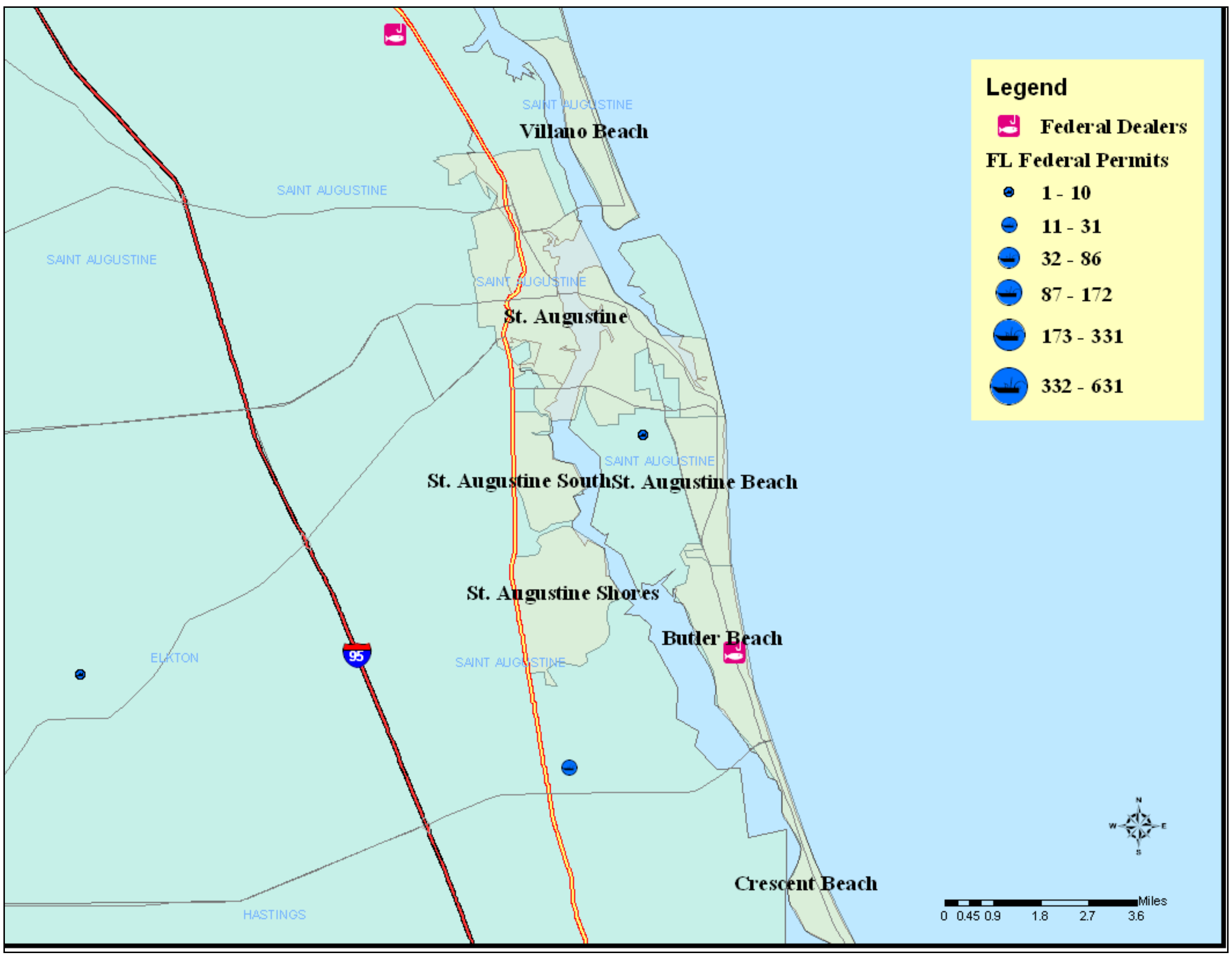

Figure 5.1.6-4. St. Augustine, Florida.

St. Augustine has the distinction of being the oldest European city in the United States. First sited by the Spanish explorer Don Juan Ponce de Leon in 1513, it was not settled until 1565 by Don Pedro Menendez de Aviles, a Spanish admiral, in the name of King Phillip II. The town's boom did not occur until the 1880s with the arrival of Henry M.

Flagler. His goal was to turn St. Augustine into a winter resort for wealthy Americans. It was this thinking that transformed the town. The construction of the railroad linked the city with much of the east coast. Flagler built three large hotels to help fulfill his dream of a tourist mecca. By the mid-1900s, St. Augustine's local economy was dominated by tourism.

The commercial fishing industry began in the St. Augustine/Fernandina area around 1900 with the arrival of a Sicilian immigrant named Sallecito Salvador. He placed an engine on his boat that allowed him to pull a shrimp seine across the ocean floor in 1902, and in 1906, he began his company, S. Salvador & Sons. Salvador moved his business to St. Augustine in 1922, where it thrived until 1929. Shrimp catch levels soared from about 1934 to 1940. These stories illustrate the longstanding culture of fishing in the St. Augustine area and the importance it holds for many of the fishing families there. Commercial fishing still continues at the port, the oldest continuously active port in the United States. Boat building, tourism, and recreational activities are also important to St. Augustine's port.

St. Augustine has seen a steady decline in its population since 1970. Both the percent of population in the labor force and unemployment have remained relatively stable over the years. Average wage and salary has grown steadily, while the number of persons living below the poverty level has dropped. The number of people employed in farm, fish and forestry has also dropped significantly over the past three decades, with the most pronounced decline from 1990 to 2000. In 2008, 3 federal charter/headboat permits were held (Table 5.1.6-33). There is significant employment in fishing related business as there are over 370 people employed in boat building according to Table 5.1.6-34 and another 75 in the seafood processing sector.

St. Augustine Census Demographics

Population

Table 5.1.6-24. Total Persons and Persons by Age category for St. Augustine, Florida 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Total Persons and Age Category	1970	1980	1990	2000
Total Persons	12352	11985	11692	11512
Persons Age 0-5	676	574	696	560
Persons Age 6-15	2550	1708	1304	1069
Persons Age 16-17	510	425	367	214
Persons Age 18-24	1242	1833	1720	1767
Persons Age 25-34	927	1418	1522	1181
Persons Age 35-44	1181	909	1404	1542
Persons Age 45-54	1300	1114	1163	1760
Persons Age 55-64	1540	1363	1098	1187
Persons Age 65+	2197	2529	2418	2232

Housing Tenure

Table 5.1.6-25. Housing Tenure for St. Augustine, Florida 1990-2000. (Source: U.S. Census Bureau).

Percent Renter Occupied	**1990**	**2000**
	37.9	40.3
Percent Owner Occupied	**1990**	**2000**
	62.1	59.7

Residence in 1985 and 1995

Table 5.1.6-26. Residence in 1985 and 1995 for St. Augustine, Florida 1990-2000. (Source: U.S. Census Bureau).

Different House Same County	**1990**	**2000**
	2239	2547
Same House	**1990**	**2000**
	5388	5121

Employment/Unemployment

Table 5.1.6-27. Employment and Unemployment for St. Augustine, Florida 1990-2000. (Source: U.S. Census Bureau).

Persons 16 yrs and over	**1990**	**2000**
Percent in labor force	57.3	61.9
Percent unemployed	5.6	5.4

Race

Table 5.1.6-28. Race for St. Augustine, Florida 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Race	**1970**	**1980**	**1990**	**2000**
Black Persons	2679	2527	2303	1,741
Latino Black Persons	0	45	30	6
Latino Persons	139	367	560	361
White Persons	9673	9383	9154	9,193
Latino White Persons	139	279	438	221

Education

Table 5.1.6-29. Years of Education by Category for those 25 Years and Older for St. Augustine, Florida 1970-2000. (Source: U.S. Census Bureau & MARFIN

Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Education	1970	1980	1990	2000
25+ w/ 0-8 years education	2293	1597	697	519
25+ w/ 9-11 years education	1291	1352	1152	1099
25+ w/ HS diploma	2193	2128	2037	2430
25+ w/ 13-15 years. education	615	1204	1528	2568
25+ w/ College Degree	753	1052	1789	3074
Drop outs	240	165	116	66

Income and Poverty

Table 5.1.6-30. Average Household Wage/Salary and Persons Below the Poverty Level for St. Augustine, Florida 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Wage or Salary	1970	1980	1990	2000
Average Household Wage/Salary Income (dollars)	$6958	$13757	$26572	$32358
Poverty Level				
Persons Below Poverty Level	2927	1876	1697	1664
Age 65+ Below Poverty Level	760	355	301	200
Households with Public Assistance	275	422	372	125

Industry

Table 5.1.6-31. Employment by Industry for St. Augustine, Florida 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Industry	1970	1980	1990	2000
Agriculture, Fishing, Mining	142	126	67	19
Construction	259	327	287	353
Business Services	111	127	253	226
Communication/Utilities	149	109	91	202
Manufacturing	522	441	437	423
Financial, Insurance & Real Estate	342	304	292	420
Services	227	193	249	2827
Wholesale/Retail Trade	1622	1237	2203	1941
Transportation	948	1123	1421	225

Occupation

Table 5.1.6-32. Employment by Occupation for St. Augustine, Florida 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Occupation	1970	1980	1990	2000

Sales	323	510	866	-
Clerical	726	6710	569	-
Craft	568	536	509	-
Exec/Managerial	481	631	536	-
Farm/Fish/Forest	86	141	105	43
Household Services	145	103	36	-
Laborer/Handler	231	220	149	-
Operative/Transport	232	256	175	-
Service, except Household	898	1125	1040	-
Technical	58	124	140	-

St. Augustine Fishing Demographics

Table 5.1.6-33. Number of Federal Permit (October 2008) by Type for St. Augustine, Florida (Source: NMFS 2008).

Type	Permits
ATLANTIC DOLPHIN/WAHOO COMMERCIAL	-
ATLANTIC DOLPHIN/WAHOO CHARTER/ HEADBOAT	1
S. ATLANTIC CHARTER/HEADBOAT FOR PELAGIC FISH	1
KING MACKEREL	-
SPINY LOBSTER & TAILING	-,-
ROCK SHRIMP & ENDORSEMENTS	-,-
S. ATL. CHARTER/HEADBOAT FOR SNAPPER-GROUPER	1
SWORDFISH & SHARKS	-,-
S. ATLANTIC SNAPPER-GROUPER (UNLIMITED)	-
S. ATLANTIC SNAPPER-GROUPER (225)	-
SPANISH MACKEREL	-
SOUTH ATLANTIC SHRIMP	-

Table 5.1.6-34. Employment in Fishing Related Industry for St. Augustine, Florida (Zip code Business Patterns, U.S. Census Bureau 1998).

Category	**NAIC Code**	**Number Employed**
Fishing	114100	0
Seafood Canning	311711	0
Seafood Processing	311712	75
Boat Building	336612	375
Fish and Seafoods	422460	3
Fish and Seafood Markets	445220	0
Marinas	713930	0
Total Fishing Employment		453

5.1.6.4 Ponce Inlet (32127)

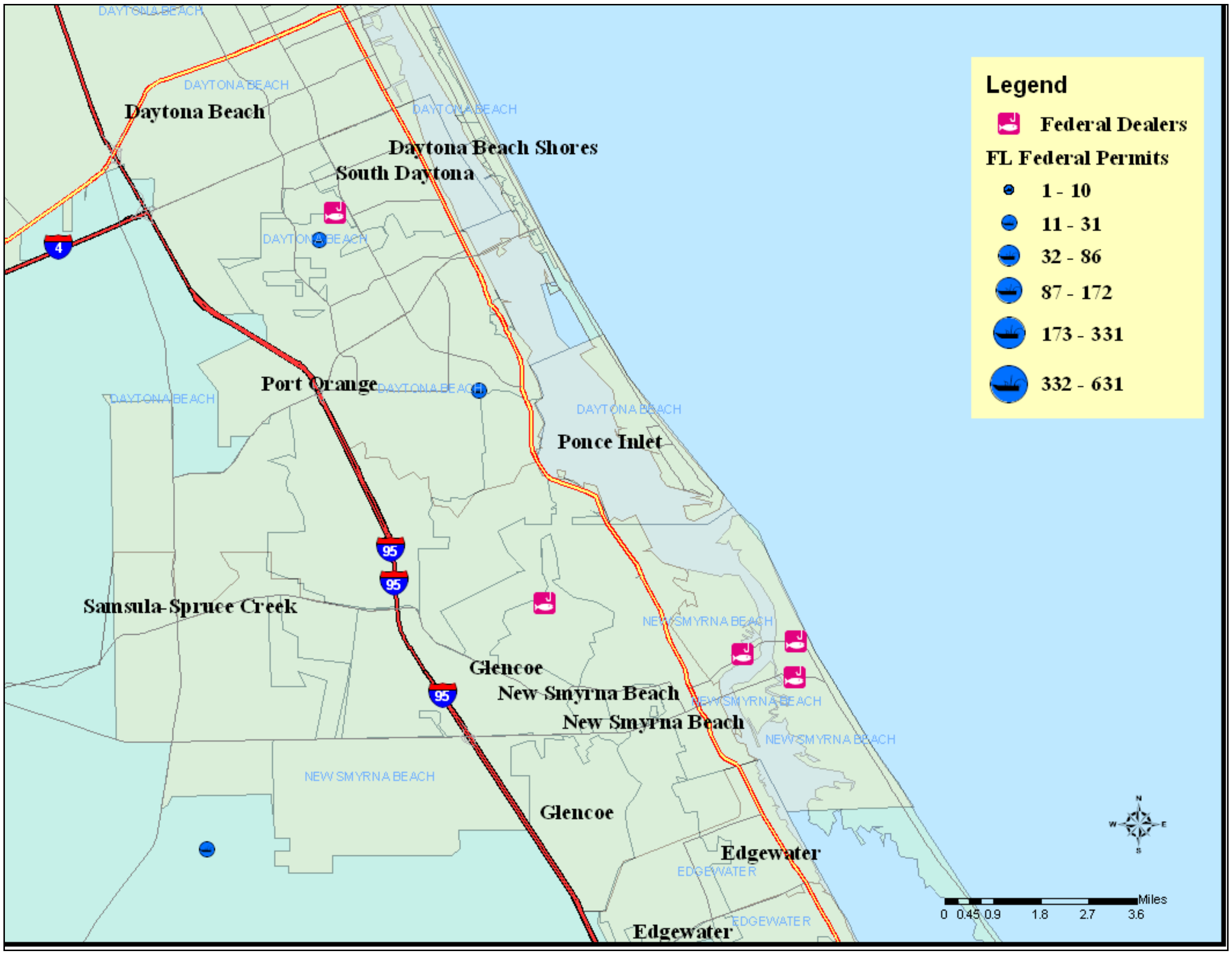

Figure 5.1.6-5. Ponce Inlet, Florida.

The town of Ponce Inlet was originally referred to as the port of mosquitoes until the early twentieth century and is located at the southern boundary of Ponce de Leon Inlet. There is some controversy as to whom actually first stepped foot on Ponce Inlet; perhaps it was Ponce de Leon in 1513 that went ashore to high ground to search for a lost vessel. Others believe it may have been Frenchman Jean Ribault in 1563 (Davies 1995).

Sport fishing became the mainstay for most residents of the Ponce Inlet area. The industry began to grow in the 1950s; however, many found that it was not very profitable. “In the winter the waters were so uncertain that sometimes the boats rocked at the dock for days while the tourist sought other recreation” (Davies 1995). However, when charter fishermen in the Florida Keys heard about the good conditions in the summer months in northern Florida, they would work out of the “growing number of docks from Daytona to the Inlet” (Davies 1995). The arrival of the head boat scared many of the original fishermen because they thought it would ruin the business. Eventually, the locals understood the economic opportunities associated with the head boat. By the 1960s, the sport fishing industry was quite successful for the fishermen of Ponce Inlet (Davies 1995).

The population of Ponce Inlet has grown over the years, but most of that growth came within the last decade. The percent of population in the labor force has remained around 45 percent and unemployment has dropped to a low of 1.9 in 2000 from 4.5 in 1990. Average wage and salary have risen significantly over the years, but so has the number of persons living below the poverty level. The number of people who work in farm, fish and forestry has dropped to fewer than 3 people according to census measures of occupation and industry. In 2008, vessels with federal permits predominantly held Atlantic dolphin/wahoo commercial (10), Atlantic dolphin/wahoo charter (19), south Atlantic charter/headboat for pelagic fish (20), or snapper grouper charter/headboat for snapper grouper (20) permits (Table 5.1.6-44). There is also some fishing related employment according to Table 5.1.6-45, which indicates over 180 people employed in the marinas sector.

Ponce Inlet Census Demographics

Population

Table 5.1.6-35. Total Persons and Persons by Age category for Ponce Inlet, Florida 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Total Persons and Age Category	1970	1980	1990	2000
Total Persons	.	1003	1704	2514
Persons Age 0-5	.	20	55	37
Persons Age 6-15	.	86	70	184
Persons Age 16-17	.	44	24	52
Persons Age 18-24	.	88	104	83
Persons Age 25-34	.	121	185	131
Persons Age 35-44	.	99	250	266
Persons Age 45-54	.	120	190	450
Persons Age 55-64	.	250	350	542
Persons Age 65+	.	163	476	769

Housing Tenure

Table 5.1.6-36. Housing Tenure for Ponce Inlet, Florida 1990-2000. (Source: U.S. Census Bureau).

Percent Renter Occupied	1990	2000
	14.6	9.6
Percent Owner Occupied	**1990**	**2000**
	85.4	90.4

Residence in 1985 and 1995

Table 5.1.6-37. Residence in 1985 and 1995 for Ponce Inlet, Florida 1990-2000. (Source: U.S. Census Bureau).

Different House Same County	**1990**	**2000**
	274	402
Same House	**1990**	**2000**
	716	1250

Employment/Unemployment

Table 5.1.6-38. Employment and Unemployment for Ponce Inlet, Florida 1990-2000. (Source: U.S. Census Bureau).

Persons 16 yrs and over	**1990**	**2000**
Percent in labor force	48.1	45.6
Percent unemployed	4.2	1.9

Race

Table 5.1.6-39. Race for Ponce Inlet, Florida 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Race	**1970**	**1980**	**1990**	**2000**
Black Persons	.	0	1	14
Latino Black Persons	.	0	1	1
Latino Persons	.	16	21	39
White Persons	.	982	1662	2420
Latino White Persons	.	7	20	36

Education

Table 5.1.6-40. Years of Education by Category for those 25 Years and Older for Ponce Inlet, Florida 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Education	**1970**	**1980**	**1990**	**2000**
25+ w/ 0-8 years education	.	52	40	50
25+ w/ 9-11 years education	.	85	145	118
25+ w/ HS diploma	.	265	463	557
25+ w/ 13-15 years. education	.	184	346	556
25+ w/ College Degree	.	167	326	877
Drop outs	.	7	2	0

Income and Poverty

Table 5.1.6-41. Average Household Wage/Salary and Persons Below the Poverty Level for Ponce Inlet, Florida 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Wage or Salary	**1970**	**1980**	**1990**	**2000**
Average Household Wage/Salary Income (dollars)	.	15923	33162	52112
Poverty Level				
Persons Below Poverty Level	.	66	116	128
Age 65+ Below Poverty Level	.	6	15	24
Households with Public Assistance	.	10	22	0

Industry

Table 5.1.6-42. Employment by Industry for Ponce Inlet, Florida 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Industry	**1970**	**1980**	**1990**	**2000**
Agriculture, Fishing, Mining	.	16	20	0
Construction	.	16	40	71
Business Services	.	26	23	67
Communication/Utilities	.	6	13	26
Manufacturing	.	28	57	99
Financial, Insurance & Real Estate	.	21	31	108
Services	.	49	83	518
Wholesale/Retail Trade	.	69	235	238
Transportation	.	107	211	55

Occupation

Table 5.1.6-43. Employment by Occupation for Ponce Inlet, Florida 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Occupation	**1970**	**1980**	**1990**	**2000**
Sales	.	74	131	-
Clerical	.	510	93	-
Craft	.	25	53	-
Exec/Managerial	.	70	121	-
Farm/Fish/Forest	.	16	20	2
Household Services	.	0	0	-
Laborer/Handler	.	0	26	-
Operative/Transport	.	2	19	-
Service, except Household	.	59	113	-
Technical	.	5	28	-

Ponce Inlet Fishing Demographics

Table 5.1.6-44. Number of Federal Permit (October 2008) by Type for Ponce Inlet, Florida (Source: NMFS 2008).

Type	Permits
ATLANTIC DOLPHIN/WAHOO COMMERCIAL	10
ATLANTIC DOLPHIN/WAHOO CHARTER/ HEADBOAT	19
S. ATLANTIC CHARTER/HEADBOAT FOR PELAGIC FISH	20
KING MACKEREL	5
SPINY LOBSTER & TAILING	5,3
ROCK SHRIMP & ENDORSEMENTS	-,-
S. ATL. CHARTER/HEADBOAT FOR SNAPPER-GROUPER	20
SWORDFISH & SHARKS	-,1
S. ATLANTIC SNAPPER-GROUPER (UNLIMITED)	5
S. ATLANTIC SNAPPER-GROUPER (225)	-
SPANISH MACKEREL	9
SOUTH ATLANTIC SHRIMP	1

Table 5.1.6-45. Employment in Fishing Related Industry for Ponce Inlet, Florida (Zip code Business Patterns, U.S. Census Bureau 1998).

Category	NAIC Code	Number Employed
Fishing	114100	0
Seafood Canning	311711	0
Seafood Processing	311712	0
Boat Building	336612	6
Fish and Seafoods	422460	3
Fish and Seafood Markets	445220	0
Marinas	713930	181
Total Fishing Employment		190

5.1.6.5 Merritt Island (32952, 32953)

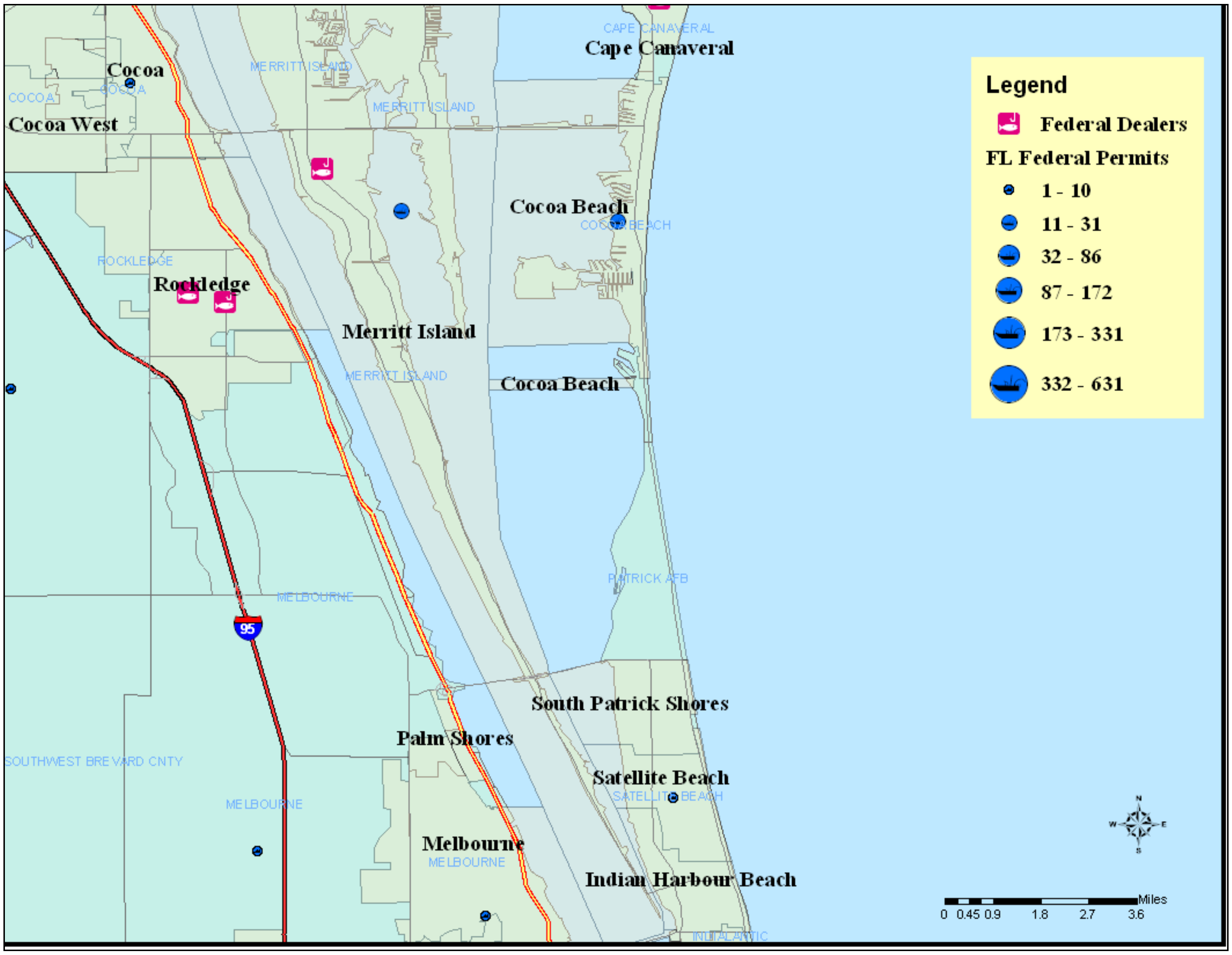

Figure 5.1.6-6. Merritt Island, Florida.

Merritt Island's population has grown slowly over the past three decades. The percent of the population in the labor force has dropped slightly over the past ten years, but unemployment has increased slightly. Average wage and salary have increased to over $40,000 for the year 2000, but the number of persons living under the poverty level has also grown considerably. As for most coastal communities the number of people working in the farm, fish and forestry sector of the economy has dropped significantly over the past decade but has shown a steady decline prior to the 2000 census. Merritt Island has only 26 federal permits issued of which 9 were for charter/headboats (Table 5.1.6-55). There is substantial employment represented in the fishing related sector of boat building with over 1100 persons employed in that sector according to Table 5.1.6-56.

Merritt Island Census Demographics

Population

Table 5.1.6-46. Total Persons and Persons by Age category for Merritt Island, Florida 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Total Persons and Age Category	1970	1980	1990	2000
Total Persons	29233	30708	32886	36091
Persons Age 0-5	2822	1558	2346	2171
Persons Age 6-15	7486	4786	3929	4496
Persons Age 16-17	1095	1380	776	1158
Persons Age 18-24	2343	3448	2476	2191
Persons Age 25-34	4813	3804	5148	3335
Persons Age 35-44	4630	4126	4817	6038
Persons Age 45-54	3170	4308	4278	5182
Persons Age 55-64	1190	3802	4055	4323
Persons Age 65+	1068	3163	5061	7197

Housing Tenure

Table 5.1.6-47. Housing Tenure for Merritt Island, Florida 1990-2000. (Source: U.S. Census Bureau).

Percent Renter Occupied	1990	2000
	27.7	25.1
Percent Owner Occupied	**1990**	**2000**
	72.3	74.9

Residence in 1985 and 1995

Table 5.1.6-48. Residence in 1985 and 1995 for Merritt Island, Florida 1990-2000. (Source: U.S. Census Bureau).

Different House Same County	1990	2000
	7987	9158
Same House	**1990**	**2000**
	15381	18634

Employment/Unemployment

Table 5.1.6-49. Employment and Unemployment for Merritt Island, Florida 1990-2000. (Source: U.S. Census Bureau).

Persons 16 yrs and over	1990	2000
Percent in labor force	65.1	58.4
Percent unemployed	4.2	5.0

Race

Table 5.1.6-50. Race for Merritt Island, Florida 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Race	**1970**	**1980**	**1990**	**2000**
Black Persons	1586	1641	1711	1871
Latino Black Persons	32	3	41	47
Latino Persons	657	759	1067	1381
White Persons	27466	28602	30345	31565
Latino White Persons	520	698	887	995

Education

Table 5.1.6-51. Years of Education by Category for those 25 Years and Older for Merritt Island, Florida 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Education	**1970**	**1980**	**1990**	**2000**
25+ w/ 0-8 years education	1601	1878	877	796
25+ w/ 9-11 years education	2018	2282	2512	2858
25+ w/ HS diploma	5899	6905	6328	7416
25+ w/ 13-15 years. education	2936	4294	6082	7020
25+ w/ College Degree	2417	3844	5457	10002
Drop outs	223	191	98	90

Income and Poverty

Table 5.1.6-52. Average Household Wage/Salary and Persons Below the Poverty Level for Merritt Island, Florida 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Wage or Salary	**1970**	**1980**	**1990**	**2000**
Average Household Wage/Salary Income (dollars)	$12011	$20355	$39680	$43532
Poverty Level				
Persons Below Poverty Level	2176	2512	2331	3334
Age 65+ Below Poverty Level	257	260	287	478
Households with Public Assistance	187	409	636	354

Industry

Table 5.1.6-53. Employment by Industry for Merritt Island, Florida 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Industry	1970	1980	1990	2000
Agriculture, Fishing, Mining	180	165	298	79
Construction	620	1014	1021	1142
Business Services	983	1001	918	1358
Communication/Utilities	312	416	371	494
Manufacturing	3169	2424	2965	2051
Financial, Insurance & Real Estate	2864	2209	2760	987
Services	357	743	1113	7378
Wholesale/Retail Trade	3156	2188	5105	3750
Transportation	1737	3107	3627	632

Occupation

Table 5.1.6-54. Employment by Occupation for Merritt Island, Florida 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Occupation	1970	1980	1990	2000
Sales	677	1805	2231	-
Clerical	1877	22430	2342	-
Craft	1426	1636	1936	-
Exec/Managerial	975	1861	2597	-
Farm/Fish/Forest	89	152	232	79
Household Services	94	13	15	-
Laborer/Handler	220	455	405	-
Operative/Transport	608	449	431	-
Service, except Household	1118	1367	2003	-
Technical	692	793	862	-

Merritt Island Fishing Demographics

Table 5.1.6-55. Number of Federal Permit (October 2008) by Type for Merritt Island, Florida (Source: NMFS 2008).

Type	Permits
ATLANTIC DOLPHIN/WAHOO COMMERCIAL	5
ATLANTIC DOLPHIN/WAHOO CHARTER/ HEADBOAT	3
S. ATLANTIC CHARTER/HEADBOAT FOR PELAGIC FISH	3
KING MACKEREL	5
SPINY LOBSTER & TAILING	-,1
ROCK SHRIMP & ENDORSEMENTS	1,1
S. ATL. CHARTER/HEADBOAT FOR SNAPPER-GROUPER	3
SWORDFISH & SHARKS	-,1
S. ATLANTIC SNAPPER-GROUPER (UNLIMITED)	1
S. ATLANTIC SNAPPER-GROUPER (225)	-
SPANISH MACKEREL	1
SOUTH ATLANTIC SHRIMP	1

Table 5.1.6-56. Employment in Fishing Related Industry for Merritt Island, Florida (Zip code Business Patterns, U.S. Census Bureau 1998).

Category	NAIC Code	Number Employed
Fishing	114100	3
Seafood Canning	311711	0
Seafood Processing	311712	0
Boat Building	336612	1125
Fish and Seafoods	422460	18
Fish and Seafood Markets	445220	7
Marinas	713930	23
Total Fishing Employment		1176

5.1.6.6 Cape Canaveral (32920)

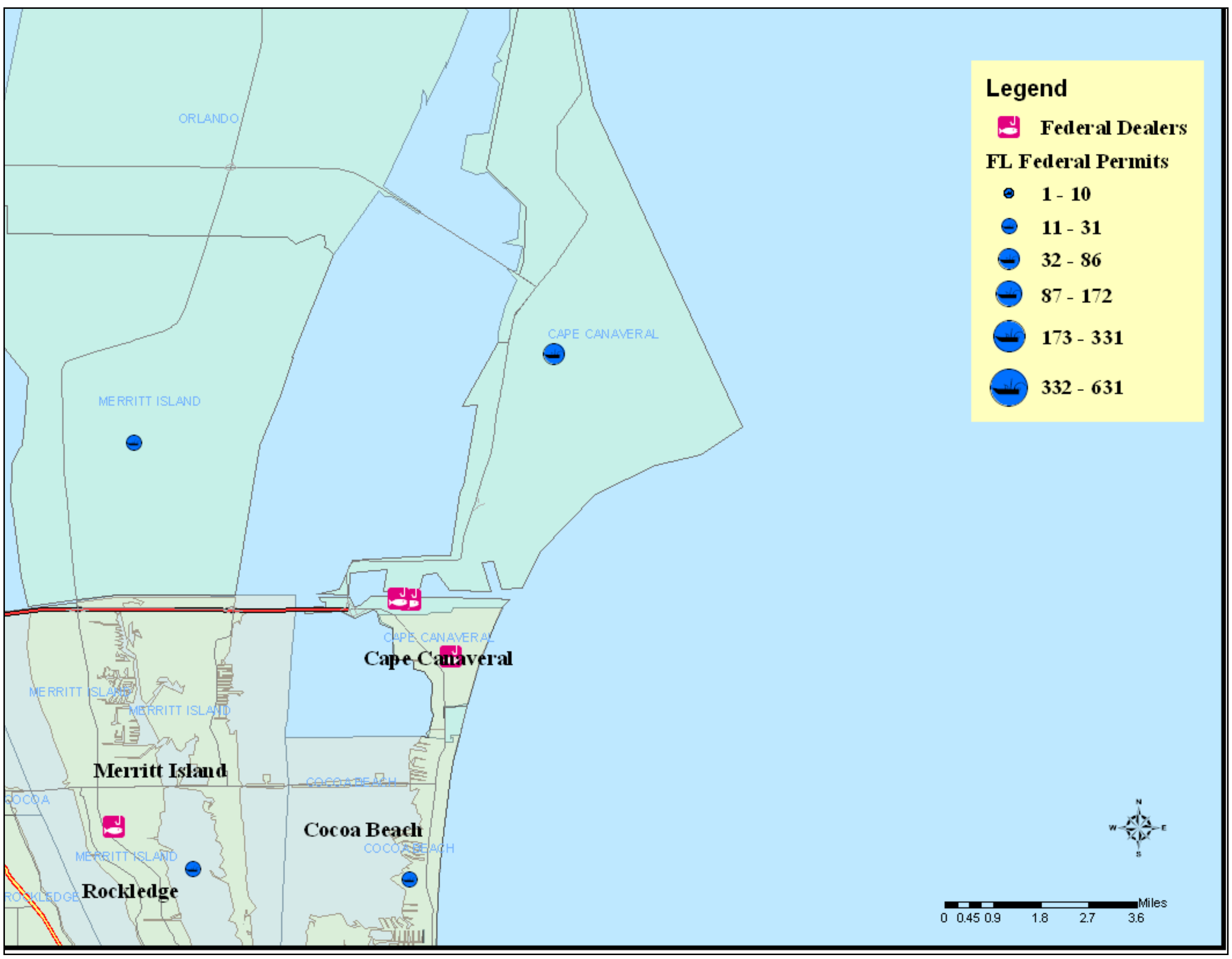

Figure 5.1.6-7. Cape Canaveral, Florida.

Cape Canaveral received its name from the Spanish explorers who found it in the early 1500s. The word "Cape" was used to describe the land formation, and the word "Canaveral" comes from the Spanish word for "canebreak." There is much debate over the exact translation and meaning of the name. A traveling exhibition for the Smithsonian Institute translates Cape Canaveral as “Place of the Cane Bearers,” so named by Spanish explorer Francisco Gordillo after he was shot by an Ais Indian arrow made of cane. Others believe it should be translated as “Point of Reeds” or “Point of Canes” because the Spanish mistook some of the indigenous plants for sugar cane. Whatever the exact translation of the name may be, all agree that it is of Spanish origin.

Even before the area of Cape Canaveral was settled, it was an important landmark for sailors. Once sighted, they would turn northeastward for the journey back to Europe. Douglas D. Dummitt arrived in the area in the 1820s, establishing Dummitt Grove on Merritt Island. He used the Indian River to ship his oranges northward, beginning in 1828. However, the actual geographic area known as Cape Canaveral was not settled until the 1840s. Cut off from the mainland, this small community remained self-reliant until the late 1800s.

The city of Cape Canaveral really began to expand in the early 1920s when a group of retired Orlando journalists were vacationing in the area and appraising its value. They invested over $150,000 in the surrounding beach areas, calling it Journalista, the area today known as Avon-by-the-Sea. Instead of the area becoming solely a beach resort for wealthy inland residents and northerners, many fishermen moved into the area as well. However, with the establishment and expansion of the space program in the United States in the late 1950s and early 1960s, Cape Canaveral, Titusville, Merritt Island, and the surrounding communities truly began to expand.

Today, the residents of Cape Canaveral and the rest of Brevard County rely on the surrounding waters. Port Canaveral, constructed in the 1950s, is the second busiest cruise port in the world and home to many charter fishing companies in the area. The more than three dozen charter fishing boats offer half-day, three-quarter-day, full-day, and gulf stream trips for dolphin, tuna, king and Spanish mackerel, wahoo, redfish, tarpon, snook, snapper, grouper, and many others. Both light tackle flats fishing on the Indian and Banana Rivers and Mosquito Lagoon as well as deep sea fishing are available. Most of the boat captains are second or third generation fishermen. The history of fishing in Brevard County dates back more than 100 years.

Cape Canaveral’s population has grown steadily over the years while the percent of the population in the labor force has dropped. Unemployment has also dropped but remains above 5 percent. Average wage and salary has grown while the number of persons living below the poverty level has dropped from a high in 1990 of 1282 to 1035 in 2000. The number of persons working in the fish, farm and forestry sector has dropped significantly to only 17 persons in 2000 for both occupation and industry. In 2008, vessels with federal permits predominantly held Atlantic dolphin/wahoo commercial (10), Atlantic dolphin/wahoo charter (13), south Atlantic charter/headboat for pelagic fish (11), or snapper grouper charter/headboat for snapper grouper (13) permits (Table 5.1.6-66) with a large portion of the employment in fishing related business in marinas with 125 according to Table 5.1.6-67 with 35 in boat building and 17 in fish and seafood.

Cape Canaveral Census Demographics

Population

Table 5.1.6-57. Total Persons and Persons by Age category for Cape Canaveral, Florida 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Total Persons and Age Category	1970	1980	1990	2000
Total Persons	4258	5733	8014	8954
Persons Age 0-5	352	251	466	308
Persons Age 6-15	618	444	540	509
Persons Age 16-17	81	100	100	163
Persons Age 18-24	838	1165	789	589
Persons Age 25-34	855	1073	1870	1155
Persons Age 35-44	664	639	1239	1504
Persons Age 45-54	435	552	850	1416
Persons Age 55-64	221	734	867	1138
Persons Age 65+	132	721	1293	2172

Housing Tenure

Table 5.1.6-58. Housing Tenure for Cape Canaveral, Florida 1990-2000. (Source: U.S. Census Bureau).

Percent Renter Occupied	1990	2000
	58.1	50.4
Percent Owner Occupied	**1990**	**2000**
	41.9	49.6

Residence in 1985 and 1995

Table 5.1.6-59. Residence in 1985 and 1995 for Cape Canaveral, Florida 1990-2000. (Source: U.S. Census Bureau).

Different House Same County	1990	2000
	2371	2812
Same House	**1990**	**2000**
	2117	3196

Employment/Unemployment

Table 5.1.6-60. Employment and Unemployment for Cape Canaveral, Florida 1990-2000. (Source: U.S. Census Bureau).

Persons 16 yrs and over	1990	2000
Percent in labor force	70.2	59.6
Percent unemployed	6.8	5.3

Race

Table 5.1.6-61. Race for Cape Canaveral, Florida 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Race	**1970**	**1980**	**1990**	**2000**
Black Persons	0	182	277	119
Latino Black Persons	0	0	40	7
Latino Persons	95	159	374	307
White Persons	4242	5410	7545	8,114
Latino White Persons	95	121	300	245

Education

Table 5.1.6-62. Years of Education by Category for those 25 Years and Older for Cape Canaveral, Florida 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Education	**1970**	**1980**	**1990**	**2000**
25+ w/ 0-8 years education	209	280	213	179
25+ w/ 9-11 years education	306	419	814	849
25+ w/ HS diploma	904	1461	1939	2315
25+ w/ 13-15 years. education	458	863	1368	2147
25+ w/ College Degree	430	696	1311	2585
Drop outs	49	58	36	13

Income and Poverty

Table 5.1.6-63. Average Household Wage/Salary and Persons Below the Poverty Level for Cape Canaveral, Florida 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Wage or Salary	**1970**	**1980**	**1990**	**2000**
Average Household Wage/Salary Income (dollars)	$9357	$14616	$27764	$30858
Poverty Level				
Persons Below Poverty Level	332	890	1282	1035
Age 65+ Below Poverty Level	40	52	74	155
Households with Public Assistance	43	115	204	147

Industry

Table 5.1.6-64. Employment by Industry for Cape Canaveral, Florida 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Industry	**1970**	**1980**	**1990**	**2000**
Agriculture, Fishing, Mining	20	32	68	17
Construction	83	276	319	398
Business Services	263	146	309	323
Communication/Utilities	77	89	32	132
Manufacturing	739	584	864	462
Financial, Insurance & Real Estate	722	501	799	283
Services	86	166	201	1722
Wholesale/Retail Trade	656	360	1438	1191
Transportation	327	621	1060	270

Occupation

Table 5.1.6-65. Employment by Occupation for Cape Canaveral, Florida 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Occupation	**1970**	**1980**	**1990**	**2000**
Sales	86	240	638	-
Clerical	492	3840	583	-
Craft	242	410	492	-
Exec/Managerial	175	353	488	-
Farm/Fish/Forest	0	23	123	17
Household Services	0	10	18	-
Laborer/Handler	30	107	143	-
Operative/Transport	119	138	199	-
Service, except Household	216	469	754	-
Technical	137	179	238	-

Cape Canaveral Fishing Demographics

Table 5.1.6-66. Number of Federal Permit (October 2008) by Type for Cape Canaveral, Florida (Source: NMFS 2008).

Type	Permits
ATLANTIC DOLPHIN/WAHOO COMMERCIAL	10
ATLANTIC DOLPHIN/WAHOO CHARTER/ HEADBOAT	13
S. ATLANTIC CHARTER/HEADBOAT FOR PELAGIC FISH	11
KING MACKEREL	6
SPINY LOBSTER & TAILING	2,3
ROCK SHRIMP & ENDORSEMENTS	6,2
S. ATL. CHARTER/HEADBOAT FOR SNAPPER-GROUPER	13
SWORDFISH & SHARKS	-,3
S. ATLANTIC SNAPPER-GROUPER (UNLIMITED)	4
S. ATLANTIC SNAPPER-GROUPER (225)	-
SPANISH MACKEREL	6
SOUTH ATLANTIC SHRIMP	5

Table 5.1.6-67. Employment in Fishing Related Industry for Cape Canaveral, Florida (Zip code Business Patterns, U.S. Census Bureau 1998).

Category	NAIC Code	Number Employed
Fishing	114100	0
Seafood Canning	311711	0
Seafood Processing	311712	0
Boat Building	336612	35
Fish and Seafoods	422460	17
Fish and Seafood Markets	445220	0
Marinas	713930	125
Total Fishing Employment		177

5.1.6.7 Sebastian (32976, 32958)

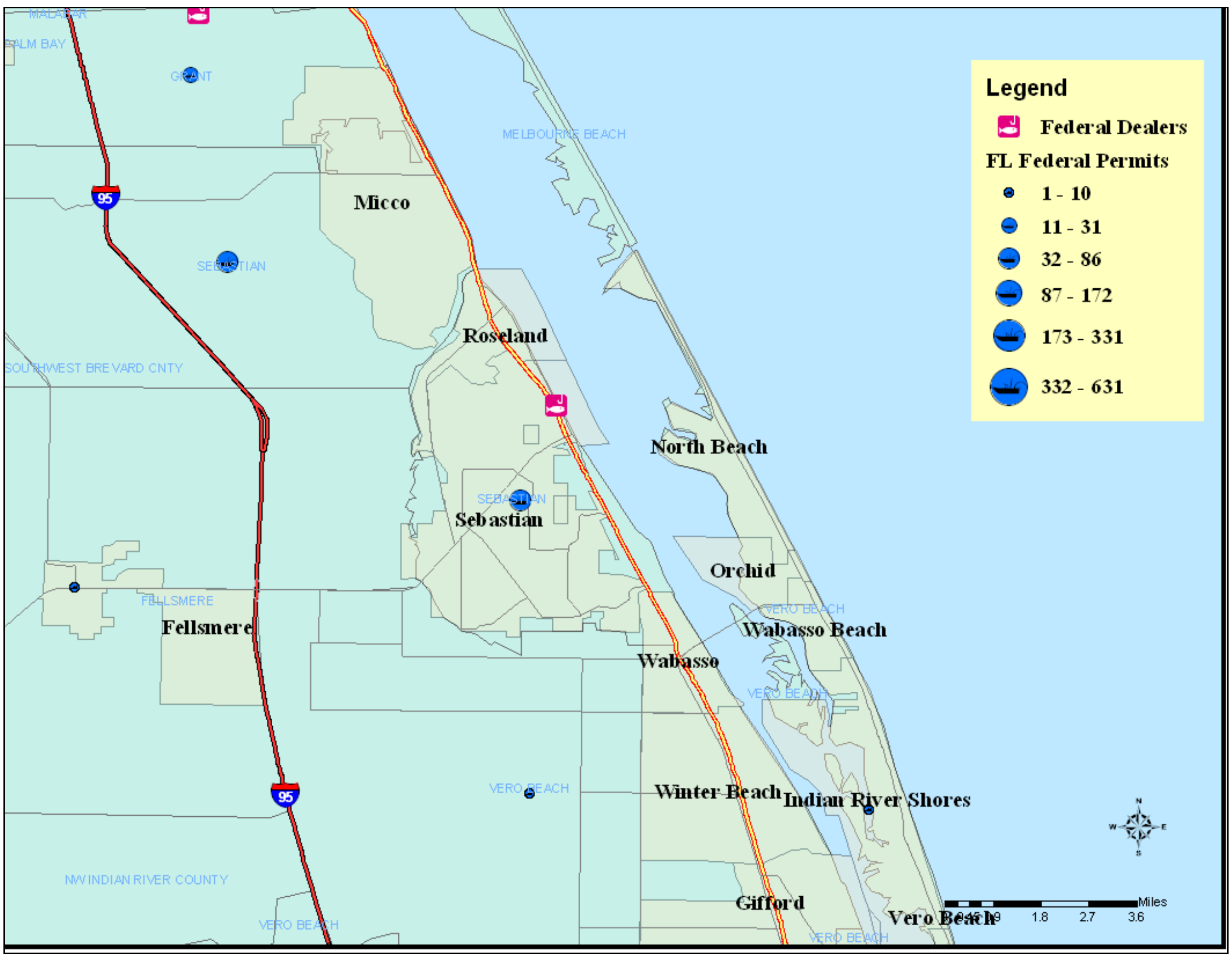

Figure 5.1.6-8. Sebastian, Florida.

Sebastian and Vero Beach are two of the five districts that comprise Indian River County. Both communities were first settled in the 1880s. Communication with the rest of the country and even other counties was difficult. Therefore, settlers had to hunt, trap, and fish for everything. The railroad was completed in time for the Spanish American War, bringing troops to Florida (Newman, 1953). The arrival of the railroad also increased the commercial fishing sector of Sebastian and Vero Beach. Icehouses developed to pack and store the fish around 1900, and the trains exported the products north. The original fish house of one of the very first commercial fishing families still operates today on Indian River Drive in Sebastian.

Today, recreational fishing, along with commercial fishing, is an important part of the Indian River County culture. The Indian River Lagoon is home to more than 700 species of fresh and saltwater fish. Saltwater anglers can fish the Sebastian Inlet and the Sebastian River for snook and red drum in the 20 to 30 pound class. Grouper, snapper, flounder, sheepshead, permit, whiting, blues, and shark can be caught off the Sebastian Inlet pier. Deep sea fishing charters also leave from Sebastian and Vero Beach, offering bottom fishing and blue water trolling for dolphin, sailfish, wahoo, grouper, and cobia.

Sebastian has seen moderate population growth since 1990 to 2000 after a large increase from 1980 to 1990. The percent of the population in the labor force has remained relatively stable while unemployment has dropped from 5.7 percent in 1990 to 3.2 in 2000. Average wage and salary have grown steadily over the past few decades, but the number of persons who live under the poverty level has increased dramatically. The number of persons working in the farm, fish and forestry sectors for occupation and industry has fluctuated since 1980, but has dropped in the most recent census. In 2008, vessels with federal permits predominantly held Atlantic dolphin/wahoo charter (13), south Atlantic charter/headboat for pelagic fish (6), snapper grouper charter/headboat for snapper grouper (13), or rock and south Atlantic shrimp (12) permits (Table 5.1.6-77). There is not much employment reported in the fishing related sectors of Table 5.1.6-78 with only15 in the marinas sector, 9 in fish and seafood and 3 in fishing.

Sebastian Census Demographics

<u>Population</u>

Table 5.1.6-68. Total Persons and Persons by Age category for Sebastian, Florida 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Total Persons and Age Category	1970	1980	1990	2000
Total Persons	.	2831	10158	16450
Persons Age 0-5	.	144	762	909
Persons Age 6-15	.	346	1201	1990
Persons Age 16-17	.	66	138	427
Persons Age 18-24	.	208	499	855
Persons Age 25-34	.	324	1475	1279
Persons Age 35-44	.	226	1267	2507
Persons Age 45-54	.	230	928	2145
Persons Age 55-64	.	587	1323	1848
Persons Age 65+	.	682	2565	4490

Housing Tenure

Table 5.1.6-69. Housing Tenure for Sebastian, Florida 1990-2000. (Source: U.S. Census Bureau).

Percent Renter Occupied	**1990**	**2000**
	19.2	12.8
Percent Owner Occupied	**1990**	**2000**
	80.8	87.2

Residence in 1985 and 1995

Table 5.1.6-70. Residence in 1985 and 1995 for Sebastian, Florida 1990-2000. (Source: U.S. Census Bureau).

Different House Same County	**1990**	**2000**
	1923	2735
Same House	**1990**	**2000**
	3066	7761

Employment/Unemployment

Table 5.1.6-71. Employment and Unemployment for Sebastian, Florida 1990-2000. (Source: U.S. Census Bureau).

Persons 16 yrs and over	**1990**	**2000**
Percent in labor force	51.3	52.0
Percent unemployed	5.7	3.2

Race

Table 5.1.6-72. Race for Sebastian, Florida 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Race	**1970**	**1980**	**1990**	**2000**
Black Persons	.	0	51	503
Latino Black Persons	.	0	0	12
Latino Persons	.	48	90	625
White Persons	.	2808	9856	14748
Latino White Persons	.	27	51	407

Education

Table 5.1.6-73. Years of Education by Category for those 25 Years and Older for Sebastian, Florida 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Education	**1970**	**1980**	**1990**	**2000**
25+ w/ 0-8 years education	.	347	532	401
25+ w/ 9-11 years education	.	413	1473	1986
25+ w/ HS diploma	.	835	2894	4859
25+ w/ 13-15 years. education	.	320	1389	3804
25+ w/ College Degree	.	134	749	2478
Drop outs	.	37	85	52

Income and Poverty

Table 5.1.6-74. Average Household Wage/Salary and Persons Below the Poverty Level for Sebastian, Florida 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Wage or Salary	**1970**	**1980**	**1990**	**2000**
Average Household Wage/Salary Income (dollars)	.	$13218	$28122	$39327
Poverty Level				
Persons Below Poverty Level	.	290	684	1025
Age 65+ Below Poverty Level	.	48	203	223
Households with Public Assistance	.	65	150	126

Industry

Table 5.1.6-75. Employment by Industry for Sebastian, Florida 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Industry	**1970**	**1980**	**1990**	**2000**
Agriculture, Fishing, Mining	.	89	149	82
Construction	.	130	567	602
Business Services	.	34	184	245
Communication/Utilities	.	42	71	222
Manufacturing	.	130	326	408
Financial, Insurance & Real Estate	.	111	264	558
Services	.	77	306	3615
Wholesale/Retail Trade	.	152	1221	1833
Transportation	.	237	1048	171

Occupation

Table 5.1.6-76. Employment by Occupation for Sebastian, Florida 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Occupation	1970	1980	1990	2000
Sales	.	138	547	-
Clerical	.	1560	620	-
Craft	.	197	591	-
Exec/Managerial	.	76	429	-
Farm/Fish/Forest	.	70	139	50
Household Services	.	2	35	-
Laborer/Handler	.	31	193	-
Operative/Transport	.	94	203	-
Service, except Household	.	114	541	-
Technical	.	12	172	-

Sebastian Fishing Demographics

Table 5.1.6-77. Number of Federal Permit (October 2008) by Type for Sebastian, Florida (Source: NMFS 2008).

Type	Permits
ATLANTIC DOLPHIN/WAHOO COMMERCIAL	
ATLANTIC DOLPHIN/WAHOO CHARTER/ HEADBOAT	13
S. ATLANTIC CHARTER/HEADBOAT FOR PELAGIC FISH	11
KING MACKEREL	6
SPINY LOBSTER & TAILING	2,3
ROCK SHRIMP & ENDORSEMENTS	6,2
S. ATL. CHARTER/HEADBOAT FOR SNAPPER-GROUPER	13
SWORDFISH & SHARKS	-,3
S. ATLANTIC SNAPPER-GROUPER (UNLIMITED)	4
S. ATLANTIC SNAPPER-GROUPER (225)	-
SPANISH MACKEREL	6
SOUTH ATLANTIC SHRIMP	5

Table 5.1.6-78. Employment in Fishing Related Industry for Sebastian, Florida (Zip code Business Patterns, U.S. Census Bureau 1998).

Category	NAIC Code	Number Employed
Fishing	114100	3
Seafood Canning	311711	0
Seafood Processing	311712	0
Boat Building	336612	0
Fish and Seafoods	422460	9
Fish and Seafood Markets	445220	0
Marinas	713930	15
Total Fishing Employment		27

5.1.6.8 Fort Pierce (34950)

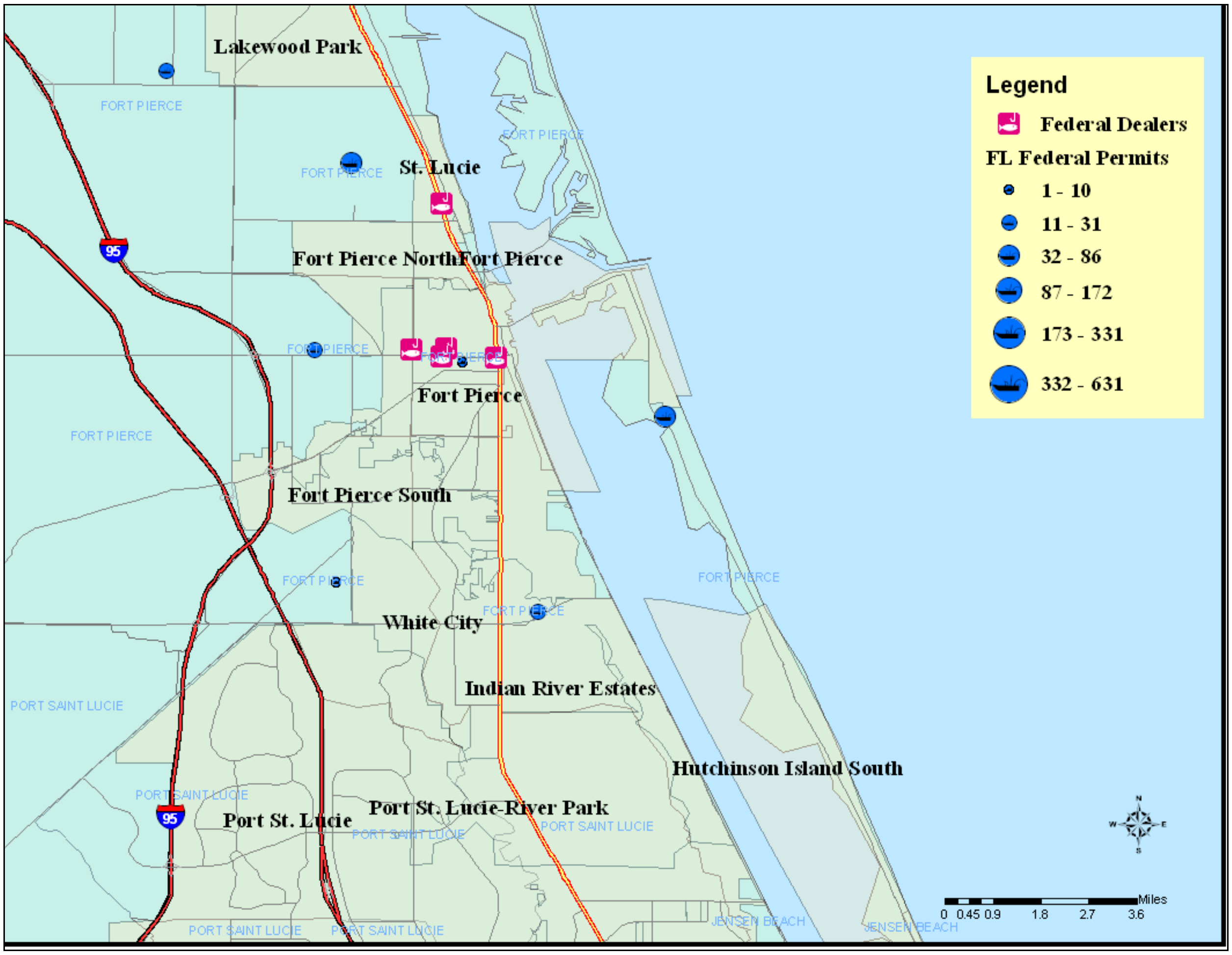

Figure 5.1.6-9. Fort Pierce, Florida.

The Spanish built Fort Santa Lucia on the Jupiter Inlet in 1565 from which the county now draws its name—St. Lucie County. Permanent U.S. inhabitance of Fort Pierce dates back to the Seminole Indian War. U.S. Army Lt. Col. Benjamin Kendrick Pierce, for whom the town is named, built a fort in 1837 to use as the army's headquarters. The war ended in the early 1840s, making way for settlement and development: "Water transportation, fishing and canning fish were key to the area's early economy." The arrival of Henry Flagler's railroad in the early 1900s opened Fort Pierce's economy to the rest of the east coast. Fort Pierce beach was used as a naval base during World War II.

The culture of fishing has been in the area since its inception. Anecdotes passed down from one generation to the next of Fort Pierce residents describe the abundance of fish in the area in the late 1800s and early 1900s. One such story, told by Newman (1953) in her book, *Early Life along the Beautiful Indian River*, tells of a man who bound his shirt at the sleeves and waist and cut a plunging neckline. He would then stand in the water until the shirt was full of fish and then empty it out into a bucket on the shore. In the late 1800s, a man from the nearby town of Titusville helped to create the commercial fishing sector in Fort Pierce. He would bring the fish to Titusville for shipping to the rest of the east coast. The first icehouse for packaging fish was built in 1900 (Newman 1953).

Recreational fishing has also become a popular pastime in Fort Pierce and the rest of St. Lucie County. This is due in part to the fleet of Spanish galleons that sunk off the St. Lucie and Martin Counties coastline. The sunken ships created artificial reefs that have resulted in excellent fishing and diving spots for locals and tourists. The reefs attract spiny lobsters, marlin, snook, flounder, and grouper. Some of the more popular fish in the St. Lucie River include channel bass, snook, ladyfish, jack crevalle, and trout. Black sea bass is another famous catch in the area. Most charter fishing boats in the area offer half, three-quarter, and full-day trips for dolphin, sailfish, wahoo, amberjack, tuna, kingfish, snapper and grouper.

Fort Pierce has seen moderate population growth over the past three decades while the percent of the population in the labor force has remained around 55 percent and unemployment dropped from 12.4 percent in 1990 to 8.8 percent in 2000. Average wage and salary has grown slowly over the past ten years while the number of persons living under the poverty level has risen significantly. The number of people working in farm, fish and forestry has remained relatively high for both occupation and industry over the years with both categories having over 1000 persons in each. In 2008, vessels with federal permits predominantly held Atlantic dolphin/wahoo commercial (49), Spanish mackerel (45), king mackerel (36), south Atlantic charter/headboat for pelagic fish (14), or snapper grouper charter/headboat for snapper grouper (14) permits (Table 5.1.6-88). There are over 260 persons employed in the boat building sector of fishing related employment according to Table 5.1.6-89.

Fort Pierce Census Demographics

Population

Table 5.1.6-79. Total Persons and Persons by Age category for Fort Pierce, Florida 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Total Persons and Age Category	1970	1980	1990	2000
Total Persons	29728	33802	36830	37489
Persons Age 0-5	2825	2672	3770	3319
Persons Age 6-15	6204	5161	5001	5685
Persons Age 16-17	1153	1227	950	961
Persons Age 18-24	3013	4263	3203	3912
Persons Age 25-34	3232	4507	5372	4627
Persons Age 35-44	3038	3110	4245	5004
Persons Age 45-54	3261	3149	3322	4135
Persons Age 55-64	2810	3691	3586	3172
Persons Age 65+	3633	5471	7381	6674

Housing Tenure

Table 5.1.6-80. Housing Tenure for Fort Pierce, Florida 1990-2000. (Source: U.S. Census Bureau).

Percent Renter Occupied	1990	2000
	46.7	47.0
Percent Owner Occupied	**1990**	**2000**
	53.3	53.0

Residence in 1985 and 1995

Table 5.1.6-81. Residence in 1985 and 1995 for Fort Pierce, Florida 1990-2000. (Source: U.S. Census Bureau).

Different House Same County	1990	2000
	10927	10892
Same House	**1990**	**2000**
	15288	16134

Employment/Unemployment

Table 5.1.6-82. Employment and Unemployment for Fort Pierce, Florida 1990-2000. (Source: U.S. Census Bureau).

Persons 16 yrs and over	1990	2000
Percent in labor force	55.0	55.1
Percent unemployed	12.4	8.8

Race

Table 5.1.6-83. Race for Fort Pierce, Florida 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Race	1970	1980	1990	2000
Black Persons	14422	14600	15666	15109
Latino Black Persons	17	63	197	217
Latino Persons	37	736	2168	5629
White Persons	15289	18978	19807	15516
Latino White Persons	20	622	851	3069

Education

Table 5.1.6-84. Years of Education by Category for those 25 Years and Older for Fort Pierce, Florida 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Education	1970	1980	1990	2000
25+ w/ 0-8 years education	5802	5688	4386	4737
25+ w/ 9-11 years education	3515	3786	5929	7004
25+ w/ HS diploma	3872	5936	6091	6839
25+ w/ 13-15 years. education	1585	2710	3590	5549
25+ w/ College Degree	1200	1808	2691	4229
Drop outs	696	753	612	1025

Income and Poverty

Table 5.1.6-85. Average Household Wage/Salary and Persons Below the Poverty Level for Fort Pierce, Florida 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Wage or Salary	1970	1980	1990	2000
Average Household Wage/Salary Income (dollars)	$6273	$13564	$23595	$25121
Poverty Level				
Persons Below Poverty Level	10006	9135	10591	11471
Age 65+ Below Poverty Level	1337	1129	1145	1168
Households with Public Assistance	857	1503	1660	863

Industry

Table 5.1.6-86. Employment by Industry for Fort Pierce, Florida 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Industry	1970	1980	1990	2000
Agriculture, Fishing, Mining	2460	1838	1324	1119
Construction	885	1258	1100	1803
Business Services	260	467	521	388
Communication/Utilities	315	693	463	365
Manufacturing	846	1149	962	1139
Financial, Insurance & Real Estate	342	485	593	625
Services	440	693	661	6453
Wholesale/Retail Trade	3110	1916	4277	3822
Transportation	2405	3005	3387	433

Occupation

Table 5.1.6-87. Employment by Occupation for Fort Pierce, Florida 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Occupation	1970	1980	1990	2000
Sales	749	1504	1658	-
Clerical	1267	15320	1869	-
Craft	1244	1786	1407	-
Exec/Managerial	891	1104	1072	-
Farm/Fish/Forest	2095	1568	1313	1289
Household Services	368	176	108	-
Laborer/Handler	884	870	805	-
Operative/Transport	876	746	578	-
Service, except Household	1708	1895	2552	-
Technical	54	155	251	-

Fort Pierce Fishing Demographics

Table 5.1.6-88. Number of Federal Permit by Type for Fort Pierce, Florida (Source: NMFS 2008).

Type	Permits
ATLANTIC DOLPHIN/WAHOO COMMERCIAL	49
ATLANTIC DOLPHIN/WAHOO CHARTER/ HEADBOAT	14
S. ATLANTIC CHARTER/HEADBOAT FOR PELAGIC FISH	14
GOLDEN CRAB	1
KING MACKEREL	37
SPINY LOBSTER & TAILING	2,3
ROCK SHRIMP & ENDORSEMENTS	-,-
S. ATL. CHARTER/HEADBOAT FOR SNAPPER-GROUPER	14
SWORDFISH & SHARKS	14,14
S. ATLANTIC SNAPPER-GROUPER (UNLIMITED)	3
S. ATLANTIC SNAPPER-GROUPER (225)	4
SPANISH MACKEREL	45
SOUTH ATLANTIC SHRIMP	-

Table 5.1.6-89. Employment in Fishing Related Industry for Fort Pierce, Florida (Zip code Business Patterns, U.S. Census Bureau 1998).

Category	NAIC Code	Number Employed
Fishing	114100	12
Seafood Canning	311711	0
Seafood Processing	311712	0
Boat Building	336612	265
Fish and Seafoods	422460	7
Fish and Seafood Markets	445220	3
Marinas	713930	21
Total Fishing Employment		308

5.1.6.9 Jupiter (33458, 33468, 33469, 33477, 33478)

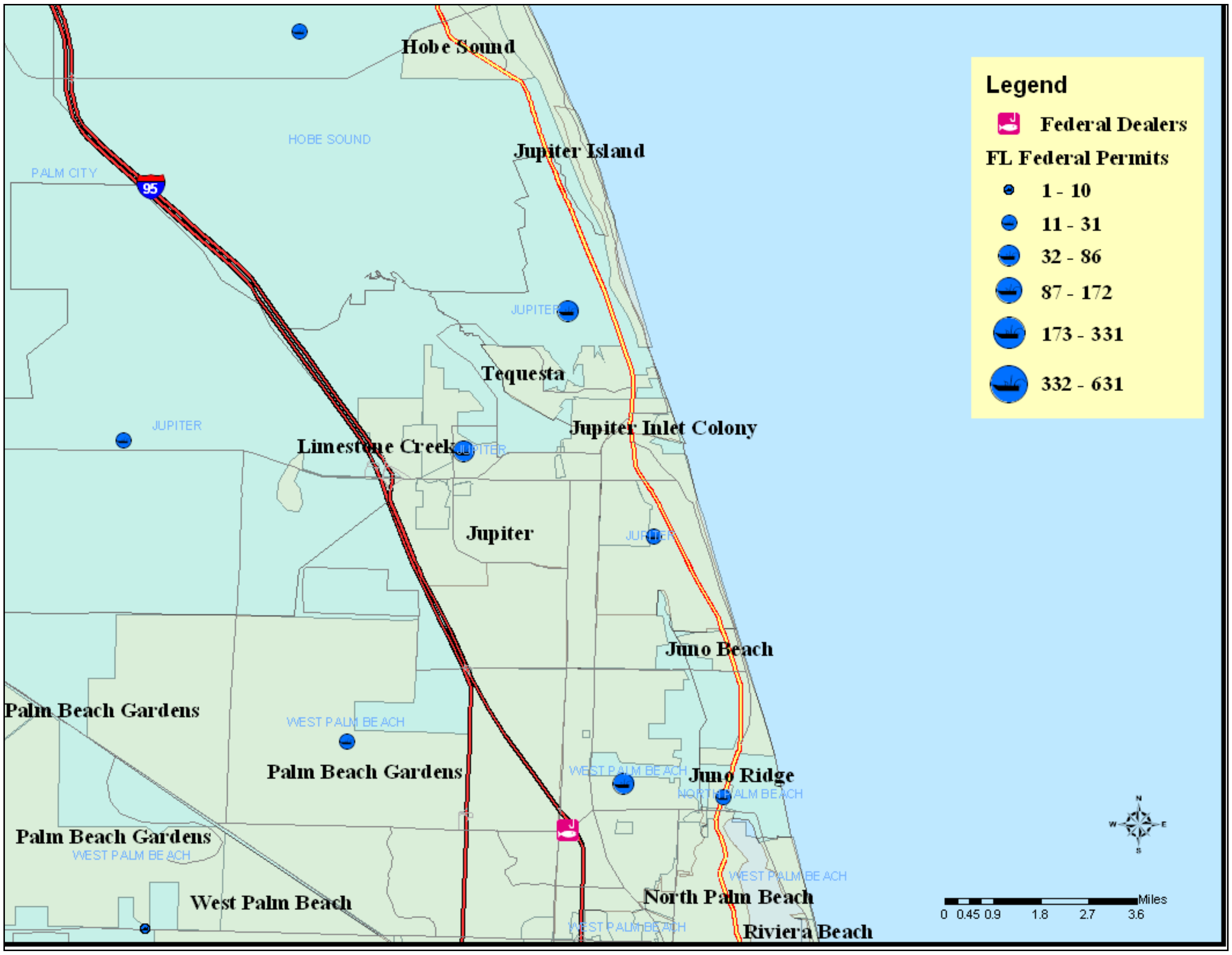

Figure 5.1.6-10. Jupiter, Florida.

The name Jupiter derives from the original inhabitants of the area, the Jeaga Indians. The Native Americans called themselves Jobe, so the Spanish explorers called the inlet the Jobe River. The English settlers who arrived in the 1760s thought the name was Jove, a mythological god also known as Jupiter. Jupiter first became famous when Jonathan Dickinson's boat the "Reformation" was shipwrecked along the coast in 1696. However, it was not until 1821 that real development of the area began. Eusebio Gomez was given 12,000 acres in a land grant in 1815. In 1821, he "started the real estate business on Jupiter Island by selling 8,000 of his acres for $8,000" (Reed 1955).

Sport fishermen have been present in the Jupiter Island region since the 1800s. Stanley (1988) lists numerous species of fish that were and still are popular in Jupiter Island. Snook, tarpon, mangrove snapper, and jack crevalle were some of the most desired fish. Later, with the advancement of boat technology, species in the Gulf Stream, such as sailfish, dolphin, wahoo, and King mackerel became popular catches of the local fishermen.

Two events of the late 1920s decreased some of the fishing in the area. A hurricane struck Lake Okeechobee in 1928. The devastation it caused led to the Okeechobee Flood Control Project. The project created high levels of silt and mud around Jupiter Island, causing a severe decline in the snapper and grouper populations, "two of the most sought after food fish" (Stanley 1988). However, this did not diminish the appeal of sport fishing. J.D. Bassett moved from Virginia to Palm Beach in 1925. He was one of the most avid fishermen in Jupiter. "He made the trip to and from Palm Beach so often that the captain of his boat said, 'Mr. Bassett, you come up here almost every day. Why don't you just move up here'" (Stanley 1988). Bassett was not the only person drawn to Jupiter's waters.

Many of the fishermen in Jupiter practice catch and release. "In February 1986, three Palm Beach-based sportfishing boats caught and released 72 sailfish in a span of five hours five miles east of the Jupiter Island Beach Club" (Stanley 1988). Many of those who enjoy fishing Jupiter Island today are said to be descended from those families that have been fishing the area for decades.

Jupiter has seen fairly steady population growth with its 2000 population reaching 39,314. The labor force has remained fairly constant with just over 60 percent of the population participating. Unemployment has also remained low at 3.3 percent for both 1990 and 2000. Average wage and salary have risen to a high of $54, 945 and the number of persons living under the poverty level has also climbed to a high of 1885 in 2000. The number of people working in farm, fish and forestry occupations and industry reached a peak in 1990 but has since declined dramatically in 2000. In 2008, vessels with federal permits predominantly held Atlantic dolphin/wahoo commercial (68), mackerel (69/66), or south Atlantic charter/headboat for pelagic fish (28) permits Table 5.9.3.1 and most of them have coastal pelagic permits with 20 holding snapper grouper class 1 permits. There is some fishing related employment according to Table 5.1.6-100 with 40 persons employed in the marinas sector and 16 in fish and seafood.

Jupiter Census Demographics

Population

Table 5.1.6-90. Total Persons and Persons by Age category for Jupiter, Florida 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Total Persons and Age Category	1970	1980	1990	2000
Total Persons	.	9868	24986	39314
Persons Age 0-5	.	655	1847	2619
Persons Age 6-15	.	1233	2568	4579
Persons Age 16-17	.	284	478	908
Persons Age 18-24	.	1160	1677	2018
Persons Age 25-34	.	1849	4609	4540
Persons Age 35-44	.	1115	4396	6868
Persons Age 45-54	.	902	2328	5939
Persons Age 55-64	.	994	2763	4469
Persons Age 65+	.	1533	4320	7374

Housing Tenure

Table 5.1.6-91. Housing Tenure for Jupiter, Florida 1990-2000. (Source: U.S. Census Bureau).

Percent Renter Occupied	1990	2000
	28.2	19.2
Percent Owner Occupied	**1990**	**2000**
	71.8	80.8

Residence in 1985 and 1995

Table 5.1.6-92. Residence in 1985 and 1995 for Jupiter, Florida 1990-2000. (Source: U.S. Census Bureau).

Different House Same County	1990	2000
	7270	8997
Same House	**1990**	**2000**
	7191	18257

Employment/Unemployment

Table 5.1.6-93. Employment and Unemployment for Jupiter, Florida 1990-2000. (Source: U.S. Census Bureau).

Persons 16 yrs and over	1990	2000
Percent in labor force	66.0	61.7
Percent unemployed	3.3	3.3

Race

Table 5.1.6-94. Race for Jupiter, Florida 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Race	1970	1980	1990	2000
Black Persons	.	90	242	461
Latino Black Persons	.	2	24	19
Latino Persons	.	128	668	2881
White Persons	.	9698	24550	35152
Latino White Persons	.	114	617	2155

Education

Table 5.1.6-95. Years of Education by Category for those 25 Years and Older for Jupiter, Florida 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Education	1970	1980	1990	2000
25+ w/ 0-8 years education	.	517	494	1153
25+ w/ 9-11 years education	.	1014	1826	2003
25+ w/ HS diploma	.	2712	5498	7725
25+ w/ 13-15 years. education	.	1164	4083	7407
25+ w/ College Degree	.	986	5020	13165
Drop outs	.	88	72	133

Income and Poverty

Table 5.1.6-96. Average Household Wage/Salary and Persons Below the Poverty Level for Jupiter, Florida 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Wage or Salary	1970	1980	1990	2000
Average Household Wage/Salary Income (dollars)	.	$19706	$45280	$54945
Poverty Level				
Persons Below Poverty Level	.	506	1450	1885
Age 65+ Below Poverty Level	.	69	259	340
Households with Public Assistance	.	111	194	109

Industry

Table 5.1.6-97. Employment by Industry for Jupiter, Florida 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Industry	1970	1980	1990	2000
Agriculture, Fishing, Mining	.	96	286	45
Construction	.	727	1095	1386
Business Services	.	186	705	1686
Communication/Utilities	.	196	494	896
Manufacturing	.	866	1733	1389
Financial, Insurance & Real Estate	.	782	1471	1738
Services	.	542	1487	9725
Wholesale/Retail Trade	.	760	4321	4334
Transportation	.	882	2962	594

Occupation

Table 5.1.6-98. Employment by Occupation for Jupiter, Florida 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Occupation	1970	1980	1990	2000
Sales	.	536	2299	-
Clerical	.	8230	1758	-
Craft	.	919	1303	-
Exec/Managerial	.	461	1898	-
Farm/Fish/Forest	.	118	226	58
Household Services	.	6	46	-
Laborer/Handler	.	201	207	-
Operative/Transport	.	184	289	-
Service, except Household	.	579	1764	-
Technical	.	96	535	-

Jupiter Fishing Demographics

Table 5.1.6-99. Number of Federal Permit (October 2008) by Type for Jupiter, Florida (Source: NMFS 2008).

Type	Permits
ATLANTIC DOLPHIN/WAHOO COMMERCIAL	68
ATLANTIC DOLPHIN/WAHOO CHARTER/ HEADBOAT	25
S. ATLANTIC CHARTER/HEADBOAT FOR PELAGIC FISH	28
KING MACKEREL	66
SPINY LOBSTER & TAILING	9,8
ROCK SHRIMP & ENDORSEMENTS	1,-
S. ATL. CHARTER/HEADBOAT FOR SNAPPER-GROUPER	40
SWORDFISH & SHARKS	3,3
S. ATLANTIC SNAPPER-GROUPER (UNLIMITED)	11
S. ATLANTIC SNAPPER-GROUPER (225)	6
SPANISH MACKEREL	69
SOUTH ATLANTIC SHRIMP	2

Table 5.1.6-100. Employment in Fishing Related Industry for Jupiter, Florida (Zip code Business Patterns, U.S. Census Bureau 1998).

Category	NAIC Code	Number Employed
Fishing	114100	6
Seafood Canning	311711	0
Seafood Processing	311712	0
Boat Building	336612	0
Fish and Seafoods	422460	15
Fish and Seafood Markets	445220	0
Marinas	713930	40
Total Fishing Employment		61

5.1.6.10 Palm Beach (33480)

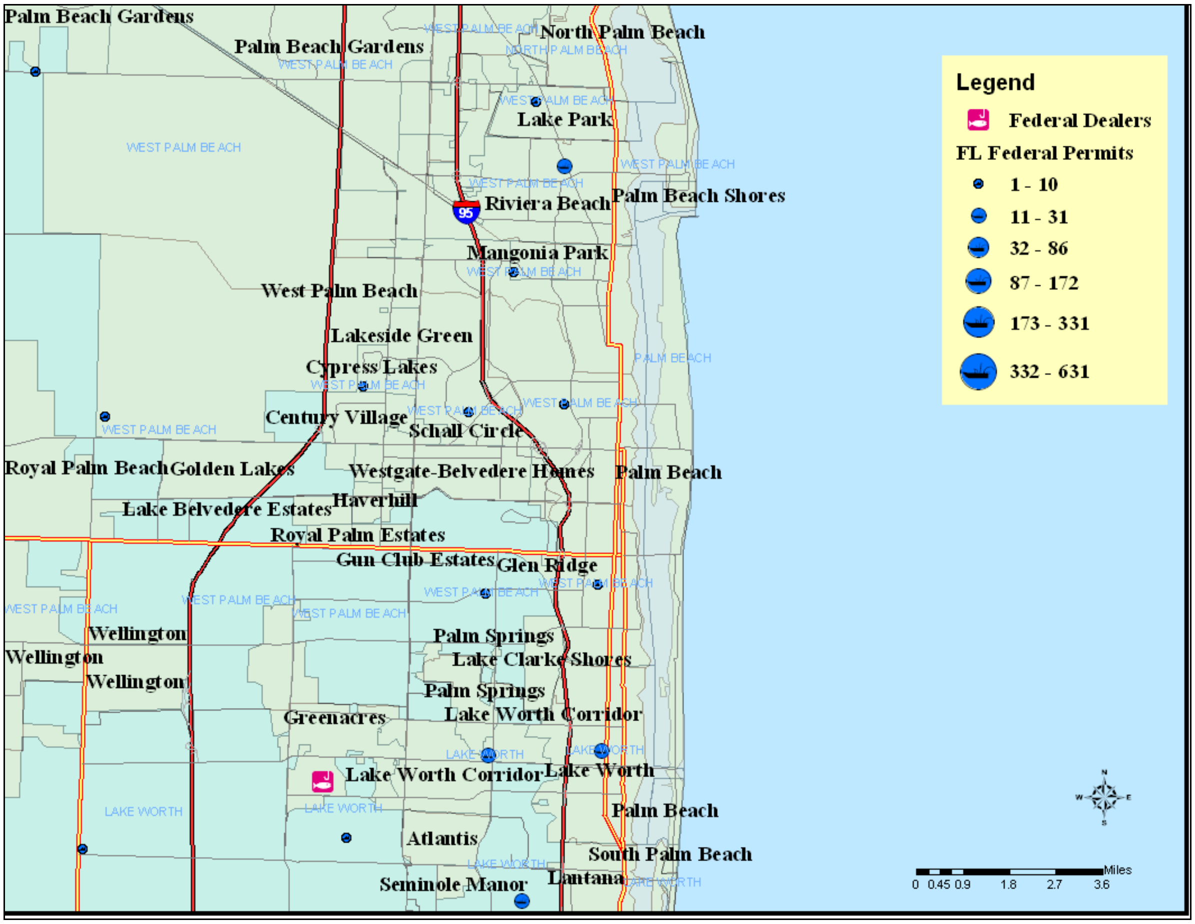

Figure 5.1.6-11. Palm Beach, Florida.

Palm Beach was originally known as Lake Worth. The name was changed to Palm Beach in the 1900s, when a man from Philadelphia noticed the coconut palm trees growing near the lake. In 1878, a ship named the “Providencia” was sailing from South America back to Barcelona with a shipment of coconuts. The ship wrecked on the beach and hundreds “of the coconuts washed ashore, embedded themselves in the sandy beaches, and sprouted into young trees” (Spencer 1975).

Life for the early settlers was difficult. The only lumber available to build their homes was from wood washed ashore from shipwrecks. Residents of Palm Beach had to sail north to Titusville for supplies, such as flour, meal, and other staples (Spencer 1975). Most of the original settlers, prior to 1900, were from Michigan, Illinois, Ohio, Iowa, and Wisconsin. A.O. Lang, a German horticulturist and one of the first residents of Palm Beach, planted numerous citrus fruit trees, such as limes, lemons, oranges, and pineapples (First Federal Savings and Loan Association of Lake Worth 1967).

Citrus groves were not the only source of food and income for the residents of Palm Beach. Fish were plentiful for the early settlers. The importance of fish dates back to the Native Americans who once inhabited the land. They partook in shark-fishing, using the teeth for cutting, the vertebrae as ornaments, and the rest for meat. Shellfish were an important part of the Indians diet as well (McGoun 1998).

The western part of Palm Beach County was known for its catfish industry. The arrival of Henry Flagler's Florida East Coast Railroad assisted in increasing the profitability of the catfish industry in Palm Beach, making it easier to ship the fish northward (McGoun 1998). However, during WWII, fishermen were not only retrieving fish from the waters. West Palm Beach was an embarkation point for the Air Force bomber crews. German submarines would sit offshore and sink US military vessels. "In the early days of the war, local fishermen would go out and pick up survivors from these ill-fated ships" (First Federal Savings and Loan Association of Lake Worth 1967).

The Frontier days of 1873 to 1893, pioneers called the area from Jupiter to Hypoluxo the "Lake Worth Region" and traveled by boat from one homestead to another. H.F. Hammon was the first to claim a homestead in the area that is now Palm Beach. E.N. "Cap" Dimick was the most influential settler by being the first hotelier in Palm Beach and the first Mayor. Most of his family had settled in the area by 1876 and his descendants still remain.

Palm Beach has seen relatively slight population growth over the past two decades. It has a low percentage of its population in the labor force with only 31 percent and unemployment is low at 3.3 percent. Average wage and salary is extremely high at $94,562 and the number of people living below the poverty line has remained fairly constant at 551. The number of persons working in farm, fish, and forestry occupation and industry has dropped considerably since 1990 as is the case for most coastal communities. Table 5.1.6-110 indicates there are 59 federal permits issued and about one third of them hold mackerel permits. There is relatively little fishing related employment according to Table 5.1.6-111 with only 3 in the fishing sector and 3 in marinas.

Palm Beach Census Demographics

Population

Table 5.1.6-101. Total Persons and Persons by Age category for Palm Beach, Florida 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Total Persons and Age Category	1970	1980	1990	2000
Total Persons	.	9729	9814	10374
Persons Age 0-5	.	115	222	302
Persons Age 6-15	.	505	357	644
Persons Age 16-17	.	168	115	78
Persons Age 18-24	.	347	253	121
Persons Age 25-34	.	575	527	456
Persons Age 35-44	.	623	917	744
Persons Age 45-54	.	1148	812	1131
Persons Age 55-64	.	1682	1443	1414
Persons Age 65+	.	4530	5168	5484

Housing Tenure

Table 5.1.6-102. Housing Tenure for Palm Beach, Florida 1990-2000. (Source: U.S. Census Bureau).

Percent Renter Occupied	**1990**	**2000**
	22.5	16.1
Percent Owner Occupied	**1990**	**2000**
	77.5	83.9

Residence in 1985 and 1995

Table 5.1.6-103. Residence in 1985 and 1995 for Palm Beach, Florida 1990-2000. (Source: U.S. Census Bureau).

Different House Same County	**1990**	**2000**
	1763	1826
Same House	**1990**	**2000**
	5853	6236

Employment/Unemployment

Table 5.1.6-104. Employment and Unemployment for Palm Beach, Florida 1990-2000. (Source: U.S. Census Bureau).

Persons 16 yrs and over	**1990**	**2000**
Percent in labor force	35.2	31.6
Percent unemployed	3.5	3.3

Race

Table 5.1.6-105. Race for Palm Beach, Florida 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Race	**1970**	**1980**	**1990**	**2000**
Black Persons	.	64	52	262
Latino Black Persons	.	7	6	7
Latino Persons	.	272	266	268
White Persons	.	9640	9456	9817
Latino White Persons	.	254	249	232

Education

Table 5.1.6-106. Years of Education by Category for those 25 Years and Older for Palm Beach, Florida 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Education	1970	1980	1990	2000
25+ w/ 0-8 years education	.	381	148	62
25+ w/ 9-11 years education	.	503	360	319
25+ w/ HS diploma	.	2235	1736	1276
25+ w/ 13-15 years. education	.	2209	2293	2093
25+ w/ College Degree	.	3230	3827	5461
Drop outs	.	13	0	18

Income and Poverty

Table 5.1.6-107. Average Household Wage/Salary and Persons Below the Poverty Level for Palm Beach, Florida 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Wage or Salary	1970	1980	1990	2000
Average Household Wage/Salary Income (dollars)	.	$29092	$78972	$94562
Poverty Level				
Persons Below Poverty Level	.	484	577	551
Age 65+ Below Poverty Level	.	155	215	161
Households with Public Assistance	.	133	125	10

Industry

Table 5.1.6-108. Employment by Industry for Palm Beach, Florida 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Industry	1970	1980	1990	2000
Agriculture, Fishing, Mining	.	47	16	18
Construction	.	100	121	86
Business Services	.	185	142	469
Communication/Utilities	.	21	11	80
Manufacturing	.	188	222	133
Financial, Insurance & Real Estate	.	100	97	807
Services	.	657	824	956
Wholesale/Retail Trade	.	984	1261	558
Transportation	.	627	596	26

Occupation

Table 5.1.6-109. Employment by Occupation for Palm Beach, Florida 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Occupation	1970	1980	1990	2000
Sales	.	659	785	-
Clerical	.	3060	200	-
Craft	.	96	117	-
Exec/Managerial	.	823	815	-
Farm/Fish/Forest	.	10	11	0
Household Services	.	235	157	-
Laborer/Handler	.	43	16	-
Operative/Transport	.	46	15	-
Service, except Household	.	537	361	-
Technical	.	40	46	-

Palm Beach Fishing Demographics

Table 5.1.6-110. Number of Federal Permit (October 2008) by Type for Palm Beach, Florida (Source: NMFS 2008).

Type	Permits
ATLANTIC DOLPHIN/WAHOO COMMERCIAL	13
ATLANTIC DOLPHIN/WAHOO CHARTER/ HEADBOAT	5
S. ATLANTIC CHARTER/HEADBOAT FOR PELAGIC FISH	6
KING MACKEREL	9
SPINY LOBSTER & TAILING	-,2
ROCK SHRIMP & ENDORSEMENTS	1,-
S. ATL. CHARTER/HEADBOAT FOR SNAPPER-GROUPER	8
SWORDFISH & SHARKS	2,-
S. ATLANTIC SNAPPER-GROUPER (UNLIMITED)	3
S. ATLANTIC SNAPPER-GROUPER (225)	1
SPANISH MACKEREL	10
SOUTH ATLANTIC SHRIMP	-

Table 5.1.6-111. Employment in Fishing Related Industry for Palm Beach, Florida (Zip code Business Patterns, U.S. Census Bureau 1998).

Category	NAIC Code	Number Employed
Fishing	114100	3
Seafood Canning	311711	0
Seafood Processing	311712	0
Boat Building	336612	0
Fish and Seafoods	422460	0
Fish and Seafood Markets	445220	0
Marinas	713930	3
Total Fishing Employment		6

5.1.6.11 Boca Raton (33487, 33431, 33486, 33496, 33432, 33434)

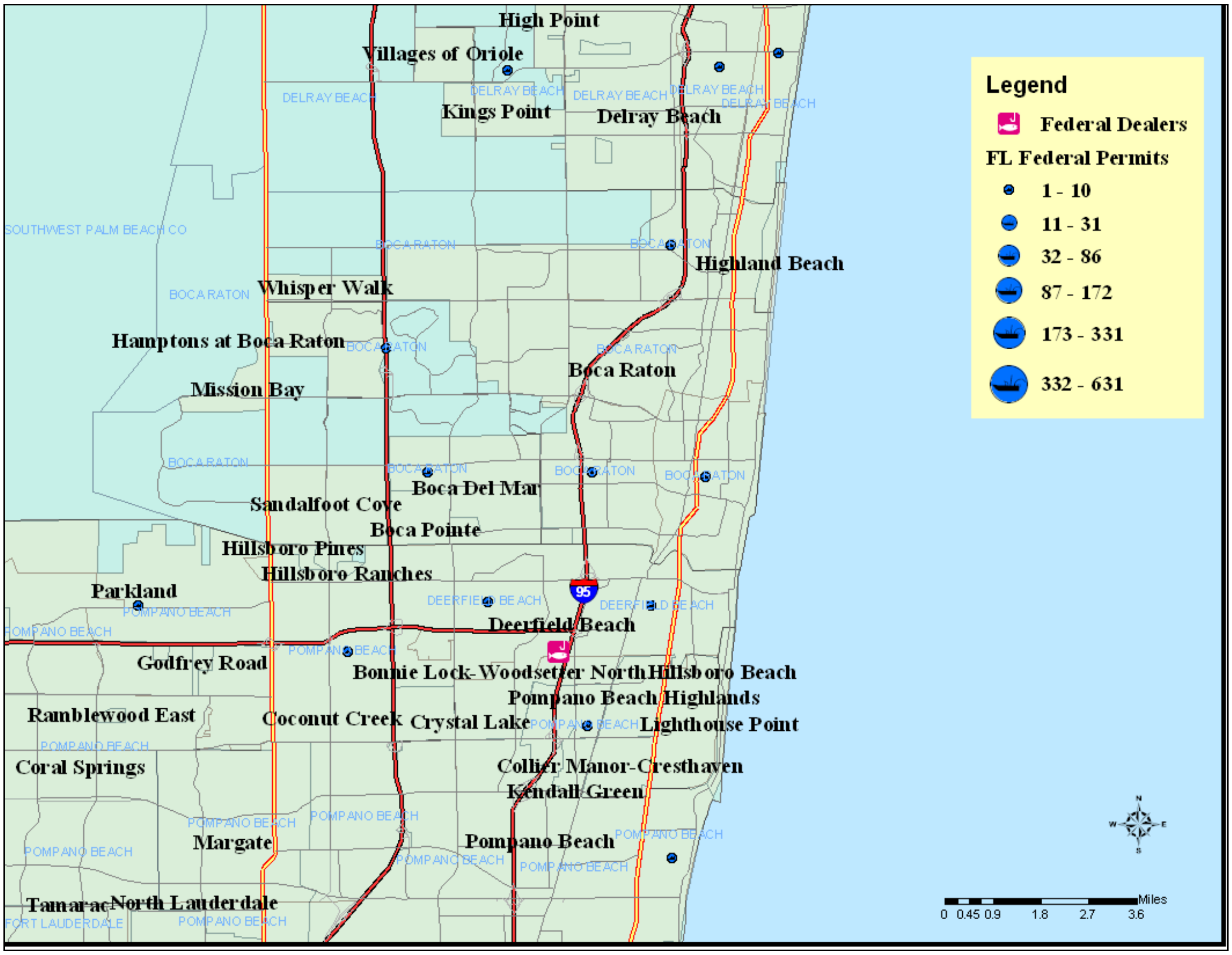

Figure 5.1.6-12. Boca Raton, Florida.

The area of current day Boca Raton was inhabited by Native Americans for nearly 1,000 years before the arrival of the Spanish. The original name given to the area by the Spanish explorers was “Boca de Ratones.” In nautical terms, “boca” denotes an inlet. Some of the translations include, “haulage inlet,” “inlet of mice,” “inlet of sharp-pointed rocks,” and “inlet of cowardly thieves.” “Rata,” not “raton” is the Spanish word for rat (Ashton 1984).

Captain Thomas Moore Rickards, Sr. of Missouri was one of the first people who wanted to settle the area of Boca Raton. He arrived in Florida in 1876 and became a citrus farmer in Candler. The freeze of 1894-5 forced him farther south to Lake Boca Raton. A year later, the tracks for Henry Flagler’s East Coast Railroad were laid in Boca Raton, allowing for easier, faster shipping and more convenient modes of transportation. By the beginning of the 1900s, Boca Raton “came into existence as a little agricultural center of orchards and farms” (Ashton 1984).

In 1904, a Japanese immigrant, Joseph Sakai, established a Japanese farming community of pineapple farmers in Boca Raton. He named the area Yamato.

The land boom of the 1920s and the arrival of famous architect Addison Mizner helped Boca Raton gain the image it still retains today as that of a luxurious resort town. He had already helped build up Palm Beach and was now aiding in the development of the areas to its south (Ashton 1984).

Boca Raton has experienced fairly steady population growth reaching 75,594 in 2000 (Table 5.1.6-112). Unemployment has risen slightly in 2000 from 1990 but the percentage of the population in the labor force has remained around 59 percent (Table 5.1.6-115). The average wage and salary is high being above $60,000 yet the number of persons living below the poverty level has grown steadily since 1970 (Table 5.1.6-118). The number of persons employed in farm, fish and forestry occupations and industry dropped dramatically in 2000 from a high in 1990. within 2008, there were 33 federal permits issued Table 5.1.6-121 but there are no federal dealers in Boca Raton. As far as fishing related employment there are 21 people listed in the fish and seafood sector according to Table 5.1.6-122.

Boca Raton Census Demographics

Population

Table 5.1.6-112. Total Persons and Persons by Age category for Boca Raton, Florida 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Total Persons and Age Category	1970	1980	1990	2000
Total Persons	28542	49505	61491	75594
Persons Age 0-5	1443	1650	3573	4282
Persons Age 6-15	4321	5681	5589	8325
Persons Age 16-17	701	1668	1334	1566
Persons Age 18-24	2901	5249	5241	6284
Persons Age 25-34	2709	5943	9418	7859
Persons Age 35-44	2794	5654	9377	9536
Persons Age 45-54	2835	5173	7155	11508
Persons Age 55-64	3900	6313	6592	8564
Persons Age 65+	6622	11789	13212	15016

Housing Tenure

Table 5.1.6-113. Housing Tenure for Boca Raton, Florida 1990-2000. (Source: U.S. Census Bureau).

Percent Renter Occupied	1990	2000
	25.6	24.3
Percent Owner Occupied	**1990**	**2000**
	74.4	75.7

Residence in 1985 and 1995

Table 5.1.6-114. Residence in 1985 and 1995 for Boca Raton, Florida 1990-2000. (Source: U.S. Census Bureau).

Different House Same County	1990	2000
	11678	15372
Same House	**1990**	**2000**
	26473	35856

Employment/Unemployment

Table 5.1.6-115. Employment and Unemployment for Boca Raton, Florida 1990-2000. (Source: U.S. Census Bureau).

Persons 16 yrs and over	1990	2000
Percent in labor force	60.1	59.1
Percent unemployed	3.3	5.8

Race

Table 5.1.6-116. Race for Boca Raton, Florida 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Race	1970	1980	1990	2000
Black Persons	730	992	1734	2725
Latino Black Persons	0	22	31	85
Latino Persons	690	2167	3378	6359
White Persons	27781	47930	58008	62925
Latino White Persons	690	2047	2880	4926

Education

Table 5.1.6-117. Years of Education by Category for those 25 Years and Older for Boca Raton, Florida 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Education	1970	1980	1990	2000
25+ w/ 0-8 years education	2464	2493	1672	1436
25+ w/ 9-11 years education	2591	2982	3615	3988
25+ w/ HS diploma	6051	11947	10984	12037
25+ w/ 13-15 years. education	3720	7748	10352	12509
25+ w/ College Degree	4034	9702	15952	29350
Drop outs	144	320	94	351

Income and Poverty

Table 5.1.6-118. Average Household Wage/Salary and Persons Below the Poverty Level for Boca Raton, Florida 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Wage or Salary	**1970**	**1980**	**1990**	**2000**
Average Household Wage/Salary Income (dollars)	$11409	$24986	$54959	$60248
Poverty Level				
Persons Below Poverty Level	1763	2458	3282	4886
Age 65+ Below Poverty Level	399	530	541	716
Households with Public Assistance	120	517	592	389

Industry

Table 5.1.6-119. Employment by Industry for Boca Raton, Florida 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Industry	**1970**	**1980**	**1990**	**2000**
Agriculture, Fishing, Mining	148	437	731	60
Construction	764	1775	1889	1875
Business Services	313	1334	1384	3854
Communication/Utilities	223	583	768	1845
Manufacturing	1726	2803	2429	2205
Financial, Insurance & Real Estate	1565	2168	1605	4648
Services	812	2552	4014	16276
Wholesale/Retail Trade	3537	4486	10629	8583
Transportation	1784	4864	8070	821

Occupation

Table 5.1.6-120. Employment by Occupation for Boca Raton, Florida 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Occupation	**1970**	**1980**	**1990**	**2000**
Sales	965	3613	6048	-
Clerical	1754	31030	4074	-
Craft	1012	2226	2183	-
Exec/Managerial	1339	3370	5692	-
Farm/Fish/Forest	51	395	477	43
Household Services	193	158	251	-
Laborer/Handler	280	402	516	-
Operative/Transport	310	541	376	-
Service, except Household	1242	2906	3518	-
Technical	150	834	1203	-

Boca Raton Fishing Demographics

Table 5.1.6-121. Number of Federal Permit (October 2008) by Type for Boca Raton, Florida (Source: NMFS 2008).

Type	Permits
ATLANTIC DOLPHIN/WAHOO COMMERCIAL	8
ATLANTIC DOLPHIN/WAHOO CHARTER/ HEADBOAT	2
S. ATLANTIC CHARTER/HEADBOAT FOR PELAGIC FISH	2
KING MACKEREL	4
SPINY LOBSTER & TAILING	-,1
ROCK SHRIMP & ENDORSEMENTS	1,-
S. ATL. CHARTER/HEADBOAT FOR SNAPPER-GROUPER	2
SWORDFISH & SHARKS	3,3
S. ATLANTIC SNAPPER-GROUPER (UNLIMITED)	2
S. ATLANTIC SNAPPER-GROUPER (225)	1
SPANISH MACKEREL	3
SOUTH ATLANTIC SHRIMP	1

Table 5.1.6-122. Employment in Fishing Related Industry for Boca Raton, Florida (Zip code Business Patterns, U.S. Census Bureau 1998).

Category	NAIC Code	Number Employed
Fishing	114100	3
Seafood Canning	311711	0
Seafood Processing	311712	0
Boat Building	336612	0
Fish and Seafoods	422460	21
Fish and Seafood Markets	445220	6
Marinas	713930	9
Total Fishing Employment		39

5.1.6.12 Key Largo (33037)

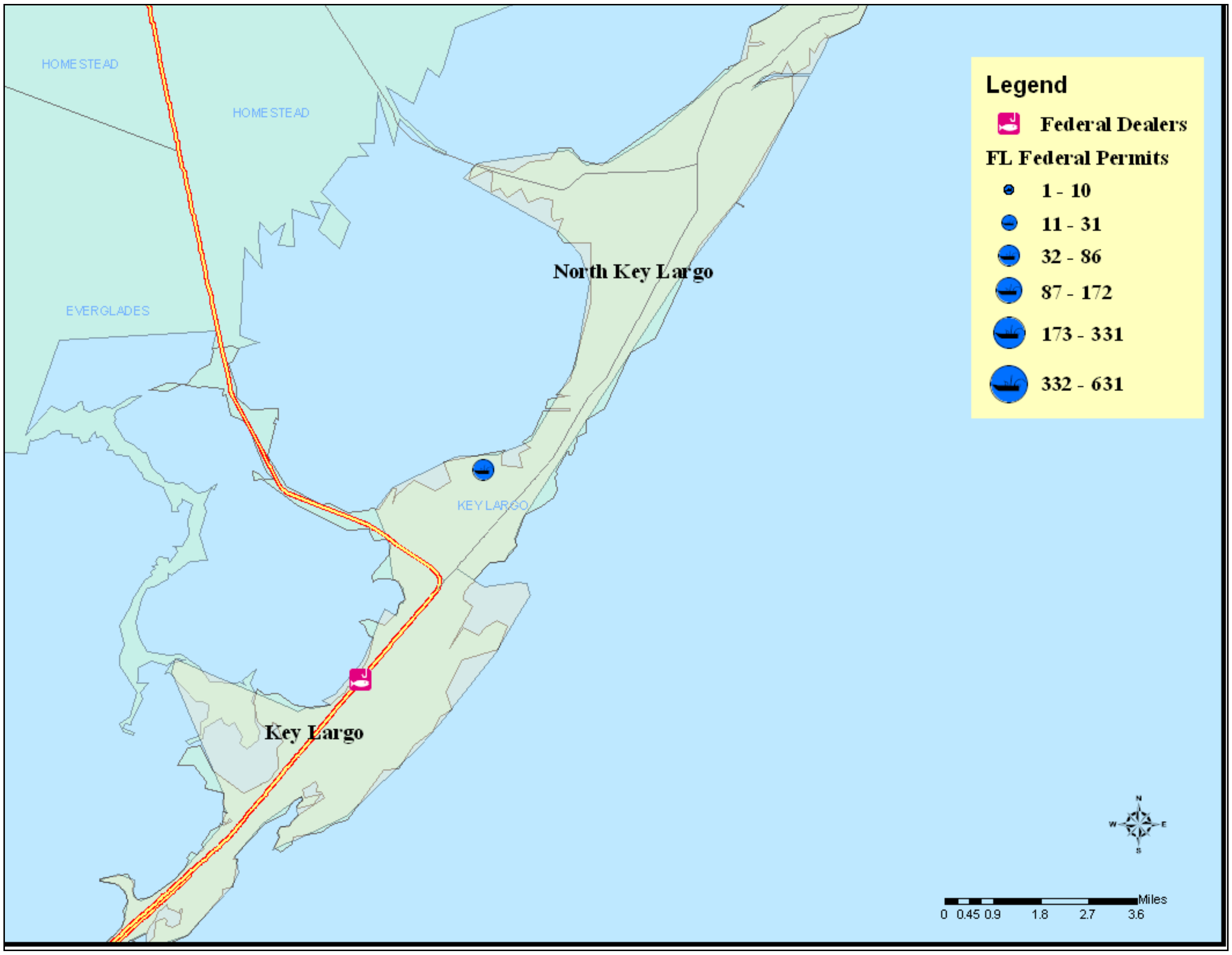

Figure 5.1.6-13. Key Largo, Florida.

The Florida Keys were first discovered by Juan Ponce de Leon in 1513. He named them Los Martires, the martyrs, "because they seemed twisted and tortured" (Williams 1991). The first permanent European settlement did not occur until the mid-1800s; however, the Keys were inhabited by the Calusa Indians for thousands of years. Williams (1991) notes that the first people to establish permanent homes in the Upper Keys—Key Largo and Islamorada—were Methodist fishermen and farmers. Ben Baker established pineapple farming in Key Largo, the longest Key and oldest named site in Florida, in 1866. He shipped his fruit on small boats to Key West, where the produce was loaded onto larger vessels for shipment to the northern states.

Key Largo Census Demographics

<u>Population</u>

Table 5.1.6-123. Total Persons and Persons by Age category for Key Largo, Florida 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Total Persons and Age Category	**1970**	**1980**	**1990**	**2000**
Total Persons	2866	7447	11350	11980
Persons Age 0-5	217	333	624	584
Persons Age 6-15	467	844	1018	1503
Persons Age 16-17	57	144	213	282
Persons Age 18-24	195	537	660	656
Persons Age 25-34	271	1045	1789	1384
Persons Age 35-44	307	738	1833	2199
Persons Age 45-54	411	1127	1491	2160
Persons Age 55-64	455	1279	1697	1451
Persons Age 65+	468	1360	2025	1761

Housing Tenure

Table 5.1.6-124. Housing Tenure for Key Largo, Florida 1990-2000. (Source: U.S. Census Bureau).

Percent Renter Occupied	**1990**	**2000**
	26.4	28.8
Percent Owner Occupied	**1990**	**2000**
	73.6	71.2

Residence in 1985 and 1995

Table 5.1.6-125. Residence in 1985 and 1995 for Key Largo, Florida 1990-2000. (Source: U.S. Census Bureau).

Different House Same County	**1990**	**2000**
	1937	2518
Same House	**1990**	**2000**
	5124	5490

Employment/Unemployment

Table 5.1.6-126. Employment and Unemployment for Key Largo, Florida 1990-2000. (Source: U.S. Census Bureau).

Persons 16 yrs and over	**1990**	**2000**
Percent in labor force	62.7	63.1
Percent unemployed	3.9	3.5

Race

Table 5.1.6-127. Race for Key Largo, Florida 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Race	1970	1980	1990	2000
Black Persons	270	276	336	227
Latino Black Persons	0	0	26	16
Latino Persons	89	265	1062	1979
White Persons	2596	7054	10758	9,446
Latino White Persons	89	257	896	1772

Education

Table 5.1.6-128. Years of Education by Category for those 25 Years and Older for Key Largo, Florida 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Education	1970	1980	1990	2000
25+ w/ 0-8 years education	535	479	598	360
25+ w/ 9-11 years education	447	1072	1333	1230
25+ w/ HS diploma	735	2048	2772	3059
25+ w/ 13-15 years. education	95	1227	1758	2528
25+ w/ College Degree	100	723	1776	2992
Drop outs	32	32	93	34

Income and Poverty

Table 5.1.6-129. Average Household Wage/Salary and Persons Below the Poverty Level for Key Largo, Florida 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Wage or Salary	1970	1980	1990	2000
Average Household Wage/Salary Income (dollars)	$6860	$14893	$38138	$42577
Poverty Level				
Persons Below Poverty Level	477	643	1233	996
Age 65+ Below Poverty Level	125	151	149	138
Households with Public Assistance	40	97	192	86

In 2008, vessels with federal permits predominantly held Atlantic dolphin/wahoo commercial (31), Atlantic dolphin/wahoo charter (15), south Atlantic charter/headboat for pelagic fish (14), snapper grouper charter/headboat for snapper grouper (16), or snapper grouper unlimited (12) permits.

Industry

Table 5.1.6-130. Employment by Industry for Key Largo, Florida 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Industry	1970	1980	1990	2000
Agriculture, Fishing, Mining	60	199	175	136
Construction	124	450	524	680
Business Services	49	110	365	302
Communication/Utilities	42	191	268	243
Manufacturing	14	221	419	160
Financial, Insurance & Real Estate	0	135	317	449
Services	25	218	454	2108
Wholesale/Retail Trade	335	530	1912	2021
Transportation	284	612	1403	281

Occupation

Table 5.1.6-131. Employment by Occupation for Key Largo, Florida 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Occupation	1970	1980	1990	2000
Sales	79	240	740	-
Clerical	145	4710	785	-
Craft	142	544	946	-
Exec/Managerial	141	315	685	-
Farm/Fish/Forest	0	195	174	129
Household Services	30	41	44	-
Laborer/Handler	90	147	223	-
Operative/Transport	67	131	126	-
Service, except Household	226	559	1053	-
Technical	0	68	242	-

Key Largo Fishing Demographics

Table 5.1.6-132. Number of Federal Permit (October 2008) by Type for Key Largo, Florida (Source: NMFS 2008).

Type	Permits
ATLANTIC DOLPHIN/WAHOO COMMERCIAL	31
ATLANTIC DOLPHIN/WAHOO CHARTER/ HEADBOAT	15
S. ATLANTIC CHARTER/HEADBOAT FOR PELAGIC FISH	14
KING MACKEREL	9
SPINY LOBSTER & TAILING	2,2
ROCK SHRIMP & ENDORSEMENTS	-,-
S. ATL. CHARTER/HEADBOAT FOR SNAPPER-GROUPER	16
SWORDFISH & SHARKS	3,3
S. ATLANTIC SNAPPER-GROUPER (UNLIMITED)	24
S. ATLANTIC SNAPPER-GROUPER (225)	4
SPANISH MACKEREL	11
SOUTH ATLANTIC SHRIMP	-

Table 5.1.6-133. Employment in Fishing Related Industry for Key Largo, Florida (Zip code Business Patterns, U.S. Census Bureau 1998).

Category	NAIC Code	Number Employed
Fishing	114100	6
Seafood Canning	311711	0
Seafood Processing	311712	0
Boat Building	336612	6
Fish and Seafoods	422460	0
Fish and Seafood Markets	445220	0
Marinas	713930	37
Total Fishing Employment		49

5.1.6.13 Islamorada (33070, 33036)

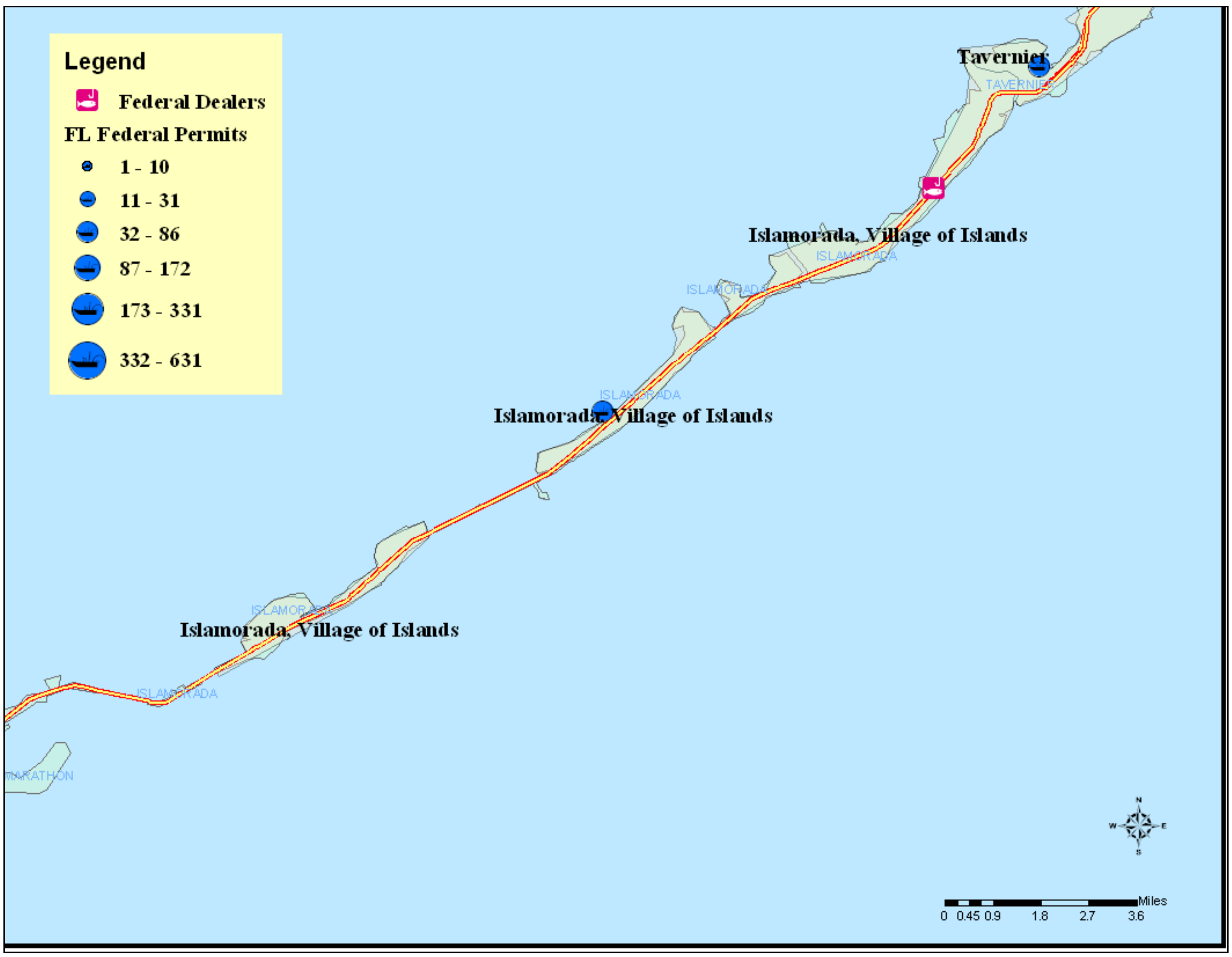

Figure 5.1.6-14. Islamorada, Florida.

Incorporated in 1997 and officially named Islamorada, Village of Islands, the community includes the islands of Upper and Lower Matecumba Keys, Plantation Key and Windley Key. The first settlers were Conchs who were of British descent by way of the Bahamas.

They fished and raised fruits and vegetables to survive. In the early 1930s wealthy Americans began to vacation in this area, particularly for the sport fishing. It has remained an important sport fishing center and self proclaimed "Sportfishing Capital of the World." It has been estimated that there are over 100 charter fishing vessels in Islamorada. In addition to offshore charters there are probably just as many guide boats that fish the nearshore and inshore waters. The community supports a large tourist economy that is centered on the charter fishing industry and has at least 24 marinas and approximately 45 hotels/motels to cater to fishermen. There are at least 6 air fill stations where divers can fill their tanks and several marinas offer dive trips. There are a few commercial operations in the community with most supporting a retail wholesale operation with a restaurant.

The community has seen substantial population growth because of its recent incorporation. Employment and unemployment have not changed dramatically. Average wage and salary have increased and so has the number of persons living below the poverty level. Both may be artifacts of the incorporation. This community is one of the few that has seen an increase in the number of persons working in farm, fish and forestry according to Table 5.1.6-141 and fishing related employment is spread out among marinas, fish and seafood and boat building (Table 5.1.6-144).

Islamorada Census Demographics

<u>Population</u>

Table 5.1.6-134. Total Persons and Persons by Age category for Islamorada, Florida 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Total Persons and Age Category	1970	1980	1990	2000
Total Persons	.	1482	1293	6847
Persons Age 0-5	.	49	46	344
Persons Age 6-15	.	149	95	590
Persons Age 16-17	.	23	7	149
Persons Age 18-24	.	144	58	313
Persons Age 25-34	.	259	148	459
Persons Age 35-44	.	148	346	1442
Persons Age 45-54	.	254	107	1377
Persons Age 55-64	.	214	238	992
Persons Age 65+	.	235	248	1181

<u>Housing Tenure</u>

Table 5.1.6-135. Housing Tenure for Islamorada, Florida 1990-2000. (Source: U.S. Census Bureau).

Percent Renter Occupied	1990	2000
	34.1	28.9
Percent Owner Occupied	**1990**	**2000**
	65.9	71.1

Residence in 1985 and 1995

Table 5.1.6-136. Residence in 1985 and 1995 for Islamorada, Florida 1990-2000. (Source: U.S. Census Bureau).

Different House Same County	**1990**	**2000**
	331	1171
Same House	**1990**	**2000**
	564	3614

Employment/Unemployment

Table 5.1.6-137. Employment and Unemployment for Islamorada, Florida 1990-2000. (Source: U.S. Census Bureau).

Persons 16 yrs and over	**1990**	**2000**
Percent in labor force	74.0	62.9
Percent unemployed	1.2	3.7

Race

Table 5.1.6-138. Race for Islamorada, Florida 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Race	**1970**	**1980**	**1990**	**2000**
Black Persons	.	0	11	12
Latino Black Persons	.	0	0	5
Latino Persons	.	177	109	66
White Persons	.	1482	1232	1137
Latino White Persons	.	177	59	42

Education

Table 5.1.6-139. Years of Education by Category for those 25 Years and Older for Islamorada, Florida 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Education	**1970**	**1980**	**1990**	**2000**
25+ w/ 0-8 years education	.	226	104	158
25+ w/ 9-11 years education	.	153	137	354
25+ w/ HS diploma	.	412	222	1726
25+ w/ 13-15 years. education	.	175	322	1538
25+ w/ College Degree	.	144	249	2054
Drop outs	.	6	6	29

Income and Poverty

Table 5.1.6-140. Average Household Wage/Salary and Persons Below the Poverty Level for Islamorada, Florida 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Wage or Salary	1970	1980	1990	2000
Average Household Wage/Salary Income (dollars)	.	$17848	$35041	$41522
Poverty Level				
Persons Below Poverty Level	.	200	117	466
Age 65+ Below Poverty Level	.	26	20	50
Households with Public Assistance	.	29	13	65

Industry

Table 5.1.6-141. Employment by Industry for Islamorada, Florida 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Industry	1970	1980	1990	2000
Agriculture, Fishing, Mining	.	134	57	129
Construction	.	69	32	232
Business Services	.	19	18	196
Communication/Utilities	.	57	26	88
Manufacturing	.	36	38	66
Financial, Insurance & Real Estate	.	36	23	193
Services	.	51	48	1345
Wholesale/Retail Trade	.	247	216	1283
Transportation	.	192	353	222

Occupation

Table 5.1.6-142. Employment by Occupation for Islamorada, Florida 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Occupation	1970	1980	1990	2000
Sales	.	81	153	-
Clerical	.	770	79	-
Craft	.	66	66	-
Exec/Managerial	.	192	153	-
Farm/Fish/Forest	.	162	65	138
Household Services	.	8	7	-
Laborer/Handler	.	29	19	-
Operative/Transport	.	8	7	-
Service, except Household	.	129	194	-
Technical	.	8	24	-

Islamorada Fishing Demographics

Table 5.1.6-143. Number of Federal Permit (October 2008)by Type for Islamorada, Florida (Source: NMFS 2008).

Type	Permits
ATLANTIC DOLPHIN/WAHOO COMMERCIAL	42
ATLANTIC DOLPHIN/WAHOO CHARTER/ HEADBOAT	57
S. ATLANTIC CHARTER/HEADBOAT FOR PELAGIC FISH	60
KING MACKEREL	9
SPINY LOBSTER & TAILING	1,2
ROCK SHRIMP & ENDORSEMENTS	-,-
S. ATL. CHARTER/HEADBOAT FOR SNAPPER-GROUPER	58
SWORDFISH & SHARKS	3,3
S. ATLANTIC SNAPPER-GROUPER (UNLIMITED)	16
S. ATLANTIC SNAPPER-GROUPER (225)	1
SPANISH MACKEREL	12
SOUTH ATLANTIC SHRIMP	-

Table 5.1.6-144. Employment in Fishing Related Industry for Islamorada, Florida (Zip code Business Patterns, U.S. Census Bureau 1998).

Category	NAIC Code	Number Employed
Fishing	114100	3
Seafood Canning	311711	0
Seafood Processing	311712	0
Boat Building	336612	10
Fish and Seafoods	422460	25
Fish and Seafood Markets	445220	0
Marinas	713930	33
Total Fishing Employment		71

5.1.6.14 Marathon (33050)

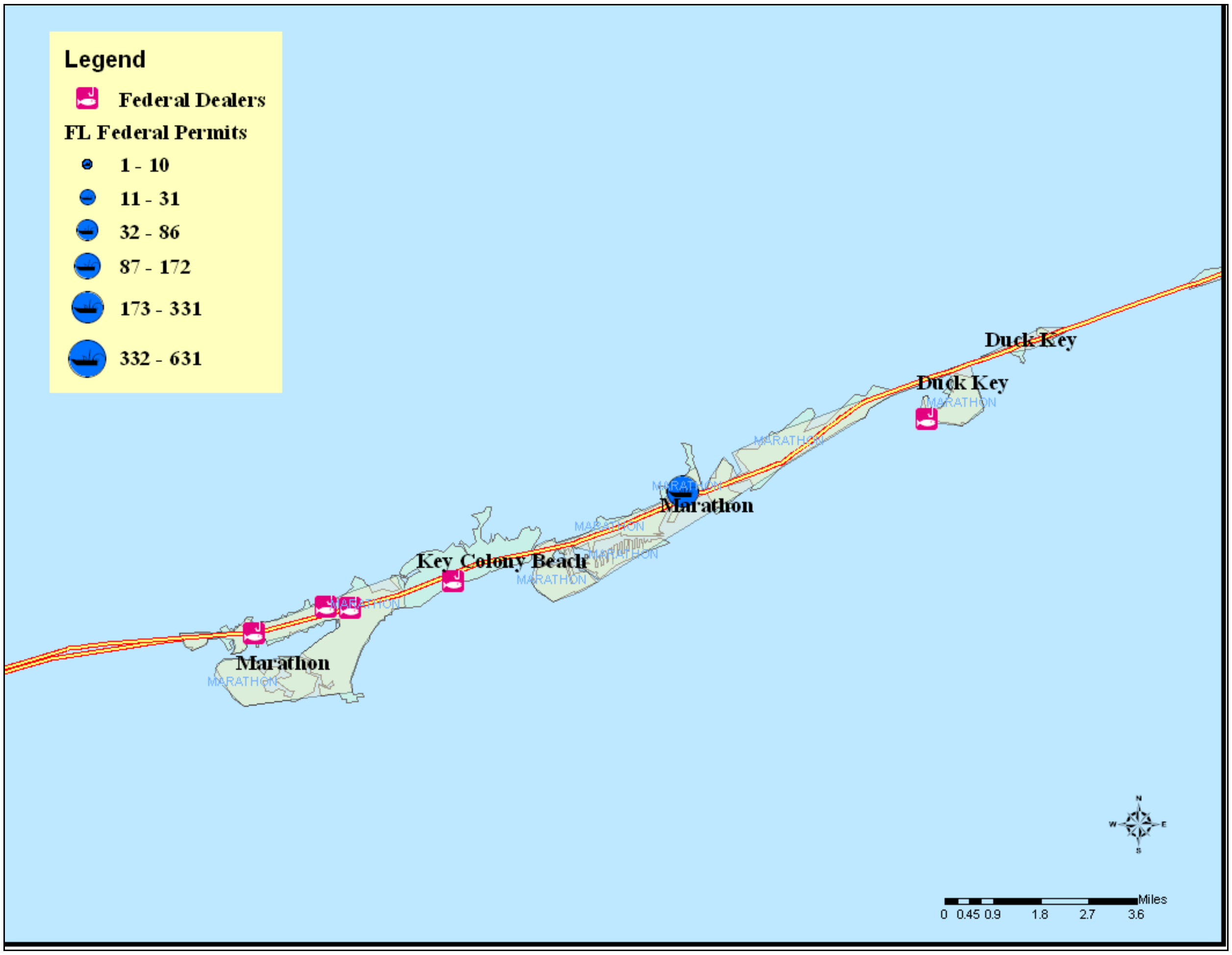

Figure 5.1.6-15. Marathon, Florida.

Marathon, or Key Vaca as it was called by the Spanish, was originally settled in the early 1800s by a group of Bahamians and numerous families from Mystic, Connecticut involved in fishing. Salvaging cargo from the Spanish Galleons in the area was also steeped in this key's history as well. Marathon has seen steady growth in its population since 1970. The percentage of the population employed in the labor force along with unemployment has remained constant over the past ten years. Average wage and salary have also slowly increased over the years, but the number of individuals living under the poverty level has also climbed to over 1400 persons. The number of persons working in occupations or industry sector of farm, fish and forestry has dropped since 1990 but still remains high at over 200 persons. In 2008, vessels with federal permits predominantly held Atlantic dolphin/wahoo commercial (72), Atlantic dolphin/wahoo charter (41), south Atlantic charter/headboat for pelagic fish (43), snapper grouper charter/headboat for snapper grouper (25), king and Spanish mackerel (27/63), or snapper grouper unlimited (25) permits (Table 5.1.6-154). According to Table 5.1.6-155 there are 92 persons employed in the fish and seafood sector of fishing related employment. There are 39 in the fishing sector and 47 in marinas.

Marathon Census Demographics

Population

Table 5.1.6-145. Total Persons and Persons by Age category for Marathon, Florida 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Total Persons and Age Category	1970	1980	1990	2000
Total Persons	4461	7568	8857	10194
Persons Age 0-5	284	267	585	482
Persons Age 6-15	740	945	864	1002
Persons Age 16-17	100	190	196	194
Persons Age 18-24	358	801	509	643
Persons Age 25-34	520	1262	1275	1198
Persons Age 35-44	482	833	1397	1778
Persons Age 45-54	620	870	1237	1961
Persons Age 55-64	686	1196	1223	1349
Persons Age 65+	589	1149	1571	1587

Housing Tenure

Table 5.1.6-146. Housing Tenure for Marathon, Florida 1990-2000. (Source: U.S. Census Bureau).

Percent Renter Occupied	1990	2000
	34.5	36.7
Percent Owner Occupied	**1990**	**2000**
	65.5	63.3

Residence in 1985 and 1995

Table 5.1.6-147. Residence in 1985 and 1995 for Marathon, Florida 1990-2000. (Source: U.S. Census Bureau).

Different House Same County	1990	2000
	2103	1898
Same House	**1990**	**2000**
	3184	5029

Employment/Unemployment

Table 5.1.6-148. Employment and Unemployment for Marathon, Florida 1990-2000. (Source: U.S. Census Bureau).

Persons 16 yrs and over	1990	2000
Percent in labor force	59.0	63.7
Percent unemployed	3.9	3.5

Race

Table 5.1.6-149. Race for Marathon, Florida 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Race	1970	1980	1990	2000
Black Persons	351	274	586	449
Latino Black Persons	0	0	85	28
Latino Persons	49	302	1075	2095
White Persons	4110	7076	8001	7,513
Latino White Persons	49	244	802	1828

Education

Table 5.1.6-150. Years of Education by Category for those 25 Years and Older for Marathon, Florida 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Education	1970	1980	1990	2000
25+ w/ 0-8 years education	586	668	635	445
25+ w/ 9-11 years education	629	859	1241	1316
25+ w/ HS diploma	931	2095	1908	2696
25+ w/ 13-15 years. education	505	918	1423	2240
25+ w/ College Degree	246	770	1080	2222
Drop outs	78	62	33	19

Income and Poverty

Table 5.1.6-151. Average Household Wage/Salary and Persons Below the Poverty Level for Marathon, Florida 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Wage or Salary	1970	1980	1990	2000
Average Household Wage/Salary Income (dollars)	$6745	$15495	$28609	$36010
Poverty Level				
Persons Below Poverty Level	677	959	1313	1422
Age 65+ Below Poverty Level	102	126	114	205
Households with Public Assistance	52	155	178	99

Industry

Table 5.1.6-152. Employment by Industry for Marathon, Florida 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Industry	1970	1980	1990	2000
Agriculture, Fishing, Mining	217	319	379	217
Construction	242	477	300	619
Business Services	85	96	157	227
Communication/Utilities	24	152	141	165
Manufacturing	69	174	184	110
Financial, Insurance & Real Estate	41	90	121	267
Services	49	146	274	1800
Wholesale/Retail Trade	601	705	1332	2003
Transportation	453	920	1278	233

Occupation

Table 5.1.6-153. Employment by Occupation for Marathon, Florida 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Occupation	1970	1980	1990	2000
Sales	144	353	617	-
Clerical	195	4580	364	-
Craft	324	476	537	-
Exec/Managerial	244	441	553	-
Farm/Fish/Forest	59	328	365	217
Household Services	32	16	18	-
Laborer/Handler	166	171	156	-
Operative/Transport	104	158	137	-
Service, except Household	339	525	958	-
Technical	46	55	81	-

Marathon Fishing Demographics

Table 5.1.6-154. Number of Federal Permit (October 2008) by Type for Marathon, Florida (Source: NMFS 2008).

Type	Permits
ATLANTIC DOLPHIN/WAHOO COMMERCIAL	72
ATLANTIC DOLPHIN/WAHOO CHARTER/ HEADBOAT	41
S. ATLANTIC CHARTER/HEADBOAT FOR PELAGIC FISH	43
GOLDEN CRAB	1
KING MACKEREL	27
SPINY LOBSTER & TAILING	8,11
ROCK SHRIMP & ENDORSEMENTS	-,-
S. ATL. CHARTER/HEADBOAT FOR SNAPPER-GROUPER	45
SWORDFISH & SHARKS	2,4
S. ATLANTIC SNAPPER-GROUPER (UNLIMITED)	25
S. ATLANTIC SNAPPER-GROUPER (225)	19
SPANISH MACKEREL	63
SOUTH ATLANTIC SHRIMP	-

Table 5.1.6-155. Employment in Fishing Related Industry for Marathon, Florida. (Zip code Business Patterns, U.S. Census Bureau 1998).

Category	NAIC Code	Number Employed
Fishing	114100	39
Seafood Canning	311711	0
Seafood Processing	311712	0
Boat Building	336612	0
Fish and Seafoods	422460	92
Fish and Seafood Markets	445220	6
Marinas	713930	47
Total Fishing Employment		184

5.1.6.15 Big Pine Key (33042, 33043)

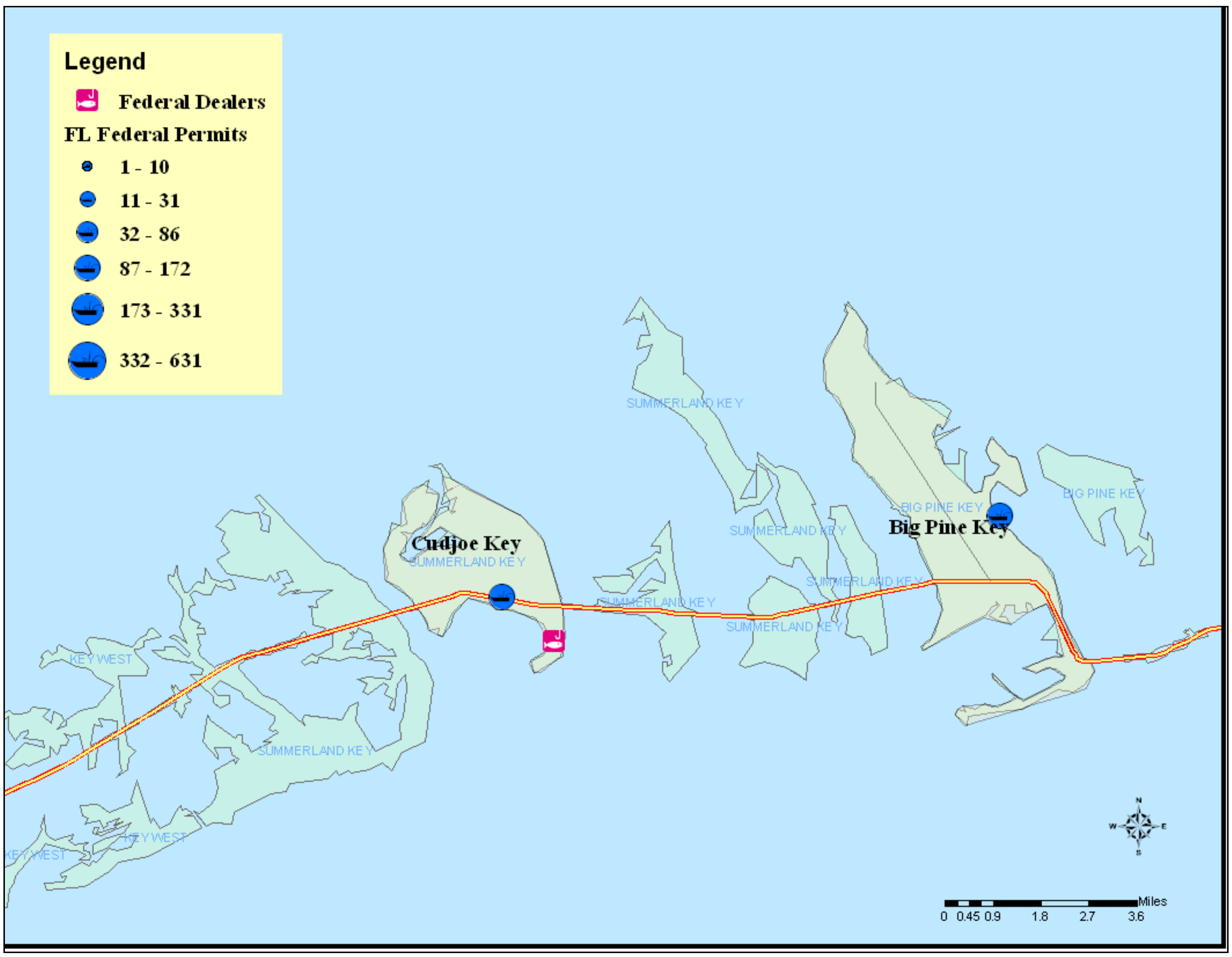

Figure 5.1.6-16. Big Pine Key, Florida.

Big Pine Key, located in the Lower Keys, does not have a true history of its own. Settlement was sparse well into the twentieth century. The 1870 census for Big Pine Key lists only one inhabitant, George Wilson. Wilson was a charcoal burner, providing his product for residents of Key West before the days of electricity. A shark processing plant was established on Big Pine in 1923 by Hydenoil Products. The sharks were harvested for their leather and liver oil. The company averaged 100 sharks a day in 1930. The fishermen caught mostly hammerhead, sand, nurse, dusky, leopard, sawfish sharks. Even with this seeming success, the plant was shut down in 1931 because of possible financial difficulty.

Big Pine Key and Cudjoe Key are included in tables for fishing demographics but the census demographics include only Big Pine Key. The population for this area has seen steady growth, while the percent of the population in the labor force and unemployment have remained fairly constant over the years with unemployment fairly low at 2.1 percent. Average wage and salary have increased steadily along with the number of persons living under the poverty level. The number of persons working in the farm, fish and forestry occupation has dropped since 1990 but still remains high compared to other coastal communities. In 2008, there were 124 federal permits issued and they are spread out among the different types with most holding permits for dolphin/wahoo, king and Spanish mackerel or snapper grouper (Table 5.1.6-165). According to Table 5.1.6-166 there are 50 people employed in the fishing sector and another 27 in the marinas sector.

Big Pine Key Census Demographics

Population

Table 5.1.6-156. Total Persons and Persons by Age category for Big Pine Key, Florida 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Total Persons and Age Category	1970	1980	1990	2000
Total Persons	.	2321	4124	5049
Persons Age 0-5	.	64	260	206
Persons Age 6-15	.	260	270	524
Persons Age 16-17	.	36	60	96
Persons Age 18-24	.	218	206	157
Persons Age 25-34	.	359	678	622
Persons Age 35-44	.	252	714	759
Persons Age 45-54	.	288	603	1033
Persons Age 55-64	.	417	603	707
Persons Age 65+	.	427	730	752

Housing Tenure

Table 5.1.6-157. Housing Tenure for Big Pine Key, Florida 1990-2000. (Source: U.S. Census Bureau).

Percent Renter Occupied	1990	2000
	22.1	23.0
Percent Owner Occupied	**1990**	**2000**

	77.9	77.0

Residence in 1985 and 1995

Table 5.1.6-158. Residence in 1985 and 1995 for Big Pine Key, Florida 1990-2000. (Source: U.S. Census Bureau).

Different House Same County	**1990**	**2000**
	1015	777
Same House	**1990**	**2000**
	1530	2743

Employment/Unemployment

Table 5.1.6-159. Employment and Unemployment for Big Pine Key, Florida 1990-2000. (Source: U.S. Census Bureau).

Persons 16 yrs and over	**1990**	**2000**
Percent in labor force	54.5	62.3
Percent unemployed	2.4	2.1

Race

Table 5.1.6-160. Race for Big Pine Key, Florida 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Race	**1970**	**1980**	**1990**	**2000**
Black Persons	.	49	49	51
Latino Black Persons	.	0	0	4
Latino Persons	.	49	144	338
White Persons	.	2256	4033	4,496
Latino White Persons	.	49	136	276

Education

Table 5.1.6-161. Years of Education by Category for those 25 Years and Older for Big Pine Key, Florida 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Education	**1970**	**1980**	**1990**	**2000**
25+ w/ 0-8 years education	.	236	125	102
25+ w/ 9-11 years education	.	299	477	479
25+ w/ HS diploma	.	628	1011	1475
25+ w/ 13-15 years. education	.	334	842	1006
25+ w/ College Degree	.	246	659	1453
Drop outs	.	30	0	8

Income and Poverty

Table 5.1.6-162. Average Household Wage/Salary and Persons Below the Poverty Level for Big Pine Key, Florida 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Wage or Salary	1970	1980	1990	2000
Average Household Wage/Salary Income (dollars)	.	$16176	$29418	$44514
Poverty Level				
Persons Below Poverty Level	.	204	330	472
Age 65+ Below Poverty Level	.	52	61	53
Households with Public Assistance	.	19	33	67

Industry

Table 5.1.6-163. Employment by Industry for Big Pine Key, Florida 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Industry	1970	1980	1990	2000
Agriculture, Fishing, Mining	.	74	195	105
Construction	.	152	174	253
Business Services	.	36	73	151
Communication/Utilities	.	23	65	111
Manufacturing	.	32	61	22
Financial, Insurance & Real Estate	.	16	43	284
Services	.	39	125	806
Wholesale/Retail Trade	.	168	627	650
Transportation	.	194	385	111

Occupation

Table 5.1.6-164. Employment by Occupation for Big Pine Key, Florida 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Occupation	1970	1980	1990	2000
Sales	.	132	248	-
Clerical	.	860	284	-
Craft	.	177	217	-
Exec/Managerial	.	55	191	-
Farm/Fish/Forest	.	93	177	81
Household Services	.	3	0	-
Laborer/Handler	.	36	61	-
Operative/Transport	.	0	24	-
Service, except Household	.	144	313	-
Technical	.	0	32	-

Big Pine Key Fishing Demographics

Table 5.1.6-165. Number of Federal Permit (October 2008) by Type for Big Pine Key, Florida (Source: NMFS 2008).

Type	Permits
ATLANTIC DOLPHIN/WAHOO COMMERCIAL	32
ATLANTIC DOLPHIN/WAHOO CHARTER/ HEADBOAT	12
S. ATLANTIC CHARTER/HEADBOAT FOR PELAGIC FISH	10
KING MACKEREL	11
SPINY LOBSTER & TAILING	-,3
ROCK SHRIMP & ENDORSEMENTS	-,-
S. ATL. CHARTER/HEADBOAT FOR SNAPPER-GROUPER	10
SWORDFISH & SHARKS	2,4
S. ATLANTIC SNAPPER-GROUPER (UNLIMITED)	15
S. ATLANTIC SNAPPER-GROUPER (225)	19
SPANISH MACKEREL	16
SOUTH ATLANTIC SHRIMP	-

Table 5.1.6-166. Employment in Fishing Related Industry for Big Pine Key, Florida (Zip code Business Patterns, U.S. Census Bureau 1998).

Category	NAIC Code	Number Employed
Fishing	114100	50
Seafood Canning	311711	7
Seafood Processing	311712	0
Boat Building	336612	0
Fish and Seafoods	422460	9
Fish and Seafood Markets	445220	0
Marinas	713930	21
Total Fishing Employment		87

5.1.6.16 Key West (33040, 33041, 33045)

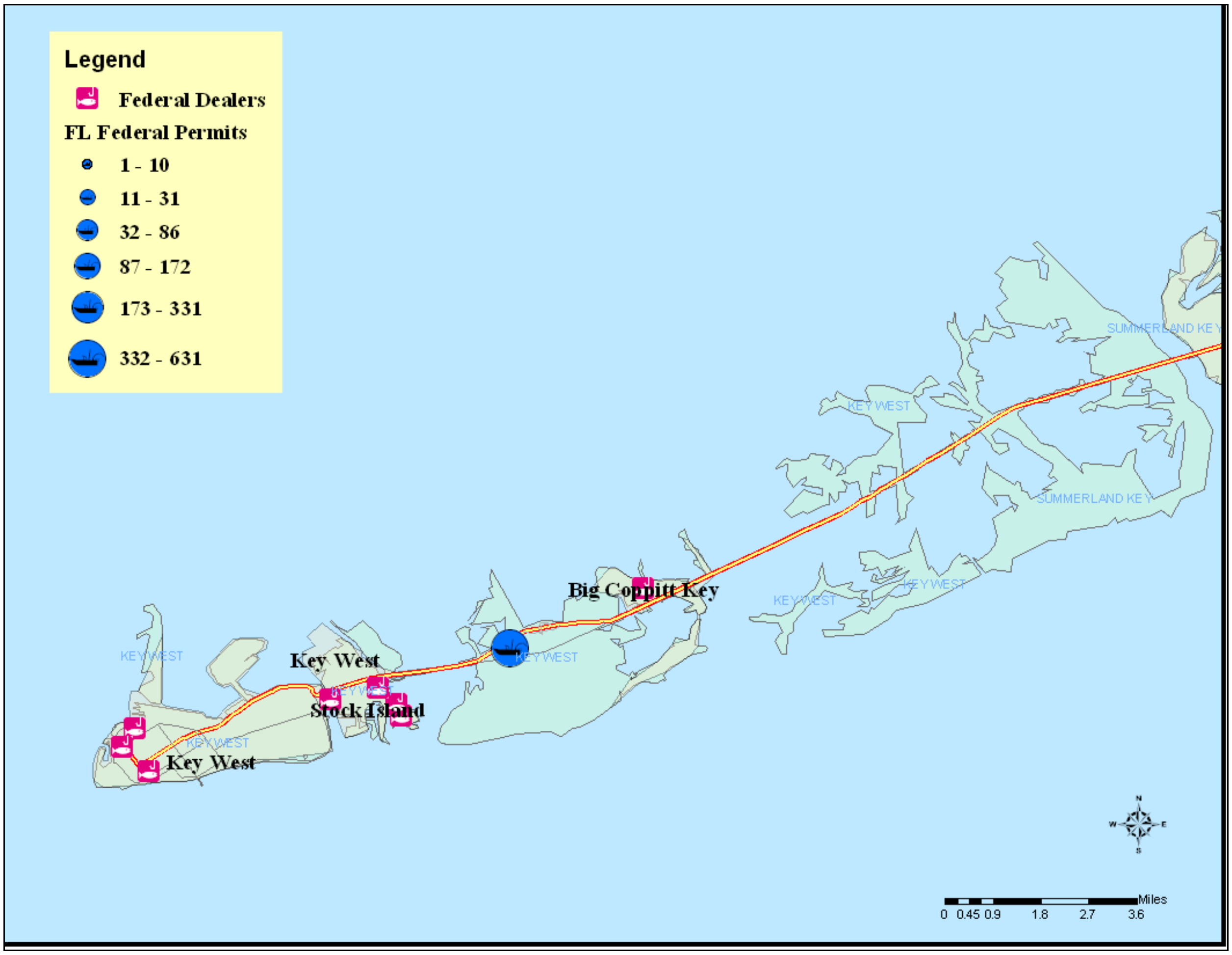

Figure 5.1.6-17. Key West, Florida.

Spanish explorer Juan Ponce de Leon and chronicler Antonio de Herrera were the first Europeans to set eyes upon Key West on May 15, 1513. It has the distinction of being the oldest city in south Florida (Williams 1991). They called the island Cayo Hueso (Isle of Bones) because of the numerous bones they found on what was either a Calusa Indian burial ground or battlefield. It is believed that the English thought the Spanish meant "oeste" (west) and changed the name to Key West. However, the first permanent occupancy of Key West did not occur until 1822. In 1822, Spaniard Juan Salas sold the city of Key West to a Mobile, Alabama businessman named John Simonton for $2,000. Naval Commodore David Porter was sent to establish a naval post to help rid the area of pirates in that same year. They also established a port in order to open the shipping lanes from the Gulf of Mexico, the Caribbean, and the Atlantic. A Customs House was established later that year. By 1830, the pirates were gone; however, hurricanes and the fear of running aground on the coral reefs still plagued boat captains. These boating difficulties gave way to one of the first profitable ventures in Key West—salvaging of shipwrecks (Williams 1991).

When salvaging was no longer profitable, sponging and Cuban cigar manufacturing became the mainstays of Key West's economy (Williams 1991). The people of Key West, or conchs as they are commonly known, began the sponge trade in Florida, and by the 1890s, they made Key West "the commercial sponging capital of the world." Nevertheless, fishing was a primary source of income and survival since the very beginning. Before permanent settlement of Key West, fishermen from New England and the Bahamas would come to take advantage of the species the waters of Key West had to offer. Similarly, in the early 1900s, fishermen from St. Augustine would fish in Key West and sell their catch in Havana. Since the beginning, grouper and spiny lobster have been the most profitable species of the Key West fishing industry.

Shrimp has been another important species for the Key West fishing community. John Salvador, a son of one of the original fishing families in St. Augustine, discovered rich shrimping grounds in the Dry Tortugas in 1950. The rush to harvest the shrimp has been related to the gold rush of 1849, naming the shrimp "pink gold." "Currently, Key West pink shrimp make up almost 50% of the total Monroe County shrimp landings." The marine resources have been the key to survival and income for conchs for nearly 200 years. Today, the port in Key West is famous for its scuba diving, sport fishing, and yachting opportunities.

The population of Key West has not grown much over the past three decades. The percent of the population in the labor force and unemployment have both remained fairly constant since 1990. Average wage and salary has grown over the years while the number of people living under the poverty level has decreased overall. Key West has the greatest number of persons working in the farm, fish and forestry categories of any coastal community with over 300 in both occupation and industry. In 2008, there were 1,010 federal permits issued and they are spread out among the different types with most holding permits for dolphin/wahoo, king and Spanish mackerel, spiny lobster or snapper grouper (Table 5.1.6-176). Given so many fishing vessels the number of persons employed in fishing related employment seems low with only 18 in the fishing sector and 49 in marinas.

The city of Key West boasts more than two dozen fishing charters in its area. Most of the boats can support between two and six anglers. Half and full-day trips seem to be the most popular, with many offering swordfish fishing excursions at night as well. Some of the most popular species for offshore sport fishing adventures in the waters off Key West include sailfish, tuna, wahoo, and dolphin. Many of the fishermen offer reef and wreck fishing trips, allowing anglers to catch various species of snapper and grouper. Some of the more popular targeted species include red snapper, yellowtail snapper, mutton snapper, black grouper, and mangrove snapper. There are about half a dozen headboats that fish the waters of Key West as well. These boats can accommodate far more fisherman. Trips usually last for about four hours. Some of these boats specifically target snappers and groupers.

Tournaments are also an important part of the recreational fishing sector in Key West. One of the largest tournaments in the area, The Key West Fishing Tournament, lasts from

April through November. Forty-four species of fish are fished, six of which are groupers and six species of snappers. Other longstanding tournaments in the area include the Mercury Redbone at Large Key West Classic and the Mercury S.L.A.M (Southernmost Light tackle Anglers Masters) held in April and September, respectively. These tournaments are an opportunity for the recreational fishing boat owners to make money as well as many of them rent their boats to tournament participants who do not have vessels of their own.

Marinas and bait and tackle shops are important to the recreational sector as well as the commercial industry. Key West has more than half a dozen marinas, many of which are full service marinas. For example, the Sunset and Oceanside Marinas offer boat repairs, fuel, storage, and repairs. Many of the recreational fishermen in the area are docked at either Garrison Bight Marina or at Amberjack Pier at the City Marina.

Key West Census Demographics

Population

Table 5.1.6-167. Total Persons and Persons by Age category for Key West, Florida 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Total Persons and Age Category	1970	1980	1990	2000
Total Persons	27323	24382	24832	25480
Persons Age 0-5	2441	1425	2135	1373
Persons Age 6-15	4902	3279	2333	2322
Persons Age 16-17	825	599	383	339
Persons Age 18-24	4717	3308	2565	2062
Persons Age 25-34	3992	5007	5659	4558
Persons Age 35-44	3045	2749	4515	4944
Persons Age 45-54	2828	2321	2452	4357
Persons Age 55-64	2054	2638	1904	2574
Persons Age 65+	1986	2795	2886	2951

Housing Tenure

Table 5.1.6-168. Housing Tenure for Key West, Florida 1990-2000. (Source: U.S. Census Bureau).

Percent Renter Occupied	1990	2000
	57.9	54.4
Percent Owner Occupied	**1990**	**2000**
	42.1	45.6

Residence in 1985 and 1995

Table 5.1.6-169. Residence in 1985 and 1995 for Key West, Florida 1990-2000. (Source: U.S. Census Bureau).

Different House Same County	1990	2000
	4471	5572
Same House	**1990**	**2000**
	8742	9569

Employment/Unemployment

Table 5.1.6-170. Employment and Unemployment for Key West, Florida 1990-2000. (Source: U.S. Census Bureau).

Persons 16 yrs and over	1990	2000
Percent in labor force	73.7	70.1
Percent unemployed	3.3	3.0

Race

Table 5.1.6-171. Race for Key West, Florida 1970-2000. (Source U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Race	1970	1980	1990	2000
Black Persons	3224	2790	2584	2237
Latino Black Persons	191	280	91	128
Latino Persons	3293	4959	3951	4215
White Persons	23795	20679	21361	18195
Latino White Persons	3102	4360	3402	3447

Education

Table 5.1.6-172. Years of Education by Category for those 25 Years and Older for Key West, Florida 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Education	1970	1980	1990	2000
25+ w/ 0-8 years education	4005	2721	1646	1196
25+ w/ 9-11 years education	2792	2199	1863	2192
25+ w/ HS diploma	4628	5462	4831	5598
25+ w/ 13-15 years. education	1232	2634	4102	5491
25+ w/ College Degree	1248	2494	3630	7080
Drop outs	697	233	132	286

Income and Poverty

Table 5.1.6-173. Average Household Wage/Salary and Persons Below the Poverty Level for Key West, Florida 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Wage or Salary	**1970**	**1980**	**1990**	**2000**
Average Household Wage/Salary Income (dollars)	$6949	$15039	$32320	$43021
Poverty Level				
Persons Below Poverty Level	4747	3760	2507	2535
Age 65+ Below Poverty Level	678	554	505	318
Households with Public Assistance	355	470	555	169

Industry

Table 5.1.6-174. Employment by Industry for Key West, Florida 1970-2000. (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Industry	**1970**	**1980**	**1990**	**2000**
Agriculture, Fishing, Mining	352	589	296	319
Construction	442	860	865	1123
Business Services	165	401	581	682
Communication/Utilities	393	433	366	463
Manufacturing	312	558	365	231
Financial, Insurance & Real Estate	101	210	150	917
Services	273	673	718	4738
Wholesale/Retail Trade	2183	1995	4176	5069
Transportation	1971	2655	4011	487

Occupation

Table 5.1.6-175. Employment by Occupation for Key West, Florida 1970-2000 (Source: U.S. Census Bureau & MARFIN Sociodemographic Database. Louisiana Population Data Center & National Marine Fisheries Service).

Occupation	**1970**	**1980**	**1990**	**2000**
Sales	595	1246	1888	-
Clerical	1555	16130	1908	-
Craft	1029	1375	1229	-
Exec/Managerial	717	1348	1541	-
Farm/Fish/Forest	67	505	265	301
Household Services	141	63	51	-
Laborer/Handler	582	353	347	-
Operative/Transport	361	268	177	-
Service, except Household	1483	2226	3003	-
Technical	59	209	314	-

Key West Fishing Demographics

Table 5.1.6-176. Number of Federal Permit (October 2008) by Type for Key West, Florida (Source: NMFS 2008).

Type	Permits
ATLANTIC DOLPHIN/WAHOO COMMERCIAL	122
ATLANTIC DOLPHIN/WAHOO CHARTER/ HEADBOAT	124
S. ATLANTIC CHARTER/HEADBOAT FOR PELAGIC FISH	123
GOLDEN CRAB	1
KING MACKEREL	134
SPINY LOBSTER & TAILING	30,72
ROCK SHRIMP & ENDORSEMENTS	9,1
S. ATL. CHARTER/HEADBOAT FOR SNAPPER-GROUPER	133
SWORDFISH & SHARKS	3,7
S. ATLANTIC SNAPPER-GROUPER (UNLIMITED)	96
S. ATLANTIC SNAPPER-GROUPER (225)	19
SPANISH MACKEREL	127
SOUTH ATLANTIC SHRIMP	-9

Table 5.1.6-177. Employment in Fishing Related Industry for Key West, Florida (Zip code Business Patterns, U.S. Census Bureau 1998).

Category	NAIC Code	Number Employed
Fishing	114100	18
Seafood Canning	311711	0
Seafood Processing	311712	0
Boat Building	336612	3
Fish and Seafoods	422460	7
Fish and Seafood Markets	445220	0
Marinas	713930	49
Total Fishing Employment		77

5.1.6.17 Florida Fishing Infrastructure and Community Characterization

The following tables provide a general view of the presence or absence of fishing infrastructure located within the coastal communities of Florida with substantial fishing activity. It should be noted that there are many other attributes that might have been included in this table, however, because of inconsistency in rapid appraisal for all communities, these items were selected as the most consistently reported or had secondary data available to determine presence or absence. It should also be noted that in some cases certain infrastructure may exist within a community but was not readily apparent or could not be ascertained through secondary data. Table 5.1.6-178 offers an overview of the presence of the selected infrastructure items and provides an overall total score which is merely the total of infrastructure present.

Table 5.1.6-178. Fishing Infrastructure Table for Florida Potential Fishing Communities.

Community	Federal Commercial Permits (5+)	State Commercial Licenses (10+)	Federal Charter Permits (5+)	Seafood Landings	Seafood retail markets	Fish processors, Wholesale fish house	Recreational docks / marinas	Recreational Fishing Tournaments	Total
Atlantic Beach	-	+	-	+	+	+	+	-	5
Big Pine Key	+	+	+	+	+	+	+	-	7
Boca Raton	+	+	-	-	+	-	+	-	4
Cape Canaveral	+	+	-	+	+	+	+	+	7
Fernandina Beach	+	+	+	+	+	+	+	+	8
Fort Pierce	+	+	+	+	+	+	+	+	8
Islamorada	+	+	+	+	+	+	+	+	8
Jupiter	+	+	+	+	+	+	+	+	8
Key Largo	+	+	+	+	+	+	+	+	8
Key West	+	+	+	+	+	+	+	+	8
Marathon	+	+	+	+	+	+	+	+	8
Merritt Island	+	+	-	+	+	+	+	-	6
Palm Beach	+	+	-	+	+	-	+	+	6
Ponce Inlet	+	+	+	+	+	+	+	+	8
Sebastian	+	+	+	+	+	+	+	+	8
St. Augustine	+	+	+	+	+	+	+	+	8

In attempting a preliminary characterization of potential fishing communities in Table 5.1.6-179, we have provided a grouping of communities that appear to have more involvement in various fishing enterprises and therefore are classified as primarily involved. These communities have considerable fishing infrastructure, but also have a history and culture surrounding both commercial and recreational fishing that contributes to an appearance and perception of being a fishing community in the mind of residents and others. The communities are not ranked in any particular order, this is merely a categorization.

Table 5.1.6-179. Preliminary Characterization of Potential Fishing Communities in Florida.

Primarily-Involved	Secondarily-Involved
Fernandina Beach	Atlantic Beach
Fort Pierce	Boca Raton
Islamorada	Palm Beach
Jupiter	
Key Largo	
Key West	
Marathon	
Fernandina Beach	
Fort Pierce	
Islamorada	

Many of these communities are in transition due to various social and demographic changes from coastal development, growing populations, increasing tourism, changing regulations, etc. This preliminary characterization is just that and should not be considered a definite designation as fishing community, but a general guide for locating communities that may warrant consideration as a potential fishing community.

5.2 Fisheries under SAFMC Management

5.2.1 Shrimp Fishery

5.2.1.1 Description of fishing practices, vessels and gear

5.2.1.1.1 Commercial penaeid shrimp fishery

Otter trawl

The otter trawl is the most common gear used to harvest these shrimp species and consists of: (1) a cone-shaped bag in which the shrimp are gathered into the tail or cod end; (2) wings on each side of the net for herding shrimp into the bag; (3) trawl doors at the extreme end of each wing for holding the wings apart and holding the mouth of the net open; and (4) two lines attached to the trawl doors and fastened to the vessel. A ground line extends from door to door on the bottom of the wings and mouth of the net while a float line is similarly extended at the top of the wings and mouth of the net. A flat net is more often used when fishing for brown shrimp since they burrow into the bottom to escape the trawl. This net has a wider horizontal spread than other designs and is believed to be more effective at capturing brown and pink shrimp. In areas where white shrimp are the main target, trawls used in the fishery have been modified to increase the efficiency in the capture of white shrimp. The tongue trawl or high-rise trawl, was designed to fish higher in the water column making it more effective in catching the more active white shrimp (SAFMC 1996b). Most trawl vessels are rigged for towing two to four nets simultaneously. In Florida, this is only the case for vessels operating in offshore waters. In inland and nearshore waters, Florida trawlers are restricted to no more than two nets each having a maximum surface area not to exceed 500 square feet. The double-rigged shrimp trawler has two outrigger booms from whose ends, through a block, the cable from the winch drum is run to the two nets. Some vessels use twin trawls, which are essentially two trawls on a single set of doors, joined together at the head and foot ropes to a neutral door connected to a third bridle leg. Thus, instead of towing two 70 foot nets the vessel tows four 40 foot nets. This rig has some advantages in ease of handling and increased efficiency. The quad trawl net configuration allows faster towing speed and wider net spread compared to double-rigged trawls. In South Carolina, it is unlawful to have onboard a vessel or to trawl with any trawl or trawls having a total foot rope length of two hundred and twenty feet or greater, not including try nets or nets bundled below deck.

Trawlers operating in Georgia and South Carolina waters are restricted to a combined maximum length of 220 feet of foot rope, defined as the measure from brail line to brail line, first tie to last tie on the bottom line, but not to include a try net up to 16 feet in length. Trawling accounts for more than 95% of the food shrimp landed in Georgia. Georgia's fleet is comprised of large trawl vessels, with 66% in excess of 40 feet in length. Hand-retrieved trawls, those with no mechanical retrieval capabilities and typically less than 25 feet in length, account for approximately 28% of all vessels harvesting food shrimp. Their minimal size restricts their effective fishing range to shallow, near-shore areas close to the shoreline. In 1977, Georgia's sounds were closed to shrimp trawling. Since that time, the sounds have been opened only five times. Each opening lasted less than seven days. Most hand-retrieved trawl fishery participants do so for personal consumption or for supplemental income.

The duration of tows varies depending on many factors including amount of bycatch species and concentration of shrimp. Small boats fishing in inshore waters make much shorter drags than the larger, offshore vessels whose tows generally last several hours (SAFMC 1993).

Wing net

In Biscayne Bay, Florida, food production shrimp are harvested with wing nets. A wing net is a net in the form of an elongated bag kept open by a rigid frame that is attached to either side of a vessel and is not towed behind a vessel or dragged along the bottom. Vessels are equipped with two such nets each with a perimeter no greater than 28 feet and a surface area not exceeding 500 square feet. This is a top water fishery and shrimp are harvested as they leave the bay. Roller frame trawls are also allowed; however, these are not used in the food shrimp fishery on the Atlantic coast.

Cast net

In Georgia, cast netting is the second most popular means of commercially harvesting food shrimp. Like the hand-retrieval fishery, most individuals who are commercially licensed utilize this fishery recreationally or as a form of supplemental income. Operating under the same season as that of the trawl fisheries, but without area restrictions, participants typically target shrimp in waters within the estuary proper, frequently fishing near or adjacent to sounds and tidal river mouths. During the initial years of its existence, the commercial cast net fishery in Georgia operated under minimal restrictions; however, regulatory changes in 1998 created gear restrictions and catch limits. Currently, the commercial catch limit for the cast net fishery is 50 quarts of shrimp at any one time, no more than 10 percent of which may be dead. Cast nets must be constructed of uniform mesh and material from the thimble or horn, to the lead line, with a minimum of ¾ pound of lead per radius. Commercial nets must have a minimum mesh size of 5/8 inch and cannot exceed a radius of 12 feet.

Channel net

In some areas, primarily North and South Carolina, channel nets are also used for commercial shrimping. Channel nets are essentially anchored shrimp trawls that fish almost the entire water column as they are held open by currents. In South Carolina channel nets are required to have top-opening turtle excluder devices (TEDs).

Other gear

In North Carolina, skimmer trawls are used in shallow tributaries. This gear is attached to frames that can be raised and lowered into the water on either side of the vessel. The tailbag can be retrieved and dumped without stopping and "hauling back." Butterfly nets, rectangular nets held open by a frame and attached to the side of the vessel, are used in a few areas. Haul or beach seines are also used to a minor extent for commercial fishing in some areas. The use of non-trawl gear, especially in North Carolina inshore waters is on the increase. Landings from these methods of fishing (e.g., beam trawls and chopstick gear) have increased from 137,000 lb in 1993 to 827,000 lb in 2002. In Georgia, seines 12 feet or less, with a maximum depth of 4 feet and maximum stretched mesh of 1 inch may be used any time in state waters. Seines less than 100 feet in length, with minimum stretched mesh size of 1 ¼ in, may be used on any sand beach or on any barrier island in Georgia but are prohibited in inlets or tidal sloughs. Seines 100-300 feet in length are allowed only on the oceanfront sides of beaches and must have a minimum stretched mesh of 2 ½ in.

Fishing area

The commercial fishing area for penaeid shrimp (white, brown and pink) species in the South Atlantic is mainly concentrated from Pamlico Sound and Ocracoke Inlet, North Carolina to Fort Pierce, Florida. There is another fishery off the Florida Keys where the main target is pink shrimp. Commercial shrimp catches in all four states are taken from internal waters, state waters out to three miles and from the EEZ. Most of the shrimp in these states are caught by otter trawls (SAFMC 1996b).

In North Carolina, the important shrimping areas are Pamlico Sound, Core Sound, major rivers and off the southern coast, south of Ocracoke Inlet. The brown shrimp fishery is the most important fishery followed by the white shrimp fishery in the fall and the pink shrimp fishery in the spring. Vessels operate night and day in Pamlico Sound, Neuse River, Bay River, Core Sound, Newport River, North River, White Oak River, New River and the Intracoastal Waterway in the southern portion of the state as well as the ocean off the central and southern coasts. Daytime shrimping in North Carolina takes place along the southern coast and in the New River during the fall.

South Carolina's major food shrimp trawling area is continuous in the Atlantic Ocean from the entrance of Winyah Bay near Georgetown southwestward to the South Carolina - Georgia state line near Savannah, Georgia, including the mouths of three sounds. Effort occurs to a lesser extent in state waters northwest of the Winyah Bay entrance to the South Carolina-North Carolina state line at Little River. Trawling often occurs in the EEZ off South Carolina prior to the opening of the territorial sea and during the open state trawling season. The summer to winter white shrimp fishery is the most important shrimp fishery for South Carolina vessels. Trawling occurs in the daylight hours in response to activity of the primary target species, white shrimp. The season generally runs from mid-May through December. The channel net fishery is prosecuted in inshore waters of North Santee Bay near Cape Romain and in Winyah Bay near Georgetown generally from mid-September through November.

In Georgia, shrimping takes place along the entire coast. Shrimp are harvested in estuarine and nearshore waters of each coastal county. Georgia law allows for state waters to be opened for the harvest of food shrimp from May 15 until December 31. At the discretion of the Commissioner of the Department of Natural Resources, the season can be extended through the last day in February. All decisions regarding the opening and closing of the state's waters to the harvest of food shrimp are based on current, sound principles of wildlife research and management. On average, Georgia waters are open from Mid-June through January. In Georgia, white shrimp comprise the largest annual portion of the commercial catch, yielding approximately 80% of all harvested shrimp and is the most economically valuable. This species is primarily harvested in state waters during the late summer, fall, winter and spring months, though it may be caught year round in federal waters adjacent to Georgia. The brown shrimp comprises approximately 18% of the total annual catch. During the summer months, when it is most prevalent in state waters, brown shrimp may comprise upwards of 70% of the total harvested shrimp. Pink shrimp makes up less than 2% of the total and is rarely if ever targeted.

The most important fishing area along Florida's east coast is the northeastern part of the state, between Fernandina Beach and Melbourne, just south of Cape Canaveral. Along Florida's east coast, the shrimp fishery is characterized by brown shrimp dominating the summer fishery and white shrimp dominating the fall and winter fisheries. Pink shrimp are harvested in Biscayne Bay generally during the period November through May.

Commercial bait shrimp fishery

The commercial bait shrimp fishery is much larger in Florida than in the other South Atlantic states. Live shrimp for bait are caught in Dade County and in six counties around the St. Johns River. A variety of gear is used in this fishery, but otter trawls (St. Johns) and roller frame trawls (Biscayne Bay) are the most commonly used. Wing nets are used in Volusia County for live bait shrimp harvest. There is very little effort directed specifically for commercial bait shrimp in either North or South Carolina.

In Georgia, however, the commercial bait shrimp fishery is the state's fourth most valuable commercial fishery. Targeting smaller shrimp than the food shrimp industry, the commercial bait shrimp fishery is restricted to designated zones inside the estuary. Prior to 1978, bait shrimp fishermen had no restrictions on area; however, as a result of consecutive freezes in the winters of 1977 and 1978, and the subsequent depletion of overwintering stocks of white shrimp, experimental "bait zones" were developed in an effort to protect nursery grounds and facilitate law enforcement (Music, Georgia DNR, pers. comm. 2003). As a result, both recreational and commercial bait fishermen are restricted to fishing in these designated zones, which are located throughout coastal Georgia in tidal creeks and rivers. Commercial bait harvesters may possess up to 50 quarts of shrimp, no more than ten percent of which can be dead. Vessels participating in the commercial bait shrimp fishery in Georgia are generally 25 feet in length or less, are equipped with large live wells and are powered by outboard motors. Typically, these vessels employ either a mongoose or flat/box net, with the headrope not to exceed 20 feet in length.

5.2.1.1.2 Recreational penaeid shrimp fishery

Recreational shrimp harvest in the South Atlantic occurs almost exclusively in state waters and is comprised mostly of penaeid shrimp (white, brown and pink) species. A variety of gear types are employed for recreational food shrimp activities and recreational shrimping for bait.

Licensing requirements are not consistent across all states and not all recreational shrimp fishermen are required to obtain a state permit or license to fish for penaeid shrimp species. In North Carolina, a person must obtain a Recreational Commercial Gear License (RCGL) to shrimp trawl for recreational purposes (i.e., not sell). The license holder can only trawl in open areas and must use a shrimp trawl with a maximum headrope length of 26 ft. The shrimp trawl must be equipped with a bycatch reduction device (BRD) and the use of mechanical methods for retrieval is prohibited. According to the RCGL data, recreational shrimping (trawling) takes place from the Pamlico District south. Areas of high activity are the tributaries of Pamlico Sound, most notably the Neuse River, Pamlico River and their tributaries. Recreational fishermen in North Carolina do not require a license to use seines and cast nets.

In South Carolina, a license to cast net for shrimp over bait during a regulated recreational season has been required since 1988. The season is restricted to 60 days during the white shrimp season generally between mid-September to mid-November. In Georgia, a Recreational Fishing License is required to engage in the not-for-sale harvest of shrimp with a cast net, seine and for the not-for-sale harvest of bait shrimp with a trawl.

The major areas for recreational shrimping in North Carolina are from Carteret County south to the state line and to a lesser extent in the tributaries of Pamlico Sound. In South Carolina, recreational shrimping takes place along the entire coast, with most activity from Winyah Bay southward to the South Carolina-Georgia state line. Georgia's sport bait trawling zones occur throughout the coastal area. Recreational beach seining is concentrated on Tybee, Sapelo, St. Simons, Jekyll and Cumberland Islands. In Florida, major sport shrimping areas are the St. Johns River area, the area around Ponce De Leon Inlet and in the southern part of the state in Biscayne Bay (SAFMC 1993).

In South Carolina, shrimp seines may be used year-round. Also, if the catch is kept for personal (non-commercial) use, a shrimp cast net not thrown over bait (without shrimp bait) can be used from May 1 through December 15 with a 48 quart limit, and 12 dozen limit from December 16 to April 30. A study conducted in South Carolina showed that shrimping over bait produces relatively little finfish bycatch compared to traditional cast netting for shrimp (Whitaker 1992).

In Georgia, cast netting for shrimp is the most popular recreational shrimping activity. Currently, the recreational catch limit in Georgia is 48 quarts of heads-on shrimp (30 quarts of shrimp tails) per day per boat. Also, certain estuarine zones are open for recreational live bait shrimping with single 10 foot trawl nets. Persons engaged in recreational, or sport, bait shrimping are limited to two quarts of bait per person, with no more than ½ pint dead, or four quarts per boat, with no more than one pint dead. Recreationally caught bait shrimp cannot be sold or consumed. Harvesting is restricted to the period ½ hour before official sunrise until ½ hour after official sunset.

Gear used by the recreational shrimp fishery in Florida consists of dip, drop and bridge nets, seines and cast nets. Cast nets and seines can be used by recreational fishermen in specified inside waters with no size restrictions.

Allowable Gear

The Shrimp Fishery Management Plan allows North and South Carolina, Georgia and east Florida to request a closure in federal waters adjacent to closed state waters for brown, pink or white shrimp following severe cold weather that results in an 80% or greater reduction in the population of white shrimp (whiting, royal red and rock shrimp fisheries are exempt from a federal closure for white shrimp).

During a federal closure, a buffer zone is established extending seaward from shore to 25 nautical miles, inside of which no trawling is allowed with a net having less than 4" stretch mesh. Vessels trawling inside this buffer zone cannot have a shrimp net aboard (i.e., a net with less than 4" stretch mesh) in the closed portion of the federal zone. Transit of the closed federal zone with less than 4" stretch mesh aboard while in possession of penaeid (white, brown and pink) species will be allowed provided that the nets are in an unfishable condition, which is defined as stowed below deck.

Bycatch reduction Devices (BRDs) - On a penaeid shrimp trawler in the South Atlantic EEZ, each trawl net that is rigged for fishing and has a mesh size less than 2.5", as measured between the centers of opposite knots when pulled taut, and each try net that is rigged for fishing and has a headrope length longer than 16.0 ft. must have a certified BRD installed. The following BRDs are certified for use by penaeid shrimp trawlers in the South Atlantic EEZ: extended funnel, expanded mesh and fisheye.

Turtle Excluder Devices (TEDs) are required in the penaeid shrimp fishery.

5.2.1.1.3 Commercial deepwater shrimp fishery

Given the distance from shore, depth of water, and gear necessary to harvest rock shrimp, there is no recreational fishery. The rock shrimp commercial fishery has existed off the east coast of Florida for approximately thirty years once extending from Jacksonville to Cape Canaveral. The relatively recent beginning for this shrimp fishery, compared to other southeast shrimp fisheries can be attributed to the lack of a viable market for the crustacean once considered "trash." Rock shrimp found a niche in the local fresh market and restaurant trade during the early 1970s, and became a regional delicacy. The increase in participants and market opportunities for smaller rock shrimp brought about a subsequent change in harvesting patterns as the fishing grounds extended south as far as St. Lucie County (SAFMC 1996a). Limited sporadic harvest has also occurred off Georgia, North Carolina and South Carolina. A limited access program was established in 2003 for vessels harvesting, in possession of and landing rock shrimp in Georgia and Florida. Expanding markets created growth within the industry that in turn has changed the composition of the rock shrimp fishery including the harvesting and the intermediate sectors (SAFMC 1996a).

In the south Atlantic region commercial trawlers are essentially the only user group exploiting the rock shrimp resource. Rock shrimp (*Sicyonia brevirostris*) harvested by commercial vessels is the only one of six species of *Sicyonia* reported for the south Atlantic coast that attains a commercial size (Keiser 1976). When the rock shrimp industry began, few vessels participated on a full-time basis with some vessels making a few trips a year when the white and brown shrimping ended, or as a bycatch of the penaeid shrimp fishery (Dennis 1992). During the period 1986 to 1994 there was an increase in effort in terms of the number of vessels participating (SAFMC 1996a).

Rock shrimp have been harvested along Florida's east coast and at one time, this fishery extended into south Georgia (statements at Public hearings for Shrimp Amendment 5). The increase in participants and market opportunities for smaller rock shrimp brought about a subsequent change in harvesting patterns as vessels began fishing as far south as St. Lucie County. This shift in effort to the south reflected new participation in the fishery as the majority of those harvesting these new areas were from the Gulf region. A control date for this fishery of April 4, 1994 was set to put the industry on notice that the Council could at some future date develop a limited access program for this fishery (SAFMC 1996a).

Amendment 1 to the Shrimp Plan established a requirement for vessel permits and dealer permits, and prohibited trawling for rock shrimp in an area off of Florida. These measures were published in the Federal Register on September 9, 1996.

Season
The peak rock shrimping season generally occurs from July through October (SAFMC 2002). Historically, the fishery did not begin until August or September (SAFMC 1996a). To a degree, the amount and timing of effort in the rock shrimp fishery are dependent on the success of the white and brown shrimp fisheries.

Harvest Area Information
During development of Shrimp Amendment 1, the Rock Shrimp Producers Association submitted information to the Council indicating that the harvest area extended between just north of New Smyrna Beach to Stuart between 36.6 m (120 ft) and 47.5 m (156 feet) and between 61 m (200 ft) and 73 m (240 feet) (SAFMC, 1996a). The fishable grounds are hard sand to shell hash bottoms, which run north and south with a width as narrow as one mile. There was an effort shift to the south of Cape Canaveral which exposed the known concentrations of *Oculina* coral and the *Oculina* Bank HAPC to bottom trawls. Trawling was prohibited in the HAPC (a 4 x 23 nm strip bounded by latitude 27°30' N and 27°53' N and longitude 79°56' W and 80°00' W) in 1982 as one of the measures under the Coral Fishery Management Plan (GMFMC and SAFMC 1982). In addition, Amendment 1 to the Snapper Grouper Fishery Management Plan prohibited the retention of snapper grouper species caught by roller rig trawls and their use on live/hard bottom habitat north of 28° 35' N latitude (SAFMC 1988). Furthermore Amendment 1 to the Shrimp Plan (SAFMC, 1996a) prohibited trawling in the area east of 80° 00' W longitude

between 27° 30' N latitude and 28° 30' N latitude shoreward of the 183 m (600 ft) contour.

In recent years, fishing activity has been concentrated off the Atlantic coast of Florida and particularly near Cape Canaveral (Sea Grant Louisiana 2006; SAFMC 1999). Some sources describe the coast between Jacksonville and St. Lucie Inlet as being of particular importance (Hill 2005b in Oceana 2007).

Trawl Vessels

There are two types of vessels in the rock shrimp fishery: ice or fresh boats and freezer boats. Most new rock shrimp trawlers are 75-80 feet in length and are rigged to tow two to four nets simultaneously. The double-rigged shrimp trawler has two outrigger booms from whose ends the cable from the winch drum is run through a block to the two nets (Figure 5.2.2-1). Testimony at Amendment 1 hearings indicated that a standard freezer trawler was around 73 feet and would pull four forty-foot nets.

Essentially the only gear used in the rock shrimp fishery is the trawl which consists of: (1) a cone-shaped bag in which the shrimp are gathered into the tail or cod end; (2) wings on each side of the net for herding shrimp into the bag; (3) trawl doors at the extreme end of each wing for holding the wings apart and holding the mouth of the net open; and (4) two lines attached to the trawl doors and fastened to the vessel. A ground line extends from door to door on the bottom of the wings and mouth of the net while a float line is similarly extended at the top of the wings and mouth of the net. A flat net is more often used when fishing for rock shrimp since they burrow into the bottom to escape the trawl. This net has a wider horizontal spread than other designs and is believed more effective (SAFMC 1996a).

Some vessels use twin trawls, which are essentially two trawls on a single set of doors, joined together at the head and foot ropes to a neutral door connected to a third bridle leg. Thus, instead of towing two seventy-foot nets the vessel tows four forty-foot nets. This rig has some advantages in ease of handling and increased efficiency. At the time Amendment 1 was developed industry advisors indicated that the cod end mesh size commonly used in the industry was between 1 7/8 and 2 inches stretched mesh measured on the diagonal (SAFMC 1996a).

The tow length varies depending on many factors including the concentration of shrimp. Large boats fishing offshore waters make much longer drags lasting several hours. Testimony at public hearings for Shrimp Amendment 1 indicated that vessels may drag up to 30 to 35 miles over a number of tows in one night fishing for rock shrimp (SAFMC 1996a).

5.2.1.2 Economic description of the shrimp fishery

This section describes the economic environment of the South Atlantic rock and penaeid shrimp fisheries. The section is primarily divided into three sub-sections. First, these fisheries are described generally where information is presented at a highly aggregated level. This information provides a larger context to the more detailed and disaggregated information that follows. In the second sub-section, the federal permit requirements that affect participants in these fisheries are described. This information is critical as it determines which entities are likely to be impacted by the management actions considered in this Amendment, and thereby in turn determines what information is necessary to determine the impacts of the actions and the alternatives being considered under each. A detailed description of the entities potentially impacted by the actions in this Amendment is presented in the third sub-section. This final sub-section is further broken down into descriptions of the harvesting (i.e., vessels), dealer/wholesaler, and processing sectors of the industry, respectively. The greatest level of attention and detail is given to the harvesting sector, and particularly the harvesting sector of the rock shrimp fishery since the actions considered in this Amendment primarily deal with this group of entities. For this group of vessels, additional descriptive information is provided based on the current status of their permits as well as their recent operational characteristics (for example, whether or not the vessel has been commercially active in general and specifically within the South Atlantic rock shrimp fishery). Such information is needed to identify the specific vessels that will be potentially impacted by the actions considered in this Amendment, as well as the nature and magnitude of those impacts.

5.2.1.2.1 General Description of and Recent Trends in the South Atlantic Rock and Penaeid Shrimp Fisheries

As Amendments 1 (SAFMC 1996a), 5 (SAFMC 2002), and 6 (SAFMC 2004) to the South Atlantic Shrimp Fisheries Management Plan (FMP) describe in detail, the South Atlantic rock shrimp fishery is quite volatile, demonstrating significant ups and downs in terms of landings, revenues, and vessel participation from one year to the next. These Amendments describe the nature of the fishery from its inception through 2002. Amendment 6 also provides considerable information on the nature and history of the South Atlantic penaeid shrimp fishery. The information from those Amendments is incorporated herein by reference. The purpose of the information provided in this section is to update this historical information and specifically focus on the years 2003 through 2006, though information specific to the rock shrimp fishery and its participants has been updated through 2007. *However, all landings-related information for 2007 should be considered preliminary.* These years were selected since data on earlier years has been provided in previous Amendments. The provisions in Amendment 5 became effective in 2003, particularly the limited access endorsement program for the rock shrimp fishery, and 2006 is the most recent year for which complete landings data are available for the penaeid shrimp fishery. However, given the nature of certain regulations governing the limited access component of the rock shrimp fishery, landings data through 2007 for this component of the fishery and its participants are needed to properly assess the impacts of the actions under consideration in this Amendment.

Landings data can be analyzed from different perspectives. For example, it is common for landings to be compiled according to the port or state of landing. This is in fact how commercial fisheries landings data are commonly reported on the NOAA Fisheries Service website. Information at this level is important when there is a need to address the importance of a particular species or group of species to a specific port, community, or state. Table 5.2.1-1 reports all shrimp (penaeid, shrimp, and other minor shrimp species) landings and revenues during the years 2003 through 2006 in the South Atlantic States (i.e., North Carolina, South Carolina, Georgia, and the east coast of Florida, not including Monroe County). These landings may come from both South Atlantic and non-South Atlantic waters (e.g., Gulf of Mexico waters). Landings data of this nature are used to assess trends in the fishery as a whole over recent years.

According to this information, total shrimp landings in the South Atlantic were fairly stable in 2003 and 2004, and in fact nearly identical to reported landings in 2001 and 2002. However, the data also indicate that the decline in shrimp prices that began and was most significant in 2001 continued during 2003 and 2004. Between 2001 and 2004, the aggregate price of shrimp in the South Atlantic declined by approximately one-third in nominal terms. In real terms (i.e., after accounting for inflation), the decline was even greater. And although prices apparently increased slightly in 2005, landings decreased precipitously, specifically by nearly 40%. In fact, landings and revenues in the South Atlantic shrimp fishery in 2005 were at their lowest level since 1978, nearly three decades ago. Although landings recovered somewhat in 2006, close to the levels seen in 2001-2004, prices fell again to approximately the same level experienced in 2003 and were thus very low by historical standards. However, preliminary landings data for 2007 suggest that, while production in 2007 may still be approximately the same as in 2006, and thus low by historical standards, prices may have increased back to a level comparable to those seen in 2001, which would represent an increase of nearly 20% over 2006 prices.

Considerable caution must be used in the use and interpretation of aggregate shrimp prices such as those reported in Table 5.2.1-1. Such prices do not take into account variations in the size composition of the landings and it is well established that larger shrimp command higher market prices, even though the magnitude of the price premium attached to larger shrimp has shrunk considerably in the past several years. So, for example, the aggregate price of shrimp could increase from one year to the next, not necessarily because the price of shrimp has increased, but simply because larger size shrimp have made up a larger proportion of the total landings. A complete analysis of trends in South Atlantic shrimp prices by standardized size counts/categories has not yet been conducted in part because such data have not been consistently collected in all States over the past several years.[1]

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[1] Florida's trip ticket data is the primary source of the problem, where it has not been uncommon for dealers to report their shrimp size data in terms such as "small," "medium," "large," and "jumbo." There is no known method to convert such categories into standard size count categories, in part because it is highly unlikely that a common interpretation of these terms is being applied across all reporting dealers. However, it should be duly noted that the shrimp size count information in Florida's trip ticket data has improved and become more consistent in 2006 and 2007, and thus an attempt to re-analyze all of the South Atlantic shrimp price data will be attempted in the near future.

Table 5.2.1-1. Shrimp Landings and Revenue in South Atlantic states, 2003-2006 (Personal communication from the National Marine Fisheries Service, Fisheries Statistics Division, Silver Spring, MD).

Year	Landings (Heads-on pounds)	Revenue (Nominal)	Average Price per Pound
2003	24,011,340	$41,175,716	$1.71
2004	25,990,290	$42,757,771	$1.65
2005	15,747,918	$29,391,036	$1.87
2006	21,724,377	$37,740,648	$1.74

However, such an analysis can and has been conducted for shrimp prices in the Gulf. For the most part, the price trends in the South Atlantic data are comparable to those found in the Gulf. For example, as in the South Atlantic, the decline in shrimp prices began in 2001 and generally continued through most of 2004. However, the largest price decline took place in 2002 as opposed to 2001. Further, Gulf shrimp prices began to increase in the latter part of 2004 and this increase continued through much of 2005. However, Gulf shrimp prices began to decline in the last quarter of 2005 after Hurricanes Katrina and Rita and this decline continued through 2006. In fact, Gulf shrimp prices in 2006 reached their lowest levels in decades, somewhat contrary to what is suggested by the aggregate South Atlantic shrimp data, which suggests the low point was experienced in 2004. Furthermore, Gulf shrimp prices appear to have declined much more between 2001 and 2006, by approximately 50%, compared to prices in the South Atlantic. Similar to the preliminary South Atlantic data, preliminary data from the Gulf suggests that prices rose in 2007, particularly for the 30-count size and larger shrimp. However, the increase in the Gulf was only about 5%, and thus considerably less than what is suggested by the preliminary South Atlantic data.

Table 5.2.1-2 provides a breakdown of the South Atlantic shrimp landings data according to state of landing between 2003 and 2006. These data provide additional insight into how the fishery has changed in recent years, such as the fact that trends in production and prices have not been the same across all states. In 2003, production between the four states was relatively equal. However, since that time, east Florida has consistently been the dominant state of production in the fishery, and in fact almost equaled the production of the other three states combined in 2004. Production has consistently declined in each year in both Georgia and South Carolina. In North Carolina, production also decreased between 2003 and 2005, but then rebounded considerably in 2006, nearly back to the level experienced in 2003. Conversely, landings on the east coast of Florida have fluctuated considerably from year to year, increasing significantly in 2004, but falling even more precipitously in 2005, and then rebounding again in 2006. Thus, although the declines in South Carolina and Georgia have been steady during these years, the decline in North Carolina and particularly east Florida led to the nearly record low level of total production in 2005. Preliminary data for 2007 suggests that landings in South Carolina and particularly Georgia have continued to decline and landings in east Florida have continued their up and down pattern in recent years by falling below their 2006 level.

Conversely, the ability of the fishery as a whole to maintain its overall level of production from 2006 to 2007 appears to be due to a significant increase in landings in North Carolina, possibly back to levels experienced in 2000 and 2002. Thus, contrary to the past three years, North Carolina will be the primary leader in shrimp production for 2007. However, unlike in 2000 and 2002, the relatively high level of production in North Carolina during 2007 appears to be due to a significant increase in white shrimp landings, as opposed to the more historically predominant brown shrimp. Reasons for this somewhat surprising result are currently under investigation, as is its potential relationship to the historically low levels of pink shrimp production in that state.

Table 5.2.1-2. Shrimp Landings and Revenue in South Atlantic states, by state 2003-2006.
(Personal communication from the National Marine Fisheries Service, Fisheries Statistics Division, Silver Spring, MD).

Year	State	Landings (Heads-on pounds)	Revenue (Nominal)	Average Price per Pound
2003	Florida East	6,231,956	$11,832,752	$1.90
2004	Florida East	11,357,169	$15,955,615	$1.40
2005	Florida East	4,940,298	$10,038,438	$2.03
2006	Florida East	8,527,276	$15,115,434	$1.77
2003	Georgia	5,478,740	$9,676,197	$1.77
2004	Georgia	4,978,825	$9,954,480	$2.00
2005	Georgia	4,493,325	$8,371,931	$1.86
2006	Georgia	3,810,588	$7,002,796	$1.84
2003	North Carolina	6,167,393	$10,930,644	$1.77
2004	North Carolina	4,880,849	$9,462,867	$1.94
2005	North Carolina	2,357,536	$4,409,143	$1.87
2006	North Carolina	5,736,664	$9,141,456	$1.59
2003	South Carolina	6,133,251	$8,736,123	$1.42
2004	South Carolina	4,773,447	$7,384,809	$1.55
2005	South Carolina	3,956,759	$6,571,524	$1.66
2006	South Carolina	3,649,849	$6,480,962	$1.78

Somewhat surprisingly, the trends in prices are also slightly different across the four States. For example, the aggregate price of shrimp has steadily increased in South Carolina, which is inconsistent with other noted price trends. As noted earlier, this trend could be due to larger shrimp composing a larger proportion of the total shrimp landed in that state, though other factors could also be at play. And while prices increased in 2004 in not only South Carolina, but North Carolina and Georgia as well, prices decreased significantly in east Florida. This price decline is clearly driving the price decrease in that year for the fishery as a whole. As discussed later, the price decline in east Florida was driven by a decline in the price of pink shrimp specifically. And while shrimp prices in east Florida rebounded significantly in 2005, they decreased slightly in Georgia and North Carolina. With the exception of South Carolina, shrimp prices decreased in all other states in 2006. Preliminary data suggest that prices increased in 2007 across all states.

Table 5.2.1-3 provides a breakdown of the South Atlantic shrimp landings according to species, excluding rock shrimp which are examined separately, between 2003 and 2006. So-called "marine" shrimp is a conglomerate of landings where the species of shrimp landed is not identified by the reporting dealer or it is a mix of species (i.e., in effect, the species is unknown). Therefore, interpretations of that set of data would not be particularly useful. And though consistently present, royal red shrimp are a minor species within the overall fishery. As has generally been the case in recent history, white shrimp has been the primary species of harvest between 2003 and 2006. Preliminary data suggest that its predominance in the total landings will be even greater in 2007, though from the state of North Carolina rather than South Carolina and Georgia, as has usually been the case in the past. Primarily due to production in east Florida, pink shrimp landings have been relatively stable during this time period, though increased somewhat significantly in 2006. However, preliminary data suggest a steep decline in pink shrimp production in 2007. Though brown shrimp landings were relatively close to white shrimp landings in 2003, they have fallen dramatically over the past four years, with much of that decline occurring in 2004. In fact, brown shrimp production in 2006 was less than one-third of its level in 2003. Preliminary data suggest that landings may have rebounded somewhat in 2007.

Table 5.2.1-3. Shrimp landings and revenue in South Atlantic states by species, 2003-2006.
(Personal communication from the National Marine Fisheries Service, Fisheries Statistics Division, Silver Spring, MD).

Year	Species	Landings (Heads-on pounds)	Revenue (Nominal)	Average Price per Pound
2003	SHRIMP, BROWN	9,478,261	$14,339,865	$1.51
2004	SHRIMP, BROWN	5,415,156	$9,227,991	$1.70
2005	SHRIMP, BROWN	4,436,744	$7,244,469	$1.63
2006	SHRIMP, BROWN	3,046,798	$5,010,256	$1.64
2003	SHRIMP, MARINE	30,998	$79,650	$2.57
2004	SHRIMP, MARINE	86,925	$219,768	$2.53
2005	SHRIMP, MARINE	348,506	$634,513	$1.82
2006	SHRIMP, MARINE	266,067	$408,815	$1.54
2003	SHRIMP, PINK	443,019	$940,413	$2.12
2004	SHRIMP, PINK	648,730	$1,028,943	$1.59
2005	SHRIMP, PINK	484,567	$560,176	$1.16
2006	SHRIMP, PINK	927,521	$907,585	$0.98
2003	SHRIMP, ROYAL RED	270,605	$410,747	$1.52
2004	SHRIMP, ROYAL RED	69,466	$139,168	$2.00
2005	SHRIMP, ROYAL RED	126,982	$211,752	$1.67
2006	SHRIMP, ROYAL RED	148,979	$282,271	$1.89
2003	SHRIMP, WHITE	11,032,356	$21,259,090	$1.93
2004	SHRIMP, WHITE	13,814,718	$27,725,627	$2.01
2005	SHRIMP, WHITE	10,223,292	$20,616,288	$2.02
2006	SHRIMP, WHITE	14,383,934	$26,960,659	$1.87

The prices of the primary species (white and brown) tended to move in the same direction between 2003 and 2006. For example, the prices of both white and brown shrimp increased slightly between 2003 and 2004, were relatively stable in 2005, while both fell in 2006. Conversely, the price of pink shrimp fell dramatically, by over 50%, between 2003 and 2006. This decline is more precipitous than trends in other shrimp price data during this time, and thus some of the decline may be due to changes in the size composition of pink shrimp landings (i.e., smaller shrimp may be making up a larger proportion of the landings in more recent years). Further research and improvements in size data are needed to test this hypothesis.

Since rock shrimp are the primary species of interest with respect to actions under consideration within this Amendment, landings and revenue information for this species is presented separately. In Table 5.2.1-4, similar to information in Table 5.2.1-4, data regarding rock shrimp landings and revenues in the South Atlantic states are presented, though preliminary data for 2007 is also included. However, from a management perspective, the landings of greatest interest are those coming from a particular body of water (e.g., South Atlantic waters under the Council's jurisdiction) or a particular group of vessels (e.g., vessels that possess a particular type of permit or endorsement issued under one of the Council's FMPs). Thus, in the current case, it is more appropriate to examine rock shrimp landings harvested from South Atlantic waters and rock shrimp landings by vessels with South Atlantic limited access rock shrimp endorsements. The former is presented in Table 5.2.1-5 for the years 2003 through 2007. These data and subsequently discussed landings and revenue information represent a compilation of Florida trip ticket data, Gulf shrimp landings data, other South Atlantic states' trip ticket data and Standard Atlantic Fisheries Information Systems (SAFIS) data, the latter two of which are maintained by the Atlantic Coastal Cooperative Statistics Program (ACCSP)[2].

Table 5.2.1-4. Rock shrimp landings and revenue in South Atlantic states, 2003-2007. (Personal communication from the National Marine Fisheries Service, Fisheries Statistics Division, Silver Spring, MD and Southeast Fisheries Science Center, Fisheries Statistics Division Miami, FL).

Year	Landings (Heads-on pounds)	Revenue (Nominal)[3]
2003	2,756,101	$4,145,951
2004	5,955,295	$4,416,274
2005	127,827	$123,838
2006	2,951,078	$4,171,062
2007*	233,712	$434,938

*2007 data are preliminary

[2] 2007 trip ticket data for South Carolina and North Carolina was provided by the North Carolina Department of Environment and Natural Resources and the South Carolina Department of Natural Resources respectively.
[3] Nominal values are those that have not been adjusted for inflation.

Table 5.2.1-5. South Atlantic rock shrimp landings, revenue, and participation, 2003-2007.[4]

Year	Number of Harvesting Vessels	Landings (Heads-on pounds)	Revenue (Nominal)	Average Price per Pound	Average Landings per Vessel	Average Revenue per Vessel	Number of Trips	Average Landings per Trip	Average Revenue per Trip
2003	97	2,980,623	$4,489,905	$1.51	30,728	$46,288	360	8,280	$12,472
2004	85	6,591,583	$5,012,147	$0.76	77,548	$58,966	300	21,972	$16,707
2005	21	109,281	$99,611	$0.91	5,204	$4,743	29	3,768	$3,435
2006	44	3,018,322	$4,264,576	$1.41	68,598	$96,922	142	21,256	$30,032
2007*	26	240,550	$441,277	$1.83	9,252	$16,972	78	3,084	$5,657

*2007 data are preliminary

The information in Tables 5.2.1-4 and 5.2.1-5 illustrate that the South Atlantic rock shrimp fishery has continued its historically cyclical nature in recent years. Recall that landings in 2002 were at their lowest level in over two decades (i.e., since 1980). In 2003, landings increased significantly, comparable to landings seen between 1997 and 1999. And in 2004, landings increased further, back to levels similar to those experienced in 2000 and 2001 even though the number of participating vessels decreased from 97 to 85 vessels. However, in 2005, landings plunged to their lowest level since South Atlantic rock shrimp landings were first tracked back in 1978 and the number of participating vessels similarly plunged to only 21 vessels. And although landings, revenues, and even prices rebounded in 2006, vessel participation in 2006 (44 vessels) was considerably less than in 2003 or during the previous decade. The fact that landings and revenues per trip and per vessel were relatively high in 2006, even compared to previous "good years," suggests that factors outside the fishery played a role in limiting participation. In 2007, production and the number of harvesting vessels fell back to levels just slightly above their historic lows in 2005. Using the MSY/OY figure of approximately 4.912 million pounds for this fishery as a reference point, landings were above this reference point in 2004, below it in 2003 and 2006, and significantly below this value in 2005 and 2007.

Thus, it would appear that the fishery's cyclical nature has intensified in the past four years. It is highly likely that the instability of various economic factors has exacerbated the fishery's biological volatility. Although a definitive explanation cannot be provided at this time, it is likely that the extremely low level of landings in 2005 were not only a function of biological factors (e.g., relatively low abundance), but also economic factors (e.g., historically low rock shrimp prices, particularly relative to other potential target species, and high fuel prices, given that rock shrimp are harvested in more distant waters relative to penaeid species) and possibly natural disasters (e.g., the impact of Hurricane Katrina on vessels from ports in the Gulf of Mexico, particularly in Alabama). For example, rock shrimp prices fell dramatically in 2004, by 50%, relative to 2003. Rock shrimp prices basically remained at this historically low level in 2005, likely

[4] With the exception of 150lbs in 2003 and 22lbs in 2004, all reported landings of rock shrimp from South Atlantic waters could be ascribed to a specific vessel, which reflects a marked improvement in the quality of the data in this respect since the analysis for Amendment 5 was conducted.

discouraging potential participants from engaging in the fishery. And although the number of trips is only a very rough estimate of effort, and thus landings per trip is similarly only a rough estimate of abundance, landings per trip was also very low in 2005 and similarly provided a significant disincentive for other vessels to prosecute the fishery that year. And though rock shrimp prices were considerably higher in 2007 than in 2005, so too were fuel prices. In a distant water fishery such as rock shrimp, the higher fuel expenses likely offset any incentive to participate in the fishery generated by the higher price for rock shrimp. And, as in 2005, the landings per trip were very low, and in fact slightly lower than in 2005. The combination of these two factors likely explains the low level of production in 2007.

Except in 2005, the landings and revenue figures in Table 5.2.1-5 are slightly larger than those in Table 5.2.1-4, which would indicate that some of the rock shrimp harvested from South Atlantic waters are being landed in Gulf of Mexico ports. Information in Amendment 5 (SAFMC 2002) suggests that participation in the fishery by vessels with homeports in the Gulf of Mexico increased during the 1990s through at least 2000. In combination with data from the NOAA Fisheries Service website, information in Amendment 5 also suggests that the "leakage" of rock shrimp landings from South Atlantic waters to Gulf ports was considerably larger in previous years, particularly in 1999 and 2000, relative to the 2003-2007 time period. And though the subject requires more research, it appears likely that market forces, particularly fuel prices, have caused it to be far less economically viable in recent years for vessels to harvest rock shrimp from South Atlantic waters, particularly off the east coast of Florida, and then transport and land them in Gulf ports, with the exception of Key West, which basically serves as a "dividing point" between South Atlantic and Gulf waters and, to a lesser extent, the Ft. Myers/Ft. Myers Beach area.

5.2.1.2.2 Federal Permit Requirements in the South Atlantic Rock and Penaeid Shrimp Fisheries

Federal permit requirements in the South Atlantic rock shrimp fishery were initially implemented under Amendment 1 to the South Atlantic Shrimp FMP (SAFMC 1996a). Specifically, the regulations that implemented Amendment 1 state that "for a person aboard a vessel to fish for rock shrimp in the South Atlantic EEZ or possess rock shrimp in or from the South Atlantic EEZ, a commercial vessel permit for rock shrimp must be issued to the vessel and must be on board." Since available information suggests that the rock shrimp fishery in the South Atlantic is prosecuted exclusively within federal waters, this requirement implies that rock shrimp in the South Atlantic can only be harvested by vessels with a federal South Atlantic rock shrimp permit. At the time of its implementation, and currently, this permit is "open access" in nature. That is, the Council did not impose any restrictions on the number of permits that could be issued or the nature of the vessels to which the permits could be issued. Therefore, in effect, a permit would basically be issued to any vessel whose owner applied for one. Amendment 1 also required permits for rock shrimp dealers. Specifically, the regulations indicate that "for a dealer to receive rock shrimp harvested from the South Atlantic EEZ, a dealer permit for rock shrimp must be issued to the dealer." Both the vessel and dealer permit requirements went into effect in November 1996. The dealer permit requirement has remained unchanged and is still in effect at this time, the importance of which is discussed under the description of the dealer/wholesaler sector in the South Atlantic rock shrimp fishery.

As has often been the case in open access fisheries, the number of open access rock shrimp permits exceeded expectations within a few years following the implementation of the vessel permit requirement. Participation in the fishery increased as did potential and expected participation in the future. As noted in Amendment 5 (SAFMC 2002), although the maximum number of active vessels (i.e., vessels with landings in a particular year) reached an apex of approximately 153 vessels in 1996, the number of permits and thus potential participants commonly averaged around 400 vessels in the late 1990s and 2000. As such, considerable concern existed with respect to "latent capacity" in the fishery and its ability to expand effort to levels that would be both biologically and economically unsustainable. The Council determined that the fishery could only sustain, biologically and economically, a maximum of 150 vessels. As a result of this determination, a limited access program was implemented under Amendment 5 for that portion of the fishery in the EEZ off of east Florida and Georgia, an area which covers the fishery's primary fishing grounds (i.e., the majority of the landings come from this area).

Amendment 5 consistently discusses the implementation of a limited access "permit," which indicates that the Council intended to implement a new "stand-alone" permit for the harvest of rock shrimp in the EZZ off of east Florida and Georgia. However, the implementing regulations state that "effective July 15, 2003, for a person aboard a vessel to fish for rock shrimp in the South Atlantic EEZ off Georgia or off Florida or possess rock shrimp in or from the South Atlantic EEZ off Georgia or off Florida, a limited access endorsement for South Atlantic rock shrimp must be issued to the vessel and must be on board" (emphasis added). This distinction has apparently been the source of some confusion for certain fishery participants and in fact is the reason for one of the actions under consideration within this Amendment. The issue may sound like mere semantics; however, the distinction is important for the following reason. First, it must be kept in mind that the new requirement did not replace the existing requirement for vessels harvesting South Atlantic rock shrimp to possess an open access permit. Second, an endorsement is basically an instrument that is "attached" to a permit. That is, in order to have the endorsement, a vessel must have the permit as well since the endorsement is "attached" to the permit. In this case, that permit would be the originally required open access permit. Thus, vessels harvesting rock shrimp from federal waters off of east Florida and Georgia must have both the limited access endorsement and the open access permit. The former cannot be issued or legally used for harvesting purposes without the latter. Similarly, possession of only the open access permit does not allow for the legal harvest of rock shrimp from the EEZ off of east Florida or Georgia. However, the open access permit requirement still applies to vessels that harvest rock shrimp from federal waters off of North and South Carolina.

Another important aspect of the rock shrimp limited access endorsement is that vessel owners must regularly renew their endorsements in order for the endorsements to be considered “active.” A vessel’s endorsement must be active in order for it to be used for harvesting purposes or to be transferred to another vessel. The latter point is important since these endorsements are fully transferable. The issue of transferability is important for other reasons discussed later in this section. Specifically, the regulations state that “the Regional Administrator (RA) will not reissue a limited access endorsement for South Atlantic rock shrimp if the endorsement is revoked or if the RA does not receive a complete application for renewal of the endorsement within 1 year after the endorsement’s expiration date.” Thus, after an endorsement’s expiration date, the endorsement can still be renewed for up to one year after that date. During this time, the endorsement is considered to be “renewable,” though it cannot be transferred nor is it legal for the vessel with the endorsement to harvest rock shrimp from federal waters off of east Florida or Georgia. If an endorsement has not been renewed by the end of the one-year time period after the expiration date, the endorsement will be “terminated.” A terminated endorsement is “non-renewable” and non-transferable and thus, in effect, is permanently retired from the fishery. Thus, the terms “terminated” and “non-renewable” are synonymous and may be used interchangeably. Though the open access permits must also be active in order for vessels to legally harvest rock shrimp from federal waters off of North and South Carolina, and can expire, no limitation exists with respect to when they can be renewed or obtained and thus they are never “terminated” per se. By definition, since they are open access permits, any vessel owner can obtain a permit at any time.

In addition to the creation of the limited access program, the Council also wanted to ensure that, after the program’s implementation, the fishery remained economically viable, benefits of the program accrued to “serious” participants in the fishery, and the issue of latent permits/capacity did not resurface. At the time the Council deliberated over the actions in Amendment 5, the rock shrimp fishery was still relatively healthy from an economic perspective and that many owners of non-qualifying vessels wanted to participate in the fishery. As such, the Amendment also included a “use it or lose it” requirement. Specifically, vessels with endorsements would have to harvest at least 15,000 pounds of South Atlantic rock shrimp in at least one out of every four calendar year time period. The Council concluded this provision was necessary to ensure a more stable supply of rock shrimp for consumers, but also believed that the poundage level was sufficiently low and the period of time sufficiently long to allow vessels to participate in other fisheries that may be economically preferable in the short-term without forcing them to forego such opportunities simply to maintain their endorsement and for vessel owners to replace lost or retired vessels.

Specifically, the implementing regulations state that “a limited access endorsement for South Atlantic rock shrimp that is inactive for a period of four consecutive calendar years will not be renewed. For the purpose of this paragraph, ‘inactive’ means that the vessel with the endorsement has not landed at least 15,000 lbs. (6,804 kg) of rock shrimp from the South Atlantic EEZ in a calendar year.” Although the regulations refer to an “inactive” endorsement and the Amendment refers to an “inactive” permit, that terminology is not carried forward throughout the remainder of this section or in the impacts analysis as it would likely only create additional confusion in conjunction with the terminology used by the Southeast Region's Permits Office as discussed above. Rather, the analysis will simply discuss whether a vessel has met this requirement or any other landings requirement that the Council may be considering and the likely impacts of such.

The combination of the landings requirement, the effective date of the limited access endorsement, and the fully transferable nature of the endorsements has created some additional issues. At the time Amendment 5 was implemented, analyses indicated that approximately 168 vessels were expected to qualify for South Atlantic limited access rock shrimp endorsements. However, after all appeals were heard and determinations were made by NOAA Fisheries Service, South Atlantic limited access rock shrimp endorsements were in fact issued to 155 vessels, thus effectively capping participation in the fishery at this level. Recalling that the Council believed that the fishery could support no more than 150 active vessels, the implementation of the Amendment led to a fishery with almost exactly the desired number of vessels. Thus, it would be logical to conclude that the Council would not consider additional, significant vessel/endorsement attrition from the fishery to be desirable. As previously noted, these endorsements are fully transferable, meaning that they can be transferred to another owner of that vessel, another vessel owned by the same owner, or an entirely different vessel and owner. As a result, the universe of vessels holding these endorsements has changed over time. In turn, when a vessel initially obtained its endorsement, and thus the period of time each vessel with a current endorsement has held that endorsement, differs across vessels. This fact is critical with respect to the current 15,000-pound landings requirement.

Specifically, for vessels that initially received their endorsements in 2003, given that the requirement to possess the endorsements in order to operate in the fishery was not effective until July 15, 2003, NOAA Fisheries Service made an internal policy decision, reflected in a Fishery Bulletin sent to all endorsement holders in September 2003, to not start the four year "clock" with respect to vessels attaining the minimum landings requirement until January 1, 2004. In general, this adjustment would be expected to work to the benefit of the initial endorsement recipients since they would not be forced to count the last 5½ months of 2003 (i.e., a partial calendar year) as one of their "calendar years." Thus, vessels initially obtaining their endorsements in 2003 would have calendar years 2004 through 2007 to meet the 15,000-pound landings requirement in a single calendar year. On the other hand, this decision would presumably not preclude a vessel owner from counting landings from 2003 towards meeting the requirement, at least with respect to whether the requirement was met during the 2003-2006 time period. However, even if the vessel did meet the requirement in 2003, but did not in any subsequent year through 2007, then it would not have met the requirement for the four-year time period running from 2004 through 2007 and thus would lose its endorsement under the current regulations. The primary point is that, although a vessel may meet this requirement in its first four-year cycle, the four-year time period is recurring from year to year and the requirement must be met in every four-year time period. In a fishery experiencing an economic downturn, the impact of this requirement on fleet size could be dramatic over several years.

However, NOAA General Counsel has determined that the regulations allow for each vessel's four year "clock" to start at the time it initially obtained the endorsement, as opposed to when the endorsement was first issued to its initial recipient. Thus, all current vessels with endorsements are not operating on the same "clock." As such, the four-year time period in which a vessel must meet the landings requirement depends on the year the vessel initially obtained its endorsement. To be consistent with the previously noted policy decision in which the four-year timeframe for vessels obtaining their endorsements in 2003 was not started until January 1, 2004, it is assumed that the same logic would be applied to vessels obtaining their endorsements in subsequent years. For example, if a vessel initially obtained its endorsement in August 2005, then its four year clock for meeting the landings requirement need not begin until January 1, 2006, and thus this vessel would have calendar years 2006 through 2009 to meet the current landings requirement. However, since the regulations do not explicitly preclude a vessel owner from doing so, it is assumed that, if it is to the vessel owner's advantage, the year in which the endorsement was initially obtained can be counted as one of the four years within which the 15,000-pound landings requirement must be met.

Finally, the Council required federal permits for trawler vessels harvesting penaeid shrimp from federal waters in the South Atlantic under Amendment 6 (SAFMC 2004). Specifically, the regulations state "for a person aboard a trawler to fish for penaeid shrimp in the South Atlantic EEZ or possess penaeid shrimp in or from the South Atlantic EEZ, a valid commercial vessel permit for South Atlantic penaeid shrimp must have been issued to the vessel and must be on board." This requirement became effective in April 2006 and therefore has only been in effect for approximately two years. These permits are "open access" in nature and thus any vessel owner can obtain one at any time and there are no restrictions with respect to how many can be issued. Thus, like the open access rock shrimp permit, these permits can expire, but they can be renewed or a new one obtained at any time and never "terminate." It is worth noting that, at this time, no federal dealer permit requirement exists for the South Atlantic penaeid shrimp fishery.

5.2.1.2.3 Number of Federal Permits

The following is an analysis of data pertaining to the previously discussed permits and endorsements from both the current Permit Information Management System (PIMS) and historical Rbase permits databases. With respect to the open access rock shrimp and penaeid shrimp permits, these data were valid and accurate as of March 31, 2008, while data pertaining to the limited access rock shrimp endorsements were valid and accurate as of April 1, 2008. The two different dates were selected to provide the most useful and accurate information possible. Specifically, permits always expire at the end of a particular month. And thus, the number of permits always decreases, particularly open access permits, on the first day of each month. Since vessel owners tend to renew their permits as the month progresses, the number of permits returns to its typical level at the end of each month. Thus, the number of open access permits at the end of the most recent month was used to ensure that they would not be systematically underestimated. Similarly, the status of the limited access rock shrimp endorsements typically changes on the first of each month and the endorsements' status is critical to the impacts analysis.

Thus, the decision was made to use the most current information possible with respect to the status of these endorsements in terms of how many are active, renewable, or terminated/nonrenewable.

Based on the available data, it was determined that there are 266 open access rock shrimp (RS) permits, 620 penaeid shrimp permits (SPA) and, as already noted, 155 limited access rock shrimp endorsements (RSE). The distribution of these permits across communities is presented in the description of fishing communities. The number of permits cannot simply be summed in order to determine the number of vessels possessing such permits/endorsements because many vessels possess two or all three of these permits/endorsements. The total number of vessels that possess one or more of these permits/endorsements is 694 and thus this is the maximum number of vessels that could be potentially impacted by the actions considered in this Amendment. For reasons explained later, it is also important to note that, of these 694 vessels, approximately 293 also possess Gulf shrimp moratorium permits and therefore only about 400 of these vessels are "unique" to the South Atlantic shrimp fisheries.

Of course, all vessels with active RSEs also possess open access RS permits. And it would be expected that the vast majority of vessels with active or renewable RSEs would also have an SPA permit since it is common for penaeid shrimp to be incidentally harvested on trips that primarily target rock shrimp. Conversely, for vessels that do not have an active or renewable RSE, a minority probably possess an RS permit only since rock shrimp are rarely harvested on penaeid shrimp trips in federal waters off of North and South Carolina. However, few vessels that possess an RS permit but not an RSE would likely not have an SPA permit since it would be nearly impossible for a vessel to only harvest rock shrimp in federal waters off of North and South Carolina without also harvesting penaeid shrimp. The data support these hypotheses. Specifically, of the 155 vessels with RSEs, 104 also possess an SPA. Of the 516 vessels that possess an SPA but not an RSE, only 121 possess an RS permit. Of the 620 vessels with an SPA permit, only 223 have an RS permit. And of the 266 vessels with RS permits, 223 also possess a SPA.

Table 5.2.1-6 presents information regarding the number of RSEs that are currently active, renewable, and terminated. This table will be referenced frequently given that it contains considerable information critical to the impacts analysis. Based on the information in columns 3 and 4, of the 155 RSEs that have been issued, 105 are active, 20 are renewable (i.e., 125 are active or renewable), and 30 have been terminated. Thus, at this time and unless the Council takes additional action to alter the status of some or all of the terminated RSEs, the maximum number of vessels allowed to operate in the limited access component of the fishery (i.e., the "cap") has already been reduced from 155 to 125 vessels. This change represents a nearly 20% reduction in the maximum fleet size, and this maximum fleet size is approximately 17% below the Council's desired fleet size. And if the vessels currently possessing renewable RSEs do not renew them in a timely manner, the maximum fleet size could further decrease.

One other piece of information is important with respect to the limited access endorsements. In the preliminary analysis that was conducted for this Amendment, it was estimated that the market value of these endorsements was approximately $10,000. However, this estimate was based only on information during the first two years of the limited access program. Since that time, data indicate that the market value of these endorsements has been steadily declining. Given the economic downturn in the rock and penaeid shrimp fisheries, such a result is to be expected since the market value of the endorsements should reflect industry participants' expectations of future profitability in the industry. As fishery participants' expectations become more pessimistic (i.e., expected profitability declines), the market value of the endorsements will decrease. Over the past five years, the average selling price of these endorsements has fallen to $5,000, and in fact this was the highest selling price of an endorsement over the past year. Thus, the market value of these endorsements is estimated to be $5,000, and that may be an overestimate.

Finally, with respect to rock shrimp dealer permits, the number of permits at any given point in time has varied between 40 and 50 over the past five years. During calendar years 2006 and 2007, 46 different dealers possessed one of these permits at one point or another. And, as will be discussed in the next section, only a fraction of these dealers are typically involved in the fishery in any given year or even across a several year time period. However, contrary to vessels with permits and/or endorsements, none of the actions being considered in this Amendment would directly impact dealers with rock shrimp permits or directly alter the number of such permits that can be issued. The only dealers expected to be indirectly impacted by the actions in this Amendment are those that have been or are expected to participate in the fishery.

Table 5.2.1-6. Distribution of South Atlantic rock shrimp endorsements (RSE).

Year Obtained	# of Vessels	Currently Active or Renewable[5]	Currently Terminated	Currently Active or Renewable Meets 15K	Currently Active or Renewable Does Not Yet Meet 15K	Currently Active or Renewable Meets 7500	Currently Active or Renewable Does Not Yet Meet 7500	Currently Terminated Meets 15K	Currently Terminated Does Not Yet Meet 15K	Currently Terminated Meets 7500	Currently Terminated Does Not Yet Meet 7500
2003	107	83 (66,17)	24	40	43	43	40	3	21	4	20
2004	14	9 (8,1)	5	5	4	5	4	2	3	2	3
2005	13	12 (12,0)	1	5	7	5	7	0	1	0	1
2006	9	9 (7,2)	0	5	4	5	4	0	0	0	0
2007	11	11 (11,0)	0	0	11	0	11	0	0	0	0
2008	1	1 (1,0)	0	0	1	0	1	0	0	0	0
Total	**155**	**125 (105, 20)**	**30**	**55**	**70**	**58**	**67**	**5**	**25**	**6**	**24**

[5] The number of active endorsements and the number of renewable endorsements are the first and second numbers in the parenthetical respectively.

5.2.1.2.4 Description of harvesting sector, dealer sector, or processing sector.

This section provides a detailed description of the harvesting sector (i.e., vessels), dealer sector, or processing sector. Entities in the harvesting sector are characterized according to their landings activities and associated revenue across various fisheries during the 2003 through 2007 time period. These vessels are also described according to their physical and certain operational characteristics. Vessels are described in the aggregate according to the types of permits or endorsements they possess. However, these descriptions are broken down further according to the status of their endorsements (for vessels that possess RSEs), whether they were active in commercial fisheries, and specifically whether they were active in the South Atlantic rock shrimp fishery. Again, these breakdowns are necessary to more accurately assess the potential impacts of particular actions considered in this Amendment on particular groups or "types" of vessels.

Description of harvesting sector (i.e., vessels), dealer sector, or processing sector
Although vessels with RS and SPA permits will be briefly characterized in this section, the focus is on vessels with RSEs since the majority of the actions considered in this Amendment are likely to directly impact all or some of these vessels. In fact, these actions will likely determine the size, structure and composition of the South Atlantic rock shrimp fishery for years to come. Because of one particular action considered in this Amendment, all 694 vessels will be briefly examined as a single fleet.

<u>Vessels with Rock Shrimp Limited Access Endorsements and Commercially Active</u>
Because of the focus on vessels with RSEs, it is necessary to refer again to certain information contained in Table 5.2.1-6. First, as already indicated, the total number of vessels initially receiving limited access endorsements was 155, and this fact is reflected in the table. These 155 vessels represent the total universe of vessels considered throughout much of the impacts analysis. Some vessels have obtained their endorsements via transfers in the years after the initial endorsements were issued. So although many endorsements were initially obtained in 2003, others were not. Column 2 of Table 5.2.1-6 presents a breakdown of the number of vessels initially obtaining their endorsements in each year. Specifically, of the 155 current vessels with endorsements, 107 were initially obtained in 2003, while the other 48 were initially obtained in subsequent years (2004 through 2008). These 155 vessels can be partially characterized based on their physical and operational characteristics as well as their commercial harvesting activities in and outside of the South Atlantic rock shrimp fishery during the 2003 through 2007 time period, both across the entire time period and from year to year. In some cases, these characteristics remained fairly constant and thus changes from year to year are not examined. In other cases, the changes from year to year are significant and thus become the focus of the analysis.

Since it is possible that some actions may directly or indirectly affect all vessels with RSEs, the physical and operational characteristics of all vessels with RSEs are presented in Tables 5.2.1-7 and 5.2.1-8. These data indicate that this fleet, though having some heterogeneity, is fairly homogeneous (i.e., the means of these characteristics are fairly large relative to the standard deviations). The average or typical vessel in this fleet is approximately 20 years old, nearly 73 feet (22 m) in length, gross tonnage of 132 tons, with a fuel capacity of approximately 16,000 gallons and a hold capacity of more than 63,000 pounds of shrimp. The average vessel typically uses four nets of an average length between 55 and 60 feet (16.7-18 m), and uses between three and four crew on each trip. More than 90% of these vessels are "large" while less than 9% are "small." The vast majority (more than 87%) has on-board freezing capacity and more than two-thirds have steel hulls. The remaining vessels are nearly equally split between fiberglass and wood hulls.

It is also possible that only commercially active vessels (i.e., those with landings from a commercial fishery) may be impacted. Statistics regarding commercially active vessels are provided in Tables 5.2.1-9 through 5.2.1-12. Of the 155 vessels currently possessing RSEs, 145 were commercially active at some point between 2003 and 2007, though not all were active in every year, and thus 10 vessels with RSEs were not commercially active during these years. All of the commercially inactive "vessels" were in fact state registered boats. Thus, as would be expected, the statistics in Tables 5.2.1-9 and 5.2.1-10 indicate that the commercially active vessels with RSEs are relatively more homogeneous, newer, larger, and more powerful on average relative to all vessels with RSEs. In other words, the vessels with endorsements that have dropped out of commercial fishing in recent years have tended to be those that are older, smaller, and less powerful.

In Tables 5.2.1-11 and 5.2.1-12, and all other tables reporting the distribution of vessels' landings and revenues, all revenues are gross revenues rather than net revenues and reported in nominal terms. Also, revenues have been broken down into the following categories: South Atlantic rock shrimp (SRS), Gulf shrimp, Gulf non-shrimp, South Atlantic penaeid shrimp, South Atlantic non-shrimp, and Northeast non-shrimp. According to information in Table 5.2.1-11, the commercially active vessels averaged nearly $284,000 in total revenue per year. Their dependence on South Atlantic rock shrimp revenues was relatively low as they only accounted for 7% of total revenues on average during this time. These vessels were most dependent on Gulf shrimp revenues during these years, as they accounted for nearly 46% of their total revenues on average. Revenues from South Atlantic penaeid shrimp landings and Northeast non-shrimp landings were also important, with each representing approximately 22% of their total revenues on average. The vast majority of the Northeast non-shrimp revenues came from Atlantic sea scallop landings.

Table 5.2.1-7. Physical characteristics and selected statistics for all vessels with limited access rock shrimp endorsements[6].

	Crew Size	Number of Nets	Net Size (ft)	Vessel Age	Length	Horsepower	Fuel Capacity (gallons)	Gross Tons	Hold Capacity (pounds)
# vessels	124	120	122	154	155	155	133	144	142
Minimum	1	2	30	5	12	5	5	51	10
Maximum	5	4	80	42	93	1,720	48,000	205	160,000
Total	429	464	6,912	3,133	11,233	86,571	2,126,333	19,036	9,015,260
Mean	3.5	3.9	56.7	20.3	72.5	558.5	15,987	132.2	63,488
St. Dev.	0.7	0.4	11.0	9.9	16.8	226.9	9,545	27.4	32,541

Table 5.2.1-8. Distribution of additional physical characteristics for all vessels with limited access rock shrimp endorsements.

Hull Type	Percent	Refrigeration	Percent	Vessel Size Category	Percent
Steel	68.2	Freezer	87.4	Large	91.6
Fiberglass	16.2	Ice	12.6	Small	8.4
Wood	14.9				
Aluminum	.6				

[6] The 2006 Vessel Operating Units File (VOUF) was the source of data for crew size, number of nets, and net size. The Permits database is the source of data for all other characteristics. Characteristics data was not available for every permitted vessel for a variety of reasons (e.g. tonnage data is not available for state registered boats, vessel owners do not always provide the requested data on their application form, etc.).

Table 5.2.1-9. Physical characteristics and selected statistics for all commercially active vessels (2003-2007) with limited access rock shrimp endorsements.[7]

	Crew Size	Number of Nets	Net Size (ft)	Vessel Age	Length	Horsepower	Fuel Capacity (gallons)	Gross Tons	Hold Capacity (pounds)
Minimum	1	2	30	5	17	125	1,500	51	800
Maximum	5	4	80	42	93	1,720	48,000	205	160,000
Mean	3.5	3.9	57.1	19.9	76.8	593.9	16,850	132.6	66,034
St. Dev.	0.7	0.4	11.0	9.8	7.6	208.6	9,005	26.4	32,067

Table 5.2.1-10. Distribution of additional physical characteristics for all commercially active vessels (2003-2007) with limited access rock shrimp endorsements.

Hull Type	Percent	Refrigeration	Percent	Vessel Size Category	Percent
Steel	74.3	Freezer	91.7	Large	99
Wood	14.1	Ice	8.3	Small	1
Fiberglass	11.6				

Table 5.2.1-11. Landings and revenue statistics, all commercially active RSE vessels, 2003-2007 combined.

Statistic	SRS landings	SRS Revenue	Gulf shrimp Revenue	SA penaeid shrimp Revenue	Gulf non-shrimp Revenue	SA non-shrimp Revenue	Northeast non-shrimp Revenue	Total SA Shrimp Revenue	Total Revenue	% of Revenue from SRS	% of Revenue from SA shrimp
Total	11,952,623	$13,147,673	$84,720,681	$39,374,596	$91,555	$919,919	$40,157,376	$52,522,269	$178,411,801	N/A	N/A
Average / Vessel / Year	19,003	$20,903	$134,691	$62,599	$146	$1,463	$63,843	$83,501	$283,644	7	34

[7] In this table, and others presenting statistics over the entire 2003-2007 time period, as opposed to each year individually, vessels active in a greater number of years during that time period are inherently given a higher weight in the calculation of the means and standard deviations since as each observation represents a combination of vessel and year and thus they will represent a greater proportion of the observations relative to vessels that were active in fewer years.

Table 5.2.1-12. Landings and revenue statistics by landing year, all commercially active RSE vessels, 2003-2007.[8]

Year	Statistic	SRS landings	SRS Revenue	Gulf shrimp Revenue	SA penaeid shrimp Revenue	Gulf non-shrimp Revenue	SA non-shrimp Revenue	Northeast non-shrimp Revenue	Total SA Shrimp Revenue	Total Revenue	% of Revenue from SRS	% of Revenue from SA shrimp
2003	# vessels	129	129	129	129	129	129	129	129	129	129	129
2003	Minimum	0	$0	$0	$0	$0	$0	$0	$0	$6,026	0.0	0.0
2003	Maximum	161,242	$252,686	$385,842	$294,047	$13,157	$90,778	$34,240	$376,455	$560,772	81.5	100.0
2003	Total	2,589,183	$3,861,674	$17,700,476	$4,830,079	$25,968	$240,066	$35,811	$8,691,753	$26,694,074	N/A	N/A
2003	Average	20,071	$29,935	$137,213	$37,442	$201	$1,861	$278	$67,378	$206,931	11.8	33.5
2003	St. Dev.	31,038	$48,041	$105,296	$59,430	$1,294	$8,733	$3,015	$83,073	$109,467	17.2	36.9
2004	# vessels	122	122	122	122	122	122	122	122	122	122	122
2004	Minimum	0	$0	$0	$0	$0	$0	$0	$0	$3,871	0.0	0.0
2004	Maximum	665,787	$469,639	$504,594	$1,768,168	$30,955	$117,122	$282,098	$1,768,168	$1,769,743	74.1	100.0
2004	Total	6,042,620	$4,532,819	$15,427,750	$10,492,766	$37,084	$246,651	$304,599	$15,025,585	$31,041,669	N/A	N/A
2004	Average	49,530	$37,154	$126,457	$86,006	$304	$2,022	$2,497	$123,161	$254,440	12.1	46.1
2004	St. Dev.	115,576	$83,606	$117,938	$182,631	$2,828	$10,822	$25,546	$203,176	$195,402	20.1	40.9
2005	# vessels	132	132	132	132	132	132	132	132	132	132	132
2005	Minimum	0	$0	$0	$0	$0	$0	$0	$0	$2,297	0.0	0.0
2005	Maximum	43,960	$32,449	$515,783	$760,206	$3,622	$14,560	$1,515,311	$761,827	$1,515,311	7.9	100.0
2005	Total	106,249	$97,159	$16,820,792	$6,064,837	$4,887	$86,596	$14,971,424	$6,161,996	$38,045,695	N/A	N/A
2005	Average	805	$736	$127,430	$45,946	$37	$656	$113,420	$46,682	$288,225	0.2	23.2
2005	St. Dev.	4,222	$3,425	$139,011	$104,665	$321	$1,949	$288,342	$105,975	$261,438	1.0	38.5

[8] SRS landings and revenues in this table will not be equivalent to those in Table 3.4-2 because of those accrued by vessels that did but no longer possess an endorsement, in addition to minor amounts that could not be ascribed to a specific vessel or to a vessel that lacked an endorsement.

Table 5.2.1-12. Landings and revenue statistics by landing year, all commercially active RSE vessels, 2003-2007 - continued.

Year	Statistic	SRS landings	SRS Revenue	Gulf shrimp Revenue	SA penaeid shrimp Revenue	Gulf non-shrimp Revenue	SA non-shrimp Revenue	Northeast non-shrimp Revenue	Total SA Shrimp Revenue	Total Revenue	% of Revenue from SRS	% of Revenue from SA shrimp
2006	# vessels	124	124	124	124	124	124	124	124	124	124	124
2006	Minimum	0	$0	$0	$0	$0	$0	$0	$0	$7,680	0.0	0.0
2006	Maximum	312,347	$493,382	$591,472	$494,619	$8,713	$16,322	$1,598,681	$925,697	$1,598,681	100.0	100.0
2006	Total	2,978,356	$4,219,206	$18,226,435	$7,637,531	$11,995	$144,934	$13,167,715	$11,856,737	$43,407,816	N/A	N/A
2006	Average	24,019	$34,026	$146,987	$61,593	$97	$1,169	$106,191	$95,619	$350,063	11.4	33.7
2006	St. Dev.	54,516	$79,094	$178,171	$108,267	$788	$2,648	$287,549	$166,472	$268,864	20.7	41.9
2007	# vessels	122	122	122	122	122	122	122	122	122	122	122
2007	Minimum	0	$0	$0	$0	$0	$0	$0	$0	$7,630	0.0	0.0
2007	Maximum	32,365	$61,656	$762,413	$675,326	$6,502	$18,786	$1,394,112	$682,867	$1,394,112	39.3	100.0
2007	Total	236,215	$436,815	$16,545,228	$10,349,383	$11,621	$201,672	$11,677,827	$10,786,198	$39,222,546	N/A	N/A
2007	Average	1,936	$3,580	$135,617	$84,831	$95	$1,653	$95,720	$88,411	$321,496	1.7	35.1
2007	St. Dev.	6,012	$11,083	$174,471	$148,096	$634	$3,511	$268,014	$153,758	$252,007	5.9	45.4

Thus, although South Atlantic rock shrimp landings were not unimportant to these vessels' operations, they were considerably more dependent on other fisheries. However, the nature of that dependence has changed considerably during these five years. That is, the distribution of revenues across fisheries varied considerably from one year to the next and certain patterns emerged over time. For example, in 2003, these vessels were highly dependent on the Gulf shrimp fishery with nearly two-thirds of their total revenues coming from this fishery. The vast majority of their other revenues came from the South Atlantic penaeid and rock shrimp fisheries. In 2004, dependence on the Gulf shrimp fishery lessened considerably, with less than 50% of their total revenues coming from that fishery and more than 30% coming from the South Atlantic penaeid shrimp fishery. Dependence on revenues from the South Atlantic rock shrimp fishery remained about the same between these two years at around 11-12%. However, these vessels' operations changed dramatically in 2005. As previously noted, South Atlantic rock shrimp landings were very low in 2005 and, as a result, accounted for only 0.2% of these vessels' total revenues. Landings from the South Atlantic penaeid shrimp fishery were still relatively important, though far less so than in 2004, accounting for nearly 16% of their total revenues. And although revenues from the Gulf shrimp fishery were still relatively important, accounting for approximately 44% of their total revenues in 2004, landings from Northeast non-shrimp fisheries were almost as important accounting for nearly 40% of total revenues on average. The vast majority of these revenues were the result of landings from the sea scallop fishery. The Northeast sea scallop fishery has seen a significant recovery both biologically and economically in recent years. Sea scallop landings and prices were particularly high in 2005.

In 2006, revenues from the Gulf shrimp, South Atlantic penaeid shrimp, and South Atlantic rock shrimp fisheries increased in absolute terms relative to their 2005 levels, while those from the Northeast non-shrimp fisheries fell slightly. But, in 2007, with the significant decline in the rock shrimp fishery, as occurred in 2005, they apparently shifted more effort into the South Atlantic penaeid shrimp fishery, while revenues from Gulf shrimp and Northeast non-shrimp fisheries declined slightly. Thus, by 2007, these vessels' operational changes resulted in them being most dependent on revenues from the Gulf shrimp fishery, followed by Northeast non-shrimp fisheries, the South Atlantic penaeid shrimp fishery, with each accounting for no less than 26% of these vessels' total revenues. In effect, these vessels changed their operations in such a way that, as a fleet, their landings and revenue "portfolio" has become more diversified over time. In an economic environment that has become increasingly uncertain in recent years, particularly in the Southeast's shrimp fisheries, this is exactly the approach these vessels' owners should have engaged in to spread risk and thereby protect their investments. Furthermore, at least in the short-term, their strategy appears to have worked remarkably well at least in terms of gross revenues, which increased on a per-vessel basis by from 2003 to 2006, average total revenues increased each year from approximately $203,000 in 2003 to $350,000 in 2006, or by approximately 70% on average. Although these vessels' total revenues decreased slightly in 2007 to approximately $321,000 on average, they were still quite high relative to 2003 through 2005. However, without accompanying cost information, it is not possible to determine how these vessels' costs and therefore profitability have changed during this time.

Another distinction among vessels with endorsements can be made between those with and without South Atlantic rock shrimp landings. Of greatest interest with respect to potential impacts from management actions are those with such landings. Statistics regarding these particular vessels are presented in Tables 5.2.1-13 through 5.2.1-17. With respect to most physical and operational characteristics, this group of vessels differs little from those who have been active in any commercial fishery. During 2003 through 2007, the only noticeable difference is that a higher proportion of vessels that were specifically active in the rock shrimp fishery tended to have steel hulls with on-board freezing capacity, and a lower proportion had wood hulls and used ice for storage purposes. However, based on information in Table 5.2.1-15, a somewhat surprising trend can be seen over this time period with respect to the physical characteristics of the vessels participating in the rock shrimp fishery. Specifically, from 2003 through 2005, the fishery was trending towards newer, larger, and more powerful vessels using larger nets. But this trend reversed in 2006 and 2007, and vessels participating in the fishery are becoming slightly older, smaller, less powerful, and using smaller nets. Though a definitive conclusion cannot be offered without additional data, particularly cost data, it is hypothesized that this change is related to the ever increasing price of diesel fuel and the fact that newer, larger, more powerful vessels that use larger nets also tend to be less fuel efficient. As such, it may be particularly unprofitable for these types of vessels to operate in or travel to a more distant, offshore fishery such as rock shrimp, particularly when other, possibly more lucrative fisheries requiring less fuel use may be available to them.

Somewhat coincidentally, according to information in Table 5.2.1-16, the average total revenue of RSE vessels with rock shrimp landings is almost identical to the average for all commercially active vessels. However, the distribution of those revenues, and thus their dependence on particular fisheries, is quite different. Specifically, these vessels are most dependent on revenues from the South Atlantic penaeid fishery, accounting for 38% of total revenues on average, followed by Gulf shrimp at 35% of total revenues, and South Atlantic rock shrimp at nearly 22%. Revenues from Northeast non-shrimp fisheries such as the sea scallop fishery are not at all important to this group of vessels.

But, as with all commercially active vessels with endorsements, this group of vessels has seen its average total revenues generally increase after 2003. The changes have been somewhat less dramatic, with total revenues only increasing from nearly $246,000 to nearly $323,000 per vessel on average between 2003 and 2005, or slightly more than 31%, and then decreasing slightly in 2006 and 2007, but still remaining above $300,000 on average. These vessels' dependence on revenues from South Atlantic rock shrimp have basically followed the same pattern during these years compared to all commercially active vessels with endorsements. And also similarly, these vessels were most dependent on revenues from the Gulf shrimp fishery in 2003 and 2004. However, in 2005, rather than shifting their effort into Northeast non-shrimp fisheries, these vessels shifted their effort into the South Atlantic penaeid fishery. And in 2006, revenues from the South Atlantic penaeid and rock shrimp fisheries comprised nearly 74% of these vessels' total revenues. And in 2007, when rock shrimp landings declined significantly, these vessels' became almost completely dependent on revenues from the South Atlantic penaeid fishery, which accounted for nearly 82% of their total revenues on average. Along with the information on physical characteristics, this information suggests that the only vessels that have continued to operate in the rock shrimp fishery over the past two years are "local" vessels, i.e., those that also operate in the South Atlantic penaeid fishery. Most or all of the newer, larger, more powerful vessels that, at least at one time, came from the Gulf have opted to operate in the Gulf shrimp fishery, which had a particularly abundant year in 2006 and would allow them to economize their fuel expenses, or have shifted into the Northeast sea scallop fishery, which has seen high prices and relatively high abundance in recent years.

As previously discussed, some of these vessels' endorsements are currently active (i.e., they have not expired), some have expired but are still renewable (i.e., they are still within the allowed one-year time frame to renew their endorsement after expiration), while others have expired but are currently terminated/nonrenewable (i.e., they did not renew their endorsements within one year after expiration). Thus, it is potentially important to examine how vessels may differ according to the current status of their endorsements.

Table 5.2.1-13. Physical characteristics and selected statistics for vessels with limited access rock shrimp endorsements and SRS landings between 2003 and 2007.

	Crew Size	Number of Nets	Net Size (ft)	Vessel Age	Length	Horsepower	Fuel Capacity (gallons)	Gross Tons	Hold Capacity (pounds)
Minimum	1	2	30	5	17	125	3,200	67	800
Maximum	5	4	80	42	93	1,720	48,000	205	160,000
Mean	3.6	3.9	56.1	19.7	76.9	601.5	16,598	132.7	68,842
St. Dev.	0.6	0.3	10.7	9.9	8.0	183.7	8,123	23.0	28,828

Table 5.2.1-14. Distribution of additional physical characteristics for vessels (2003-2007) with limited access rock shrimp endorsements and SRS landings between 2003 and 2007.[9]

Hull Type	Percent	Refrigeration	Percent	Vessel Size Category	Percent
Steel	79.6	Freezer	96.6	Large	99.5
Fiberglass	13.0	Ice	3.4	Small	.5
Wood	7.4				

[9] Though these characteristics were mostly consistent between 2003 and 2007, some noticeable changes took place in 2007. Specifically, representation of steel hulled vessels with on-board freezing capacity in the fishery declined by approximately 10%, while vessels with fiberglass or wood hulls and no such capacity increased concomitantly. These changes are consistent with those noted in Table 5.2.1-15, though information in that table suggests changes began in 2006. The reasons for this change are not apparent at this time, though higher fuel costs associated with operating larger, more powerful vessels may have played a role.

Table 5.2.1-15. Average physical characteristics by year for vessels with limited access rock shrimp endorsements and SRS landings between 2003 and 2007.

Year	Crew Size	Number of Nets	Net Size (ft)	Vessel Age	Length	Horsepower	Fuel Capacity (gallons)	Gross Tons	Hold Capacity (pounds)
2003	3.6	3.9	57.0	20.7	76.7	605.2	17,171	131.3	71,173
2004	3.6	3.9	57.5	18.9	77.1	594.9	17,169	132.3	71,255
2005	3.7	4.0	59.1	18.5	78.7	638.4	18,059	139.5	69,194
2006	3.6	3.9	53.9	19.2	76.2	588.9	15,585	134.0	64,412
2007	3.7	3.9	51.4	20.6	76.5	601.3	14,181	130.5	63,600

Table 5.2.1-16. Landings and revenue statistics, RSE vessels with SRS landings, 2003-2007 combined.

Statistic	SRS landings	SRS Revenue	Gulf shrimp Revenue	SA penaeid shrimp Revenue	Gulf non-shrimp Revenue	SA non-shrimp Revenue	Northeast non-shrimp Revenue	Total SA Shrimp Revenue	Total Revenue	% of Revenue from SRS	% of Revenue from SA shrimp
Total	11,952,623	$13,147,673	$21,376,657	$23,493,361	$68,702	$681,503	$2,471,022	$36,641,034	$61,238,918	N/A	N/A
Average / Vessel / Year	55,336	$60,869	$98,966	$108,766	$318	$3,155	$11,440	$169,634	$283,514	21.5	57.5

Table 5.2.1-17. Landings and revenue statistics by landing year, RSE vessels with SRS landings, 2003-2007.[10]

Year	Statistic	SRS landings	SRS Revenue	Gulf shrimp Revenue	SA penaeid shrimp Revenue	Gulf non-shrimp Revenue	SA non-shrimp Revenue	Northeast non-shrimp Revenue	Total SA Shrimp Revenue	Total Revenue	% of Revenue from SRS	% of Revenue from SA shrimp
2003	# vessels	74	74	74	74	74	74	74	74	74	74	74
2003	Minimum	81	$190	$0	$0	$0	$0	$0	$190	$37,209	0.1	0.1
2003	Maximum	161,242	$252,686	$364,472	$294,047	$13,157	$90,778	$671	$376,455	$560,772	81.5	100.0
2003	Total	2,589,183	$3,861,674	$10,361,889	$3,736,988	$19,335	$213,136	$765	$7,598,662	$18,193,788	N/A	N/A
2003	Average	34,989	$52,185	$140,026	$50,500	$261	$2,880	$10	$102,685	$245,862	20.6	43.5
2003	St. Dev.	34,060	$53,570	$102,965	$66,605	$1,543	$11,267	$79	$88,236	$100,067	18.4	32.9
2004	# vessels	58	58	58	58	58	58	58	58	58	58	58
2004	Minimum	67	$50	$0	$0	$0	$0	$0	$91	$21,279	0.0	0.1
2004	Maximum	665,787	$469,639	$308,163	$387,347	$30,955	$117,122	$1,622	$704,369	$725,024	74.1	100.0
2004	Total	6,042,620	$4,532,819	$7,237,284	$4,758,580	$35,721	$208,137	$1,622	$9,291,399	$16,774,162	N/A	N/A
2004	Average	104,183	$78,152	$124,781	$82,044	$616	$3,589	$28	$160,197	$289,210	25.5	54.5
2004	St. Dev.	150,208	$107,601	$101,235	$91,666	$4,095	$15,519	$213	$150,330	$134,717	22.5	33.2
2005	# vessels	18	18	18	18	18	18	18	18	18	18	18
2005	Minimum	191	$201	$0	$0	$0	$0	$0	$243	$147,145	0.1	0.1
2005	Maximum	43,960	$32,449	$395,019	$760,206	$3,622	$14,560	$384,521	$761,827	$765,096	7.9	99.9
2005	Total	106,249	$97,159	$1,555,428	$3,043,027	$3,670	$48,094	$1,062,122	$3,140,186	$5,809,501	N/A	N/A
2005	Average	5,903	$5,398	$86,413	$169,057	$204	$2,672	$59,007	$174,455	$322,750	1.7	50.1
2005	St. Dev.	10,271	$7,986	$112,086	$190,522	$853	$4,300	$126,138	$192,328	$163,588	2.2	41.9

[10] The number of vessels in this table will not be equivalent to those in Table 5.2.1-2 because landings by vessels that no longer possess or never possessed an endorsement vessel are not included in this table.

Table 5.2.1-17. Landings and revenue statistics by landing year, RSE vessels with SRS landings, 2003-2007 - Continued.

Year	Statistic	SRS landings	SRS Revenue	Gulf shrimp Revenue	SA penaeid shrimp Revenue	Gulf non-shrimp Revenue	SA non-shrimp Revenue	Northeast non-shrimp Revenue	Total SA Shrimp Revenue	Total Revenue	% of Revenue from SRS	% of Revenue from SA shrimp
2006	# vessels	43	43	43	43	43	43	43	43	43	43	43
2006	Minimum	364	$455	$0	$0	$0	$0	$0	$455	$19,000	0.4	0.4
2006	Maximum	312,347	$493,382	$259,741	$494,619	$8,713	$16,322	$206,357	$925,697	$925,952	100.0	100.0
2006	Total	2,978,356	$4,219,206	$1,715,116	$6,174,709	$9,759	$116,026	$1,165,856	$10,393,915	$13,400,672	N/A	N/A
2006	Average	69,264	$98,121	$39,886	$143,598	$227	$2,698	$27,113	$241,719	$311,644	32.8	73.7
2006	St. Dev.	74,130	$109,004	$67,596	$137,436	$1,328	$3,666	$52,698	$206,894	$205,670	23.1	28.1
2007	# vessels	23	23	23	23	23	23	23	23	23	23	23
2007	Minimum	186	$353	$0	$0	$0	$0	$0	$1,563	$62,920	0.1	1.4
2007	Maximum	32,365	$61,656	$315,349	$675,326	$155	$18,786	$240,658	$682,867	$683,114	39.3	100.0
2007	Total	236,215	$436,815	$506,940	$5,780,057	$217	$96,110	$240,658	$6,216,872	$7,060,796	N/A	N/A
2007	Average	10,270	$18,992	$22,041	$251,307	$9	$4,179	$10,463	$270,299	$306,991	9.2	85.8
2007	St. Dev.	10,456	$19,226	$68,885	$206,900	$34	$4,685	$50,181	$212,817	$202,664	10.9	29.5

Vessels with Active or Renewable Rock Shrimp Endorsements

With respect to the 125 vessels with currently active or renewable endorsements, statistics regarding their physical, operational, landings, and revenue characteristics are in Tables 5.2.1-18 through 5.2.1-23. The data indicate that 117 of these 125 vessels participated in some type of commercial fishing activity during these five years, while the other eight vessels were not engaged in commercial fishing. Again, all eight vessels that were not active in commercial fishing are state-registered boats. In general, the physical and operating characteristics are "between" those noted for all vessels with rock shrimp endorsements and those that were commercially active, though not significantly different from either. Also, total landings and revenues, the distribution of landings and revenues, and the trends in this distribution between 2003 and 2007 for vessels with active or renewable rock shrimp endorsements are very similar to those noted for all commercially active vessels with endorsements, both across all years and from year to year. The only difference is that the vessels with active or renewable rock shrimp endorsements are slightly more dependent on revenues from the various shrimp fisheries in the Southeast region and slightly less dependent on revenues from Northeast non-shrimp fisheries (i.e., sea scallops) relative to all commercially active vessels with rock shrimp endorsements. This finding suggests that it may be the vessels with terminated endorsements that have become the most highly involved in the Northeast's sea scallop fishery.

Table 5.2.1-18. Physical characteristics and selected statistics for vessels with active or renewable limited access rock shrimp endorsements.

	Crew Size	Number of Nets	Net Size (ft)	Vessel Age	Length	Horsepower	Fuel Capacity (gallons)	Gross Tons	Hold Capacity (pounds)
# of vessels	108	104	106	125	125	125	119	117	116
Minimum	1	2	30	5	14	15	5	67	50
Maximum	5	4	80	38	93	1,720	48,000	205	160,000
Total	383	404	6,091	2,386	9,223	72,963	1,968,123	15,757	7,695,750
Mean	3.5	3.9	57.5	19.1	73.8	583.7	16,539	134.7	66,343
St. Dev.	0.7	0.4	10.3	9.9	16.2	234.9	9,621	26.2	33,462

Table 5.2.1-19. Distribution of additional physical characteristics for vessels with active or renewable limited access rock shrimp endorsements.

Hull Type	Percent	Refrigeration	Percent	Vessel Size Category	Percent
Steel	72.8	Freezer	87.5	Large	93.6
Fiberglass	13.6	Ice	12.5	Small	6.4
Wood	13.6				

Table 5.2.1-20. Physical characteristics and selected statistics for commercially active vessels (2003-2007) with active or renewable limited access rock shrimp endorsements.

	Crew Size	Number of Nets	Net Size (ft)	Vessel Age	Length	Horsepower	Fuel Capacity (gallons)	Gross Tons	Hold Capacity (pounds)
Minimum	1	2	30	5	62	125	3,200	67	800
Maximum	5	4	80	38	93	1,720	48,000	205	160,000
Mean	3.6	3.9	57.6	18.9	77.5	611.6	17,273	134.1	67,978
St. Dev.	0.7	0.4	10.5	9.9	7.2	215.0	9,071	25.8	32,589

Table 5.2.1-21. Distribution of additional physical characteristics for commercially active vessels (2003-2007) with active or renewable limited access rock shrimp endorsements.

Hull Type	Percent	Refrigeration	Percent	Vessel Size Category	Percent
Steel	77.8	Freezer	91.5	Large	100
Wood	13.0	Ice	8.5	Small	0
Fiberglass	9.1				

Table 5.2.1-22. Landings and revenue statistics, vessels with active or renewable RSEs, 2003-2007, combined.

Statistic	SRS landings	SRS Revenue	Gulf shrimp Revenue	SA penaeid shrimp Revenue	Gulf non-shrimp Revenue	SA non-shrimp Revenue	Northeast non-shrimp Revenue	Total SA Shrimp Revenue	Total Revenue	% of Revenue from SRS	% of Revenue from SA shrimp
Total	11,114,782	$12,266,454	$76,737,920	$33,924,711	$81,682	$889,854	$29,528,225	$46,191,165	$153,428,845	N/A	N/A
Average / Vessel / Year	20,698	$22,843	$142,901	$63,175	$152	$1,657	$54,987	$86,017	$285,715	8	34

Table 5.2.1-23. Landings and revenue statistics by landing year, vessels with active or renewable RSEs, 2003-2007.

Year	Statistic	SRS landings	SRS Revenue	Gulf shrimp Revenue	SA penaeid shrimp Revenue	Gulf non-shrimp Revenue	SA non-shrimp Revenue	Northeast non-shrimp Revenue	Total SA Shrimp Revenue	Total Revenue	% of Revenue from SRS	% of Revenue from SA shrimp
2003	# vessels	107	107	107	107	107	107	107	107	107	107	107
2003	Minimum	0	$0	$0	$0	$0	$0	$0	$0	$6,026	0.0	0.0
2003	Maximum	161,242	$252,686	$385,842	$294,047	$13,157	$90,778	$34,240	$376,455	$560,772	81.5	100.0
2003	Total	2,244,574	$3,408,871	$15,447,789	$3,914,541	$22,597	$237,415	$34,910	$7,323,412	$23,066,123	N/A	N/A
2003	Average	20,977	$31,859	$144,372	$36,584	$211	$2,219	$326	$68,443	$215,571	12.1	31.3
2003	St. Dev	32,718	$51,111	$106,490	$58,301	$1,413	$9,556	$3,310	$86,794	$110,997	18.2	35.9
2004	# vessels	103	103	103	103	103	103	103	103	103	103	103
2004	Minimum	0	$0	$0	$0	$0	$0	$0	$0	$4,463	0.0	0.0
2004	Maximum	665,787	$469,639	$504,594	$512,952	$30,955	$117,122	$282,098	$704,369	$725,024	74.1	100.0
2004	Total	5,635,841	$4,233,144	$13,627,620	$7,765,211	$37,084	$237,506	$301,998	$11,998,355	$26,202,563	N/A	N/A
2004	Average	54,717	$41,098	$132,307	$75,390	$360	$2,306	$2,932	$116,489	$254,394	13.1	45.4
2004	St. Dev	123,460	$89,446	$121,242	$100,553	$3,076	$11,747	$27,801	$142,068	$141,200	21.1	40.2
2005	# vessels	111	111	111	111	111	111	111	111	111	111	111
2005	Minimum	0	$0	$0	$0	$0	$0	$0	$0	$2,297	0.0	0.0
2005	Maximum	43,960	$32,449	$515,783	$501,701	$3,622	$14,560	$1,515,311	$501,701	$1,515,311	7.9	100.0
2005	Total	99,964	$90,892	$15,280,090	$4,864,468	$4,887	$84,026	$11,883,338	$4,955,360	$32,207,701	N/A	N/A
2005	Average	901	$819	$137,658	$43,824	$44	$757	$107,057	$44,643	$290,159	0.3	22.2
2005	St. Dev	4,578	$3,705	$141,872	$88,272	$350	$2,107	$276,068	$89,936	$245,499	1.0	37.1

Table 5.2.1-23. Landings and revenue statistics by landing year, vessels with active or renewable RSEs, 2003-2007 - Continued.

Year	Statistic	SRS landings	SRS Revenue	Gulf shrimp Revenue	SA penaeid shrimp Revenue	Gulf non-shrimp Revenue	SA non-shrimp Revenue	Northeast non-shrimp Revenue	Total SA Shrimp Revenue	Total Revenue	% of Revenue from SRS	% of Revenue from SA shrimp
2006	# vessels	107	107	107	107	107	107	107	107	107	107	107
2006	Minimum	0	$0	$0	$0	$0	$0	$0	$0	$45,450	0.0	0.0
2006	Maximum	312,347	$493,382	$591,472	$494,619	$8,713	$16,322	$1,505,452	$925,697	$1,505,452	76.7	100.0
2006	Total	2,898,188	$4,096,732	$16,939,810	$7,349,595	$11,995	$137,357	$9,107,973	$11,446,327	$37,643,461	N/A	N/A
2006	Average	27,086	$38,287	$158,316	$68,688	$112	$1,284	$85,121	$106,975	$351,808	11.7	34.5
2006	St. Dev	57,801	$83,841	$183,533	$113,913	$848	$2,793	$246,530	$175,517	$239,896	19.5	41.5
2007	# vessels	109	109	109	109	109	109	109	109	109	109	109
2007	Minimum	0	$0	$0	$0	$0	$0	$0	$0	$7,630	0.0	0.0
2007	Maximum	32,365	$61,656	$762,413	$675,326	$2,504	$18,786	$1,394,112	$682,867	$1,394,112	39.3	100.0
2007	Total	236,215	$436,815	$15,442,611	$10,030,897	$5,119	$193,549	$8,200,006	$10,467,712	$34,308,998	N/A	N/A
2007	Average	2,167	$4,007	$141,675	$92,027	$47	$1,776	$75,229	$96,034	$314,761	1.9	37.5
2007	St. Dev	6,324	$11,658	$179,416	$153,812	$258	$3,657	$238,454	$159,728	$238,040	6.2	45.9

Vessels with Terminated Rock Shrimp Endorsements

Regarding the 30 vessels with terminated endorsements, statistics regarding their physical, operational, landings, and revenue characteristics are in Tables 5.2.1-24 through 5.2.1-29. This group of vessels is quite different from the other groups of vessels previously discussed. First, with respect to physical and operational characteristics, vessels with terminated endorsements are, on average, older, smaller, and less powerful relative to those with active or renewable endorsements. They also tend to use fewer crew and smaller nets on average. Further, although nearly the same proportion have on-board freezing capacity, a much smaller proportion of these vessels are steel-hulled, and thus a much higher proportion have either fiberglass or wood hulls. These differences hold regardless of whether the comparison is between all vessels with terminated as opposed to active or renewable endorsements or only those that are commercially active. However, it is still the case that, on average, commercially active vessels with terminated endorsements tend to be somewhat newer, larger, and more powerful on average compared to all vessels with terminated endorsements.

According to the data, 28 of the 30 vessels with terminated endorsements have been involved in commercial fishing at some point during the past five years. Therefore, the proportion of vessels with terminated endorsements active in commercial fishing is almost identical to that for those with active or renewable endorsements. However, based on the information in Tables 5.2.1-28 and 5.2.1-29, the nature of that activity has been quite different. Specifically, relative to the vessels with active or renewable endorsements, these vessels' total revenues were significantly less in 2003, about the same in 2004 through 2006, but higher in 2007. To provide some perspective on the magnitude of this change, on average, these vessels' total revenue per year increased by 129% between 2003 and 2007, which is even more striking than the increase in total revenues for the vessels with active or renewable endorsements. Furthermore, during this time period, these vessels were considerably more dependent on revenues from Northeast non-shrimp fisheries (approximately 42% of total revenues compared to 19% for active and renewable endorsement holders), considerably less dependent on revenues from the Gulf shrimp (approximately 32% compared to 50% for active and renewable endorsement holders), and equally dependent on the South Atlantic penaeid fishery (approximately 22% of total revenues for both groups), and much less dependent on revenues from the South Atlantic rock shrimp fishery (approximately 4% of total revenues as compared to 8% for those with active or renewable endorsements). However, these differences between the two groups of vessels did not always exist.

In 2003, the distribution of revenues from the various fisheries between these two groups of vessels was very similar in that they were most dependent on Gulf shrimp landings, followed by South Atlantic penaeid shrimp, and South Atlantic rock shrimp landings respectively. However, changes in the distribution of landings and revenues thereafter for vessels with terminated endorsements do not mirror those seen for vessels with active or renewable endorsements. For example, in 2004, although dependence on revenues from the South Atlantic penaeid shrimp fishery increased, as with vessels with active or renewable endorsements, the vessels with terminated endorsements remained relatively dependent on revenues from Gulf shrimp landings while dependence on revenues from

South Atlantic rock shrimp landings declined, contrary to the vessels with active or renewable endorsements. In 2005, these vessels' operations changed dramatically such that nearly 53% of their revenues came from Northeast non-shrimp fisheries, only 26% came from Gulf shrimp landings, and approximately 21% came from South Atlantic penaeid shrimp landings. In 2006 and 2007, their dependence on Northeast non-shrimp landings became even more pronounced, representing approximately 70% of their total revenues, with Gulf shrimp and South Atlantic penaeid shrimp landings accounting for only 22% and 5-6% of their total revenues, respectively. After 2004, these vessels had little or no landings of South Atlantic rock shrimp. In effect, relative to vessels with active or renewable endorsements, vessels with terminated endorsements changed from being primarily dependent on revenues from the Gulf shrimp fishery in 2003 and 2004 to being primarily dependent on revenues from the Northeast sea scallop fishery in 2005 and particularly 2006 and 2007. That is, rather than diversifying their landings and revenue portfolio during this time period, they simply changed the fishery in which they specialize. Moreover, these vessels basically divested themselves of the South Atlantic rock shrimp fishery after 2004.

Table 5.2.1-24. Physical characteristics and selected statistics for vessels with terminated limited access rock shrimp endorsements.

	Crew Size	Number of Nets	Net Size (ft)	Vessel Age	Length	Horsepower	Fuel Capacity (gallons)	Gross Tons	Hold Capacity (pounds)
# of vessels	16	16	16	29	30	30	14	27	26
Minimum	2	2	30	5	12	5	10	51	10
Maximum	4	4	80	42	83	720	28,000	190	100,000
Total	46	60	821	747	2,009	13,608	158,210	3,279	1,319,510
Mean	2.9	3.8	51.3	25.8	67.0	453.6	11,301	121.4	50,750
St. Dev.	0.7	0.6	13.8	7.9	18.4	153.3	7,644	30.0	24,805

Table 5.2.1-25. Distribution of additional physical characteristics for vessels with terminated limited access rock shrimp endorsements.

Hull Type	Percent	Refrigeration	Percent	Vessel Size Category	Percent
Steel	48.3	Freezer	86.7	Large	83.3
Fiberglass	27.6	Ice	13.3	Small	16.7
Wood	20.7				
Aluminum	3.4				

Table 5.2.1-26. Physical characteristics and selected statistics for commercially active vessels (2003-2007) with terminated limited access rock shrimp endorsements.

	Crew Size	Number of Nets	Net Size (ft)	Vessel Age	Length	Horsepower	Fuel Capacity (gallons)	Gross Tons	Hold Capacity (pounds)
Minimum	2	2	30	6	17	325	1,500	51	6,000
Maximum	4	4	80	42	83	720	28,000	190	100,000
Mean	3.0	3.8	53.0	25.7	72.6	490.6	12,728	123.7	53,905
St. Dev.	0.7	0.6	14.3	6.8	9.0	123.4	7,196	28.6	25,604

Table 5.2.1-27. Distribution of additional physical characteristics for commercially active vessels (2003-2007) with terminated limited access rock shrimp endorsements.

Hull Type	Percent	Refrigeration	Percent	Vessel Size Category	Percent
Steel	53.3	Freezer	93.2	Large	93.5
Wood	26.1	Ice	6.8	Small	6.5
Fiberglass	20.6				

Table 5.2.1-28. Landings and revenue statistics, vessels with terminated RSEs, 2003-2007, combined.

Statistic	SRS landings	SRS Revenue	Gulf shrimp Revenue	SA penaeid shrimp Revenue	Gulf non-shrimp Revenue	SA non-shrimp Revenue	Northeast non-shrimp Revenue	Total SA Shrimp Revenue	Total Revenue	% of Revenue from SRS	% of Revenue from SA shrimp
Total	837,841	$881,219	$7,982,761	$5,449,886	$9,873	$30,066	$10,629,151	$6,331,105	$24,982,955	N/A	N/A
Average / Vessel / Year	9,107	$9,578	$86,769	$59,238	$107	$327	$115,534	$68,816	$271,554	4	25

Table 5.2.1-29. Landings and revenue statistics by landing year, vessels with terminated RSEs, 2003-2007.

Year	Statistic	SRS landings	SRS Revenue	Gulf shrimp Revenue	SA penaeid shrimp Revenue	Gulf non-shrimp Revenue	SA non-shrimp Revenue	Northeast non-shrimp Revenue	Total SA Shrimp Revenue	Total Revenue	% of Revenue from SRS	% of Revenue from SA shrimp
2003	# vessels	22	22	22	22	22	22	22	22	22	22	22
2003	Minimum	0	$0	$0	$0	$0	$0	$0	$0	$16,575	0.0	0.0
2003	Maximum	66,682	$101,705	$277,303	$229,343	$1,395	$1,243	$807	$236,293	$396,316	43.7	100.0
2003	Total	344,609	$452,803	$2,252,687	$915,538	$3,371	$2,651	$901	$1,368,341	$3,627,951	N/A	N/A
2003	Average	15,664	$20,582	$102,395	$41,615	$153	$120	$41	$62,197	$164,907	10.5	44.0
2003	St. Dev	21,076	$27,760	$93,844	$65,944	$370	$335	$172	$63,289	$92,846	12.2	40.6
2004	# vessels	19	19	19	19	19	19	19	19	19	19	19
2004	Minimum	0	$0	$0	$0	$0	$0	$0	$0	$3,871	0.0	0.0
2004	Maximum	173,749	$107,024	$267,438	$1,768,168	$0	$6,696	$1,575	$1,768,168	$1,769,743	37.8	100.0
2004	Total	406,779	$299,675	$1,800,130	$2,727,556	$0	$9,145	$2,600	$3,027,231	$4,839,106	N/A	N/A
2004	Average	21,409	$15,772	$94,744	$143,556	$0	$481	$137	$159,328	$254,690	6.7	49.7
2004	St. Dev	49,321	$32,862	$94,580	$403,456	$0	$1,543	$420	$401,857	$379,064	12.5	45.7
2005	# vessels	21	21	21	21	21	21	21	21	21	21	21
2005	Minimum	0	$0	$0	$0	$0	$0	$0	$0	$8,418	0.0	0.0
2005	Maximum	4,811	$4,646	$325,736	$760,206	$0	$1,434	$1,182,625	$761,827	$1,182,625	2.1	99.9
2005	Total	6,285	$6,267	$1,540,702	$1,200,369	$0	$2,570	$3,088,087	$1,206,636	$5,837,994	N/A	N/A
2005	Average	299	$298	$73,367	$57,160	$0	$122	$147,052	$57,459	$278,000	0.1	28.2
2005	St. Dev	1,083	$1,057	$110,550	$169,534	$0	$326	$352,121	$170,087	$340,703	0.5	45.8

Table 5.2.1-29. Landings and revenue statistics by landing year, vessels with terminated RSEs, 2003-2007 - Continued.

Year	Statistic	SRS landings	SRS Revenue	Gulf shrimp Revenue	SA penaeid shrimp Revenue	Gulf non-shrimp Revenue	SA non-shrimp Revenue	Northeast non-shrimp Revenue	Total SA Shrimp Revenue	Total Revenue	% of Revenue from SRS	% of Revenue from SA shrimp
2006	# vessels	17	17	17	17	17	17	17	17	17	17	17
2006	Minimum	0	$0	$0	$0	$0	$0	$0	$0	$7,680	0.0	0.0
2006	Maximum	64,968	$103,474	$373,145	$150,902	$0	$4,028	$1,598,681	$150,902	$1,598,681	100.0	100.0
2006	Total	80,168	$122,474	$1,286,625	$287,937	$0	$7,577	$4,059,743	$410,411	$5,764,356	N/A	N/A
2006	Average	4,716	$7,204	$75,684	$16,937	$0	$446	$238,808	$24,142	$339,080	2.4	28.2
2006	St. Dev	15,957	$25,231	$120,913	$41,102	$0	$1,252	$459,710	$51,584	$417,484	27.5	45.1
2007	# vessels	13	13	13	13	13	13	13	13	13	13	13
2007	Minimum	0	$0	$0	$0	$0	$0	$0	$0	$55,277	0.0	0.0
2007	Maximum	0	$0	$395,954	$197,014	$6,502	$5,555	$1,019,171	$197,014	$1,019,171	0.0	98.7
2007	Total	0	$0	$1,102,617	$318,486	$6,502	$8,122	$3,477,821	$318,486	$4,913,548	N/A	N/A
2007	Average	0	$0	$84,817	$24,499	$500	$625	$267,525	$24,499	$377,965	0.0	14.9
2007	St. Dev	0	$0	$118,735	$61,757	$1,803	$1,642	$420,441	$61,757	$355,710	0.0	36.5

Vessels with Open Access Rock Shrimp Permits and South Atlantic Penaeid Permits
Though not the primary focus of the actions considered in this Amendment, information pertaining to vessels with open access South Atlantic rock shrimp permits is presented in Tables 5.2.1-30 through 5.2.1-35 and information pertaining to vessels with South Atlantic penaeid shrimp permits is presented in Tables 5.2.1-36 through 5.2.1-41. Table 5.2.1-42 presents an overall picture of landings and revenue for all vessels with South Atlantic shrimp permits/endorsements across the 2003 through 2007 time period.

Compared to vessels with limited access rock shrimp endorsements, vessels with open access rock shrimp permits tend to be somewhat smaller and less powerful on average. Proportionally fewer have steel hulls and a much lower percentage have on-board freezing capacity. Given that vessels with endorsements are a significant subset of vessels with open access permits, this result implies that vessels with open access permits that do not have endorsements are probably quite a bit smaller, less powerful, and less technologically advanced than those that do have endorsements. As with the other vessel groups that have been discussed, those vessels with open access rock shrimp permits that have been commercially active are somewhat larger and more powerful compared to all vessels that possess such permits. Of the 266 vessels with these permits, 245 (92%) have been commercially active in fishing at one point in time or another between 2003 and 2007, though not all of these vessels were active in each year, varying between 198 and 255 in 2004 and 2007, respectively.

With respect to their landings and revenues, vessels with open access rock shrimp permits are actually quite similar to vessels with terminated rock shrimp endorsements. For example, their average total revenues between 2003 and 2007 are nearly identical, at approximately $272,000. Further, from 2003 through 2007, they were most dependent on revenues from Northeast non-shrimp fisheries, followed by Gulf shrimp, and South Atlantic penaeid shrimp. Their involvement in the South Atlantic rock shrimp fishery during this time has been very limited, particularly during the past three years. Furthermore, as with the vessels with terminated endorsements, their dependence on revenues from the Northeast non-shrimp fisheries has grown over time, though not quite to the same extent given that only between 48 and 55% of their revenues came from these fisheries between 2005 and 2007. That is, revenues from the Gulf shrimp and South Atlantic penaeid shrimp fisheries are still important to these vessels.

Compared to the other vessel groups previously discussed, vessels with South Atlantic penaeid shrimp permits are the most dissimilar. Specifically, compared to vessels with rock shrimp endorsements or permits, vessels with penaeid shrimp permits are considerably older, smaller, less powerful, and less technologically advanced, though their gear and number of crew are comparable. A much higher proportion of these vessels rely on ice for storage purposes and a much higher proportion have fiberglass and particularly wood hulls. Also, the differences among all vessels with such permits and those that are commercially active are minimal at best, again contrary to vessels with rock shrimp permits or endorsements. Of the 620 vessels with penaeid shrimp permits, 585 (94%) have been involved in commercial fishing at some point during the past five years. Though again, not all of these vessels were commercially fishing in each year, ranging from 491 in 2003 to 512 in both 2004 and 2006.

In terms of landings and revenues, on average, these vessels' total revenues between 2003 and 2007 were considerably lower (approximately $179,000) than for vessels with rock shrimp permits or endorsements. Somewhat surprisingly, like the commercially active vessels with endorsements, these vessels were most dependent on revenues from the Gulf shrimp fishery (36%), followed by revenues from Northeast non-shrimp fisheries (29%), and the South Atlantic penaeid shrimp fishery (26%). An additional 7% of their revenues came from South Atlantic non-shrimp fisheries. Another similarity is that their average total revenues steadily increased from $124,000 in 2003 to $221,000 in 2006, or by approximately 78%. Their average total revenues decreased somewhat in 2007 due to a decline in revenues from the Gulf shrimp fishery and South Atlantic non-shrimp fisheries. Also similar to what was seen for the vessels with rock shrimp permits or endorsements, these vessels became much more dependent on revenues from the Northeast non-shrimp fisheries, though not to the same extent as vessels with rock shrimp permits or endorsements. Still, revenues from Northeast non-shrimp fisheries accounted for between 36% and 39% of these vessels' total revenues on average in 2006 and 2007, while revenues from the Gulf shrimp and South Atlantic penaeid shrimp each accounted for around 30% of total revenues. Thus, even within this group of vessels, diversification across the fleet as a whole has taken place, with some vessels specializing in Northeast non-shrimp fisheries, others in the Gulf shrimp fishery, and others in the South Atlantic penaeid shrimp fishery.

<u>All Vessels with South Atlantic Penaeid or Rock Shrimp Permits/Endorsements</u>
Finally, as previously noted, many vessels possess two or all three of these permits/endorsements. The total number of vessels that possess one or more South Atlantic penaeid or rock shrimp permits/endorsements is 694. Information regarding these vessels' physical and operational characteristics is presented in Tables 5.2.1-42 and 3.4-43. Since the vast majority of these vessels possess penaeid shrimp permits, these vessels' physical and operational characteristics are nearly identical to those with penaeid shrimp permits on average. That is, this fleet of vessels is very heterogeneous with respect to its physical characteristics. For example, approximately 65% of the vessels are large while 35% are small. Less than 40% have on-board freezing capacity while nearly 60% rely on ice for storage purposes. With respect to their hulls, the fleet is approximately evenly split between steel, wood, and fiberglass. On average, this group of vessels is somewhat smaller, older, less technologically advanced and uses less crew and gear relative to vessels that only possess limited access rock shrimp endorsements.

The same logic applies to these vessels' participation in and distribution of landings and revenues across commercial fisheries. Specifically, 648 of these 694 vessels, or more than 93%, were active in commercial fishing at some point between 2003 and 2007. Further, information in Table 3.4-44 indicates that revenues from the Gulf shrimp, Northeast non-shrimp, and South Atlantic penaeid shrimp fisheries have accounted for 36%, 31% and 24% of these vessels' total revenues on average between 2003 and 2007, respectively, which again is very similar to the distribution for vessels with penaeid shrimp permits. The average total revenue per vessel during this time was approximately $185,000, which is comparable to vessels with penaeid shrimp permits though 35% less than vessels that possess a limited access rock shrimp endorsement.

Table 5.2.1-30. Physical characteristics and selected statistics for vessels with open access rock shrimp permits.

	Crew Size	Number of Nets	Net Size (ft)	Vessel Age	Length	Horsepower	Fuel Capacity (gallons)	Gross Tons	Hold Capacity (pounds)
Number of vessels	202	147	157	265	266	266	238	238	237
Minimum	1	1	16	2	14	15	5	8	50
Maximum	7	4	130	50	96	1,720	48,000	232	160,000
Total	690	563	9,167	5,580	18,059	144,447	3,110,403	27,760	13,395,250
Mean	3.4	3.8	58.4	21.1	67.9	543.0	13,069	116.6	56,520
St. Dev	0.9	0.6	13.8	11.2	18.8	233.2	10,182	42.9	37,642

Table 5.2.1-31. Distribution of additional physical characteristics for vessels with open access rock shrimp permits.

Hull Type	Percent	Refrigeration	Percent	Vessel Size Category	Percent
Steel	57.9	Freezer	59.4	Large	78.6
Fiberglass	22.9	Ice	39.5	Small	21.4
Wood	19.2	Live Well	1.1		

Table 5.2.1-32. Physical characteristics and selected statistics for commercially active vessels (2003-2007) with open access rock shrimp permits.

	Crew Size	Number of Nets	Net Size (ft)	Vessel Age	Length	Horsepower	Fuel Capacity (gallons)	Gross Tons	Hold Capacity (pounds)
Minimum	1	1	21	2	23	125	30	8	800
Maximum	7	4	130	50	96	1,720	48,000	232	160,000
Mean	3.4	3.8	58.7	21.5	71.7	566.0	13,924	119.5	58,592
St. Dev	0.9	0.6	13.0	11.0	14.4	219.2	9,855	39.4	35,874

Table 5.2.1-33. Distribution of additional physical characteristics for commercially active vessels (2003-2007) with open access rock shrimp permits.

Hull Type	Percent	Refrigeration	Percent	Vessel Size Category	Percent
Steel	62.7	Freezer	64.7	Large	86.1
Wood	20.2	Ice	35.1	Small	13.9
Fiberglass	17.2	Live Well	.2		

Table 5.2.1-34. Landings and revenue statistics, all commercially active open access rock shrimp vessels, 2003-2007, combined.

Statistic	SRS landings	SRS Revenue	Gulf shrimp Revenue	SA penaeid shrimp Revenue	Gulf non-shrimp Revenue	SA non-shrimp Revenue	Northeast non-shrimp Revenue	Total SA Shrimp Revenue	Total Revenue	% of Revenue from SRS	% of Revenue from SA shrimp
Total	10,401,633	$11,390,318	$104,102,673	$47,671,815	$1,417,101	$9,436,764	$114,543,571	$59,062,133	$288,562,241	N/A	N/A
Average / Vessel / Year	9,804	$10,735	$98,117	$44,931	$1,336	$8,894	$107,958	$55,666	$271,972	3.8	29.4

Table 5.2.1-35. Landings and revenue statistics by landing year, all commercially active open access rock shrimp vessels, 2003-2007.

Year	Statistic	SRS landings	SRS Revenue	Gulf shrimp Revenue	SA penaeid shrimp Revenue	Gulf non-shrimp Revenue	SA non-shrimp Revenue	Northeast non-shrimp Revenue	Total SA Shrimp Revenue	Total Revenue	% of Revenue from SRS	% of Revenue from SA shrimp
2003	# vessels	203	203	203	203	203	203	203	203	203	203	203
2003	Minimum	0	$0	$0	$0	$0	$0	$0	$0	$91	0.0	0.0
2003	Maximum	161,242	$252,686	$385,842	$294,047	$68,439	$306,600	$84,201	$376,455	$560,772	79.5	100.0
2003	Total	2,040,421	$3,039,599	$22,387,725	$5,444,129	$202,999	$2,331,623	$193,115	$8,483,728	$33,599,190	N/A	N/A
2003	Average	10,051	$14,973	$110,284	$26,818	$1,000	$11,486	$951	$41,792	$165,513	5.9	27.3
2003	St. Dev	23,010	$34,762	$107,443	$48,035	$5,872	$39,482	$8,192	$64,826	$111,397	13.0	37.3

Table 5.2.1-35. Landings and revenue statistics by landing year, all commercially active open access rock shrimp vessels, 2003-2007 - Continued.

2004	# vessels	198	198	198	198	198	198	198	198	198	198	198
2004	Minimum	0	$0	$0	$0	$0	$0	$0	$0	$490	0.0	0.0
2004	Maximum	665,787	$469,639	$504,594	$512,952	$99,510	$385,283	$1,715,493	$704,369	$1,861,321	74.1	100.0
2004	Total	5,325,685	$4,008,793	$18,834,968	$11,373,225	$307,607	$2,690,911	$5,162,016	$15,382,018	$42,378,010	N/A	N/A
2004	Average	26,897	$20,246	$95,126	$57,441	$1,554	$13,590	$26,071	$77,687	$214,030	6.9	38.0
2004	St. Dev	85,179	$62,281	$114,676	$88,420	$9,213	$47,354	$166,827	$113,705	$205,401	16.1	41.2
2005	# vessels	217	217	217	217	217	217	217	217	217	217	217
2005	Minimum	0	$0	$0	$0	$0	$0	$0	$0	$165	0.0	0.0
2005	Maximum	43,960	$32,449	$632,262	$372,749	$118,590	$283,475	$2,940,904	$405,198	$3,081,622	7.9	100.0
2005	Total	105,212	$95,897	$20,702,702	$6,744,140	$249,876	$1,947,415	$37,081,809	$6,840,037	$66,821,839	N/A	N/A
2005	Average	485	$442	$95,404	$31,079	$1,152	$8,974	$170,884	$31,521	$307,935	0.1	21.5
2005	St. Dev	3,311	$2,690	$137,028	$66,344	$8,760	$34,997	$426,823	$67,611	$406,412	0.8	37.7
2006	# vessels	218	218	218	218	218	218	218	218	218	218	218
2006	Minimum	0	$0	$0	$0	$0	$0	$0	$0	$45	0.0	0.0
2006	Maximum	312,347	$493,382	$591,472	$494,619	$125,247	$260,706	$3,674,195	$925,697	$3,686,083	76.7	100.0
2006	Total	2,696,877	$3,816,504	$22,370,751	$10,196,642	$315,192	$2,267,451	$35,713,040	$14,013,146	$74,679,580	N/A	N/A
2006	Average	12,371	$17,507	$102,618	$46,774	$1,446	$10,401	$163,821	$64,280	$342,567	5.8	27.8
2006	St. Dev	39,150	$56,740	$157,645	$92,494	$10,843	$37,720	$455,077	$129,904	$433,040	15.0	39.9
2007	# vessels	225	225	225	225	225	225	225	225	225	225	225
2007	Minimum	0	$0	$0	$0	$0	$0	$0	$0	$137	0.0	0.0
2007	Maximum	32,365	$61,656	$762,413	$625,093	$132,221	$18,786	$1,400,839	$682,867	$1,400,839	39.3	100.0
2007	Total	233,438	$429,525	$19,801,637	$13,913,679	$341,427	$199,364	$36,393,591	$14,343,204	$71,083,622	N/A	N/A
2007	Average	1,038	$1,909	$88,007	$61,839	$1,517	$886	$161,749	$63,748	$315,927	0.9	33.2
2007	St. Dev	4,523	$8,335	$150,655	$113,600	$10,618	$2,627	$356,599	$117,949	$325,840	4.4	44.9

Table 5.2.1-36. Physical characteristics and selected statistics for vessels with penaeid shrimp permits.

	Crew Size	Number of Nets	Net Size (ft)	Vessel Age	Length	Horsepower	Fuel Capacity (gallons)	Gross Tons	Hold Capacity (pounds)
# of vessels	441	339	286	619	620	618	564	582	546
Minimum	1	1	11	2	14	70	30	6	10
Maximum	7	4	130	87	131	1,720	41,000	232	160,000
Total	1,361	1,169	14,935	16,633	38,623	278,846	4,397,072	51,965	19,917,910
Mean	3.1	3.4	52.2	26.9	62.3	451.2	7,796	89.3	36,480
St. Dev	0.9	1.0	14.5	11.2	15.9	190.7	7,911	43.8	33,417

Table 5.2.1-37. Distribution of additional physical characteristics for vessels with penaeid shrimp permits.

Hull Type	Percent	Refrigeration	Percent	Vessel Size Category	Percent
Wood	35.8	Ice	61.2	Large	64
Steel	33.9	Freezer	38.0	Small	36
Fiberglass	30.2	Live Well	.8		
Aluminum	.2				

Table 5.2.1-38. Physical characteristics and selected statistics for commercially active vessels (2003-2007) with penaeid shrimp permits.

	Crew Size	Number of Nets	Net Size (ft)	Vessel Age	Length	Horsepower	Fuel Capacity (gallons)	Gross Tons	Hold Capacity (pounds)
Minimum	1	1	11	2	23	85	55	6	500
Maximum	7	4	130	87	131	1,720	41,000	232	160,000
Mean	3.1	3.5	52.6	27.1	64.4	462.1	8,226	92.0	38,029
St. Dev.	0.9	1.0	13.9	11.0	14.0	186.8	7,890	42.5	33,044

Table 5.2.1-39. Distribution of additional physical characteristics for commercially active vessels (2003-2007) with penaeid shrimp permits.

Hull Type	Percent	Refrigeration	Percent	Vessel Size Category	Percent
Wood	38.2	Ice	58.4	Large	68.9
Steel	35.2	Freezer	41.1	Small	31.1
Fiberglass	25.8	Live Well	.4		
Aluminum	.2				

Table 5.2.1-40. Landings and revenue statistics, all commercially active penaeid shrimp vessels, 2003-2007 combined

Statistic	SRS landings	SRS Revenue	Gulf shrimp Revenue	SA penaeid shrimp Revenue	Gulf non-shrimp Revenue	SA non-shrimp Revenue	Northeast non-shrimp Revenue	Total SA Shrimp Revenue	Total Revenue	% of Revenue from SRS	% of Revenue from SA shrimp
Total	10,296,413	$11,275,523	$160,823,771	$115,518,193	$730,479	$32,817,677	$130,250,455	$126,793,716	$451,416,099	N/A	N/A
Average / Vessel / Year	4,075	$4,462	$63,638	$45,714	$289	$12,987	$51,544	$50,176	$178,637	1.6	48.1

Table 5.2.1-41. Landings and revenue statistics by landing year, all commercially active penaeid shrimp vessels, 2003-2007.

Year	Statistic	SRS landings	SRS Revenue	Gulf shrimp Revenue	SA penaeid shrimp Revenue	Gulf non-shrimp Revenue	SA non-shrimp Revenue	Northeast non-shrimp Revenue	Total SA Shrimp Revenue	Total Revenue	% of Revenue from SRS	% of Revenue from SA shrimp
2003	# vessels	491	491	491	491	491	491	491	491	491	491	491
2003	Minimum	0	$0	$0	$0	$0	$0	$0	$0	$42	0.0	0.0
2003	Maximum	161,242	$252,686	$513,483	$350,927	$30,814	$591,837	$84,201	$376,455	$591,837	79.5	100.0
2003	Total	2,064,808	$3,041,584	$34,475,639	$16,324,873	$183,461	$6,900,384	$193,115	$19,366,457	$61,119,056	N/A	N/A
2003	Average	4,205	$6,195	$70,216	$33,248	$374	$14,054	$393	$39,443	$124,479	2.5	44.2
2003	St. Dev.	15,890	$23,884	$99,942	$51,792	$2,506	$52,230	$5,281	$59,238	$104,884	9.0	45.1
2004	# vessels	512	512	512	512	512	512	512	512	512	512	512
2004	Minimum	0	$0	$0	$0	$0	$0	$0	$0	$11	0.0	0.0
2004	Maximum	665,787	$469,639	$526,518	$512,952	$35,554	$741,110	$1,715,493	$704,369	$1,861,321	74.1	100.0
2004	Total	5,241,387	$3,943,766	$31,025,983	$25,514,900	$149,470	$8,811,281	$6,356,381	$29,458,666	$75,801,780	N/A	N/A
2004	Average	10,237	$7,703	$60,597	$49,834	$292	$17,210	$12,415	$57,536	$148,050	2.7	52.6
2004	St. Dev.	54,388	$39,777	$102,469	$68,704	$2,509	$66,381	$105,694	$83,140	$157,412	10.5	45.8
2005	# vessels	509	509	509	509	509	509	509	509	509	509	509
2005	Minimum	0	$0	$0	$0	$0	$0	$0	$0	$456	0.0	0.0
2005	Maximum	43,960	$32,449	$653,671	$372,749	$18,574	$796,414	$2,940,904	$405,198	$3,081,622	7.9	100.0
2005	Total	104,425	$95,346	$31,673,357	$19,281,930	$72,969	$7,870,856	$44,329,636	$19,377,276	$103,324,095	N/A	N/A
2005	Average	205	$187	$62,227	$37,882	$143	$15,463	$87,092	$38,069	$202,994	0.1	42.4
2005	St.Dev.	2,172	$1,768	$112,819	$61,881	$1,357	$62,135	$287,055	$62,442	$293,202	0.5	47.4
2006	# vessels	512	512	512	512	512	512	512	512	512	512	512
2006	Minimum	0	$0	$0	$0	$0	$0	$0	$0	$96	0.0	0.0
2006	Maximum	312,347	$493,382	$722,203	$494,619	$89,513	$836,402	$3,674,195	$925,697	$3,686,083	76.7	100.0
2006	Total	2,649,795	$3,758,403	$34,481,455	$25,122,699	$135,486	$8,944,590	$40,474,673	$28,881,102	$112,917,306	N/A	N/A
2006	Average	5,175	$7,341	$67,346	$49,068	$265	$17,470	$79,052	$56,408	$220,542	2.4	47.3
2006	St.Dev.	26,172	$37,912	$136,928	$76,681	$4,070	$67,034	$300,176	$97,263	$313,852	10.1	46.6

Table 5.2.1-41. Landings and revenue statistics by landing year, all commercially active penaeid shrimp vessels, 2003-2007 - Continued.

Year	Statistic	SRS landings	SRS Revenue	Gulf shrimp Revenue	SA penaeid shrimp Revenue	Gulf non-shrimp Revenue	SA non-shrimp Revenue	Northeast non-shrimp Revenue	Total SA Shrimp Revenue	Total Revenue	% of Revenue from SRS	% of Revenue from SA shrimp
2007	# vessels	503	503	503	503	503	503	503	503	503	503	503
2007	Minimum	0	$0	$0	$0	$0	$0	$0	$0	$82	0.0	0.0
2007	Maximum	32,365	$61,656	$762,413	$625,093	$64,950	$18,786	$1,400,839	$682,867	$1,400,839	39.3	100.0
2007	Total	235,998	$436,424	$29,167,337	$29,273,791	$189,094	$290,567	$38,896,649	$29,710,215	$98,253,862	N/A	N/A
2007	Average	469	$868	$57,986	$58,198	$376	$578	$77,329	$59,066	$195,336	0.4	53.7
2007	St. Dev.	3,066	$5,654	$126,773	$90,628	$3,851	$2,053	$245,772	$93,129	$245,255	3.0	47.9

Table 5.2.1-42. Physical characteristics and selected statistics for all vessels with rock or penaeid shrimp permits/endorsements.

	Crew Size	Number of Nets	Net Size (ft)	Vessel Age	Length	Horsepower	Fuel Capacity (gallons)	Gross Tons	Hold Capacity (pounds)
Number of vessels	484	374	322	692	694	692	614	641	601
Minimum	1	1	11	2	12	5	5	6	10
Maximum	7	4	130	87	131	1,720	48,000	232	160,000
Total	1,497	1,300	17,072	18,236	43,228	316,446	5,086,822	59,147	22,936,570
Mean	3.1	3.5	53.0	26.4	62.3	457.3	8,284.7	92.3	38,164.0
Standard Dev	0.9	0.9	14.7	11.2	17.0	200.7	8,554.5	44.9	33,827.0

Table 5.2.1-43. Distribution of additional physical characteristics for all vessels with rock or penaeid shrimp permits/endorsements.

Hull Type	Percent	Refrigeration	Percent	Vessel Size Category	Percent
Steel	35.4	Ice	59.8	Large	64.4
Wood	33.9	Freezer	39.5	Small	35.6
Fiberglass	30.4	Live Well	.7		
Aluminum	.3				

Table 5.2.1-44. Landings and revenue statistics, all commercially active RSE, open access RS, and penaeid shrimp vessels, 2003-2007 combined.

Statistic	SRS landings	SRS Revenue	Gulf shrimp Revenue	SA penaeid shrimp Revenue	Gulf non-shrimp Revenue	SA non-shrimp Revenue	Northeast non-shrimp Revenue	Total SA Shrimp Revenue	Total Revenue	% of Revenue from SRS	% of Revenue from SA shrimp
Total	12,204,716	$13,381,159	$188,031,300	$123,348,395	$1,597,708	$34,524,455	$159,151,536	$136,729,554	$520,034,553	N/A	N/A
Average / Vessel / Year	4,339	$4,757	$66,844	$43,849	$568	$12,273	$56,577	$48,606	$184,868	1.8	45.3

Recent Economic Condition of the South Atlantic Shrimp Fisheries

To the extent possible, landings, revenues, and prices have been described in the aggregate and according to particular groups of vessels with various types of South Atlantic shrimp permits or endorsements. Limited historical information on vessel costs and profitability was discussed in Amendment 6 (SAFMC 2004) and is incorporated herein by reference. However, the only relatively recent information on costs and profitability was limited to shrimp trawlers in South Carolina. Given the reduced importance of the South Carolina fleet within the overall fishery and the fact that very few South Carolina vessels participate in the limited access rock shrimp fishery, those data are not only outdated but undoubtedly not representative of the vessels potentially impacted by the actions in this Amendment. An attempt was made to voluntarily collect information on South Atlantic shrimp vessels' costs and net revenues in 2005. This project was only partially successful in its attempts to collect the desired data (i.e., the achieved sample size was considerably smaller than the desired sample size). It was determined that the collected information was likely not representative of the fishery as a whole or specifically of vessels participating in the federal component of the fishery. However, some information on how vessels' costs have likely been changing during the past several years is presented below, as are insights into why domestic shrimp prices declined, almost continually, from 2001 through 2006.

According to available information, the shrimp fisheries in the Southeast region had a banner year in 2000. However, economic conditions took an abrupt turn in the latter half of 2001. Current evidence indicates that as shrimp imports surged in that year, macroeconomic conditions deteriorated, and when the post-September 11-era began, the industry was hit by sharply declining prices and higher insurance premiums. The deteriorating trend apparently continued through 2002 and 2003, exacerbated by increases in fuel prices that began in the latter part of 2002 and continued through 2003. According to average price data reported by the Bureau of Labor Statistics (BLS), from 2002 to 2003, fuel prices increased between 21% and 29%, depending on the selected fuel price index. Regardless of which index is used, fuel prices increased significantly which, in turn, significantly increased shrimp vessels' operating costs.

However, rapidly declining prices appear to have been the primary source of the recent deterioration in the industry's economic condition. Revenues decreased even more as a result of relatively lower landings in 2001 and 2002 relative to 2000. According to Haby *et al.* (2003), increases in shrimp imports have been the primary cause of the recent decline in U.S. shrimp prices. A complete discussion of the factors contributing to the increase in imports can be found in Haby *et al.* (2003). In general, recent surges in imports have been caused by increases in the production of foreign, farm-raised shrimp. More specifically, increased competition from shrimp imports has been due to three primary factors: 1) changes in product form due to relatively lower wages in the exporting countries, 2) shifts in production to larger count sizes, and 3) tariff and exchange rate conditions which have been favorable to shrimp imports into the U.S. With respect to the first factor, lower wage rates have allowed major shrimp exporters (e.g., Thailand) to increase production of more convenient and higher value product forms, such as hand-peeled raw and cooked shrimp. With respect to the second factor, changes in farming technology and species have allowed production of foreign product to shift towards larger, more valuable sizes. As a result of these factors, imports are more directly competing with the product traditionally harvested by the domestic industry, thereby reducing the latter's historical comparative advantage with respect to these product forms and sizes. Finally, with respect to the third factor, the lack of duties on shrimp imports into the U.S., the presence of relatively significant duties on shrimp imports into the European Union, and the recent strength of the U.S. dollar relative to foreign currencies have created favorable conditions for countries exporting products to the U.S.

As Haby *et. al.* (2003) note, the increase in imports caused the domestic industry's share of the U.S. shrimp market to decrease from 44.6% to 14.8% between 1980 and 2001. While the growth in imports was relatively steady throughout most of this time period (for example, 4-5% in the late 1990s), shrimp imports surged by 16% in 2001. Since 2001, which is the last year accounted for in their analysis, shrimp imports have continued to rise. Although the increase in 2002 was a modest 7.2%, relative to the increase in 2001, a significant increase of 19.1% occurred in 2003 according to the most recently available data. These increases led to further erosion in the domestic industry's market share and additional price declines.

Available information at the time indicated that domestic shrimp prices had continued to decline in 2003, which would lead to the expectation that vessels may not have been able to cover their variable costs. If vessels cannot cover their variable costs, they will be forced to cease operations (i.e., exit the fishery) until conditions change. Many changes have continued to occur that would likely affect the economic status of the Gulf shrimp harvesting sector. Most of these changes would be expected to adversely affect the industry's economic status. For example, fuel prices have risen significantly since 2002. Probably the best proxy to use for fuel prices paid by commercial shrimpers (or commercial fishermen in general) is the diesel fuel price paid by farmers, statistics for which are generated by the USDA. This price is more appropriate than the diesel fuel price "paid on the street," which is typically generated by the BLS, because it removes fuel excise taxes, which neither commercial fishermen nor farmers pay. The diesel fuel price per gallon paid by farmers changed as follows in each year from 2002 and 2006: $.96, $1.24, $1.31, $1.97 and $2.28, respectively. This represents a price increase of nearly 138% between 2002 and 2006, with the largest increases occurring in 2003, 2005, and 2006. Preliminary data for 2007 indicates that fuel prices increased further to as much as $2.43 per gallon on average. Early data in 2008 indicates that diesel fuel prices may be more than a $1 higher at present, which could cause the fuel costs associated with operating in the commercial shrimp fishery to be nearly prohibitive unless shrimp prices were to increase proportionally, which recent history suggests is unlikely.

To provide some context, it is helpful to think of how these fuel price increases translate into increases in a typical vessel's fuel expenses. With respect to the cost of filling up a shrimp vessel, the average fuel capacity of a commercial active vessel with a limited access rock shrimp endorsement is approximately 17,000 gallons (see Table 5.2.1-9). Thus, between 2002 and 2007, the cost of filling up an "average" active rock shrimp vessel rose from approximately $16,300 to more than $41,300. Thus, the cost of filling up a typical rock shrimp vessel with fuel has increased nearly 153% between 2002 and 2007.

As previously noted, shrimp prices increased somewhat in late 2004 and through much of 2005. These price gains were likely due to the impact of duties imposed on imported shrimp and the relative stabilization in the volume of imports coming into the U.S. In 2004, shrimp imports increased by only 1% over their 2003 level. And in 2005, shrimp imports increased by only 2.5% over their level in 2004. However, shrimp imports once more surged into the U.S. market beginning in late 2005 and through 2006, and this is more than likely the primary cause of the general price decreases for domestic shrimp during that year. Specifically, shrimp imports were approximately 11.6% higher in 2006 than they were in 2005. Preliminary data do seem to suggest that prices have increased in 2007, particularly for the 30-count and larger size categories, based on data from the Gulf shrimp fishery. In general, though depending on the size category, prices appear to have returned to their levels in 2005 and possibly 2004. Not coincidentally, preliminary 2007 data also appear to indicate that imports have not only stabilized, but may have actually decreased by as much as 5% in 2007.

Rock Shrimp Dealers

As previously noted, between 40 and 50 dealers have typically held rock shrimp dealer permits at any given point in time during recent years and 46 dealers held one at one time or another during 2006 and 2007. Thus, it is not unexpected that 36 dealers purchased South Atlantic rock shrimp between 2003 and 2007. Some dealers apparently have obtained these permits on the off-chance that one or more of the vessels they typically buy shrimp from harvest South Atlantic rock shrimp. Further, not all of these dealers were active in each year and most were in fact active in only one or two years during this time. However, a careful review of the landings and permit data has revealed some disturbing information. Specifically, of the 36 dealers that have purchased South Atlantic rock shrimp in the past five years, only 21 of them had the legally required federal South Atlantic rock shrimp dealer permit (i.e., 15 dealers did not have the required permit). For some of these dealers, the alleged amount of South Atlantic rock shrimp illegally purchased was relatively minor. In other cases, the amount was more substantial. As can be seen in Table 5.2.1-45, in the aggregate, these non-permitted dealers are not the most significant dealers in the fishery with respect to landings and revenue. And during 2004, 2005, and 2007, the amount of rock shrimp alleged to have been illegally purchased was relatively trivial or non-existent. However, the problem was more widespread in 2003 and 2006 when more than 7% and approximately 6% of the landings were apparently purchased by dealers that lacked the required permit. These amounts cannot be considered trivial and the problem should be addressed in some manner.

Table 5.2.1-45. South Atlantic rock shrimp landings and revenue, federally permitted and non-federally permitted rock shrimp dealers, 2003-2007.

Year	Landings (Permitted)	Revenue (Permitted)	Landings (Non-Permitted)	Revenue (Non-Permitted)	Landings (All)	Revenue (All)
2003	2,755,465	$4,169,465	225,159	$320,443	2,980,623	$4,489,905
2004	6,588,574	$5,009,071	3,009	$3,080	6,591,583	$5,012,147
2005	109,281	$99,612	0	$0	109,281	$99,611
2006	2,840,711	$3,964,522	177,610	$300,058	3,018,322	$4,264,576
2007*	236,468	$428,169	4,081	$13,108	240,550	$441,277

*2007 data are preliminary

Although these allegedly illegal purchases may have repercussions for the non-permitted dealers, and possibly even for their permitted competitors, these sales may also have impacts on the vessels from which the rock shrimp were purchased. Specifically, if the rock shrimp were in fact illegally purchased, in general, they cannot count towards those vessels' catch histories and, moreover, they cannot be counted towards meeting the current 15,000-pound landing requirement. As such, it is quite possible that some vessels may not meet the landings requirement, not because they had insufficient landings, but because some or all of those landings were sold through dealers without the federal permit. Although the allegedly illegal purchases of rock shrimp in 2003 may not be critical in this regard, those made in 2006 certainly could be.

Notwithstanding this important issue, it is still necessary to characterize the detailed landings and sales activities of all dealers participating in the fishery regardless of whether they were or currently are permitted to purchase South Atlantic rock shrimp. For current purposes, it is most important to examine changes in the number of dealers in the fishery and their purchasing activities in recent years. In turn, this information will yield insights into the relative importance of the fishery to these dealers and how they have adapted to changes in the harvesting sector.

According to information presented in Table 5.2.1-46, the number of dealers active in the South Atlantic rock shrimp fishery was fairly stable from 2003 to 2004 (23 and 22 dealers, respectively), fell dramatically in 2005 to a level not seen in recent history (7 dealers), increased somewhat in 2006 (14 dealers), and then decreased again in 2007 to a level slightly above the historic low in 2005 (10 dealers). As would be expected, this trend in the number of participating dealers closely mirrors that of the number of participating vessels.

Table 5.2.1-46. Distribution of landings and revenue for active South Atlantic rock shrimp dealers, 2003-2007.

Year	Statistic	SA rock shrimp landings	SA rock shrimp Revenue	Gulf non-shrimp landings	Gulf non-shrimp Revenue	Gulf shrimp landings	Gulf shrimp Revenue	SA non-shrimp landings	SA non-shrimp Revenue	SA other shrimp landings	SA other shrimp Revenue	Total Revenue	SA rock shrimp as % of Revenue
2003	# Dealers	23	23	23	23	23	23	23	23	23	23	23	23
2003	Minimum	25	$45	0	$0	0	$0	0	$0	0	$0	$5,723	0.0
2003	Maximum	1,451,706	$2,002,549	261,503	$460,587	2,218,709	$4,624,105	1,116,327	$458,956	1,260,265	$2,819,440	$5,547,911	85.1
2003	Total	2,980,624	$4,489,908	321,813	$609,212	6,301,097	$11,315,550	1,633,834	$753,259	4,451,577	$8,783,514	$25,951,443	N/A
2003	Average	129,592	$195,213	13,992	$26,487	273,961	$491,980	71,036	$32,750	193,547	$381,892	$1,128,324	23.1
2003	St. Dev	303,301	$425,011	54,335	$96,893	571,787	$1,084,021	239,744	$97,681	287,038	$607,794	$1,486,748	26.2
2004	# Dealers	22	22	22	22	22	22	22	22	22	22	22	22
2004	Minimum	1	$1	0	$0	0	$0	0	$0	710	$1,669	$23,240	0.0
2004	Maximum	3,100,851	$2,114,596	475,048	$920,459	1,688,681	$3,898,364	3,239,165	$3,796,349	2,155,369	$4,575,481	$5,516,648	71.1
2004	Total	6,591,583	$5,012,151	983,545	$1,962,105	7,292,414	$12,819,876	4,290,724	$5,275,928	5,350,387	$11,294,844	$36,364,904	N/A
2004	Average	299,617	$227,825	44,707	$89,187	331,473	$582,722	195,033	$239,815	243,199	$513,402	$1,652,950	18.2
2004	St. Dev.	704,867	$496,557	121,748	$242,044	521,696	$989,536	692,626	$817,183	447,414	$959,817	$1,631,107	25.5
2005	# Dealers	7	7	7	7	7	7	7	7	7	7	7	7
2005	Minimum	369	$277	0	$0	0	$0	0	$0	11,862	$22,980	$805,341	0.0
2005	Maximum	59,795	$47,808	316,727	$622,730	668,784	$1,068,502	912,771	$1,046,985	1,473,040	$3,479,982	$4,540,954	3.5
2005	Total	109,281	$99,612	321,520	$629,696	1,368,939	$2,299,239	1,017,678	$1,161,760	2,828,736	$6,261,433	$10,451,740	N/A
2005	Average	15,612	$14,230	45,931	$89,957	195,563	$328,463	145,383	$165,966	404,105	$894,490	$1,493,106	1.1
2005	St. Dev.	20,559	$16,497	119,423	$234,945	263,936	$429,147	339,674	$389,939	510,708	$1,200,060	$1,357,096	1.3
2006	# Dealers	14	14	14	14	14	14	14	14	14	14	14	14
2006	Minimum	105	$263	0	$0	0	$0	0	$0	0	$0	$52,864	0.0
2006	Maximum	876,284	$1,232,689	2,134,487	$5,636,798	3,164,586	$6,831,619	759,661	$1,724,774	1,962,679	$4,284,836	$7,617,680	97.7
2006	Total	3,018,321	$4,264,580	2,532,597	$6,469,548	5,668,772	$10,933,947	1,673,665	$2,992,110	3,674,707	$7,787,785	$32,447,970	N/A
2006	Average	215,594	$304,613	180,900	$462,111	404,912	$780,996	119,548	$213,722	262,479	$556,270	$2,317,712	23.2
2006	St. Dev.	322,913	$445,540	572,154	$1,505,685	904,750	$1,874,201	267,547	$518,384	511,513	$1,126,532	$2,645,485	29.9

Table 5.2.1-46. Distribution of landings and revenue for active South Atlantic rock shrimp dealers, 2003-2007-- Continued.

Year	Statistic	SA rock shrimp landings	SA rock shrimp Revenue	Gulf non-shrimp landings	Gulf non-shrimp Revenue	Gulf shrimp landings	Gulf shrimp Revenue	SA non-shrimp landings	SA non-shrimp Revenue	SA other shrimp landings	SA other shrimp Revenue	Total Revenue	SA rock shrimp as % of Revenue
2007	# Dealers	10	10	10	10	10	10	10	10	10	10	10	10
2007	Minimum	46	$69	0	$0	0	$0	0	$0	0	$0	$286,657	0.0
2007	Maximum	89,427	$171,990	1,304,467	$4,172,221	629,392	$1,087,291	4,365,021	$5,320,863	2,741,196	$6,014,590	$8,247,955	20.3
2007	Total	240,549	$441,277	1,314,298	$4,183,907	1,051,040	$1,755,289	6,230,962	$10,147,144	4,339,538	$9,647,916	$26,175,533	N/A
2007	Average	24,055	$44,128	131,430	$418,391	105,104	$175,529	623,096	$1,014,714	433,954	$964,792	$2,617,553	3.4
2007	St. Dev	35,545	$66,629	412,171	$1,318,964	203,232	$347,925	1,362,541	$1,813,492	838,027	$1,838,139	$3,233,212	6.1

Also as expected, these dealers' dependence on South Atlantic rock shrimp purchases also closely mirrors the dependence of vessels, or more specifically vessels with RSEs that had South Atlantic rock shrimp landings in particular, on South Atlantic rock shrimp revenues. Landings and revenues are broken down into the following categories: South Atlantic rock shrimp, Gulf shrimp, Gulf non-shrimp, South Atlantic non-shrimp, and other South Atlantic shrimp (primarily penaeids). For example, in 2003, South Atlantic rock shrimp purchases accounted for nearly one-quarter of these dealers' total purchases, and thus they were fairly dependent on these purchases at the time. In 2004, the average South Atlantic rock shrimp landings per dealer increased fairly significantly. However, because of the significant decrease in rock shrimp prices, and because purchases of penaeid shrimp and other types of seafood increased even more, causing their total revenues to increase on average, their dependence on rock shrimp purchases decreased slightly in that year. And in 2005, given the steep decline in rock shrimp landings, their total revenues decreased, but not significantly as their purchases of Gulf shrimp and South Atlantic penaeid shrimp increased fairly significantly and thus mostly compensated for the lack of rock shrimp. And in 2006, their dependence on rock shrimp increased again, basically back to the same level seen in 2003. However, though fewer in number, the dealers participating in the rock shrimp fishery were actually better off on average in 2006 than those in 2003. In addition to the recovery in rock shrimp landings and sales, with the exception of South Atlantic penaeid shrimp landings and sales, landings and sales in all other species categories increased, thereby leading to a significant increase in total revenues. Again, somewhat similar to the trend in the rock shrimp harvesting sector, participating dealers' dependence on rock shrimp declined precipitously in 2007, as did their dependence on Gulf shrimp sales. However, once more, their total revenues increased on average, due to significant increases in South Atlantic penaeid shrimp sales and particularly revenues from non-shrimp landings from the South Atlantic.

So, as in the harvesting sector, even for the dealers that remain involved in the South Atlantic rock shrimp fishery, they have adjusted their "portfolio" of seafood purchases in order to stay in business. However, one major difference is the source of this diversification. Unlike vessels, which are mobile and can travel in order to diversify their landings (e.g., vessels that have shifted into the Northeast scallop fishery), dealers are based on land and must diversify into other local fisheries. Of course, their ability to adjust does not mean that other dealers no longer involved in the rock shrimp fishery have been able to adjust as well. In fact, it is quite likely that some dealers that used to be involved in the fishery are no longer in business, though a definitive conclusion on this subject will require additional research. Further, the ability of these dealers to adjust their purchases of seafood may not satisfy the desires of certain companies (e.g., processors, institutional buyers, restaurants, etc.) that want to purchase rock shrimp and would prefer a steady supply of the product from year to year.

Rock Shrimp Processors

At present, data on shrimp processors in the Southeast region (i.e., South Atlantic and Gulf) are only available through 2006 since these data are typically not available until the September following each calendar year. Based on a review of these data from 2003 through 2006, no rock shrimp were processed by any processors in the South Atlantic. The processing of rock shrimp appears to be specialized and only handled by a select number of processors primarily located in the Panhandle area of Florida. Processing of rock shrimp by firms in this particular area has likely been driven by the presence of a seasonal fishery for rock shrimp in the Gulf in the areas off of the Panhandle and Big Bend area on the west coast of Florida. Since no shrimp processors in the South Atlantic are involved in the processing of rock shrimp, it is assumed that the processing of South Atlantic rock shrimp takes place in the Gulf.[11] Given existing data constraints, it is not possible to directly determine how much of the rock shrimp processed by these firms comes from the South Atlantic as opposed to the Gulf. However, the data suggest that not all rock shrimp harvested from either region is processed. Thus, the following information focuses on firms that process rock shrimp and, in order to provide some context, also provides some information on the current and historical status of the Gulf shrimp processing sector in general.

Statistics describing rock shrimp processors are provided in Table 5.2.1-47. The number of firms involved in rock shrimp processing has remained fairly constant in most recent years, with 7 firms participating in the industry in 2003 and 6 firms participating thereafter. Of the 7 processors in 2003, 6 were small processors (i.e., those with less than $5 million in processed value) and 1 was large (i.e., more than $20 million in processed value). One small processor stopped processing rock shrimp in 2004 and had exited the shrimp processing industry completely by 2006. Also by 2006, one of the small processors had become a medium sized processor (i.e., between $5 million and $20 million in processed value).

Though processed rock shrimp poundage and value has been somewhat up and down during these years, the general trend appears to be downward. This fact is more clearly illustrated by the decreased dependence of these processors on rock shrimp as opposed to penaeid shrimp. On average, rock shrimp accounted for 24% of these processors' total processed value, but only accounted for 11%, or less than half, by 2006. Contrariwise, these firms' total processed poundage and value has trended upwards during this time. As explained below, this trend is reflective of consolidation in the Gulf shrimp processing sector, as well as relatively high shrimp abundance in the Gulf in 2006.

As would be expected, the trends in poundage and prices fairly closely mirror those in the harvesting sector. For example, as with landings, processed poundage increased slightly from 2003 to 2004, fell significantly in 2005, and then recovered somewhat in 2006. Similarly, as with the ex-vessel price to harvesters, the processed value per pound decreased significantly from 2003 to 2004 ($4.99/lb to $3.94/lb), though the proportional decrease in the processed price was less than the decrease in the ex-vessel price, but then subsequently recovered to $4.93/lb in 2005. However, the processed price fell in 2006 to $4.17/lb contrary to the ex-vessel price. Although it is typical for the processed price to

[11] Uncertainty exists with respect to the accuracy of this assumption, not only because existing data collection systems do not track the movement of shrimp from dealers to processors, but also because the collection of processing data in the South Atlantic and Gulf is voluntary in nature. Therefore, it is possible that the processing data used in this analysis is incomplete.

exceed the ex-vessel price, the differential in the case of rock shrimp is clearly larger than the differential typically seen between processed and ex-vessel prices for penaeid shrimp. Again, this illustrates the fact that the processing of rock shrimp is a highly specialized activity that apparently adds a considerable amount of value added to the final product.

Table 5.2.1-47. Production, value, and employment in the rock shrimp processing sector, 2003-2006.

Statistic	Year	Rock Shrimp Processed Pounds	Rock Shrimp Processed Value	Total Processed Pounds	Total Processed Value	Rock Shrimp as % of Processed Value	Employment
# Processors	2003	7	7	7	7	7	7
Total	2003	864,890	$4,315,693	10,882,946	$36,120,191	N/A	94
Average	2003	123,556	$616,528	1,554,707	$5,160,027	24	13
St. Dev.	2003	123,792	$662,766	2,897,567	$9,639,042	24	17
# Processors	2004	6	6	6	6	6	6
Total	2004	945,298	$3,723,049	10,846,992	$34,561,211	N/A	100
Average	2004	157,550	$620,508	1,807,832	$5,760,202	24	17
St. Dev.	2004	165,176	$626,371	2,985,340	$9,634,283	23	18
# Processors	2005	6	6	6	6	6	6
Total	2005	536,000	$2,647,050	12,506,272	$44,871,010	N/A	93
Average	2005	89,333	$441,175	2,084,379	$7,478,502	16	16
St. Dev.	2005	87,243	$462,389	3,283,621	$10,998,624	28	18
# Processors	2006	6	6	6	6	6	6
Total	2006	633,110	$2,640,466	14,259,655	$46,960,169	N/A	91
Average	2006	105,518	$440,078	2,376,609	$7,826,695	11	15
St. Dev.	2006	140,601	$644,020	3,531,637	$11,871,521	20	18

With respect to the Gulf shrimp processing sector in general, currently available information indicates that the number of Gulf shrimp processors decreased from 74 to 55 between 2002 and 2006, which reflects additional consolidation in the Gulf shrimp processing sector from what had taken place in previous years. The data also indicate that the surviving firms have expanded their production (i.e., average production per firm has increased, thereby causing an increase in the number of large processors), which has helped to maintain the value of their production in the face of generally declining prices (i.e., processed value per firm has remained relatively stable).[12] Also, in general, the firms that have exited the industry in the last few years are the smaller processors. In 2006, eight processors left the industry (five small and three medium/large). Rather interestingly though, three new processors entered the industry and, in effect, “picked up the slack.” The entry of these new processing firms was timely given the significant

[12] Even though ex-vessel prices decreased significantly in 2006, prices at the processor level were surprisingly unchanged from 2005, a finding that deserves further investigation.

increase in the volume of processed shrimp in 2006, which was driven by the significant increase in domestic landings and led to an increase in the processed value per firm.

The data also indicate that a majority of these firms are highly dependent on the processing of food shrimp. Unfortunately, it has not been historically possible to determine with certainty how much of the shrimp being processed is domestic as opposed to imported by using the NOAA Fisheries Service's processor data. However, by cross-referencing multiple data sources, Keithly *et al.* (2005) attempted to approximate this figure.[13] According to their findings, use of imports by domestic processors increased steadily through the 1980s and for example, in 1986, accounted for about one-third of production. Between 1992 and 1994, which was apparently the peak period, domestic and imported product accounted for nearly equal proportions of total processed shrimp products in the Southeast region. Even though, as noted previously, imports have continued to increase since then, Southeast shrimp processing activities have not increased proportionately as a result.

Keithly *et al.* (2005) hypothesized that this outcome is a direct result of a significant and steady decrease in the deflated price of processed shrimp from over $7.00/pound in the early 1980s to less than $4.00/pound in recent years. This decline has also precipitated a decline in processors' marketing margins (i.e., per unit profitability). As a result of the declining margins, some processors have adjusted by increasing output in order to compensate; but many have been unable to make such an adjustment, and thus have been forced to exit the industry. This is illustrated by the fact that the number of Gulf shrimp processors fell from 124 to 72 between 1980 and 2001. Thus, the situation illustrates the classic case of an industry in economic decline, wherein the number of firms falls, and those who remain become larger in size (as measured by output). That is, the industry has become more concentrated. Moreover, Keithly *et al.* (2005) concluded that, if production of farm-raised shrimp continues to increase and a substantial portion of that production enters the U.S. market, the price of processed shrimp will continue to decline; margins will continue to narrow; and consolidation will continue to occur as additional firms exit and remaining firms attempt to compensate by increasing their output.

A more recent study by Keithly *et al.* (2006) supports many of the conclusions and hypotheses offered in Keithly *et al.* (2005), and also helps to explain the changes that have occurred in this sector between 2002 and 2004, as noted above. In the recent study, Keithly *et al.* (2006) conducted a survey of shrimp processors in order to better estimate their marketing margins and their dependency on domestic as opposed to imported product. The survey information was combined with data from the NOAA Fisheries Service's processor database for analysis. A critical finding of this study is that shrimp processors' marketing margins have continued to decrease in recent years because the price of processed shrimp has been declining at a faster rate than the price of raw product. The decrease in the price of processed shrimp has been caused by increased imports of

[13] The one weakness with their approach is the assumption that all domestic production is utilized by the processing sector. While this assumption would be plausible under stable economic conditions, it is less reasonable in dire economic times when harvesters shift from traditional sales channels and instead sell directly to the public.

value-added product that directly compete with the domestic processors' product. The price decline has caused marketing margins to decrease, which in turn has forced firms to either exit the industry or increase their production. In general, smaller processors have exited while medium to larger sized processors have expanded, probably due to differences in their respective access to financial capital (i.e., smaller firms likely have less access to financial capital than their larger counterparts).

In addition, the study found that, in recent years, domestic processors have used a very limited amount of imported, raw product and instead are heavily dependent on domestically harvested product, contrary to popular belief. As such, the health of the processing sector is heavily dependent on domestic harvesting production. Keithly *et al.* (2006) note that the remaining firms' ability to maintain operations is dependent on their ability to expand, assuming processed shrimp prices continue to decline, which would be the case if imports of value-added product continue to increase. Therefore, if domestic harvesting production decreases, processors will be constrained in their ability to expand production, and additional consolidation of the industry will be likely. The decrease in Gulf shrimp landings in 2005 may have exacerbated the decline in the economic health of the Gulf shrimp processing sector. On the other hand, as previously noted, domestic landings rebounded significantly in 2006, which in turn likely helped to stabilize the processing sector and in fact encouraged three new firms to join the industry. Various reports also indicate that the processing sector was significantly impacted by Hurricane Katrina, either directly as a result of wind/storm surge damage or indirectly as a result of population shifts/displacement which in turn created labor shortages. Processors located in Biloxi, D'iberville, and Ocean Springs, Mississippi as well as in New Orleans and Violet, Louisiana were particularly hard hit (IAI 2007). However, the data suggest that most of these processors were back in operation, at least to some level, in 2006.

Global shrimp supply trends

Shrimp is produced throughout the world with more than 100 countries reporting production in 2003. United States shrimp imports expanded from about 260 million pounds (headless, shell-on basis) in 1980, to 563 million pounds in 1989 and 579 million pounds in 1990 (Vondruska 1991). Imports continued to steadily increase and reached 721 million pounds in 1996. Subsequently, this growth continued at a more rapid rate and in 2000 imported shrimp products, converted to shell-on headless weight, was estimated at 1.024 billion pounds (Haby et al. 2003).

During 2000 to 2003 the quantity of imports of all product forms increased (Table 5.2.1-48). It must be noted that these imports are not converted to equivalent shell-on weight and are not directly comparable to the statistics referenced in the previous paragraph. The cost of shrimp imports was $3.7 billion in 2003 (http://www.st.nmfs.gov/st1.html). The increase in the breaded/frozen shrimp category more than quadrupled during 2000 to 2003, and is noted because of its possible negative impact on the segment of the domestic processing sector which relies on adding value through breading. While the breaded fraction of total shrimp imports has increased from 4.2 million pounds in 2000 to 19.3 million pounds in 2003, breaded shrimp represented only 1.7 percent of total shrimp imports in 2003 (Table 5.2.1-48).

Table 5.2.1-48. Shrimp imported into the United States by product category (pounds): 2000-2003. Source: NOAA Fisheries web site (http://www.st.nmfs.gov/st1.html).

Product	2000	2001	2002	2003
SHRIMP PEELED FROZEN	283,800,134	274,297,936	274,997,820	329,397,233
SHRIMP FROZEN OTHER PREPARATIONS	124,487,832	147,616,830	190,631,863	194,407,195
SHRIMP SHELL-ON FROZEN < 15	35,983,449	46,605,838	54,675,513	51,967,520
SHRIMP SHELL-ON FROZEN 15/20	36,553,966	49,782,207	50,037,537	56,548,153
SHRIMP SHELL-ON FROZEN 26/30	34,857,537	58,077,008	43,040,523	66,132,673
SHRIMP SHELL-ON FROZEN 21/25	30,872,448	47,142,663	43,713,870	53,565,679
SHRIMP SHELL-ON FROZEN 31/40	63,811,647	78,559,023	71,370,922	101,764,370
SHRIMP OTHER PREPARATIONS	3,150,572	4,852,335	6,281,385	9,403,112
SHRIMP SHELL-ON FROZEN 41/50	36,241,889	45,483,346	48,317,238	63,575,934
SHRIMP SHELL-ON FROZEN > 70	45,590,547	43,897,454	50,568,874	45,767,088
SHRIMP SHELL-ON FROZEN 51/60	31,005,095	40,938,412	52,062,503	62,632,671
SHRIMP BREADED FROZEN	4,221,615	7,086,717	9,931,684	19,265,613
SHRIMP CANNED	3,647,941	4,263,618	4,067,351	3,899,007
SHRIMP SHELL-ON FROZEN 61/70	21,217,935	28,431,315	39,693,969	44,940,694
SHRIMP PEELED FRESH/DRIED/SALTED/BRINE	1,366,952	1,642,337	2,140,470	2,012,435
SHRIMP FROZEN IN ATC	463,804	325,336	1,567,852	3,811,361
SHRIMP SHELL-ON FRESH/DRIED/SALTED/BRINE	1,895,674	1,739,278	1,366,631	797,331
Total	759,169,037	880,741,653	944,466,006	1,109,888,072

When the fraction of total U.S. shrimp supplies attributable to domestic landings as opposed to imports is calculated using shell-on, headless values for domestic landings but product weights for imported shrimp, imports represent only about 70% of the total U.S. shrimp supply (i.e., the domestic market share is approximately 30%). Total domestic shrimp landings in 2001 and 2002 averaged 366.3 million pounds (http://www.st.nmfs.gov/st1.html). This quantity represents both warm water and cold water domestic shrimp harvests. However, as would be expected, the domestic market share estimate drops by approximately 15% when imports are converted from product weights to a shell-on, headless equivalent (Haby et al. 2003). Thus, imports comprise at least 85% of the U.S. shrimp supply. Determining the most appropriate market form (e.g., live weight, shell-on, headless, etc.) depends on the purpose for which the information is to be used. For example, Fisheries of the United States expresses commercial shrimp landings in two different market forms: round or live weight and shell-on, headless weight. Live or round weight is typically used when comparing the biomass of different species. However, since shell-on headless weight is the customary market form packed by primary processors, it is the more appropriate market form to use when determining the contribution of domestic landings to U.S. shrimp supplies. Further, although shrimp imports are expressed in actual product weights in the foreign trade segment of Fisheries of the United States, these weights are converted into shell-on, headless equivalents when determining the contribution of imports to U.S. shrimp supplies.

Much of the increase in shrimp imports to the United States since the 1980s came from farm-raised production. During the early 1980s, the growth in imports was attributed to farm raised production in Ecuador. Currently, most of the production and supply to the U.S. market originates from Asian countries led by Thailand and China. In fact, imports of shrimp products from Thailand are at about the same level as domestic landings from the Gulf of Mexico and South Atlantic states (Table 5.2.1-49a).

Table 5.2.1-49a. Top countries exporting shrimp to the United States (pounds): 2000-2003.

Country	2000	2001	2002	2003
THAILAND	278,185,622	299,372,465	253,229,970	293,084,816
CHINA	40,046,222	61,637,979	108,916,491	178,224,354
VIET NAM	34,580,060	73,189,541	98,309,902	126,230,784
INDIA	62,425,031	72,334,764	97,338,450	100,031,232
ECUADOR	42,013,398	58,871,089	65,372,600	74,864,117
MEXICO	63,963,757	66,036,705	53,453,631	56,086,708
BRAZIL	12,970,445	21,600,880	39,012,701	47,923,539
INDONESIA	36,865,176	34,864,806	38,361,213	47,658,378

The continual trend for increased imports has also resulted in decreased prices for imported shrimp products and is observed for all product forms. The price of imports will also be affected by the demand for shrimp in the other major markets of Japan and Europe. Import restrictions or an economic recession in either of these countries would have a downward influence on U.S. import prices for shrimp products.

Table 5.2.1-49b. Average price (per pound) of shrimp imported into the United States by product category: 2000-2003.

Product	2000	2001	2002	2003
SHRIMP PEELED FROZEN	$4.47	$4.38	$3.64	$3.06
SHRIMP FROZEN OTHER PREPARATIONS	$3.74	$3.47	$2.92	$2.85
SHRIMP SHELL-ON FROZEN < 15	$7.23	$6.96	$6.82	$6.92
SHRIMP SHELL-ON FROZEN 15/20	$6.65	$6.27	$5.63	$5.30
SHRIMP SHELL-ON FROZEN 26/30	$5.61	$4.68	$4.01	$3.94
SHRIMP SHELL-ON FROZEN 21/25	$6.23	$5.41	$4.66	$4.57
SHRIMP SHELL-ON FROZEN 31/40	$4.95	$4.15	$3.45	$3.27
SHRIMP OTHER PREPARATIONS	$4.29	$5.35	$4.53	$4.48
SHRIMP SHELL-ON FROZEN 41/50	$4.36	$3.38	$2.72	$2.61
SHRIMP SHELL-ON FROZEN > 70	$3.00	$3.01	$2.23	$2.24
SHRIMP SHELL-ON FROZEN 51/60	$3.94	$3.23	$2.63	$2.30
SHRIMP BREADED FROZEN	$3.76	$3.48	$2.99	$3.03
SHRIMP CANNED	$3.03	$2.87	$2.65	$2.51

SHRIMP SHELL-ON FROZEN 61/70	$3.44	$2.84	$2.39	$2.24
SHRIMP PEELED FRESH/DRIED/SALTED/BRINE	$5.94	$5.25	$5.00	$6.02
SHRIMP FROZEN IN ATC	$2.20	$2.52	$1.56	$2.75
SHRIMP SHELL-ON FRESH/DRIED/SALTED/BRINE	$6.17	$5.07	$4.67	$4.72

A more detailed examination of domestic prices in South Carolina indicates that since 2002 price per pound has decreased for all domestic shrimp count sizes by at least 28% (Table 5.2.1-50).

Table 5.2.1-50. Average price (per pound) of shrimp by count size for South Carolina (Source: SCDNR, 2008).

	Size category (count per pound)										
Year	**21**	**31**	**21**	**51**	**21**	**61**	**21**	**71**	**21**	**81**	**21**
2002	4.37	2002	4.37	2002	4.37	2002	4.37	2002	4.37	2002	4.37
2003	4.54	2003	4.54	2003	4.54	2003	4.54	2003	4.54	2003	4.54
2004	2.79	2004	2.79	2004	2.79	2004	2.79	2004	2.79	2004	2.79
2005	2.71	2005	2.71	2005	2.71	2005	2.71	2005	2.71	2005	2.71
2006	2.51	2006	2.51	2006	2.51	2006	2.51	2006	2.51	2006	2.51
2007	3.31	2007	3.31	2007	3.31	2007	3.31	2007	3.31	2007	3.31

A study conducted in 1988 examined the economic consequences of shrimp imports to shrimp harvesters in the South Atlantic and Gulf of Mexico (Keithly et al. 1989). Results of this econometric model demonstrated that farm raised shrimp elevated U.S. import levels by about 175 million pounds. At that time (1989) 563 million pounds of shrimp were imported. This model also indicated that import prices and domestic dockside prices would have been about 70% higher in the short run in the absence of imports of farm-raised shrimp. The authors suggested, however, that any rise in domestic warm water ex-vessel prices brought about by a reduction in U.S. shrimp imports would encourage additional effort in the domestic shrimp fleet and this would dissipate initial gains in profits as well as increase total harvest costs for the industry. Ward (1992) found that there was an asymmetrical response between change in vessel profits and entry/exit behavior in the Gulf of Mexico shrimp fishery. There is a higher probability that vessels will enter the fishery if profits increase while for the same magnitude in decreased profits fewer vessels will exit the industry.

Another econometric study directly evaluated the impact of shrimp imports on prices to South Atlantic shrimpers (Houston and Nieto 1988). Results suggest that shrimp imports have a different effect on regional markets. There was a significantly greater impact on South Atlantic shrimp prices, than on Gulf of Mexico, West Coast or New England markets. Although the authors concluded that restricting imports of shrimp would increase dockside prices in the short run, the merits of that action are debatable because new entrants would be expected to dissipate any economic rents derived from the fishery in the long run.

From the point of view of shrimp fishermen, imports decrease benefits by depressing dockside prices as demonstrated by Keithly et al. (1989). However, imports increase the aggregate U.S. supply of shrimp leading to lower retail prices for consumers (Anderson 1986). Thus, consumers in this country clearly benefit from imports although there are also balance of trade considerations with imports, which affect the buying power of U.S. consumers in the long run. Import restrictions would probably raise both dockside and retail prices and increased retail prices would decrease benefits to consumers. In addition, import restrictions would also impact U.S. wholesalers and retailers who currently depend on imports for a substantial portion of their sales volume.

Profile of the shrimp fishery in the South Atlantic states

Information from previous amendment documents and more recent databases showed that the contribution of each species to total landings varies in a relatively consistent pattern among the four southeastern states. In North Carolina, brown shrimp dominates total harvest, and generates more than 60% of overall revenue. In contrast to other South Atlantic states, white shrimp makes up a smaller component of the overall catch. In some years, pink shrimp catches in North Carolina can exceed 500,000 pounds (Table 5.2.1-51).

In South Carolina and Georgia, there are virtually no pink shrimp in the landings which are dominated by white shrimp. In 2002, white shrimp accounted for nearly 80% of the revenue from all shrimp species in Georgia and nearly 75% of the revenue from all species in South Carolina (Table 5.2.1-52, Table 5.2.1-53). The relative contribution of brown shrimp to the catch varies yearly, but rarely exceeds the catch of white shrimp. Nevertheless, this species is somewhat important to the shrimp industry in these two states. Most of the pink shrimp harvest on the east coast of Florida comes from the offshore areas around the Dry Tortugas and the Florida Keys. In northeast Florida, some pink shrimp enter the catch primarily as a bycatch of the rock shrimp fishery. Overall shrimp revenue in Florida's South Atlantic fishery is not dominated by the harvest and sale of any one species (Table 5.2.1-54). White shrimp is probably the most important species in terms of overall revenue in the northeast Florida shrimp fishery (SAFMC 1993). In some years, rock shrimp accounted for the dominant share of ex-vessel value (Table 5.2.1-54).

Table 5.2.1-51. Ex-vessel value of shrimp landings in North Carolina by species (Source: NCDMF, 2008).

Species	1999	2000	2001	2002
Brown	$4,323,442	$16,000,250	$8.830,577	$10,905,493
Pink	$11,294	$383,245	$449,929	$1,503,822
White	$9,812,191	$8,066,365	$1,976,927	$4,894,187
Other	$7,590,023	$956,056	$653,514	$1,061,263
Total	$21,737,061	$25,405,916	$11,911,070	$18,364,776

Species	2003	2004	2005	2006	2007
Brown	$8,210,280	$5,301,307	$2,559,206	$3,331,938	$4,896,325
Pink	$459,906	$308,718	$99,351	$135,004	$148,452
White	$2,211,871	$3,695,206	$1,722,220	$5,569,978	$12,873,802
Other	$57,021	$157,620	$28,346	$104,515	$16,904
Total	$10,939,078	$9,462,853	$4,409,124	$9,141,435	$17,935,483

Table 5.2.1-52. Ex-vessel value of shrimp landed in South Carolina by species.

Species	1999	2000	2001	2002
Brown	$3,070,695	$3,063,183	$3,928,255	$2,253,873
White	$15,270,512	$12,429,765	$4,746,388	$6,723,195
Other	$227,049	$179,767	$190,510	$85,282
Total	$18,568,256	$15,672,714	$8,865,152	$9,062,350

Table 5.2.1-53. Ex-vessel value of shrimp landings in Georgia by species.

Species	1999	2000	2001	2002
Brown	$2,432,979	$2,116,366	$3,323,971	$1,668,970
White	$15,706,844	$14,954,395	$6,690,629	$9,257,364
Other	$890,785	$700,191	$748,235	$745,235
Total	$19,030,608	$17,770,952	$10,762,834	$11,671,569

Species	2003	2004	2005	2006	2007
Brown	$1,898,250	$845873.98	$2,449,458	$289,936	$732,862
White	$74,156			$62,726	$12,499
Rock	$7,843,501	$9,177,696	$6,090,328	$6,737,155	$5,104,650
Grand Total	$9,815,906	$10,023,57	$8,539,787	$7,089,816	$5,850,010

Table 5.2.1-54. Ex-vessel value of shrimp harvested in Florida by species.

Species	1999	2000	2001	2002
Brown	$3,735,373	$2,256,383	$3,537,742	$2,074,932
Pink	$11,861,145	$12,177,794	$11,468,843	$10,523,606
White	$11,947,840	$8,695,483	$6,927,633	$7,419,840
Other	$9,128,031	$15,098,190	$9,552,743	$3,670,227
Total	$36,672,390	$38,227,850	$31,486,961	$23,688,605

Data presented in previous amendments indicated that in North Carolina almost all of the shrimp catch comes from internal waters. In South Carolina, it was estimated that about 5 to 10% of the shrimp catch is taken in the EEZ. In Georgia, because of extensive nearshore shoaling, significant effort is expended beyond three miles, and a higher percentage of the catch was reportedly taken from the EEZ (SAFMC 1996b). In Florida, it was estimated that 12 to 15% of the non-rock shrimp catch came from the EEZ. The more recent data used in Amendment 6 to the Shrimp FMP confirms that a substantial quantity of the shrimp harvest is taken in state waters. An average of 20% of the shrimp catch in the South Atlantic was recorded as harvested within Federal waters. This may not represent the total harvest taken from Federal waters. Tows on a single shrimp trip could traverse several locations or statistical reporting areas yet only one location is reported for each trip on the data reporting form. Thus, harvest from several locations could be attributed to one area especially in the case of multi-day trips.

In terms of the ex-vessel revenue generated, the states of North Carolina and Florida are more important to the South Atlantic shrimp industry (Table 5.2.1-51, Table 5.2.1-54). The revenue generated by the shrimp industry in Georgia and South Carolina is fairly comparable. It must be noted that the sum of landings and value in these four states will be less than the same statistics presented in Table 5.2.1-5 for the entire South Atlantic. This is due to the fact that the shrimp profile for the entire South Atlantic also includes statistics on shrimp caught in the South Atlantic and landed at Gulf of Mexico ports and shrimp landings in the Atlantic where the area caught or state landed was unknown.

The industry in all four states faced lower prices in 2001 and 2002 compared to previous years. For the three states where vessel level landings are available it appears that vessel identification information is not always reported or it is not possible to link landings to a particular vessel. Compliance with this reporting requirement in the states of Georgia and North Carolina appears to have improved over time. Of concern are the data from Florida. For 2002, it was not possible to identify the vessels that landed 1.31 million pounds of shrimp in Florida (Table 5.2.1-55).

There are two ways to represent shrimp catches on the east coast of Florida. The first table contains the data on shrimp harvested on the east coast of Florida some of which was landed at ports on the west coast of Florida (Table 5.2.1-55). The second table contains data on shrimp catches landed at east coast Florida ports (Table 5.2.1-56).

Table 5.2.1-55. Shrimp harvested from the east coast of Florida (South Atlantic): annual landings, ex-vessel revenue and effort.

Year	1997	1998	1999	2000	2001	2002
Landings (lb)	12,564,991	16,875,159	14,598,511	16,829,921	14,538,855	11,601,699
Ex-vessel revenue	$32,254,006	$37,605,629	$36,672,390	$38,227,850	$31,486,961	$23,688,605
Real revenue in $2002	$36,159,200	$41,507,317	$39,603,013	$39,945,507	$31,998,944	$23,688,605
Price/lb	$2.57	$2.23	$2.51	$2.27	$2.17	$2.04
Real price/lb $2002	$2.88	$2.46	$2.71	$2.37	$2.21	$2.04
Number of trips	15,169	15,782	14,750	13,276	11,745	11,771
Number of Dealers	176	156	153	155	145	144
Landings (lb) without information on vessel id	567,544	1,086,470	529,735	306,671	707,739	1,311,951
Number of Vessels	840	831	755	759	625	573
Vessel fishing exclusively in inshore areas				134	101	101

Includes harvest taken from area 0029 for all years.

Table 5.2.1-56. Shrimp landings on the east coast of Florida: annual landings, ex-vessel revenue and effort.

Year	1997	1998	1999	2000	2001	2002
Landings (lb)	6,271,129	6,898,796	8,148,395	10,894,135	10,413,789	6,176,387
Ex-vessel revenue	$14,032,122	$15,736,525	$20,712,380	$23,054,217	$20,198,256	$13,180,214
Real revenue in $2002	$15,731,078	$17,369,233	$22,367,581	$24,090,091	$20,526,683	$13,180,214
Price/lb	$2.24	$2.28	$2.54	$2.12	$1.94	$2.13
Real price/lb $2002	$2.51	$2.52	$2.74	$2.22	$1.97	$2.13

The value of all seafood landed on the east coast of Florida amounted to $48.14 million in 2001 and $38.9 million in 2002 (NOAA Fisheries 2003b). The average dockside value of shrimp landings in those years amounted to $16.69 million (using data presented in Table 5.2.1-15). Therefore, east coast shrimp landings comprised an average of 38% of the value of seafood sold at the dock in the past two years. In comparison, for South Carolina the total ex-vessel value of commercial landings was $23.9 million and $20.8 million dollars in 2001 and 2002 respectively (NOAA Fisheries 2003b). Shrimp comprised an average of 40% of the total value for those two years. Shrimp harvests comprised an average of 75% of the total ex-vessel revenue of landings in Georgia during the years 2001 and 2002. Reported commercial landings for the state of Georgia were $14.8 million and $15.1 million in 2001 and 2002 respectively (NOAA Fisheries 2003b).

In contrast, North Carolina's shrimp harvesting sector is relatively less important to the entire commercial industry in this state.

The ex-vessel value of shrimp comprised 16% of the average overall value of commercial landings in 2001 and 2002 ($94.6 million) (NOAA Fisheries 2003b).

In North Carolina, brown shrimp and white shrimp landings were lower than normal in 2001 (Table 5.2.1-57). This 5.1 million pound decline coupled with lower prices decreased overall shrimp revenue by $13.5 million compared to 2000. Revenue and landings increased in 2002. However, average prices decreased in 2002 even though the supply increased by 4.7 million pounds over the harvest in 2001 (Table 5.2.1-57).

Table 5.2.1-57. Shrimp landings in North Carolina: annual landings, ex-vessel revenue and effort (Source: NCDMF, 2008).

Year	1997	1998	1999	2000	2001	2002
Landings (lb)	6,988,826	4,636,343	9,004,430	10,334,916	5,254,214	9,954,785
Ex-vessel revenue	$18,203,357	$10,858,874	$21,746,596	$25,400,172	$11,908,561	$18,337,677
Real revenue in $2002	$20,407,351	$11,985,512	$23,484,445	$26,541,455	$12,102,196	$18,337,677
Price/lb	$2.60	$2.34	$2.42	$2.46	$2.27	$1.84
Real price/lb $2002	$2.91	$2.58	$2.61	$2.57	$2.31	$1.84
Number of trips	18,974	14,130	19,179	18,474	14,084	18,394
Number of dealers	248	234	272	254	225	283
Landings without information on vessel id			2,407,572	6,649	5,009	2,166
Number of vessels				773	595	585
Vessels fishing in inshore areas				465	337	322

Year	2003	2004	2005	2006	2007
Landings (lb)	6,167,371	4,880,817	2,357,516	5,736,649	9,551,135
Ex-vessel revenue	$10,939,078	$9,462,853	$4,409,124	$9,141,435	$17,935,483
Real revenue in $2002					
Price/lb					
Real price/lb $2002					
Number of trips	14,512	12,415	6866	8385	
Number of dealers					
Landings without information on vessel id					
Number of vessels					
Vessels fishing in inshore areas					

North Carolina and Florida have the largest fleets in the South Atlantic shrimp harvesting sector. Vessels in these states' shrimp fishery tend to be more diverse. Many vessels participate in other non-shrimp fisheries, and shrimp species comprise a smaller proportion of their overall revenue base compared to vessel firms in other states. Also, many of the restrictions that apply to shrimp trawling in inshore areas of other states do not exist in North Carolina. This provides more opportunities for smaller vessels to participate in the North Carolina shrimp fishery. As a result of these differences in operations, catch per vessel may not be directly comparable across all states.

The decrease in shrimp landings in South Carolina and Georgia during 2002 and 2001 is reflective of a reduction in white shrimp harvest in both states (Table 5.2.1-58., Table 5.2.1-59). In North Carolina, average ex-vessel prices were lower in 2002 and 2001 even though supply declined. In the Georgia fishery, there has been a steady decline in number of trips from 1997 through 2001. In contrast, the number of trips harvesting shrimp fluctuated during this time period with no distinct trend for North Carolina (Table 5.2.1-16).

It was not possible to determine the actual number of vessels that operated in the South Carolina shrimp fishery since this state recently implemented a trip ticket program in 2003. The number of trawler licenses sold may not equate to the number of vessels participating in this fishery as some vessel owners may purchase a license in a given year but not go shrimping. However, the marked decrease in license sales indicates a reduced demand for shrimp fishing in 2001 and 2002 (Table 5.2.1-58).

It would be misleading to interpret the observed trend of increased vessel participation with actual changes in fleet size in the Georgia fishery because there is a large portion of shrimp landings not associated with any vessel in years prior to 2002. Compliance with the vessel identification reporting requirement improved substantially in 2002 compared to previous years. Other data from commercial shrimp license sales may provide a better indicator of participation trends in the Georgia shrimp fishery. License sales data for fiscal year 1998/99 through 2003/04 are 496, 467, 469, 484, 407 and 362 respectively. There is a noticeable decrease in license sales during the last two years compared to previous years. There may also have been a shift in the composition of the fleet during this period as the number of Coast Guard registered vessels has consistently declined throughout the entire time period while the number of state registered boats actually increased in fiscal years 2000/01 and 2001/02, before dropping sharply in 2002/03 (Travis, NOAA Fisheries, pers. comm. 2004).

Table 5.2.1-58. Shrimp landings in South Carolina: annual landings, ex-vessel revenue and effort.

Year	1997	1998	1999	2000	2001	2002
Landings (lb)	6,904,351	6,402,768	8,062,014	6,112,047	4,497,780	5,238,237
Ex-vessel revenue	$19,288,432	$15,641,722	$18,568,256	$15,672,714	$8,865,152	$9,062,350
Real revenue in $2002	$21,623,803	$17,264,594	$20,052,112	$16,376,922	$9,009,301	$9,062,350
Price/lb	$2.79	$2.44	$2.30	$2.56	$1.97	$1.73
Real price/lb $2002	$3.13	$2.69	$2.48	$2.68	$2.00	$1.73
Number of dealers	104	89	93	82	93	94
Number of trawler vessel licenses**	887	922	884	915	693	720

**These data are available by fiscal year and not calendar year.

Table 5.2.1-59. Shrimp landings in Georgia: annual landings, ex-vessel revenue and effort.

	1997	1998	1999	2000	2001	2002
Landings (lb)	7,301,864	6,996,499	7,013,620	5,629,096	4,379,989	5,412,940
Ex-vessel revenue	$22,933,018	$19,714,697	$19,030,608	$17,770,952	$10,762,834	$11,671,569
Real revenue in $2002	$25,709,661	$21,760,151	$20,551,413	$18,569,438	$10,937,839	$11,671,569
Price/lb	$3.14	$2.82	$2.71	$3.16	$2.46	$2.16
Real price/lb $2002	$3.52	$3.11	$2.93	$3.30	$2.50	$2.16
Number of trips	12,845	11,460	10,418	8,620	5,696	7,387
Number of dealers	78	66	77	89	74	136
Landings without information on vessel id						
Number of vessels**	287	312	280	268	289	340
Vessel that only operate in the inshore areas					30	65

** These data are somewhat misleading since there was a fair amount of landings reported without corresponding vessel identification information. Reporting compliance increased over time. Note: License sales data for fiscal year 1998/99 through 2003/04 are 496, 467, 469, 484, 407 and 362 respectively.

	2003	2004	2005	2006	2007
Pounds (tails)	3,519,644	3,223,113	2,882,969	2,457,065	1,737,326
Ex-vessel value	$9,815,906	$10,023,570	$8,539,787	$7,089,816	$5,850,010
Price/lb	$2.78	$3.10	$2.96	$2.88	$3.37
Trips	6,947	5,315	4,945	4,235	3,436
Dealers	100	66	56	58	62
Vessels	283	209	190	161	153
Inshore only	51	25	23	34	37

In 2001 the State of Georgia began requiring all commercial castnet shrimpers to report as dealers. Castnet shrimpers often sell directly to the consumer and/or split their catch between several small markets. By requiring all castnetters to report as dealers, Georgia is able to collect more reliable trip level data. The marked increase in shrimp dealers in 2002 can be attributed to two factors: more castnetters selling their catch rather than keeping it for personal consumption; and more shrimp trawl owners marketing their own catch rather than selling to a shrimp packing house. For reporting purposes, those vessel owners are considered dealers. In the past, it was very unusual for vessel owners to market their entire catch directly to final consumers and retail outlets. With shrimp prices at an all-time low, vessel owners are employing non-traditional marketing methods in an attempt to command higher prices than the packing house can offer. Thus, there has not been an actual increase in the number of shrimp docks in Georgia but there was an increased number of individuals acting as dealers. For the other states there is a definite increase in the number of dealers in 2002 compared to 2000.

Seafood dealer operations are usually diverse in that they depend on more than one type of seafood product. For example, dealers in the shrimp industry may also handle clams, oysters and finfish. The relative health of these separate seafood markets would determine the financial viability of dealer operations or fish houses. Some dealers and vessel owners may also operate processing facilities where there is considerable value added to the final shrimp product.

The declining trend in prices and ex-vessel revenue in the shrimp harvesting sector, observed across all states, could play a major role in the financial solvency of dealers and fish houses that depend on shrimp. These businesses would be especially vulnerable if they are not able to transition to alternative sources of revenue from other fisheries.

Reduced revenues in the shrimp harvesting sector would also result in reduced economic activity to the sectors of the economy that are directly and indirectly associated with the shrimp industry in the South Atlantic. If vessels respond to lower revenues by reducing input costs, there would be negative effects on the sectors that supply inputs such as fuel and gear. If there is a reduction in the number of vessels, there would be further direct economic losses to impacted industries since annual and fixed expenditures would not be incurred. Apart from the direct effects there will also be indirect and induced effects on other sectors of the economy (the multiplier effect) which could have far reaching implications in the short-term. Assuming the economy is operating at full employment, economists theorize that these economic losses are distributional, and unlike net revenue to commercial fishermen there is no resulting changes in national GDP (gross domestic product). It is assumed that these monetary resources would be redirected to purchases that increase economic activity in other industries/sectors. The economy will adjust to these changes in the long run but there could be sectoral and regional shifts in the number of jobs, wages and business revenue.

Recreational fishery

Data on the number of recreational shrimp fishermen and recreational shrimp catches are not routinely collected throughout the South Atlantic region. Recreational licenses are only required for certain gear types and licensing requirements are not consistent across all states making it somewhat difficult to estimate total participation. However, there have been a number of ad hoc studies conducted to provide estimates of catch, participation and effort information on these recreational fisheries. Some of these studies are dated and estimates of catch and participation may not reflect current activity levels or recreational harvest of penaeid shrimp.

In South Carolina, sales for shrimp baiting permits increased from 5,509 in 1988 to a record high of 17,497 in 1998. After 1998, there was a decline in permit sales (Table 5.2.1-60). South Carolina conducts a post-season annual survey of these license holders to collect information on participation, effort and catches. Recreational shrimp harvests have fluctuated over time but ranged from a low of 0.91 million pounds in 2000 (an unusually poor year) to a high of 3.63 million pounds in 1997. In certain years, the recreational harvest by shrimp baiters comprised a large proportion of the total fall shrimp harvest (Table 5.2.1-60). The estimates from this survey does not represent the total recreational shrimp catch in South Carolina since landings of all shrimp species caught by recreational shrimpers using other gear are not recorded.

Table 5.2.1-60. Summary of results from the annual shrimp baiting surveys in South Carolina (Low 2002, SCDNR 2008).

Year	Permits issued	Participants	Trips	Pounds (heads on) million	Pounds/ participants
1987		21,735	40,101	1.80	83
1988	5,509	17,749	35,609	1.16	65
1989	6,644	17,171	31,624	1.25	73
1990	9,703	34,662	71,153	2.75	79
1991	12,005	34,821	71,034	2.14	61
1992	11,571	31,812	62,459	2.35	74
1993	12,984	40,620	80,709	2.72	67
1994	13,366	38,081	70,429	1.91	50
1995	13,919	41,971	81,632	3.40	81
1996	14,156	38,932	68,927	1.73	44
1997	15,488	48,544	94,154	3.63	75
1998	17,497	50,436	92,484	2.91	58
1999	15,895	39,514	66,396	2.02	51
2000	15,929	38,622	61,445	0.91	24
2001	13,698	38,699	69,847	2.09	54
2002	13,901	32,038	54,610	1.11	35
2003	12,465	28,028	58,530	1.87	67
2004	10,617	19,668	39,893	0.99	50
2005	9,004	20,753	31,238	1.09	52
2006	10,091	21,268	29,268	0.91	43
2007	9,488	N/A	N/A	N/A	N/A

It has been speculated that shrimp baiting could reduce the catches of commercial shrimp trawlers in South Carolina in the fall season (Henry et al. 2001). In fact, the findings from this cost and earnings study indicated that commercial shrimp vessels in the larger size categories could exit the industry if the harvest declined. This would reduce economic benefits in the commercial harvesting sector. However, recreational shrimp baiting also generates economic activity within the State of South Carolina from expenditures on travel, fuel, poles, bait and other items to participate in this sport.

From a survey conducted in North Carolina it was estimated that recreational shrimpers caught 91,000 pounds of shrimp, or less than 3% of the reported commercial catch in 1979 (Maiolo and Faison 1980). A more recent survey of recreational/commercial gear license holders conducted by the North Carolina Division of Marine Fisheries during 2002 estimated that this group made 5,035 trips. Shrimp accounted for 101,154 pounds of the 118,468 pounds captured by the use of shrimp trawls. Blue crab and flounders were the only other species contributing greater than 1,000 pounds to the overall shrimp trawl harvest (NCDNR 2003). A combined telephone/intercept access survey was carried out in coastal Georgia during 1989 to estimate recreational shrimp catch and effort. Total cast netting participation was estimated at 47,723 and 23,298 individuals during the summer and fall waves respectively. These cast netters were estimated to have taken 184,887 total trips and to have caught 576,000 pounds of shrimp, most of which were white shrimp (Williams 1990). There are no estimates of recreational shrimp catches for Florida, but it is believed that the recreational catch is substantial.

5.2.1.3 Social and cultural environment

Introduction

This Section identifies "shrimp" communities throughout the U.S. Southeast and focuses on recent data regarding shrimp fishing, shrimp fishermen, and ultimately the potentially impacted communities themselves. These "shrimp" communities were identified based on factors such as commercial licenses held by local residents, the number of shrimp "dealers" in such communities as the value of the shrimp landed. Information for many of the South Atlantic community descriptions were referenced from the report, *Potential Fishing Communities in the Carolinas, Georgia and Florida: An effort in baseline profiling and mapping* by Jepson *et al.* (2006). Demographic data came from the U.S. Census Bureau Decennial census. Other fishery dependent data were derived from the Accumulated Landings System (ALS) database and licensing information from the NMFS Regional Office. Each state is addressed and communities are selected based on data from the Southeast Regional Office which highlight the number of licensed shrimp fishermen most likely impacted by potential policy changes. Communities from the Gulf were also included as many Gulf shrimpers and dealers from the region are also impacted by participation in the South Atlantic shrimp fisheries (the community descriptions are based on reports created by Impact Assessment Inc.). The potentially impacted communities are discussed on a state by state basis with individual communities listed in alphabetical order, no way reflecting on the relative importance of shrimp to the region, state or local economy.

5.2.1.3.1 *North Carolina Shrimp Communities*

Beaufort Community Description

Beaufort was built on a former Native American village, called Warelock which translates to "fish town" or "fishing village." It is located near Cape Lookout and borders the southern portion of the Outer Banks. Because of its physical characteristics, especially the deep water harbor, it is an ideal home to vessels of all sizes and types and maintains a maritime infrastructure making it a favorite stop-over for transient boaters. Originally a fishing village and port of safety, it was known as "Fishtowne" until incorporated in 1722.[1] In addition to the fishing activities in Beaufort, a whaling community called Diamond City existed on Shackleford Banks, a barrier island six miles to the southeast by boat. This community was present during the eighteenth and nineteenth centuries. The export economy of the areas centered round lumber, barrel staves, rum, and molasses. However, when the port declined as a trade center, commercial fishing gained greater importance and became the primary economic activity. Up until recently, Beaufort served as home port for a large menhaden fishing fleet and had numerous processing facilities for menhaden products.[2]

Currently, tourism, service industries, retail businesses and construction are the important mainstays of the area, with many shops and restaurants catering to visitors from outside the area. Beaufort's population has slightly increased from 3,808 in 1990 to 4,216 in 2007

(Table 5.2.1-61). The community has some exclusive homes along the waterfront but overall most housing is modest. Even with modest housing Beaufort has seen its housing values more than double from $65,400 in 1990 to $128,500 in 2007 (Table 5.2.1-61). It is home to both the NOAA Center for Coastal Fisheries and Habitat Research and Duke Marine Sciences Center. Directly across the bridge from Morehead city is Radio Island, which is the commercial fishing hub for Beaufort. There are a few private boats along the waterfront in downtown Beaufort, but the commercial enterprises are predominantly located on Radio Island. The waterfront does have two tour/party boats, in addition to private boats, some of which may be smaller charter vessels. There are several marinas in the community and several businesses that provide support services for both the recreational and commercial fishing industries. According to one individual, Beaufort is a commercial fishing community, although less so now, than in the past. This seems to be largely due to fewer young people getting into the fishing business as it does not seem to pay well. This same individual has seven trawlers and four small snapper/grouper boats as part of his business. There are accounts that during summer months three longline vessels travel from New York and dock at his facility. The majority of fish purchased is marketed in Virginia and farther north. Shrimp is a large part of the local seafood industry, but, like everywhere else throughout the southeast region imports are having an impact on the domestic market lowering prices.

Fish houses and facilities are commonly full service in that they serve as a fish house, with processing, ice, fuel, as well as gear and net repair. Like many facilities related to the commercial fishing industry, the glory days of fishing have past them by and many owners have sold-out or relocated leaving in their wake developers who have come to take advantage of the prime coastal real estate. During research in 2002 it was noted that there existed an ice plant across the bridge from Beaufort which has now become a condominium development. The pressure to redevelop has even affected the last shad factory in the state, located on Front St. in Beaufort. Popular fisheries such as the shad fishery have been eliminated and as one remaining owner suggests shad built the fishing industry in Beaufort. While there are efforts or forces to put it out of out of business due to the property valuable, he will hold on until it is time to retire. Asked if he would like his family to continue on the business when he retires, he said no, and that there was little future anymore in this type of fishing.

In 2002 fishermen estimated that on Radio Island there were 20 trawlers that docked there permanently. Another local fisherman said that his fish house used to process year round, but now only operates seven months of the year due to various seasonal closures. This has forced employment levels to change, as for one fish house owner who used to employ four people year round, he now only needs to employ two. It was in1987 that Beaufort had its best year for shrimp. This benefit was said to have a positive impact on the local communities as most the fishermen involved in the fishery live in Beaufort or Morehead City. There are three fish houses in Beaufort, one of which deals primarily in bait. In 1987 there were about 25 larger commercial vessels (70-90') in addition to a lot of smaller boats; now there are approximately 11 large commercial vessels in Beaufort.[3]

Shrimp has always been an important and valuable species in Beaufort, currently second to summer flounder (Figure 5.2.1-1). In 2006 Beaufort landed 630,885 pounds of shrimp valued at $914,602 (Table 5.2.1-62). There were only 10 federally permitted vessels in Beaufort in 2001and those vessels held primarily coastal pelagic permits (Jepson *et al.* 2006). Most of the employment that is fishing related according to census business pattern data is related to boat building with 184 persons employed in that business. Others are employed in fish processing and fish and seafood. There are over 400 commercial vessels registered with the state from Beaufort with almost 300 standard commercial fishing licenses. There are 172 shellfish licenses and 32 dealer license (Jepson *et al.* 2006).

Table 5.2.1-61. Beaufort, NC, demographic data from 1990-2006 (Source: U.S. Census) Bureau Decennial census).

Beaufort, NC	**1990**	**2000**	**2006**
Population	3,808	3,771	4,261
Median Education Attainment	Some college, no degree	Some College less than 1 yr.	
White	2,852	2,861	
Black or African American	908	754	
American Indian & Alaska Native	18	4	
Asian, Native Hawaiian & Other Pacific Islander	14	16	
Some Other Race	16	90	
Hispanic or Latino (or any race)	25	134	
Total Housing Units	2,085	2,187	
Vacant	364	407	
Median Gross Rent	$373	$502	
Median Housing Value	$65,400	$119,200	$128,500
Median Household Income	$21,532	$28,763	$28,300
Per Capita Income	$11,385	$19,356	
Unemployment %	4.80%	2.60%	
Employment by Industry (Top 5)			
Retail Trade	24.20%	15%	
Public Administration	12.70%	DO	
Education, health and social services	15.20%	13.20%	
Manufacturing, durable goods	7.80%	DO	
Other Professional & related services	DO	9.30%	
Construction	DO	10%	
Accommodation & food services, art, entertainment	DO	18%	
Manufacturing, nondurable goods	5.80%	DO	
Transportation	5.80%	DO	
DO= Dropped Out			

1 www.clis.com/beaufortnc
2 http://www.beaufort-nc.com/history/bn-his02.html
3 Interviews conducted by Ana Pitchon, May 2002

Table 5.2.1-62. Top five species by pounds caught in Beaufort, NC from 2006 data.

SPECIES	DEALERS	FISH RANK	POUNDS	TRIPS	VALUE
SUMMER FLOUNDER	7	1	992,888	146	$2,103,158
SHRIMP	18	2	630,885	1,228	$914,602
BLUE CRABS	7	3	297,597	624	$157,908
SWORDFISH	*	4	*	30	*
STRIPED MULLET	7	5	183,268	247	$104,226

* The number of dealers falls below the rule of three.

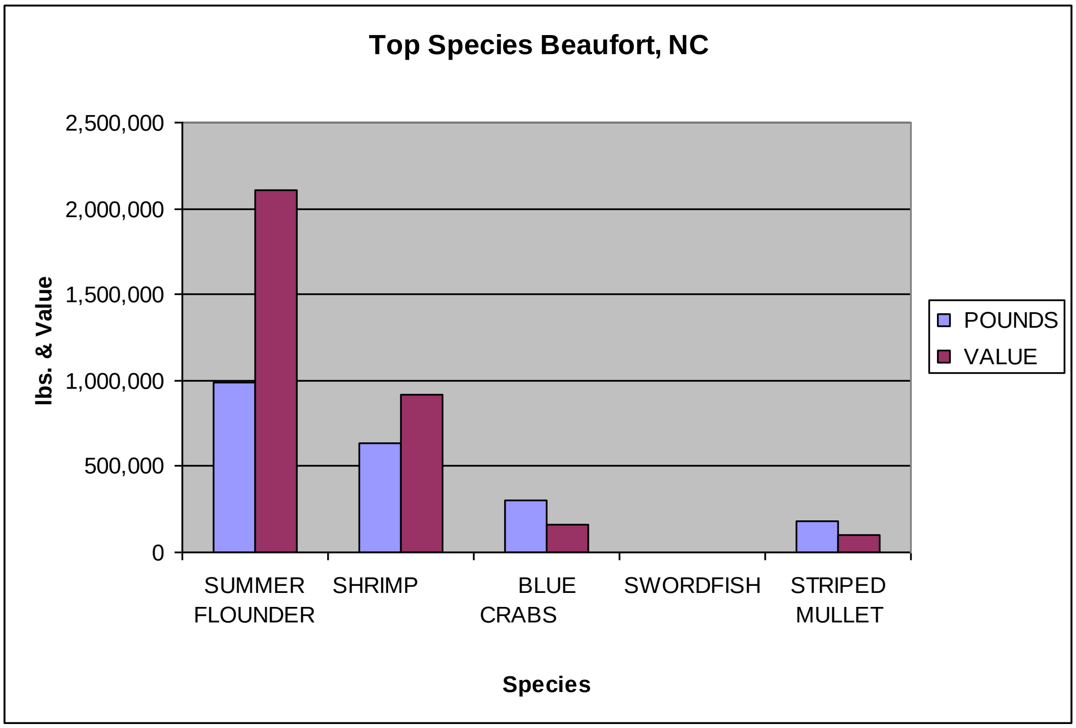


Figure 5.2.1-1. Value and pounds of top five species in Beaufort, NC for 2006.

Engelhard Community Description

Engelhard is located on the shore of Far Creek (Pamlico Sound) and is said to date as far back as 1650. It features a dredged channel that tailors to the many types of commercial fishing boats. The community is small (population), and described as having a laid back atmosphere. Its existence seems to depend equally on commercial fishing and agriculture.[4] Between 1990 and 2000 the community experienced a slight decrease in population and a decrease in unemployment (Table 5.2.1-63). Engelhard holds an annual Seafood Festival every May with this year, 2008, being the 21st year in existence.[5] The event is described as family oriented with a blessing of the fleet, live music, a pageant, and of course local food. One of the most popular local species is shrimp. In fact, shrimp is the second most valuable commercial species in Engelhard, just after summer flounder (Figure 5.2.1-2). In 2006 Engelhard brought in 862,740 pounds of shrimp, taken during 427 trips (Table 5.2.1-64).

[4] http://www.vergie.com/engelhard.html
[5] http://www.engelhardseafoodfestival.com

Table 5.2.1-63. Engelhard, NC, demographic data from 1990-2006. (Source U.S. Census Bureau Decennial census)

Engelhard/Lake Landing, NC	**1990**	**2000**
Population	2,027	1,852
Median Education Attainment	High School Graduate	High School Graduate
White	1,115	986
Black or African American	905	828
American Indian & Alaska Native	4	1
Asian, Native Hawaiian & Other Pacific Islander	1	3
Some Other Race	2	22
Hispanic or Latino (or any race)	4	62
Total Housing Units	956	1,018
Vacant	183	249
Median Gross Rent	$262	$387
Median Housing Value	$35,900	$64,000
Median Household Income	$16,949	$23,199
Per Capita Income	$8,844	$14,589
Unemployment %	6%	3%
Employment by Industry (Top 5)		
Fisheries, agriculture, forestry	**22%**	**11.50%**
Retail Trade	23.20%	DO
Construction	8.60%	13.20%
Education, health and social services	7.20%	15.30%
Public Administration	DO	11.10%
Finance, insurance, real estate	6.30%	DO
Manufacturing, durable goods	DO	10.50%
DO= Dropped Out		

Table 5.2.1-64. Top five species by pounds caught in Engelhard, NC from 2006 data.

SPECIES	DEALERS	FISH RANK	POUNDS	TRIPS	VALUE
CROAKER	5	1	1,158,491	307	$413,123
BLUE CRABS	8	2	869,991	1,635	$452,866
SHRIMP	5	3	862,740	427	$1,520,196
SUMMER FLOUNDER	3	4	811,893	89	$1,721,099
SHARKS, DOGFISHES	*	5	*	52	*

* The number of dealers falls below the rule of three.

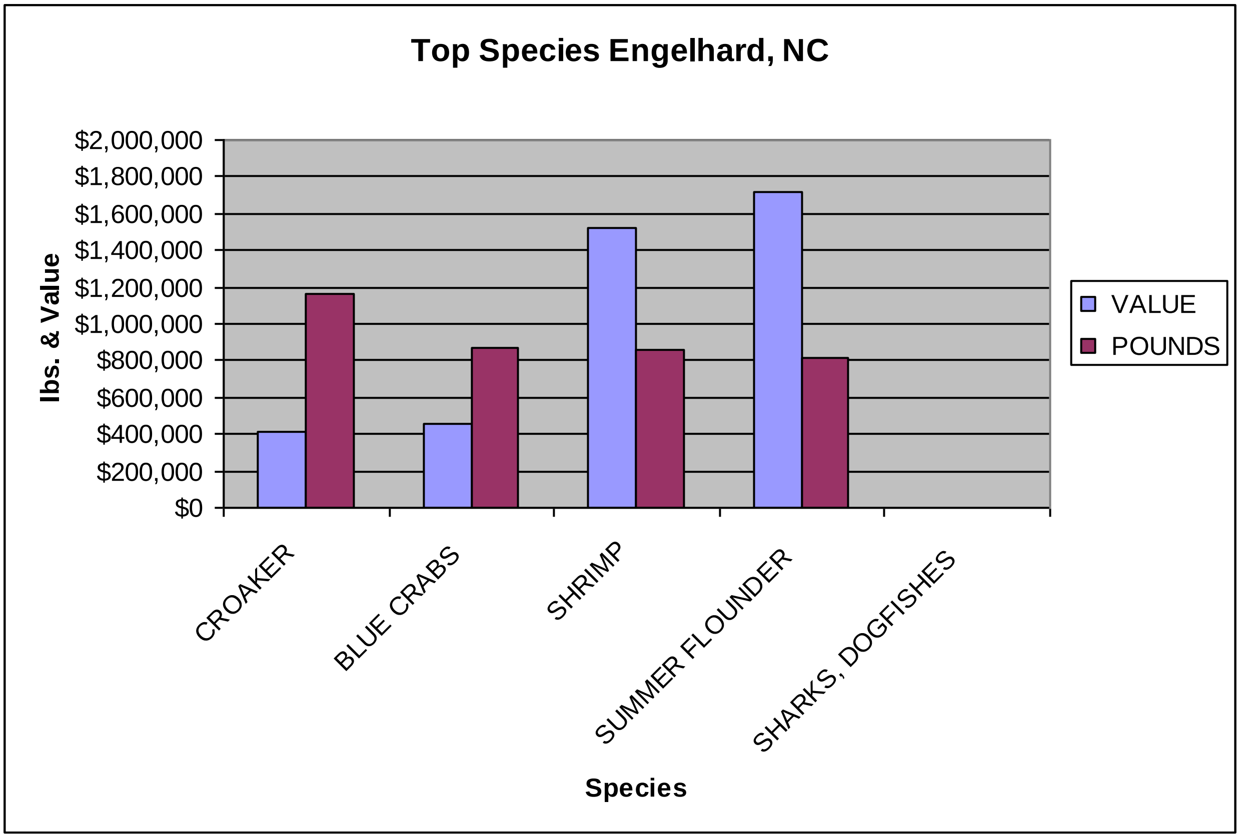


Figure 5.2.1-2. Value and pounds of top five species in Engelhard, NC for 2006.

<u>Swan Quarter Community Description</u>
Swan Quarter is located in Hyde County and is one of the oldest counties in North Carolina. Swan Quarter was settled by Samuel Swann in the 1700's near the head of Swan Bay, along the Pamlico Sound.[7]
Fishing, oystering, and crabbing have long been the principal occupations of Swan Quarter citizens. This salty duty is supplemented by farming the rich land surrounding the town. Today, the village sees many more visitors than in times past. Tourists pass through on their way to and from the Ocracoke-Swan Quarter ferry, located nearby. The increased traffic doesn't seem to have changed the town much, however.[8] Swan's Quarter has seen a steady population with a large increase in unemployment from 2.30% in 1990 to 5.30% in 2000 (Table 5.2.1-65).

Shrimp in Swan Quarter is second in value and pounds landed to blue crabs (Figure 5.2.1-3). Swan Quarter fishermen landed 346,887 pounds of shrimp valued at $613,910 (Table 5.2.1-66).

[7]Lemme, Ingrid and Dominic Piosczyk-Lemme. Town of Swan Quarter, NC. Retrieved from http://www.swanquarter.net/history.asp.

[8]http://www.albemarle-nc.com/hyde/CGNC/

Table 5.2.1-65. Swan Quarter, NC demographic data from 1990-2006 (Source: U.S. Census Bureau Decennial census.)

Swan Quarter, NC	**1990**	**2000**
Population	985	958
Median Education Attainment	High School Graduate	High school graduate
White	594	592
Black or African American	385	337
American Indian & Alaska Native	0	2
Asian, Native Hawaiian & Other Pacific Islander	2	2
Some Other Race	4	5
Hispanic or Latino (or any race)	11	20
Total Housing Units	489	511
Vacant	120	143
Median Gross Rent	$234	$362
Median Housing Value	$39,100	$61,300
Median Household Income	$13,140	$31,136
Per Capita Income	$8,219	$12,776
Unemployment %	2.10%	5.30%
Employment by Industry (Top 5)		
Fisheries, agriculture, forestry	26.70%	16.50%
Finance, insurance, real estate	19%	8.40%
Public Administration	13%	35.80%
Other Professional & related services	8%	DO
Construction	7.60%	DO
Education, health and social services	DO	16%
Retail Trade	DO	6.90%
DO= Dropped Out		

Table 5.2.1-66. Top five species by pounds caught in Swan Quarter, NC from 2006 data.

SPECIES	DEALERS	FISH RANK	POUNDS	TRIPS	VALUE
BLUE CRABS	3	1	1,131,113	2,647	$714,654
SHRIMP	5	2	346,887	236	$613,910
SHARKS, DOGFISHES	*	3	*	9	*
MENHADEN	*	4	*	38	*
OYSTERS	4	5	72,706	1,331	$362,736

* The number of dealers falls below the rule of three.

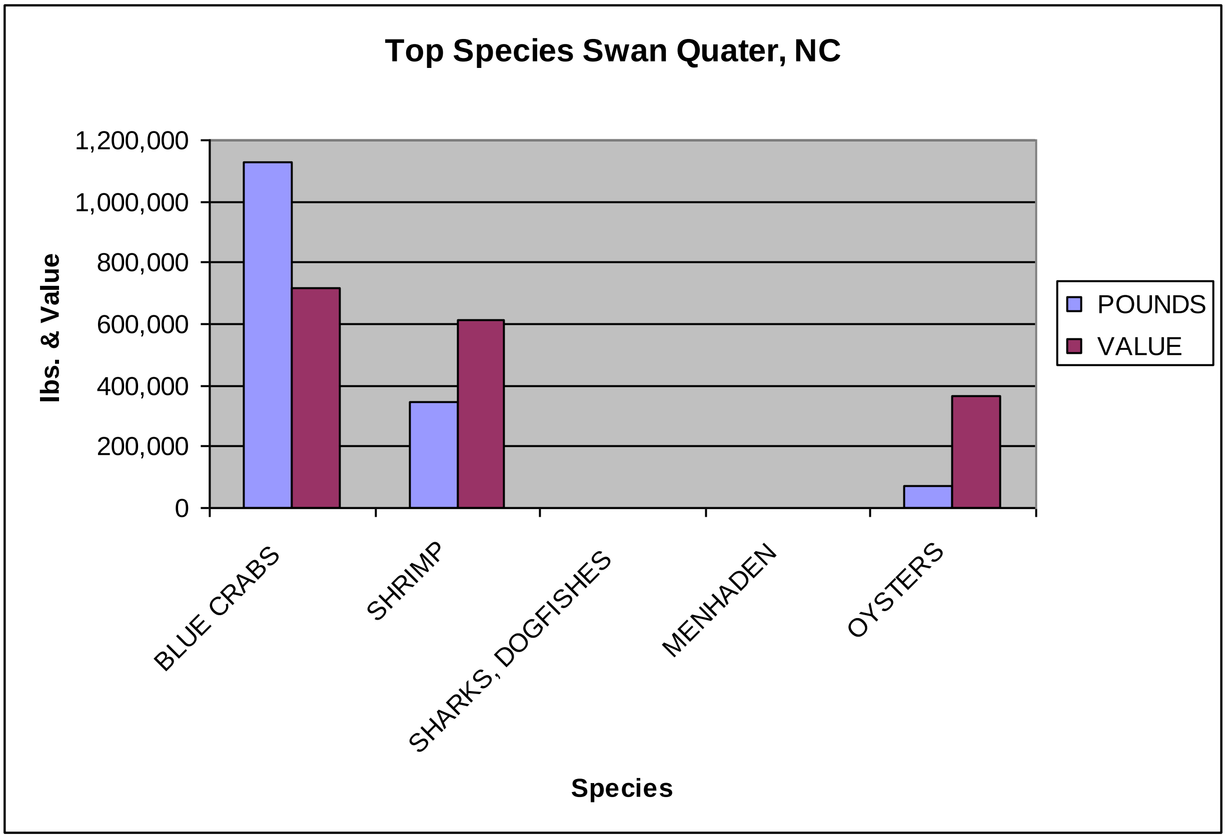


Figure 5.2.1-3. Value and pounds of top five species in Swan Quarter, NC for 2006.

5.2.1.3.2 *South Carolina Community Descriptions*

McClellanville Community Description

The population of McClellanville dropped in the 1990 census but has since increased again in the 2000 census to 459 and is currently at 741 (Table 5.2.1-67). The median household income has almost doubled from 1990 to 2006 while the median housing value has increased from $78,600 in 1990 to $225,700 in 2006 (Table 5.2.1-67).

There are 4 vessels with federal permits homeported in McClellanville and all four have rock shrimp permits (Jepson *et al.* 2006). All employment in fishing related business is in fish and seafood and the percent employed through fishing has increased from 12.6% in 1990 to 18%in 2000 (Table 5.2.1-67). There are 133 state permits in McClellanville, with 52 of those being saltwater licenses. There are 27 trawler licenses, 16 handheld equipment licenses and 5 wholesale dealer licenses.

Table 5.2.1-67. McClellanville, SC, demographic data from 1990-2006. (Source: U.S. Census Bureau Decennial census).

McClellanville,SC	**1990**	**2000**	**2006**
Population	333	459	471
Median Education Attainment	Some College, no degree	Some college, 1 or more years, no degree	
White	300	425	
Black or African American	33	34	
American Indian & Alaska Native	0	0	
Asian, Native Hawaiian & Other Pacific Islander	0	0	
Some Other Race	0	0	
Hispanic or Latino (or any race)	0	10	
Total Housing Units	198	241	
Vacant	67	46	
Median Gross Rent	$396	$357	
Median Housing Value	$78,600	$147,200	$225,700
Median Household Income	$25,536	$42,500	$48,600
Per Capita Income	$10,447	$22,425	
Unemployment %	1.10%	0.50%	
Employment by Industry (Top 5)			
Educational, Health, social services	27%	15.40%	
Accommodation, food services, entertainment	7%	DO	
Construction	15.30%	13%	
Professional, scientific, mgmt, administrative, waste services	10.20%	DO	
Public Administration	7%	9.50%	
Fishing	**12.60%**	**18%**	
Retail Trade	DO	15.00%	
DO= Dropped Out			

Mt. Pleasant Community Description

The first inhabitants of the Mount Pleasant area were the Sewee Indians. The first English settlers arrived around 1680 under the leadership of Captain Florentia O' Sullivan. He had been granted 2,340 acres and each time a new family arrived, they were allotted several hundred acres. The first small settlement of the area was the village of Greenwich, which was adjacent to Jacob Motte's "Mount Pleasant" estate. Motte's estate was purchased in 1803 and divided into 35 large lots. In 1837, the village of Greenwich was merged with Mount Pleasant. Many of the families in this area had timber concerns and some maintained the ferries. Mount Pleasant also played a leading role in the first major military engagement of the Revolutionary War in 1775. After the war, the area was known as a resort town with many stores and rentals available. The area is still widely known as a vacation area and "model town" in South Carolina.[10] Mount Pleasant has seen its population double every ten years from 1970 to 1990 and reached 59,113 in 2006. The number of persons in the labor force has dropped slightly to 69.9 percent while percent unemployed has increased from 1.5% in 2000 to 3.3% in 2006. Average wage and salary has risen substantially but so has the number of persons living below the poverty level.

While there are only 6 vessels with federal permits homeported in Mount Pleasant, there are 12 persons listed as fishing and 28 persons employed in fish and seafood and markets (Jepson *et al.*2006). There are 170 state permits in Mt. Pleasant with 57 saltwater licenses. There were 23 trawler licenses and 11 wholesale dealer licenses.

[10] www.townofmountpleasant.com/index.cfm?section=11&page=5

Table 5.2.1-68. Mt. Pleasant, SC demographic data from 1990-2006 (Source: U.S. Census Bureau Decennial census).

Mt. Pleasant, SC	**1990**	**2000**	**2006**
Population	30,108	47,609	59,113
Median Education Attainment	Some College, no degree	Bachelor's degree	
White	27,075	42,515	
Black or African American	2,766	3,445	
American Indian & Alaska Native	39	67	
Asian, Native Hawaiian & Other Pacific Islander	190	561	
Some Other Race	38	386	
Hispanic or Latino (or any race)	279	635	
Total Housing Units	12,443	20,129	
Vacant	655	1,223	
Median Gross Rent	$537	$838	
Median Housing Value	$96,900	$185,500	$284,400
Median Household Income	$38,605	$61,054	$69,800
Per Capita Income	$18,932	$30,823	
Unemployment %	1.50%	1.50%	3.30%
Employment by Industry (Top 5)			
Educational, Health, social services	24%	26%	
Accommodation, food services, entertainment	DO	10.10%	
Professional, scientific, mgmt, administrative, waste services	DO	11.60%	
Retail Trade	15.40%	11.20%	
Finance, insurance, real estate	8.60%	8.20%	
Construction	8.40%	DO	
Other Related Professional services	8%	DO	
DO= Dropped Out			

<u>Murrells Inlet Community Description</u>

Murrells Inlet is known as the Seafood Capital of South Carolina. The origin of its name remains a mystery, however Murrells Inlet was officially named by the post office in 1913. The first settlers of the area were Native American Tribes. It is stated that beginning in the 16th and 17th Centuries, Spanish and English colonists arrived in the area. The frequency of ships led to pirate activity and pirates were said to have utilized the Inlet's winding creeks for refuge and a hiding place. Historically, large tracts of land were cultivated into successful rice plantations. By 1850, almost 47 million pounds of rice were produced in this area. Murrells Inlet was used a port during the Civil War to sneak cotton and other products to England in exchange for war supplies, such as food and medicine. The Civil War led to the decline of the rice culture and in 1916, the last remaining commercial rice grower was out of business. By this time, commercial and recreational fishing became a popular industry. By 1914, captain-led fishing excursions cost $5 per person for a day trip out of the Inlet on a 20-foot skiff. Today, charter, recreational and commercial fishing are still popular in Murrells Inlet. Murrells Inlet has seen its population increase to a high of 5,519 in 2000. The percent of the population in the labor force has remained practically the same while unemployment has risen from 3 percent in 1990 to 5.2 percent in 2000 (Table5.2.1-69). The number of persons working in farm, fish and forestry occupations has seen a decline like most communities.

There are a total of 33 vessels with federal permits. The majority have king mackerel and snapper grouper class 1 permits. Almost half of those permitted vessels have charter permits for either coastal pelagics or snapper grouper (Jepson *et al.*2006). There are four federal dealers in the community. Most of the fishing employment is in fish and seafood markets with 10 persons employed in that sector out of the 16 total. There are 111 state permits issued to residents of Murrells Inlet. Forty-four of those permits are for saltwater licenses. Another 14 are for handheld equipment and 12 are for crab pots. There are 10 wholesale dealer licenses held by Murrells Inlet residents (Jepson *et al.*2006).

Table 5.2.1-69. Murrells Inlet, SC demographic data from 1990-2006 (Source: U.S. Census**)**
Bureau Decennial census).

Murrells Inlet, SC	**1990**	**2000**	**2006**
Population	3,334	5,519	
Median Education Attainment	High School Graduate	Some college, less than 1 year	
White	2,904	5,055	
Black or African American	419	393	
American Indian & Alaska Native	4	9	
Asian, Native Hawaiian & Other Pacific Islander	7	18	
Some Other Race	0	44	
Hispanic or Latino (or any race)	14	34	
Total Housing Units	1,843	3,182	
Vacant	421	592	
Median Gross Rent	$472	$689	
Median Housing Value	$95,600	$198,500	$162,800
Median Household Income	$25,422	$29,307	$33,100
Per Capita Income	$16,033	$28,197	
Unemployment %	3.20%	5.20%	
Employment by Industry (Top 5)			
Educational, Health, social services	DO	11%	
Accommodation, food services, entertainment	DO	16.70%	
Construction	10.20%	13%	
Retail Trade	28%	17.50%	
Finance, insurance, real estate	6%	8.80%	
Personal Services	12.70%	DO	
Business & Repair Services	10%	DO	
DO= Dropped Out			

Wadmalaw Island Community Description

Wadmalaw Island was landed upon by Captain Robert Sandford and the crew of the Berkeley Bay in mid-June of 1666 after an excursion up the Bohicket Creek.[12] Wadmalaw Island is located southwest of Johns Island and more than halfway encircled by it. To the north it is bordered by Church Creek; to the northeast and east by Bohicket Creek; to the south by the North Edisto River; and to the west by the Bohicket Creek. The island's only connection to the mainland is via a bridge over the Wadmalaw River. The island is about 10 miles long by 6 miles wide. It has a land area of 108.502 km² (41.893 sq mi).[11]

[11] Zepke, Terrance. 2006. Coastal South Carolina. Pineapple Press Inc. Publishing. p.157.
[12] http://en.wikipedia.org/wiki/Wadmalaw_Island_South_Carolina

Wadmalaw Island has seen a decrease in unemployment from 5.90% in 1990 to 3% in 2000 (Table 5.2.1-70).

Table 5.2.1-70. Wadmalaw Island, SC demographic data from 1990-2006 (Source: U.S. Census**)**
Bureau Decennial census).

Wadmalaw Island, SC	**1990**	**2000**	**2006**
Population	2,570	2,611	
Median Education Attainment	High School Graduate	High school graduate	
White	754	985	
Black or African American	1,788	1,589	
American Indian & Alaska Native	2	7	
Asian, Native Hawaiian & Other Pacific Islander	0	2	
Some Other Race	26	28	
Hispanic or Latino (or any race)	58	108	
Total Housing Units	896	1,063	
Vacant	112	114	
Median Gross Rent	$294	$595	
Median Housing Value	$57,800	$92,100	$141,200
Median Household Income	$26,434	$31,653	$36,200
Per Capita Income	$9,532	$18,989	
Unemployment %	5.90%	3%	
Employment by Industry (Top 5)			
Educational, Health, social services	22%	22%	
Accommodation, food services, entertainment	DO	10.40%	
Construction	11.40%	10.30%	
Professional, scientific, mgmt, administrative, waste services	DO	10.30%	
Retail Trade	11.10%	12.50%	
Fishing	**12.60%**	**DO**	
Transportation	6.50%	DO	
DO= Dropped Out			

5.2.1.3.3 Georgia Community Descriptions

Midway Community Description

Midway, located in Liberty County, was named after the Midway River in England and settled in 1754.

Currently Midway has a major industrial park with nine manufacturing facilities.[13] Midway has seen a slow population increase and a steady unemployment rate (Table 5.2.1-71). Blue, hard crabs were the number one caught species in 2006 (Table 5.2.1-72 and Figure 5.2.1-4)

Table 5.2.1-71. Midway, GA demographic data from 1990-2006 (Source: U.S. Census Bureau Decennial census).

Midway, GA	**1990**	**2000**	**2006**
Population	863	1,100	1,037
Median Education Attainment	High School Graduate	High School Graduate Degree	
White	480	647	
Black or African American	370	409	
American Indian & Alaska Native	1	6	
Asian, Native Hawaiian & Other Pacific Islander	7	16	
Some Other Race	5	5	
Hispanic or Latino (or any race)	7	26	
Total Housing Units	322	396	
Vacant	57	64	
Median Gross Rent	$311	$550	
Median Housing Value	$49,400	$85,400	$89,300
Median Household Income	$20,938	$29,205.00	$28,200
Per Capita Income	$8,620	13,078	
Unemployment %	2.40%	2.80%	
Employment by Industry (Top 5)			
Retail Trade	18.20%	17.70%	
Manufacturing	10%	11.90%	
Construction	10.30%	14.50%	
Educational, health, social services	23.30%	15.10%	
Accommodation, food services, recreation, entertainment, art		10.40%	
Personal Services	11%	DO	
DO= Dropped Out			

Table 5.2.1-72. Top species by pounds caught in Midway, GA from 2006 data.

SPECIES	FISH RANK	POUNDS	VALUE	DEALERS
CRABS,BLUE,HARD	1	120,542	$101,785	74
SHRIMP	2	9,044	$53,831	33
OYSTERS	3	512	$2,120	*
CRAB,BLUE,PEELER	4	179	$497	*

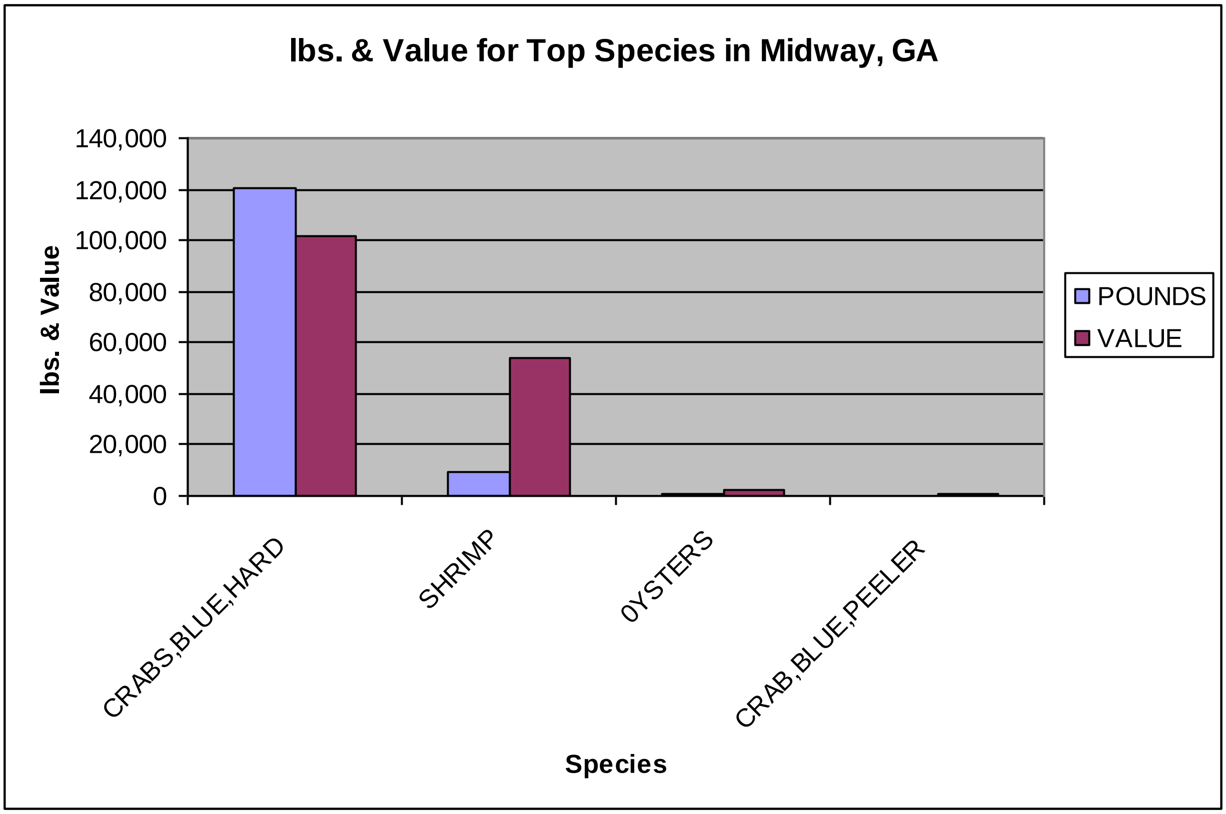


Figure 5.2.1-4. Value and pounds of top species in Midway, GA for 2006.

<u>Richmond Hill Community Description</u>

Richmond Hill, found in Byron County, is located 20 miles from Savannah on Georgia's coast with a total area of 10 square miles. Richmond Hill has a history that is similar to that of our nation: Exploration, Indian and Colonial settlements, the American Revolution, the War Between the States, Henry Ford Era, and recent military conflicts.[15] For centuries, the Guale people inhabited the shores of the Ogeechee River, taking advantage of the seafood and temperate climate. Spanish exploration in the late 1500s led to English settlement by 1792.[15] Then in 1862 Fort McAllister was built for the civil war and was the site of the end of Sherman's March to the Sea in 1864.[15] During this time the town was known as Ways Station. It was renamed in 1939 to its current name, Richmond Hill, after Henry Ford moved into the town and built an estate. The Ford era transformed this town through their philanthropic efforts, turning the backwater town of Ways Station into a vibrant community with new schools and employment opportunities.[15]

The next major development in Richmond Hill was Fort Stewart Military Reservation that was built prior to World War II and is still in operation.[14] More recently the J.F. Gregory City Park opened in 1999 in Richmond Hill where the first annual "Great Ogeechee Seafood Festival" was celebrated.[14]

Richmond Hill has seen an increase a moderate increase in population from 1990 to 2006 and a slight decrease in unemployment from 2.60% in 1990 to 1.80% in 2000 (Table 5.2.1-73). Blue, hard crabs were the number one species caught by pounds in 2006 (Table 5.2.1-74 and Figure 5.2.1-5).

[14] http://www.richmondhillga.com/.
[15] http://www.richmondhill-ga.gov/AboutRichmondHill/History/tabid/55/Default.aspx

Table 5.2.1-73. Richmond Hill, GA demographic data from 1990-2006 (Source: U.S. Census Bureau Decennial census).

Richmond Hill, GA	**1990**	**2000**	**2006**
Population	2,934	6,959	9,806
Median Education Attainment	Some college no degree	Some College Less than 1 yr.	
White	2,771	5,656	
Black or African American	119	953	
American Indian & Alaska Native	5	42	
Asian, Native Hawaiian & Other Pacific Islander	26	102	
Some Other Race	13	89	
Hispanic or Latino (or any race)	42	26	
Total Housing Units	1,047	2,639	
Vacant	47	140	
Median Gross Rent	$277	$547	
Median Housing Value	$67,600	$97,100	$101,500
Median Household Income	$32,917	$47,061	$45,400
Per Capita Income	$12,156	18,891	
Unemployment %	2.60%	1.80%	
Employment by Industry (Top 5)			
Retail Trade	20.80%	13%	
Manufacturing	10.70%	12.40%	
Educational, health, social services	DO	18.10%	
Accommodation, food services, recreation, entertainment, art	DO	11.30%	
Transportation & warehousing, & utilities	DO	7.70%	
Construction	8.80%	DO	
Public Administration	9.30%	DO	
Wholesale Trade	6.30%	DO	
DO= Dropped Out			

Table 5.2.1-74. Top species by pounds caught in Richmond Hill, GA from 2006 data.

SPECIES	FISH RANK	POUNDS	VALUE	DEALERS
CRABS,BLUE,HARD	1	137,849	$94,790	55
SHRIMP	2	53,756	$153,663	51

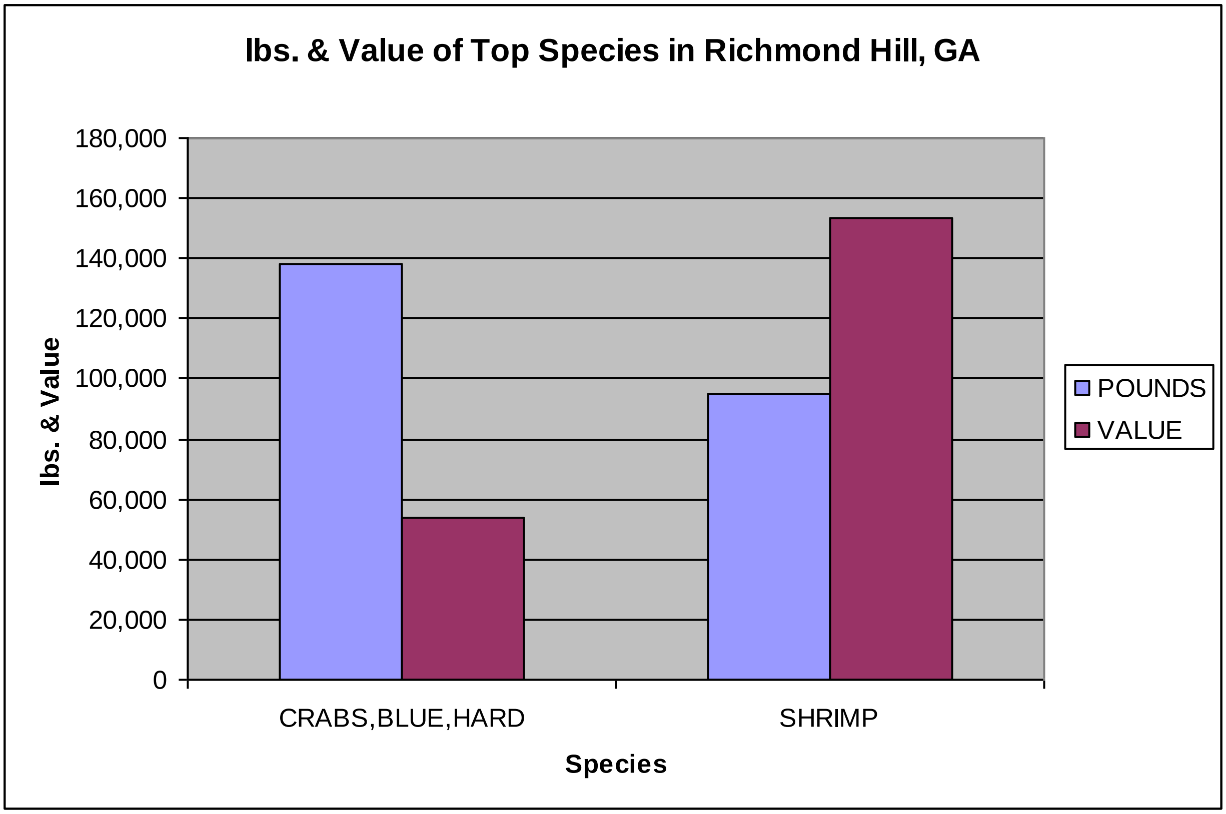


Figure 5.2.1-5. Value and pounds of top species in Richmond Hill, GA for 2006.

<u>St. Mary's Community Description</u>
St. Mary's has seen steady population growth since 1970. The percent of the population in the labor force has remained fairly constant while unemployment has risen to 3.9 percent (Table 5.2.1-75). Average wage and salary has risen consistently over the years along with a rising median housing value. Those employed in farm, fish and forestry sector have seen a steady decline in their numbers since 1970 also.

There were only 2 vessels registered with federal permits from the community (Jepson *et al.*2006) but there were 42 persons listed in the fishing. The state has 19 vessels registered with 9 of those having shrimp gear and 13 of those owners considered full time fishermen (Jepson *et al.*2006). Blue, hard crabs were the top species caught in 2006 in St. Mary's (Table 5.2.1-76 and Figure 5.2.1-6).

Table 5.2.1-75. St. Mary's, GA demographic data from 1990-2006 (Source: U.S. Census Bureau Decennial census).

St. Mary's, GA	**1990**	**2000**	**2006**
Population	8,187	13,761	15,967
Median Education Attainment	Some college no degree	Some college no degree	
White	6,478	10,267	
Black or African American	1,407	2,751	
American Indian & Alaska Native	42	65	
Asian, Native Hawaiian & Other Pacific Islander	173	176	
Some Other Race	87	214	
Hispanic or Latino (or any race)	228	614	
Total Housing Units	3,166	5,307	
Vacant	284	514	
Median Gross Rent	$393	$556	
Median Housing Value	$66,400	$85,300	$89,200
Median Household Income	$28,552	$42,087.00	$40,600
Per Capita Income	$11,189	18,099	
Unemployment %	3%	3.90%	
Employment by Industry (Top 5)			
Retail Trade	17.20%	10.80%	
Manufacturing	11.60%	13.20%	
Educational, health, social services	DO	19%	
Accommodation, food services, recreation, entertainment, art	DO	14.30%	
Professional, scientific, management, administrative, & waste mgmt.	DO	13%	
Construction	7.60%	DO	
Public Administration	17.30%	DO	
Other Professional Services	7.30%	DO	
DO= Dropped Out			

Table 5.2.1-76. St. Mary's, GA demographic data from 1990-2006

SPECIES	FISH RANK	POUNDS	VALUE	DEALERS
CRABS,BLUE,HARD	1	60,949	$32,590	23
SHRIMP	2	30,648	$77,744	45
SNAILS(CONCHS)	3	776	$932	*

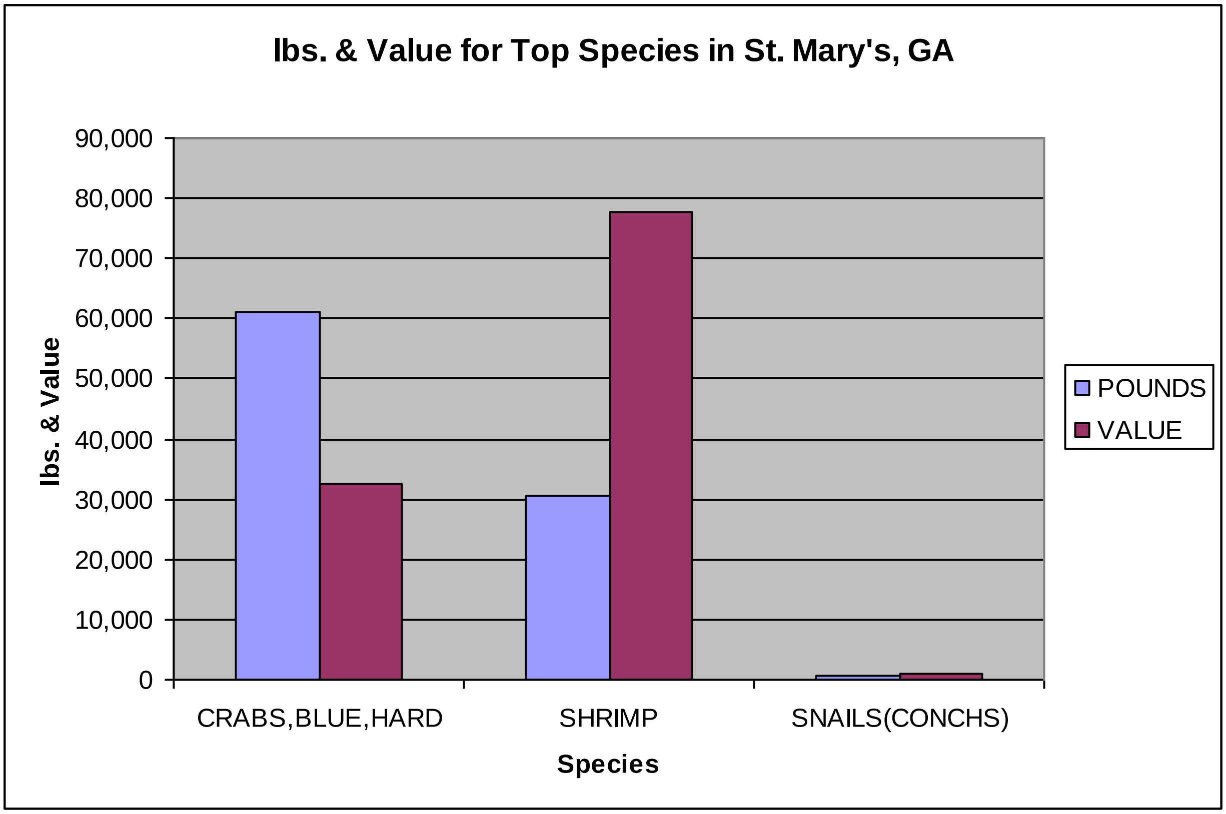


Figure 5.2.1-6. Value and pounds of top species in St. Mary's, GA for 2006.

<u>Townsend Community Description</u>

Townsend has seen a slight increase in population and steady unemployment rates (Table 5.2.1-77). Median household income has only slightly risen from $23,324 in 1990 to $32,300 in 2006 while median housing value has greatly increased from $33,000 in 1990 to $102,600 in 2006 (Table 5.2.1-77). Blue, hard, crabs were the number one species caught in 2006 with 538,127 lbs. (Table 5.2.1-78 and Figure 5.2.1-7).

Table 5.2.1-77. Townsend, GA demographic data from 1990-2006 (Source: U.S. Census Bureau Decennial census).

Townsend, GA	**1990**	**2000**	**2006**
Population	2,413	3,538	
Median Education Attainment	High School Graduate	High School Graduate	
White	1,465	2,437	
Black or African American	947	1,048	
American Indian & Alaska Native	1	7	
Asian, Native Hawaiian & Other Pacific Islander	0	8	
Some Other Race	0	13	
Hispanic or Latino (or any race)	2	27	
Total Housing Units	1,548	2,308	
Vacant	740	867	
Median Gross Rent	$158	$431	
Median Housing Value	$33,000	$98,100	$102,600
Median Household Income	$23,314	$33,531	$32,300
Per Capita Income	$9,965	17,261	
Unemployment %	2.70%	2.80%	
Employment by Industry (Top 5)			
Retail Trade	16.20%	17.30%	
Manufacturing	19%	16.20%	
Construction	10.60%	13.60%	
Educational, health, social services	15%	12.30%	
Accommodation, food services, recreation, entertainment, art	DO	7.50%	
Transportation	6.50%	DO	
DO= dropped out			

Table 5.2.1-78. Top 5 species by pounds caught in Townsend, GA from 2006 data.

SPECIES	FISH RANK	POUNDS	VALUE	DEALERS
CRABS,BLUE,HARD	1	538,127	$331,928	308
SHRIMP	2	120,699	$266,743	114
SNAPPER,VERMILION	3	100,283	$287,411	52
SHAD,BUCK	4	49,621	$49,600	11
CLAM,HARD	5	32,842	$22,485	34

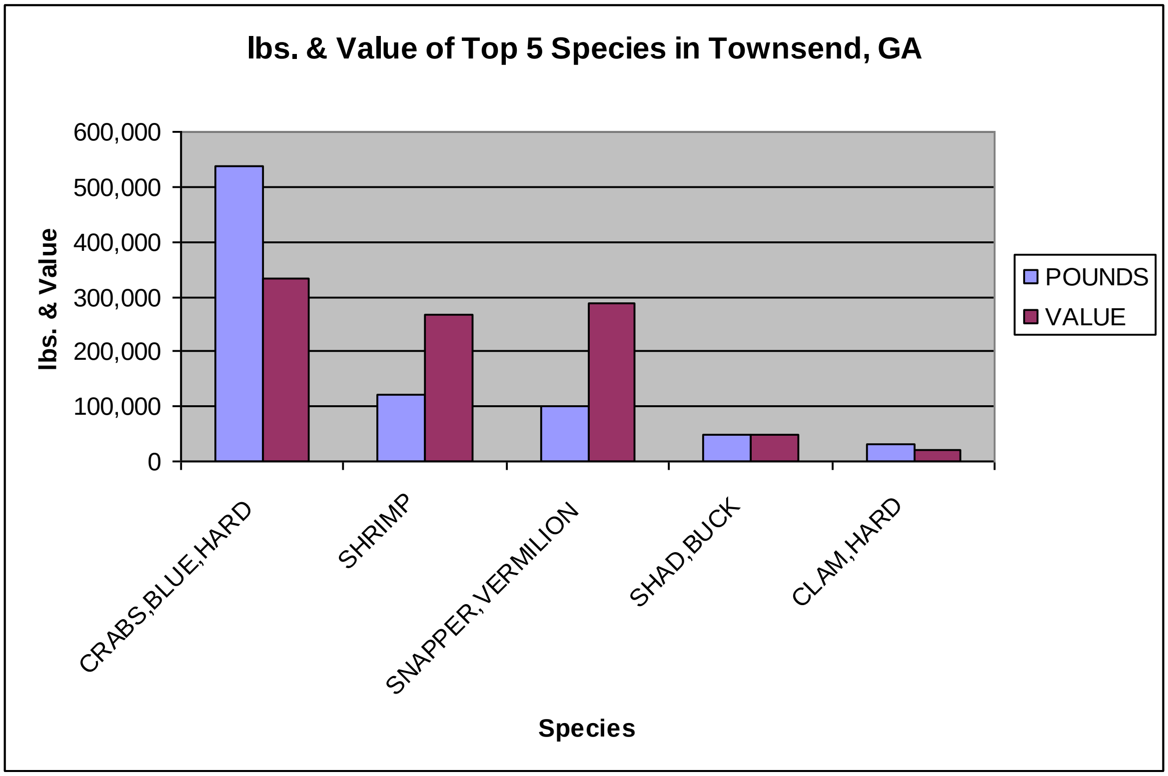


Figure 5.2.1-7. Value and pounds of top 5 species in Townsend, GA for 2006.

5.2.1.3.4 Florida Community Descriptions

Atlantic Beach Community Description

The community of Atlantic Beach has remained fairly small throughout its history. The arrival of Henry Flagler's Florida East Coast Railroad in 1900 helped spur development and prominence within this coastal community. However, it was not until the construction of the Mayport Naval Station in the 1940s and the completion of the Matthews Bridge in the 1950s that the area truly became ready for development. Beginning in the 1990s, the Atlantic Beach community embarked on environmental endeavors regarding their aquatic resources. They created the Tideviews Preserve and the Dutton Island Preserve.

Preserve, fishing off the pier is a popular activity for park visitors. Atlantic Beach has seen steady growth in its population. There has been a decline in the percent of the population in the labor force and unemployment has dropped to 2.1 percent in 2000 (Table 5.2.1-79). Average wage and salary rose significantly between 1980 and 1990, but only slightly in 2000. Jobs in the sector of farm, fish and forestry have fluctuated over the past three decades, but dropped to low levels in 2000. Although there is only one vessel with federal permits in Atlantic Beach (Jepson *et al.* 2006) there are 56 persons employed in the fish and seafood sector. In 2006 blue, hard crabs were the top species by pound (Table 5.2.1-80 and Figure 5.2.1-8).

Table 5.2.1-79. Atlantic Beach, FL demographic data from 1990-2006 (Source: U.S. Census Bureau Decennial census).

Atlantic Beach, FL	**1990**	**2000**	**2006**
Population	11,636	13,368	13,268
Median Education Attainment	Some College no degree	Some College no degree	
White	9,333	10,992	
Black or African American	1,792	1,697	
American Indian & Alaska Native	34	35	
Asian, Native Hawaiian & Other Pacific Islander	383	329	
Some Other Race	94	150	
Hispanic or Latino (or any race)	355	559	
Total Housing Units	4,948	6,003	
Vacant	407	380	
Median Gross Rent	$412	$722	
Median Housing Value	$96,900	$169,800	$282,000
Median Household Income	$35,486	$48,353	$53,100
Per Capita Income	$19,291	$28,618	
Unemployment %	3.10%	2.10%	
Employment by Industry (Top 5)			
Educational, health and social services	18.80%	17.50%	
Arts, entertainment, recreation, accommodation and food services	DO	12.60%	
Professional, scientific, management, administrative, and waste management services	DO	13.20%	
Retail Trade	21.50%	9.90%	
Finance, insurance, real estate, and rental and leasing	9.50%	9.70%	
Public Administration	6.40%	DO	
Construction	6.30%	DO	
DO= Dropped Out			

Table 5.2.1-80. Top five species by pounds caught in Atlantic Beach, FL from 2006 data.

SPECIES	FISH RANK	POUNDS	VALUE	DEALERS
CRABS,BLUE,HARD	1	37,561	$48,749	34
SHRIMP	2	17,387	$35,732	35
MULLET	3	13,030	$16,791	14
MENHADEN	4	10,343	$2,089	5
GROUPER	5	5,158	$17,505	25

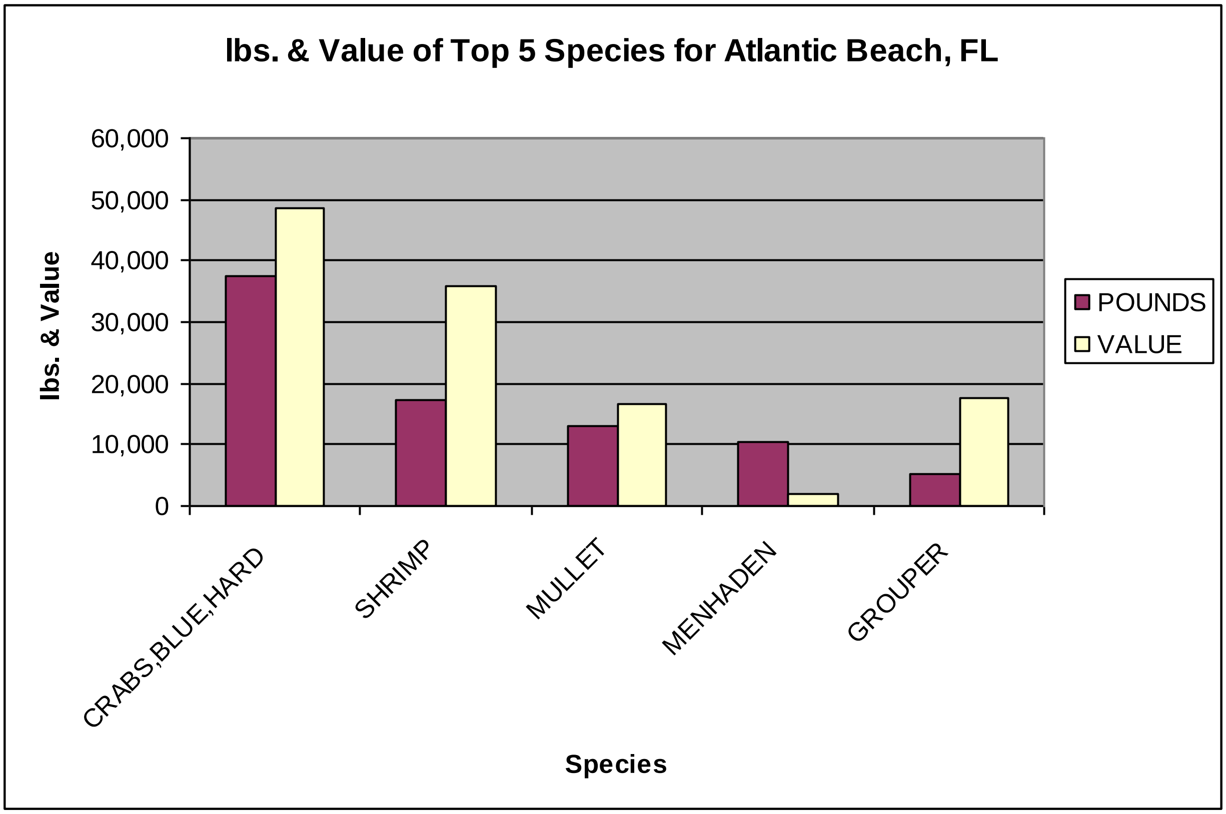


Figure 5.2.1-8. Value and pounds of top five species in Atlantic Beach, FL for 2006.

Cocoa Beach Community Description

Cocoa Beach is six miles long and not more than a mile wide located on a barrier island between the Atlantic Ocean and the Banana River Lagoon on Florida's Central East Coast. Cocoa Beach is a residential community and a tourist destination with 12,800 permanent residents increasing to 30,000 persons during peak tourist season.[20]

Cocoa Beach has seen a fairly steady population while the median housing value has almost tripled from $127,000 in 1990 to $308,000 in 2006 (Table 5.2.1-81). In 2006 King Mackerel were the top species caught by pound (Table 5.2.1-82 and Figure 5.2.1-9).

[20]http://www.ci.cocoa-beach.fl.us/.

Table 5.2.1-81. Top five species by pounds caught in Atlantic Beach, FL from 2006 data. (Source: U.S. Census Bureau Decennial census).

Cocoa Beach, FL	**1990**	**2000**	**2006**
Population	12,123	12,482	12,800
Median Education Attainment	Some College, no degree	Some college, 1 or more years, no degree	
White	11,882	12,062	
Black or African American	61	78	
American Indian & Alaska Native	31	28	
Asian, Native Hawaiian & Other Pacific Islander	110	141	
Some Other Race	39	38	
Hispanic or Latino (or any race)	334	314	
Total Housing Units	8,266	8,686	
Vacant	2,245	2,206	
Median Gross Rent	$549	$631	
Median Housing Value	$127,000	$150,100	$308,000
Median Household Income	$35,862	$42,372	$45,700
Per Capita Income	$23,359	$28,968	
Unemployment %	1.80%	2.60%	
Employment by Industry (Top 5)			
Food services, accommodation, recreation, entertainment, arts	DO	16.10%	
Educational, health, social services	DO	13.50%	
Retail Trade	19%	12.10%	
Manufacturing	13.50%	11.40%	
Finance, Insurance, real estate	8.90%	DO	
Other professional related services	8.50%	9.80%	
Public Administration	7.50%	DO	
DO= Dropped Out			

Table 5.2.1-82. Top five species by pounds caught in Cocoa Beach, FL from 2006 data.

SPECIES	FISH RANK	POUNDS	VALUE	DEALERS
KING MACKEREL	1	1,277,396	$2,145,204	149
SPANISH MACKEREL	2	1,264,886	$792,271	215
SHARK,SANDBAR	3	269,203	$90,889	50
SHARK,ATLANTIC,SHARPNOSE	4	148,707	$49,691	58
TILEFISH	5	134,242	$303,894	34

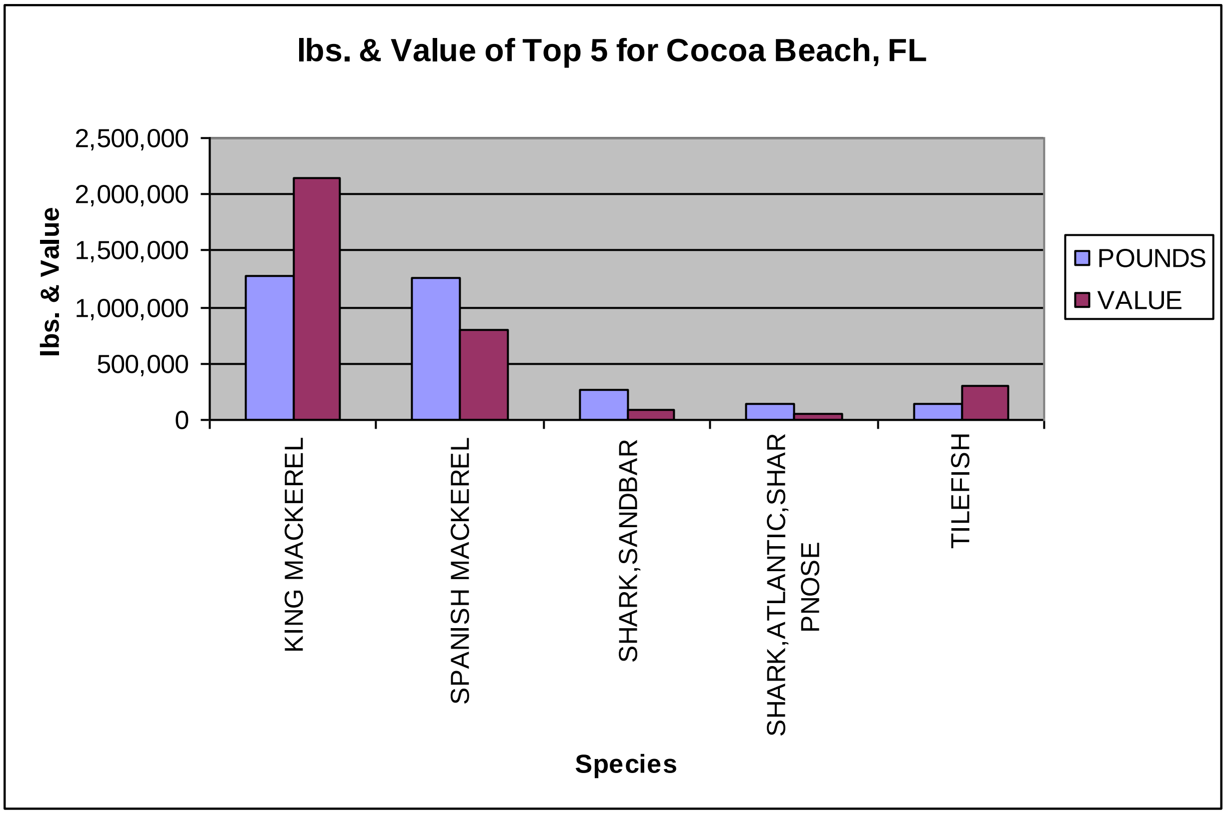


Figure 5.2.1-9. Value and pounds of top five species in Cocoa Beach, FL for 2006.

<u>Fort Pierce Community Description</u>
The Spanish built Fort Santa Lucia on the Jupiter Inlet in 1565 from which the county now draws its name-St. Lucie County.[21] Permanent U.S. inhabitance of Fort. Pierce dates back to the Seminole Indian War. US Army Lt. Col. Benjamin Kendrick Pierce, for whom the town is named, built a fort in 1837 to use as the army's headquarters. The war ended in the early 1840s, making way for settlement and development: "Water transportation, fishing and canning fish were key to the area's early economy."[22] The arrival of Henry Flagler's railroad in the early 1900s opened Fort. Pierce's economy to the rest of the east coast. Fort. Pierce beach was used as a naval base during World War II.[23]

The culture of fishing has been in the area since its inception. Anecdotes passed down from one generation to the next of Fort. Pierce residents describe the abundance of fish in the area in the late 1800s and early 1900s. One such story, told by Newman (1953) in her book, *Early Life Along the Beautiful Indian River*, tells of a man who bound his shirt at the sleeves and waist and cut a plunging neckline. He would then stand in the water until the shirt was full of fish and then empty it out into a bucket on the shore. In the late 1800s, a man from the nearby town of Titusville helped to create the commercial fishing sector in Fort. Pierce. He would bring the fish to Titusville for shipping to the rest of the east coast. The first icehouse for packaging fish was built in 1900 (Newman, 1953).

Recreational fishing has also become a popular pastime in Fort. Pierce and the rest of St. Lucie County. This is due in large part to the fleet of Spanish galleons that sunk off the St.

Lucie and Martin Counties coastline. These artificial reefs have created excellent fishing and diving spots for locals and tourists. The reefs attract spiny lobsters, marlin, snook, flounder, and grouper.[24] Some of the more popular fish in the St. Lucie River include channel bass, snook, ladyfish, jack crevalle, and trout. Black sea bass is another famous catch in the area.[25] Most charter fishing boats in the area offer half, three-quarter, and full-day trips for dolphin, sailfish, wahoo, amberjack, tuna, kingfish, snapper, and grouper. Fort Pierce has seen moderate population growth over the past three decades while unemployment has increased from 4.90% percent in 2000 to 11.5% percent in 2006 (Table 5.2.1-83). Average wage and salary has grown slowly over the past ten years while the number of persons living under the poverty level has risen significantly. The number of people working in farm, fish and forestry has remained relatively high for both occupation and industry over the years with both categories having over 1000 persons in each. There are over 100 vessels with federal permits homeported in Fort. Pierce and most of those have coastal pelagic permits (Jepson *et al.* 2006). There are over 260 persons employed in the boat building sector of fishing related employment. In 2006 Spanish mackerel were the top species caught by pound (Table 5.2.1-84 and Figure 5.2.1-10).

[24] www.flausa.com/destinations/location.php/location=ci-fpi
[25] http://www.visitstluciefla.com/marinas.html
[21] www.rootsweb.com/~flstluci/slchistory.htm
[22] http://plato.stlucie.k12.fl.us/html/ft._pierce.html
[23] www.cityoffortpierce.com/fp000.html

Newman, A.P.L. 1953. Early Life Along the Beautiful Indian River. Stuart Daily News: Stuart, FL.

Table 5.2.1-83. Fort. Pierce, FL demographic data from 1990-2006 (Source: U.S. Census Bureau Decennial census).

Ft. Pierce, FL	**1990**	**2000**	**2006**
Population	36,830	37,516	39,365
Median Education Attainment	High School graduate	High school graduate	
White	19,772	18,585	
Black or African American	15,604	15,326	
American Indian & Alaska Native	118	122	
Asian, Native Hawaiian & Other Pacific Islander	198	328	
Some Other Race	1,138	2,011	
Hispanic or Latino (or any race)	2,370	5,629	
Total Housing Units	17,250	17,213	
Vacant			
Median Gross Rent			
Median Housing Value	$56,100	$62,800	$142,400
Median Household Income	$18,913	$25,121	$29,600
Per Capita Income	$9,961	$14,345	
Unemployment %	6.80%	4.90%	11.50%
Employment by Industry (Top 5)			
Food services, accommodation, recreation, entertainment, arts	DO	10.80%	
Educational, health, social services	17%	16.90%	
Retail Trade	20.90%	12.50%	
Manufacturing	DO	8%	
Construction	8.16%	12.60%	
Fisheries, agriculture, forestry	**9.80%**	**DO**	
Public administration	6%	DO	
DO= Dropped Out			

Table 5.2.1-84. Top five species by pounds caught in Fort. Pierce, FL from 2006 data.

SPECIES	FISH RANK	POUNDS	VALUE	DEALERS
SPANISH MACKEREL	1	1,223,602	$838,232	123
KING MACKEREL	2	415,045	$693,181	63
MULLET WITH ROE	3	198,949	$109,192	31
MULLET,STRPED	4	122,394	$57,611	84
MULLET,SILVER	5	100,073	$45,001	63

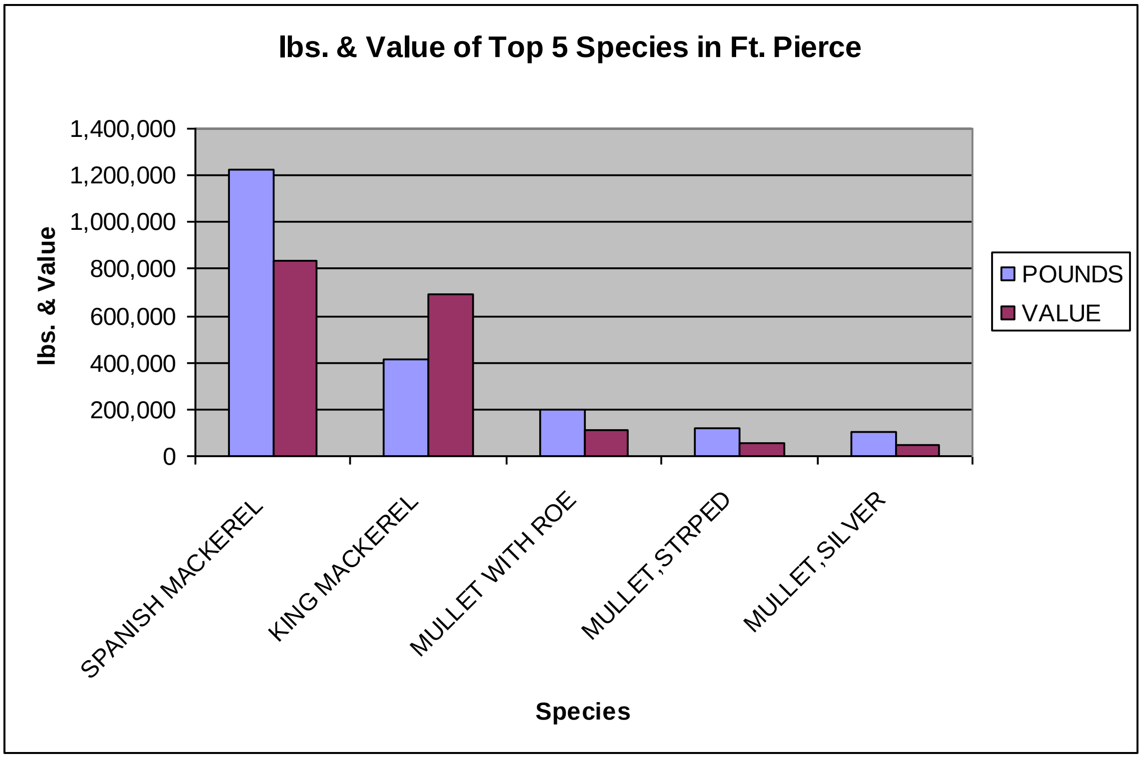


Figure 5.2.1-10. Value and pounds of top five species in Fort. Pierce, FL for 2006.

Melbourne Community Description

The city of Melbourne is located on east central Florida's Space Coast in Brevard County. The contemporary city of Melbourne is the result of the 1969 merger of the separate communities of Melbourne and Eau Gallie.[27] Today Melbourne is also a part of the Palm Bay-Melbourne-Titusville metropolitan area.[28] The city is close to 40 square miles in size, with about 75% of that land in use with a population of approximately 77,000 that is continuing to grow at a modest rate.[26] While most of Melbourne is located on the Florida mainland, a small portion is located on a barrier island. The Indian River Lagoon separates the mainland from the island.[26] Melbourne's industry is centered on defense and technology companies with a high concentration of high-tech workers.[28] Melbourne has seen its population rise greatly from 59,649 in 1990 to 76,963 to 2006 (Table 5.2.1-85). Unemployment has slightly risen from 3.20% in 2000 to 4.40% in 2006.

The Banana and Indian Rivers run through Brevard County and offer excellent flats fishing for a wide variety of species. The popular Mosquito Lagoon is located at the north end of Brevard County and offers good redfish fishing. Brevard has two inlets: the Sebastian Inlet which is located at the south end of the Indian River and Port Canaveral which is located at the north end of the Banana River. These inlets offer fishing for snook, redfish, tarpon, and flounder.[29] In 2006 hard, blue crab were the top species by pound (Table 5.2.1-86 and Figure 5.2.1-11).

[26]http://www.melbourneflorida.org/info/
[27]http://www.melbourneflorida.org/info/history.htm.
[28]http://en.wikipedia.org/wiki/Melbourne,_Florida
[29]http://www.fishmore.com/local_fishing.htm

Table 5.2.1-85. Melbourne, FL demographic data from 1990-2006 (Source: U.S. Census Bureau Decennial census).

Melbourne, FL	**1990**	**2000**	**2006**
Population	59,649	71,382	76,963
Median Education Attainment		Some College no degree	
White	52,145	60,339	
Black or African American	5,666	6,658	
American Indian & Alaska Native	192	245	
Asian, Native Hawaiian & Other Pacific Islander	1,224	1,671	
Some Other Race	419	858	
Hispanic or Latino (or any race)	2,075	3,958	
Total Housing Units	28,070	33,678	
Vacant	3,005	2,890	
Median Gross Rent	391	$588	
Median Housing Value	$65,100	$85,400	$167,100
Median Household Income	$25,893	$34,571	$40,471
Per Capita Income	$13,224	$19,175	
Unemployment %	3.90%	3.20%	4.40%
Employment by Industry (Top 5)			
Educational, health and social services	13.80%	17.10%	
Retail Trade	20%	15.60%	
Manufacturing	DO	14.30%	
Arts, entertainment, recreation, accommodation and food services	DO	10.90%	
Professional, scientific, management, administrative, and waste management services	DO	9.90%	
Manufacturing	17.80%	DO	
Construction	8%	DO	
Business & repair services	6.60%	DO	
DO= Dropped out			

Table 5.2.1-86. Top five species by pounds caught in Melbourne, FL from 2006 data.

SPECIES	FISH RANK	POUNDS	VALUE	DEALERS
CRAB,BLUE,HARD	1	32,147	$40,079	50
MULLET,STRIPED	2	8,605	$8,035	20
POMPANO	3	6,628	$29,431	38
MOJARRAS	4	3,933	$2,677	13
PINFISH	5	2,769	$13,290	18

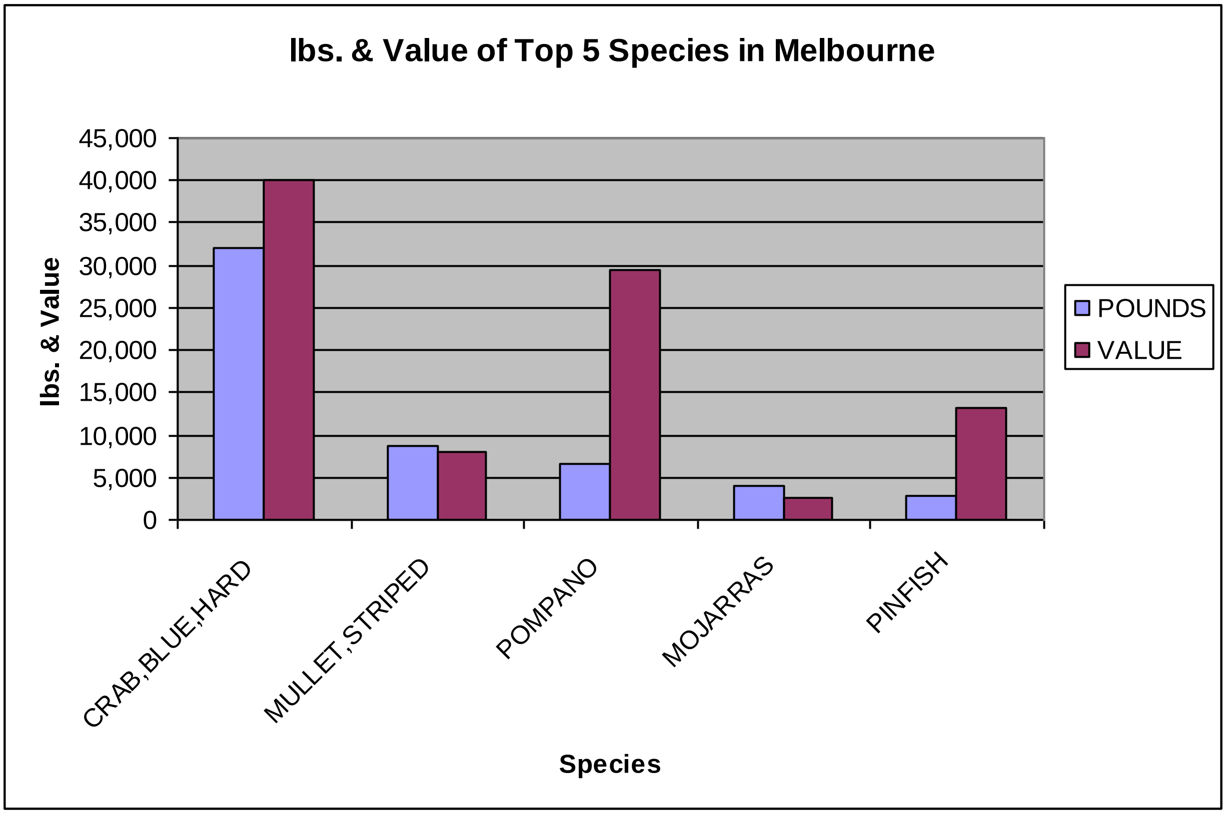


Figure 5.2.1-11. Value and pounds of top five species in Melbourne, FL for 2006.

<u>Merritt Island Community Description</u>

Merritt Island's population has grown slowly over the past three decades. The percent of the population in the labor force has dropped slightly over the past ten years, but unemployment has increased slightly (Table 5.2.1-87). Average wage and salary have increased to over $40,000 for the year 2000, but the number of persons living under the poverty level has also grown considerably. As for most coastal communities the number of people working in the farm, fish and forestry sector of the economy has dropped significantly over the past decade but has shown a steady decline prior to the 2000 census. Merritt Island has only 8 vessels with federal permits and half of them have charter permits (Jepson *et al.* 2006). There is substantial employment represented in the fishing related sector of boat building with over 1100 persons employed in that sector according to (Jepson *et al.* 2006). In 2006 blue, hard crab were the top species by pound (Table 5.2.1-88 and Figure 5.2.1-12).

Table 5.2.1-87. Top five species by pounds caught in Melbourne, FL from 2006 data. (Source: U.S. Census Bureau Decennial census).

Merritt Island, FL	**1990**	**2000**	**2006**
Population	32,886	36,090	
Median Education Attainment	Some college, no degree	Some college, no degree	
White	30,397	32,560	
Black or African American	1,786	1,918	
American Indian & Alaska Native	121	149	
Asian, Native Hawaiian & Other Pacific Islander	428	618	
Some Other Race	154	246	
Hispanic or Latino (or any race)	909	1,381	
Total Housing Units	14,424	15,813	
Vacant	1,044	858	
Median Gross Rent	$395	$566	
Median Housing Value	$91,400	$118,300	$242,700
Median Household Income	$35,803	$43,532	$47,000
Per Capita Income	$17,400	$23,961	
Unemployment %	2.70%	2.90%	
Employment by Industry (Top 5)			
Educational, health and social services	DO	17.10%	
Professional, scientific, management, administrative, and waste management services	8%	12.40%	
Retail Trade	19%	13.30%	
Manufacturing	16.70%	12.60%	
Arts, entertainment, recreation, accommodation and food services	DO	10.80%	
Public Administration	7.20%	DO	
Finance, insurance, & real estate	6.70%	DO	
DO= Dropped Out			

Table 5.2.1-88. Top five species by pounds caught in Merritt Island, FL from 2006 data.

SPECIES	FISH RANK	POUNDS	VALUE	DEALERS
CRAB,BLUE,HARD	1	59,222	$59,222	13
COBIA	2	2,250	$6,124	15
TRIPLETAIL	3	2,124	$4,677	12
SHEEPSHEAD,ATLANTIC	4	1,828	$2,412	10
GROUPER,RED	5	1,271	$4,047	7

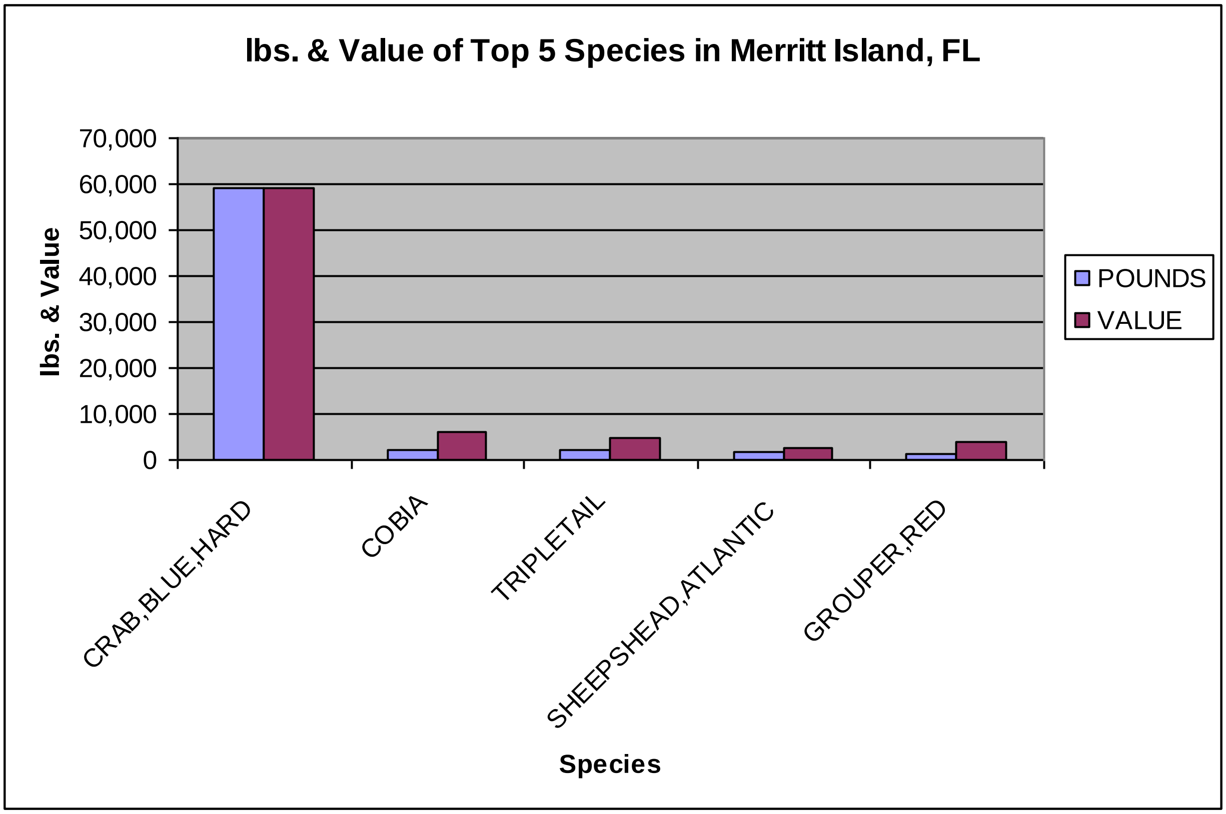


Figure 5.2.1-12. Value and pounds of top five species in Merritt Island, FL for 2006.

Miami Community Description

In 1891 Julia Tuttle moved to Florida and purchased 640 acres of land on the north bank of the Miami River. Tuttle then talked railroad builder Henry Flagler into extending his railroad into Miami, building a luxury hotel and laying out a new town. These developments resulted in the birth of a new city. The city of Miami was incorporated on July 28, 1896.[31]

The city of Miami is located in Miami-Dade County on the Miami River, between the Florida Everglades and the Atlantic Ocean. The population of Miami has steadily increased from 358,548 in 1990 to 404,048 in 2006 (Table 5.2.1-89). In 1990 the median household income was only $16,925 and has only slightly risen to $25,211 in 2006 while the median housing value has increased from $79,200 in 1990 to $248,500 in 2006. Unemployment remains high but has decreased from 6.50% in 1990 to 4.4% in 2006. In 2006 shrimp were the top species caught by pound (Table 5.2.1-90 and Figure 5.2.1-13).

[30]http://www.miamigov.com/press/pressreleases/miami/AbouttheCity.asp.
[31]http://www.miamigov.com/press/pressreleases/miami/history.asp

Table 5.2.1-89. Miami, FL demographic data from 1990-2006 (Source: U.S. Census Bureau Decennial census).

Miami, FL	**1990**	**2000**	**2006**
Population	358,548	362,470	404,048
Median Education Attainment	9-12th grade, no diploma	High School Graduate	
White	235,358	241,470	
Black or African American	98,207	80,858	
American Indian & Alaska Native	545	810	
Asian, Native Hawaiian & Other Pacific Islander	2,272	2506	
Some Other Race	22,166	19644	
Hispanic or Latino (or any race)	223,964	238,351	
Total Housing Units	144,550	148,554	
Vacant	14,298	14,195	
Median Gross Rent	$404	$535	
Median Housing Value	$79,200	$120,100	$248,500
Median Household Income	$16,925	$23,483	$25,211
Per Capita Income	$9,799	$15,128	
Unemployment %	6.50%	5.90%	4.4.%
Employment by Industry (Top 5)			
Food services, accommodation, recreation, entertainment, arts	DO	12%	
Educational, health, social services	7.60%	15%	
Retail Trade	18.50%	11%	
Professional, scientific, mgmt., administrative, waste mgmt. services	DO	11.80%	
Construction	7.90%	10%	
Manufacturing, durable goods	7.60%	DO	
Personal Services	7.80%	DO	
DO= Dropped Out			

Table 5.2.1-90. Top five species by pounds caught in Miami, FL from 2006 data.

SPECIES	FISH RANK	POUNDS	VALUE	DEALERS
SHRIMP	1	411,462	$706,225	104
LOBSTER,SPINY	2	253,105	$1,575,878	104
BALLYHOO	3	79,450	$62,724	35
SHARKS	4	74,561	$16,223	14
KING MACKEREL	5	72,048	$128,327	153

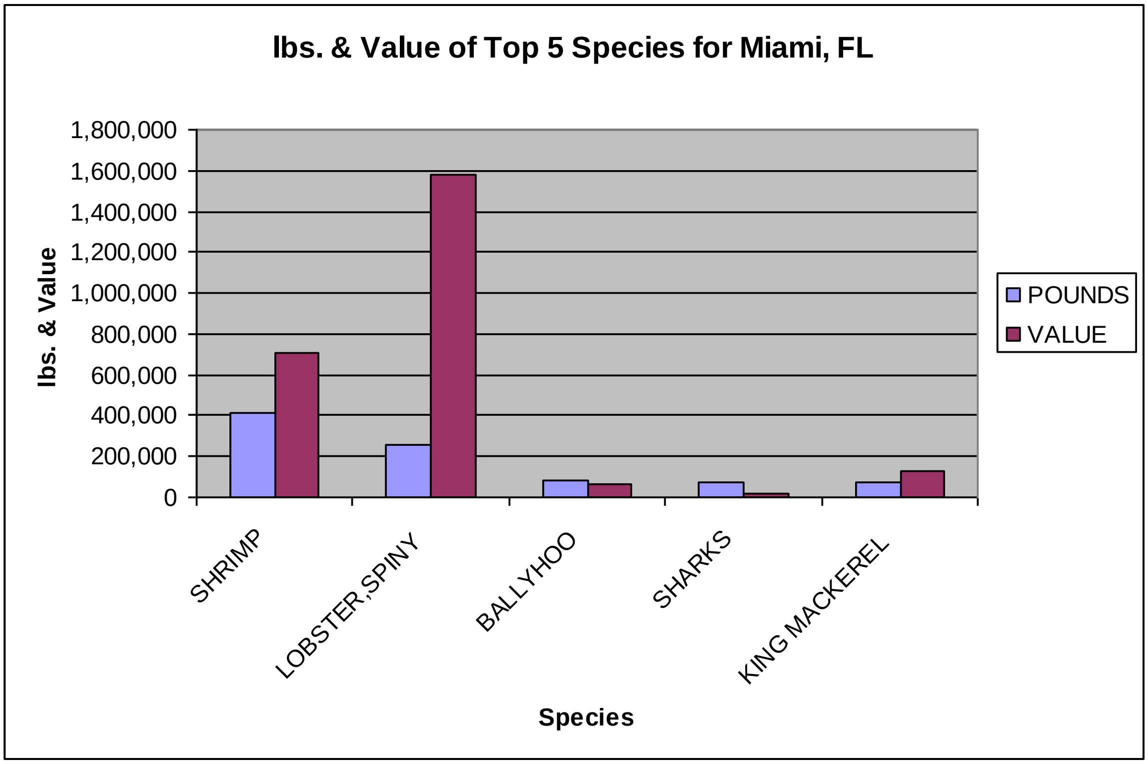


Figure 5.2.1-13. Value and pounds of top five species in Miami, FL for 2006.

Port Orange Community Description

On April 26, 1867 the community of Port Orange was established on the banks of the Halifax River. It was not until the mid 1970s when Dunlawton Avenue was extended from the FEC railroad to Nova Road did Port Orange start to see the early growth that would happen in the mid 1980s. According to the 1970 US Census, there were only 3,871 calling Port Orange home (Cardwell & Cardwell, 2000). With the second western extension of Dunlawton all the way out to Interstate 95, did Port Orange begin to blossom into the large metropolitan community that we know today.[32] Now some 140 years later, Port Orange is a community of 54,851 people extending 28 square miles (Table 5.2.1-91). In 2006 sandbar shark were the top species caught by pound (Table 5.2.1-92 and Figure 5.2.1-14).

[32]http://www.port-orange.org/

Cardwell, Harold D. Sr. and Priscilla D. Cardwell. 2000. Port Orange. Arcadia Publishing.

Table 5.2.1-91. Port Orange, FL demographic data from 1990-2006 (Source: U.S. Census Bureau Decennial census).

Port Orange, FL	**1990**	**2000**	**2006**
Population	35,317	45,823	54,851
Median Education Attainment	High School graduate	Some college, less than 1 year	
White	34,512	43,803	
Black or African American	354	722	
American Indian & Alaska Native	97	121	
Asian, Native Hawaiian & Other Pacific Islander	275	533	
Some Other Race	79	245	
Hispanic or Latino (or any race)	689	1,151	
Total Housing Units	17,019	20,845	
Vacant	2,055	1,415	
Median Gross Rent	$547	$682	
Median Housing Value	$78,900	$95,500	$176,300
Median Household Income	$26,472	$38,783	$42,400
Per Capita Income	$13,391	$20,628	
Unemployment %	2.60%	1.60%	3.40%
Employment by Industry (Top 5)			
Food services, accommodation, recreation, entertainment, arts	DO	11.30%	
Educational, health, social services	7.23%	20.10%	
Retail Trade	21.30%	15.60%	
Professional, scientific, mgmt., administrative, waste mgmt. services	DO	9.30%	
Construction	9.70%	8.40%	
Manufacturing, durable goods	8%	DO	
Finance, Insurance, real estate	9.90%	DO	
DO = Dropped Out			

Table 5.2.1-92. Top five species by pounds caught in Port Orange, FL from 2006 data.

SPECIES	FISH RANK	POUNDS	VALUE	DEALERS
SHARK,SANDBAR	1	109,003	$36,484	12
TILEFISH	2	105,174	$236,068	18
SHRIMP	3	91,414	$208,683	21
MULLET with ROE	4	60,476	$49,870	14
GLOUNDER,ATLANTIC	5	37,683	$85,035	90

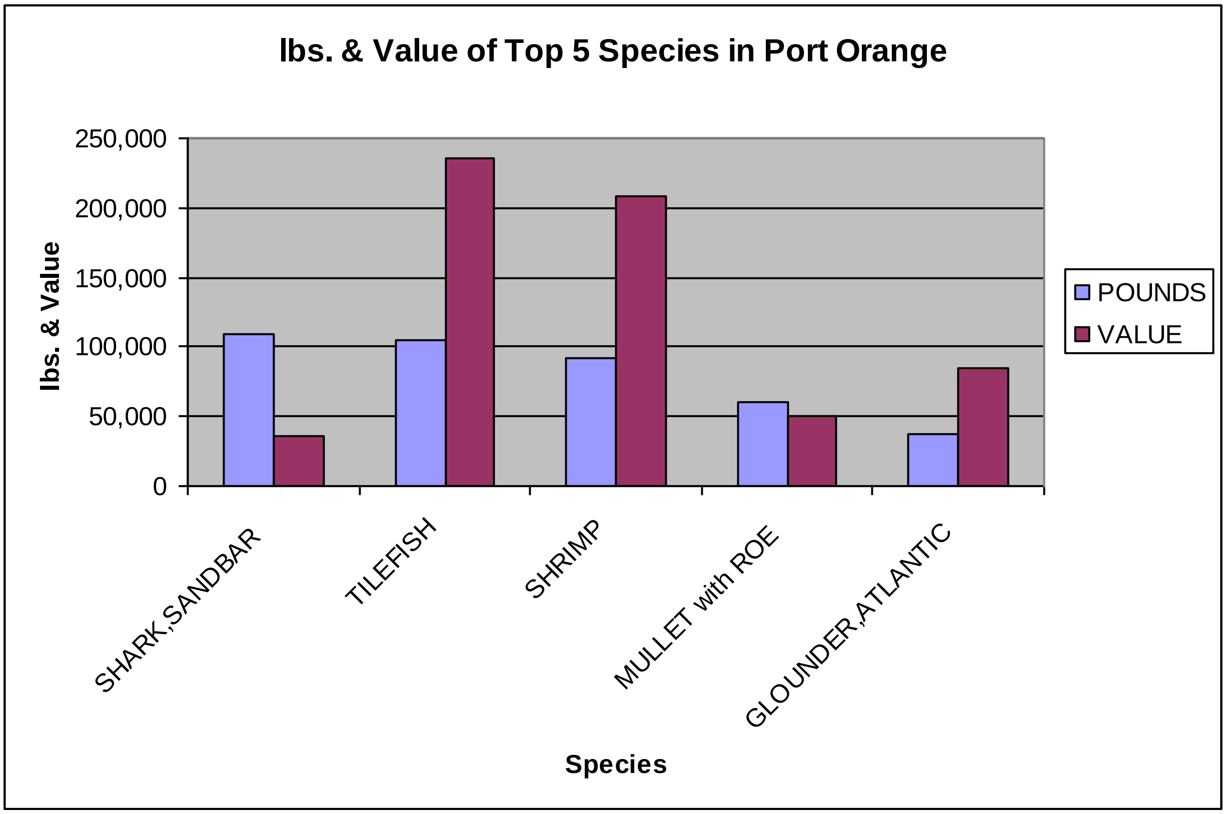


Figure 5.2.1-14. Value and pounds of top five species in Port Orange, FL for 2006.

St. Augustine Community Description

St. Augustine has the distinction of being the oldest European city in the United States. First sited by the Spanish explorer Don Juan Ponce de Leon in 1513, it was not settled until 1565 by Don Pedro Menendez de Aviles, a Spanish admiral, in the name of King Phillip II.[33] The town's boom did not occur until the 1880s with the arrival of Henry M. Flagler. His goal was to turn St. Augustine into a winter resort for wealthy Americans. It was this thinking that transformed the town. The construction of the railroad linked the city with much of the east coast. Flagler built three large hotels to help fulfill his dream of a tourist mecca. By the mid-1900s, St. Augustine's local economy was dominated by tourism.[34] The commercial fishing industry began in the St. Augustine/Fernandina area around 1900 with the arrival of a Sicilian immigrant named Sallecito Salvador. He placed an engine on his boat that allowed him to pull a shrimp seine across the ocean floor in 1902, and in 1906, he began his company, S. Salvador & Sons. Salvador moved his business to St. Augustine in 1922, where it thrived until 1929. Shrimp catch levels soared from about 1934 to 1940.[35]

These stories illustrate the longstanding culture of fishing in the St. Augustine area and the importance it holds for many of the fishing families there. Commercial fishing still continues at the port, the oldest continuously active port in the United States. Boat building, tourism, and recreational activities are also important to St. Augustine's port.[36]

St. Augustine has seen a steady decline in its population since 1970 until recently in 2006 (Table 5.2.1-93). Both the percent of population in the labor force and unemployment have remained relatively stable over the years. Average wage and salary has grown steadily, while the number of person living below the poverty level has dropped. The number of people employed in farm, fish and forestry has also dropped significantly over the past three decades, with the most pronounced decline from 1990 to 2000. St. Augustine has 28 vessels with federal permits and the majority of them have charter permits for either snapper grouper or coastal pelagics (Jepson *et al.* 2006). There is significant employment in fishing related business as there are over 370 people employed in boat building (Jepson *et al.* 2006) and another 75 in the seafood processing sector. In 2006 blue, hard crab were the number one species caught by pound (Table 5.2.1-94 and Figure 5.2.1-15).

[33] http://www.stjohns.k12.fl.us/history/history.html
[34] http://www.ci.st-augustine.fl.us/visitors/history_fullprint.html
[35] http://www.fl-seafood.com/water/places/fernidina.htm
[36] http://dhr.dos.state.fl.us/maritime/ports/port.cfm?name=St_Augustine

Table 5.2.1-93. St. Augustine, FL demographic data from 1990-2000 (Source: U.S. Census Bureau Decennial census).

St. Augustine, FL	**1990**	**2000**	**2006**
Population	11,692	11,592	12,604
Median Education Attainment	Some College, no degree	Some college, 1 or more years, no degree	
White	9,135	9,414	
Black or African American	2,365	1,747	
American Indian & Alaska Native	26	48	
Asian, Native Hawaiian & Other Pacific Islander	84	94	
Some Other Race		102	
Hispanic or Latino (or any race)	82	361	
Total Housing Units	5,181	5,619	
Vacant	580	670	
Median Gross Rent	$380	$645	
Median Housing Value	$61,800	$153,700	$193,400
Median Household Income	$21,722	$32,358	$37,000
Per Capita Income	$12,012	$21,225	
Unemployment %	3.10%	3.30%	
Employment by Industry (Top 5)			
Food services, accommodation, recreation, entertainment, arts	DO	17.10%	
Educational, health, social services	22.10%	19.10%	
Retail Trade	24.10%	15.70%	
Manufacturing	DO	7.40%	
Professional, scientific, mgmt., administrative, waste mgmt. services	6.30%	7.70%	
Personal Services	6%	DO	
Public administration	5.70%	DO	
DO = Dropped Out			

Table 5.2.1-94. Top five species by pounds caught in St. Augustine, FL from 2006 data.

SPECIES	FISH RANK	POUNDS	VALUE	DEALERS
CRABS,BLUE,HARD	1	219,975	$234,279	115
SHRIMP	2	189,946	$419,478	63
DOLPHINFISH	3	43,310	$72,850	20
OYSTER	4	52,686	$187,164	34
SNAPPER,VERMILION	5	37,258	$101,296	40

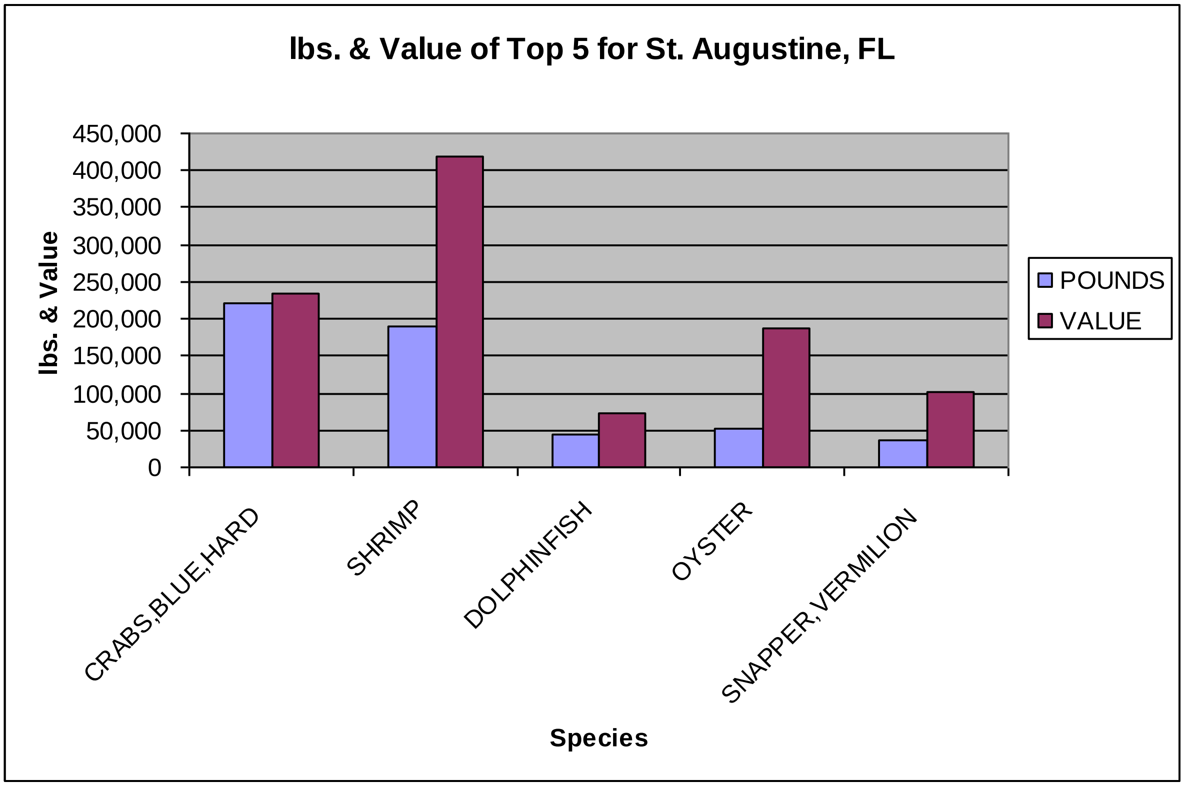


Figure 5.2.1-15. Value and pounds of top five species in St. Augustine, FL for 2006.

<u>Fort Myers Community Description</u>

Fort Myers is located on the east banks of the Caloosahatchee River in central Lee County. Access to the Gulf of Mexico can be over ten miles via the Caloosahatchee River to San Carlos Bay. Fort Myers served as a military operations base during the Seminole Indian Wars in the mid-1800s. Following the platting of the town in 1876, Fort Myers' economic focus turned from defense to agriculture (tomatoes, castor beans, and avocados), cattle, and logging.

The year 2000 census counted 48,208 persons in Fort Myers, an increase of 3,002 persons from the 1990 census (Table 5.2.1-95). Shrimp is the principal landing for the commercial fleet in Lee County, though a wide range of species are landed, including some pelagics (Table 5.2.1-96). There are numerous seafood dealers, marinas, and various other fishing-related businesses active in Fort Myers throughout the course of the year. Charter fishing is popular here.

Table 5.2.1-95 Fort Myers, FL demographic data from 1990-2000 (Source: U.S. Census Bureau Decennial census).

Fort Myers, FL	**1990**	**2000**
Population	45,206	48,208
Education Attainment	High school graduate	High school graduate
White	27,091	27,166
Black or African American	14,183	6,095
American Indian & Alaska Native	83	181
Asian, Native Hawaiian & Other Pacific Islander	334	520
Some Other Race	26	2,745
Hispanic or Latino (or any race)	3,489	6,984
Total Housing Units	21,388	21,836
Vacant	3,244	2,729
Median Gross Rent	$373	$272
Median Housing Value	$60,500	$76,700
Median Household Income	$22,102	$28,514
Per Capita Income	$12,329	$17,312
Unemployment %	3.90%	3.70%
Employment by Industry (Top 5)		
Educational, health & social services	11%	18.90%
Arts, entertainment, recreation, accommodation & food services	DO	13%
Professional, scientific, mgmt. administrative, & waste mgmt. services	DO	12%
Retail trade	30.20%	15.60%
Construction	7%	11.30%
Personal services	10%	DO
Public administration	9.20%	DO
DO= Dropped Out		

<u>Fort Myers Beach Community Description</u>

Fort Myers Beach is located on the northern tip of Estero Island in western Lee County. It is surrounded by water: the Gulf of Mexico to the west, Estero Bay to the east, and San Carlos Bay to the north.

Anglo homesteaders arrived in the late 1800s and quickly developed the island's commercial fishing industry; mullet was the primary catch. Investors gradually bought up the majority of available subdivisions on the island during the 1920s; however, commercial development remained slow through the 1960s. In the meantime, the island's fishing industry continued to thrive. In particular, the Coquina clam– the area's most common shellfish– was a popular pre-war product. By the 1950s, Fort Myers Beach was an important shrimp port. In the 1960s, recreational fishing became popular in the area, with snook, trout, ladyfish, jacks, mackerel, kingfish, bonito, grouper, and tarpon being the primary species of interest. Fort Myers Beach incorporated in 1995 (Town of Fort Myers Beach).

The year 2000 population of Fort Myers Beach was 6,561, down from 9,284 in 1990 (Table 5.2.1-96). Fort Myers Beach is primarily a beach/tourist destination island. Numerous fishing-associated businesses are located here, and sightseeing and diving tours are popular activities. There is substantial recreational fishing infrastructure, as marinas, docking facilities, head boat operations, and charter boats are all available here. Fort Myers Beach is the site of docking facilities for about 60 or more Gulf shrimp vessels. Some trawler captains and crew are local, while many are transient and come from as far away as Texas. Offloading facilities, fuel, and maintenance (including net building and repair) are available at the docks.

Table 5.2.1-96. Fort Myers Beach, FL demographic data from 1990-2000 (Source: U.S. Census Bureau Decennial census).

Fort Myers Beach, FL	**1990**	**2000**
Population	9,284	6,561
Education Attainment	High school graduate	Some college, no degree
White	9,248	6,380
Black or African American	7	5
American Indian & Alaska Native	12	25
Asian, Native Hawaiian & Other Pacific Islander	11	21
Some Other Race	6	65
Hispanic or Latino (or any race)	110	227
Total Housing Units	9,977	8,429
Vacant	5,643	5,004
Median Gross Rent	$476	$700
Median Housing Value	$137,100	$193,900
Median Household Income	$28,536	$48,045
Per Capita Income	$19,445	$34,703
Unemployment %	6.80%	1.40%
Employment by Industry (Top 5)		
Arts, entertainment, recreation, accommodation & food services	DO	24.90%
Construction	12.30%	11.30%
Retail Trade	25.10%	12.10%
Finance, insurance, real estate, & rental and leasing	7.50%	15%
Educational, health & social services	10.80%	12.10%
Personal services	8.20%	DO
DO= Dropped Out		

Table 5.2.1-97. Top five species by pounds caught in Lee County, FL from 2006 data.

SPECIES	FISH RANK	POUNDS	VALUE
SHRIMP	1	5,590,206	$13,541,584
BLUE,HARD,CRABS	2	2,441,161	$1,813,104
MULLET, STREIPED	3	627,608	$389,977
MULLET with ROE	4	500,034	$426,617
GROUPER	5	282,323	$723,041

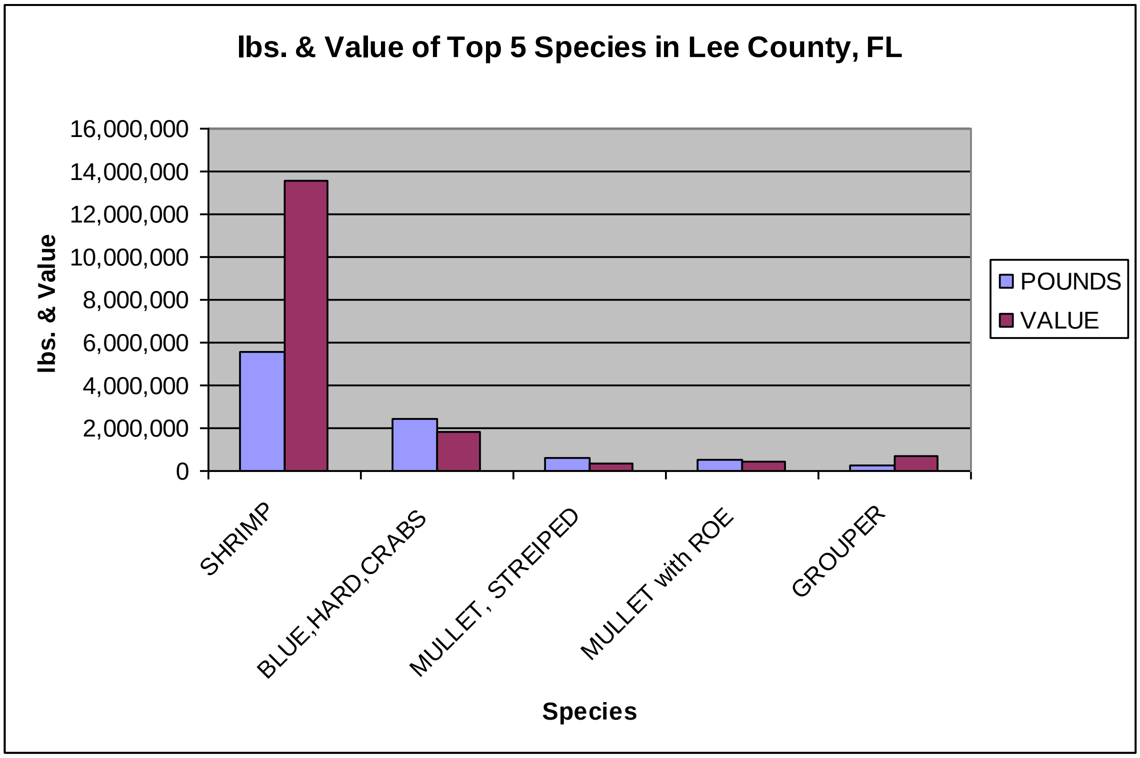


Figure 5.2.1-16. Value and pounds of top five species in Lee County, FL for 2006.

<u>Tarpon Springs Community Description</u>

Tarpon Springs is located about 25 miles northwest of Tampa, adjacent to a well-protected anchorage near the mouth of the Anclote River. The town has roots in the commercial sponge-diving industry and still supports the largest natural sponge operation in the country. Tarpon Springs was incorporated in 1887 in Hillsborough County, but became part of Pinellas County in 1911. According to city historians, from 1905 to 1945, and again during the 1980's, a local fleet of 180 sponge boats worked from Apalachicola to Key West, bringing in $3 million annually to the local economy. A commercial fishing industry developed around 1920, with several fish houses and wholesale retail operations that continue today near the Sponge Docks. There were as many as eight fish houses operating in Tarpon Springs.

The year 2000 census enumerated 21,066 persons in Tarpon Springs, a 17 percent increase from 1990 (Table 5.2.1-98). Today, there are three active sponge factories and four active wholesale fish houses in Tarpon Springs.

Table 5.2.1-98. Tarpon Springs, FL demographic data from 1990-2000 (Source: U.S. Census Bureau Decennial census).

Tarpon Springs, FL	1990	2000
Population	17,906	21,003
Education Attainment	High School graduate or higher, no college degree	Some College, no degree
White	16,277	18,918
Black or African American	1,439	1,292
American Indian & Alaska Native	39	61
Asian, Native Hawaiian & Other Pacific Islander	124	232
Some Other Race	77	171
Hispanic or Latino (or any race)	323	909
Total Housing Units	9,116	10,759
Vacant	1,718	1,692
Median Gross Rent	$355	$528
Median Housing Value	$80,700	$107,100
Median Household Income	$25,380	$38,251
Per Capita Income	$13,557	$21,504
Unemployment %	6.90%	4.10%
Employment by Industry (Top 5)		
Retail trade	24.10%	13.70%
Professional, scientific, mgmt. administrative, & waste mgmt. services	6.50%	14.40%
Educational, health & social services	16.10%	18.90%
Arts, entertainment, recreation, accommodation and food services	DO	9.80%
Construction	10.40%	8.80%
Finance, insurance, and real estate	6.40%	DO
DO= Dropped Out		

Local fleet participants report that the number of active fishing vessels has decreased by half in the past ten years, going from approximately 100 to 50 vessels. They attribute the decrease to regulatory pressures, diminishing docking space, and the recent national and regional economic downturn. Most vessel owners feel that it is too expensive to rent docking space in the immediate area, and free space (that is, attached to fish house properties) is decreasing due to the increasing value and sale of waterfront property. Meanwhile, the number of recreational vessels moored at the local marinas has increased significantly. The town now has seven marinas that allow only recreational clientele. This number has increased over the past ten years, and marina owners now feel pressure to expand their docking space. One marina owner stated that he could not keep up with the number of recreational vessels coming into the community. Grouper are the top species landed in Pinellas County (Table 5.2.1-99 and Figure 5.2.1-17).

Table 5.2.1-99. Top five species by pounds caught in Pinellas County, FL from 2006 data.

SPECIES	FISH RANK	POUNDS	VALUE
GROUPER	1	3,628,451	$8,898,020
MULLET WITH ROE	2	1,271,936	$1,278,168
SHRIMP	3	886,845	1,918,293
SHARKS	4	685,124	193,605
CRABS,BLUE,HARD	5	584,000	$643,708

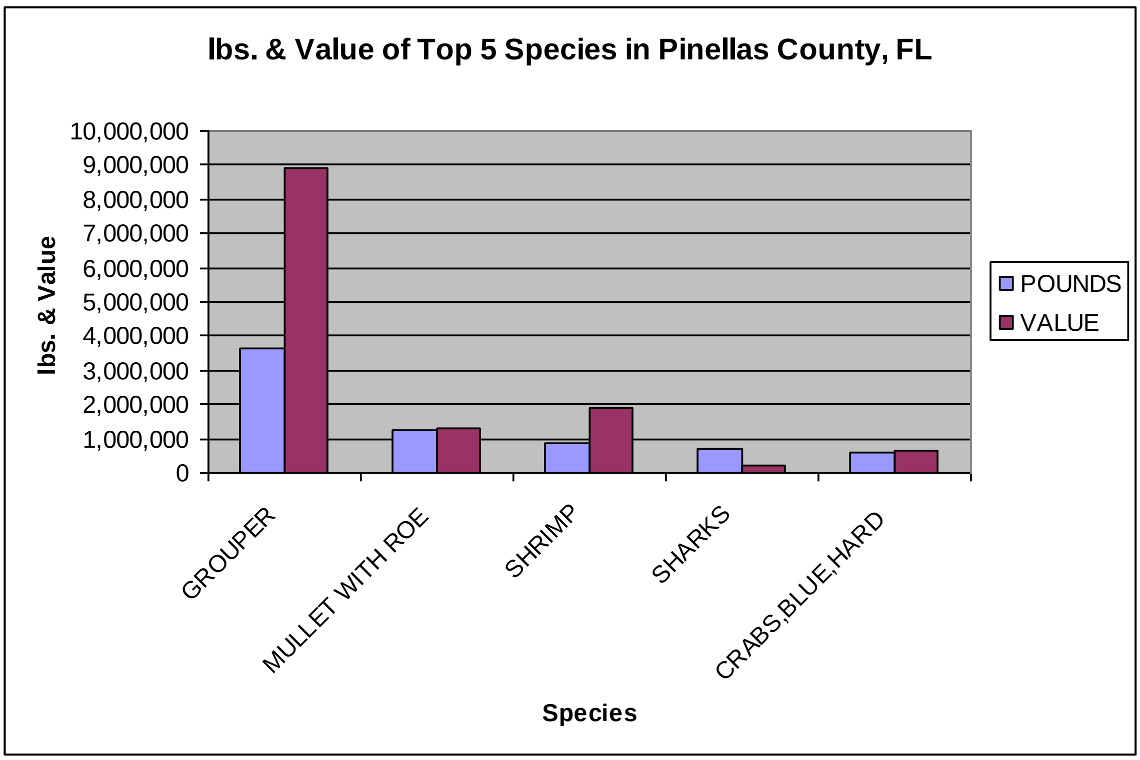


Figure 5.2.1-17. Value and pounds of top five species in Pinellas County, FL for 2006.

5.2.1.3.5 <u>*Alabama Communities*</u>

<u>Grand Bay Community Description</u>

Grand Bay is located in Mobile County, 25 miles south of the Gulf of Mexico. Grand Bay was founded in 1870 and in 2000 had a population of 3,918 (Table 5.2.1-100). Two wholesale seafood dealers are based here. One processes primarily oysters and the other crab. Most commercial fishermen who live in Grand Bay work from Bayou La Batre. The fleet is highly productive in shrimp, crabs, and oysters. Four Gulf shrimp permit holders were working from the area in 2003.

Table 5.2.1-100. Grand Bay, AL demographic data from 1990-2000.(Source: U.S. Census Bureau Decennial census).

Grand Bay, AL	**1990**	**2000**
Population	3,383	3,918
Education Attainment	High School graduate or higher, no college degree	High School graduate or higher, no college degree
White	2,998	3,487
Black or African American	665	348
American Indian & Alaska Native	13	9
Asian, Native Hawaiian & Other Pacific Islander	12	33
Some Other Race	5	5
Hispanic or Latino (or any race)	33	34
Total Housing Units	12,454	1,441
Vacant	113	77
Median Gross Rent	$238	$521
Median Housing Value	$53,600	$76,500
Median Household Income	$26,651	$38,941
Per Capita Income	$11,046	$15,741
Unemployment %	4.30%	6.20%
Employment by Industry (Top 5)		
Retail Trade	18%	10.80%
Construction	11.70%	9.20%
Manufacturing	20.40%	26.50%
Educational, health services	13%	11.40%
Wholesale Trade	7.20%	DO
Transportation and warehousing, and utilities	DO	6.80%
DO = Dropped Out		

Fairhope Community Description

Fairhope is located along the eastern shore of Mobile Bay in west-central Baldwin County, approximately 25 miles northeast of the Gulf of Mexico. Fairhope was established as a "utopian" community by "single-tax colonists" in 1894. These political idealists embraced theories advanced by Henry George, advocating no taxes other than a single land tax. One of the first local endeavors was to build a municipal pier, completed in 1885.

The year 2000 population of Fairhope was 12,480 persons, up from 8,485 in 1990 (Table 5.2.1-101). Several locally-owned shrimp boats are docked at one marina; according to the manager, the owners are retired and fish only occasionally.

Table 5.2.1-101. Fairhope, AL demographic data from 1990-2000. (Source: U.S. Census Bureau Decennial census).

Fairhope, AL	**1990**	**2000**
Population	8,485	12,480
Education Attainment	High School graduate or higher, no college degree	High School graduate or higher, no college degree
White	7,850	11,259
Black or African American	580	972
American Indian & Alaska Native	17	25
Asian, Native Hawaiian & Other Pacific Islander	26	82
Some Other Race	12	26
Hispanic or Latino (or any race)	91	130
Total Housing Units	3,808	6,000
Vacant	258	655
Median Gross Rent	$307	$710
Median Housing Value	$70,100	$149,900
Median Household Income	$28,824	$42,913
Per Capita Income	$14,987	$25,237
Unemployment %	3.80%	2.40%
Employment by Industry (Top 5)		
Educational, health, social services	16%	25%
Retail Trade	16.80%	11.20%
Arts, entertainment, recreation, accommodation, food services	DO	9.20%
Professional, scientific, mgmt. administrative, waste mgmt. services	DO	9.20%
Manufacturing	12.60%	7.20%
Other professional and related services	7.60%	DO
Finance, insurance, and real estate	7.20%	DO
DO= Dropped Out		

Two marina managers stated that most of their customers are interested in pleasure boating rather than fishing. Four charter operations are based here, as is a small group of commercial license holders. Shrimp were the principal commercial landings during 2002 (Table 5.2.1-102 and Figure 5.2.1-18).

Table 5.2.1-102. Top five species by pounds caught in Baldwin County, AL from 2006 data.

SPECIES	FISH RANK	POUNDS	VALUE
SHRIMP	1	3,068,199	$6,069,491
STRIPED MULLET	2	712,763	$383,117
TENPOUNDER	3	639,138	$383,626
SHARK	4	472,678	$170,426
SPANISH MACKEREL	5	591,629	$375,066

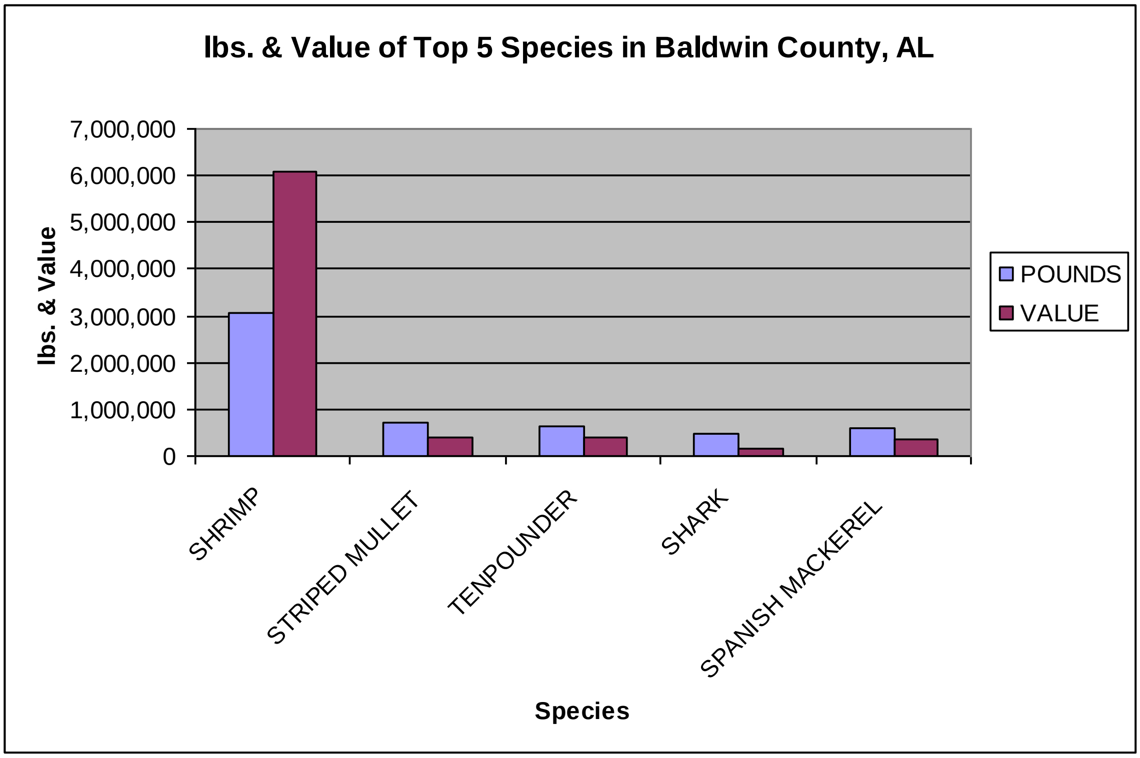


Figure 5.2.1-18. Value and pounds of top five species in Baldwin County, AL for 2006.

5.2.1.3.6 *Mississippi Communities*

Pascagoula Community Description

Pascagoula is located in Jackson County and is bordered by three bodies of water: Pascagoula Bay to the west, Mississippi Sound to the south, and Point aux Chenes Bay to the east. The Gulf of Mexico is roughly ten miles south.

This city is home to the Naval Station Pascagoula and one of Mississippi's leading and busiest deepwater ports, the Port of Pascagoula. The shipbuilding industry is very active in Pascagoula, as are the oil and petrochemical industries. The year 2000 census enumerated 26,200 persons in Pascagoula, an increase of 301 from 1990 (Table 5.2.1-103). The Pascagoula seafood industry is an important source of local jobs and income. The shipbuilding industry is particularly important, however, and one of the larger shipbuilding operations in the area employees more than 11,000 persons. The operation is the largest employer in the state. As of the year 2000, six seafood processors employed an average of 24 persons each. Some 12.4 million pounds of seafood totaling 8.2 million dollars were processed in Pascagoula that year. A large fleet of small boat commercial operators is also based here; most pursue shrimp and various finfish in the inshore and nearshore waters of the sound and Gulf. Menhaden is the number one species landed (Table 5.2.1-104 and Figure 5.2.1-19).

Table 5.2.1-103. Pascagoula, MS demographic data from 1990-2000. (Source U.S. Census Bureau Decennial census.)

Pascagoula, MS	**1990**	**2000**
Population	25,899	26,200
Education Attainment	High School graduate or higher, no college degree	High School graduate or higher, no college degree
White	19,998	17,594
Black or African American	5,557	7,590
American Indian & Alaska Native	49	47
Asian, Native Hawaiian & Other Pacific Islander	239	259
Some Other Race	56	437
Hispanic or Latino (or any race)	252	1,019
Total Housing Units	11,053	10,942
Vacant	1,279	
Median Gross Rent	$265	$486
Median Housing Value	$49,100	$69,000
Median Household Income	$24,986	$32,042
Per Capita Income	$9,056	$16,891
Unemployment %	7.80%	9.30%
Employment by Industry (Top 5)		
Retail Trade	17.50%	11.40%
Manufacturing	31.50%	24.40%
Education, health services	14.80%	18.70%
Other professional & related services	6%	5.70%
Construction	5.60%	8.20%
Arts, entertainment, recreation, accommodation & food services	DO	8.10%
DO= Dropped Out		

Table 5.2.1-104. Top five species by pounds caught in Jackson County, MS from 2006 data.

	FISH RANK	POUNDS	VALUE
MENHADEN	1	211,163,171	$8,446,609
BUTTERFISH	2	537,636	$134,412
SCADS	3	104,391	$36,539
STRIPED MULLET	4	65,358	$22,924
TUNA, LITTLE	5	54,999	$19,248

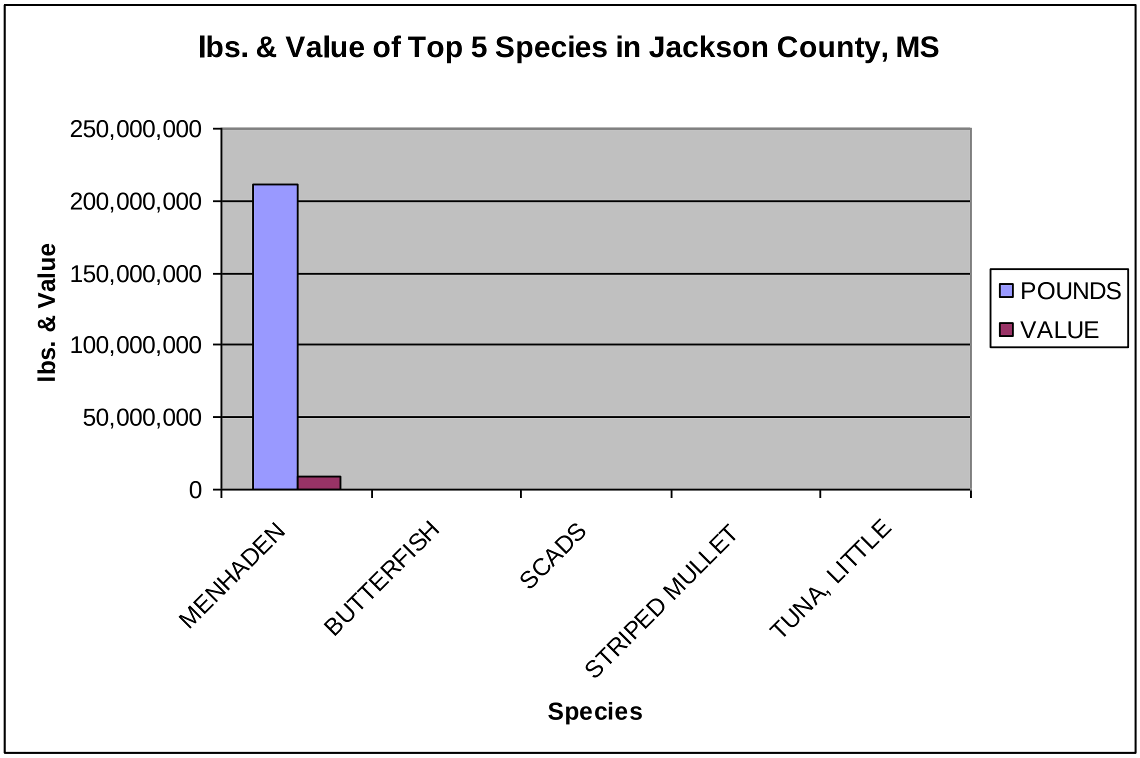


Figure 5.2.1-19. Value and pounds of top five species in Jackson County, MS for 2006.

5.2.1.3.7 *Texas Communities*

Port Arthur Community Description

Port Arthur is located along the Intracoastal Waterway and Sabine Lake in eastern Jefferson County. Port Arthur is about 14 miles north of the Gulf of Mexico and the Gulfgate Bridge connects it with Pleasure Island and provides access to the Sabine Lake Causeway. The town of Port Arthur was founded in the late 1800s by railroad pioneer Arthur E. Stilwell, with financial support from Dutch investors. Growth occurred in the early 1900s after the port opened for shipping. Economic prosperity was closely tied to the Spindletop oil field in nearby Beaumont. The Gulf Oil Corporation and Texaco established refineries in Port Arthur. The year 2000 census reported a population of 57,755 persons, a loss of 969 from 1990 (Table 5.2.1-105). Extensive fishing-related infrastructure is in place here, including numerous boat builders and brokers, marinas, processors, and retail and wholesale seafood dealers. A fleet of charter vessels is also based here. A relatively large fleet of trawlers is based here, with 35 persons holding Gulf shrimp permits in 2003. Shrimp are the number one species landed (Table 5.2.1-106 and Figure 5.2.1-20).

Table 5.2.1-105. Port Arthur, TX demographic data from 1990-2000. (Source U.S. Census Bureau Decennial census.)

Port Arthur, TX	**1990**	**2000**
Population	58,724	57,755
Education Attainment	High School graduate or higher, no college degree	High School graduate or higher, no college degree
White	28,955	22,528
Black or African American	24,778	25,240
American Indian & Alaska Native	147	260
Asian, Native Hawaiian & Other Pacific Islander	2,825	3,413
Some Other Race	2,019	5,127
Hispanic or Latino (or any race)	4,829	10,081
Total Housing Units	25,746	24,713
Vacant	3,420	2,874
Median Gross Rent	$226	$405
Median Housing Value	$30,400	$35,900
Median Household Income	$18,548	$26,455
Per Capita Income	$9,706	$14,183
Unemployment %	6.90%	7.00%
Employment by Industry (Top 5)		
Educational, health & social services	19.20%	22%
Manufacturing	17.60%	13.10%
Retail Trade	20.50%	12.60%
Construction	8.40%	9.50%
Arts, entertainment, recreation, accommodation & food services	DO	7.20%
Business & repair services	5.40%	DO
DO=Dropped Out		

Table 5.2.1-106. Top five species by pounds caught in Jefferson County, TX from 2006 data.

SPECIES	FISH RANK	POUNDS	VALUE
SHRIMP	1	24,504,592	$42,546,350
CRABS,BLUE,HARD	2	504,105	$303,813
CATFISH	3	48,747	$44,143
SNAPPER	4	28,278	$77,571
SUCKERS	5	2,748	$1,648

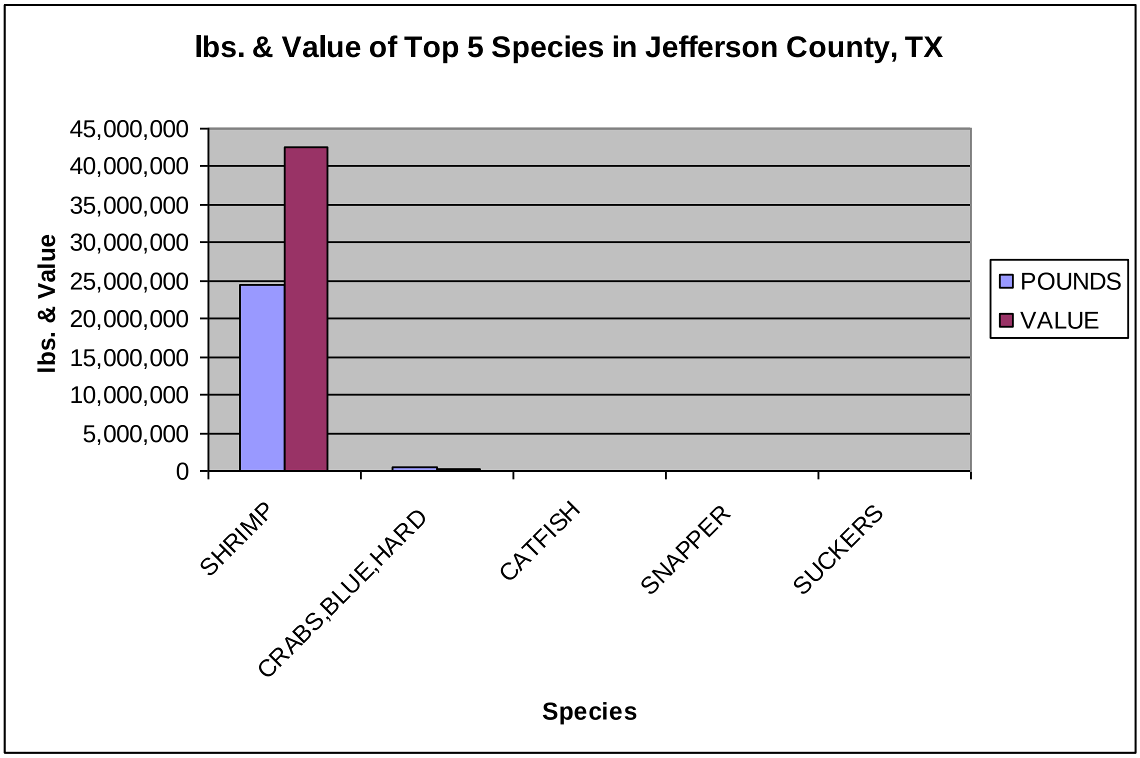


Figure 5.2.1-20. Value and pounds of top five species in Jefferson County, TX for 2006.

5.2.1.4 Bycatch in the Shrimp Fishery

5.2.1.4.1 Bycatch in the Penaeid Shrimp Fishery

Description of bycatch in the penaeid shrimp fishery prior to the use of BRDs

The discarded bycatch of fish and invertebrates in the penaeid shrimp trawl fishery is highly variable according to season and area. The following information reflects bycatch levels and composition in the penaeid shrimp fishery prior to the requirement for use of bycatch reduction devices (BRDs). It has been documented that federally approved BRDs reduce overall finfish bycatch by approximately 30% in the South Atlantic. These devices also reduce the numbers of weakfish and Spanish mackerel in the catch by 40%.

Results of initial studies to document bycatch in the penaeid shrimp fishery were described in Amendment 2 to the South Atlantic Shrimp Fishery Management Plan (SAFMC 1996b). Previous determinations of the ratio of finfish (lb) to shrimp (lb heads on) in North Carolina indicated that the daytime ratios were consistently higher than the nighttime ratios due to larger shrimp catches rather than lower finfish catches.

The first integrated bycatch program was part of the congressionally mandated Bycatch Research Program from February 1992 through December 1996. This program was carried out to characterize the entire southeast shrimp fishery prosecuted in both the Gulf and South Atlantic region. To ensure the integrity and validity of the results, the following research protocols were followed:

1. A voluntary observer program using trained observers was undertaken. The program included vessel insurance and compensation for cooperating vessels.
2. Using a stratified sampling approach indexed to shrimping effort, NOAA Fisheries and other cooperating institutions deployed observers throughout the fleet to document bycatch during normal fishing operations using standard data collection methods.
3. All data were entered into a common database managed by NOAA Fisheries' Southeast Fisheries Science Center's Galveston Laboratory.
4. Characterization data were analyzed, and these data and analyses were made available to other program researchers and fishery managers.

For characterization sampling, the entire catch of each trawl was sampled, and all species quantified. For BRD evaluations, a select group of finfishes and other species were quantified, with the remainder of the catch grouped into general categories. Therefore, both bycatch characterization sampling and BRD evaluation data were use to determine general categories of bycatch. Sampling was stratified based on shrimp effort, and given that the South Atlantic shrimp fishery accounts for approximately 10-15 % of the total U.S. shrimp production, the sampling effort was limited for some temporal and spatial strata. Nevertheless, the sampling that occurred provided a sufficient basis for NOAA Fisheries to characterize the fishery in the South Atlantic region. During that program, observers logged a total of 920 sea days documenting bycatch in the South Atlantic shrimp fishery. The majority of the effort was expended during 1992 through 1994.

In response to this federally mandated research program, NOAA Fisheries began cooperative work with the shrimp industry through the Gulf and South Atlantic Fisheries Foundation. The cooperative bycatch research program studied bycatch and gear options in shrimp trawl fisheries throughout the southeast region. The study estimated the catch rate for shrimp and bycatch in the South Atlantic penaeid shrimp fishery.

The South Atlantic observer program included 920 sea days of sampling effort from February 1992 through December 1996. These sea days were accomplished during 604 trips, varying in length from 1 to 54 days (Nance 1998). The results of the program are detailed in Nance (1998) and Nance et al. (1997), and presented in Tables 5.2.1-107 and 5.2.1-108. In summary, the study indicated that about 27 kg (59.5 lb) of organisms per hour are taken during trawling operations, and that the finfish to shrimp ratio for the South Atlantic shrimp fishery was 2.83 to 1 by weight and 2.35 to 1 by number. Finfish comprised the majority (51%) of the catch by weight, followed by non-commercial invertebrates (31%), and commercial shrimp species (18%), including brown shrimp, white shrimp, pink shrimp, seabobs, sugar/blood shrimp and rock shrimp. Finfish represented about 54% of the 1,450 organisms taken per hour during normal trawling operations. Non-commercial invertebrates and commercial shrimp species each comprised about 23% of the catch by number (Nance et al. 1997).

Shrimp trawl catch per hour changed seasonally, being lowest during the first trimester of the year (ca. 12 kg/hr [26.5 lb/hr]), while the summer and post-summer seasons had very similar catch rates at around 28-30 kg per hour (Table 5.2.1-107). Finfish catch rates always comprised more than 44% of the catch, while shrimp catch rates were approximately 15% to 18% in the summer and post-summer periods, respectively, but 37% in the pre-summer season. Finfish catch by weight for the entire shrimp fishery was highest between May and August. The highest catch rate of finfish by number occurred in September through December, with nearly 1,800 individual finfish caught per hour. Shrimp catches were higher then too, resulting in a finfish to shrimp ratio of only 2.59 individual finfish to 1 shrimp.

Similarly, shrimp trawl catch per hour differed by latitude as well. By weight, the northern area (>34 N) had the highest overall catch rates (37 kg/hr [81.6 lb/hr]), while areas to the south of 34 N had catch rates at around 25 kg/hr (55.1 lb/hr) (Nance et al. 1997).

Table 5.2.1-107. Average percent composition of shrimp trawl catch by season in the South Atlantic (NOAA Fisheries 1998).

Catch	**Weight**	**Weight**	**Weight**	**Number**	**Number**	**Number**
Time period	Jan-April	May-Aug	Sept-Dec	Jan-April	May-Aug	Sept-Dec
Finfish	44%	58%	44%	65%	58%	44%
Shrimp	37%	15%	18%	11%	26%	17%
Crustaceans	9%	14%	14%	21%	14%	9%
Invertebrates	9%	13%	25%	3%	3%	30%
Total catch (per hr)	12 kg 26.5 lb	30 kg 66.1 lb	28 kg 61.7 lb	850	1350	1800
Finfish:Shrimp ratio	1.19 to 1	3.87 to 1	2.44 to 1	5.91 to 1	2.23 to 1	2.59 to 1

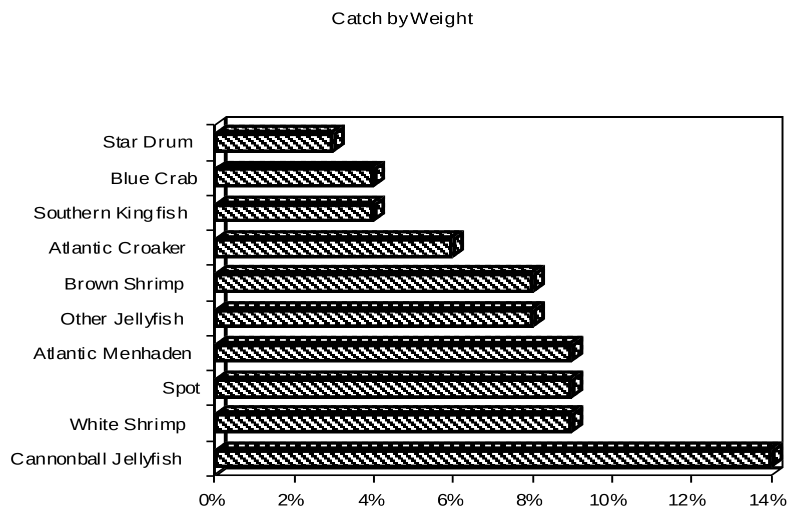
Additional information collected during the Bycatch Program was presented in Amendment 2 to the Shrimp FMP. When looking at catch according to depth of the fishing effort across all shrimp fisheries, the highest bycatch of finfish came from vessels fishing in 60 ft (18.3 m) or greater depths, with 56% of the catch being finfish and 18% shrimp or a ratio of 3.1 finfish caught for each shrimp caught (Table 5.2.1-108).

Table 5.2.1-108. Percent average hourly shrimp trawl catch by area and depth (Data Source: NOAA Fisheries 1995).

Area	**Finfish**	**Shrimp**	**Crustaceans**	**Invertebrates**	**Total Catch (number)**	**Finfish to Shrimp**
South Atlantic < 18.3 m (60 ft)	46%	29%	11%	14%	1229	1.6 to 1
> 18.3 m (60 ft)	56%	18%	21%	5%	726	3.1 to 1
Florida < 18.3 m (60 ft)	37%	30%	27%	6%	1207	1.2 to 1
> 18.3 m (60 ft)	43%	29%	23%	4%	802	1.5 to 1

* 393 sea days, 63 trips and 679 tows

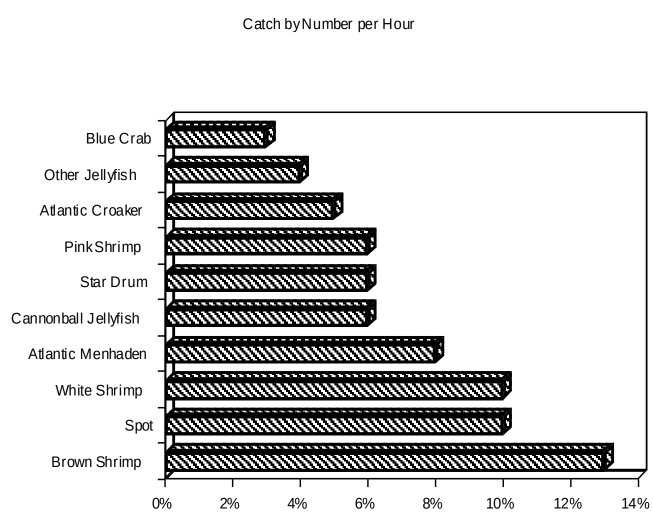
When summarizing catch of the South Atlantic shrimp fleet by species, cannonball jellyfish constituted 14% of the catch by weight and brown shrimp made up 8% of the catch by weight and 13% of the catch by number (Figure 5.2.1-21, Figure 5.2.1-22). White shrimp constituted 9% of the catch by weight and 10% of the catch by number. The highest catch of an individual finfish species was spot, which accounted for 9% of the catch by weight and 10% by number (Figure 5.2.1-21, Figure 5.2.1-22).



* 393 sea days, 63 trips and 679 tows

Figure 5.2.1-21. Top ten species caught in South Atlantic shrimp trawls by weight

(Data Source: SAFMC 1996a).



* 393 sea days, 63 trips and 679 tows

Figure 5.2.1-22. Top ten species caught in South Atlantic shrimp trawls by number

(Data Source: SAFMC 1996a).

BRD research program

The second part of the congressionally mandated Bycatch Research Program, from 1992 through 1996, involved the development and review of bycatch reduction devices (BRDs). These trawl gear modifications were identified as the most cost-effective and least disruptive way to minimize finfish bycatch in the shrimp fishery. A four-phase development program was successfully used under this program structure to develop several BRD designs that are used in the fishery. Within this framework, the research and development of candidate devices was carried out independently by NOAA Fisheries, Sea Grant, state agencies, universities and industry, drawing on a variety of funding sources, primarily the Saltonstall-Kennedy (S-K) and MARFIN (Marine Fisheries Initiative) grants programs.

From 1992 to 1996, fishery researchers and commercial fishers developed and tested a total of 145 bycatch reduction device (BRD) designs throughout the southeast region. Research conducted by the Gulf and South Atlantic Fisheries Foundation, Inc. (Foundation), indicated that reductions in general catch and bycatch were 22% or less (Table 5.2.1-109). Spanish mackerel catch rate was reduced by 0%-83% and weakfish catch rate was reduced by 6%-58% (Table 5.2.1-110). The State of North Carolina also conducted testing on BRDs and Table 5.2.1-111 presents a summary of the observed reduction rates for BRDs that were proposed for use in federal waters when Shrimp Amendment 2 was developed (SAFMC 1996b). Detailed information on reductions associated with TEDs and BRDs are presented in Shrimp Amendment 2 (SAFMC 1996b) and included here by reference.

Table 5.2.1-109. Summary of reductions (kg/hr) attributed to BRD designs tested in the South Atlantic during 1993 and 1994 (Sources: Watson, NOAA Fisheries, pers. comm. 1995 and Branstetter, GSAFDF pers. comm. 1996).

	Fish-eye 4"Hx7"W 30 meshes from front	Fish-eye 5"Hx 12"W 30 meshes from front	Fish-eye 5"Hx 12"W 45 meshes from front	Large mesh extended funnel
Total biomass (kg/hr)	-4(27)	-9*(66)	-9(117)	-12(156)
Crustaceans (kg/hr)	+6(27)	-13*(66)	-14*(80)	-13*(156)
Other invertebrates (kg/hr)	-2(27)	-7(66)	-4(111)	-9*(156)
Total finfish (kg/hr)	-16(27)	-16*(66)	-12*(117)	-22*(156)
Comm. shrimp (kg/hr)	-3(27)	-1(66)	-1(116)	+2(156)
Misc. fish spp. (kg/hr)	-15(26)	-6(66)	-14(122)	-22*(156)

* statistical difference from zero where Ho = CPUE of control net - CPUE of the BRD net = 0. Numbers in ( ) represent sample size.

Table 5.2.1-110. Reduction rates (kg/hr) for weakfish, shrimp and Spanish mackerel for the large mesh extended funnel BRD tested primarily off Georgia and South Carolina (1995 GSAFDF data); (Data Source: Watson, NOAA Fisheries, pers. comm. 1995).

Large mesh extended funnel	Reduction rate (kg/hr)	Number	95% Conf.
Weakfish	-37%	63	35%-39%
Spanish mackerel	-44%	26	39%-48%
Shrimp	+2%	63	

Table 5.2.1-111. Reduction rates (kg/hr) for weakfish and Spanish mackerel for Florida fisheye and large mesh extended funnel BRDs tested primarily off North Carolina (NCDMF 1992-1994 data) (Data Source: Watson, NOAA Fisheries, pers. comm. 1995).

Florida fisheye		Reduction rate (kg/hr)	Number = 213
	Weakfish	-58%	
	Spanish mackerel	-34%	
	Shrimp	-8%	
Large mesh extended funnel		Reduction rate (kg/hr)	Number = 36
	Weakfish	-56%	
	Spanish mackerel	-83%	
	Shrimp	-2%	

The fisheye tested by NCDMF off North Carolina reduced weakfish bycatch by 58% with high reductions for other species including spot and Atlantic croaker, which were reduced by more than 50%. The NCDMF tests showed that the fisheye reduced total finfish bycatch by 48% and total biomass by 28% (SAFMC 1996b).

A comparison of reduction rates attributable to various fisheye configurations tested aboard commercial trawlers in North Carolina between 1992 and 1994 indicated that the 9" by 9" fisheye reduced total biomass by over 60% and the 5.5" by 6.5" fisheye showed the greatest finfish reduction of about 60%. The 9" by 9" fisheye reduced Spanish mackerel approximately 50% and the 5.5" by 6.5" fisheye reduced weakfish by over 70% (Table 5.2.1-112). Tests of large mesh extended funnel BRDs were conducted by NCDMF and showed reduction rates of 55% in finfish numbers and 56% in the number of weakfish (SAFMC 1996b).

Table 5.2.1-112. Reduction rates (kg/hr) for weakfish, trout and Spanish mackerel for large mesh extended funnel and midsize fisheyes tested primarily off South Carolina and Georgia (1993-1994 NOAA Fisheries and GSAFDF data) (Data Source: Watson, NOAA Fisheries, pers. comm. 1995).

Large mesh extended funnel	Reduction rate (kg/hr)	Number	95% Conf.
Weakfish	-6%	39	
Spanish mackerel	-38%	67	16%-59%
Trout	-27%	148	15%-39%
Shrimp	+3%	186	

Midsize fisheye w/hard TEDs 30-mesh position	Reduction rate (kg/hr)	Number	95% Conf.
Weakfish	-40%	58	29%-52%
Spanish mackerel	-34%	47	24%-44%
Trout	-29%	174	21%-37%
Shrimp	+3%	268	3%-10%

Midsize fisheye, w/soft TEDs 30-mesh position	Reduction rate (kg/hr)	Number	95% Conf.
Weakfish	-7%	26	-
Spanish mackerel	-0%	20	-
Trout	-20%	32	-
Shrimp	-2%	112	-

Midsize fisheye, 45-mesh position	Reduction rate (kg/hr)	Number	95% Conf.
Weakfish	-16%	95	
Spanish mackerel	-0%	30	
Trout	-81%	4	
Shrimp	+3%	160	

These evaluations resulted in the approval of 3 BRD designs for use by the South Atlantic penaeid shrimp fishery. Regulations implementing the actions described in Amendment 2 to the FMP were promulgated effective April 21, 1997. The final rule established a requirement, with limited exceptions, for the use of certified BRDs in penaeid (brown, pink and white) shrimp trawls towed in the South Atlantic exclusive economic zone (EEZ).

Re-evaluations of all Gulf of Mexico and South Atlantic datasets generated by NOAA Fisheries and the Foundation were utilized in determining the effectiveness of BRDs for use in the eastern Gulf of Mexico (Amendment 10 to the Gulf of Mexico Shrimp Fishery Management Plan; Table 5.2.1-113). The BRDs currently certified in the South Atlantic (the fisheye and the expanded mesh) achieve a 30% reduction in overall finfish bycatch.

Table 5.2.1-113. Reduction rate estimates of various BRDs and one TED for the Gulf of Mexico and South Atlantic
(taken from GMFMC Shrimp FMP Amendment 10).

Species	n	Reduction Rate (%)	P - Value	95% C.I. (%)
12x5 Fisheye BRD				
Shrimp (wt)	157	4	0.16	--
Total Fish (wt)	141	35	0	30 to 39
12x5 Fisheye BRD in the 2.6 Meter Position				
Shrimp (wt)	105	4	0.17	--
Total Fish (wt)	98	44	0	38 to 49
12x5 Fisheye BRD in the 3.8 Meter Position				
Shrimp (wt)	35	-1*	0.78	--
Total Fish (wt)	35	31	0	24 to 37
Extended Funnel Device				
Shrimp (wt)	299	0	0.74	--
Total Fish (wt)	280	38	0	32 to 44
Jones/Davis BRD				
Shrimp (wt)	33	4	0.07	0 to 9
Total Fish (wt)	31	58	0	53 to 63
Parker TED				
Shrimp (wt)	68	7	0.00	4 to 10
Total Fish (wt)	67	32	0.00	28 to 36

*Negative values represent a nominal increase. Source: NOAA Fisheries (unpublished data).

It has been demonstrated that the use of a turtle excluder device (TED) also reduces finfish bycatch in penaeid shrimp trawls. A number of experimental trials were conducted in Cape Canaveral, Florida, during 1986 to test the bycatch reduction capability of various TED designs and configurations. Based on the results of these trials, the Atlantic States Marine Fisheries Commission Weakfish Management Board granted a 23.9% TED credit for weakfish reduction (GSAFF 1999). However, many of those TEDs were soft (net webbing) TEDs that were never certified for use by NOAA Fisheries. Soft TEDs have much greater bycatch exclusion capability than hard (metal grid) TEDs.

The Foundation tested several hard TEDs during the late 1990s for their bycatch exclusion capabilities. A common TED, the Super Shooter, had 0% reduction in finfish bycatch compared to the catch of a "naked" (no TED) net (GSAFF 1997). NOAA Fisheries has similar data on the results of a variety of hard TEDs and none have demonstrated more than a minimal reduction in finfish catch.

Currently, only one soft TED is certified. Changes to the TED regulations (68 FR 8456, February 21, 2003) have greatly modified the shape, size and configuration of hard TEDs. No information is available on the bycatch exclusion capability of these TEDs. However, their configurations would suggest that little bycatch reduction would be expected, except for the mechanical exclusion of large fishes such as sharks and rays.

Bycatch Practicability Analysis for Penaeid Shrimp Fishery

The Magnuson-Stevens Act requires the Council to establish a standardized bycatch reporting methodology for federal fisheries and to identify and implement conservation and management measures that, to the extent practicable and in the following order: (A) minimize bycatch and (B) minimize the mortality of bycatch that cannot be avoided (16 U.S.C. 1853(a)(11)). The Act defines bycatch as fish that are harvested in a fishery, but that are not sold or kept for personal use. This definition includes economic discards and regulatory discards and excludes fish released alive under a recreational catch-and-release fishery management program (16 U.S.C. 1802(2)). Economic discards are fish that are discarded because they are undesirable to the harvester. This category of discards generally includes certain species, sizes and/or sexes with low or no market value. Regulatory discards are fish that are required by regulation to be discarded such as fish below a minimum size limit, but also include fish that may be retained but not sold.

NOAA Fisheries outlines at 50 CFR 600.350(d)(3)(i) ten factors that should be considered in determining whether a management measure minimizes bycatch or bycatch mortality to the extent practicable. These are:

1. Population effects for the bycatch species;
2. Ecological effects due to changes in the bycatch of that species (effects on other species in the ecosystem);
3. Changes in the bycatch of other species of fish and the resulting population and ecosystem effects;
4. Effects on marine mammals and birds;
5. Changes in fishing, processing, disposal and marketing costs;
6. Changes in fishing practices and behavior of fishermen;
7. Changes in research, administration and enforcement costs and management effectiveness;
8. Changes in the economic, social or cultural value of fishing activities and non-consumptive uses of fishery resources;
9. Changes in the distribution of benefits and costs; and
10. Social effects.

Agency guidance provided at 50 CFR 600.350(d)(3)(ii) suggests the Councils adhere to the precautionary approach outlined in the Food and Agriculture Organization of the United Nations Code of Conduct for Responsible Fisheries (Article 6.5) when faced with uncertainty concerning these ten practicability factors. According to Article 6.5 of the Code, using the absence of adequate scientific information as a reason for postponing or failing to take measures to conserve target species, associated or dependent species, and non-target species and their environment, would not be consistent with a precautionary approach.

The South Atlantic penaeid shrimp fishery occurs in an area extending from Fort Pierce, Florida to Pamlico Sound and Ocracoke Inlet, North Carolina. The federal fishery is primarily prosecuted with otter trawl gear (SAFMC 1993). Other gear (e.g., cast nets, haul seines, wing nets, etc.) also is used, but accounts for a minor portion of the annual commercial landings. Trawl gear is predominantly used in federal waters. Management actions implemented by the Council to minimize bycatch in the penaeid shrimp fishery and the effects of those actions on finfish and invertebrates and on sea turtles are described below. Section 3.1.12.1.3 contains an evaluation of the effects of management measures on bycatch and bycatch mortality of finfish using the ten practicability factors provided at 50 CFR 600.350(d)(3)(i).

In summary, technological devices mandated for use in the South Atlantic penaeid shrimp trawl fishery are estimated to reduce finfish bycatch by at least 30% and to reduce sea turtle bycatch by as much as 97%. More data are needed to improve the reliability of information on the current level of finfish bycatch, which generally continues to exceed the catch of shrimp. However, based on a review of the status of the five species of greatest concern in the South Atlantic (weakfish, king mackerel, Spanish mackerel, Atlantic croaker and spot), there is no evidence to indicate that the mortality of finfish caused by the shrimp trawl fleet (with TEDs implemented) is having a significant adverse affect on finfish stocks. This practicability analysis concluded that current management measures minimize bycatch and bycatch mortality to the extent practicable in the penaeid shrimp fishery.

Bycatch in the shrimp trawl fishery could have adverse socioeconomic effects on finfish fisheries that target the same species that are taken as bycatch in the shrimp fishery. But any adverse effects associated with reducing the number of fish available to the directed commercial and recreational finfish fisheries are likely outweighed by the socioeconomic benefits of the high value shrimp fishery in which some level of bycatch is unavoidable. The revenue generated by the South Atlantic commercial shrimp fishery is the highest in the region relative to other commercial harvesting sectors.

The technology certified by the Council for use in the penaeid shrimp fishery attempts to balance the above described biological, ecological, social and economic tradeoffs by reducing finfish bycatch while minimizing shrimp loss. As a result, current management measures are believed to have minimized finfish bycatch and finfish bycatch mortality to the extent practicable. Researchers continue working to improve the performance and efficiency of bycatch reduction devices.

<u>Managing finfish and invertebrate bycatch in the penaeid shrimp fishery</u>

The key focus of the Shrimp FMP when it was implemented in 1993 was to provide for concurrent closures of state and federal waters following severe winter weather to eliminate fishing mortality on overwintering white shrimp when necessary to ensure the sustainability of the stock (SAFMC 1993). The Council recognized at the time that mortality in the shrimp trawl fishery had an adverse impact on a number of finfish stocks that are important to commercial and/or recreational fisheries in the South Atlantic, including the weakfish, king mackerel, Spanish mackerel, Atlantic croaker and spot (Nance 1998). But an amendment to the Magnuson-Stevens Act in 1990 specifically prohibited the Council from implementing bycatch reduction measures until January 1, 1994. This prohibition was later extended for three months.

The intent of the 1990 Magnuson-Stevens Act incidental harvest provision was to ensure that bycatch reduction requirements were based on reliable information on the magnitude and composition of bycatch, and that such requirements minimized adverse effects on shrimp fishery participants to the extent practicable. The 1990 Magnuson-Stevens Act amendment authorized a 3-year study of bycatch in the Gulf of Mexico and South Atlantic shrimp trawl fishery to characterize bycatch and to develop gear options that could reduce bycatch with minimum loss of shrimp production. Results of these studies are summarized in sections above.

Upon completion of this study, the Council developed Amendment 2 to the Shrimp FMP (SAFMC 1996b). Effective April 1997, Amendment 2 required that shrimp trawl gear operating in federal waters of the South Atlantic use one of three BRDs certified by the Council based on their ability to reduce finfish bycatch while minimizing shrimp loss. These federally approved BRDs include the 12x5 fisheye, the extended funnel BRD and the expanded mesh BRD, which are estimated to achieve a 30% reduction in overall finfish bycatch.

<u>Managing sea turtle bycatch in the penaeid shrimp fishery</u>

The South Atlantic penaeid shrimp trawl fishery also is regulated to minimize interactions with sea turtles, all species of which are listed as either threatened or endangered under the 1973 ESA. The incidental take and mortality of sea turtles as a result of trawling activities has been documented along the Atlantic Ocean seaboard. Federal regulations under the ESA require most shrimp trawlers operating in the South Atlantic to have a NOAA Fisheries approved turtle excluder device (TED) installed in each net that is rigged for fishing to provide for the escape of sea turtles. To be approved by NOAA Fisheries, a TED design must be shown to be at least 97% effective in excluding sea turtles during experimental TED testing (68 FR 8456; February 21, 2003).

The use of TEDs is believed to have had a significant beneficial impact on the survival and recovery of at least some sea turtle species (68 FR 8456; February 21, 2003). However, information from Epperly and Teas (2002) demonstrated that these devices, as originally designed, were not adequately protecting all species and size classes of turtles. Leatherback sea turtles were too large to escape through the TED openings. According to a biological opinion completed in December 2002, as many as 2.5% of the loggerhead turtles in the Atlantic also were too large to exit through the TEDs (68 FR 8456; February 21, 2003). Consequently, NOAA Fisheries amended regulations in February 2003 to 1) modify the dimensions of approved TEDs so that they are effective at excluding leatherbacks and large sexually mature loggerhead and green turtles, and 2) modify trynet and bait shrimp exemptions to the TED requirements to decrease lethal take of sea turtles.

In the 2002 Biological Opinion, NOAA Fisheries determined that “shrimp trawling in the southeastern United States under the proposed revisions to the sea turtle conservation regulations and as managed by the fishery management plans for shrimp in the South Atlantic and Gulf of Mexico is not likely to jeopardize the continued existence of endangered green, leatherback, hawksbill and Kemp’s ridley sea turtles and threatened loggerhead sea turtles” (NOAA Fisheries 2002). The new rule is expected to decrease shrimp trawl related mortality by 94% for loggerheads and by 96% for leatherbacks (68 FR 8456; February 21, 2003).

Bycatch practicability analysis

Population effects for the bycatch species

The population effects of bycatch mortality are the same as fishing mortality from directed fishing efforts. If not properly managed and accounted for, either form of mortality could potentially reduce stock biomass to an unsustainable level. One important difference in the effects of the penaeid shrimp trawl fishery and directed fisheries on finfish is that fishes taken in shrimp trawls are generally small and young. Juveniles are more expendable in one respect because they occur in high numbers, and relatively few actually survive to adulthood. But the reproductive potential of a stock can be compromised if fish are not provided sufficient opportunities to reproduce before they are exposed to fishing or bycatch mortality. The risk of stock collapse increases markedly if the fish are subject to fishing or bycatch mortality before they mature (Myers and Mertz 1998).

Early weakfish management plans indicated that bycatch of juvenile weakfish in the shrimp trawl fishery reduced yield per recruit and spawning stock biomass per recruit of the weakfish stock. The amount of weakfish discarded in the shrimp trawl fishery often approached or exceeded directed landings in South Atlantic states (Nance 1998). BRDs have reduced discards of weakfish and other finfish species by at least 30% since that time. Although some soft TEDs were also documented to reduce finfish bycatch, most of the current hard TED configurations suggest that they will have little impact on bycatch reduction, except for the mechanical exclusion of large fishes such as sharks and rays.

The current level of bycatch in the penaeid shrimp trawl fishery continues to be substantial despite these advancements in bycatch reduction. However, bycatch mortality is incorporated in assessments of finfish stocks where bycatch estimates are available (e.g., weakfish and sharks) (Nance 1998). Additionally, the sustainability of finfish species taken as bycatch in shrimp trawls does not appear to be threatened by this source of mortality.

The following summarizes available information on the status of the five species of greatest concern in the South Atlantic: weakfish, king mackerel, Spanish mackerel, Atlantic croaker and spot. Two of these five species, Atlantic croaker and spot, represent major components of the total shrimp trawl finfish bycatch. The remaining species are represented in the catch in lesser numbers. All were selected for review by Nance (1998) because of their commercial and recreational importance, and because bycatch mortality has the potential to significantly impact their abundance.

The weakfish stock has been declining since the late 1990s (ASMFC 2004a). King mackerel and Spanish mackerel are neither overfished nor experiencing overfishing (NOAA Fisheries 2003a). Spanish mackerel stock biomass has more than doubled since the mid-1990s (ASFMC 2004b). The first coast-wide assessment of the Atlantic croaker stock has not yet been completed (ASMFC 2004c). However, the 2001 review of the Atlantic croaker FMP based on a more limited assessment indicates that the population is increasing in size and expanding in age/size structure (Desfosse et al. 2001). Data are inadequate to conduct a formal, coast-wide assessment of spot. But the current BRD and minimum size limit requirements are believed to have reduced mortality sufficiently to protect this stock until an assessment can be completed (ASMFC 2004d).

Observed increases in nesting levels of the Kemp's ridley sea turtles exemplify the significant beneficial impact of TEDs on the survival and recovery of several sea turtle populations. The total annual mortality of Kemp's ridley turtles has been reduced by 44%-50% since 1990, when TEDs became more widely used in U.S. waters. Once the most critically endangered sea turtle, Kemp's ridley nesting levels have increased from 700-800 nests per year in the mid-1980s to over 6,000 nests in 2000. Recent modifications to the TED rule designed to better protect larger species of sea turtles are expected to decrease shrimp trawl related mortality by 94%-96% for loggerheads and leatherbacks, respectively (68 FR 8456; February 21, 2003).

Ecological effects due to changes in the bycatch of shrimp (effects on other species in the ecosystem)

There is limited bycatch of shrimp in the shrimp trawl fishery because nearly all shrimp harvested is marketed. Interaction with BRDs and trawl gear could result in some mortality on those shrimp that subsequently escape the devices. However, the BRDs certified by the Council minimize shrimp loss to the extent possible and have not adversely affected the status of shrimp stocks. According to NOAA Fisheries' most recent report to Congress, none of the South Atlantic penaeid shrimp stocks is overfished or experiencing overfishing (NOAA Fisheries 2003a). Consequently, the ecosystem effects of such losses are expected to be minimal.

Changes in the bycatch of other species of fish and invertebrates and the resulting population and ecosystem effects

Reductions in finfish bycatch attributed to the mandated use of BRDs may result in increased predation on shrimp if affected finfish are shrimp predators. Only 14 of 161 fish species examined during NOAA Fisheries' offshore bycatch characterization surveys on commercial vessels from 1992-1996 were identified as predators on penaeid shrimp. These are the Atlantic croaker, sand seatrout, spotted seatrout, silver seatrout, ocellated flounder, inshore lizardfish, bighead searobin, smooth puffer, red snapper, lane snapper, Spanish mackerel, rock sea bass, dwarf sand perch and Atlantic sharpnose shark (Nance 1998).

Predator-prey relationships are largely dependent on the size structure of predator and prey populations. Juvenile fish that could not prey on large shrimp because of their small size may be able to do so if their exclusion from trawl gear allows them to grow larger. However, it is also possible that some fish will reduce their preference for shrimp as they grow larger and their dietary habits change (Nance 1998).

Simulations using an ecosystem-based model of the interactions among shrimp and finfish stocks in the Gulf of Mexico indicate that shrimp stock biomass could increase by 4.7% or decrease by 17% depending on bycatch exclusion rates and assumptions relative to predator selection of shrimp prey (Nance 1998). Predation is the primary cause of the simulated decrease in shrimp stock biomass. A reduction in the amount of nitrogen recycled from discards is a contributing factor. However, nitrogen returned to the ecosystem through discards is minimal in comparison to the large nitrogen input from rivers (Nance 1998).

The possible outcomes simulated by the model are uncertain, as multiple factors that are not well understood will influence the actual response of the ecosystem to changes in shrimp trawl bycatch. Generally, scientific data are inadequate to reliably predict ecosystem effects, particularly with respect to stock size, and interactions between predators and prey, and species, such as bottomfish, sharks, birds and dolphins, which compete with each other for food and other resources (Nance 1998; Cook 2003). Consequently, the ecosystem model is based on a number of assumptions about which scientists are uncertain, including a discard mortality rate of 100%. The limitations of the model are discussed more fully in Nance (1998).

Changes in the bycatch of non-shrimp invertebrates (e.g., crustacea and molluscs) also could have ecosystem effects. These species have ecological functions in addition to serving as prey for other invertebrates and fishes. For example, some species, like barnacles and hydrozoans, condition habitat for other organisms by providing a growing surface or by contributing to the bioturbation of bottom sediments.

Effects on marine mammals and birds

Under Section 118 of the Marine Mammal Protection Act (MMPA), NOAA Fisheries must publish, at least annually, a List of Fisheries (LOF) that places all U.S. commercial fisheries into one of three categories based on the level of incidental serious injury and mortality of marine mammals that occurs in each fishery. The 2003 List of Fisheries classifies the Southeastern U.S. Atlantic Shrimp Trawl fishery as a Category III fishery, meaning that the annual mortality and serious injury of a stock resulting from the fishery is less than or equal to 1% of the maximum number of animals, not including natural mortalities, that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population (68 FR 135; July 15, 2003). No changes in this fishery's classification were proposed in the 2004 proposed LOF (69 FR 71; April 13, 2004).

Species of large whales protected by the ESA can be found in or near the area in which the South Atlantic shrimp trawl fishery occurs. The slow speed (1 to 2 knots) at which shrimp trawlers operate while trawling is sufficient to allow both whales and fishing vessels time to avoid a collision. There have been no reported interactions between large whales and shrimp vessels in the South Atlantic. A biological opinion conducted by NOAA Fisheries in December 2002 identified the chances of the South Atlantic shrimp trawl fishery affecting these species as "discountable" and determined they were not likely to be adversely affected (NOAA Fisheries 2002). Discountable effects are defined as effects that are extremely unlikely to occur.

There have been no documented seabird-gear interactions in the South Atlantic penaeid shrimp fishery. This finding is based on more than 117,000 hours of observer coverage while trawling on 1,310 trips completed from February 1992 through December 2003 during 12,749 sea days in the U.S. Gulf of Mexico and southeastern Atlantic. A total of 668 trips (1,475 sea days) occurred off the east coast, and 5 trips (127 sea days) targeted waters off both the east coast and in the Gulf of Mexico (E. Scott-Denton, NOAA Fisheries, personal communication). Seabirds that feed on discards would be expected to be affected by any increases or decreases in the amount of discards produced by the shrimp trawl fishery (Nance 1998; Cook 2003). Discards and offal produced by fishing vessels makes food more easily available to seabirds, and have been linked to population increases in a number of species (Cook 2003).

Changes in fishing, processing, disposal and marketing costs

Penaeid shrimp fishermen have experienced direct costs as a result of the BRD and TED requirements. The cost of a BRD ranges from about $20 for a fisheye design to less than $100 for the large mesh extended funnel (SAFMC 1996b). The cost of outfitting small fishing vessels with BRDs is estimated at $200 (four BRDs at a cost of $50 per BRD). These vessels trawl with two nets. Larger shrimp vessels typically use four nets, and keep a spare set onboard. As a result, these vessels are required to purchase approximately eight BRDs, with a resulting cost of $400. The purchase of these gear modifications is a recurring expense. Currently, the cost of a TED typically used for an offshore, larger vessel runs approximately $320 to $350. For shrimpers whose TED frames were large enough to be compliant with the new rule and only needed to have the opening modified – the cost ran approximately $50. In general, shrimpers will have their TEDs re-worked every year, which if it does not require replacing the TED, will run approximately $100/TED.

The use of BRDs could result in some shrimp loss. But studies suggest that the use of BRDs or similar techniques to reduce finfish capture would not negatively affect shrimp production in the long-term if finfish exhibit even moderate selectivity against shrimp as prey (Nance 1998). The amount of shrimp loss associated with the three BRDs certified for use in the South Atlantic region is expected to be minimal.

The bycatch reduction achieved by BRDs could benefit shrimp fishermen by reducing the time required to cull unwanted species. Reducing culling time could improve the quality of the shrimp processed by decreasing the amount of time it takes to get shrimp into cold storage. The net economic effect of BRDs has not been quantified. But anecdotal information indicates that some fishermen favor using these devices because they increase net revenue per trawling operation (SAFMC 1996b).

Changes in fishing practices and behavior of fishermen

Some fishermen could perceive BRD and TED requirements as unnecessarily restrictive. However, there are few data available to adequately define how the requirements are perceived, and how these perceptions have changed fishing practices and behavior. A survey conducted by Kitner in 1987 to collect information on shrimp fishermen’s response to TEDs found that reactions were more favorable among those who had experience with the devices. The fishermen’s response to the BRD requirement in Shrimp Amendment 2 was similar. Those fishermen most familiar with BRDs appeared to be most accepting of the regulations. However, the Council received relatively few comments in opposition to the regulation overall. This could indicate that the industry was resigned to having to use the new technology. Also, it could indicate that shrimp fishermen understand the value of BRDs.

Bycatch mortality can reduce the availability of finfish to directed fisheries. Finfish taken in shrimp trawls are generally juveniles, and most of these fish would likely be subject to natural mortality before they become available to directed fisheries. However, bycatch mortality can adversely affect the status of stocks taken in directed fisheries by reducing the opportunity for bycatch species to mature and reproduce before they are subject to mortality. Because declining landings have precipitated the imposition of state and federal catch restrictions in some directed fisheries, participants in those fisheries likely perceive the BRD requirement as a regulation that promotes equity in the fisheries (Nance 1998).

Changes in research, administration and enforcement costs and management effectiveness

Research needed to understand the effectiveness of BRDs and TEDs is costly, as are administrative and enforcement efforts needed to implement and enforce these regulations. However, the implementation of these gear modification requirements has improved management effectiveness by decreasing turtle and finfish bycatch in the fishery.

Changes in the economic, social, or cultural value of fishing activities and non-consumptive uses of fishery resources

The combined landings from U.S. shrimp fisheries in 2002 ranked highest in value of all domestic fisheries that year (NOAA Fisheries 2003b). The South Atlantic shrimp fishery generates the most revenue for the commercial harvesting sector in this region. During the last two years for which data are available (2001 and 2002), commercial shrimp landings in the South Atlantic generated an average of $63.56 million annually (Section 5.4.1.1 above).

The U.S. Congress recognized the need to balance the costs of bycatch reduction with the social and economic benefits provided by the shrimp fishery when it mandated the study of shrimp trawl bycatch (and potential gear modifications) through the 1990 reauthorization of the Magnuson-Stevens Act. The resulting cooperative bycatch research program was effective in identifying gear options that could reduce shrimp trawl bycatch with minimum loss of shrimp production.

While BRD and TED requirements certainly present direct costs to participants in the shrimp fishery, they could reduce overall costs by making operations more efficient. Additionally, studies of BRDs suggest that the use of these devices or similar techniques to reduce finfish capture would not negatively affect shrimp production in the long-term if finfish exhibit even moderate selectivity against shrimp as prey (Nance 1998).

Decreases in bycatch mortality attributed to these technologies are believed to have contributed to the survival and recovery of at least some sea turtle populations and finfish stocks. The societal benefits associated with recovering these species are not easily quantified, but are believed to outweigh any short-term costs to penaeid shrimp fishermen related to the required use of bycatch reduction technology.

Changes in the distribution of benefits and costs

Prior to the mandated use of bycatch reduction technology in the penaeid shrimp fishery, there was a general perception that benefits and costs were not equitably distributed between the shrimp trawl fisheries and directed finfish fisheries and between the shrimp trawl fisheries and the broader public. Commercial and recreational fishermen who target finfish taken incidental to the trawl fishery believe that shrimp fishermen should share the burden of regulations needed to sustain declining fish stocks (Nance 1998). And at least some members of the public view bycatch as unnecessary waste. Discarded finfish provide an ecological service in that they are consumed by other marine species. However, the ecological role of discarded finfish would have been different had they been allowed to mature. The mandated use of BRDs and TEDs was intended to address these perceived inequities while maintaining a productive, high value shrimp fishery.

Social effects

There are few data available to adequately define the social effects of BRD and TED requirements. Penaeid shrimp fishermen could be experiencing negative effects related to the costs of installing and using the devices and to feeling overregulated. They also could be experiencing positive effects related to improved efficiency. The concerned public is likely experiencing social benefits related to knowing that the organisms they value for aesthetic and existence reasons are better protected. However, some members of the public could be of the opinion that the reductions in bycatch achieved through BRD and TED requirements are insufficient.

Conclusion

This section evaluates the practicability of taking additional action to minimize bycatch and bycatch mortality in the South Atlantic penaeid shrimp fisheries based on the findings in above and using the ten factors provided at 50 CFR 600.350(d)(3)(i). In summary, technological devices mandated for use in the South Atlantic penaeid shrimp trawl fishery are estimated to reduce finfish bycatch by at least 30% and to reduce sea turtle bycatch by as much as 97%. More data are needed to improve the reliability of information on the current level of finfish bycatch, which generally continues to exceed the catch of shrimp. However, based on a review of the status of the five species of greatest concern in the South Atlantic (weakfish, king mackerel, Spanish mackerel, Atlantic croaker and spot), there is no evidence to indicate that the mortality of finfish caused by the shrimp trawl fleet (with TEDs implemented) is having a significant adverse affect on finfish stocks. Therefore, the Council concluded that current management measures minimize bycatch and bycatch mortality to the extent practicable in the penaeid shrimp fishery.

5.2.1.4.2 Bycatch in the Deepwater Shrimp Fishery

The discarded bycatch of fish and crustaceans in the rock shrimp trawl fishery is highly variable by season and area. Comments received from industry representatives at scoping meetings and public hearings for Amendment 1 to the Shrimp Plan indicated that the catches have very little bycatch north of Cape Canaveral and in deeper water. As vessels began fishing earlier in the year, in June and July versus August or September, discards of unmarketable juvenile rock shrimp increased dramatically. Industry representatives also indicated that beyond 36 meters (120 ft) 90% of the catch is rock shrimp; therefore, it can be assumed that the remaining is bycatch (SAFMC, 1996a). The data on bycatch from trips that target rock shrimp are still limited, however. There was an early attempt to characterize the catch composition of rock shrimp trips in the South Atlantic. However, only one rock shrimp bycatch characterization observer trip was completed between January 26 and February 4, 1995 (SAFMC 1996a).

In order to document species associated with rock shrimp benthic habitats, NMFS SEFSC Pascagoula Laboratory compiled lists of species associated with rock shrimp catches in research trawling efforts for finfish and shrimp conducted between 1956 and 1991 (See Appendix A in Shrimp Amendment 5). At a minimum, these lists will provide potential bycatch associated with rock shrimp trawling. In order to identify possible key species caught in association with harvestable levels of rock shrimp, only trawl records when rock shrimp catches met or exceeded 40 pounds per hour per 40 foot of head rope were used based on input from public hearings and discussions with people in the industry.

From industry accounts, as the rock shrimp fishery developed and vessels began fishing earlier in the year, in June and July versus August or September, discards of unmarketable juvenile rock shrimp increased. Members of the South Atlantic Rock Shrimp Advisory Panel recommended gear modifications that were implemented in Amendment 5 to the South Atlantic Shrimp Plan to address this problem (SAFMC 2002).

The most recent information on bycatch in this fishery comes from a preliminary report of a NOAA Fisheries observer study conducted during the period September 2001 through December 2002 (See Appendix C in Shrimp Amendment 6). Nine rock shrimp trips were observed from September 2001 through December 2002. Six trips occurred off the east coast of Florida, two trips operated in the Gulf of Mexico and off the east coast of Florida and one trip targeted Gulf of Mexico waters exclusively.

A total of 177 tows was sampled from eight trips off the east coast of Florida. A total of 233 unique species was collected. There were 37 species of crustacea, 166 fish species, 29 other invertebrate species and 1 category of miscellaneous debris. All of these vessels were using BRDs voluntarily. Therefore, the results of the sampling reflect the catch that was not excluded by BRDs.

The following summarizes the main findings in this report:

1. Rock shrimp comprised 10% of the catch by weight and 13% by number.
2. Extrapolated catch per unit effort (CPUE) for rock shrimp was 3.6 kilograms per hour (approximately 7.9 pounds per hour).
3. Penaeid shrimp comprised 6% of the catch by weight and 4% by number.
4. Finfish comprised 54% of the catch by weight and 32% of the catch by number.
    - i. During the summer 2002 (June, July and August) 53% of the catch (by weight) was finfish (65 tows observed).
    - ii. During the fall 2002 (September, October and November) 54% of the catch (by weight) was finfish (41 tows observed).
    - iii. During the winter 2002 (December, January and February) 64% of the catch (by weight) was finfish (8 tows observed).
    - iv. CPUE of finfish was highest in winter 2002 (27.1 kg./hr) followed by fall 2002 (19.8 kgs/hr) and summer 2002 (19.0 kgs/hr).

Weight extrapolations from the species composition samples for both years, all areas, seasons and depths indicate that:

1. Dusky flounder (*Syacium papillosum*) comprised 13% of the total catch.
2. Iridescent swimming crab (*Portunus gibbesii*) comprised 10% of the total catch.
3. Rock shrimp comprised 10% of the total catch.
4. Inshore lizardfish (*Synodus foetens*) comprised 9% of the total catch.
5. Longspine swimming crab (*Portunus spinicarpus*) at 8%.
6. Spot (*Leiostomus xanthurus*) at 6%.
7. Blotched swimming crab (*Portunus spinimanus*) at 5%.
8. Brown shrimp (*Farfantepenaeus aztecus*) at 4%.
9. Red goatfish (*Mullus auratus*) at 2%.
10. All other species combined comprised 33% of the total weight.

Data from one additional trip in 2002 were not included in these results because the data were not computerized at the time the report was prepared. These observed trips were sampled during an atypical rock shrimp season where harvest was especially low compared to previous years. Thus, these findings should be considered preliminary and a more realistic evaluation of this fishery is expected from analyses of results at the completion of this observer program.

A different catch composition could be observed during a year when rock shrimp harvest is at a “normal” level. From preliminary data on rock shrimp landings and industry reports it appears that rock shrimp harvests rebounded during 2003. Observer coverage in the rock shrimp fishery extended through 2003. Information from these trips will be analyzed and presented to the Council for future evaluation of the rock shrimp fishery. From preliminary data for the 2003 portion of the observer coverage program, it appears that rock shrimp catch rates were higher and they comprised a larger proportion of the catch compared to the 2002 observer data. For all 125 tows in the 2001/2002 observer program, rock shrimp made up 9.6% of the overall catch. A preliminary examination of the data from the 95 tows observed in 2003 indicated that 21.3% of the total catch was comprised of rock shrimp (Scott-Denton, NOAA Fisheries, Southeast Fisheries Science Center, pers. comm. 2003).

See Section 5.4.1.4 for more detailed information on bycatch in the South Atlantic shrimp fisheries.

Bycatch Practicability Analysis for the Deepwater Shrimp Fishery

Bycatch is defined as fish harvested in a fishery, but not sold or retained for personal use. This definition includes both economic and regulatory discards, and excludes fish released alive under a recreational catch-and-release fishery management program. Economic discards are generally undesirable from a market perspective because of their species, size, sex, and/or other characteristics. Regulatory discards are fish required by regulation to be discarded, but also include fish that may be retained but not sold.

Agency guidance provided at 50 CFR 600.350(d)(3) identifies ten factors to consider in determining whether a management measure minimizes bycatch or bycatch mortality to the extent practicable. These are:

1. Population effects for the bycatch species;
2. Ecological effects due to changes in the bycatch of that species (effects on other species in the ecosystem);
3. Changes in the bycatch of other species of fish and the resulting population and ecosystem effects;
4. Effects on marine mammals and birds;
5. Changes in fishing, processing, disposal, and marketing costs;
6. Changes in fishing practices and behavior of fishermen;
7. Changes in research, administration, and enforcement costs and management effectiveness;
8. Changes in the economic, social, or cultural value of fishing activities and non-consumptive uses of fishery resources;
9. Changes in the distribution of benefits and costs; and
10. Social effects.

The Councils are encouraged to adhere to the precautionary approach outlined in Article 6.5 of the Food and Agriculture Organization of the United Nations Code of Conduct for Responsible Fisheries when uncertain about these factors.

The South Atlantic rock shrimp fishery is concentrated in an area off northeast Florida south to Jupiter Inlet. The fishery is prosecuted primarily by commercial otter trawl gear. Management measures regulating harvest in the fishery include requirement of bycatch reduction devices (BRDs), a minimum mesh-size restriction, a limited access program, and area closures (east of 80°W longitude, between 27°30'N and 28°30'N latitude, in depths less than 100 fathoms). The primary purpose of the area closures is to minimize the impacts of the rock shrimp fishery on essential bottom habitat, including the fragile coral species located in the *Oculina* Bank Habitat Area of Particular Concern (HAPC). These closures are enforced using vessel monitoring systems (VMS) (SAFMC 2002).

The magnitude and composition of bycatch in the rock shrimp fishery based on a preliminary report of observer coverage of the southeastern Atlantic rock shrimp fishery from September 2001 through September 2006. Samples from 221 successful tows (eight vessels with 838.3 hours of trawling) were analyzed for species composition by weight and numbers. By weight, 49% of the total catch throughout the study period was composed of finfish. Weight extrapolations from the species composition samples indicated dusky flounder was the finfish caught in the greatest number (13% of the total catch), followed by the inshore lizardfish (11%), spot (5%), and horned sea robin (2%). Rock shrimp represented the second largest component of the catch by weight (19%). Non-shrimp crustaceans comprised 18%: the iridescent swimming crab was the non-shrimp crustacean caught in the greatest number (7%) followed by the longspine swimming crab (6%) and the blotched swimming crab (3%). Non-crustacean invertebrates (8%), penaeid shrimp (4%), and debris (2%) comprised the smallest portion of the total catch. Highest catch per unit effort (CPUE) for rock shrimp was in 26-45 fathoms, while CPUEs for finfish, invertebrates and other crustaceans were highest in 0-25 fathoms.

Population Effects for the Bycatch Species

The population effects of bycatch mortality are the same as fishing mortality from directed fishing efforts. If not properly managed and accounted for, either form of mortality could potentially reduce stock biomass to an unsustainable level. One important difference in the effects of the shrimp trawl fishery and directed fisheries on finfish is fishes taken in shrimp trawls are generally small and young. Juveniles are more expendable in one respect because they occur in high numbers, and relatively few actually survive to adulthood. But the reproductive potential of a stock can be compromised if fish are not provided sufficient opportunities to reproduce before they are exposed to fishing or bycatch mortality. The risk of stock collapse increases markedly if the fish are subject to fishing or bycatch mortality before they mature (Myers and Mertz 1998).

The current level of bycatch in the penaeid shrimp trawl fishery continues to be substantial despite these advancements in bycatch reduction. However, bycatch mortality is incorporated in assessments of finfish stocks if estimates are available (e.g., weakfish and sharks). Additionally, the sustainability of finfish species taken as bycatch in shrimp trawls does not appear to be threatened by this source of mortality (Nance 1998).

Little is known about the status of those finfish (e.g., dusky flounder, inshore lizardfish, spot, and red goatfish) and invertebrate (e.g., iridescent swimming crab, longspine swimming crab, and blotched swimming crab) species present in rock shrimp trawl bycatch in the greatest numbers. None of these species have undergone (or are likely to undergo) formal stock assessments because most, with the exception of spot, are not targeted in commercial or recreational fisheries. Data are inadequate to conduct a formal, coast-wide assessment of spot. But fishery managers believe a combination of BRD and minimum size limit requirements is sufficient to protect this stock until such an assessment can be completed (ASMFC 2004).

Observed increases in nesting levels of the Kemp's ridley sea turtles exemplify the significant beneficial impact of TEDs on the survival and recovery of several sea turtle populations. The total annual mortality of Kemp's ridley turtles has been reduced by 44-50% since 1990, when TEDs became more widely used in U.S. waters. Once the most critically endangered sea turtle, Kemp's ridley increased nesting levels from 700-800 nests per year in the mid-1980s to over 6,000 nests in 2000. Recent modifications to the TED rule, which were designed to better protect larger species of sea turtles, are expected to decrease shrimp trawl related mortality by 94 and 96% for loggerheads and leatherbacks, respectively (68 FR 8456; February 21, 2003).

During five years of observer coverage in the Southeast Atlantic rock shrimp fishery (Appendix C), 11 sea turtles (six loggerhead, two Kemps ridley, three unidentified) were captured in trawls. Three escaped through TEDs, nine were released alive and conscious, and two were released in unknown condition.

NOAA Fisheries Service determined in a 2002 Biological Opinion that shrimp trawling in the southeastern United States under the proposed revisions to the sea turtle conservation regulations and as managed by the South Atlantic and Gulf of Mexico Shrimp FMPs is not likely to jeopardize the continued existence of endangered green, leatherback, hawksbill or Kemp's ridley sea turtles, or threatened loggerhead sea turtles.

Anecdotal information suggests bycatch of the coral, *Oculina varicosa*, in the rock shrimp trawl fishery was negatively affecting that species. *Oculina* coral fragments may continue to survive after an impact (Brooke and Young 2003, 2005). However, the likelihood impacted corals could be smothered by sediments, or sufficiently removed from the current's influence as to deprive them of nutrients, is greatly increased. Researchers estimate past fishery-related impacts, primarily from trawl gear, have greatly reduced the amount of intact *Oculina* coral habitat remaining within the *Oculina* Experimental Closed Area (Reed *et al.* 2007). The Vessel Monitoring System (VMS) requirement implemented through Amendment 5 to the Shrimp FMP (SAFMC 2002) is expected to improve compliance with the prohibition on rock shrimp trawling within the *Oculina* HAPC.

Ecological Effects Due to Changes in Bycatch

Rock shrimp discards in the fishery have not been quantified. Anecdotal reports indicate economic discards of unmarketable juvenile rock shrimp have increased as the temporal and spatial distribution of the fishery has changed over time. Vessels fish earlier in the year and have moved south relative to historical fishing. However, the mesh-size restrictions implemented through Amendment 5 (SAFMC 2002) were intended to address this problem. Consequently, the ecosystem effects of rock shrimp discards (if any) are likely to be minimal.

Changes in Bycatch of Other Fish Species and Resulting Population and Ecosystem Effects

If affected finfish are shrimp predators, reductions in bycatch due to BRDs may result in increased predation on shrimp. During NOAA Fisheries Service's offshore bycatch surveys on commercial vessels from 1992-1996, only 14 of 161 fish species were identified as predators on penaeid shrimp. These are the Atlantic croaker, sand seatrout, spotted seatrout, silver seatrout, ocellated flounder, inshore lizardfish, bighead searobin, smooth puffer, red snapper, lane snapper, Spanish mackerel, rock sea bass, dwarf sand perch, and Atlantic sharpnose shark (Nance 1998).

Predator-prey relationships largely depend on the size structure of predator and prey populations. Juvenile fish that are too small to prey on large shrimp may be able to do so later if their exclusion from trawl gear allows them to grow larger. However, it is also possible some fish will reduce predation on shrimp as they grow and their dietary habits change (Nance 1998).

Changes in the bycatch of non-shrimp invertebrates (e.g., crustaceans and mollusks) also could have ecosystem effects. These species have ecological functions in addition to serving as prey for other invertebrates and fishes. For example, some species, like barnacles and hydrozoans, condition habitat for other organisms by providing a growing surface or by contributing to the bioturbation of bottom sediments.

Effects on Marine Mammals and Birds

Bycatch of marine mammals and seabirds is not considered to be a problem in the South Atlantic rock shrimp fishery. The southeastern U.S. Atlantic shrimp trawl fishery is classified as a Category III fishery, meaning the annual mortality and serious injury of a stock resulting from the fishery is less than or equal to 1% of the maximum number of animals, not including natural mortalities, that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population (68 FR 135; July 15, 2003).

No documented seabird-gear interactions were recorded on 1,310 trips in the Gulf of Mexico and southeastern Atlantic penaeid and rock shrimp fisheries between February 1992 and December 2003 (E. Scott-Denton, NOAA Fisheries, personal communication). However, the potentially high level of bycatch in the rock shrimp fishery could be affecting some seabird species. Cook (2003) notes the availability of discards and offal has been linked to population increases in a number of species.

Changes in fishing, processing, disposal and marketing costs

The potentially high bycatch in the rock shrimp fishery could adversely affect production by unnecessarily increasing drag time, culling time, and crew fatigue. Regulatory measures implemented to reduce bycatch have direct costs related to purchasing and installing new technology, or limiting where and/or when a vessel could operate. But such measures could result in long-term benefits if they increase the efficiency of shrimp trawl operations. BRD technology reduces shrimp trawl bycatch with minimal cost to shrimp fishermen.

Changes in Fishing Practices and Behavior of Fishermen

At least some participants in the rock shrimp fishery deny a bycatch problem exists. Consequently, regulatory requirements to reduce bycatch could provide a disincentive to responsible participation in the fishery. For example, fishermen could potentially ignore a BRD or closed season requirement, or violate the prohibition on trawling within the *Oculina* Bank HAPC. The VMS requirement is expected to improve compliance with seasonal closure regulations and ease the enforcement burden.

Changes in Research, Administration, and Enforcement Costs and Management Effectiveness

Bycatch in southeastern shrimp trawl fisheries has been a priority issue for scientists and administrators for a number of years. This focus is likely to continue as the Council addresses future management needs in the fishery.

Changes in the Economic, Social, or Cultural Value of Fishing Activities and Non-Consumptive Uses of Fishery Resources

The U.S. Congress recognized the need to balance the costs of bycatch reduction with the social and economic benefits provided by the shrimp fishery when it mandated the study of shrimp trawl bycatch (and potential gear modifications) through the 1990 Magnuson-Stevens Act reauthorization. The resulting cooperative bycatch research program identified gear options that could reduce shrimp trawl bycatch with minimum loss of shrimp production.

While BRD and TED requirements certainly present direct costs to participants in the shrimp fishery, they could reduce overall costs by increasing efficiency. Additionally, studies suggest the use of BRDs or similar techniques to reduce finfish capture would not negatively affect shrimp production in the long-term if finfish exhibit even moderate selectivity against shrimp as prey (Nance 1998).

Decreases in bycatch mortality attributed to these technologies are believed to have contributed to the survival and recovery of at least some sea turtle populations and finfish stocks. The societal benefits associated with recovering these species are not easily quantified, but are believed to outweigh any short-term costs to penaeid shrimp fishermen related to the required bycatch reduction technology.

Changes in the Distribution of Benefits and Costs

Prior to the mandated use of bycatch reduction technology in the rock shrimp fishery, people perceived benefits and costs were not equitably distributed between the shrimp trawl fisheries and directed finfish fisheries, and between the shrimp trawl fisheries and the broader public. Commercial and recreational fishermen who target finfish taken incidental to the trawl fishery believe shrimp fishermen should share the regulatory burden needed to sustain declining fish stocks (Nance 1998). Some members of the public view bycatch as unnecessary waste. The mandated use of BRDs and TEDs was intended to address these perceived inequities while maintaining a productive, high value shrimp fishery.

Social Effects

Few data are available to adequately define the social effects of BRD and TED requirements. Shrimp fishermen could experience negative effects related to the costs of installing and using the devices and to feeling overregulated. They also could experience positive effects related to improved efficiency. The concerned public is likely to experience social benefits related to knowing that the organisms they value for aesthetic and existence reasons are better protected. However, some members of the public may believe bycatch is not sufficiently reduced through BRD and TED requirements.

Conclusion

This section evaluates the practicability of taking additional action to minimize bycatch and bycatch mortality in the South Atlantic rock shrimp fishery by using the ten factors provided at 50 CFR 600.350(d)(3)(i). In summary, technological devices mandated for use in the South Atlantic shrimp trawl fishery are estimated to reduce finfish bycatch by at least 30% and to reduce sea turtle bycatch by as much as 97%. More data are needed to improve the reliability of information on the current level of bycatch, which generally continues to exceed the catch of shrimp. However, no evidence exists to indicate the mortality of finfish caused by the rock shrimp trawl fleet (with BRDs and TEDs implemented) is having a significant adverse affect on finfish stocks. Therefore, the Council concluded that current management measures minimize bycatch and bycatch mortality to the extent practicable in the rock shrimp fishery.

5.2.2 Snapper Grouper

5.2.2.1 Description of fishing practices, vessels and gear

Additional detailed description of the snapper-grouper fishery is contained in Snapper Grouper Amendment 13C (SAFMC 2006), Snapper Grouper Amendment 15A (SAFMC 2007), and Snapper Grouper Amendment 15B (SAFMC 2008)] and is incorporated herein by reference. The following section updates and summarizes the operations of the commercial and recreational sectors of the snapper grouper fishery as part of the overall human impact on the South Atlantic ecosystem.

Commercial fishery

Commercial fishermen utilize vertical lines, longlines, black sea bass pots/traps, spears, and powerheads to harvest snapper grouper species. An economic survey of commercial snapper grouper vessels along the South Atlantic coast done in the mid-1990s found that the average length of a boat was 32.7 feet, with nearly all sampled boats being less than 50 feet in length. Boats with bottom longlines tended to be the longest, had the most powerful engines, the greatest fuel capacities, and the largest holding boxes for fish and ice. On the other hand, boats with vertical lines, especially in the southern area, tended to be the shortest, had the least powerful engines, the smallest fuel capacities, and the smallest holding boxes for fish and ice.

Vertical Lines

The vertical line sector of the commercial snapper grouper fishery operates throughout the Council's area of jurisdiction from the North Carolina/Virginia border to the Atlantic side of Key West, Florida. According to NMFS Logbook data, there were 15,302 trips reported in 2001 in which vertical line (hook and line) gear was identified as the main gear for that trip. Fishermen use this gear in about 13 to 110 fathoms (78 to 660 feet) of water, both day and night.

The majority of hook and line fishermen use either electric or hydraulic reels known as "bandit" gear due to its resemblance to slot machines ("one-armed bandits") that are used in casinos. Boats generally have 2 to 4 bandit reels attached. A typical bandit reel is attached to the gunwale of the boat and consists of a fiberglass reel that holds about 1,000 feet of cable; an L-bar or spreader, which keeps the leader from tangling with the main line; a pulley to feed the cable from the reel through the L-bar; a fiberglass arm; and an electronic or hydraulic reel motor.

Captains of boats with bandit gear maneuver the boat back and forth across an area of high relief that runs northeast and southwest looking for fish using a color machine and relying on fishing spots that have been previously marked on their plotter. The captain uses the color machine to differentiate bottom type and fish presence, and can tell what kind of fish may be in the area based on where they appear in the water column, the size of the air bladder that shows up on screen, and how the fish are congregated.

Fishing begins with a baited line that is thrown out over the gunwale of the boat as the fisherman releases the drag on the spool of the bandit reel and sends the line down in search of the bottom or desired depth. If dropping on a spot for the first time, the fisherman may have to adjust the depth at which s/he fishes, first finding the bottom and then reeling up the line enough to be fishing above the bottom.

Fishermen tend to either "sit and soak" or "get up and down" when using bandit gear in the mid-shelf fishery (mostly targeting vermilion snapper and some groupers). When they sit and soak, they are fishing live or dead baits with circle or "jap" hooks and letting their rigs (generally a 20- to 40-foot leader with 2 hooks) soak near the bottom for anywhere from 15 minutes to an hour. Fishermen will use the sit-and-soak method to catch grouper and some snapper, such as red snapper in about 13 to 50 fathoms (78 to 300 feet) of water. When fishermen get up and down, they are actively fishing 2 to 3 straight hooks per reel with cut bait. When fishing this way, the line is tended constantly and brought up to the surface as soon as a bite is felt. Fishermen using the get-up-and-down method catch most of the vermilion snapper, triggerfish, and porgies. Fishermen also fish for grouper using this method, but with larger hooks.

When fishing for deepwater snapper grouper species (primarily snowy grouper but also large red porgy, blueline tilefish, Warsaw grouper, and speckled hind) in 50 to 100 fathoms (300 to 600 feet) of water, fishermen bait multi-hook rigs with anywhere from 2 to 10 circle hooks with squid, Boston mackerel, or other cut bait.

In South Florida, fishermen use handlines to harvest yellowtail snapper, which is mostly a day boat fishery. Fishermen chum for yellowtail by grinding or cutting up bait fish and distributing the chum on top of the water with the intention of drawing the yellowtail snapper closer to the surface in a school to make them easier to catch. The fish are caught on handlines with "j" hooks and then chill-killed for high quality. Sometimes these fishermen use a splatter or spider pole to catch the fish when chumming, which is a 10- to 12-foot bamboo pole with a single line and a barb-less hook attached.

There is no consistent day/night pattern of fishing within the vertical line sector of the South Atlantic snapper grouper fishery. The time of day and/or night varies from captain to captain as a matter of personal preference. The majority of the bandit fleet fishes year round for snapper grouper. The only seasonal differences in catch are associated with the spawning season closures in March and April for gag grouper. Most fluctuations in fishing effort in the vertical line fishery are a result of the weather, such as hurricanes and tropical and winter storms, which limit effort. When king mackerel are running, some fishermen stop bandit fishing for snapper grouper species to target king mackerel.

Longlines
The Council allows the use of bottom longlines only in waters deeper than 50 fathoms (300 feet) and north of St. Lucie Inlet, Florida. Fishermen with longline gear onboard may only retain deepwater species. Fishermen use this gear to target snowy grouper and golden tilefish, while incidentally catching blackbelly rosefish.

Longline boats are typically bigger, have longer trips, and cost more to operate than bandit boats because they operate farther offshore. From a port such as Charleston, South Carolina, a South Carolina longline boat will travel 90 miles offshore to reach the fishing grounds, stay out for as many as 9 to 10 days, and incur expenses equivalent to $2,500.

The longline is located on a spool about midway back on the stern of the boat, and a spool generally holds about 15 miles of cable. When fishing begins, the cable is paid out through a fair lead on top of the spool and then another at the stern of the boat. A poly- ball and a high flyer are paid out first to mark the longline at one end. At the stern are usually two crewmembers that stand near baskets full of made up rigs (previously baited hooks and leaders). As the line pays out, they snap the leaders onto the mainline as fast as possible, but generally every two feet.

While the line is paying out, the Captain may steer the boat in a zigzag fashion or make exaggerated turns to set the gear in the desired location. Some crews use weights as the Captains make big turns to prevent the mainline from rolling over and drifting on top of itself. When the desired amount of longline is paid out, the crew breaks it loose from the drum and snaps on another poly-ball and high flyer to indicate the end of the longline.

The amount of mainline that is paid out and the length of soak time of the line varies by boat and circumstance. Sometimes boats will set out 5 miles of cable at a time making as many as 4 or more sets a day, while others will set out 15 miles at a time and make only 2 sets a day. Soak time will vary depending upon how well fishing is going; however, the longest amount of time that longline gear is in the water is about 2 hours. The gear is hauled back from a haul back station with a boom that swings over the side of the boat that helps feed the cable through a block and pulley system. As the line is hauled back on board, catch is removed from the leaders, leaders are removed, and the main line is fed back into the level wind and back to the spool.

Longlines are fished only from daylight to dark because sea lice come out at night and eat the flesh of fish that would hook up on the line. Snapper grouper fishermen use longlines all year long with little or no seasonal fluctuation barring a busy hurricane season.

Black Sea Bass Pots
Black sea bass pots are used exclusively to target black sea bass, though bycatch of other snapper grouper species is allowed. The pots have mesh size, material, and construction restrictions to facilitate bycatch reduction and to prevent ghost fishing if pots are lost. All sea bass pots must have a valid identification tag attached.

Fishing practices within the black sea bass pot fishery vary by buoy practices, setting/pulling strategies, number of pots set, and length of set, with seasonal variations. Many fishermen set individual pots with one buoy line per pot. Others set doubles, which are two pots attached to one buoy line. Individual pots may also be connected to a ground line. This configuration is commonly referred to as a "trawl" and has a buoy line on each end. Indications are that only one person in North Carolina may be fishing with trawls. Both sinking and floating buoy lines are used. Many fishermen off North Carolina use floating lines because they are less likely to get hung up on the bottom, while several South Carolina fishermen reported using sinking lines. In South Carolina, fishermen report using ¼-inch poly line attached to a buoy or high flyer. Buoy lines are typically 200 feet (61 meters) in length. In the South Atlantic EEZ, the use of buoys is not required but, if used, each buoy must display the boat's assigned official number and color code.

Fishermen use different strategies for targeting black sea bass, but the most common technique is "precision setting" in which fishermen target areas located with on-board electronics, set pots on suspected aggregations of fish, and locate, pull, and move pots depending upon how well an area is producing. Pots may be clustered with only a few set in one area and numerous set in a different area depending upon the availability of hard bottom and how successful the catch rate. There may be anywhere from a 3 to 5 mile (4.8 to 8 kilometers) distance between pots or just 10 to 14 feet (3 to 4.5 meters). Another strategy scatters pots over a wide area or in rows, regardless of bottom habitat, and leaves the set of pots with the intention of having the fish come to the pot. This technique targets more migratory individuals and the pots tend to stay in the water for a longer period of time.

How pots are fished varies depending on the fisherman, season, or area. Typically, fewer pots (on average 60 or less) are fished during the winter than during the summer with the majority of fishermen taking their pots in every night. In the summer when more fish are scattered, the fishermen may fish a few hundred pots and leave them out for extended periods of time, pulling them no more than twice a day. During the winter, soak times are shorter with pots being pulled 2 to 3 times a day or more. Pots set as doubles or in trawls usually have longer soak times than those individually set. In general, how long pots are soaked or whether they are removed daily depends upon the number of pots set, gear configuration, season, and the preference of the fisherman. Preferences may also vary by region.

The South Carolina black sea bass pot fishery is mainly a winter fishery. The season begins in November and, depending upon the water temperature (the colder the better for bass trapping), generally goes through April. Pots are fished individually with short soak times (in some cases about an hour), and the number of pots fished range from 6 to 30 depending upon the fisherman. Most fishermen haul their pots from the water when they return home. In the fall, most pots are set in 70 to 90 feet (21.3 to 27.4 meters) of water, and as the season progresses, fishermen tend to move their pots out to about 100 to 200 feet (30.5 to 36.6 meters). Most trips are day trips.

The North Carolina pot fishery is mainly a winter fishery as well; however, some fishermen continue to pot fish through the summer. The number of pots fished typically ranges from

25 to 60, but more pots are fished in the summer. Fishermen usually set their pots in water depths ranging from 30 to 90 feet (9 to 27.4 meters), though in areas further south, pots are generally set at depths ranging from 70 to 100 feet (21.3 to 30.5 meters). The duration of most trips is one day, however, some extend over multiple days. Roughly half of the fishermen in North Carolina pull their pots when heading home, while the other half leaves them and lets them soak for several days.

Overall, it appears that for the South Atlantic black sea bass pot fishery, the number of trips tends to be greater during the winter months than the summer. Data from the Reef Fish Logbook Program show that there were 1,054 trips in 2001 in which sea bass pots were reported as the main gear. Of these trips, 53 percent were conducted from November through March. Logbook data going back to 1998 show a range of 63 to 72 percent of reported trips occur during the November through March time period with the number of trips falling off in March.

Assessing the actual fishing effort at any given time within the black sea bass pot fishery is difficult. Many participants are active in other fisheries, including the recreational charter fishery during the summer months. The effort placed in the black sea bass pot fishery is often dependent on how well the income generated by black sea bass fishing compares to the income generated by the fisherman's other endeavors. Many snapper grouper permit holders maintain pot endorsements, but are not active in the pot fishery.

The number of fishermen permitted to fish with pots is higher than the actual number fishing. In South Carolina, logbook data suggests that as many as 50 to 60 fishermen are permitted to use pots as either their primary or secondary gear, but only a quarter of them are actively involved in pot fishing during the season.

Since most fishermen tend to fish only a portion of their pots while keeping the remaining pots available to replace any losses during the season, the number of tags purchased is often not an accurate count of how many pots are actively being fished.

Powerheads and Spears

In federal waters, fishing commercially by diving and killing the fish by spear or powerheads is most commonly practiced off the coast of Florida. The use of powerheads to kill snapper grouper is illegal in the EEZ off the coast of South Carolina (50 CFR 622.31(g)) and in Special Management Zones. Powerheads, or bangsticks, are underwater firearms that usually use 12-gauge or .357 Magnum rounds. Sharp contact from a thrust against a solid object activates a heavy, spring loaded, stainless steel firing pin, which detonates the round from a short barrel. Much of the damage inflicted on the target comes from the rapidly expanding gases forced into the body by the barrel end pressed at that moment against it.

There are 3 common methods to kill fish. First, in clear water, some fishermen shoot just a spear, because it has the capability of being more accurate at longer distances (40 to 50 feet) than a powerhead. Second, there is a traditional powerhead (also known as a bangstick), which is a powerhead attached to a metal shaft or wooden pole. The initial injury to the fish comes from a spear tip and then the powerhead is used to kill the fish. The third way is when a powerhead is on the shaft of the spear and once the trigger is pulled, the powerhead hits the fish and the round is detonated in the fish.

Bottom time is a function of depth. It is also important to separate total dive time from spearing/working time on the dive. The following two estimates of spearing/working times on the bottom are based on input from divers:

Estimate 1: about ¾ of bottom time is spearing/working time. At 100 to 120 feet a diver has about 15 minutes of spearing/working time on the bottom, and an 80 cubic foot tank lasts about 20 minutes at 100 feet. A diver can use 4 tanks per day so total spearing/working time ranges between 1 to 1.5 hours per diver per day.

Estimate 2: the maximum allowable bottom time is about 16 minutes per tank in the summer and 12 minutes in the winter. At 4 tanks per diver per day, the maximum bottom time would be 64 minutes in the summer and 48 minutes in the winter.

Private recreational fishery

Recreational fishermen for the large part use hook and line gear although in some areas spearfishing for reef fish can be popular. Methods that recreational fishermen use to fish for snapper grouper are very diverse. The distance people can go offshore in search of reef fish depends in part on the size of their boat, engine power, comfort level, and fuel prices. Experience levels vary among recreational fishermen and therefore fishing methods and efficacy differ. Bottom fishing for snapper and shallow water grouper can be accessible to many recreational fishermen as they do not have to travel as far offshore and there is somewhat less skill involved than deep drop fishing that targets mostly big grouper. As with the commercial fleet, many recreational anglers rely on technology such as fish finders and color machines to find fish. There is little or no technology gap between the professional (for-hire and commercial) fishermen and those who fish for fun on the weekends.

Recreational anglers will use both electric and manual reels for bottom fishing. Twelve volt Electric reels such (commonly called elec-tra-mates) attach to fishing rods and reels to assist fishermen in reeling in catches from deep water. People who use electric reels tend to be more serious about fishing or who fish deeper water.

Fishermen will choose to use lighter or heavier tackle based on which species they are targeting, the level of skill of the fishermen and a multitude of other factors including limiting gear loss. Generally when fishing for grouper they will use heavier line (80 to 120 pound test) and larger hooks (6/0 and larger) which mostly calls for larger weights. Fishing for snappers, porgies and grunts generally means lighter tackle (1/0 to 4/0 hooks and 20 and 40 pound test).

Like tackle, the use of bait also varies very widely among the region and among fishermen and according to target species. Cut bait, live baits and even artificial plugs are all used to fish for various snapper and grouper species. Popular cut baits include menhaden, herring, bluefish, sardines and cigar minnows.

For-hire recreational fishery

Headboats (also called party boats) are popular in the southeast. These vessels are larger than the commercial hook and line fleet and private and charter boats. Many are longer than 100 feet in length. They provide easy and economical access to successful fishing for the beginning angler and tourist. These boats take as many as 100 people offshore to fish for snapper grouper and a host of other fish.

Fishing trips on headboats can either be all day or half day. Generally when fishing off the Carolinas on half day trips they are fishing the black fish banks targeting sea bass, porgies, sharks, flounder, and other bottom species. On all day headboat trips, they will fish 40 to 50 miles offshore to target snapper, grouper, large sea bass, and trigger fish. Occasionally larger fish such as king mackerel, cobia, amberjack, and dolphin may be landed. In general, headboats are fishing the same grounds as the commercial fleets and they can often be seen fishing side by side.

Generally, customers are provided with gear and bait. The fishing methods on headboats for snapper grouper species are similar to those of the commercial fishery and the private charter fishery. Customers will be set up with a 4/0 or 6/0 reel rigged with 80 pound test monofilament, a rig with a 16 ounce weights and the same variety of hook sizes as commercial fleet uses. Most reels will be set up with two hook rigs. Cut squid is generally the preferred bait among headboat crews because it is easy to prepare and stays on the hook longer than other baits.

Headboats will make special trips to fish during the night. Generally, headboat trips will either last half a day (4 hours) or an entire day (11 hours).

Allowable gear

Commercial

The following gear represents the only gear allowable for this fishery:

- Vertical hook-and-line including hand-held hook-and-line and bandit gear
- Spearfishing gear without rebreathers
- Powerheads, except where expressly prohibited in Special Management Zones and in the EEZ off South Carolina.
- *Bottom longline, only in depths 50 fathoms or more, and only north of St. Lucie Inlet (27°10' N. lat.), Florida. (Bottom longline cannot be used for wreckfish).
- Black sea bass pots except in SMZs and only north of Cape Canaveral, Florida (Vehicle Assembly Building), (28°35.1' N. lat.)
- Sink net fishermen (NC only) can make multi-gear trips and all legal species harvested with black sea bass pots and/or vertical hook and line gear may be retained.

*Vessels with longline gear aboard may only possess snowy grouper, Warsaw grouper, yellowedge grouper, misty grouper, golden, blueline and sand tilefish.

Black Sea Bass Pot Requirements: A black sea bass pot or trap that is used or possessed in the South Atlantic must meet the following requirements:

- For sides other than the back panel: hexagonal mesh (chicken wire) — at least 1.5 inches between wrapped sides; square mesh — at least 1.5 inches between sides; OR rectangular mesh — at least 1 inch between the longer sides and two inches between the shorter sides.
- For the entire panel, i.e., the side of the pot opposite the side that contains the pot entrance, mesh that is at least 2 inches between sides.
- It must have an escape panel or door with an opening equal to or larger than the interior end of the trap's throat (funnel) placed on at least one side, excluding the top and bottom. Its hinges or fasteners must be made of one of the following degradable materials: ungalvanized or uncoated iron wire no larger than 19 gauge or 0.041 inches diameter OR galvanic, timed release mechanisms with a letter grade no higher than J.
- It must have an unobstructed escape vent opening on at least two opposite vertical sides (excluding top and bottom) meeting the following requirements: The escape vent opening must measure at least 1 1/8 x 5 3/4" for rectangular vents, 1.75 x 1.75" for square vents (inside measure), or 2 diameter for circular vents.
- Sea bass pots must be removed from the water in the South Atlantic EEZ when the quota is reached.

Recreational

- Vertical hook-and-line including hand-held hook-and-line, and bandit gear
- Spearfishing gear without rebreathers
- Powerheads, except where expressly prohibited in Special Management Zones (SMZs). In addition, the use of explosive charges, including powerheads is prohibited in the EEZ off South Carolina.

5.2.2.1.1 Commercial Fishery

Gear and Fishing Behavior

The commercial snapper-grouper fishery utilizes vertical lines, longlines, black sea bass pots/traps, spears, and powerheads (i.e., spears with spring-loaded firearms). Vertical lines are used from the North Carolina/Virginia border to the Atlantic side of Key West, Florida. The majority of hook and line fishermen use either electric or hydraulic reels (bandit gear) and generally have 2-4 bandit reels per boat. The majority of the bandit fleet fishes year round for snapper-grouper with the only seasonal differences in catch associated with the regulatory spawning season closures in March and April for gag. Most fluctuations in fishing effort in this fishery are a result of the weather. Trips can be limited during hurricane season and also during the winter months from December through March. Some fishermen stop bandit fishing to target king mackerel when they are running.

The Council allows the use of bottom longlines north of St. Lucie Inlet, Florida, in depths greater than 50 fathoms. Bottom longline gear is used to target snowy grouper and golden tilefish. Longline boats are typically bigger than bandit boats, their trips are longer, and they cost more to operate because they operate farther offshore. A longline spool generally holds about 15 miles of cable. Longlines are fished from daylight to dark because sea lice eat the flesh of hooked fish at night. The fishery is operated year long with little or no seasonal fluctuation barring hurricane disruption.

Spears or powerheads are most commonly used off Florida and are illegal for killing snapper-grouper species in South Carolina and Special Management Zones.

Black sea bass pots are used exclusively to target black sea bass, though bycatch of other snapper-grouper species is allowed. The pots have mesh size, material, and construction restrictions to facilitate bycatch reduction. All sea bass pots must have a valid identification tag attached and more than 87% of tags in April, 2003 were for vessels with homeports in North Carolina. Fishing practices vary by buoy practices, setting/pulling strategies, number of pots set, and length of set, with seasonal variations. The South Carolina pot fishery is mainly a winter fishery with short soak times (in some cases about an hour) and relatively few pots per boat. Most trips are day trips with pots being retrieved before heading to port. The North Carolina pot fishery also is primarily a winter fishery with some fishermen continuing to pot through the summer. North Carolina fishermen tend to use more pots than those in South Carolina. Although most North Carolina trips with sea bass pots last one day, more pots are left to soak for several days than in South Carolina. Many participants in the black sea bass fishery are active in other fisheries, including the recreational charter fishery during the summer months. Many snapper-grouper permit holders maintain pot endorsements but are not active in the pot fishery.

Landings, Ex-vessel Value, Price, and Effort

Landings of all species in the snapper-grouper management unit averaged 6.77 million pounds from 2001 through 2006, with an average annual dockside value of $12.99 million in current year dollars and $13.55 million in constant 2005 dollars (Table 3-5). The shallow water groupers and mid-shelf snappers are the largest species groups by volume and value within the snapper-grouper fishery. Vermilion snapper in the mid-shelf snapper group is the largest volume species in the fishery, and accounts for 13% of total landings and 17% of dockside revenues on trips with at least one pound of snapper-grouper species. Gag is the largest volume shallow water grouper, and accounts for 6% of total landings and 10% of dockside revenues on trips that landed at least one pound of snapper-grouper species. Fishermen also landed an average of 1.84 million pounds of non-snapper-grouper species worth $1.95 million in current year dollars on trips that landed at least one pound of species in the snapper-grouper management unit. These trips included trips that targeted species in the snapper-grouper management unit and trips that landed snapper-grouper species while targeting non-snapper-grouper species.

Landings and dockside revenues declined between 2001 and 2006 for species in the snapper-grouper management unit (Table 5.2.2-1). Part of the declines appear to be attributable to variation in landings of vermilion snapper, which experienced a significant decline in 2003 due to unusually cold water temperatures in the summer and fall of 2003. Landings of vermilion snapper recovered in 2004 and 2005, but not to the levels experienced in 2001 and 2002, and declined again in 2006.

Table 5.2.2-1. Annual landings and dockside (ex-vessel) revenues for trips with at least one pound of species in the snapper-grouper fishery management unit in the south Atlantic.

Item	2001	2002	2003	2004	2005	2006	Average
	Trips with at least one pound of snapper-grouper species						
Snapper-grouper landings (million pounds, whole wgt)	7.60	7.36	6.50	6.70	6.39	6.07	6.77
Dockside revenue from snapper-grouper species (million dollars)	$13.95	$13.55	$12.12	$12.70	$12.98	$12.63	$12.99
Dockside revenue in constant 2005 dollars (millions)*	$15.38	$14.71	$12.87	$13.13	$12.98	$12.23	$13.55
Price/lb (whole wgt) for snapper-grouper species	$1.83	$1.84	$1.86	$1.90	$2.03	$2.08	$1.92
Price/lb in constant 2005 dollars*	$2.02	$2.00	$1.98	$1.96	$2.03	$2.01	$2.00
Producer price index for #2 diesel fuel, adjusted to constant 2005 price levels (index=100 for 2005)	44.1	41.2	53.1	67.8	100.0	114.7	70.2
Landings of other species on these trips (million lbs)	1.71	1.76	2.10	1.65	1.74	2.06	1.84
Dockside revenue from other species on these trips (million $)	$1.97	$1.96	$1.92	$1.78	$1.92	$2.17	$1.95
Dockside revenue from other species in constant 2005 dollars (millions)	$2.17	$2.13	$2.04	$1.84	$1.92	$2.10	$2.03
Vermilion snapper landings (million pounds)	1.65	1.31	0.77	1.07	1.16	0.86	1.14
Gag landings (million pounds)	0.52	0.53	0.60	0.53	0.54	0.50	0.54

Source: NOAA Fisheries Service, Southeast Fisheries Science Center logbook database as of October 10, 2007. *The Consumer Price Index for all Urban Consumers was used to adjust dockside revenues and average annual prices for inflation.

In addition, participation in the snapper-grouper fishery has declined over time. The number of boats with snapper-grouper permits declined from 1,264 in 2001 to 1,007 in 2005 (Table 5.2.2-2). Two types of permits were created with the limited access program for the snapper-grouper fishery that was implemented in 1998. The number of transferable permits that allow an unlimited harvest per trip declined from 959 in 2001 to 801 in 2005, while the number of vessels with non-transferable permits with a 225-pound trip limit declined from 305 in 2001 to 206 in 2005. Preliminary information suggests additional declines in 2006. The number of transferable permits declined, in part, because new entrants into the fishery must buy two permits and retire one as the condition for entry into the fishery. Furthermore, it is likely that the number of vessels in the snapper-grouper fishery declined for economic reasons. Average annual prices, as indexed by the ratio of annual commercial revenues to landings, for species in the snapper-grouper management unit remained relatively constant when adjusted for inflation, whereas fuel prices more than doubled since 2001 (Table 3-5). The net result has been a decline since 2001 in the number of vessels, trips and days fished for species in the snapper-grouper management unit (Table 5.2.2-2). The decline in the number of vessels is evident in all harvest categories except for the highest producing category of 50,000 pounds or more per year. The number of fish dealers with permits to operate in the snapper-grouper fishery reached a maximum in 2003 and has declined since then (Table 5.2.2-2).

From 2001 through 2006, an average of 922 boats averaged 15,500 trips per year on which at least one pound of snapper-grouper species was landed (Table 5.2.2-2). On average, 528 boats landed at least 1000 pounds of snapper-grouper species annually; 260 boats landed at least 5000 pounds; 173 boats landed at least 10,000 pounds; and 27 boats landed at least 50,000 pounds of snapper-grouper species.

Table 5.2.2-2. Fishing effort and distribution of catch for trips with at least one pound of species in the snapper-grouper fishery management unit in the south Atlantic.

Item	2001	2002	2003	2004	2005	2006	Average
	Trips with at least one pound of snapper-grouper species						
Number of trips	17,278	17,199	16,563	15,045	13,757	13,159	15,500
Days away from port	29,932	29,580	27,620	24,828	22,810	23,005	26,296
Number of vessels landing snapper-grouper species	1,002	976	931	905	858	857	922
Number of vessels with more than 100 lbs of snapper-grouper spp.	867	829	791	749	720	697	776
Number of vessels with more than 1,000 lbs of snapper-grouper spp.	593	589	546	524	476	442	528
Number of vessels with more than 5,000 lbs of snapper-grouper spp.	287	280	277	261	238	217	260
Number of vessels with more than 10,000 lbs of snapper-grouper spp.	195	198	173	165	153	154	173
Number of vessels with more than 50,000 lbs of snapper-grouper spp.	26	27	20	32	29	26	27
Number of permitted vessels	1,264	1,174	1,123	1,066	1,007	974	1,101
Number of vessels with transferable permits	959	907	879	841	801	783	862
Number of vessels with non-transferable permits	305	267	244	225	206	191	240
Number of dealer permits	252	246	271	269	268	251	260

Source: NOAA Fisheries Service, Southeast Fisheries Science Center logbook database as of October 10, 2007 and NOAA Fisheries Service, Southeast Regional Office permits database.

5.2.2.1.1.1 Snapper Grouper Fishery by State

The following discussion provides annual averages from 2001 to 2006. To maintain the confidentiality of individual reporting units, summaries are provided for regions defined as North Carolina, South Carolina, Georgia and northeast Florida combined, and central and south Florida combined. The northeast Florida region consists of trips landed in Nassau, Duval and St. Johns Counties, and the central and south Florida region consists of trips landed from Flagler through Miami-Dade Counties and trips from Atlantic waters off the Florida Keys and landed in Monroe County.

The average annual quantities of snapper-grouper species harvested from 2001-2006 included 1.86 million pounds worth $3.46 million per year in North Carolina, 1.64 million pounds worth $3.44 million in South Carolina, 0.81 million pounds worth $1.65 million in Georgia and northeast Florida, and 2.46 million pounds worth $4.44 million in central and south Florida (Table 5.2.2-3). Snapper-grouper landings by state were not proportional to total days fished in each state. Boats in central and south Florida made 72% of the trips that landed species in the snapper-grouper management unit and accounted for 36% of the total snapper-grouper harvest. Conversely, boats in other states accounted for relatively larger portions of the total snapper-grouper harvest. Boats in North Carolina made 18% of the trips and landed 27% of the snapper-grouper harvest. Boats in South Carolina made 6% of the trips and landed 24% of the harvest. In addition, boats in Georgia and northeast Florida made 4% of the trips and landed 12% of the snapper-grouper harvest. Boats in South Carolina and Georgia and northeast Florida took fewer but longer trips than their counterparts in North Carolina or central and south Florida.

Gag and other shallow water groupers and vermilion snapper and other mid-shelf snappers tend to be landed in North Carolina, South Carolina, and Georgia and northeast Florida, while jacks and shallow water snappers tend to be landed in central and south Florida (Tables 5.2.2-4 and 5.2.2-5). The species groups that accounted for more than 10% of total landings and revenues in North Carolina include shallow water groupers with nearly 22% of total pounds landed and nearly 30% of total revenues on trips with at least one pound of snapper-grouper species; black sea bass with 20% of total landings and 19% of total revenues; and mid-shelf snappers with 18% of total landings and 25% of total revenues. In South Carolina, the shallow water groupers accounted for 27% of total pounds and 38% of total revenues, and the mid-shelf snappers accounted for 26% of total pounds and 30% of total revenues. In Georgia and northeast Florida, mid-shelf snappers accounted for 45% of total pounds and 52% of total revenues, shallow water groupers accounted for 18% of total pounds and nearly 25% of total revenues, and jacks accounted for 16% of total pounds and 6% of total revenues. In central and south Florida, the shallow water snappers accounted for 29% of total pounds and nearly 41% of total revenues, and jacks accounted for 17% of total pounds and 10% of total revenues on trips with at least one pound of snapper-grouper species. Fishermen in central and south Florida, especially in the Keys, tend to catch larger quantities of non-snapper-grouper species such as mackerels.

Table 5.2.2-3. Average annual landings and dockside revenues for trips with at least one pound of species in the snapper-grouper fishery, averages for 2001-2006 by state.

Item	North Carolina	South Carolina	Georgia and Northeast Florida	Central and South Florida	Total
	Trips with at least one pound of snapper-grouper species				
Snapper-grouper landings (million pounds, whole wgt)	1.86	1.64	0.81	2.46	6.77
Percent of total snapper-grouper pounds	27.4%	24.2%	12.0%	36.4%	100%
Dockside revenue from snapper-grouper species (million dollars)	$3.46	$3.44	$1.65	$4.44	$12.99
Percent of total snapper-grouper revenues	26.7%	26.5%	12.7%	34.2%	100%
Landings of other species on these trips (million lbs)	0.29	0.14	0.07	1.34	1.84
Dockside revenue from other species on these trips (million $)	$0.32	$0.18	$0.15	$1.30	$1.95
Number of boats*	170	66	50	650	922
Number of trips	2,801	956	560	11,183	15,500
Percent of trips	18.1%	6.2%	3.6%	72.1%	100%
Number of days	4,979	4,835	2,290	14,192	26,296
Trips per boat	16.5	14.5	11.2	17.2	16.8
Days per trip	1.8	5.1	4.1	1.3	1.7

Source: NOAA Fisheries Service, Southeast Fisheries Science Center logbook database as of October 10, 2007. ***Some boats land in more than one state.**

Table 5.2.2-4. Average annual landings (in thousands of pounds, whole weights) on trips that landed at least one pound of snapper-grouper species: averages for 2001-2006 by state and species group.

Item	North Carolina		South Carolina		Georgia and Northeast Florida		Central and South Florida		Total	
	lbs, 1000s	column percent	lbs, 1000s	column percent	lbs, 1000s	column percent	lbs, 1000s	column percent	lbs, 1000s	column percent
Shallow water groupers	464	21.6%	480	26.9%	163	18.5%	225	5.9%	1,332	15.5%
Deep water groupers	95	4.5%	98	5.5%	7	0.8%	113	3.0%	313	3.6%
Tilefishes	105	4.9%	150	8.4%	3	0.3%	252	6.6%	509	5.9%
Shallow water snappers	12	0.6%	18	1.0%	23	2.7%	1,104	29.1%	1,157	13.4%
Mid-shelf snappers	385	18.0%	467	26.2%	400	45.4%	68	1.8%	1,320	15.3%
Triggerfish /Spadefish	117	5.4%	69	3.8%	51	5.8%	6	0.2%	242	2.8%
Jacks	118	5.5%	159	8.9%	142	16.1%	647	17.0%	1,066	12.4%
Grunts & porgies	126	5.9%	80	4.5%	16	1.8%	42	1.1%	265	3.1%
Sea basses	436	20.3%	120	6.7%	6	0.7%	5	0.1%	567	6.6%
Snapper-grouper	1,858	86.6%	1,641	91.9%	811	92.1%	2,462	64.8%	6,771	78.7%
Coastal pelagics	205	9.5%	55	3.1%	40	4.6%	907	23.9%	1,207	14.0%
Sharks	11	0.5%	19	1.1%	7	0.8%	319	8.4%	357	4.1%
Tunas	25	1.1%	2	0.1%	1	0.1%	1	0.0%	29	0.3%
Other species	46	2.1%	68	3.8%	21	2.4%	109	2.9%	244	2.8%
All species	2,145	100.0%	1,785	100.0%	881	100.0%	3,798	100.0%	8,608	100.0%
Vermilion snapper	365	17.0%	424	23.8%	330	37.5%	18	0.5%	1,138	13.2%
Gag	146	6.8%	206	11.5%	99	11.3%	86	2.3%	537	6.2%

Source: NOAA Fisheries Service, Southeast Fisheries Science Center logbook database as of October 10, 2007.

Table 5.2.2-5. Average annual dockside revenues in thousands of constant 2005 dollars on trips that landed at least one pound of snapper-grouper species: averages for 2001-2006 by state and species group.

Item	North Carolina		South Carolina		Georgia and Northeast Florida		Central and South Florida		Total	
	dollars, 1000s	column percent	dollars, 1000s	column percent	dollars, 1000s	column percent	dollars, 1000s	column percent	dollars, 1000s	column percent
Shallow water groupers	1,165	29.5%	1,433	38.0%	463	24.6%	600	10.0%	3,661	23.5%
Deep water groupers	212	5.4%	247	6.6%	17	0.9%	276	4.6%	752	4.8%
Tilefishes	128	3.2%	255	6.8%	6	0.3%	511	8.5%	899	5.8%
Shallow water snappers	24	0.6%	43	1.1%	51	2.7%	2,435	40.7%	2,553	16.4%
Mid-shelf snappers	1,001	25.4%	1,110	29.5%	984	52.2%	173	2.9%	3,268	21.0%
Triggerfish /Spadefish	123	3.1%	73	1.9%	54	2.9%	7	0.1%	256	1.6%
Jacks	100	2.5%	143	3.8%	123	6.5%	593	9.9%	959	6.2%
Grunts and porgies	117	3.0%	78	2.1%	17	0.9%	37	0.6%	249	1.6%
Sea basses	737	18.7%	199	5.3%	9	0.5%	8	0.1%	953	6.1%
Snapper-grouper	3,607	91.5%	3,581	95.1%	1,724	91.5%	4,638	77.4%	13,550	86.9%
Coastal pelagics	262	6.7%	93	2.5%	69	3.7%	950	15.9%	1,375	8.8%
Sharks	3	0.1%	13	0.3%	2	0.1%	121	2.0%	139	0.9%
Tunas	33	0.8%	4	0.1%	1	0.1%	2	0.0%	40	0.3%
Other species	39	1.0%	76	2.0%	88	4.7%	278	4.6%	481	3.1%
All species	3,943	100.0%	3,767	100.0%	1,885	100.0%	5,989	100.0%	15,584	100.0%
Vermilion snapper	943	23.9%	984	26.1%	776	41.2%	40	0.7%	2,743	17.6%

Item	North Carolina		South Carolina		Georgia and Northeast Florida		Central and South Florida		Total	
	dollars, 1000s	column percent	dollars, 1000s	column percent	dollars, 1000s	column percent	dollars, 1000s	column percent	dollars, 1000s	column percent
Gag	400	10.1%	639	17.0%	290	15.4%	255	4.2%	1,583	10.2%

Source: NOAA Fisheries Service, Southeast Fisheries Science Center logbook database as of October 10, 2007, and NOAA Fisheries Service, Southeast Fisheries Science Center Accumulated Landings System as of October 5, 2007.

5.2.2.1.1.2 The Snapper Grouper Fishery by Gear

The following discussion provides annual averages from 2001 to 2006. To maintain the confidentiality of individual reporting units, summaries are provided for vertical lines, longlines, black sea bass pots, and all other gears combined. The all-other-gear category includes trolling lines, diving gear, nets and other gears.

Most of the snapper-grouper harvest, including vermilion snapper and gag, is taken by some type of vertical hook-and-line gear. The exceptions include black sea bass, which is harvested primarily with black sea bass pots, and golden tilefish and yellowedge grouper, which are harvested primarily with bottom longlines. Some species, such as snowy grouper, are harvested by both vertical lines and longlines. Longlines also are used in the shark fishery and may catch species in the snapper-grouper management unit as secondary species.

The average quantities of snapper-grouper species harvested from 2001-2006 included 5.36 million pounds worth $10.48 million per year with vertical lines, 0.54 million pounds worth $1.02 million with longlines, 0.53 million pounds worth $0.83 million with black sea bass pots, and 0.34 million pounds worth $0.65 million with other gears (Table 5.2.2-6). Trips with vertical lines accounted for 78% of all trips that landed species in the snapper-grouper management unit and 79% of the total snapper-grouper harvest. Trips with longlines tend to be longer than trips with other gears. Longline trips accounted for 2% of the trips and 8% of the snapper-grouper harvest. Trips with black sea bass pots represented 5% of the trips and accounted for 8% of the harvest, while trips with other gears represented 15% of the trips and 5% of the harvest.

Table 5.2.2-6. Average annual landings and dockside revenues for trips with at least one pound of species in the snapper-grouper fishery: averages for 2001-2006 by primary gear.

Item	Vertical Lines	Longlines	Traps / Pots	Other Gears	Total
	Trips with at least one pound of snapper-grouper species				
Vermilion snapper landings (million pounds, whole wgt)	1.13	0.00	0.00	0.01	1.14
Percent of total vermilion snapper pounds	99.3%	0.0%	0.1%	0.5%	100.0%
Gag landings (million pounds, whole wgt)	0.44	0.00	0.00	0.09	0.54
Percent of total gag pounds	81.7%	0.7%	0.2%	17.4%	100.0%
Snapper-grouper landings (million pounds, whole wgt)	5.36	0.54	0.53	0.34	6.77
Percent of total snapper-grouper pounds	79.2%	7.9%	7.8%	5.1%	100%
Dockside revenue from snapper-grouper species (million dollars)	$10.48	$1.02	$0.83	$0.65	$12.99
Percent of total snapper-grouper revenues	80.7%	7.9%	6.4%	5.0%	100%
Dockside revenue in constant 2005 dollars (millions)*	$10.93	$1.07	$0.87	$0.68	$13.55
Landings of other species on these trips (million lbs)	0.60	0.35	0.02	0.87	1.84
Dockside revenue from other species on these trips (million $)	$0.78	$0.19	$0.03	$0.96	$1.95
Dockside revenue from other species in constant 2005 dollars (millions)	$0.80	$0.20	$0.03	$1.01	$2.03
Number of boats*	749	33	53	304	922
Number of trips	12,065	286	793	2,357	15,500
Percent of trips	77.8%	1.8%	5.1%	15.2%	100%
Number of days	21,187	1,239	1,027	2,844	26,296
Trips per boat	16.1	8.7	15.0	7.8	16.8
Days per trip	1.8	4.3	1.3	1.2	1.7

Source: NOAA Fisheries Service, Southeast Fisheries Science Center logbook database as of October 10, 2007.
Some boats fish with more than one primary gear.

5.2.2.1.1.3 Long-term Trends

The snapper grouper fishery has been heavily regulated since the fishery management plan was implemented in 1983 (Figure 5.2.2-1). Apart from the response to fishery management regulations, fluctuations in landings can be partly attributed to changes in stock abundance and availability, water quality, environmental conditions, market conditions (e.g., price), and fleet dynamics. Ex-vessel prices for the various species in the fishery depend on the quantity of landings, product quality, market conditions such as the availability of imports and the relative prices of substitutes, and consumer income levels.

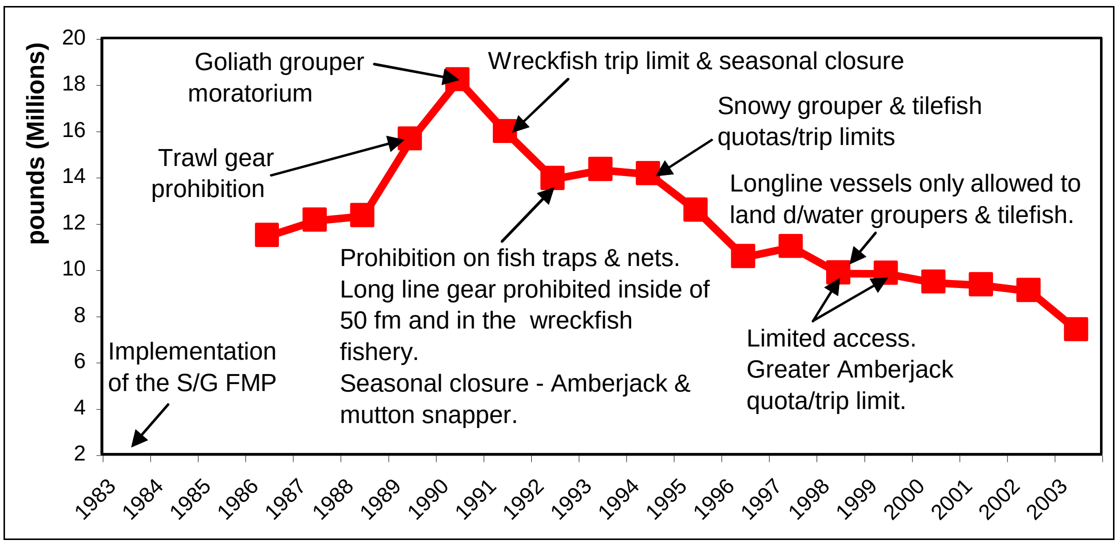


Figure 5.2.2-1. Major events in the regulatory history of the snapper grouper fishery superimposed on total snapper grouper landings during 1983-2003. Source: Accumulated landings system, Southeast Fisheries Science Center, Beaufort Lab.

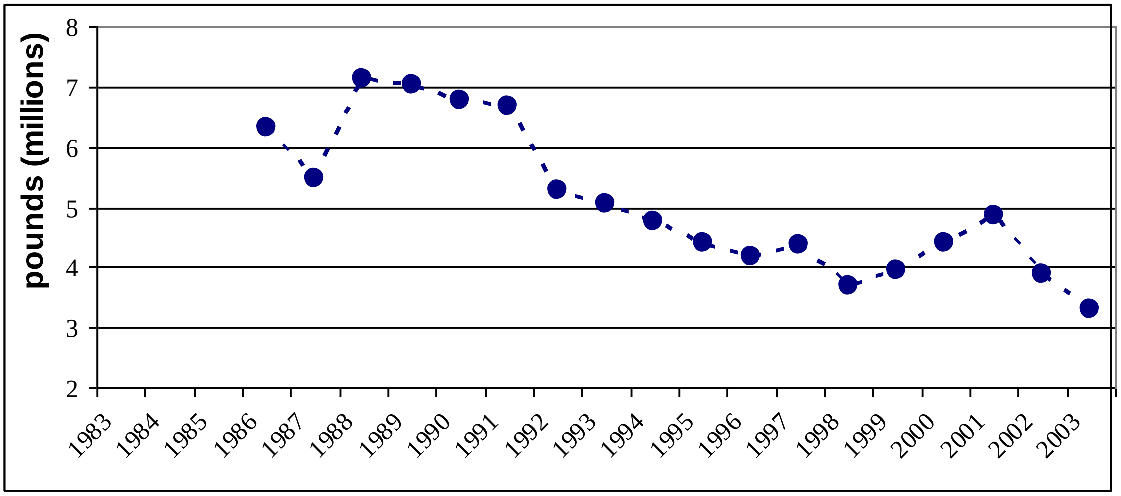


Figure 5.2.2-2. Trends in total harvest of species in Amendment 13C (SAFMC 2006) during 1983-2003. Source: Accumulated landings system, Southeast Fisheries Science Center, Beaufort Lab.

Snapper grouper ex-vessel landings and value increased from 1986 to 1990. During this period, real ex-vessel revenue increased from approximately $26 million to $35 million (Figure 5.2.2-2). Even though the overall average unit price of the fish, adjusted for inflation, was on a decreasing trend during this period (Figure 5.2.2-3), the 59% increase in landings resulted in the growth in overall ex-vessel revenue from 1986 through 1990. Data from the Accumulated Landings System (ALS) were used to examine long-term trends in prices, landings and revenue (see Appendix E in Snapper Grouper Amendment 13C, SAFMC 2006). These data will not correspond exactly to the statistics in Table 5.2.3-1 since this table contains statistics derived from the Southeast logbook database.

Since the peak in snapper grouper landings and revenue in 1990, there has been a steady decline in landings, ex-vessel revenue, and real ex-vessel revenue (Figure 5.2.2-3, Figure 5.2.2-4). The cause of this decline can be partly attributed to restrictive regulations taken to improve/maintain the health of species in the snapper grouper complex and protect essential fish habitat. This fishery was first regulated in 1983 with a number of size limit measures and gear restrictions. In 1992, Amendment 4 prohibited fish traps, entanglements nets, longlines for wreckfish, and the use of longline gear inside of 50 fathoms for snapper grouper species in the South Atlantic EEZ. Also, additional minimum size regulations and bag limits went into effect during 1992 (Figure 5.2.2-1).

The implementation of a limited access program in 1998/1999 partly contributed to the decline in the number of commercial vessels in the snapper grouper fishery (SAFMC 1997). Since 1999, the annual number of permitted vessels has declined by 375; the number of vessels with unlimited permits has declined by 244 (Table 5.2.2-1). Commercial and recreational fishermen in the snapper grouper fishery have faced additional restrictive measures implemented in Amendment 9 (SAFMC 1998c) and Amendment 12 (SAFMC 2000). A detailed account of these regulations is contained in the history of management section of this document. If current permit requirements remain in effect, it is likely fishing effort will continue to decline since each new entrant will have to purchase two existing snapper grouper permits. Also, the number of non-transferable permits will decline over time as their owners retire.

The trend in aggregate harvest of all species in this amendment follows a similar pattern to landings in the snapper grouper fishery (Figure 4.2.2-1). There was a continual decline in harvest from 1991 until 1998. However, unlike the trend in total snapper grouper landings, the total harvest of these five species increased between 1998 and 2001, before declining again during the following three years (Figure 5.2.2-1).

The average unit price for all snapper grouper species was fairly stable from 1986 to 1992 (Figure 5.2.2-4). Under normal conditions one would expect nominal prices to increase over time to account for inflation. However, landings increased during this period, which could partly account for the decreasing trend in inflation-adjusted prices up until 1991. Real prices remained relatively stable between 1992 and 2001 and declined afterwards. Other factors that influence snapper grouper prices include landings and market conditions in the Gulf of Mexico and the quantity of imports. The overall average price for snapper grouper species is calculated from data for a large number of individual species with different price trends. Also, prices for individual species will vary by size and for some species like black sea bass there is a large difference in price per lb among the various size categories.

In 2004, the volume of snappers and groupers imported into the U.S. was 43 million lbs valued at $75.6 million dollars. In comparison, domestic harvest of snappers and groupers landed at ports in the Gulf of Mexico and South Atlantic states amounted to 23.4 million lbs in 2003 (NOAA Fisheries 2004). Imports of snappers and groupers are classified into two product forms: fresh and frozen. Fresh fish comprised over 70% of total snapper grouper imports in 2004 (Table 5.2.2-7), which increased almost threefold from 16 million lbs in 1991 to 44.4 million lbs in 2003. Imports of other product forms cannot be identified by species group.

It is reasonable to expect that imports influence domestic prices. From the point of view of fishermen, imports contribute to depressing dockside prices. However, imports increase the aggregate U.S. supply of snappers and groupers, which leads to lower retail prices for consumers. Thus, consumers in this country benefit from imports, although there are also balance of trade considerations with imports, which affect the buying power of U.S. consumers in the long run. Imports also benefit some wholesalers and retailers in the fishing industry, especially at times when the domestic fishery is unable to supply market needs.

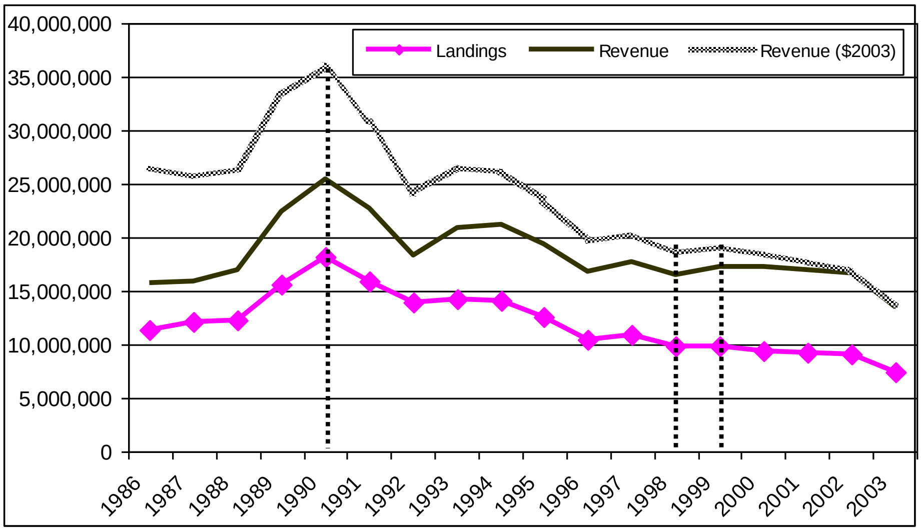


Figure 5.2.2-3. Trends in dockside landings and nominal and real ex-vessel revenue for all snapper grouper species in the South Atlantic region during 1986-2003. (Source: Accumulated landings system, Southeast Fisheries Science Center, Beaufort Lab).
Florida landings include all of Monroe County
*landings data are presented in whole weight equivalents
**Real value was calculated using the Consumer Price Index (CPI) and represents the purchasing power of earnings of a respective year in 2003 dollars.

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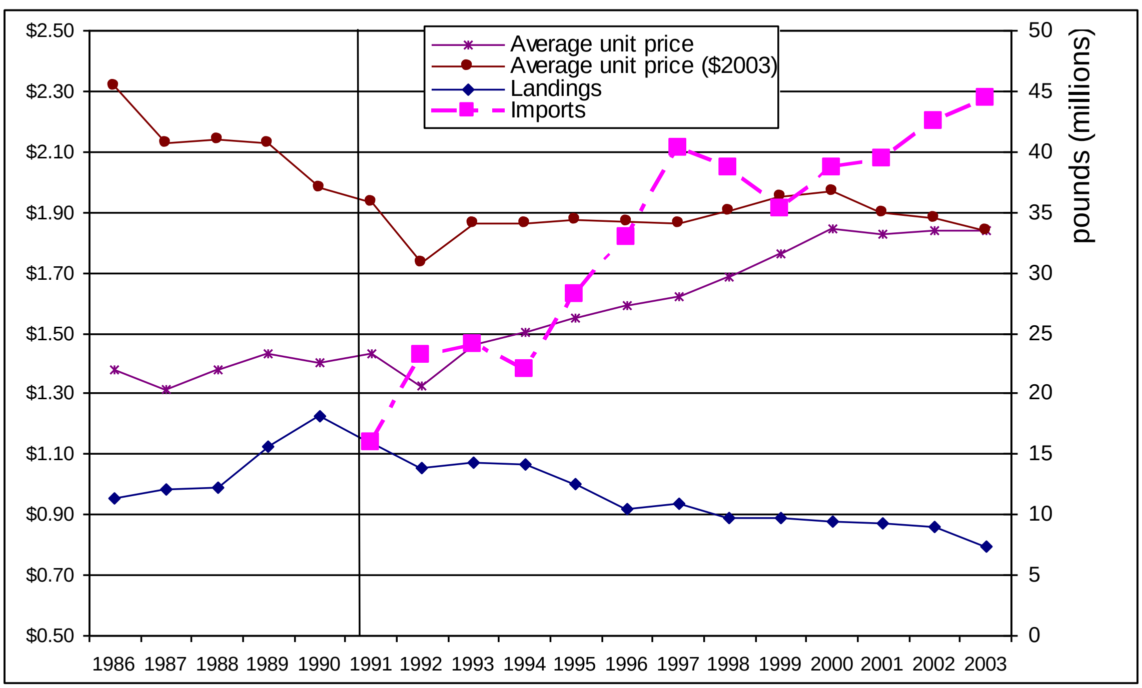


Figure 5.2.2-4. Trends in unit price, imports, and landings of snapper grouper species. Average unit prices are expressed in nominal value and real value (2003 dollars). Source: Accumulated landings system, Southeast Fisheries Science Center, Beaufort Lab.

Table 5.2.2.7 U.S. imports of snappers and groupers from 1991 to 2004. Source: NMFS, Foreign Trade Database.

YEAR	Pounds of imports by product form Millions of pounds**			Value of imports by product form Millions of dollars		
	FRESH	FROZEN	TOTAL	FRESH	FROZEN	TOTAL
1991	12.6	3.4	16.0	$16.3	$4.0	$20.2
1992	19.4	3.9	23.2	$28.0	$4.6	$32.6
1993	20.8	3.2	24.0	$28.9	$3.9	$32.9
1994	20.0	2.0	22.0	$28.4	$2.5	$30.9
1995	26.1	2.1	28.2	$35.9	$2.6	$38.5
1996	30.7	2.2	32.9	$44.8	$2.7	$47.5
1997	36.8	3.5	40.2	$53.8	$4.2	$58.0
1998	35.1	3.6	38.7	$53.3	$5.2	$58.5
1999	32.0	3.3	35.3	$49.4	$4.6	$53.9
2000	32.5	6.1	38.6	$53.5	$9.5	$63.0
2001	31.1	8.4	39.4	$51.7	$10.6	$62.3
2002	33.3	9.2	42.5	$57.1	$12.3	$69.5
2003	34.2	10.2	44.4	$58.9	$14.4	$73.3
2004	33.2	9.8	43.0	$61.7	$13.9	$75.6

5.2.2.1.1.4 The Snowy Grouper Fishery

Landings of snowy grouper averaged 0.288 million pounds between 2001 and 2005, with average annual dockside revenues of $0.644 million in current-year dollars and $0.683 million in constant 2005 dollars (Table 5.2.2-8). Fishermen also landed an average of 1.416 million pounds of other species worth $2.434 million in current-year dollars on trips that landed at least one pound of snowy grouper.

According to NOAA Fisheries Service logbook trip reports, an average of 190 boats per year landed at least one pound of snowy grouper (Table 5.2.2-8). On average, 56 boats landed at least 1,000 pounds of snowy grouper per year, 15 boats landed at least 5,000 pounds per year, and 6 boats landed at least 10,000 pounds of snowy grouper per year. Landings and fishing effort for snowy grouper declined from 2001 through 2005.

Logbook data for 2001-2005 provided information about the extent to which snowy grouper was a primary or secondary source of trip revenue. Fishing trips were classified as targeting a particular species if revenues from that species were greater than revenues from any other individual species. (This is an imperfect measure of targeting behavior.) Snowy grouper were landed on an average of 1,332 trips per year, with less than 39% of them classified as targeted snowy grouper trips (Table 5.2.2-8). Targeted snowy grouper trips accounted for approximately 70% of total snowy grouper landings. Snowy grouper were caught frequently as a lesser source of revenue on trips for vermilion snapper, tilefishes, and other groupers, with the volume of secondary catch accounting for 30% of the average annual harvest of snowy grouper.

Snowy grouper are landed primarily with vertical lines and longlines. Trips with vertical lines accounted for 70% of landings of snowy grouper, while longlines accounted for 29% (Table 3-8). Approximately 48% of all trips with longlines that caught species in the snapper grouper management unit also caught snowy grouper, whereas approximately 9% of all trips with vertical lines in the snapper grouper fishery landed snowy grouper. Snowy grouper were landed as the primary revenue and secondary revenue species on trips with both gears. As a secondary-revenue species on trips with vertical lines, snowy grouper were landed frequently on trips that targeted vermilion snapper or other groupers. As a secondary-revenue species on trips with longlines, snowy grouper were landed on trips with golden tilefish.

On average from 2001-2005, snowy grouper were landed in approximately equal quantities in North Carolina, South Carolina and central-south Florida (Table 3-9). The greatest amount of fishing effort for snowy grouper occurred in central-south Florida, where snowy grouper contributed about 3.8% to total snapper grouper landings. Snowy grouper represented 5% of total snapper grouper landings in North Carolina and 6% in South Carolina.

Table 5.2.2-8. Annual landings, dockside (ex-vessel) revenues, and fishing effort for snowy grouper, 2001-2005.

Item	2001	2002	2003	2004	2005	Average
Trips with at least 1 pound of snowy grouper						
Snowy grouper landings (million pounds, whole wgt)	0.352	0.311	0.287	0.239	0.249	0.288
Dockside revenue from snowy grouper (million dollars)	$0.766	$0.670	$0.638	$0.549	$0.597	$0.644
Dockside revenue in constant 2005 dollars (millions)*	$0.844	$0.728	$0.678	$0.568	$0.598	$0.683
Price/lb (whole wgt) for snowy grouper	$2.17	$2.16	$2.22	$2.29	$2.40	$2.24
Price/lb in constant 2005 dollars*	$2.40	$2.34	$2.36	$2.37	$2.40	$2.37
Landings of other species on trips with snowy grouper (million lbs)	1.848	1.566	1.403	1.159	1.105	1.416
Dockside revenue from other species on trips with snowy grouper (million $)	$3.183	$2.641	$2.170	$2.055	$2.122	$2.434
Dockside revenue from other species in constant 2005 dollars (millions)	$3.510	$2.868	$2.303	$2.122	$2.125	$2.568
Number of boats that landed snowy grouper	226	206	189	167	163	190
Number of boats landing 1,000 lbs or more per year of snowy grouper	70	68	58	48	39	56
Number of boats landing 5,000 lbs or more per year of snowy grouper	17	15	14	18	13	15
Number of boats landing 10,000 lbs or more per year of snowy grouper	7	6	7	5	5	6
Number of trips with at least 1 pound of snowy grouper	1,721	1,552	1,347	1,060	980	1,332
Number of trips with snowy grouper as primary source of trip revenue	603	599	543	433	435	523
Number of trips with snowy grouper as a lesser source of trip revenue	1,118	953	804	627	545	809

Source: NOAA Fisheries Service logbook database as of April 5, 2007, Southeast Fisheries Science Center.

The Consumer Price Index for all Urban Consumers was used to adjust dockside revenues and average annual prices for inflation.

Table 5.2.2-9. Description of fishing activities for trips with at least 1 pound of snowy grouper, by primary gear, 2001-2005 averages.

Item	Vertical Lines	Longlines	Other Gears	Total
Trips with at least 1 pound of snowy grouper				
Number of boats that landed snowy grouper*	173	23	18	190
Number of trips that landed snowy grouper	1,151	147	34	1,332
Percent of trips with snowy grouper, by gear	86.4%	11.0%	2.6%	100%
Trips with snowy grouper as percent of all snapper grouper trips with this gear	9.2%	48.4%	1.0%	8.3%
Landings of snowy grouper (million lbs)	0.201	0.083	0.004	0.288
Percent of snowy grouper landings by gear	69.8%	28.8%	1.4%	100%
Snowy grouper landings as percent of snapper grouper landings with this gear	3.7%	15.4%	0.4%	4.2%
Dockside revenues for snowy grouper (million $)	$0.442	$0.194	$0.007	$0.644
Landings other species (million lbs)	0.986	0.408	0.022	1.416
Revenues other species (million $)	$1.830	$0.577	$0.027	$2.434
Number of trips with snowy grouper as primary source of revenue	476	40	6	522
Number of trips with snowy grouper as a lesser source of trip revenue	675	107	28	810

Source: NOAA Fisheries Service logbook database as of April 5, 2007, Southeast Fisheries Science Center.

* Some boats fish with more than one primary gear.

Table 5.2.2-10. Annual landings and dockside revenues for trips with at least 1 pound of snowy grouper, 2001-2005 averages by state.

Item	North Carolina	South Carolina	Georgia and Northeast Florida	Central and South Florida	Total
Trips with at least 1 pound of snowy grouper					
Number of boats that landed snowy grouper*	44	36	16	99	190
Number of trips that landed snowy grouper	378	205	88	661	1,332
Percent of trips with snowy grouper, by state	28.3%	15.4%	6.6%	49.7%	100%
Trips with snowy grouper as percent of all snapper grouper trips in this area	13.3%	21.2%	14.9%	5.7%	8.3%
Landings of snowy grouper (million lbs)	0.092	0.090	0.008	0.098	0.288
Percent of snowy grouper landings by are	32.0%	31.4%	2.5%	34.0%	100%
Snowy grouper landings as percent of snapper grouper landings with this gear	5.0%	5.5%	0.8%	3.8%	4.2%
Dockside revenues for snowy grouper (million	$0.189	$0.217	$0.017	$0.221	$0.644
Landings other species (million lbs)	0.362	0.536	0.220	0.295	1.413
Revenues other species (million $)	$0.600	$0.976	$0.422	$0.432	$2.430
Number of trips with snowy grouper as primary source of revenue	128	44	4	347	523
Number of trips with snowy grouper as a lesser source of trip revenue	250	161	84	314	809

Source: NOAA Fisheries Service logbook database as of April 5, 2007, Southeast Fisheries Science Center.

***** Some boats land in more than one state.

5.2.2.1.1.5 The Red Porgy Fishery

Landings of red porgy averaged 0.048 million pounds between 2001 and 2005, with average annual dockside revenues of $0.065 million in current-year dollars and $0.069 million in constant 2005 dollars (Table 5.2.2-11). Fishermen also landed an average of 2.025 million pounds of other species worth $4.091 million in current-year dollars on trips that landed at least one pound of red porgy.

According to NOAA Fisheries Service logbook trip reports, an average of 179 boats per year landed at least one pound of red porgy (Table 5.2.2-11). Red porgy have been landed almost exclusively as an incidental species and secondary source of trip revenue since restrictive regulations were implemented in 1999. From 2001 through 2005, red porgy were landed on an average of 1,534 trips per year, with only 1% of them classified as trips for which red porgy was the single species with the largest source of revenue. Targeted trips accounted for 7% of total landings of red porgy. Approximately 84% of the total catch of red porgy between 2001 and 2005 occurred on trips for vermilion snapper or groupers, with the remaining 9% of red porgy caught on trips for a variety of other species.

Red porgy are landed primarily with vertical line gear (Table 5.2.2-12). Despite the restrictive regulatory environment on red porgy between 2001 and 2005, red porgy were landed on nearly 12% of all snapper grouper trips with vertical lines. Red porgy are landed primarily in North Carolina, South Carolina, and Georgia-northeast Florida (Table 5.2.2-13).

Table 5.2.2-11. Annual landings, dockside (ex-vessel) revenues, and fishing effort for red porgy, 2001-2005.

Item	2001	2002	2003	2004	2005	Average
Trips with at least 1 pound of red porgy						
Red porgy landings (million pounds, whole wgt)	0.052	0.057	0.045	0.045	0.040	0.048
Dockside revenue from red porgy (million dollars)	$0.077	$0.081	$0.060	$0.056	$0.050	$0.065
Dockside revenue in constant 2005 dollars (millions)*	$0.084	$0.088	$0.064	$0.058	$0.050	$0.069
Price/lb (whole wgt) for red porgy	$1.46	$1.43	$1.34	$1.27	$1.25	$1.36
Price/lb in constant 2005 dollars*	$1.61	$1.55	$1.42	$1.30	$1.25	$1.44
Landings of other species on trips with red porgy (million lbs)	2.337	1.978	1.915	1.894	2.002	2.025
Dockside revenue from other species on trips with red porgy (million $)	$4.527	$3.887	$3.868	$3.858	$4.317	$4.091
Dockside revenue from other species in constant 2005 dollars (millions)	$4.976	$4.207	$4.100	$3.968	$4.295	$4.309
Number of boats that landed red porgy	200	180	175	174	167	179
Number of boats landing 1000 lbs or more per year of red porgy	6	7	4	**	**	**
Number of boats landing 5000 lbs or more per year of red porgy	0	0	0	0	0	0
Number of trips with at least 1 pound of red porgy	1,790	1,695	1,540	1,325	1,321	1,534
Number of trips with red porgy as primary source of trip revenue	11	41	11	8	9	16
Number of trips with red porgy as a lesser source of trip revenue	1,779	1,654	1,529	1,317	1,312	1,518

Source: NOAA Fisheries Service logbook database as of April 5, 2007, Southeast Fisheries Science Center.

* The Consumer Price Index for all Urban Consumers was used to adjust dockside revenues and average annual prices for inflation.** Numbers of boats fewer than 4 cannot be tabulated.

Table 5.2.2-12. Description of fishing activities for trips with at least 1 pound of red porgy, by primary gear, 2001-2005 averages.

Item	Vertical Lines	Other Gears	Total
Number of boats that landed red porgy*	169	26	179
Number of trips that landed red porgy	1,473	61	1,534
Percent of trips with red porgy, by gear	96.0%	4.0%	100%
Trips with red porgy as percent of all snapper grouper trips with this gear	11.8%	1.7%	9.6%
Landings of red porgy (million lbs)	0.047	0.001	0.048
Percent of red porgy landings by gear	97.9%	2.1%	100%
Red porgy landings as percent of snapper grouper landings with this gear	0.9%	< 0.1%	0.7%
Dockside revenues for red porgy (million $)	$0.064	$0.001	$0.065
Landings other species (million lbs)	1.963	0.062	2.025
Revenues other species (million $)	$3.964	$0.127	$4.091
Number of trips with red porgy as primary source of revenue	16	0	16
Number of trips with red porgy as a lesser source of trip revenue	1,457	61	1,518

Source: NOAA Fisheries Service logbook database as of April 5, 2007, Southeast Fisheries Science Center.
***** Some boats fish with more than one primary gear.

Table 5.2.2-13. Annual landings and dockside revenues for trips with at least 1 pound of red porgy, 2001-2005 averages by state.

Item	North Carolina	South Carolina	Georgia and Northeast Florida	Central and South Florida	Total
Trips with at least 1 pound of red porgy					
Number of boats that landed red porgy*	82	48	30	24	179
Number of trips that landed red porgy	833	425	196	80	1,534
Percent of trips with red porgy, by state	54.3%	27.7%	12.8%	5.2%	100%
Trips with red porgy as percent of all snapper grouper trips	29.4%	43.9%	33.2%	0.7%	9.6%
Landings of red porgy (million lbs)	0.026	0.013	0.007	0.002	0.048
Percent of red porgy landings by state	54.2%	27.1%	14.5%	4.2%	100%
Red porgy landings as percent of snapper grouper landings	1.4%	0.8%	0.8%	< 0.1%	0.7%
Dockside revenues for red porgy (million $)	$0.033	$0.020	$0.009	$0.002	$0.065
Landings other species (million lbs)	0.804	0.779	0.415	0.027	2.025
Revenues other species (million $)	$1.590	$1.634	$0.813	$0.054	$4.091
Number of trips with red porgy as primary source of revenue	5	1	0	10	16
Number of trips with red porgy as a lesser source of trip revenue	828	424	196	70	1,518

Source: NOAA Fisheries Service logbook database as of April 5, 2007, Southeast Fisheries Science Center.
*Some boats land in more than one state.

5.5.2.1.1.6 The Tilefish Fishery

Landings of golden tilefish averaged 0.372 million pounds between 2001 and 2005, with average annual dockside revenues of $0.695 million in current-year dollars and $0.737 million in constant 2005 dollars (Table 5.2.2.14). Fishermen also landed an average of 0.307 million pounds of other species worth $0.450 million in current-year dollars on trips that landed at least one pound of golden tilefish.

According to NOAA Fisheries Service logbook trip reports, an average of 73 boats per year landed at least one pound of golden tilefish (Table 5.2.2-15). On average, 25 boats landed at least 1,000 pounds of golden tilefish per year, 14 boats landed at least 5,000 pounds per year, and 10 boats landed at least 10,000 pounds of golden tilefish per year. Landings and fishing effort for golden tilefish declined from 2001 through 2005.

Logbook data for 2001-2005 provided information about the extent to which golden tilefish was a primary or secondary source of trip revenue. Fishing trips were classified as targeting a particular species if revenues from that species were greater than revenues from any other individual species. Golden tilefish were landed on an average of 426 trips per year, with 65% of them classified as targeted golden tilefish trips that accounted for approximately 90% of total golden tilefish landings (Table 5.2.2-15). Golden tilefish also were caught as a secondary source of revenue on trips for snowy grouper and yellowedge grouper, with the volume of secondary catch accounting for 10% of the average annual harvest of golden tilefish.

Boats with bottom longlines account for 91% of the total harvest of golden tilefish (Table 5.2.2-16). On average, 62% of golden tilefish were landed in central-south Florida, 33% in South Carolina, and 4% in North Carolina (Table 3-15).

Table 5.2.2-14. Annual landings, dockside (ex-vessel) revenues, and fishing effort for golden tilefish, 2001-2005.

Item	2001	2002	2003	2004	2005	Average
Trips with at least 1 pound of golden tilefish						
Golden tilefish landings (million pounds, whole wgt)	0.489	0.444	0.349	0.272	0.307	0.372
Dockside revenue from golden tilefish (million dollars)	$0.869	$0.797	$0.630	$0.510	$0.668	$0.695
Dockside revenue in constant 2005 dollars (millions)*	$0.959	$0.864	$0.669	$0.527	$0.666	$0.737
Price/lb (whole wgt) for golden tilefish	$1.78	$1.79	$1.81	$1.87	$2.18	$1.87
Price/lb in constant 2005 dollars*	$1.96	$1.94	$1.92	$1.94	$2.17	$1.98
Landings of other species on trips with golden tilefish (million lbs)	0.387	0.383	0.346	0.231	0.189	0.307
Dockside revenue from other species on trips with golden tilefish (million $)	$0.535	$0.551	$0.497	$0.331	$0.335	$0.450
Dockside revenue from other species in constant 2005 dollars (millions)	$0.591	$0.596	$0.526	$0.343	$0.335	$0.478
Number of boats that landed golden tilefish	87	86	64	65	65	73
Number of boats landing 1,000 lbs or more per year of golden tilefish	29	26	20	24	24	25
Number of boats landing 5,000 lbs or more per year of golden tilefish	18	15	16	11	8	14
Number of boats landing 10,000 lbs or more per year of golden tilefish	14	12	12	7	6	10
Number of trips with at least 1 pound of golden tilefish	472	570	395	336	359	426
Number of trips with golden tilefish as primary source of trip revenue	295	362	236	233	250	275
Number of trips with golden tilefish as a lesser source of trip revenue	177	208	159	103	109	151

Source: NOAA Fisheries Service logbook database as of April 5, 2007, Southeast Fisheries Science Center.

The Consumer Price Index for all Urban Consumers was used to adjust dockside revenues and average annual prices for inflation.

Table 5.2.2-15. Description of fishing activities for trips with at least 1 pound of golden tilefish, by primary gear, 2001-2005 averages.

Item	Vertical Lines	Longlines	Other Gears	Total
Trips with at least 1 pound of golden tilefish				
Number of boats that landed tilefish*	54	21	9	73
Number of trips that landed golden tilefish	212	201	13	426
Percent of trips with golden tilefish, by gear	49.8%	47.2%	3.0%	100%
Trips with tilefish as pct of all snapper grouper trips with this gear	1.7%	66.1%	0.4%	2.7%
Landings of tilefish (million lbs)	0.031	0.340	0.002	0.372
Percent of tilefish landing by gear	8.3%	91.4%	0.3%	100%
Tilefish landings as percent of snapper groupe landings with this gear	0.6%	63.0%	0.2%	5.4%
Dockside revenues for tilefish (million $)	$0.057	$0.633	$0.004	$0.695
Landings other species (million lbs)	0.045	0.257	0.004	0.307
Revenues other species (million $)	$0.085	$0.359	$0.005	$0.450
Number of trips with tilefish as primary source of revenue	122	149	4	275
Number of trips with tilefish as a lesser source of trip revenue	90	52	9	151

Source: NOAA Fisheries Service logbook database as of April 5, 2007, Southeast Fisheries Science Center.
***** Some boats fish with more than one primary gear.

Table 5.2.2-16. Annual landings and dockside revenues for trips with at least 1 pound of tilefish, 2001-2005 averages by state.

Item	North Carolina	South Carolina	Georgia and Northeast Florida	Central and South Florida	Total
Trips with at least 1 pound of golden tilefish					
Number of boats that landed tilefish*	10	6	1	57	73
Number of trips that landed golden tilefish	22	59	2	343	426
Percent of trips with golden tilefish, by state	5.2%	13.8%	0.5%	80.5%	100%
Trips with tilefish as Pct of all snapper grouper trips win this state	0.8%	6.1%	0.3%	3.0%	2.7%
Landings of tilefish (million lbs)	0.016	0.122	0.003	0.231	0.372
Percent of tilefish landings by state	4.3%	32.8%	0.8%	62.1%	100%
Tilefish landings as percent of snapper grouper landings in this state	0.9%	7.4%	0.4%	9.1%	5.4%
Dockside revenues for tilefish (million $)	$0.035	$0.203	$0.006	$0.451	$0.695
Landings other species (million lbs)	0.035	0.155	0.003	0.114	0.307
Revenues other species (million $)	$0.047	$0.258	$0.006	$0.139	$0.450
Number of trips with tilefish as primary source of revenue	7	32	1	235	275
Number of trips with tilefish as a lesser source of trip revenue	15	27	1	108	151

Source: NOAA Fisheries Service logbook database as of April 5, 2007, Southeast Fisheries Science Center.
***** Some boats land in more than one state.

5.2.2.1.1.7 The Gag Fishery

Logbook data provide information about commercial landings for gag from 1993 through 2006. Between 1993 and 2006, commercial landings of gag ranged from a high of 0.85 million pounds (whole weight) worth approximately $2.03 million in 1996 to a low of 0.50 million pounds worth $1.32 million in 2000 (Figure 5.2.2-5). Preliminary data for 2006 indicate that landings of gag were approximately 0.50 million pounds worth $1.46 million. Dockside revenues and pounds landed fluctuate in the same direction, which suggests that ex-vessel demand is price elastic. The policy implication is that regulations that reduce industry landings in the short-term are expected to reduce dockside revenues in the short-term. Conversely, dockside revenues are expected to increase over time if regulation successfully increases biomass and landings.

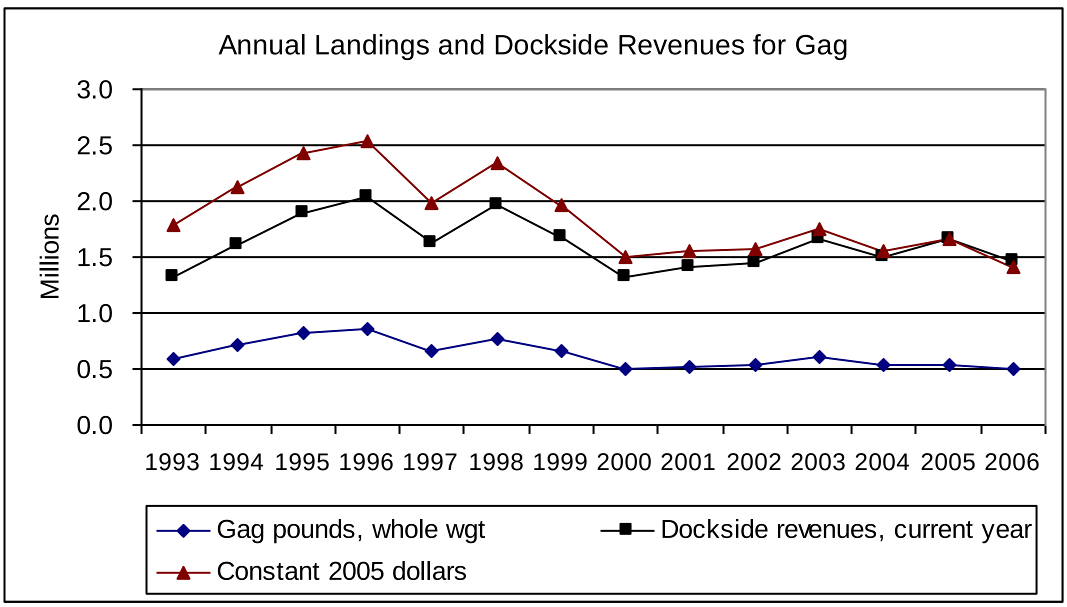


Figure 5.2.2-5. Annual landings and dockside revenues for gag, 1993-2006.

Source: NOAA Fisheries Service, Southeast Fisheries Science Center logbook database as of October 10, 2007, and NOAA Fisheries Service, Southeast Fisheries Science Center Accumulated Landings System as of October 5, 2007.

The time series for gag is defined by regulatory periods, with landings between 1993 and 1999 usually exceeding landings between 2000 and 2006. Between 1992 and 1998, the fishery for gag was regulated with a 20-inch minimum size limit. Beginning in 1999, the size limit was increased to 24 inches and the fishery was closed in March and April to protect the spawning stock. Prior to 1998, average monthly landings were highest in May and lowest in August (Figure 5.2.2-6). After the closure and larger size limit were implemented, average monthly landings increased in May, but otherwise declined in the remaining open months when compared to the 1993-1998 period, especially in September.

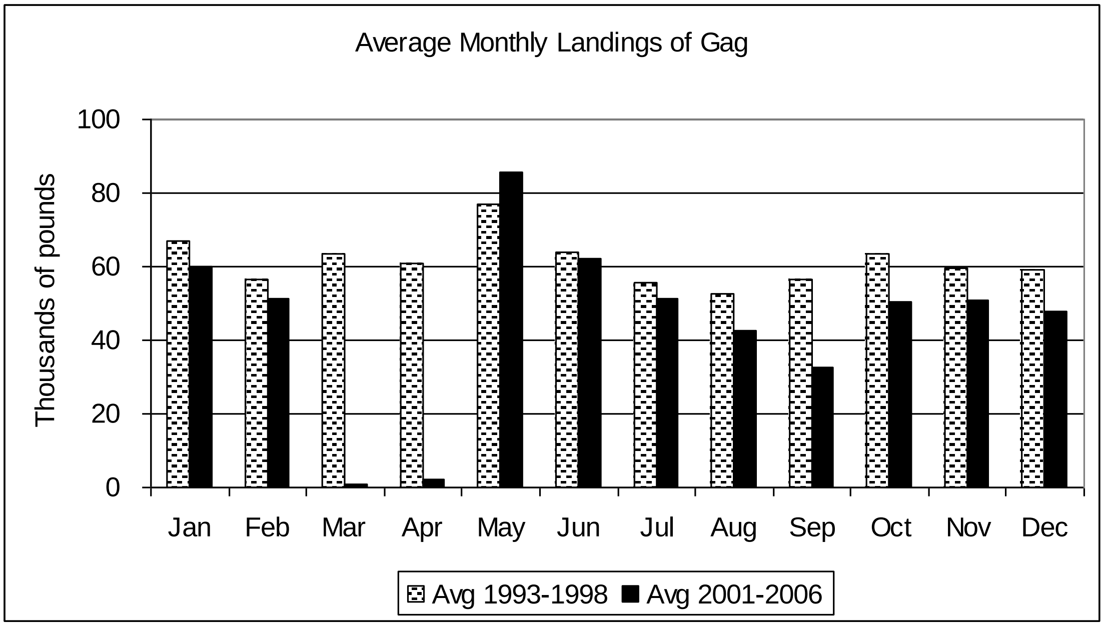


Figure 5.2.2-6. Average monthly landings of gag for the 1993-1998 and 2001-2006 periods.

Source: NOAA Fisheries Service, Southeast Fisheries Science Center logbook database as of October 10, 2007.

On average from 2001-2006, there were 2,417 trips that landed at least one pound of gag, and totaled an annual average of 0.54 million pounds of gag worth $1.52 million in current year dollars and $1.58 million in constant 2005 dollars (Table 5.2.2-17). In addition, these trips annually produced an average of 2.13 million pounds of other species worth $3.98 million in current year dollars. Gag was the primary revenue species on some trips and a lesser source of revenue on other trips.

Table 5.2.2-17 Annual landings, dockside revenues and fishing effort on trips for gag, 2001-2006.

Item	2001	2002	2003	2004	2005	2006	Average
	Trips with at least one pound of gag						
Gag landings (million pounds, whole wgt)	0.52	0.53	0.60	0.53	0.54	0.50	0.54
Dockside revenue from gag (million dollars)	$1.41	$1.44	$1.66	$1.50	$1.65	$1.46	$1.52
Dockside revenue in constant 2005 dollars (millions)*	$1.55	$1.57	$1.76	$1.55	$1.65	$1.41	$1.58
Landings of other species on trips with gag (million lbs)	2.67	2.20	1.98	1.98	2.05	1.87	2.13
Dockside revenue from other species on trips with gag (mill $)	$4.87	$4.00	$3.52	$3.71	$4.03	$3.78	$3.98
Dockside revenue from other species in constant 2005 dollars	$5.36	$4.34	$3.73	$3.83	$4.02	$3.65	$4.16
Number of boats that landed gag	337	305	302	292	302	257	299
Number of boats landing 1000 lbs or more per year of gag	117	99	114	100	99	95	104
Number of boats landing 5000 lbs or more per year of gag	27	35	39	33	35	34	34
Number of boats landing 10,000 lbs or more per year of gag	10	10	13	13	13	14	12
Number of trips with at least one pound of gag	2,787	2,767	2,484	2,183	2,203	2,079	2,417

Source: NOAA Fisheries Service, Southeast Fisheries Science Center logbook database as of October 10, 2007.

Gag was the primary source of trip revenue on an average of 1,062 trips per year and a lesser source of revenue on 1,355 trips per year (Table 5.2.2-18). Therefore, gag was the primary source of trip revenue on less than 45% of the total number of trips on which they were landed. However, these trips accounted for approximately 67% of the total commercial harvest of gag. Trips on which gag was the primary source of revenue accounted for an annual average of 0.36 million pounds of gag worth $1.03 million in current dollars and 0.43 million pounds of other species, including other groupers, snappers, jacks, grunts, porgies and non-snapper-grouper species, worth $0.78 million. Trips on which gag was a lesser source of revenue accounted for an annual average of 0.17 million pounds of gag worth $0.49 million in current dollars and 1.70 million pounds of other species worth $3.20 million. Gag were caught as a lesser source of revenue on trips for vermilion snapper, scamp, red grouper, jacks and other species.

Table 5.2.2-18. Annual landings, dockside revenues and fishing effort on trips with gag as the primary source of trip revenue, 2001-2006.

Item	2001	2002	2003	2004	2005	2006	Average
	Trips with gag as primary source of revenue						
Number of trips with at least one pound of gag	2,787	2,767	2,484	2,183	2,203	2,079	2,417
Number of trips with gag as primary source of trip revenue	1,084	1,194	1,192	993	1,026	885	1,062
Number of trips with gag as a lesser source of trip revenue	1,703	1,573	1,292	1,190	1,177	1,194	1,355
Landings of gag on trips with gag as primary source of revenue (million pounds)	0.32	0.36	0.42	0.38	0.37	0.34	0.36
Dockside revenue for gag on trips with gag as primary source of revenue (million $)	$0.86	$0.97	$1.16	$1.08	$1.13	$1.00	$1.03
Landings of other species on trips with gag as primary source of revenue	0.39	0.38	0.51	0.47	0.43	0.39	0.43
Dockside revenues for other species on trips with gag as the primary source of revenue	$0.67	$0.66	$0.91	$0.86	$0.83	$0.75	$0.78

Source: NOAA Fisheries Service, Southeast Fisheries Science Center logbook database as of October 10, 2007.

The number of boats that reported landing at least one pound of gag declined from 337 in 2001 to 257 in 2006, and averaged 299 boats per year (Table 5.2.2-17). The fleet was not uniformly productive in the fishery for gag, which is consistent with the observation that gag was the primary source of trip revenue on some trips and a lesser source of revenues on other trips. On average for 2001-2006, the top 20 boats for gag production made 20% of the trips that landed gag and recorded 44% of the total commercial harvest of gag (Figure 5.2.2-7). The top 50 producing boats made 46% of the trips and recorded 72% of the total harvest, while the top 100 producing boats made 72% of the trips and landed 91% of the total harvest. On average, 104 boats landed at least 1,000 pounds of gag per year, 34 boats landed at least 5,000 pounds per year, and 12 boats landed at least 10,000 pounds of gag per year (Table 5.2.2-18). Approximately 80% of gag is landed with vertical lines, and most of the remainder is landed with dive gear (Table 5.2.2-17).

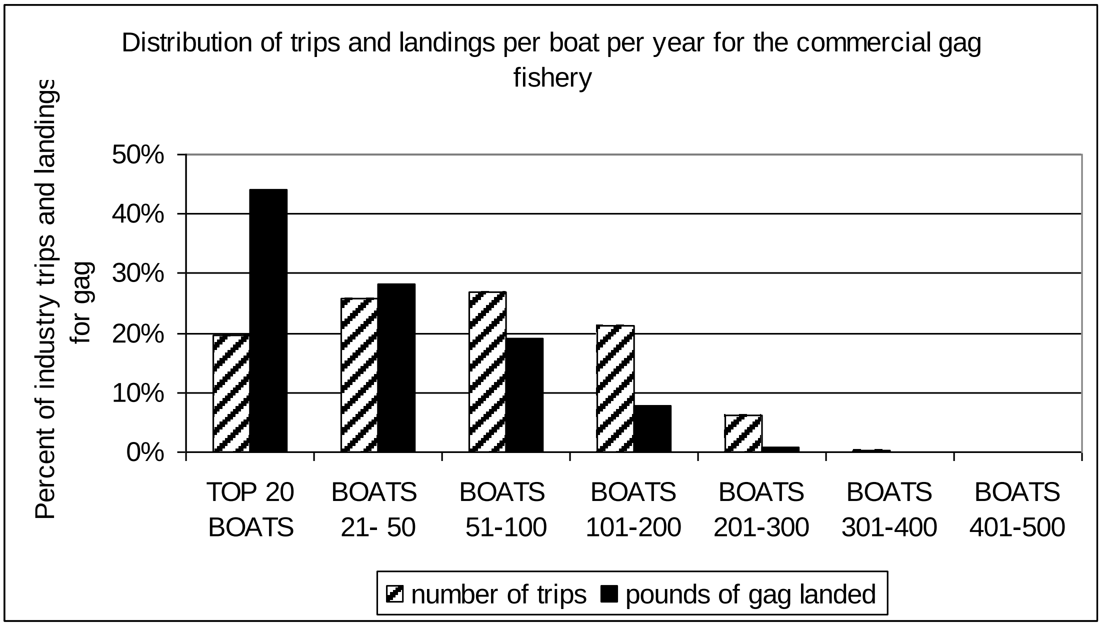


Figure 5.2.2-7. Distribution of trips and landings per boat per year, based on trips that reported at least one pound of gag.
Source: NOAA Fisheries Service, Southeast Fisheries Science Center logbook database as of October 10, 2007.

5.2.2.1.1.8 The Vermilion Snapper Fishery

Based on logbook data from 1993 through 2006, commercial landings of vermilion snapper ranged from a low of 0.68 million pounds (whole weight) worth $1.33 million in 1993 to a high of 1.65 million pounds worth approximately $3.54 million in 2001 (Figure 5.2.2-8). Landings of vermilion snapper began to increase in 1999 coincident with the implementation of more restrictive regulations for gag, peaked in 2001, and then declined through 2003 when unusually cold water temperatures reduced the availability of fish in the summer and fall of 2003. Landings of vermilion snapper recovered in 2004 and 2005, but not to the levels experienced in 2001 and 2002. Preliminary data for 2006 indicate that landings of vermilion snapper were approximately 0.86 million pounds worth $2.23 million. Dockside revenues generally displayed the same trend over time as commercial landings, which suggests that ex-vessel demand for vermilion snapper is price elastic. Hence, regulations that reduce industry landings in the short-term are expected to reduce dockside revenues in the short-term. Conversely, dockside revenues are expected to increase over time if regulation successfully increases biomass and landings.

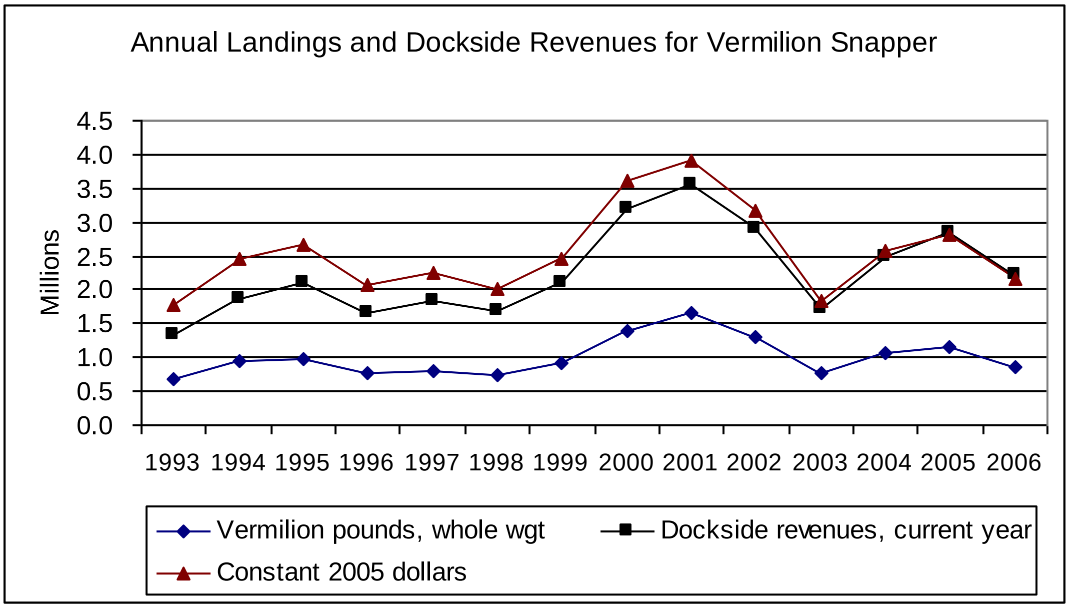


Figure 5.2.2-8. Annual landings and dockside revenues for vermilion snapper, 1993-2006.
Source: NOAA Fisheries Service, Southeast Fisheries Science Center logbook database as of October 10, 2007, and NOAA Fisheries Service, Southeast Fisheries Science Center Accumulated Landings System as of October 5, 2007.

Vermilion snapper are landed throughout the year, with peak months from August through December (Figure 5.2.2-9). Average monthly landings were higher for all months except December during the 2001-2006 period compared to the 1993-1998 period. The greatest relative monthly increases in average landings between the two periods occurred during March and April, apparently as fishermen shifted their fishing effort from gag to vermilion in response to the closed season that was implemented in 1999.

On average from 2001-2006, there were 2,423 trips that landed at least one pound of vermilion snapper, and totaled an average of nearly 1.14 million pounds of vermilion snapper worth $2.62 million in current-year dollars and $2.74 million in constant 2005 dollars (Table 5.2.2-19). In addition, these trips annually produced an average of 2.14 million pounds of other species combined worth $4.07 million in current year dollars. Vermilion snapper was the primary revenue species on some trips and a lesser source of revenue on other trips.

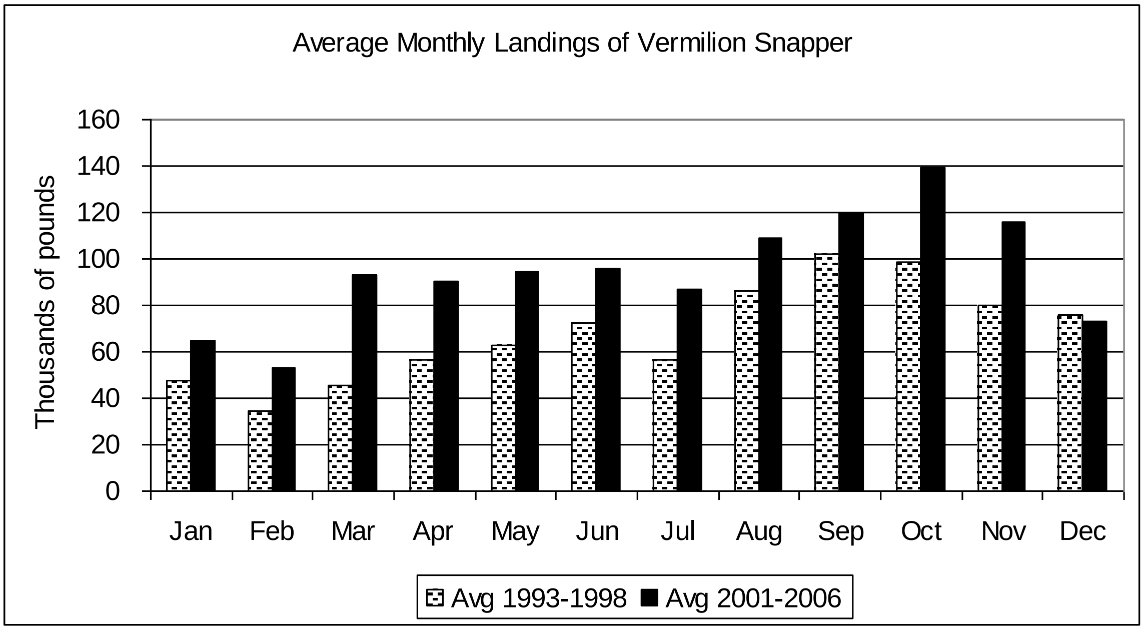


Figure 5.2.2-9. Average monthly landings of vermilion snapper for the 1993-1998 and 2001-2006 periods.
Source: NOAA Fisheries Service, Southeast Fisheries Science Center logbook database as of October 10, 2007.

Vermilion snapper was the primary source of trip revenue on an average of 1,186 trips per year and a lesser source of revenue on 1,237 trips per year (Table 5.2.2-19). Therefore, vermilion snapper was the primary source of trip revenue on slightly less than 50% of the total number of trips on which they were landed. However, these trips accounted for approximately 86% of total vermilion snapper landings. Trips on which vermilion snapper was the primary source of revenue accounted for an annual average of 0.98 million pounds of vermilion snapper worth $2.27 million in current dollars and 0.92 million pounds of other species, including groupers, jacks, grunts, porgies and non-snapper-grouper species, worth $1.53 million. Trips on which vermilion snapper was a lesser source of revenue accounted for an annual average of 0.16 million pounds of vermilion snapper worth $0.35 million in current dollars and 1.22 million pounds of other species worth $2.54 million. Vermilion snapper were caught as a lesser source of revenue on trips for gag, scamp and red grouper in the shallow water grouper fishery, and snowy grouper in the deep water grouper fishery.

Table 5.2.2-19. Annual landings, dockside revenues and fishing effort on trips for vermilion snapper, 2001-2006.

Item	2001	2002	2003	2004	2005	2006	Average
	Trips with at least one pound of vermilion snapper						
Vermilion snapper landings (million pounds, whole wgt)	1.65	1.31	0.77	1.07	1.16	0.86	1.14
Dockside revenue from vermilion snapper (million dollars)	$3.54	$2.92	$1.73	$2.49	$2.83	$2.23	$2.62
Dockside revenue in constant 2005 dollars (millions)*	$3.90	$3.16	$1.83	$2.57	$2.83	$2.16	$2.74
Landings of other species on trips with vermilion snapper (million lbs)	2.36	2.20	2.03	2.06	2.07	2.15	2.14
Dockside revenue from other species on trips with vermilion snapper (million $)	$4.34	$3.99	$3.82	$3.90	$4.16	$4.19	$4.07
Dockside revenue from other species in constant 2005 dollars (millions)	$4.78	$4.33	$4.06	$4.03	$4.16	$4.05	$4.24
Number of boats that landed vermilion snapper	295	274	248	255	252	232	259
Number of boats landing 1000 lbs or more per year of vermilion snapper	118	106	91	84	91	80	95
Number of boats landing 5000 lbs or more per year of vermilion snapper	17	72	53	56	53	45	49
Number of boats landing 10,000 lbs or more per year of vermilion snapper	62	53	27	44	38	33	43
Number of trips with at least one pound of vermilion snapper	3,029	2,911	2,173	2,148	2,173	2,102	2,423

Source: NOAA Fisheries Service, Southeast Fisheries Science Center logbook database as of October 10, 2007.

Table 5.2.2-20. Annual landings, dockside revenues and fishing effort on trips with vermilion snapper as the primary source of trip revenue, 2001-2006.

Item	2001	2002	2003	2004	2005	2006	Average
	Trips with vermilion snapper as primary source of revenue						
Number of trips with at least one pound of vermilion snapper	3,029	2,911	2,173	2,148	2,173	2,102	2,423
Number of trips with vermilion snapper as primary source of trip revenue	1,693	1,495	924	1,053	1,084	867	1,186
Number of trips with vermilion snapper as a lesser source of trip revenue	1,336	1,416	1,249	1,095	1,089	1,235	1,237
Landings of vermilion snapper on trips with vermilion as primary source of revenue (million lbs)	1.47	1.16	0.62	0.93	1.00	0.71	0.98
Dockside revenue for vermilion on trips with vermilion as primary source of revenue (million $)	$3.17	$2.58	$1.39	$2.16	$2.47	$1.86	$2.27
Landings of other species on trips with vermilion as primary source of revenue	1.16	1.04	0.69	0.86	0.99	0.80	0.92
Dockside revenues for other species on trips with vermilion as the primary source of revenue	$1.89	$1.66	$1.13	$1.42	$1.72	$1.36	$1.53

Source: NOAA Fisheries Service, Southeast Fisheries Science Center logbook database as of October 10, 2007.

The number of boats that reported landing at least one pound of vermilion snapper declined from 295 in 2001 to 232 in 2006, and averaged 259 boats per year (Table 5.2.2-20). The fleet was not uniformly productive in the fishery for vermilion snapper, which is consistent with the observation that vermilion snapper was the primary source of trip revenue on some trips and a lesser source of revenues on other trips. On average for 2001-2006, the top 20 boats for the production of vermilion snapper made 20% of the trips that landed vermilion and recorded 50% of the total commercial harvest of vermilion snapper (Figure 5.2.2-10). The top 50 producing boats made 48% of the trips and recorded 82% of the total harvest, while the top 100 producing boats made 77% of the trips and landed 98% of the total harvest. On average, 95 boats landed at least 1,000 pounds of vermilion snapper per year, 49 boats landed at least 5,000 pounds per year, and 43 boats landed at least 10,000 pounds of vermilion snapper per year (Table 5.2.2-20). Virtually all vermilion snapper are landed with vertical lines (Table 5.2.2-20).

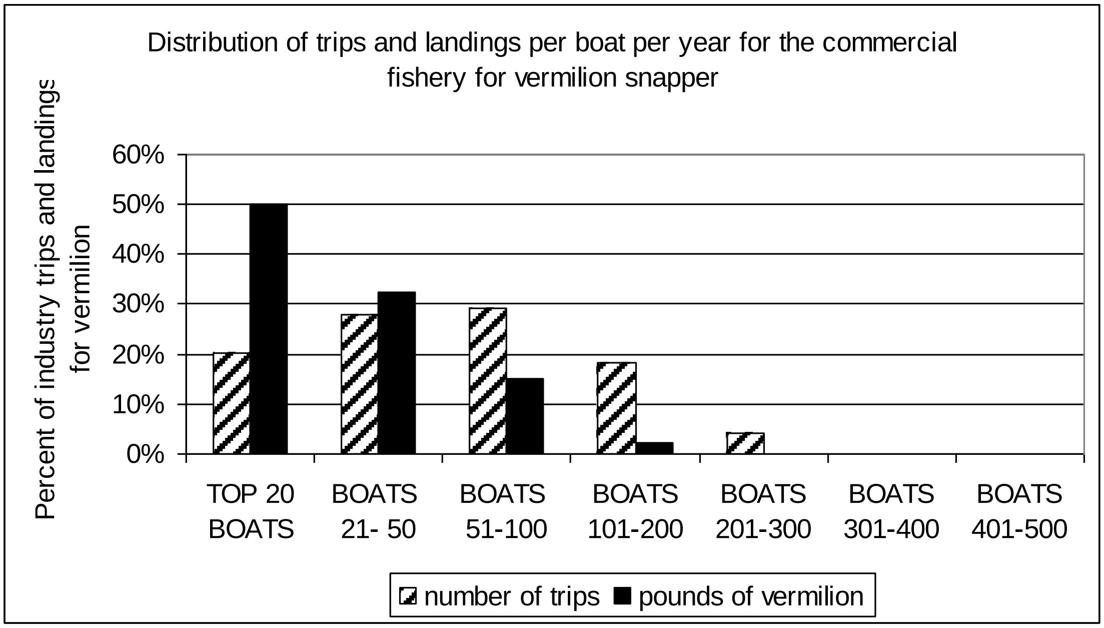


Figure 5.2.2-10. Distribution of trips and landings per boat per year, based on trips that reported at least one pound of vermilion snapper.
Source: NOAA Fisheries Service, Southeast Fisheries Science Center logbook database as of October 10, 2007.

5.2.2.1.1.9 Imports

Imports have been a major source of seafood supply in the U.S., and the domestic snapper-grouper market is not an exception. For the period 2001-2006, imports of fresh and frozen snappers and groupers have stayed at relatively high levels, averaging at about 44.7 million pounds (Table 5.2.2-21). Compare this with the average overall landings of snapper-grouper in the South Atlantic for the same period of 6.77 million pounds (Table 5.2.2-21), and one can immediately see the dominance of imports in the snapper-grouper market. At an annual average of $79.2 million for the years 2001-2006, imports clearly dwarf the $12.99 million ex-vessel value of South Atlantic snapper-grouper landings. The dominance of imports in the snapper-grouper market may be expected to exert limits on the movement of domestic ex-vessel prices resulting from changes in domestic landings of snappers and groupers.

Table 5.2.2-21. U.S. imports of snappers and groupers, 2001-2006.

YEAR	Pounds of imports by product form Millions of pounds*			Value of imports by product form Millions of dollars		
	FRESH	FROZEN	TOTAL	FRESH	FROZEN	TOTAL
2001	31.1	8.4	39.4	$51.7	$10.6	$62.3
2002	33.4	9.2	42.6	$57.1	$12.3	$69.5
2003	34.3	10.2	44.5	$58.9	$14.4	$73.3
2004	33.3	9.8	43.1	$61.7	$13.9	$75.6
2005	35.9	13.8	49.7	$72.0	$21.0	$93.0
2006	35.2	13.4	48.6	$78.8	$22.9	$101.7
Average	33.9	10.8	44.7	$63.4	$15.9	$79.2

Source: NOAA Fisheries, Foreign Trade Database.
*Weights are not converted to equivalent whole weights.

5.2.2.1.2 Recreational Fishery

The South Atlantic recreational fishery is comprised of the private sector and for-hire sector. The private sector includes anglers fishing from shore (all land-based structures) and private/rental boats. The for-hire sector is composed of the charterboat and headboat (also called partyboat) sectors. Charterboats generally carry fewer passengers and charge a fee on an entire vessel basis, whereas headboats carry more passengers and payment is per person. The type of service, from a vessel- or passenger-size perspective, affects the flexibility to search different fishing locations during the course of a trip and target different species since larger concentrations of fish are required to satisfy larger groups of anglers.

5.2.2.1.2.1 Harvest

Recreational snapper grouper harvest has been variable during the period 2001-2006, averaging at a little over 10 million pounds (Table 5.2.2-22). The private/shore mode of fishing accounted for around 67 percent of all harvests, followed by the charter mode (17%), then by headboats (16%). Harvests in each state also fluctuated during the same time period (Table 5.2.2-23). On average, Florida accounted for around 66 percent of total harvests, followed by North Carolina (16%), South Carolina (12%), and Georgia (6%).

Gag and vermilion snapper are the main species addressed in this amendment, but there are also other species that may be affected especially by the closure alternatives in this amendment. These other species include black grouper, red grouper, scamp, red hind, rock hind, yellowmouth grouper, tiger grouper, yellowfin grouper, graysby, and coney. For the period 2001-2006, gag averaged at 627,266 pounds, vermilion snapper at 581,567 pounds, and other species at 517,789 pounds (Table 5.2.2-24). The private/shore mode dominated the harvest of gag (71%) while the headboat sector dominated the harvest of vermilion snapper (60%). The private/shore mode also dominated the harvest of other species (56%). Summing across species, total harvest is dominated by the private/mode sector, followed by the headboat sector, and lastly by the charterboat sector.

Table 5.2.2-22. Harvest of snapper grouper species by mode in the South Atlantic.

Year	Charterboat[1]	Headboat[2]	Shore and Private/Rental Boat[1]	Total
2001	1,347,441	1,655,941	7,984,461	10,987,843
2002	1,362,090	1,432,450	5,182,763	7,977,303
2003	2,301,303	1,375,688	7,265,886	10,942,877
2004	1,517,384	1,889,010	6,688,596	10,094,990
2005	2,313,468	1,649,210	6,123,049	10,085,727
2006	1,998,902	1,648,405	7,282,328	10,929,635
Average	**1,676,139**	**1,608,451**	**6,754,514**	**10,039,103**

Source: The Headboat Survey, NOAA Fisheries, SEFSC, Beaufort Lab and MRFSS database, NOAA Fisheries, NMFS, SERO.
[1] Pounds of A and B1 fish estimated from the MRFSS Survey.
[2] The total annual estimate of headboat catch derived from data collected through the NMFS headboat survey.

Table 5.2.2-23. Harvest of snapper grouper species by state in the South Atlantic.

Year	Florida	Georgia	South Carolina	North Carolina
2001	7,480,907	740,040	1,517,191	1,249,704
2002	5,741,379	366,369	711,612	1,157,941
2003	7,848,011	770,993	1,042,157	1,281,714
2004	5,970,816	763,609	1,625,212	1,735,353
2005	6,696,212	622,302	852,105	1,915,107
2006	6,474,221	746,982	1,466,944	2,241,489
Average	6,701,924	668,383	1,202,537	1,596,885

Source: The Headboat Survey, NOAA Fisheries, SEFSC, Beaufort Lab and MRFSS database, NOAA Fisheries, NMFS, SERO.

Florida accounted for the largest amount of harvests, followed by North Carolina, then by South Carolina, and lastly by Georgia (Table 5.2.2-25). Florida accounted for the largest share in the harvest of gag (67%) and other species (46%). South Carolina, on the other hand accounted for the largest share of vermilion snapper harvests (36%).

Table 5.2.2-24. Average harvest (lbs) of gag, vermilion snapper, and other species in this amendment by sector, 2001-2006.

Sector	Gag	Vermilion snapper	Other species*	Total
Charterboat	118,080	137,400	86,743	342,223
Headboat	62,117	351,767	140,820	554,704
Private/shore	447,069	92,400	290,226	829,695
Total	627,266	581,567	517,789	1,726,622

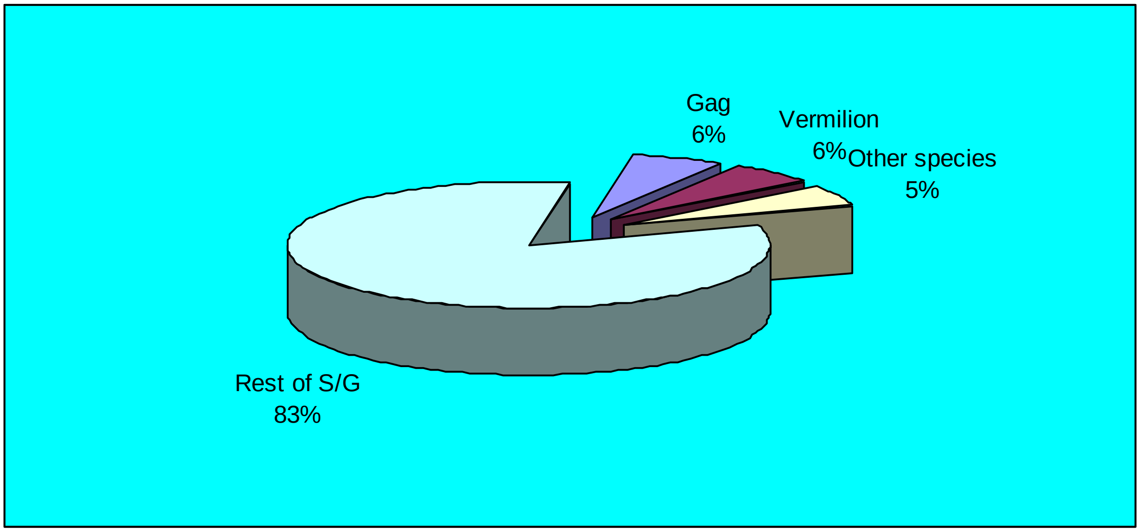
Source: The Headboat Survey, NOAA Fisheries, SEFSC, Beaufort Lab and MRFSS database, NOAA Fisheries, NMFS, SERO.
*Other species includes black grouper, red grouper, scamp, red hind, rock hind, yellowmouth grouper, tiger grouper, yellowfin grouper, graysby, and coney.

Table 5.2.2-25. Average harvest (lbs) of gag, vermilion snapper, and other species in this amendment by state, 2001-2006.

Sector	Gag	Vermilion snapper	Other species*	Total
Florida	422,571	147,223	227,140	796,934
Georgia	24,377	108,430	12,936	145,743
South Carolina	33,921	219,321	86,033	339,275
North Carolina	150,726	140,772	171,878	463,376
Total	631,595	615,746	497,987	1,745,328

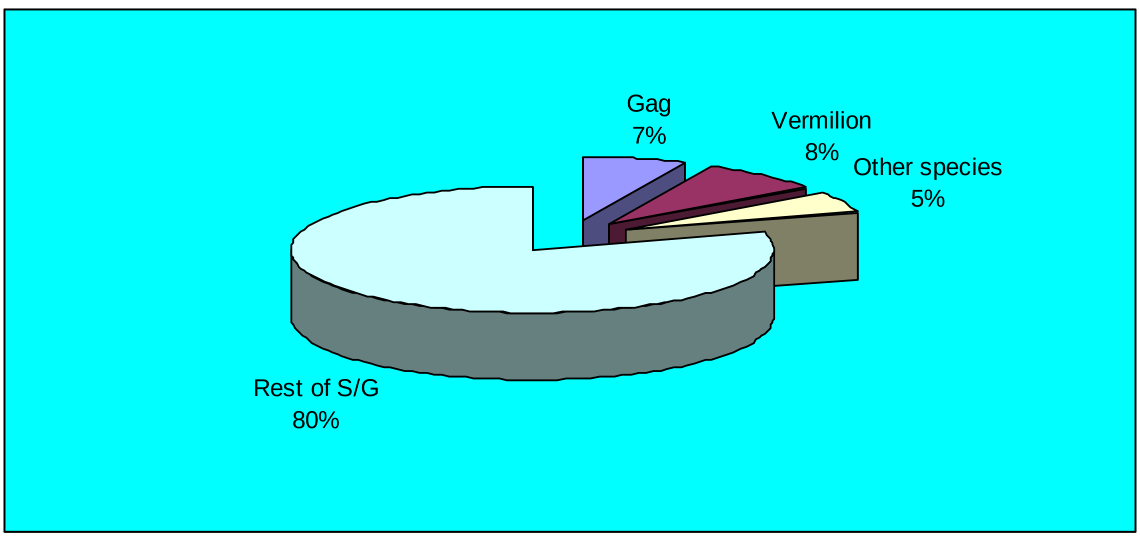
Source: The Headboat Survey, NOAA Fisheries, SEFSC, Beaufort Lab and MRFSS database, NOAA Fisheries, NMFS, SERO.
*Other species includes black grouper, red grouper, scamp, red hind, rock hind, yellowmouth grouper, tiger grouper, yellowfin grouper, graysby, and coney.

The species addressed by this amendment accounted for 17 percent of total recreational harvests of snappers and groupers for the period 2001-2006 (Figure 5.2.2-11). Gag and vermilion snapper accounted for 6 percent each of total harvests while other species accounted for 5 percent of total harvests. The subject species in this amendment vary in importance by sector. In the charterboat sector, the species in this amendment comprised 20 percent of this sector's total harvest (Figure 5.2.2-12). Of this sector's total harvest, vermilion comprised 8 percent, gag 7 percent, and other species 5 percent. For headboats, the species in this amendment accounted for 35 percent of total harvest (Figure 5.2.2-13). This can be broken down into 22 percent vermilion, 9 percent other species, and 4 percent gag. Among the various sectors, the private/shore mode has the lowest percentage of harvest affected by this amendment. The species in this amendment accounted for 12 percent of this sector's total harvest, with the following breakdown: 7 percent gag, 4 percent other species, and 1 percent gag (Figure 5.2.2-14).



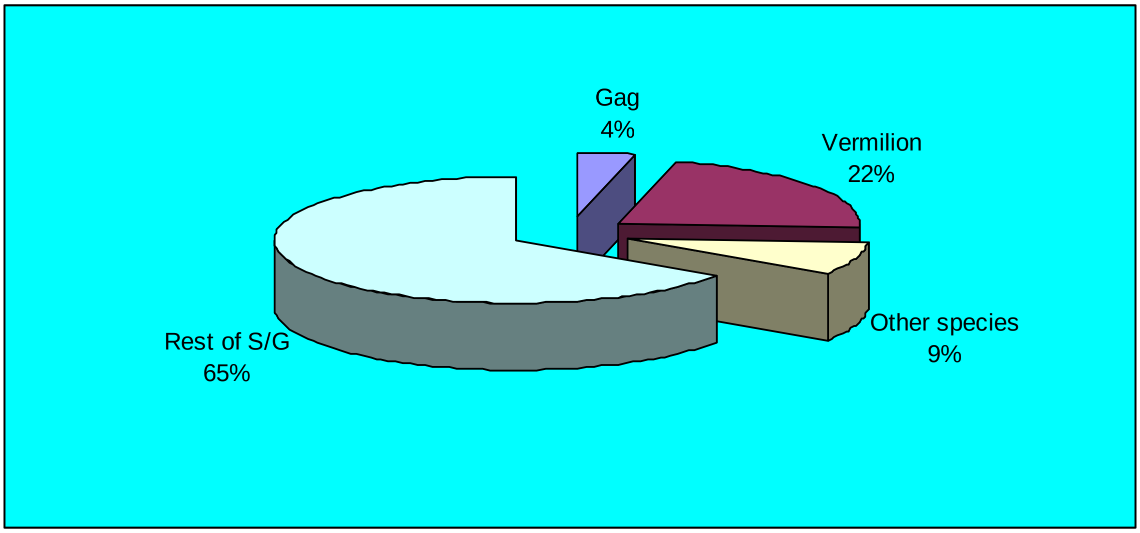
Sources: Headboat Survey, NOAA Fisheries, SEFSC, Beaufort Lab and MRFSS database, NOAA Fisheries, NMFS, SERO.

Figure 5.2.2-11. Average composition of harvests (all modes) of species, 2001-2006.



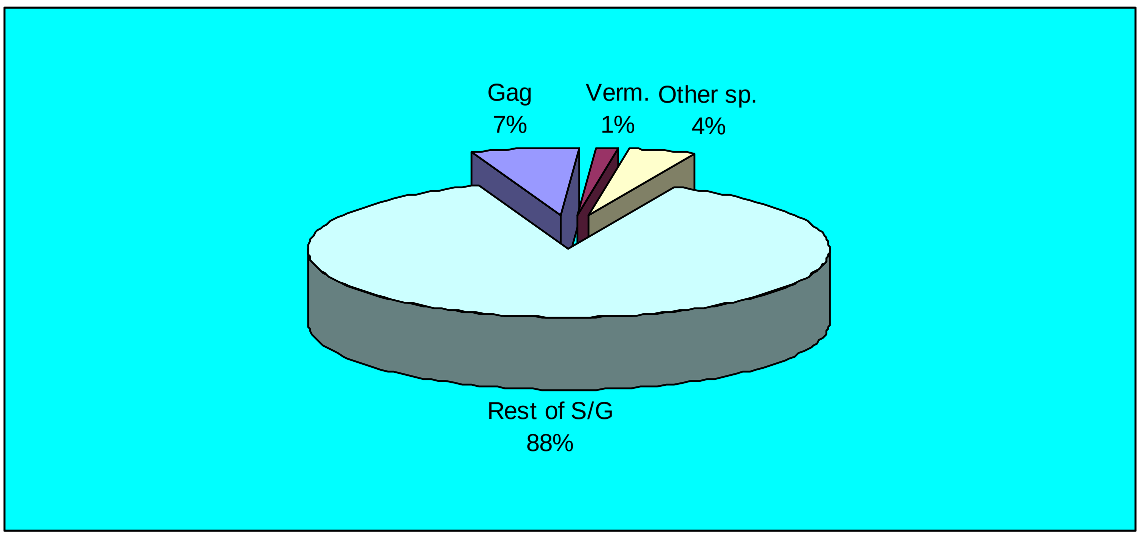
Source: MRFSS database, NOAA Fisheries, NMFS, SERO.

Figure 5.2.2-12. Average composition of charterboat harvests of species, 2001-2006.



Source: Headboat Survey, NOAA Fisheries, SEFSC, Beaufort Lab.

Figure 5.2.2-13. Average composition of headboat harvests of species, 2001-2006.



Source: MRFSS database, NOAA Fisheries, NMFS, SERO.

Figure 5.2.2-14. Average composition of private/shore mode harvests of species, 2001-2006.

5.2.2.1.2.2 Effort

Recreational effort derived from the MRFSS can be characterized in terms of the number of trips as follows:

1. Target effort - The number of individual angler trips, regardless of duration, where the intercepted angler indicated that the species or a species in the species group was targeted as either the first or second primary target for the trip. The species did not have to be caught.
2. Catch effort - The number of individual angler trips, regardless of duration and target intent, where the individual species or a species in the species group was caught. The fish did not have to be kept.
3. Total recreational trips - The total estimated number of recreational trips in the South Atlantic, regardless of target intent or catch success.

Estimates of average effort for the entire snapper grouper fishery are provided in Table 5.2.2-26 for trips by mode and Table 5.2.2-27 for trips by state. The total column refers to the total number of trips taken by anglers in the South Atlantic snapper-grouper fishery and not to the sum catch and target trips. On average, catch trips were highest on those taken through the private mode and lowest on those through the charter mode. The same is true with target trips: they were highest for private mode and lowest for charter mode. For the charter mode, both catch and target trips increased over time although there was some downward blip in the last year. Shore mode catch and target trips remained about flat around their means. Catch trips for the private fluctuate around their mean, but high levels were experienced in the last two years. On the other hand, private mode target trips declined over time, with a slight uptick in the last year.

Table 5.2.2-26. Recreational effort for the snapper-grouper fishery in the South Atlantic, in thousand trips, by mode, 2001-2006.

	Charter Mode Trips			Shore Mode Trips			Private Mode Trips		
	Catch	Target	Total	Catch	Target	Total	Catch	Target	Total
2001	102	21	497	1,200	355	11,534	1,803	607	9,565
2002	105	22	440	919	233	9,057	1,744	495	8,266
2003	118	23	412	1,103	263	10,872	2,105	648	9,963
2004	129	28	418	987	209	11,186	1,985	477	9,488
2005	373	69	971	1,095	195	11,240	2,096	473	9,886
2006	285	68	834	1,276	272	12,511	2,603	530	10,749
Avg.	185	39	595	1,097	255	11,067	2,056	538	9,653

Source: MRFSS database, NOAA Fisheries, NMFS, SERO.

Table 5.2.2-27. Recreational effort for the snapper-grouper fishery in the South Atlantic, in thousand trips, by state, 2001-2006.

	Florida			Georgia			South Carolina			North Carolina		
	Catch	Target	Total	Catch	Target	Total	Catch	Target	Total	Catch	Target	Total
2001	2,620	772	12,464	78	53	807	123	96	1,676	283	61	6,650
2002	2,395	628	10,303	57	20	619	87	51	1,254	230	51	5,586
2003	2,860	723	11,444	92	46	971	143	86	2,098	231	80	6,733
2004	2,530	532	10,800	90	26	960	191	84	2,224	289	71	7,107
2005	2,835	579	12,200	96	28	859	178	60	2,188	454	70	6,849
2006	3,325	633	13,349	71	28	799	248	133	2,670	520	76	7,276
Avg.	2,761	645	11,760	81	34	836	162	85	2,018	335	68	6,700

Source: MRFSS database, NOAA Fisheries, NMFS, SERO.

For the period 2001-2006, an annual average of 295,593 trips taken by anglers caught snapper grouper species (Table 5.2.2-28). This is about 9 percent of all catch trips taken by anglers in the South Atlantic snapper-grouper fishery. An average of 96,800 trips caught gag, 81,815 caught vermilion snapper, and 116,978 caught other species. The private mode accounted for the largest number of catch trips for all species groups in this amendment. The charter and shore modes registered substantially lower catch trips than the private mode. There were more trips catching other species than either gag or vermilion, and more vermilion catch trips than gag.

The number of trips that targeted gag and vermilion snapper species (55,485) was substantially lower than catch trips. This is about 7 percent of all target trips in the South Atlantic snapper-grouper fishery. Again, the private mode dominated all other modes in terms of number of target trips. In fact, target trips by the charter and shore modes registered at very low levels (Table 5.2.2-28). There were substantially more target trips for gag (47,330) than for vermilion snapper (1,381) or other species (6,774).

Table 5.2.2-28. Average recreational effort for species, by mode, 2001-2006.

	Gag	Vermilion	Other Species	Total
	Catch Trips			
Charter	11,405	36,148	25,461	73,014
Shore	7,423	310	3,098	10,831
Private	77,972	45,357	88,419	211,748
Total	96,800	81,815	116,978	295,593
	Target Trips			
Charter	3,155	250	177	3,582
Shore	2,151	0	379	2,530
Private	42,024	1,131	6,218	49,373
Total	47,330	1,381	6,774	55,485

Source: MRFSS database, NOAA Fisheries, NMFS, SERO.

The regional distribution of catch and target trips for species is presented in Table 5.2.2-29. Florida, with 233,188 total catch trips, dominated all other states, but catch trips in South Carolina (36,382) and North Carolina (17,753) were also relatively high. Florida also had the largest catch trips for each of the three species groups, followed by North Carolina, South Carolina, and Georgia.

In terms of target trips, only Florida registered large numbers while all other states showed relatively minimal target trips. In fact, Florida, with a total of 54,550 target trips, accounted for about 98 percent of all target trips for species. It may be pointed out, though, that most of the Florida target trips (85%) were for gag, and there were more target trips for other species than for vermilion snapper.

Table 5.2.2-29. Average recreational effort for snapper grouper species, by state, 2001-2006.

	Gag	Vermilion	Other Species	Total
	Catch Trips			
Florida	81,200	52,713	99,275	233,188
Georgia	1,607	5,784	879	8,270
South Carolina	3,358	10,831	3,564	17,753
North Carolina	10,636	12,486	13,260	36,382
Total	96,801	81,814	116,978	295,593
	Target Trips			
Florida	46,635	1,145	6,770	54,550
Georgia	252	0	0	252
South Carolina	14	22	0	36
North Carolina	429	214	3	646
Total	47,330	1,381	6,773	55,484

Source: MRFSS database, NOAA Fisheries, NMFS, SERO.

The fact that target trips were substantially lower than catch trips has implications on the determination of the economic effects of regulations. It may be contended that target trips contain more meaningful economic valuation of the fishing experience than catch trips from the standpoint of predicting the economic outcome of regulations. One reason for this is that a target trip carries with it an indication of an angler's assignment of some positive values to the species targeted. On the other hand, some catch trips may simply be accidental and as such may not provide any indication of an angler's assignment of value on certain species. It is possible, of course, that past catch trips may shape future target trips, but this would necessitate further research to determine the nature and extent of the effects of past catch trips on future target trips. At any rate, the substantial difference between catch and target trips may imply that if regulations in this amendment were effective in reducing harvest by reducing catch trips more than target trips, then the resulting economic effects would likely be less than harvest reductions.

Similar analysis is not possible for the headboat sector since data are not collected at the angler level. Estimates of effort in the headboat sector are provided in terms of angler days, or the number of standardized 12-hour fishing days that account for the different half-, three-quarter-, and full-day fishing trips by headboats. Despite the inability to associate headboat effort with specific species, the stationary bottom nature of headboat fishing, as opposed to trolling, suggests that all headboat trips and, hence, angler days, are snapper grouper trips by intent, though not necessarily success.

Headboat angler days are presented in Table 5.2.2-30. Due to very low headboat angler days for Georgia, entries for Georgia were combined with those of Florida. For the period 2001-2006, total headboat angler days fluctuated around the mean of 238,012 days. On average, Florida accounted for the largest number of angler days (163,375), or about 69 percent of all headboat angler days. Nevertheless, the numbers for South Carolina (44,810 days) and North Carolina (27,824 days) are far from being negligible.

Table 5.2.2-30. Estimate of headboat angler days for the U.S. South Atlantic.

	Florida	South Carolina	North Carolina	Total
2001	163,389	49,265	31,779	246,434
2002	151,546	42,467	27,601	223,616
2003	145,011	36,556	22,998	206,568
2004	173,701	50,461	27,255	253,421
2005	171,078	34,036	31,573	238,692
2006	175,522	56,074	25,736	259,338
Average	163,375	44,810	27,824	238,012

Source: The Headboat Survey, NOAA Fisheries, SEFSC, Beaufort Lab.

5.2.2.1.2.3 Permits

For-hire vessels in the South Atlantic are required to have a snapper grouper for-hire permit to fish for or possess snapper grouper species in the EEZ. The number of permitted vessels for the period 2001-2006 is provided in Table 5.2.2-31. This sector operates as an open access fishery and not all permitted vessels are necessarily active in the fishery. Some vessel owners have been known to purchase open access permits as insurance for uncertainties in the fisheries in which they currently operate.

The number of for-hire permits issued in the South Atlantic snapper-grouper fishery increased over the period 2001-2006, with 1,095 permits in 2001 to 1,681 permits in 2006. Most of the increases would likely be for strictly for-hire business, since permits issued for vessels operating as for-hire and commercial entities remained about flat during the same period. The majority of snapper grouper for-hire permitted vessels were home-ported in Florida; a good number of vessels were also home-ported in North Carolina and South Carolina. Interestingly, there were several vessels with home ports in states other than those within the South Atlantic Council's area of jurisdiction. Most of the vessels with both for-hire and commercial permits were home-ported in the South Atlantic Council's area of jurisdiction.

Table 5.2.2-31. Snapper grouper for-hire permit holders by home port state.

	Number of vessels issued for-hire vessel permits						Number of vessels with both a for-hire permit and a commercial snapper grouper permit					
Home Port State	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
Florida	675	776	957	1,084	1,119	1,108	144	145	148	151	148	151
North Carolina	180	195	206	232	254	284	39	35	45	42	43	46
South Carolina	137	129	122	108	121	119	39	34	34	33	33	34
Georgia	25	27	36	27	33	33	4	5	4	2	2	2
Virginia	10	11	5	13	10	10	6	6		4	3	2
Other States	33	38	69	48	51	62	3	2	8	3	5	3
Gulf States	35	44	82	82	79	65						
Total	**1,095**	**1,220**	**1,477**	**1,594**	**1,667**	**1,681**	**235**	**227**	**239**	**235**	**234**	**238**

Source: Southeast Permits Database, NOAA Fisheries, SERO.

The for-hire permit does not distinguish between whether the vessel operates as a charterboat or headboat. Based on a 1997 survey, Holland *et al.* (1999) estimated that a total of 1,080 charter vessels and 96 headboats supplied for-hire services in all South Atlantic fisheries during 1997.

5.2.2.1.2.4 Economic Value and Expenditures

Participation, effort, and harvest are indicators of the value of saltwater recreational fishing. However, a more specific indicator of value is the satisfaction that anglers experience over and above their costs of fishing. The monetary value of this satisfaction is referred to as consumer surplus. The value or benefit derived from the recreational experience is dependent on several quality determinants, which include fish size, catch success rate, and the number of fish kept. These variables help determine the value of a fishing trip and influence total demand for recreational fishing trips.

Estimates of the economic value of a day of saltwater recreational fishing in the South Atlantic indicate that the mean value of access per marine recreational fishing trip is $109.31 for the South Atlantic (Haab *et al.* 2001). While this estimate is not specific to snapper-grouper fishing trips, it may shed light on the magnitude of an angler's willingness to pay for this type of recreational experience.

Willingness to pay for an incremental increase in catch and keep rates per trip was also estimated to be $3.01 for bottom fish species by Haab *et al.* (2001). Whitehead *et al.* (2001) estimated the marginal willingness to pay to avoid a one fish red snapper bag limit decrease to be $1.06 to $2.20. Finally, Haab *et al.* (2001) provided a compensating variation (the amount of money a person would have to receive to be no worse off after a reduction of the bag limit) estimate of $2.49 per fish when calculated across all private boat anglers that targeted snapper grouper species in the South Atlantic.

These valuation estimates should not be confused with angler expenditures or economic activity. While expenditures for a specific good or service may represent a proxy or lower bound of value (a person would not logically pay more for something than it was worth to them), they do not represent the net value (benefits minus cost), nor the change in value associated with a change in the fishing experience. However, angler expenditures benefit a number of sectors that provide goods and services for salt-water sport fishing. Gentner *et al.* (2001) provides estimates of saltwater recreational fishing trip expenditures (Table 5.2.2-32). These estimates do not include expenditures in Monroe County, Florida, or expenditures in the headboat sector.

Table 5.2.2-32. Summary of expenditures on saltwater trips.

	North Carolina		**South Carolina**		**Georgia**		**Florida**	
Item	**Resident**	**Non Resident**	**Resident**	**Non Resident**	**Resident**	**Non Resident**	**Resident**	**Non Resident**
Shore mode trip expenses	$63.61	$75.53	$54.12	$104.27	$31.78	$115.13	$36.90	$141.30
Private/rental boat trip expenses	$71.28	$92.15	$35.91	$67.07	$161.34	$77.51	$66.59	$94.15
Charter mode trip expenses	$201.66	$110.71	$139.72	$220.97	$152.45	$155.90	$96.11	$196.16
Charter fee-average-per day	$133.76	$70.59	$114.26	$109.97	$73.68	$80.99	$71.37	$100.79

Source: 1999 MRFSS add-on survey (Gentner *et al.* 2001).

5.2.2.1.2.5 Financial Operations of the Charter and Headboat Sectors

Holland *et al.* (1999) estimated that the charterboat fee in the South Atlantic ranged from $292 to $2,000. The actual cost depended on state, trip length, and the variety of services offered by the charter operation. Depending on the state, the average fee for a half-day trip ranged from $296 to $360, for a full day trip the range was $575 to $710, and for an overnight trip the range was $1,000 to $2,000. Most (>90 percent) Florida charter operators offered half-day and full-day trips and about 15 percent of the fleet offered overnight trips. In comparison, only about 3 percent of operations in the other South Atlantic states offered overnight trips.

For headboats, the average fee in Florida was $29 for a half-day trip and $45 for a full day trip. For North and South Carolina, the average base fee was $34 per person for a half-day trip and $61 per person for a full day trip. Most of these headboat trips operated in Federal waters in the South Atlantic (Holland *et al.* 1999).

Capital investment in charter vessels averaged $109,301 in Florida, $79,868 for North Carolina, $38,150 for South Carolina and $51,554 for Georgia (Holland *et al.* 1999). Charterboat owners incur expenses for inputs such as fuel, ice, and tackle in order to offer the services required by their passengers. Most expenses incurred in 1997 by charter vessel owners were on crew wages and salaries and fuel. The average annual charterboat business expenditures incurred was $68,816 for Florida vessels, $46,888 for North Carolina vessels, $23,235 for South Carolina vessels, and $41,688 for vessels in Georgia in 1997. The average capital investment for headboats in the South Atlantic was approximately $220,000 in 1997. Total annual business expenditures averaged $135,737 for headboats in Florida and $105,045 for headboats in other states in the South Atlantic.

The 1999 study on the for-hire sector in the Southeastern U.S. presented two sets of average gross revenue estimates for the charter and headboat sectors in the South Atlantic (Holland *et al*., 1999). The first set of estimates were those reported by survey respondents and were as follows: $51,000 for charterboats on the Atlantic coast of Florida; $60,135 for charterboats in North Carolina; $26,304 for charterboats in South Carolina; $56,551 for charterboats in Georgia; $140,714 for headboats in Florida; and $123,000 for headboats in the other South Atlantic states (Holland *et al*., 1999). The authors generated a second set of estimates using the reported average trip fee, average number of trips per year, and average number of passengers per trip (for the headboat sector) for each vessel category for Florida vessels. Using this method, the resultant average gross revenue figures were $69,268 for charterboats and $299,551 for headboats. Since the calculated estimates were considerably higher than the reported estimates (22 percent higher for charterboats and 113 percent higher for headboats), the authors surmised that this was due to sensitivity associated with reporting gross receipts, and subsequent under reporting. Alternatively, the respondents could have overestimated individual components of the calculated estimates. Although the authors only applied this methodology to Florida vessels, assuming the same degree of under reporting in the other states results in the following estimates in average gross revenues: $73,365 for charterboats in North Carolina, $32,091 for charterboats in South Carolina; $68,992 for charterboats in Georgia; and $261,990 for headboats in the other South Atlantic states.

It should be noted that the study's authors were concerned that while the reported gross revenue figures may be underestimates of true vessel income, the calculated values could overestimate gross income per vessel from for-hire activity (Holland *et al.*, 1999). Some of these vessels are also used in commercial fishing activities and that income is not reflected in these estimates.

5.2.2.1.3 Social and cultural environment

Additional detailed description of the social and cultural nature of the South Atlantic snapper-grouper fishery is contained in Snapper Grouper Amendment 13C (SAFMC 2006), Snapper Grouper Amendment 15A (SAFMC 2007), and Snapper Grouper Amendment 15B (SAFMC 2008)] and is incorporated herein by reference. The following section updates and summarizes social and cultural information for commercial and recreational sectors of the snapper grouper fishery as part of the human component of the South Atlantic ecosystem. Key communities were identified primarily based on permit and employment activity. These data were obtained from the U.S. Bureau of the Census and from state and federal permitting agencies.

Permit trends are hard to determine, since several factors may affect how many vessels are homeported in certain communities, including vessel mobility, shifting stock locations, and resettlement of fishermen due to coastal development. Nevertheless, although vessel location shifts occur, static geographical representations help determine where impacts may be felt.

Data from the US Census Bureau must be used with some caution. Census data may not reflect shifting community demographics. Businesses routinely start up and fail or move and the census data collection cycle may fail to capture key changes. Further, census estimates do not include seasonal visitors and tourists, or those that live less than half the year in a surveyed area. Many of the latter group may work as seasonal employees and not be counted. Census data also misses some types of labor, such as day laborers, undocumented crew members, or family members that help with bookkeeping responsibilities.

Permit requirements for the commercial snapper grouper fishery were established in 1998 by Amendment 8 (SAFMC 1997). This amendment created a limited entry system for the fishery and established two types of permits based on the historic landings associated with a particular permit. Those who could demonstrate a certain amount of landings over a certain time period received permits that did not limit the number of pounds of snapper grouper that could be landed from federal waters (hereafter referred to as “unlimited commercial permits”). These permits were transferable. Vessels with verified landings, but did not meet the threshold were issued permits that allowed them to land 225 pounds of snapper grouper species from federal waters each trip (hereafter referred to as “limited commercial permits”). These permits were not transferable. New entry into the fishery required the purchase of two unlimited permits from existing permit holders for exchange for a new permit. This “two for one” system was intended to gradually decrease the number of permits in the fishery. These restrictions only applied to the commercial snapper grouper permit.

Impacts on fishing communities from coastal development, rising property taxes, decreasing access to waterfront due to increasing privatization of public resources, rising cost of dockage and fuel, lack of maintenance of waterways and ocean passages, competition with imported fish, and other less tangible (often political) factors have combined to put all these communities and their associated fishing sectors under great stress.

While studies on the general identification of fishing communities have been undertaken in the past few years, little social or cultural investigation into the nature of the snapper grouper fishery itself has occurred. A socioeconomic study by Waters *et al.* (1997) covered the general characteristics of the fishery in the South Atlantic, but those data are now almost 10 years old and do not capture important changes in the fishery. Cheuvront and Neal (2004) conducted survey work of the North Carolina commercial snapper grouper fishery south of Cape Hatteras, but did not include ethnographic examination of communities dependent upon fishing.

To help fill information gaps, members of the South Atlantic Council's Snapper Grouper Advisory Panel, Council members, Advisory Panel members, and representatives from the angling public identified communities they believed would be most impacted by the management measures proposed in Amendment 13C on the species addressed by this amendment. Details of their designation of particular communities, and the factors considered in this designation, can be found in Amendment 13C (SAFMC 2006).

Because so many communities in the South Atlantic benefit from snapper grouper fishing, the following discussion focuses on "indicator communities," defined as communities thought to be most heavily impacted by snapper grouper regulations.

5.2.2.1.3 .1 North Carolina

Figure 5.2.2-15. North Carolina communities with substantial fishing activity, as identified by South Atlantic Advisory Panels.

Statewide

Overview

Of the four states in the South Atlantic region, North Carolina (Figure 5.2.2-15) is often recognized as possessing the most "intact" commercial fishing industry; that is, it is more robust in terms of viable fishing communities and fishing industry activity than the other three states. The state offers a wide variety of fishing opportunities, including sound fishing, trolling for tuna, bottom fishing, and shrimping. Perhaps because of the wide variety of fishing opportunities, fishermen have been better able to weather regulations and coastal development pressures, adjusting their annual fishing patterns as times have changed.

Commercial Fishing

There has been a steady decline in the number of federal commercial snapper grouper permits North Carolina since 1999, with 194 unlimited commercial permits in 1999, but only 139 in 2004. Limited permits similarly declined from 36 to16.

State license sale and use statistics for all types of licenses also indicate an overall decrease since 1994. While the overall number of state licenses to sell any species of fish or shellfish increased from 6,781 in 1994 to 9,712 in 2001/2002, the number of license holders actually reporting sales decreased from 6,710 in 1994/1995 to 5,509 in 2001/2002 (SAFMC 2006).

North Carolina fishermen demographics are detailed in Cheuvront and Neal (2004). Ninety eight percent of surveyed fishermen were white and 58 percent had completed some college or had graduated from college. Of those who chose to answer the question, 27 percent of respondents reported a household income of less than $30,000 per year, and 21 percent made at least $75,000 per year. On average, respondents had been fishing for 18 years, and had lived in their communities for 27 years.

Cheuvront and Neal (2004) also provided an overview of how North Carolina commercial snapper grouper fishermen carry out their fishery. Approximately 65 percent of surveyed fishermen indicated year-round fishing. Gag is the fish most frequently targeted by these fishermen, with 61 percent of fishermen targeting gag at some point in the year, despite the prohibition of commercial sales and limit to the recreational bag limit in March and April. Vermilion snapper (36.3 percent) and black sea bass (46 percent) are the next most frequently targeted species. A significant number of fishermen land king mackerel during each month, with over 20 percent of fishermen targeting king mackerel between October and May. During the gag closed season, king mackerel are targeted by about 35 percent of the fishermen. Other snapper/grouper complex species landed by at least 5 percent of the fishermen in any given month were red grouper (39.5 percent), scamp (27.4 percent), snowy grouper (9.7 percent), grunts (14.5 percent), triggerfish (13.7 percent), and golden tilefish (5.6 percent). Non-snapper/grouper complex species landed by at least 5 percent of the fishermen in any given month included Atlantic croaker, yellowfin tuna, bluefin tuna, dolphin, and shrimp.

Recreational Fishing

Recreational fishing is well developed in North Carolina and, due to natural geography, is not limited to areas along the coast. Data show that North Carolina is almost on par with east Florida for total recreational fishing participation effort (data not shown; see SAFMC (2006)). A brief discussion of public boat ramps and local recreational fishing clubs, as well as sources of information used by these anglers, can be found in SAFMC (2006).

The North Carolina state legislature approved the creation of a state recreational saltwater fishing license in 2004. The license created controversy for both the recreational and commercial sectors, each believing that it will hurt or help their access to marine resources. Possession of the license, subject to exemptions, was required beginning on January 1, 2007 (http://www.ncdmf.net/recreational/NCCRFLfaq.htm).

Hatteras Village

A detailed history of this community, from its discovery by Italian explorers in the 16th century to establishment of a National Seashore in 1953, can be found in SAFMC (2006).

Overview

Census data indicate there was not a significant increase in population size in Hatteras Village from 1990 to 2000 (SAFMC 2006). The demographics of the island have shifted, as is evidenced in the decreasing percentage of the population that is actively in the workforce, perhaps reflecting a larger number of retirees in the community, and the increasing proportion of residents with higher education, also reflecting a retired, professional segment of the population. Hatteras Village has also experienced a significant increase in the percent of the population in the farming, fishing, and forestry occupations, from 5.6 percent to 10.8 percent. This may be reflective of the increasing number of persons employed in businesses related to recreational fishing, such as charter boat captains and crew, boat repair and sales, marinas, etc. See SAFMC (2006) for the raw data describing community demographics. Figure 5.2.2-16 includes two maps detailing the area.

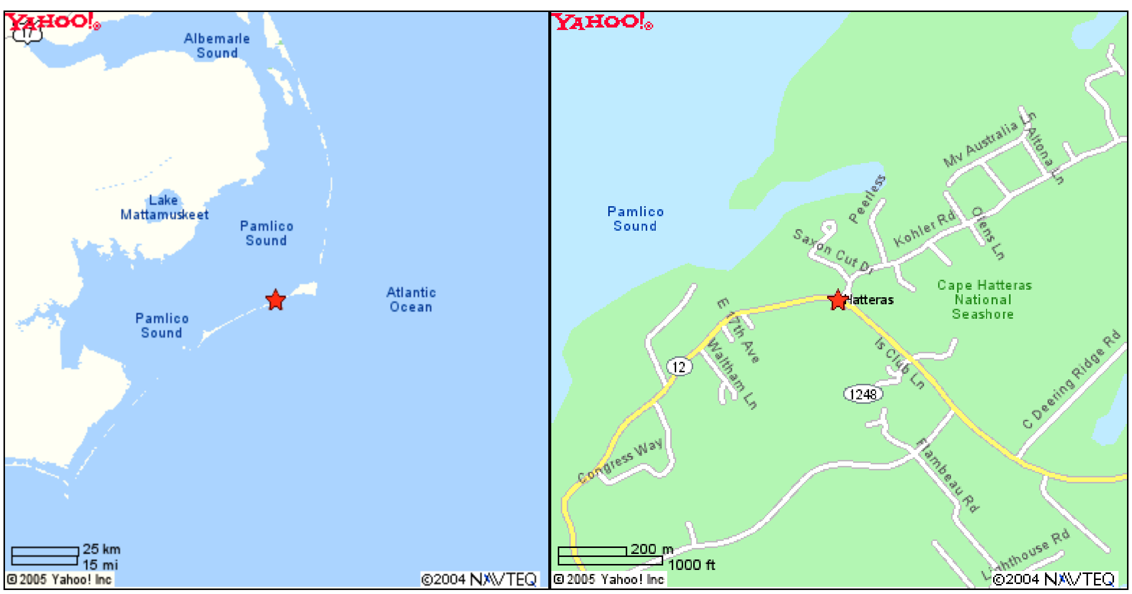


Figure 5.2.2-16. Hatteras Island and Village, Outer Banks, North Carolina. Source: Yahoo Maps, http://www.yahoo.com.

Commercial Fishing

Anecdotal information from Hatteras residents indicates the number of fish houses has decreased as tourism has increased (SAFMC 2006). Residents, however, still promote the fisherman's way of life through festivals and special community designations (SAFMC 2006).

Mirroring the statewide trend, the number of unlimited commercial permits held by residents of Hatteras decreased from 1999 (9 permits) to 2004 (5 permits). The number of limited commercial permits has remained at 3 (SAFMC 2006). Twenty people stated they were employed in fishing related industry in the 1998 census, with 18 of these employed by marinas. A listing of the six marinas and eight bait and tackle stores in Hatteras Village can be found in SAFMC (2006).

Recreational Fishing

Hatteras is host to several prestigious fishing tournaments and is homeport for the island's famous charter fishing fleet. The number of charter/headboat permits held by Hatteras residents has dramatically increased, from one permit in 1999 to 28 in 2004.

Wanchese

A history of this community, and neighboring Manteo, describing its persistence as a small, close-knit community focused on making its living from the sea, can be found in SAFMC (2006).

Source: Kitner 2005.

Figure 5.2.2-17. Map of Roanoke Island, North Carolina, showing Wanchese and Manteo.

Overview

Figure 5.2.2-17 provides a map of Roanoke Island, including Wanchese and Manteo. While Wanchese has maintained its identity as a commercial fishing community, it faces continuing pressure from developers in nearby Manteo and other Outer Banks communities. However, the town has recently approved a zoning document that would prevent unplanned growth and would help preserve working waterfronts and residential areas (Kozak 2005). A partial community profile detailing local traffic patterns, businesses, and prominent families can be found in SAFMC (2006).

The largest industrial area in Wanchese is centered on the Wanchese Seafood Industrial Park, built to enhance business opportunities in the seafood and marine trades. Tenants of the park are able to ship products overnight to major domestic and international markets through the airport in Norfolk, Virginia. The park is utilized by fishermen and seafood dealers, as well as boatbuilding and boat maintenance businesses. The park is full of activity and it is common to find large numbers of people, especially Hispanics, working in the marine trade industries.

Census statistics from 2000 show the population of Wanchese is aging and very homogenous, with little ethnic diversity. There has been a slight increase in the Hispanic population since 1990, mirroring most other communities in North Carolina. Education levels have also increased, and the poverty rate has decreased. A higher percentage of people are employed in fishing-related professions in Wanchese than in almost any other community – 10 percent – although even that number has decreased nearly 50 percent since 1990.

Commercial Fishing

Commercial landings and value for Wanchese/Stumpy Point declined from 31.9 million pounds valued at $26.1 million in 2001 to 28.7 million pounds valued at $23.2 million in 2002. In 2001, Wanchese/Stumpy Point was listed as the 28th most prominent United States port based on the value of the product landed, declining to 30th in 2002. While landings increased in 2003, to 33 million pounds, value further declined to $21 million (31st place), with further declines in both poundage (31 million pounds) and value ($20.5 million) in 2004.

Amendment 8, which limited entry into the commercial snapper grouper fishery, does not appear to have caused a decrease in the number of commercial permits held by residents of Wanchese (SAFMC 2006). In 1999, seven unlimited commercial permits were held, with eight in 2004. Three limited commercial licenses were held in both 1999 and in 2004.

One hundred twenty residents of Wanchese stated they were employed in fishing related industries in the 1998 census (SAFMC 2006). Sixteen of these were listed as employed in fishing, 56 in fish and seafood, and 40 in boatbuilding.

There were 228 commercial vessels registered and 201 state standard commercial fishing licenses issued in the community in 2002 (SAFMC 2006). Wanchese residents also held 12 dealer licenses. The town is an important unloading port for many vessels transiting to and from the Mid-Atlantic and South Atlantic.

Recreational Fishing

As of 2005, nine boatbuilding businesses were located in Wanchese, building either pleasure yachts, recreational fishing vessels or, less often, commercial fishing vessels. There were two bait and tackle businesses and two marinas in town. All these businesses rely on the fishing industry. Manteo also maintains an active private and for-hire recreational fishing community. From 1999 to 2004, there was an increase in the number of charter/headboat licenses held, from two permits to nine permits. As most of the recreational sector for the region operates out of Manteo and Nags Head, these communities would be more affected by recreational fishing restrictions than would Wanchese.

Figure 5.2.2-18. Area of Carteret County, North Carolina, showing Morehead City, Atlantic Beach (at the red star), and Beaufort.
Source: Yahoo Maps, http://www.yahoo.com.

Morehead City

In Carteret County, Morehead City, Beaufort, and Atlantic Beach form a triad of different but complementary communities in close geographic proximity (Figure 5.2.2-18). A detailed history of Morehead City, from its founding in the 1840s-1850s to its development as a center for sport and tournament fishing in recent years, can be found in SAFMC (2006).

Overview

Morehead City’s economy is currently based on tourism, fishing (commercial and recreational), light industry, government, and other service and professional industries. The town has regained its commercial viability as a modern port terminal, and benefits from its location on the “sound-side” of the Atlantic Beach resort trade. Diving has become an important tourist activity; Rodale’s Scuba Diving magazine recently named North Carolina as the best wreck diving destination in North America, and Morehead City as the best overall dive destination. Recreational fishing effort is growing quickly, as new marinas, boat storage areas, boat builders, and marine supply stores open in the city.

Detailed statistics detailing community demographics of Morehead City in 1990 and 2000 can be found in SAFMC (2006). The population of Morehead City increased from 1990 to 2000, with sizable increases in the number of people declaring non-white ethnicities. Median income increased from approximately $20,000 to nearly $29,000 from 1990 to 2000. Median home value nearly doubled, and median rent increased 35 percent. The percentage of those completing high school increased by 10 percent, and there was a seven percent increase in those receiving a bachelor's degree or higher. The poverty level decreased. However, the unemployment rate increased. The occupations of farming, fishing, and forestry employ more than one percent of the population of Morehead City.

Commercial Fishing

In 1998, 100 people were employed in fishing related businesses according to census figures, with 40 employed in marinas and 36 employed in fish and seafood businesses (SAFMC 2006). Over 200 state commercial vessel licenses, 150 state standard commercial fishing licenses, and 14 dealer licenses were issued by the state to residents of Morehead City in 2002. The number of unlimited commercial permits held by Morehead City residents was 15 in 1999 and 14 in 2004, while the three limited commercial permits held in 1999 were no longer held by 2004 (SAFMC 2006). As of 2002, the state had issued 211 commercial vessel registrations, 150 standard commercial licenses, and 14 dealer licenses to Morehead City residents. Residents of Morehead City were primarily employed by marinas (40 percent) and fish and seafood (36 percent), with 16 percent employed in boatbuilding businesses.

A narrative detailing the fishing methods, habits, and observations of a bandit-rig fisherman in Morehead City can be found in SAFMC (2006).

Recreational Fishing

The number of charter/headboat permits held by Morehead City residents nearly doubled, from seven in 1999 to 13 in 2004.

Beaufort

Beaufort is located on the coast near Cape Lookout, and borders the southern portion of the Outer Banks. Its deep harbor is home to vessels of all sizes, and its marinas are a favorite stop-over for transient boaters. A detailed history of Beaufort, from its establishment to its importance as a trade center during the 18th and 19th centuries, to its later involvement in the menhaden fishing industry, can be found in SAFMC (2006).

Overview

Tourism, service industries, retail businesses, and construction are important mainstays of the Beaufort area, with many shops and restaurants catering to people from outside the area. Census data show a slight decrease in population size from 1990 to 2000, from 3,808 inhabitants to 3,771, perhaps due to the aging population. Educational attainment rose over the last decade, and the percentage of individuals below the poverty line fell slightly. The percentage of those in the labor force decreased, another possible indication of an aging population. However, the percentage unemployed also decreased. The number of people working in farming, fishing, and forestry remained about the same from 1990 to 2000. According to census business pattern data from 1998, most of the fishing-related employment in Beaufort (total 300 persons) occurs in the boat building industry, which employs 184 residents (SAFMC 2006). Forty-eight people reported working in marinas, while others are employed in fish processing, fish harvesting, and seafood marketing.

Commercial Fishing

There has been a slight decrease in the number of unlimited commercial permits held by residents of Beaufort, from 5 permits in1999 to 4 permits in 2004. In the last two years, the one limited commercial permit held by a Beaufort resident was no longer reported. As of 2002, the state had issued 430 commercial vessel registrations, 294 standard commercial licenses, and 32 dealer licenses to Beaufort residents.

Recreational Fishing

There has been virtually no change in the number of charter/headboat permits, 1 permit in 2003 and 2004, held by residents.

Atlantic Beach

Atlantic Beach has been a popular resort town since the 1870s. The first bathing pavilion was built on Bogue Banks in 1887. Tourists flocked to the resorts, and ferry service to Atlantic Beach increased. Other resorts and tourism related development occurred over the next century, and the area remains a popular vacation destination (www.atlanticbeach-nc.com/history_part-1.html).

Overview

Atlantic Beach demographic data from 1990 and 2000 show a slight population decline since 1990, as well as decreases in the percent of the population involved in farming, fishing, and forestry (SAFMC 2006). The median age of the population has increased, perhaps a reflection of the growing number of retirees moving to this area of the coast.

Commercial Fishing

As observed in other areas of North Carolina, since limited access was put into place, the number of commercial permits has decreased from eight unlimited commercial permits in 1999 to four in 2004, and four limited commercial permits to zero (SAFMC 2006). In 1998, 60 residents of Atlantic Beach were employed in fishing related industry, with 93 percent of those employed by the marine sector. In 2002, 56 vessels were registered with the state as commercial fishing vessels, 42 standard commercial fishing licenses were held by Atlantic Beach residents, and there were ten valid dealer licenses issued to community members (SAFMC 2006).

Recreational Fishery

Since 1999, the number of federal charter/headboat permits held by Atlantic City residents has increased from six to 19, though only one permit was recorded in 2002. Of the 60 individuals reporting working in a fishing related industry in 1998, 46 worked in marinas. Two state permits were issued to recreational fishing tournaments to sell licenses in 2002 (SAFMC 2006).

Figure 5.2.2-19. General area of Sneads Ferry, North Carolina.
Source: Yahoo Maps, http://www.yahoo.com.

Sneads Ferry

Sneads Ferry is a historical fishing village located on the New River near the northern tip of Topsail Island (Figure 5.2.2-19). The river joins the Intracoastal Waterway at Sneads Ferry, with easy access to the Atlantic Ocean. A very active commercial fishing community, Sneads Ferry takes in more fish than any other Onslow County port (http://www.cbcoastline.com/areainfo.htm). It also includes Camp Lejeune, a U.S. Marine base. The Sneads Ferry Shrimp Festival has been held annually since 1971. Now grown to a two-day event, the annual shrimp festival is the town's major fund-raiser. From its proceeds, the town established a 14-acre community park and built a 7200-sq. ft. Shrimp Festival Community Building (www.sneadsferry.com/areahistory/his_sf.htm).

Overview

Census data indicate the population of Sneads Ferry increased by about 10 percent from 1990 to 2000, from 2,031 inhabitants to 2,248. Most new residents were white, and the number of black or African American residents decreased from 159 to 115. Median income increased from about $20,000 to nearly $35,000. Median home value increased from $65,000 to $110,000, but median rent remained about the same. The percentage of those completing high school increased by 10 percent and the percent of residents with at least a Bachelor's degree doubled, from six percent to 12.8 percent. The poverty level decreased from 20.9 percent to 13.5 percent, and the percentage of the population unemployed decreased from 8.3 percent to 2.2 percent. The percentage of residents employed in farming, fishing, and forestry decreased by half from 18.2 percent to 9 percent, while employment in sales and office occupations increased by over 17 percent. It is unclear who may be buying home sites on newly developed land in the town, but the town's current demographics may point to an increase in retirees in Sneads Ferry, as they are better educated, have higher incomes, and are older. The dramatic decline by approximately 50 percent of persons employed in extractive natural resource occupations may be due to increasing job opportunities outside of the community, the changing impacts of regulations, or status of the resources

Commercial Fishing

Sneads Ferry is a small town with little of the large-scale development seen elsewhere on the North Carolina coast. Many houses in the community have fishing vessels docked in front of the house or on the lawn. The white rubber boots worn by commercial fishermen in this community and many other parts of North Carolina are commonly referred to as "Sneads Ferry Sneakers", suggesting the importance of commercial fishing to the area. Most of the fishermen in town are shrimpers and net fishermen who go out daily. There is also a strong contingent of black sea bass pot fishermen resident in the town. The species with the highest consistent landings in the town are black sea bass, button clams, blue crab, flounders, mullet, shrimp, spot, and whiting.

The number of federal charter/headboat permits held by residents increased from six in 1999 to 13 in 2004, while the number of unlimited commercial permits decreased from 22 to 17, and the number of limited commercial permits remained at one (SAFMC 2006).

Over 347 commercial fishing vessels were registered with the state in 2002, and 228 residents held state-issued standard commercial fishing licenses. There were also 18 dealer licenses in the community and 169 shellfish licenses. In 1998, 16 persons were employed in fishing related industry, with 75 percent working in fish and seafood.

Recreational Fishing

Recreational fishing in Sneads Ferry is not as prominent an activity as in Morehead City. However, there are a large number of vessels with charter permits for snapper grouper homeported there. Little is currently known about recreational fishing out of Sneads Ferry, aside for its advertisement as an important tourist attraction in many websites that discuss the community. At least five marinas cater to recreational fishermen. There are two other marinas at Camp LeJeune Marine Base, just across the Neuse River. Some smaller river and sound fishing charters operating out of the area and one headboat runs from Sneads Ferry. Other than black sea bass, it does not appear that many snapper grouper species are frequently caught recreationally from Sneads Ferry.

5.2.2.1.3.2 South Carolina

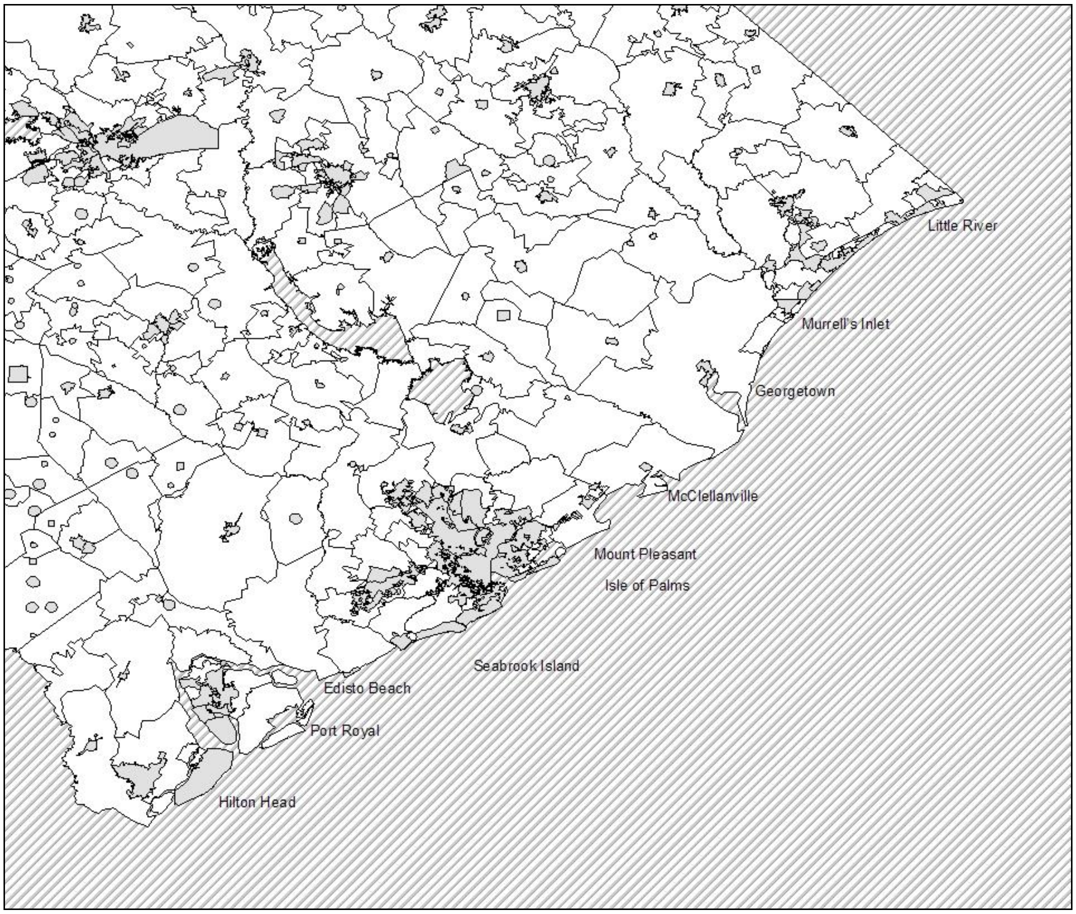


Figure 5.2.2-20. South Carolina communities with substantial fishing activity, as identified by South Atlantic Advisory Panels.

Statewide

Overview

South Carolina communities with substantial fishing activity are less developed than those in North Carolina and, over the past 20 to 30 years, the state has seen much more tourist-oriented development along its coasts than Georgia or North Carolina. In Horry County, the urban area of Myrtle Beach has expanded greatly in the past few decades, and much of the coastal area has been developed as vacation homes, condominiums, and golf courses. The communities most impacted by this development are Little River, Murrells Inlet, Pawleys Island, and Georgetown, although the latter three are located in Georgetown County (Figure 5.2.2-20). The same is true of rapid developing Charleston County, and the cities and communities of McClellanville, Mt. Pleasant, Sullivans Island, Wadmalaw and Edisto Islands feel the impact of urban sprawl from the city of Charleston. Further south along the coast, the Hilton Head Island resort development has been the impetus for changing coastal landscapes in the small towns of Port Royal, Beaufort, St. Helena Island, and Bluffton.

For the purpose of this document, only Little River will be singled out as a community with a high concentration of both commercial and recreational fishing, along with other types of coastal oriented leisure pursuits. Other analyses will consider South Carolina as a whole.

Commercial Fishing

While pockets of commercial fishing activities remain in the state, most are being displaced by the development forces and associated changes in demographics. The number of unlimited commercial permits, however, increased from 74 in 1999 to 87 in 2004, while the number of limited commercial permits decreased by 75 percent from 12 to 4 (SAFMC 2006).

Recreational Fishing

Many areas that used to be dedicated to commercial fishing endeavors are now geared towards the private recreational angler and for hire sector. The number of federal charter/headboat permits held by South Carolina residents increased from 41 in 1999 to 111 in 2004. The majority of saltwater anglers fish for coastal pelagic species such as king mackerel, Spanish mackerel, tunas, dolphins, and billfish. A lesser number focus primarily on bottom fish such as snapper and groupers and often these species are the specialty of the headboats that run out of Little River, Murrells Inlet, and Charleston. There are 35 coastal marinas in the state and 34 sportfishing tournaments (SAFMC 2006).

Little River

A history of Little River detailing its settlement in the late 1600s, its popularity as a vacation destination in the 1920s, and the concurrent rise in charter fishing, can be found in SAFMC (2006).

Figure 5.2.2-21. Little River, South Carolina, and surrounding area.
Source: Yahoo Maps, http://www.yahoo.com.

Overview

Figure 5.2.2-21 shows Little River and the surrounding area. A detailed description of changes in land-use patterns in and near Little River can be found in SAFMC (2006). Nearby Murrells Inlet is gradually transforming into a residential community for Myrtle Beach, and SAFMC (2006) argues this is also true for Little River.

Census data indicate the Little River population more than doubled from 1990 (3,470 persons) to 2000 (7,027 persons) and became more ethnically diverse with more people of American Indian or Alaskan Native, and Hispanic or Latino ethnicities. Median income increased by over 40 percent, from nearly $29,000 to over $40,000. Median home value also increased by over 40 percent, and median rent increased by nearly 35 percent. The percentage of those completing high school and those with a Bachelor's degree remained about the same. The poverty level decreased by nearly two-thirds to 4.7 percent, and the percentage of the population unemployed decreased from 6.6 percent to 3.4 percent. The percentage of residents employed in farming, fishing, and forestry decreased from 3.6 percent to 0.9 percent.

Commercial Fishing

In 1998, 38 residents of Little River were employed in fishing related industry according to the U.S. Census, with 81 percent of those employed by the marina sector. The number of snapper grouper unlimited harvest commercial permits held by community residents remained about the same between 1999 and 2004, from 15 permits to 16 permits, and one resident still held a limited harvest commercial license. Twenty-four Little River residents held state permits, with the most being saltwater licenses (8 permits) or trawler licenses (5 permits) (SAFMC 2006).

Recreational Fishing

As observed in other coastal communities described herein, the number of charter/headboat permits held by community residents increased from nine in 1999 to 16 in 2004. Three headboats operated out of Little River, and this part of the for-hire industry has a long and storied past in the community. Recreational fishing, primarily as headboat effort, came about as a way for commercial fishermen to continue fishing in the summer months. A detailed account of how recreational fishing developed in Little River can be found in Burrell (2000). Most of the private recreational fishing effort in this area occurs out of marinas in North Myrtle Beach, Myrtle Beach, and Murrells Inlet.

5.2.2.1.3.3 Georgia

Statewide

Overview

Only one community in Georgia (Townsend) lands a substantial amount of the snapper grouper species addressed in this amendment. Other parts of the state involved in the commercial harvest of seafood are focused on penaeid shrimp, blue crabs, and other finfish such as flounder, shad, croaker, and mullet.

Brunswick, the other community that has a commercial fishing presence, was once a more thriving commercial fishing community but now tourism and other related activities are competing for waterfront in the town. The most commonly harvested species in Brunswick are blue crab and different species of penaeid shrimp. According to the ACCSP website, there have been no snapper grouper species landed in Brunswick in since 2001. Other parts of the state involved in the commercial harvest of seafood are focused on penaeid shrimp, blue crabs, and other finfish such as flounder, shad, croaker, and some mullet.

Commercial Fishing

Unlike the pattern observed in many other areas, the number of unlimited commercial permits and limited commercial permits held by Georgia residents did not decrease from 1999 to 2004, with eight permits and one permit, respectively. In 2002, 947 vessels were registered with the state as commercial fishing vessels, 612 full-time state commercial fishing licenses were held by Georgia residents, and 147 residents held part-time state commercial fishing licenses. Within the commercial fishing fleet, four hundred and eighty two vessels had shrimp gear on board in that year (SAFMC 2006).

Recreational Fishing

As observed in other areas, the number of charter/headboat permits held by Georgia residents increased markedly from five permits in 1999 to 27 permits in 2004 (SAFMC 2006). Recreational vessels are located at Tybee Island close to Savannah, on the barrier islands off Brunswick, and between Savannah and Brunswick.

Townsend

A history of the area, describing its economy before the Civil War, the rise and fall of lumbering, and the building of the railroad, can be found in SAFMC (2006). Townsend is a small, rural community. In 2005, the fish house in this community was relocating inland. It is not known if this relocation was successful and whether that fish house will be handling domestically harvested fish in the future.

Overview

The population of Townsend increased by over 1,000 residents from 2,413 in 1990 to 3,538 in 2000. Although there was a large relative increase in the number of Hispanic or Latino residents, from 2 to 27, most of the new inhabitants were white (1,465 in 1990 and 2,437 in 2000). Median income increased from approximately $23,000 to $35,000. Median home value nearly tripled, from $33,000 in 1990 to $98,100 in 2000, and monthly rent nearly doubled, from $213 to $431. In 1990, 26.9 percent of residents had less than a 9th grade education, but by 2000, that number declined to 11.0 percent. The percentage of those completing high school increased by nearly 15 percent, while the percent receiving a bachelor's degree or higher remained about the same (8.4 percent to 8.9 percent). The percent of the population with an income below the poverty line deceased by four percent, but remained high at 14.6 percent. The percentage of the population unemployed increased from 3.4 percent to 6.5 percent. There has been a sizeable decline in the percentage of the population employed in manufacturing, from 29.0 percent to 16.2 percent, and the proportion of the population employed in farming, fishing, and industry remained unchanged at approximately three percent.

Commercial Fishing

A comprehensive description of the historic and current fish houses of coastal Georgia and how they operate, focusing on Phillips Seafood of Townsend, can be found in SAFMC (2006). For nearly a decade, only one fish house has consistently handled snapper grouper species. A fish house in Brunswick may have landed these species in the past, but has not reported landings since 2001.

Recreational Fishing

Offshore recreational anglers do not often target or harvest snapper grouper species in Georgia (http://www.st.nmfs.noaa.gov/st1/recreational/overview/overview.html). Of the snapper grouper species harvested, black sea bass, sheepshead, and vermilion snapper are the most commonly harvested fish at five, seven, and two percent, respectively. As of 2004, residents of the Savannah area held 11 charter/headboat permits for snapper grouper, and many of these vessels are docked on Tybee Island. Residents of the area around the city of Brunswick, including Jekyll Island and Sea Island, held four snapper grouper charter/headboat permits. Interestingly, unlike the cities profiled in the Carolinas, the number of federally permitted for-hire vessels has declined dramatically. From 2003 to 2004, the number of snapper grouper permitted for hire vessels declined from 43 to 27 (NMFS 2004). The cause of this decline is unknown.

5.2.2.1.3.4 Florida

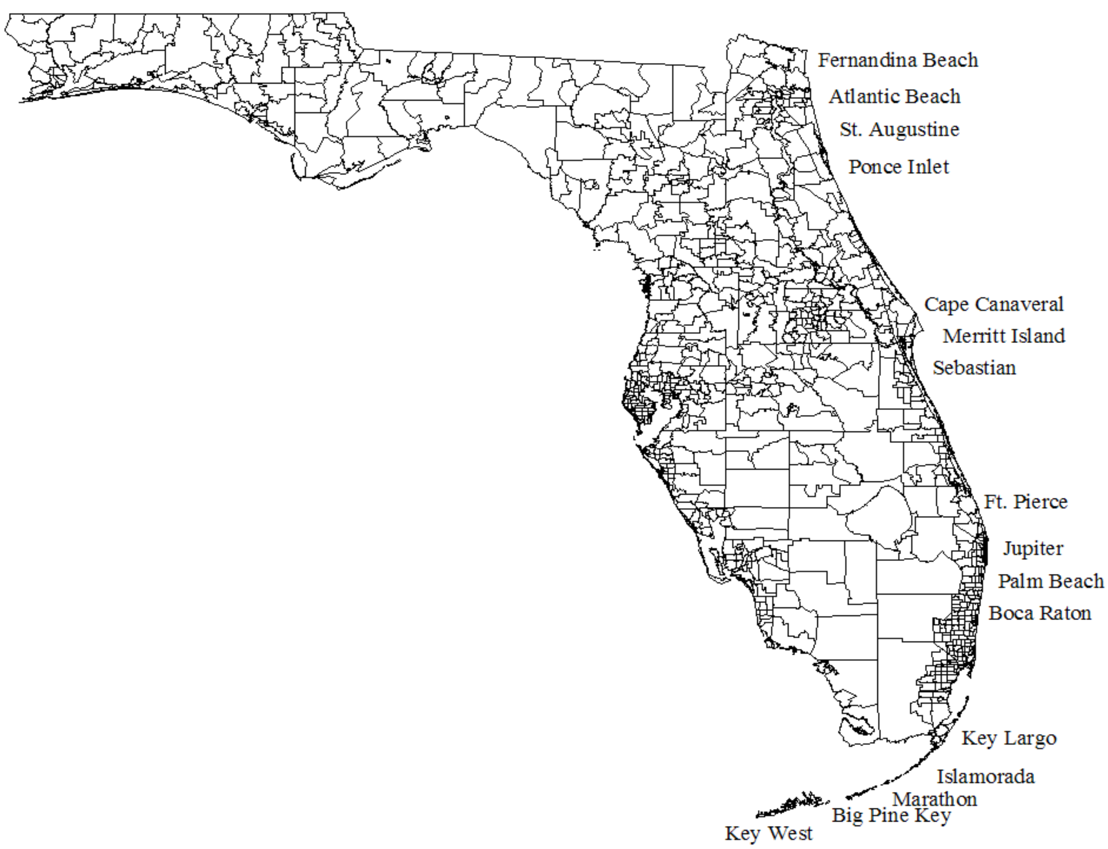


Figure 5.2.2-22. Florida communities with substantial fishing activity. Identified by South Atlantic Advisory Panels.
Source: Jepson *et al.* (2005).

Statewide

Overview

Florida stands apart from other states in the South Atlantic region in fishing behaviors, history, and demographics. Florida has one of the fastest growing populations in the United States, estimated to increase each day by 750 to 1,000 new immigrants. Twenty-five percent of all vacation homes in the United States are located in Florida's coastal counties (Coastal Ocean Resource Economics 2005).

Along with being heavily populated on land, coastal waters off Florida are also heavily used by recreational users of all kinds. This growth of a leisured class occupying coastal areas has led, in part, to conflicts over natural resource access and use-rights. One example of this type of struggle was the conflict over the use of gillnets in state waters. The conflict culminated in a state-wide ban on the use of gillnets, which dealt a resounding blow to many Florida fishermen, ending in the loss of many commercial fishing properties and the displacement of many fishermen. There have also been conflicts between the "environmental community" and commercial fishermen over the closing of the *Oculina* Bank off of Florida's central coast, and the creation of both the Florida Keys National Marine Sanctuary and the Tortugas Sanctuary, both in the Keys.

The natural geography of Florida also sets it apart from other South Atlantic states, particularly in the area from central Florida through the Keys. The weather is amenable to fishing almost year round, though hurricanes in 2004 were particularly devastating and took a toll on all fisheries in the state, both east and west coast. There was also a cold water event that started near West Palm Beach in 2003, which moved up the east coast causing a substantial decline in snapper grouper fishing that year. The continental shelf is much narrower in Florida than elsewhere in the region, allowing fishermen to access deep waters quickly and return the same day. Finally, the species of snapper grouper available to fishermen in southern Florida are different than further north, with yellowtail snapper, gag and black grouper, and other alternative species such as stone crab, spiny lobster, dolphin, kingfish, and billfish allow a greater variety of both commercial and recreational fishing opportunities. These fisheries are important to many Florida communities identified by the Snapper Grouper Advisory Panel as shown in Figure 5.2.2-22.

Commercial Sector

Considering the high population growth rates and emphasis on a tourism economy in Florida, the commercial fishing sector in Florida is still robust in some areas. Although total landings and dollar values of all species landed on the Florida East coast have decreased from 1998 to 2003 (from nearly 30 million pounds worth approximately $44 million to approximately 23 million pounds worth $33 million dollars; SAFMC 2006), there is still a considerable commercial fishing presence in east Florida.

Recreational Sector

While the commercial fishing industry, though still strong, may be in decline, the recreational sector appears to be stable. Excluding the headboat sector, although the number of participants declined in 2004 to approximately 1.9 million from 2.2 million in 2003 and from a high of 2.6 million in 2001, the number of trips taken in 2003 and 2004 remained at approximately 21 million. However, the headboat sector has exhibited a steady decline. In 2004, many homeports hosted at least one vessel holding both federal charter/headboat permits and federal unlimited commercial permits. Key West and Miami stand out, with 35 and 15 such vessels, respectively.

Cape Canaveral

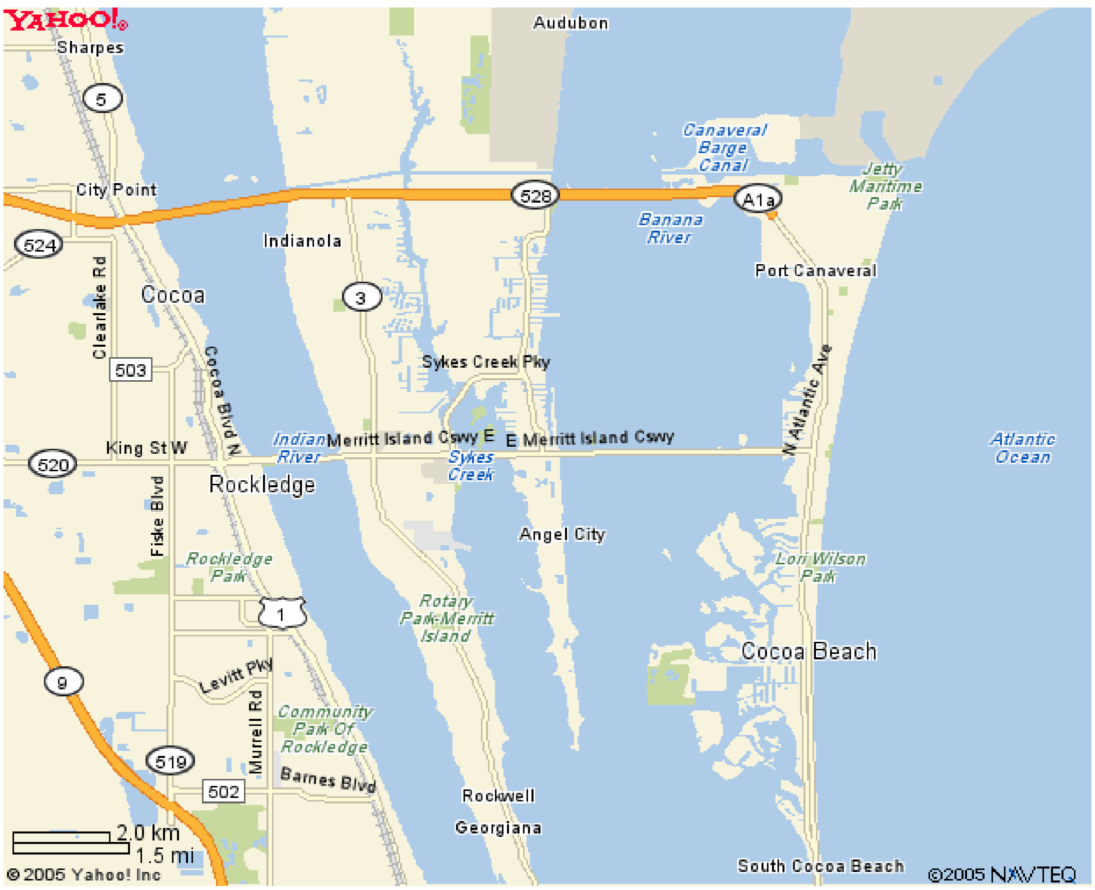


Figure 5.2.2-23. Area map of Cape Canaveral, Florida.

A detailed history of Cape Canaveral, Florida, from its first habitation 10,000 years ago, its settlement by the United States in the early 1800s, the establishment of the Banana River Naval Air Station in World War II, to NASA's arrival in 1952, can be found in SAFMC (2006). A map of the area is shown in Figure 5.2.2-23.

Overview

Cape Canaveral has a fairly homogenous, aging population, with those 65 years and older growing from 16.1 percent of the population to 23.1 percent since 1990. Overall, educational attainment has increased. The number of persons who speak a language other than English at home has increased 2.5 percent, and fewer people have incomes below the poverty line. Unemployment has decreased, but fewer people are in the labor force today than in 1990, perhaps due to an aging population. The percentage of persons in a service occupation has grown from 14.1 percent to 20.4 percent, while there has been a sizeable decline in the percent of residents employed in forestry, mining, and fishing, from 2.7 percent in 1990 to 0.4 percent in 2000.

Fisheries in central Florida generally operate in two different environments, inshore river or inlet fishing with associated lagoons, which primarily attracts recreational fishing, and offshore areas, where commercial fishing primarily occurs. Popular inshore areas include the Indian, St. Johns, and Banana Rivers and associated lagoons. Commercial exploitation of the rivers and lagoons declined after implementation of the Florida Net Ban of 1994.

Many commercial fish houses have gone out of business or have shifted to selling imported products to supplement their local supplies. At the same time, the number of businesses possessing federal dealer permits has increased from about 180 in 1999 to a little over 200 in 2001. There is some industry speculation that the increasing number of dealer permits reflects increased decentralization in the domestic fishing markets and the need to increase profits by self-marketing.

Commercial Fishing

Cape Canaveral draws fishermen from Cocoa/Cocoa Beach, Merritt Island, Melbourne, and Titusville. These fishermen target many snapper grouper species, as well as coastal migratory pelagics such as mackerel, highly migratory species such as sharks and swordfish, and shellfish such as oysters, quahogs, and shrimp. Snowy grouper and tilefish (particularly golden or sand tilefish) landings exceed 10,000 pounds per year. Total commercial landings decreased, however, from 8.9 million pounds to 6.0 million pounds from 1998 to 2004 (SAFMC 2006).

The number of unlimited commercial permits in this area increased from nine in 1999 to 16 in 2004. The number of limited commercial permits fluctuated over this period, but ultimately declined from four permits in 1999 to one in 2004 (SAFMC 2006).

The number of Florida Saltwater Products Licenses issued to residents of Brevard County (where Cape Canaveral is located) decreased from 872 in 1998/99 to 492 in 2004/05 (SAFMC 2006). This license is needed to sell marine species in the state. There have also been declines in license sales for various crustacean fisheries.

Recreational Fishing

In 2004, Brevard county supported 36 bait and tackle stores, with five in Cape Canaveral, and 70 marinas with over 3,000 wet slips, indicating the importance of recreational fishing to the area. Fourteen fishing tournaments consistently occur in the area. Additional details about these businesses and tournaments can be found in SAFMC (2006).

As in other coastal areas of Florida, there is a fairly heavy presence in Brevard County of charter boat businesses, private marinas, and other associated businesses catering to the recreational fishing sector. The number of federally permitted charter/headboat vessels in Cape Canaveral increased from zero to seven from 1999 to 2004. According to Holland *et al.* (1999), there were approximately 32 charter boats and 2 headboats in the Canaveral/Melbourne area. Current estimates from permit files show at least 38 for-hire vessels with Snapper grouper permits homeported in Cape Canaveral or Port Canaveral, which includes approximate four headboats. That is likely a low estimate for total the total number of for-hire vessels in the area since it does not include vessels in the nearby Merritt Island and in the Cocoa/Cocoa Beach areas.

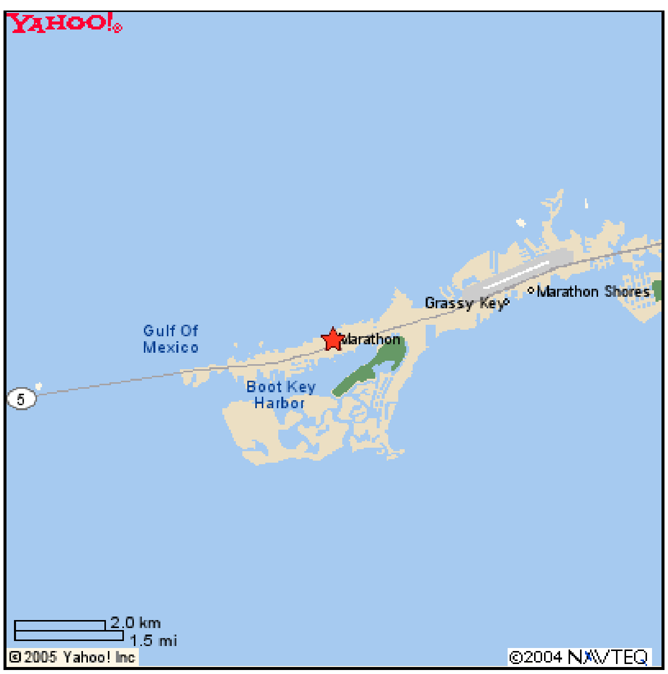


Figure 5.2.2-24. Marathon, Florida.

Source: Yahoo Maps, http://www.yahoo.com.

Marathon

A history of Marathon, detailing its settlement in the 1800s, the rise of industry, the effects of the Great Hurricane of 1935, the rise of tourism, and the importance of commercial fishing, can be found in SAFMC (2005). Figure 5.2.2-24 shows a map of Marathon, which lies in Monroe County.

Overview

Census data from 1990 and 2000 show there was an increase in overall population in Marathon from 8,857 in 1990 to 10,255 in 2000. During this period, the Hispanic population more than doubled, increasing from 1,040 to 2,095. This increase accounts for more than two thirds of the total population increase for the area. During this period of time, the median household income increased from approximately $25,000 to over $36,000.

Marathon has maintained a relatively high percentage of the total population, 4.1 percent in 2000, involved in farming, fishing, and forestry, though the percentage has declined from 8.7 percent in 1990. Since there is little commercial farming and forestry occurring in the area, the majority of percentage can be assumed to relate to fishing activities. The percentage of people that live below the poverty line decreased slightly from 15.1 percent in 1990 to 14.2 percent in 2000.

Commercial Fishing

In 1998, 184 Marathon residents were employed in fishing related industry according to the Census data, with 39 of those in the "fishing" category, 92 employed in "fish and seafood," and 47 employed by marinas (SAFMC 2006). The number of unlimited commercial permits held by community residents decreased from 65 permits to 44 permits between 1999 and 2004. Similarly, the number of limited commercial permits decreased from 43 permits to 31 permits.

Recreational Fishing

While most of the waters around Marathon are open to fishing, some areas have been set aside for eco-tourism and fish-viewing by divers and snorkelers. Sombrero Reef, said to be one of the most beautiful sections of North America's only living coral barrier reef, lies several miles offshore and is protected by the Florida Keys National Marine Sanctuary (http://www.fla-keys.com/marathon).

The importance of recreational boating and fishing to the economy of Marathon is shown by the businesses reliant upon it. As of 2004, there were at least 25 charterboat businesses, two party boat businesses, eight bait and tackle shops, and 27 marinas in the area. The number of vessels holding the federal charter/headboat permit increased from 16 in 1999 to 30 in 2004. In addition, there were seven fishing tournaments in Marathon. Most tournaments are centered on tarpon fishing. However, there are inshore and offshore fishing tournaments as well. These tournaments begin in February and run through June. Hotels and restaurants fill with participants and charters, guides and bait shops reap the economic benefits of these people coming to the area. These tournaments are positive economic pulses in the local economy, one that thrives on the existence of tourism and recreational fishing.

5.2.3.2 Bycatch

The South Atlantic Council is required by MSFCMA §303(a)(11) to establish a standardized bycatch reporting methodology for federal fisheries and to identify and implement conservation and management measures that, to the extent practicable and in the following order, (A) minimize bycatch and (B) minimize the mortality of bycatch that cannot be avoided. The MSFCMA defines bycatch as "fish which are harvested in a fishery, but which are not sold or kept for personal use, and includes economic discards and regulatory discards. Such term does not include fish released alive under a recreational catch-and-release fishery management program" (MSFCMA §3(2)). Economic discards are fish that are discarded because they are undesirable to the harvester. This category of discards generally includes certain species, sizes, and/or sexes with low or no market value. Regulatory discards are fish that are required by regulation to be discarded, but also include fish that may be retained but not sold.

NMFS outlines at 50 CFR §600.350(d)(3)(i) ten factors that should be considered in determining whether a management measure minimizes bycatch or bycatch mortality to the extent practicable. These are:

1. Population effects for the bycatch species;
2. Ecological effects due to changes in the bycatch of that species (effects on other species in the ecosystem);
3. Changes in the bycatch of other species of fish and the resulting population and ecosystem effects;
4. Effects on marine mammals and birds;
5. Changes in fishing, processing, disposal, and marketing costs;
6. Changes in fishing practices and behavior of fishermen;
7. Changes in research, administration, enforcement costs and management effectiveness;
8. Changes in the economic, social, or cultural value of fishing activities and non-consumptive uses of fishery resources;
9. Changes in the distribution of benefits and costs; and
10. Social effects.

Agency guidance provided at 50 CFR §600.350(d)(3)(ii) suggests the Councils adhere to the precautionary approach found in the Food and Agriculture Organization of the United Nations (FAO) Code of Conduct for Responsible Fisheries (Article 6.5) when faced with uncertainty concerning these ten practicability factors. According to Article 6.5 of the FAO Code of Conduct for Responsible Fisheries, using the absence of adequate scientific information as a reason for postponing or failing to take measures to conserve target species, associated or dependent species, and non-target species and their environment, would not be consistent with a precautionary approach.

Population effects for the bycatch species

The directed commercial fishery for snowy grouper is prosecuted primarily with hook and line gear (70%) followed by bottom longline gear (28%). Other gear types capture 2% of the landings. Snowy grouper is largely a commercial fishery as only 4% of the landings are from recreational sources. Golden tilefish are also primarily taken by commercial fishermen (97%) and most are caught with bottom longline gear (93%). The catch of vermilion snapper is dominated by commercial landings (68%). Almost all vermilion snapper are caught with hook and line gear. Based on data from ALS, MRFSS, and the Headboat survey during 2000 to 2003, landings from the commercial and recreational sectors were evenly split for black sea bass. The SEDAR Assessment Update #1 (2005) indicated most black sea bass were taken by the recreational sector (57%) during 2002 to 2003. Most commercial landings of black sea bass (85%) are from pots. Red porgy landings are fairly evenly split between the commercial (49%) and recreational (51%) sectors, and are almost entirely taken with hook and line gear.

Restrictions, which are currently being used to manage these species, include quotas (snowy grouper, golden tilefish), size limits (vermilion snapper, black sea bass, and red porgy), bag limits (snowy grouper, golden tilefish, vermilion snapper, black sea bass, and red porgy), closed seasons (red porgy), and minimum size limits (vermilion snapper, black sea bass, and red porgy).

Management measures in Amendment 13C would establish or reduce commercial quotas for snowy grouper, golden tilefish, vermilion snapper, black sea bass, and red porgy; modify trip limits for snowy grouper, golden tilefish, and red porgy; modify bag limits for snowy grouper, golden tilefish, black sea bass, and red porgy; establish a recreational closed season for vermilion snapper; and modify the size limits for black sea bass and vermilion snapper.

The directed commercial fishery for gag is prosecuted primarily with hook and line gear (86%) followed by diving gear (12%). Other gear types capture 2% of the landings. Landings are split fairly evenly between commercial and recreational sources. The catch of vermilion snapper is dominated by commercial landings (68%). Almost all vermilion snapper are caught with hook and line gear.

Restrictions, which are currently being used to manage these species, include quotas (vermilion snapper), size limits (vermilion snapper and gag), bag limits (vermilion snapper and gag), and closed seasons (gag).

Management measures in Amendment 16 would establish sector allocations for gag and vermilion snapper, reduce commercial quotas for gag and vermilion snapper; modify bag limits for vermilion snapper and gag; establish a recreational closed season for vermilion snapper; modify the size limits for gag and vermilion snapper; and exclude captain and crew on for-hire vessels from retaining gag or vermilion snapper.

Commercial Fishery

During 2001 to 2006, approximately 20% of snapper grouper permitted vessels from the Gulf of Mexico and South Atlantic were randomly selected to fill out supplementary logbooks. A small number of trips that reported discards but did not report numbers or species were not included in analyses. On average, the total number average number of trips per year during 2001 to 2006 was 15,500 (Table 5.2.2-33). Fishermen spent an average of 1.70 days at sea per trip.

Table 5.2.2-33. Snapper grouper fishery effort for South Atlantic.

YEAR	Trips	Days	Days per Trip
2001	17,283	29,940	1.73
2002	17,231	29,683	1.72
2003	16,586	27,680	1.67
2004	15,060	24,911	1.65
2005	13,773	22,880	1.66
2006	13,067	22,926	1.75
Mean	15,500	26,337	1.70

Source: NMFS SEFSC Logbook Program.

For species in Amendment 13C (SAFMC 2006), the number of trips that reported discards was greatest for red porgy followed by vermilion snapper and black sea bass (Table 5.2.2-34.). Discards of snowy grouper and golden tilefish were rare. The percentage of trips that reported discards ranged from 4.03% for red porgy to 0.05% for snowy grouper (Table 5.2.2-35).

Table 5.2.2-34. Annual number of trips reporting discard of red porgy, black sea bass, vermilion snapper, snowy grouper, and golden tilefish in the South Atlantic.
Source: NMFS SEFSC Logbook Program.

YEAR	Red Porgy	Black Sea Bass	Vermilion Snapper	Snowy Grouper	Golden Tilefish
2001	92	70	107	4	125
2002	242	112	212	2	0
2003	151	111	116	1	0
2004	81	61	63	0	0
2005	10	9	9	0	0
Total	576	363	507	7	125
Mean	115.2	72.6	101.4	1.4	25
YEAR	Red Porgy	Black Sea Bass	Vermilion Snapper	Snowy Grouper	Golden Tilefish
2001	92	70	107	4	125

2002	242	112	212	2	0
2003	151	111	116	1	0
2004	81	61	63	0	0
2005	10	9	9	0	0
Total	576	363	507	7	125
Mean	115.2	72.6	101.4	1.4	25

Note: Data from 2004 and 2005 may be incomplete.

Table 5.2.2-35. Percentage of trips that discarded red porgy, black sea bass, vermilion snapper, snowy grouper, or golden tilefish in the South Atlantic.
Source: NMFS SEFSC Logbook Program.

YEAR	Red Porgy	Black Sea Bass	Vermilion Snapper	Snowy Grouper	Golden Tilefish
2001	46.1	612.7	78.0	1.8	0.01
2002	74.4	231.9	77.5	2.5	-
2003	62.7	195	67.2	2	-
2004	51.1	30.7	62.3	-	-
2005	104.4	25.1	66.1	-	-
Mean	67.7	219.1	70.2	1.3	<0.01

Since the discard logbook database represents a sample, data were expanded to estimate the number of discard fish in the whole fishery. The method for expansion was to (1) estimate the probability of discarding a species; (2) estimate the number of fish discarded per trip; and (3) estimate the number discarded in the whole fishery (total discarded = total trips * discard probability * discard number). During 2001-2005, an average of 124,231 black sea bass were discarded per year (Table 5.2.2-36). The number of discarded red porgy and vermilion snapper was lower (~40,000). Snowy grouper and golden tilefish were rarely discarded.

Table 5.2.2-36. Expanded number of discarded red porgy, black sea bass, vermilion snapper, snowy grouper, and golden tilefish for the South Atlantic.

YEAR	Red Porgy	Black Sea Bass	Vermilion Snapper	Snowy Grouper	Golden Tilefish
2001	41,316	417,828	81,298	68	10
2002	76,397	110,253	69,716	21	0
2003	33,604	76,780	27,646	7	0
2004	19,637	8,879	18,603	0	0
2005	34,263	7,417	19,527	0	0
Total	205,217	621,157	216,790	96	10
Mean	41,043	124,231	43,358	19	2

Black sea bass, vermilion snapper, and red porgy were the top three discarded species during 2001-2005 (Tables 5.2.2-37, 5.2.2-38).

For species in Amendment 15B, the number of trips reporting discards was greatest for red porgy (Table 5.2.2-37). Discards of snowy grouper and golden tilefish were rare.

The percentage of trips that reported discards ranged from 3.89% for red porgy to 0.00% for golden tilefish (Table 5.2.2-38).

Table 5.2.2-37. Annual number of trips reporting discards of selected species in the South Atlantic.
Source: NOAA Fisheries Service SEFSC Logbook Program.

YEAR	Warsaw Grouper	Speckled Hind	Snowy Grouper	Golden Tilefish	Yellowedge Grouper	Misty Grouper	Blueline Tilefish	Silk Snapper	Queen Snapper	Black Sea Bass	Vermilion Snapper	Red p
2002	10	63	2	0	0	1	0	5	1	116	217	25
2003	18	55	2	0	0	0	1	0	0	115	118	15
2004	1	13	0	0	0	0	2	0	0	65	65	8
2005	1	27	3	0	2	0	2	1	0	63	86	14
Mean	7.5	39.5	1.8	0.0	0.5	0.3	1.3	1.5	0.3	89.8	121.5	15

Table 5.2.2.38. Percentage of trips that discarded selected species in the South Atlantic.
Source: NOAA Fisheries Service SEFSC Logbook Program.

YEAR	Warsaw Grouper	Speckled Hind	Snowy Grouper	Golden Tilefish	Yellowedge Grouper	Misty Grouper	Blueline Tilefish	Silk Snapper	Queen Snapper	Black Sea Bass	Vermilion Snapper	Red po
2002	0.227	1.433	0.045	0.000	0.000	0.023	0.000	0.114	0.023	2.639	4.936	5.68
2003	0.355	1.085	0.039	0.000	0.000	0.000	0.020	0.000	0.000	2.269	2.328	2.97
2004	0.025	0.331	0.000	0.000	0.000	0.000	0.051	0.000	0.000	1.655	1.655	2.06
2005	0.033	0.881	0.098	0.000	0.065	0.000	0.065	0.033	0.000	2.055	2.805	4.82
Mean	0.16	0.93	0.05	0.00	0.02	0.01	0.03	0.04	0.01	2.15	2.93	3.8

During 2002-2005, for species in Amendment 15B, the average number of individuals discarded per trip was greatest for red porgy (Table 5.2.2-39). Snowy grouper and golden tilefish were rarely discarded.

Table 5.2.2-39. Average number of species discarded per trip in the South Atlantic.
Source: NOAA Fisheries Service SEFSC Logbook Program.

YEAR	Warsaw Grouper	Speckled Hind	Snowy Grouper	Golden Tilefish	Yellowedge Grouper	Misty Grouper	Blueline Tilefish	Silk Snapper	Queen Snapper	Black Sea Bass	Vermilion Snapper	Red p
2002	2.2	16.3	2.5	0.0	0.0	1.0	0.0	16.4	2.0	224.6	78.1	75
2003	2.3	15.4	1.5	0.0	0.0	0.0	1.0	0.0	0.0	188.3	66.1	62
2004	1	3.9	0.0	0.0	0.0	0.0	1.0	0.0	0.0	30.0	61.5	51
2005	1	4.9	1.3	0.0	2.5	0.0	1.0	5.0	0.0	32.0	96.8	56
Mean	1.6	10.1	1.3	0.0	0.6	0.3	0.8	5.4	0.5	118.7	75.6	61

Since the discard logbook database represents a sample, data were expanded to estimate the number of discarded fish in the whole fishery. The method for expansion was to (1) estimate the probability of discarding a species; (2) estimate the number of fish discarded per trip; and (3) estimate the number discarded in the whole fishery (total discarded = total trips * discard probability * discard number). During 2002-2005, an average of

41,838 red porgy were discarded per year (Table 5.2.2-40). Snowy grouper and golden tilefish were rarely discarded.

Table 5.2.2-40. Expanded number of discarded species for the South Atlantic.

YEAR	Warsaw Grouper	Speckled Hind	Snowy Grouper	Golden Tilefish	Yellowedge Grouper	Misty Grouper	Blueline Tilefish	Silk Snapper	Queen Snapper	Black Sea Bass	Vermilion Snapper	Red
2002	89	4,179	20	0	0	4	0	333	8	105,820	68,873	76,
2003	148	3,019	11	0	0	0	4	0	0	77,453	27,910	33,
2004	4	217	0	0	0	0	9	0	0	8,283	16,998	17,
2005	5	625	19	0	24	0	9	24	0	9,574	39,494	39,
Mean	62	2,010	12	0	6	1	5	89	2	50,283	38,319	41,

Dominant among the top species discarded by fishermen were yellowtail snapper, red porgy, vermilion snapper, and black sea bass (Tables 5.2.2-41 and 5.2.2-42).

For species in Amendment 16, the number of trips that reported discards was greatest for vermilion snapper followed by scamp and gag (Table 5.2.2-41). The percentage of trips that reported discards was 5.55% for vermilion snapper and 4.21% for gag (Table 5.2.2-42).

Table 5.2.2-41. Annual number of trips reporting discard of vermilion snapper, gag, and shallow water groupers in the South Atlantic.

YEAR	red grouper	red hind	rock hind	yellowmouth grouper	tiger grouper	black grouper	yellowfin grouper	graysby	coney	scamp	vermilion snapper
2001	26	0	0	0	0	4	0	0	0	95	114
2002	101	2	5	0	0	34	1	0	0	202	217
2003	123	0	17	0	0	21	0	0	0	137	118
2004	121	1	1	0	0	5	0	7	0	60	63
2005	134	7	2	1	0	43	1	3	0	132	107
2006	75	4	1	0	0	14	1	0	0	94	123
Mean	96.7	2.3	4.3	0.2	0.0	20.2	0.5	1.7	0.0	120.0	123.7

Source: NMFS SEFSC Logbook Program.

Table 5.2.2-42. Percentage of trips that discarded vermilion snapper, gag, and shallow water groupers in the South Atlantic.

YEAR	red grouper	red hind	rock hind	yellowmouth grouper	tiger grouper	black grouper	yellowfin grouper	graysby	coney	Scamp	vermi snap
2001	2.21	0.00	0.00	0.00	0.00	0.34	0.00	0.00	0.00	8.09	9.7
2002	3.73	0.07	0.18	0.00	0.00	1.26	0.04	0.00	0.00	7.46	8.0
2003	3.41	0.00	0.47	0.00	0.00	0.58	0.00	0.00	0.00	3.80	3.2
2004	4.17	0.03	0.03	0.00	0.00	0.17	0.00	0.24	0.00	2.07	2.1
2005	5.31	0.28	0.08	0.04	0.00	1.70	0.04	0.12	0.00	5.23	4.2
2006	3.60	0.19	0.05	0.00	0.00	0.67	0.05	0.00	0.00	4.52	5.9
Mean	3.74	0.10	0.14	0.01	0.00	0.79	0.02	0.06	0.00	5.20	5.5

Source: NMFS SEFSC Logbook Program.

During 2001-2006, the average number of individuals discarded per trip was greatest for black sea bass followed by vermilion snapper and red porgy (Table 5.2.2-43).

Table 5.2.2-43. Average number (unexpanded) of vermilion snapper, gag, and shallow water groupers discarded per trip in the South Atlantic.

YEAR	red grouper	red hind	rock hind	yellowmouth grouper	tiger grouper	black grouper	yellowfin grouper	graysby	coney	scamp	vermilion snapper
2001	3.2	0.0	0.0	0.0	0.0	23.8	0.0	0.0	0.0	15.2	75.8
2002	5.4	2.5	2.4	0.0	0.0	41.7	0.0	0.0	0.0	11.5	78.1
2003	4.0	0.0	1.6	0.0	0.0	12.3	0.0	0.0	0.0	14.6	66.1
2004	0.0	0.0	3.0	0.0	0.0	30.6	0.0	17.6	0.0	13.9	62.4
2005	4.9	0.0	2.0	5.0	0.0	17.7	0.0	1.7	0.0	10.0	99.4
2006	0.0	0.0	0.0	0.0	0.0	14.5	0.0	0.0	0.0	10.7	58.3

Mean	2.9	0.4	1.5	0.8	0.0	23.4	0.0	3.2	0.0	12.7	73.4

Source: NMFS SEFSC Logbook Program.

Since the discard logbook database represents a sample, data were expanded to estimate the number of discard fish in the whole fishery. The method for expansion was to (1) estimate the probability of discarding a species; (2) estimate the number of fish discarded per trip; and (3) estimate the number discarded in the whole fishery (total discarded = total trips * discard probability * discard number). During 2001-2006, an average of 65,779 vermilion snapper and 5,003 gag were discarded per year (Table 5.2.2-44).

Table 5.2.2-44. Expanded number of discarded vermilion snapper, gag, and shallow water grouper for the South Atlantic.

YEAR	red grouper	red hind	rock hind	yellowmouth grouper	tiger grouper	black grouper	yellowfin grouper	graysby	coney	scam	vermilion snapper
2001	1,222	0	0	0	0	1,399	0	0	0	21,302	127,252
2002	3,464	32	76	0	0	9,036	0	0	0	14,849	107,971
2003	2,279	0	129	0	0	1,188	0	0	0	9,219	35,935
2004	0	0	16	0	0	795	0	639	0	4,336	20,419
2005	3,592	0	22	27	0	4,165	0	27	0	7,189	58,056
2006	0	0	0	0	0	1,275	0	0	0	6,304	45,041
Mean	1,760	5	40	5	0	2,976	0	111	0	10,533	65,779

The most commonly discarded species are shown in Table 5.2.2-45.

Table 5.2.2-45. The 50 most commonly discarded species during 2001-2006 for the South Atlantic.

Species (Table 4-66)	Number trips reported discarding the species	Number discarded
SEA BASSE,ATLANTIC,BLACK,UNC	526	98,206
PORGY,RED,UNC	907	60,138
SNAPPER,VERMILION	743	55,144
MENHADEN	162	22,445
SHARK,DOGFISH,SPINY	138	22,193
SNAPPER,YELLOWTAIL	1496	14,134
SNAPPER,RED	358	9,867
SEA BASS,ROCK	115	9,469
SCAMP	720	8,937
GRUNT,WHITE	71	4,518
FINFISHES,UNC,BAIT,ANIMAL FOOD	43	4,351
GROUPER,GAG	609	4,258
KING MACKEREL and CERO	584	4,193
GROUPERS	73	3,858
GRUNTS	153	3,780
SHARK,ATLANTIC SHARPNOSE	143	3,654
SHARK,DOGFISH,UNC	50	3,043
GROUPER,RED	580	2,986
GROUPER,BLACK	424	2,891
SHARK,UNC	375	2,702
GRUNT,TOMTATE	23	2,652
HIND,SPECKLED	202	2,444
AMBERJACK,GREATER	327	2,120
SHARK,BLACKTIP	163	2,042
SNAPPER,MANGROVE (Duplicate of 3760)	203	2,035
BLUEFISH	50	1,799
TRIGGERFISH,GRAY	118	1,655
KING MACKEREL	241	1,647
SHARK,SANDBAR	97	1,544
TRIGGERFISHES	133	1,500
BALLYHOO	31	1,472
TUNA,LITTLE (TUNNY)	242	1,364
SHARK,DOGFISH,SMOOTH	34	1,339
DOLPHINFISH	192	1,225
BONITO,ATLANTIC	252	1,139
BLUE RUNNER	162	1,084
SCUPS OR PORGIES,UNC	101	1,028
SKATES	42	1,020
SNAPPER,MANGROVE	126	944
FINFISHES,UNC FOR FOOD	110	919
SHARK,TIGER	64	918
BARRACUDA	178	848

Species (Table 4-66)	Number trips reported discarding the species	Number discarded
AMBERJACK	191	797
SPANISH MACKEREL	85	782
SNAPPERS,UNC	28	702
PINFISH,SPOTTAIL	38	571
SNAPPER,MUTTON	184	560
STINGRAYS	49	507
CHUBS	27	493
AMBERJACK,LESSER	10	489

Recreational Fishery

For the recreational fishery, estimates of the number of recreational discards are available from MRFSS. There are no estimates from the headboat survey. The MRFSS system classifies recreational catch into three categories:

- Type A - Fishes that were caught, landed whole, and available for identification and enumeration by the interviewers.
- Type B - Fishes that were caught but were either not kept or not available for identification.
    - Type B1 - Fishes that were caught and filleted, released dead, given away, or disposed of in some way other than Types A or B2.
    - Type B2 - Fishes that were caught and released alive.
- During 2001-2006, 75% of gag and 39% of vermilion snapper were released by recreational fishermen (Table 67).
-
- Amendment 13C increased the size limit of vermilion snapper taken by recreational fishermen from 11 inches TL to 12 inches TL. Examination of Waves 1-5 during 2007 relative to 2006 reveal an increase in the number of discards during Waves 3, 4, and 5 when most of the vermilion snapper are caught (Table 4-67).

The percentage of fish released was highest for black sea bass (79.2%) and lowest for yellow edge grouper (0%) (Table 5.2.2-46). The number of fish released per year was greatest for black sea bass (10,323,548 individuals) and lowest for yellow edge grouper (0 individuals).

Table 5.2.2-46. Total number (A+B1+B2) of fish caught from MRFSS interviews, estimated total number of fish released (B2), percent released, and estimate total number of dead discards during 2001-2005. Source: MRFSS Web Site.

Species	Est Total	Est Released	% Released	Est Dead Discards
Snowy Grouper	44,043	5,693	12.93%	5,693
Golden Tilefish	97,690	3,124	3.20%	3,124
Speckled Hind	11,618	10,940	94.16%	10,940
Warsaw Grouper	7,444	1,668	22.41%	1,668
Yellowedge Grouper	3,756	0	0.00%	0
Misty Grouper	54	0	0.00%	0
Blueline Tilefish	23,526	4,301	18.28%	4,301
Silk Snapper	8,486	1,010	11.90%	1,010
Queen Snapper	907	319	35.17%	319
Black Sea Bass	13,039,834	10,323,548	79.17%	1,548,532
Red Porgy	308,238	183,909	59.66%	14,713
Vermilion Snapper	1,718,019	692,683	40.32%	173,171

Of species in Amendment 15B, the number of fish released was highest for red porgy and lowest for golden tilefish (Table 5.2.2-47). Total dead discards was determined by applying the SEDAR 4 (2004) suggested release mortality rates the number of fish released alive and adding the value to the number of fish released dead. Estimates of dead discards are based on accepted recreational release mortality rates: 100%, snowy grouper; 100%, golden tilefish, 15%, black sea bass; 8%, red porgy; and 25%, vermilion snapper.

Table 5.2.2-47. Total number of fish released alive or dead on sampled headboat trips during 2004-2006.
Source: NMFS Headboat Survey.

Species	released alive	mean#/trip	released dead	mean#/trip	# sampled trips	Total dead discards
Snowy Grouper	18	0.37	1	0.02	49	19
Golden Tilefish	0	0.00	0	0.00	0	0
Speckled Hind	884	5.05	8	0.05	175	unknown
Warsaw Grouper	32	0.49	0	0.00	65	unknown
Yellowedge Grouper	1	0.04	0	0.00	25	unknown
Misty Grouper	0	0.00	0	0.00	0	0
Blueline Tilefish	0	0.00	0	0.00	40	0
Silk Snapper	202	2.59	3	0.04	78	unknown
Queen Snapper	0	0.00	0	0.00	0	0
Black Sea Bass	83,402	22.28	1,747	0.47	3,744	14,257
Red Porgy	60,347	59.87	2,365	2.35	1,008	7,193
Vermilion Snapper	78,487	30.71	4,658	1.82	2,556	24,280

Finfish Bycatch Mortality

Snowy grouper are primarily caught in water deeper than 300 feet and golden tilefish are taken at depths greater than 540 feet; therefore, release mortality of the species is extremely high. The Council's Scientific and Statistical Committee (SSC) indicates release mortality rates are probably near 100%.

SEDAR 2 (2003) estimates release mortality rates of 25% and 40% for vermilion snapper taken by recreational and commercial fishermen, respectively. However, release mortality rates might be higher than 40%. Release mortality rates from SEDAR 2 (2003) are based on cage studies conducted by Collins (1996) and Collins *et al*. (1999). Burns *et al*. (2002) suggest release mortality rates of vermilion snapper may be higher than estimated from cage studies because cages protect vermilion snapper from predators. A higher release mortality rate is supported by low recapture rates of vermilion snapper in tagging studies. Burns *et al*. (2002) estimate a 0.7% recapture rate for 825 tagged fish; whereas, recapture rates for red grouper, gag, and red snapper range from 3.8% to 6.0% (Burns *et al*. 2002). McGovern and Meister (1999) estimate a 1.6% recapture rate for 3,827 tagged vermilion snapper. Higher recapture rates are estimated for black sea bass (10.2%), gray triggerfish (4.9%), gag (11%), and greater amberjack (15.1%) (McGovern and Meister 1999; McGovern *et al*. 2005). Burns *et al*. (2002) suggest released vermilion snapper do not survive as well as other species due to predation. Vermilion snapper, which do not have air removed from swim bladders, are subjected to predation at the surface of the water. Individuals with a ruptured swim bladder or have air removed from the swim bladder are subject to bottom predators since fish would not be able to join schools of other vermilion snapper hovering above the bottom (Burns *et al*. 2002). Alternatively, recapture rates could be low if population size was very high or tagged fish were unavailable to fishing gear. However, Harris and Stephen (2006) indicate approximately 50% of released vermilion snapper caught by one commercial fisherman were unable to return to the bottom.

SEDAR 10 (2007) estimates release mortality rates of 25% and 40% for gag taken by recreational and commercial fishermen, respectively. A tagging study conducted by McGovern *et al.* (2005) indicated recapture rate of gag decreased with increasing depth. The decline in recapture rate was attributed to depth related mortality. Assuming there was no depth related mortality at 0 m, McGovern *et al* (2005) estimated depth related mortality ranged from 14% at 11– 20 m (36 – 65 feet) to 85% at 71 – 80 m (233 – 262 feet). Similar trends in depth related mortality were provided by a gag tagging study conducted by Burns *et al.* (1992).

A recent study conducted by Rudershausen *et al.* (2007) estimated release mortality rates of 15% for undersized vermilion snapper and 33% for undersized gag taken with J- hooks in depths of 25 – 50 m off North Carolina. Immediate mortality vermilion snapper was estimated to be 10% at depths of 25 – 50 m and delayed mortality was estimated to be 45% at the same depths. For gag caught at depths of 25 – 50 m, no immediate mortality was observed but delayed mortality was estimated to be 49%. McGovern *et al.* (2007) estimated a release mortality rate of 50% at 50 m, which is similar to the findings of Rudershausen *et al.* (2007). Rudershausen *et al.* (2007) concluded minimum size limits were moderately effective for vermilion snapper and gag over the shallower portions of their depth range.

5.2.3 Golden Crab

5.2.3.1 Description of fishing practices, vessels and gear

The Golden Crab Fishery

Description of fishing practices, vessels and gear

The description below was summarized from observations recorded by Council staff (Gregg Waugh) on a commercial golden crab fishing trip aboard the *Lady Mary*, the fishing vessel belonging to the Nielsen family. Additional information was obtained during the course of presentations by fishermen at the April 1995 Council meeting and the 2008 Golden Crab Advisory Panel meeting.

The golden crab fishery employs baited traps attached with gangions to a 5/8" polypropylene line up to 5 miles long. There are 20 to 50 traps per line, or "trawl," set 500 feet apart. Fishermen may fish 4 trawls in a two-week period pulling 100 traps one week and 100 the next (Howard Rau, Golden crab AP). In 2008, vessels in the golden crab fishery averaged 57 feet in length (Golden Crab AP, 2008)

A typical trip to fish for golden crabs begins with the vessel leaving the dock at 3:00 a.m. Bait wells to be placed in the traps are prepared on the way out. The bait consists of available fish heads and racks (cod, snapper, grouper, dolphin, mackerel or any other available fish), chicken parts, pigs' feet, etc. Four and a half hours after leaving dock, the vessel is on site and the crew ready to begin the process of picking up traps and deploying new ones. When the traps are retrieved, the empty bait container is removed and a full one is put in place. It was estimated that at least 65 tons of bait were being used in this fishery at the time this description was compiled.

The location of the traps is noted using GPS; buoys are not used to mark the location of traps due to strong currents. Trawls are set south to north with the current. Retrieval begins at the south end of the trawl. To begin retrieval of traps, the main line, which may be sitting 1,000 feet below, must be grappled. The success of this operation depends on currents and sea conditions. At different times of the year, when the current is not as swift and is moving in a favorable direction, it is easier to place the grapple on the bottom. The grapple consists of links of large chain and is used to hook the main line towards one end of the string. On the observed trip, the grapple did not appear to have disturbed the bottom. Sometimes, however, the grapple or the trap itself may have mud adhered to it when it is pulled out of the water.

Once the grapple successfully hooks the main line, the line is pulled up and looped over the pulley allowing crew members to pull over to the first trap on the line. Traps are stacked on deck as the string is worked toward the short end of the line. Upon reaching one end of the line, the vessel turns around to work the string toward the other end. It takes approximately two hours to work a string of traps. The determining factor for how long a day of fishing will last is how quickly each trap string can be grappled. Sometimes it is necessary to move traps up or down the slope, keeping the same latitude and moving in a range of 5 to 15 miles east or west in order to avoid hardbottom or to follow the crabs. After a soak period, traps may be moved as described depending on the success of the catch. Twenty to 30 lbs of crabs per trap is a desirable catch. On a good season, fishermen may catch 70 to 100 lbs per trap.

Golden crab traps have two entrances, one on the top and one on the bottom. As each trap is brought on deck, the empty bait wells are replaced with full ones. A spike coming up from the bottom of the frame holds the bait well in place. The trap string is deployed off the stern. The end of the string is weighted and its position recorded using GPS.

Towards the stern of the vessel is a spacious ice hold. As the traps are retrieved and brought on deck, golden crabs are removed by hand. The crabs are immediately placed into plastic boxes or coolers and layered with ice. As each crab is removed from the trap, a crew member checks its size (weight) and sex. All females and individuals weighing less than 1 ¼ pounds are released back into the water. Only male crabs are harvested because, since the beginning of this fishery, fishermen felt that an integral factor in the sustainable harvest of this resource was not to harvest the females. Besides, females are smaller than males and therefore less marketable.

On the observed trip, three trawls were retrieved (about 100 traps) out of which only 20-25 crabs were discarded. Such a low number of crabs are released upon trap retrieval because the majority of the culling is being accomplished through the escape panels while the traps are still submerged. Thus, escape gaps are very effective in culling out undersized individuals.

<u>Detailed trap description</u>

The modern golden crab traps are constructed of 3/8" smooth rebar. The latter makes it easier to place the stainless steel hog rings on it to hold the wire in place. The trap is 4 feet long, 30 inches wide and 18 inches high. The body of the trap consists of 1" x 2" mesh and 14 gauge galvanized wire with plastic coating. The corners of the trap are reinforced with zinc to prevent the wire from falling off. The zinc reinforcements are replaced every four or five months as they wear out. At the time this description was compiled (1995), golden crab traps cost about $100 to construct. A golden crab trap weighs approximately 30 lbs.

The trap has two funnels through which the crabs enter the trap. Initially one entrance funnel was placed in the center of the trap. However, fishermen soon realized that traps sometimes landed on the bottom upside down thus preventing the crabs' from entering the trap. The only crabs that would then have access to the bait would be the smaller ones that could enter through the escape gaps. Fishermen then designed the traps with two funnels on opposite sides of the trap that were offset to either side. That way, if the trap landed in such a way as to cover up one of the funnels, it would still be able to fish through the other.

Degradable wire is used to lock the traps. To open the trap, the wire is simply cut. Since the main trap door is shut using degradable wire, ghost fishing is not a concern if the trap becomes lost. In addition, traps are required to have two escape gaps on either side of the trap to allow females and small individuals to escape.

Allowable gear

Traps are the only allowable gear in the golden crab fishery. Rope is the only allowable material for mainlines and buoy line. Maximum trap size is 64 cubic feet in volume in the Northern zone and 48 cubic feet in volume in the Middle and Southern zones. Traps must have at least 2 escape gaps or rings and an escape panel. Traps must be identified with a permit number.

Economic Description

The golden crab Fishery Management Plan went into effect beginning on August 27, 1996 and established three golden crab fishing zones. The Northern Zone is defined as the EEZ north of 28 degrees N. latitude. The Middle Zone is contained within the EEZ between 25 degrees North and 28 degrees North latitude. The Southern Zone extends south from 25 degrees North latitude within the South Atlantic Council's EEZ. Federal permits are issued for a specific zone and fishing is allowed only in that zone for which the permit is issued.

In the South Atlantic region initially 35 vessels were granted permits to operate in this fishery: 27 permits were issued for the southern zone; 6 permits were issued for the middle zone; and 2 permits were granted to vessels for the northern zone. Other management regulations imposed by the golden crab FMP included: dealer and vessel permitting and reporting; limitations on the size of vessels; prescribing allowable gear (including escape gaps and escape panels); and prohibiting possession of female crabs (see the FMP for a complete list of measures).

Number of Participants

The number of permit holders that land golden crab has fluctuated from year to year (Table 5.2.3-1). The greatest number of vessels making landings since 1995 was 14 (Table 5.2.3-2). In recent years, only 5 to 6 vessels have landed any golden crab. The majority of vessels currently fishing for golden crab have Middle Zone permits. In 1997, 1998, and 2000, there were more vessels fishing for golden crab with Southern Zone permits than Middle Zone permits. Only in 2006 and 2007 have vessels with Northern Zone permits participated in the fishery.

Table 5.2.3-1. Numbers of active permit holders and vessels landing golden crab, 1995-2007. (Source: SEFSC, 2008).

Year	Permit Holders	Vessels Making Landings
1996	34	4
1997	35	14
1998	29	14
1999	11	8
2000	10	10
2001	8	6
2002	12	7
2003	14	6
2004	12	5
2005	11	5
2006	12	6
2007	11	6

Table 5.2.3-2. Number of vessels making landings by Zone, 1995-2007.
Source: SEFSC, 2008.

Year	Northern	Middle	Southern
1995	0	confidential	0
1996	0	4	0
1997	0	5	9
1998	0	7	7
1999	0	6	confidential
2000	0	4	6
2001	0	4	confidential
2002	0	5	confidential
2003	0	5	confidential
2004	0	confidential	confidential
2005	0	5	0
2006	confidential	4	confidential
2007	confidential	5	0

Information on the golden crab fishery participation was taken from logbook data (SEFSC 2008), and Accumulative Landings System (ALS) data.

Annual and Monthly Landings

Total landings and landings by zone of golden crab are shown in Table 5.2.3-3. Figure 5.2.3-1 shows these data in chart form. Golden crab landings reached a peak of over 1 million pounds in 1997. Since then, landings have averaged about 550,000 annually. However, the trend shows an average of 665,000 pounds from 1998-2002 and 355,000 pounds from 2003-2006.

The overwhelming majority of landings in recent years have come from the Middle Zone (90-100%) (Table 5.2.3-3). However, historically, a significant portion of landings came from the Southern Zone (up to 36%). Only in the past two years have any landings at all come from the Northern Zone. Landings from the Middle Zone have averaged around 470,000 pounds since 1996 with a high of about 662,000 pounds in 1997. Landings from the Southern Zone were significant 1997 through 2001. Landings peaked at about 373,000 pounds in 1997.

Table 5.2.3-3. Landings of golden crab by Zone, 1995-2007 (Source: SEFSC, 2008).

Year	Northern Zone	Middle Zone	Southern Zone	Total
1995	0	confidential	confidential	61,660
1996	0	523,160	0	523,160
1997	0	661,896	372,551	1,034,447
1998	0	361,480	156,836	518,316
1999	0	confidential	confidential	682,224
2000	0	584,130	257,617	841,747
2001	0	confidential	confidential	781,138
2002	0	confidential	confidential	500,774
2003	0	confidential	confidential	359,087
2004	0	confidential	confidential	278,336
2005	0	432,846	0	432,846
2006	confidential	566,780	confidential	599,374
2007	confidential	confidential	0	502,292

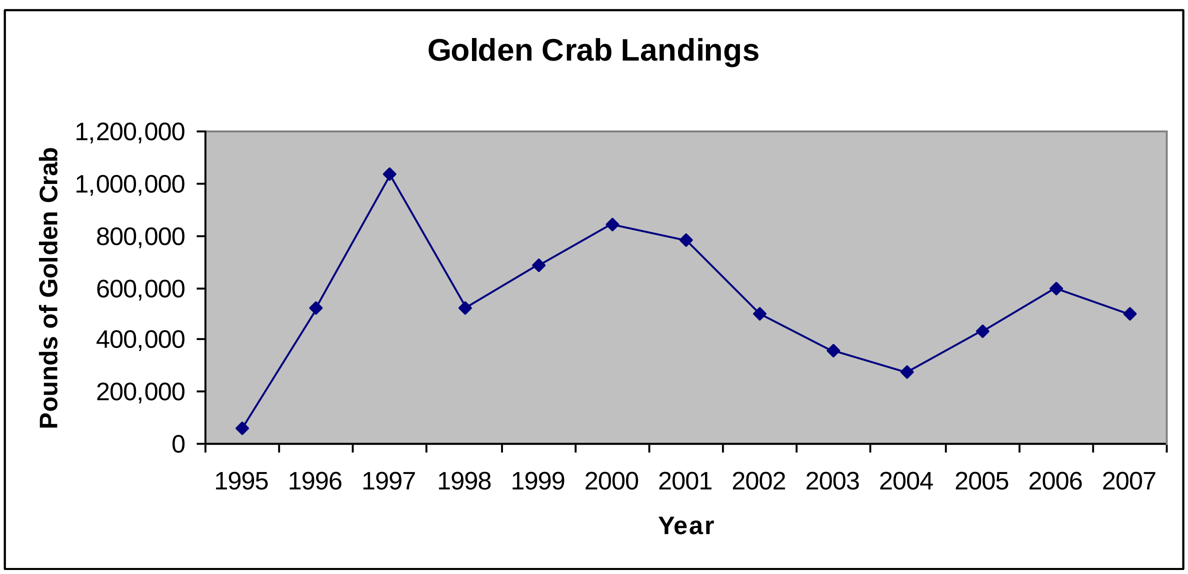


Figure 5.2.3-1. Landings of Golden Crab, 1995-2007 (Source: SEFSC 2008).

Figure 5.2.3-2 shows monthly golden crab landings from 2003 to 2007. Golden crab landings have varied widely from month to month over the past 5 years. In general, more golden crab are landed from May to December than in the first half of the year due to Keys fishermen entering the fishery in the second half of the year after the spiny lobster season winds down. On average, from 1996 to 2007, 45% of total golden crab landings were made between January and May while 55% of landings were made between May and December.

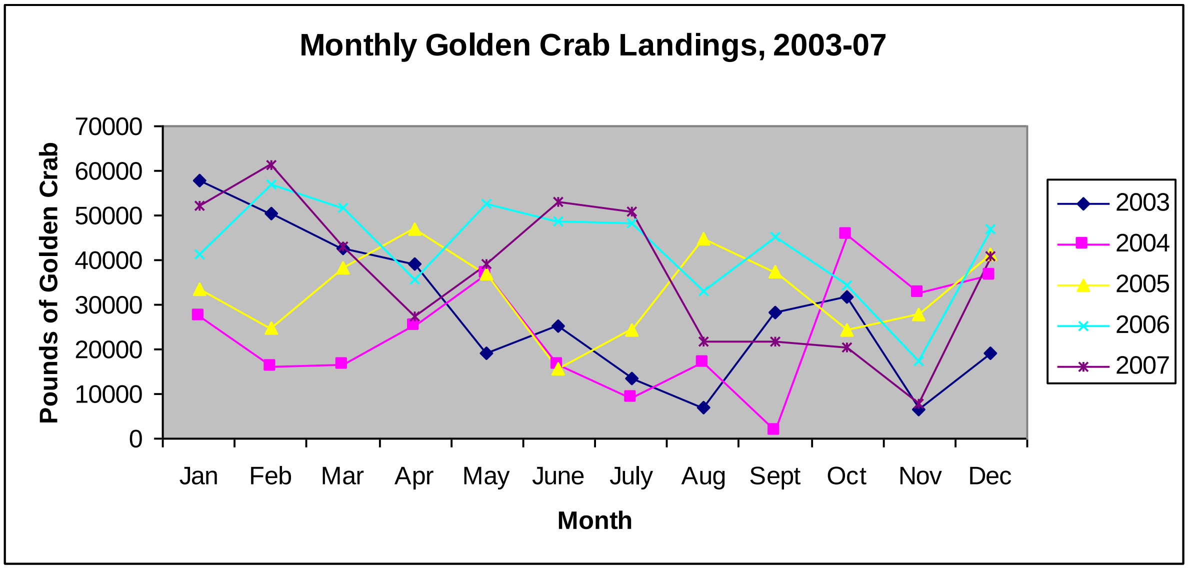


Figure 5.2.3-2. Monthly golden crab landings, 2003-2007 (Source: ALS data).

Golden crab is viewed in the marketplace as a substitute for snow crab clusters. Most of the product is processed into clusters, which is not as favored as other large crab species such as snow crabs. The golden crab market is strongly influenced by the wholesale market for snow crabs (Antozzi 1998). A large proportion of the Alaskan catch of snow crab goes to Japan and the drop in the yen reduced the export demand for this product. The excess supply entered the domestic market and lowered snow crab prices, which may be partly responsible for depressed golden crab prices. The increase in production from Russia and Canada also magnified this problem.

Antozzi (1997) concluded that the market for golden crab is inhibited from expanding due to a supply constraint. He attributes this lack of production to the difficulty and cost of operating in this fishery, which requires a sizable investment in specialized gear including on-board holding facilities that keep crabs alive. This fishery takes place in deep water and this can result in lengthy trips under adverse sea conditions. Some industry members have stated that vessels larger than 50 feet are needed to cope with rough sea conditions offshore and to provide the stability needed for trap deployment and retrieval.

The future outlook for this market will be strongly influenced by the market supply of other large crabs, and the health of export markets. The outlook on this market would improve if this product could be viewed as more than just a substitute for snow crabs.

In recent years, ex-vessel price value has ranged from $1.25 to $1.55 per pound (personal communication, Howard Rau, 2008).

5.2.3.2 Bycatch

Bycatch in the golden crab fishery is minimal and consists almost entirely of isopods (Golden Crab AP discussion, January 2008).

5.2.4 Coastal Migratory Pelagics

5.2.4.1 Description of fishing practices, vessels and gear

Commercial fishery

In the South Atlantic region, runaround gill nets are an important gear for Spanish mackerel, but other kinds of gill nets, cast nets, and handline gear now account for the majority of the landings. Though the effect of the State of Florida's 1995 prohibition on the use of various net gear had more of an impact on the Florida west coast (state waters extend to 9 nautical miles from shore), it did reduce landings on the Florida east coast (state waters extend to 3 nautical miles from shore). Reportedly, Spanish mackerel were concentrated more in state rather than federal waters off the Florida east coast in 2001-2003 than in 1995-2000, and cast nets may be used in state waters. Therefore, cast nets became an increasingly important gear and accounted for 1.88 out of 3.20 million pounds (MP) in 2003, or approximately 59% of total South Atlantic Spanish mackerel harvest. Cast nets were followed by "other" gill nets (0.44 MP), run-around gill nets (0.35 MP) and handlines (0.32 MP).

Various federal and state regulations greatly reduced the use of gill nets for king mackerel, and most are caught with handline gear. Compared with 1966-1988 when gill nets were the predominant gear for the king mackerel fishery in the South Atlantic region, king mackerel are now caught predominantly by various handline gears, which accounted for 2.78 MP out of 2.84 MP for the South Atlantic region in 2003.

Gill nets are not authorized gear for the directed commercial harvest of king mackerel, little tunny, and cobia south of Cape Lookout, North Carolina (34° 37.3'North Latitude). Off North Carolina, the majority of gill-net effort occurs within state waters. During the period between 1999 and 2003, 90% of gill-net trips targeting king mackerel were conducted south of Hatteras within 3 miles from shore using sink gill nets. In federal waters, fishermen also used sink gill nets though a small proportion (0.2%) used runaround gill nets.

The peak fishing months for king mackerel are September through November. For king mackerel, the minimum mesh size averages 5" to 6" (12.7 to15.24 cm). Typically, not more than 15 boats participate in this fishery though the number can fluctuate. Fishermen usually fish 5 or 6 nets (400 yards in length or 365.76 m) working from one net to another throughout the day. They generally fish the gear within a couple of hours, depending on the catch. As mentioned above, this fishery is not allowed below Cape Lookout, North Carolina and is rarely prosecuted above Oregon Inlet, North Carolina.

Between 1999 and 2003, over 100 gill-net trips for Spanish mackerel were conducted per month (May through October) with effort being greatest during October (over 300 trips).

Trips occurred mainly south of Hatteras (90%) of which 96% occurred within state waters. Sink gill nets are the primary gill-net gear used on Spanish mackerel trips (over 99%) with a small proportion of runaround gill nets (0.3%) and float gill nets (0.5%). The summer fishery typically involves 10 to 14 boats, and the fall fishery usually includes another 10 to 12 boats with catches generally higher after the first of September. Fishermen usually fish 3.5 inches (8.9 cm) stretched-mesh nets, the minimum mesh size allowed.

Off the east coast of Florida, cast nets have accounted for more of the landings of Spanish mackerel in recent years than gill nets, and the main season occurs in October-March, compared with May-October farther north Spanish mackerel is the primary species targeted by gill nets off the Florida east coast, and the main season for this activity is September through December. Beginning in January, many of the fishermen using gill nets switch to shark fishing or they will participate in the cast net fishery that occurs in state waters. The Spanish mackerel gill-net fishery mainly occurs between Fort Pierce to just north of Cape Canaveral. Less than 30 vessels are active in the fishery with many being outfitted to use either round-around gill nets or stab nets. Vessels fishing for Spanish mackerel in the South Atlantic EEZ off Florida north of the line directly east from the Miami-Dade/Monroe County, Florida boundary (25<20.4' N. lat.) may not have a float line longer than 800 yds. (732 m), set more than one at any one time, or soak for more than 1 hour.

Harvest in the Commercial Fishery

For the king mackerel fishery, commercial landings have been below 3 million pounds since 1989/90. Over that period of time, commercial landings peaked during the 2004/05 fishing season at 2.8 million pounds. In 2005/06, landings reached 2.4 million pounds, a decrease from 2004/05 of about 400,000 pounds (Table 8). The king mackerel fishery experiences commercial landings primarily in North Carolina and Florida. Table 5.2.4-1 provides commercial landings by area for 2001/02 to 2005/06.

For the Spanish mackerel fishery, since 1995/96 the commercial landings have been below 4 million pounds. In 2005/06, commercial landings were approximately 3.6 million pounds, a slight decrease from the 3.7 million pounds landed in 2004/05 (Table 5.2.4-2). Prosecuted predominantly in state waters from Virginia to Florida, the majority of the commercial fishery for Spanish mackerel occurs in Florida and North Carolina. Table 5.2.4-2 provides information on Atlantic migratory group Spanish mackerel commercial landings by major area.

Table 5.2.4-1 shows that North Carolina and Florida take the majority of commercial landings of Atlantic migratory group king mackerel. North Carolina landings have varied widely over the past five years with a low of 592,000 taken in 2003/04. Since then, North Carolina landings have surpassed landings in 2001/02. Central and south Florida landings peaked in 2004/05, as did North Carolina’s. However, central and south Florida landings have returned to levels similar to those occurring in 2001/02.

Table 5.2.4-2 shows that landings of Atlantic migratory group Spanish mackerel occur predominately in Florida. Atlantic landings to Florida peaked in 2003/04 and those landings have been maintained. North Carolina landings reached a five year low in 2005/06, almost 200,000 pounds less compared to 2001/02.

Table 5.2.4-1. Atlantic migratory group king mackerel commercial landings by area, thousand of pounds, 2001/02 - 2005/06.

	2001/02	2002/03	2003/04	2004/05	2005/06
NY through Flagler County	1,008	854	642	1,193	1,157
North Carolina	930	777	592	1,130	1,087
Volusia County through Miami-Dade County	958	847	1,065	1,593	996
Monroe County	56	44	23	34	34

Note: Season is April through March for 2001/02 through 2004/05 and March through the end of February for 2005/06.
Note: South Carolina and Georgia were not included in this table due to confidentiality issues.

Table 5.2.4-2. Atlantic migratory group Spanish mackerel commercial landings by area, thousands of pounds, 2001/02 - 2005/06.

	2001/02	2002/03	2003/04	2004/05	2005/06
NY – GA	873	852	589	547	454
North Carolina	653	699	457	456	445
Florida east Coast	2,163	2,355	3,152	3,130	3,125

Note: Season is April through March for 2001/02 through 2004/05 and March through the end of February for 2005/06.
Note: South Carolina and Georgia were not included in this table due to confidentiality issues.

Recreational fishery

Participation

Table 5.2.4-3 depicts the number of saltwater anglers in the South Atlantic. This includes participants engaged in all fisheries and those anglers who either fished from private/rental boats, from charter boats or by shore/beach bank mode. Overall, recreational fishing participation increased by about 450,000 (9%) from 2001 to 2005. Most saltwater anglers fish on the east coast of Florida and North Carolina. In Florida, in recent years, recreational participation hit a five year low in 2004 before rebounding in 2005 to rival participation in 2001. In Georgia, participation has increased in the past three years from a low of about 150,000 in 2002. North Carolina participation has increased to reach a five year high in 2005. South Carolina has experienced the largest percentage increase in participation by doubling since 2002.

Anglers target a variety of species including South Atlantic group king and Spanish mackerel./. A more specific estimate of recreational activity in the king and Spanish mackerel can be obtained from the harvest data reported in the latter part of this section.

Table 5.2.4-3. Participants in recreational fisheries by state, 2001-2007.

	2001	2002	2003	2004	2005	2006	2007
FL east coast	2,649,299	2,088,671	2,206,209	1,846,642	2,509,632	2,594,527	3,175,731
Georgia	212,215	147,901	267,641	277,845	244,721	219,483	308,155
North Carolina	2,006,661	1,765,205	2,102,925	2,057,873	2,250,275	2,226,955	1,908,162
South Carolina	481,426	392,301	571,448	661,703	798,134	996,919	940,775
Total	**5,349,601**	**4,394,078**	**5,148,223**	**4,911,104**	**5,807,794**	**4,911,104**	**5,807,794**

Source: MRFSS, NOAA Fisheries (http://www.st.nmfs.gov/st1/recreational/data.html).

Recreational Fishing Effort

Shore, Charter, Private/Rental Trips

Table 5.2.4-4 shows the number of recreational fishing trips made from shore, charter vessel and private or rental vessel over the past five years by state. Trips made by headboats are included in the next sub-section. These trips are not species specific since the data set cannot be divided in that manner.

Table 5.2.4-4. Number of trips by state, 2001-2007.

	2001	2002	2003	2004	2005	2006	2007
Florida east coast	12,464,111	10,303,392	11,443,784	10,660,059	12,049,280	13,114,986	15,169,108
Georgia	806,849	619,085	971,208	935,704	851,487	790,298	926,484
North Carolina	6,649,546	5,586,122	6,733,464	7,027,118	6,785,918	7,246,517	6,979,308
South Carolina	1,675,601	1,254,295	2,097,813	2,239,474	2,126,046	2,660,933	2,577,099
Total	**21,596,107**	**17,762,894**	**21,246,269**	**20,862,355**	**21,812,731**	**23,812,734**	**25,651,999**

Source: MRFSS, NOAA Fisheries
(http://www.st.nmfs.gov/st1/recreational/data.html).

The number of fishing trips from shore, charter vessels, and through private or rental trips in the South Atlantic reached a five year high in 2005. Florida experiences the most fishing trips with North Carolina experiencing the second largest amount (about half that of Florida). The number of recreational trips in Florida declined slightly between 2001 and 2004 and increased from 2005 through 2007. The number of trips in Georgia reached almost 1 million in 2003, 2004 and 2007. North Carolina trips reached a six year high in 2006 and ended in 2007 with about the same number of trips that occurred in 2001. South Carolina trips have increased since 2001 by about 30% with the highest number of trips occurring in 2006 and 2007.

Headboat Trips

Table 5.2.4-5 shows the total number of angler days for the headboat sector in the U.S. South Atlantic. This represents all headboat effort and not only those trips where South Atlantic group king and Spanish mackerel species were caught. These estimates are calculated from a survey where it is not possible to associate catch with a specific angler on the trip. However, it is expected that a significant portion of these trips target mackerel species.

Table 5.2.4-5. Estimated headboat angler days for the U.S. South Atlantic.

Year	Florida	Georgia	North Carolina	South Carolina	Total
2001	138,390	na	31,779	49,263	219,432
2002	125,322	na	27,601	42,467	195,390
2003	122,313	na	22,998	36,556	181,867
2004	149,542	na	27,255	50,461	227,258
2005	145,686	na	31,573	34,036	211,295

Source: The Headboat Survey, NOAA Fisheries, SEFSC, Beaufort Lab.
Note: "Na" indicates the data is not available due to confidentiality issues.
Note: With regard to data for Florida, only half of the headboat trips taken from the Florida Keys and Tortugas areas were counted in this table in order to give a better approximation of trips taken that might result in harvest of South Atlantic migratory group king or Spanish mackerel.

Table 5.2.4-5 indicates that total headboat angler days have been relatively stable over the past five years. Florida trips have increased slightly since 2001 while North Carolina trips have remained almost exactly the same, although a five year low of 23,000 occurred in 2003. The number of South Carolina angler days has decreased 31% since 2001.

Headboat operators usually offer their passengers options for choosing trip packages of different durations. It appears that the majority of headboat trips are of half a day duration in Florida (78%) and South Carolina (59%). In North Carolina and Georgia the majority of trips are full day trips (Table 5.2.4-6).

Table 5.2.4-6. Average number of headboat trips (1999-2003) by trip length and percent of total trips by trip length.

Average Number of trips 1999-2003					Percent of total trips		
State	**Full day**	**¾ day**	**½ day**		**Full day**	**¾ day**	**½ day**
NC	561	17	374		56%	2%	38%
SC	642	110	1,144		33%	6%	59%
GA	152	1	10		93%		6%
FLA	1,972	546	9,038		17%	5%	78%
Total	1,014	123	2,079		23%	5%	72%

Source: The Headboat Survey, NOAA Fisheries, SEFSC, Beaufort Lab.

Harvest in the Recreational Fishery

<u>Shore, Charter, Private/Rental</u>

King mackerel harvested by the recreational fishery has fluctuated between almost 2.7 and 6.3 million pounds since 1989/90, peaking in 1992/93 at 6.3 million pounds (Table

5.2.4-2). Table 5.2.4-7 shows harvest of king mackerel by state over the past five years. Florida and North Carolina have the highest harvest levels with Florida harvesting over twice as much as North Carolina in 2005. Florida harvest levels peaked in 2003 at over 4 million pounds before declining to 2.8 million pounds in 2005. Georgia's recreational harvest of king mackerel fluctuated a great deal over the past five years with a low of 20,146 in 2006 and a high of 130,966 in 2003. North Carolina recreational harvest of king mackerel has varied over the past five years between about 700,000 and 1.8 million pounds. South Carolina recreational harvest of king mackerel peaked in 2004 at about 240,000 before reaching a five year low in 2005 at about 120,000 pounds.

Table 5.2.4-7. Recreational harvest (lbs) of king mackerel by state, 2001-2007.

	2001	2002	2003	2004	2005	2006	2007
Florida east coast	2,443,614	2,843,643	4,262,627	3,395,121	2,453,859	3,655,101	4,432,267
Georgia	156,374	14,370	130,966	26,731	67,313	20,146	91,473
North Carolina	1,862,838	733,973	949,700	1,218,310	1,348,131	1,120,448*	2,004,574
South Carolina	148,958	132,673	150,792	245,864	119,935	139,681	299,654

(Source: MRFSS, NOAA Fisheries (http://www.st.nmfs.gov/st1/recreational/data.html).
*NCDMF,2007 Annual Report , pp. III-41

The amount of Spanish mackerel harvested by the recreational fishery increased in recent years after reaching a low in 1998/99. Table 5.2.4-8 shows harvest of Spanish mackerel by state over the past five years. Florida and North Carolina recreationally harvest the majority of Spanish mackerel with the Florida harvest at about three times that of North Carolina. Florida harvest peaked in 2002 at about 1.5 million pounds and reached a five year low in 2004 at about 900,000 pounds. Georgia recreational harvest of Spanish mackerel has fluctuated between about 2,500 pounds and 35,000 pounds over the past five years. North Carolina harvest decreased from 2001 and peaked in 2004 before reaching a five year low in 2005. South Carolina harvest has achieved relatively high levels for the state over the past two years.

Table 5.2.4-8. Recreational harvest (lbs) of Spanish mackerel by state, 2001-2007.

	2001	2002	2003	2004	2005	2006	2007
Florida east coast	1,232,506	1,475,232	1,021,204	915,099	1,088,720	807,327	1,003,340
Georgia	23,056	4,795	34,855	11,799	16,296	2,487	26,513
North Carolina	499,829	475,742	446,052	558,968	359,927	454,749	729,687
South Carolina	46,945	47,057	29,107	147,609	138,517	83,069	119,207

Source: MRFSS, NOAA Fisheries (http://www.st.nmfs.gov/st1/recreational/data.html).

Headboats

Harvest by headboats over the past five years is shown in Tables 5.2.4-9, 5.2.4-10. Harvest for the Florida Keys and Tortugas areas was halved in order to better represent potential harvest of South Atlantic migratory group king and Spanish mackerel.

Table 5.2.4-9 shows that total headboat harvest of king mackerel has increased by almost 100,000 pounds since 2001 and more than doubled since 2003 when a five year low occurred. In general, in all states, king mackerel harvests hit a five year low in 2003 when angler days also hit a five year low.

Table 5.2.4-9. Headboat harvest (lbs) of Atlantic migratory group king mackerel, 2001-2005.

	2001	**2002**	**2003**	**2004**	**2005**
North Carolina	4,081	1,672	1,384	8,711	6,376
South Carolina	23,970	13,026	7,227	13,528	6,014
Georgia	na	na	na	na	Na
Florida	108,703	91,134	81,498	138,935	215,740
Total	**136,754**	**105,831**	**90,109**	**161,175**	**228,129**

Source: The Headboat Survey, NOAA Fisheries, SEFSC, Beaufort Lab.
Note: “Na” indicates the data is not available due to confidentiality issues.
Note: With regard to data for Florida, only half of the headboat trips taken from the Florida Keys and Tortugas areas were counted in this table in order to give a better approximation of trips taken that might result in harvest of South Atlantic migratory group king or Spanish mackerel.

Total harvest of Spanish mackerel by headboats reached a five year low in 2003 but then recovered to 2001 levels in 2005. Harvest levels varied widely over the past five years for all three states shown (Table 5.2.4-10).

Table 5.2.4-10. Headboat harvest (lbs) of Atlantic migratory group Spanish mackerel, 2001-2005.

	2001	**2002**	**2003**	**2004**	**2005**
North Carolina	81	8	51	186	65
South Carolina	9,007	3,670	1,417	10,897	8,512
Georgia	na	na	na	na	na
Florida	2,120	1,825	1,409	4,703	3,157
Total	**11,209**	**5,503**	**2,877**	**15,786**	**11,735**

Source: The Headboat Survey, NOAA Fisheries, SEFSC, Beaufort Lab.
Note: “Na” indicates the data is not available due to confidentiality issues.
Note: With regard to data for Florida, only half of the headboat trips taken from the Florida Keys and Tortugas areas were counted in this table in order to give a better approximation of trips taken that might result in harvest of South Atlantic migratory group king or Spanish mackerel.

<u>Characteristics of the Charter and Headboat Sectors</u>

There is no specific economic information on the for-hire sector that currently operates in the South Atlantic snapper grouper fishery. Holland et al. (1999) conducted a study of the charterboat sector in 1998 and provided information on charterboats and headboats engaged in all fisheries (Table 5.2.4-11).

Table 5.2.4-11. Charterboats and headboats operating in the South Atlantic during 1998.

State	Number of Headboats	Number of Charter Boats
North Carolina	18	207
South Carolina	18	174
Georgia	2	56
Florida-Atlantic Coast	42	413
Florida –Keys	16	230
Total	**96**	**1,080**

Source: Holland et al. (1999).

Holland et al. (1999) surmised that charterboats in Florida tend to be less specific in terms of species targeting behavior when compared to charterboats in the other South Atlantic states. In their study 47.7% of all captains in Atlantic Florida said they don't have specific targets but spend their time trolling or bottomfishing for any species. The most popular species for the Florida Atlantic vessels that had specific targets were king mackerel, dolphin, billfish, wahoo, and amberjack.

Allowable gear

Authorized commercial gears for Atlantic migratory group king mackerel north of Cape Lookout Light (34° 37.3' North Latitude), North Carolina are all gears, except drift gill nets and long gill nets. South of Cape Lookout, authorized gear includes automatic reel, bandit gear, handline, and rod and reel. A minimum size of 4.75-inch stretched mesh is required for run-around gill nets. No more than 400,000 pounds may be harvested by purse seines.

Authorized commercial gear for Spanish mackerel is automatic reel, bandit gear, handline, rod & reel, cast net, run around gill net and stab net. Minimum size of 3.5" stretch mesh required for all run around gill nets.

Other commercial coastal migratory pelagics may be harvested with longline, handline, rod and reel and bandit gear.

Coastal migratory pelagics may be caught recreationally using bandit gear, rod and reel, handline and spear.

5.2.4.2 Economic description of the fishery

Commercial fishery

Ex-vessel Prices

Annual real ex-vessel prices (2004 dollars) for Atlantic migratory group king and Spanish mackerel, during the fishing years 1981/82 through 2005/06 are shown in Table 5.2.4-12 Figure 5.2.4-1 for the Atlantic coastal states (Maine through Florida east coast). In general, prices for both species have increased since 1981/82, by 25% for Atlantic migratory group king mackerel and by about 45% for Atlantic migratory group Spanish mackerel. King mackerel prices peaked several times in the 1990s and early 2000s at about $2.03/pound and Spanish mackerel peaked at $0.82 in the late 1990s. In general, prices for Atlantic migratory group king mackerel are somewhat lower that prices received for most of the 1990s and early part of this decade while prices for Spanish mackerel have remained relatively steady over this period of time.

Table 5.2.4-12. Ex-vessel prices for Atlantic migratory group king and Spanish mackerel (2004 dollars).

Year	Atlantic king mackerel ex-vessel prices	Atlantic Spanish mackerel ex-vessel prices
1981/82	$1.42	$0.52
1982/83	$1.51	$0.48
1983/84	$1.41	$0.42
1984/85	$1.51	$0.41
1985/86	$1.66	$0.45
1986/87	$1.62	$0.50
1987/88	$1.71	$0.57
1988/89	$1.66	$0.53
1989/90	$1.75	$0.53
1990/91	$1.72	$0.51
1991/92	$1.76	$0.54
1992/93	$2.03	$0.57
1993/94	$1.92	$0.55
1994/95	$1.91	$0.59
1995/96	$1.95	$0.78
1996/97	$1.81	$0.64
1997/98	$1.76	$0.71
1998/99	$2.03	$0.69
1999/00	$1.94	$0.82
2000/01	$2.04	$0.75
2001/02	$2.03	$0.75
2002/03	$1.98	$0.73
2003/04	$1.64	$0.67
2004/05	$1.68	$0.77
2005/06	$1.78	$0.73

Note: Season is April through March for 2001/02 through 2004/05 and March through the end of February for 2005/06.

Ex-vessel prices of king mackerel, the U.S. market, and estimated imports of king mackerel and possible substitute species have been described and analyzed using econometric models (Easeley et al. 1993; Vondruska and Antozzi 1999; Vondruska 1999). The model results indicate that demand for king mackerel is relatively price elastic for the U.S. market as a whole. That is, compared with any given percentage change in market supply, the expected percentage change in ex-vessel price is much smaller, holding other factors constant.

The models also indicate statistically significant shifts in ex-vessel prices of king mackerel during the year because of variations in landings. Landings of king mackerel exhibit extreme seasonal variation in some major harvest areas, more so for the Gulf group than the Atlantic group, and this affects the annual average ex-vessel price.

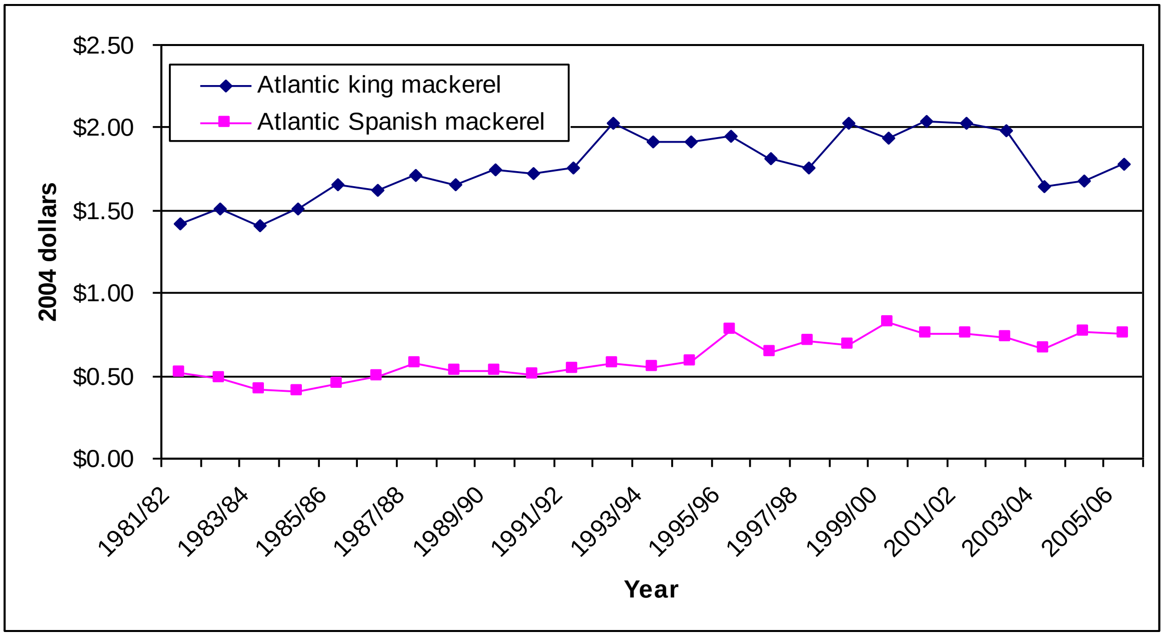


Figure 5.2.4-1. Ex-vessel prices for Atlantic migratory groups of king and Spanish mackerel, 1981-2006.

Logbook indicators of commercial fishing activity

Since 1998, fishermen have completed and submitted FMP-mandated logbooks for commercial fishing trips for king and Spanish mackerel. The data base management systems for fisherman-supplied logbooks and southeast coastal state-collected commercial landings are administered by the NOAA Fisheries Southeast Fisheries Science Center, Miami. Table 5.2.4-13 and Table 5.2.4-14 provide average values for various categories for the Atlantic migratory group king and Spanish mackerel fisheries over the past five years. The reader should note that while all federally permitted vessels are required to fill out and send in logbooks, there are vessels in state waters that fish for Atlantic migratory group Spanish mackerel that are not required to fill out logbooks.

Information from vessels fishing in state waters and not required to fill our logbooks for fishing in these areas, has not been incorporated into the data shown below. Therefore, the number of vessels is likely an underestimate of the number of vessels actually fishing for Atlantic migratory group Spanish mackerel. However, the below information is correct for the number of vessels turning in logbooks and these vessels serve as a representation of the entire fleet.

Over the past five years total commercial pounds landed pounds landed per vessel annually, and pounds landed per trip (Table 5.2.4-13) have increased while the number of vessels declined. At the same time, real ex-vessel value remained unchanged due to the decrease in ex-vessel prices from $2.03 in 2001/2002 to $1.78 in 2005/06 (Table 5.2.4-12). Ex-vessel value of Atlantic migratory group king mackerel increased in the percentage of value it contributed to all species caught in the year. The total number of trips and days away from port on fishing trips for king mackerel declined from 2001 to 2005. It appears that while the fleet has decreased in size, those remaining have increased landings but not value due to market changes. Given increasing fuel prices over the past several years, the average vessel likely experienced decreased net income since 2001.

Table 5.2.4-13. Atlantic migratory group king mackerel mean statistics, 2001/02 - 2005/06 (2004 dollars).

	2001	2002	2003	2004	2005
Vessels	750	718	715	695	661
Pounds landed (king mackerel)	2,287	2,043	2,727	3,147	2,571
Pounds landed per trip (king mackerel)	167	163	203	247	232
Real ex-vessel value (king mackerel), 2004 $	$4,288	$3,882	$4,269	$4,982	$4,249
Real ex-vessel value (% all species caught in yr), 2004 $	33.2%	31.5%	33.3%	39.3%	37.7%
Real ex-vessel value per trip (king mackerel), 2004 $	$313	$311	$317	$391	$384
Real ex-vessel value per trip (% all species), same trips, 2004 $	77%	76%	80%	81%	77%
Trips (king mackerel)	13.7	12.5	13.5	12.7	11.08
Crew size per king mackerel trip	1.5	1.5	1.4	1.5	1.6
Days away from port (king mackerel)	19.7	17.7	17.5	16.2	15.6
Days away from port (trips all species)	47.7	48.5	47.6	42	39.8

Note: Not all vessels providing logbooks provided data for every category included in the table.
Source: NMFS Southeast Coastal Fisheries Logbook, 2005/06. As of May 26, 2006. ALS data accessed August 9, 2006.

Over the past five years total commercial pounds landed pounds landed per vessel annually, and pounds landed per trip (Table 5.2.5-14) for Atlantic migratory group Spanish mackerel increased while the number of vessels declined. Annual and per trip real ex-vessel value increased while ex-vessel prices remained at the same level ($0.75) (Table 5.2.5-12). Ex-vessel value of Atlantic migratory group Spanish mackerel increased slightly in the percentage of value it contributed to all species caught in the year. The total number of trips increased slightly and days away from port on fishing trips for Spanish mackerel increased slightly from 2001 to 2005. However, total days away from port fishing for all species declined from 44 to 39 from 2001 to 2005. While the fleet decreased in size, those remaining have increased landings and real ex-vessel value has increased somewhat. Increasing fuel prices over the past several years may have negated any revenue increases.

Table 5.2.5-14. Atlantic migratory group Spanish mackerel mean statistics, 2001/02 - 2005/06 (2004 dollars).

	2001	2002	2003	2004	2005
Vessels	348	371	323	310	312
Pounds landed (Spanish mackerel)	4,608	5,019	5,903	5,300	5,391
Pounds landed per trip (Spanish mackerel)	495	498	592	536	545
Real ex-vessel value (Spanish mackerel), 2004 $	$3,323	$3,521	$3,714	$4,012	$3,813
Real ex-vessel value (% all species caught in yr), 2004 $	22.4%	22.7%	22.6%	22.7%	24%
Real ex-vessel value per trip (Spanish mackerel), 2004 $	$357	$349	$372	$405	$386
Real ex-vessel value per trip (% all species), same trips, 2004 $	65%	64%	71%	72%	71%
Trips (Spanish mackerel)	9.3	10.1	10	9.9	9.9
Crew size per trip	1.5	1.5	1.5	1.5	1.5
Days away from port (mackerel)	9.7	10.4	10.3	10.3	10.2
Days away from port (all species)	44	44	47	39	39

Note: Not all vessels providing logbooks provided data for every category included in the table.
Source: NMFS Southeast Coastal Fisheries Logbook, 2005/06. As of May 26, 2006. ALS data accessed August 9, 2006.

Table 5.2.5-15 and Table 5.2.5-16 provide various statistics regarding landings, revenue, vessel specifications, trips, and crew size for the Atlantic migratory group king and Spanish mackerel fisheries. The 661 vessels that submitted logbooks with Atlantic migratory group king mackerel landings in 2005/06 were, on average, 31 feet in length, had 350 horsepower, spent 15 days away from port each year fishing for king mackerel, and used 1.5 crew members per trip for Atlantic migratory group king mackerel. Although this information does not encompass the entire population of vessels fishing for Atlantic migratory group king mackerel, this data set can provide some indication of characteristics of the fleet.

A large portion of the vessels fishing for Atlantic migratory group king mackerel obtain a significant portion of total ex-vessel revenue from the species as a percentage of all species caught in the year. The data shows that the median vessel obtains 27% of real ex-vessel value from king mackerel as a percentage of all species caught in the year. The 75th – 90th percentile range received about 70% - 100% of real ex-vessel value from king mackerel as a percentage of all species caught in that year. However, for the 75th - 90th percentile this amounts to only about $4,300 – $12,400 ex-vessel value. On a per trip basis, the 75th – 90th percentile range makes about $475 - $1000 ex-vessel per trip from landings of king mackerel. This encompasses 100% of ex-vessel value from all species for those trips.

The 312 vessels that submitted logbooks with Atlantic migratory group Spanish mackerel landings in 2005/06 were, on average, 30 feet in length, had 295 horsepower, spent 10 days away from port each year fishing for Spanish mackerel, and used 1.5 crew members per trip for Atlantic migratory group Spanish mackerel.

Table 5.2.4-15. Atlantic migratory group king mackerel statistics by vessel, 2005/06 (2004 dollars). The table features data contained in 661 logbooks.

	Mean	25th percentile	50th percentile	75th percentile	90th percentile	99^{th} percentile
Length (ft)	31	26	30	35	42	53
Horsepower	350	220	300	425	590	900
Depth fished for king mackerel (ft)	94	70	85	100	135	230
Pounds landed (king mackerel)	2571	116	643	2,521	7,136	28,465
Pounds landed per trip (king mackerel)	232	38	110	276	595	1,151
Real ex-vessel value (king mackerel)	$4,249	$193	$1,010	$4,311	$12,379	$45,254
Real ex-vessel value (% all species caught in yr)	37.7%	2%	27%	69%	100%	100%
Real ex-vessel value per trip (king mackerel)	$384	$67	$194	$474	$993	$2,392
Real ex-vessel value (% of all species caught on trip)	77	66	98	100	100	100
Real ex-vessel value per trip (% all species), same trips	77%	66%	98%	100%	100%	100%
Trips (king mackerel)	11.08	2	6	15	29	58
Crew size per king mackerel trip	1.57	1	1	2	3	4
Days away from port (king mackerel)	15.6	3	8	22	42	90
Days away from port (trips all species)	39.8	9	25	57	97	170

Note: Not all 661 vessels providing logbooks provided data for every category included in the table.
Source: NMFS Southeast Coastal Fisheries Logbook, 2005/06. As of May 26, 2006. ALS data accessed August 9, 2006.

A portion of the vessels fishing for Atlantic migratory group Spanish mackerel obtain a significant portion of total ex-vessel revenue from the species as a percentage of all species caught in the year. The data shows that while the median vessel obtains only 7% of real ex-vessel value from Spanish mackerel as a percentage of all species caught in the year, the 75th – 90th percentile range receives about 38% - 87% of real ex-vessel value from Spanish mackerel as a percentage of all species caught in that year. However, for the 75th -90th percentile this amounts to only about $4,300 – $12,400 ex-vessel value. On a per trip basis, the 75th – 90th percentile range makes about $550 - $970 ex-vessel per trip from landings of Spanish mackerel and this encompasses 100% of ex-vessel value from all species for those trips. Clearly, fishermen fishing for Atlantic migratory group king and Spanish mackerel participate in a portfolio of other fisheries and/or supplement their income by other means (second job).

Table 5.2.4-16. Atlantic migratory group Spanish mackerel statistics by vessel, 2005/06 (2004 dollars). The table features data contained in 312 logbooks.

	Mean	25th percentile	50th percentile	75th percentile	90th percentile	99th percentile
Length (ft)	30	25	28	34	40	51
Horsepower	295	200	250	375	454	840
Depth fished for Spanish mackerel (ft)	42.5	20	30	60	80	150
Pounds landed (Spanish mackerel)	5,391	37	487	4,579	16,836	60,674
Pounds landed per trip (Spanish mackerel)	545	37	259	800	1,488	3,271
Real ex-vessel value (Spanish mackerel)	$3,813	$40	$432	$3,120	$12,412	$34,366
Real ex-vessel value (% all species caught in yr)	24%	1%	7%	38%	87%	100%
Real ex-vessel value per trip (Spanish mackerel)	$386	$35	$212	$551	$972	$2,237
Real ex-vessel value per trip (% all species), same trips	71%	38%	95%	100%	100%	100%
Trips (Spanish mackerel)	9.89	2	4	13	25	67
Trips (all species)	36.2	13	27	54	80	120
Crew size per trip	1.5	1	1	2	2	3
Days away from port (mackerel)	10.2	2	5	13	25	67
Days away from port (all species)	39.1	13	29	57	87	157

Note: Not all 312 vessels providing logbooks provided data for every category included in the table.
Source: NMFS Southeast Coastal Fisheries Logbook, 2005/06. As of May 26, 2006. ALS data accessed August 9, 2006.

Recreational fishery

The statistics presented in Section 5.2.4.1 (Recreational Fishery) document marine recreational fishing participation, recreational effort, and harvest of South Atlantic migratory group king and Spanish mackerel. Participation, effort, and harvest are indicators of the value of saltwater recreational fishing. However, a more specific indicator of value is the satisfaction that anglers experience over and above their costs of fishing. The monetary value of this satisfaction is referred to as compensating variation (same as non-market benefit). The magnitude of this non-market benefit derived from the recreational experience is dependent on several quality determinants which include fish size, catch success rate, the number of fish kept, and aesthetics. These quality variables are important not only in their determination of the value of a recreational fishing trip but also in their influence on total demand for recreational fishing trips. For example, as the population of fish increases it is expected that angler success rate would increase and the marginal value of the fishing trip to the angler would increase, provided all other conditions remain the same.

Recent estimates of the economic value of a day of saltwater recreational fishing are available for the South Atlantic from different sources. These estimates are not specific to king or Spanish mackerel but shed some light on the magnitude of an angler's willingness to pay for this recreational experience. The mean value of access per marine recreational fishing trip was estimated at $109.31 for the South Atlantic (Haab et al. 2001). Such values can be considered good estimates of the opportunity cost of time for saltwater recreational fishing.

The valuation estimates previously discussed should not be confused with angler expenditures or economic activity generated as a result of these expenditures. Angler expenditures benefit a number of sectors that provide goods and services for saltwater sport fishing. A study conducted by NOAA Fisheries (Gentner et al. 2001) provides estimates of saltwater recreational fishing trip expenditures (Table 5.2.4-17). The average expenditure per trip varies depending on the state, type of trip, duration, travel distance, and other factors. As expected, trip expenditures for non-residents are higher than for in-state residents. Compared to in-state residents, non-residents travel longer distances and incur expenses for food and lodging. Some in-state residents will incur higher trip expenses if they reside far away from the coast. These estimates do not include expenditures on recreational fishing in Monroe County or expenditures made on headboat angler trips.

Financial Operations of the Charter and Headboat Sectors

Holland et al. (1999) defined charterboats as boats for-hire carrying 6 or less passengers that charge a fee to rent the entire boat. Data from their study conducted in 1998 indicated that this trip fee reportedly ranged from $292 to $2,000. The actual cost to the passenger depended on state, trip length, and the variety of services offered by the charter operation. In the South Atlantic, depending on the state, the average fee for a half day trip ranged from $296 to $360, for a full day trip the range was $575 to $710, and for an overnight trip the range in average fee was $1,000 to $2,000. Most (>90%) Florida charter operators offered half day and full day trips and about 15% of the fleet offered overnight trips. In comparison, in the other South Atlantic states about 3% of the total charter trips were overnight trips.

Table 5.2.4-17. Summary of expenditures on saltwater trips estimated from a 1999 MRFSS add-on survey (Source: Gentner et al. 2001).

	North Carolina	South Carolina	Georgia	Florida

Item	Resident	Non Resident	Resident	Non Resident	Resident	Non Resident	Resident	Non Resident
Shore mode trip expenses	$63.61	$75.53	$54.12	$104.27	$31.78	$115.13	$36.90	$141.30
Private/rental boat trip expenses	$71.28	$92.15	$35.91	$67.07	$161.34	$77.51	$66.59	$94.15
Charter mode trip expenses	$201.66	$110.71	$139.72	$220.97	$152.45	$155.90	$96.11	$196.16
Charter fee-average-per day	$133.76	$70.59	$114.26	$109.97	$73.68	$80.99	$71.37	$100.79

Headboats tend to be larger, diesel powered and generally can carry a maximum of around 60 passengers. The average vessel length of the headboats whose owners responded to the survey was around 62 feet. In Florida, the average headboat fees was $29 for a half day trip and $45 for a full day trip. For North and South Carolina, the average base fee was $34 per person for a half day trip and $61 per person for a full day trip. Most of these headboat trips operated in Federal waters in the South Atlantic (Holland et al. 1999).

The demand for charter and headboat trips will depend on the fee charged and the quality of the fishing experience. As noted previously, variables such as catch success rates, bag (keep) limits, and aesthetics are determinants of the quality of the experience to the angler. Profits within the for-hire sector will depend on trip demand, the fee charged, and cost of the fishing operation. It is expected that the cost of fishing will bear some inverse relationship to the population size of the species as it is expected that costs of searching for fish will decrease as the population size increases.

On the east coast of Florida, the average charter vessel length and horsepower was 39 feet and 617 hp respectively. The average vessel length in North Carolina was comparable to Florida. Also, for the other states it appears that charter vessels tended to be smaller than vessels in Florida and North Carolina. Electronics such as global positioning systems (GPS) and fish finders are common on most charter vessels in the South Atlantic. Capital investment in charter vessels averaged $109,301 in Florida, $79,868 for North Carolina, $38,150 for South Carolina, and $51,554 for Georgia (Holland et al. 1999). Charterboat owners incur expenses for inputs such as fuel, ice, and tackle in order to offer the services required by their passengers. Most expenses incurred in 1997 by charter vessel owners were on crew wages and salaries and fuel (Holland et al. 1999). The average annual charterboat business expenditures incurred was $68,816 for Florida vessels, $46,888 for North Carolina vessels, $23,235 for South Carolina vessels, and $41,688 for vessels in Georgia in 1997. The average capital investment for headboats in the South Atlantic was around $220,000 in 1997. Total annual business expenditures averaged $135,737 for headboats in Florida and $105,045 for headboats in other states in the South Atlantic.

The 1999 study on the for-hire sector in the Southeastern United States presented two sets of revenue estimates for the charter and headboat sectors in the South Atlantic (Holland et al. 1999). The first set of average gross revenue per vessel estimates were those reported by survey respondents as follows: $51,000 for charterboats on the Atlantic coast of Florida; $60,135 for charterboats in North Carolina; $26,304 for charterboats in South Carolina; $56,551 for charterboats in Georgia; $140,714 for headboats in Florida; and $123,000 for headboats in the other South Atlantic states (Holland et al. 1999). These authors concluded that survey respondents were reluctant to report gross income, and it is possible that these are underestimates of the true income received by these business entities. As a result, a second set of estimates on the for-hire sector was calculated by multiplying the average trip fee by the average number of trips per year for each vessel category. Using this method the average per vessel gross revenue was estimated at $69,268 for charterboats and $299,551 for headboats operating on the Atlantic coast of Florida (Holland et al. 1999). The calculated vessel gross revenue estimate for the charter sector was 22% higher than the reported charter gross revenue per vessel on the east coast of Florida (Holland et al., 1999). The calculated vessel gross revenue figure for the headboat sector was 113% higher than the reported headboat gross revenue per vessel on the east coast of Florida (Holland et al. 1999). The second set of gross revenue estimates were only calculated for vessels in Florida. To obtain revised estimates for average gross vessel income for the other South Atlantic states, the reported per vessel gross income was multiplied by the percent increase calculated for Florida by sector. The revised estimates of average gross revenue per vessel for the other states are as follows: $73,365 ($60,135 x 1.22) for charterboats in North Carolina, $32,091 ($26,304 x 1.22) for charterboats in South Carolina; $68,992 ($56,551 x 1.22) for charterboats in Georgia; and $261,990 ($123,000 x 2.13) for headboats in the other South Atlantic states.

It must be noted that the study's authors were concerned that while the reported gross revenue figures are underestimates of true vessel income, these calculated values could overestimate gross income per vessel from for-hire activity (Holland et al. 1999). Some of these vessels are also used in commercial fishing activities and that income is not reflected in these estimates.

Permit Ownership

Amendment 15 established an indefinite limited access program for the king mackerel fishery in the exclusive economic zone under the jurisdiction of the Gulf of Mexico, South Atlantic and Mid-Atlantic Fishery Management Councils. Permits may be transferred. Tables 5.2.5-18 and 5.2.5-19 provide the number of king mackerel and Spanish mackerel permits by area, respectively. While all vessels with permits for king and Spanish mackerel are included in the table, only a portion of these fish for Atlantic migratory group king and Spanish mackerel. For our purposes, it is assumed that vessels located on the east coast of the U.S. and Florida fish for Atlantic migratory group king and Spanish mackerel. It is assumed that Florida west coast and non-coastal numbers are split evenly between fishing for Atlantic migratory group king and Spanish mackerel and Gulf migratory king and Spanish mackerel. While these assumptions are rather simplifying and perhaps not entirely realistic, they allow us to discuss the data included in the tables below in an approximate way.

In total, there are about 1,119 commercial vessels, 243 charter vessels, and 5 headboats with federal permits for king mackerel that likely fish for Atlantic migratory group king mackerel. The majority of the commercial permits are registered to vessels homeported on the east coast of Florida and Monroe County. While a large portion of the commercial and charter boats with federal king mackerel permits are registered to vessels homeported in Florida, a significant portion (21% and 40%) are homeported in North Carolina. Most of the headboat permits are registered to vessels homeported in Florida.

Table 5.2.4-18. Boats with federal permits for commercial fishing for king mackerel by region, January 2006.

Home State or Region	Not Specified	Commercial	Charter	Headboat	All
Northeast (Maine-Virginia)	-	64	4	-	68
North Carolina	6	238	98	1	343
South Carolina	-	38	7	-	45
Georgia	1	10	2	-	13
Florida east coast	4	433	57	2	496
Florida west coast	4	469	126	3	602
Florida non-coastal	2	204	23	1	230
Alabama	-	25	3	-	28
Mississippi	-	10	-	-	10
Louisiana	-	78	3	-	81
Texas	1	25	7	-	33
Other states	1	13	1	-	15
TOTAL BOATS	19	1,607	331	7	1,964
FLORIDA					
Northeast (Nassau-Flagler)	-	26	9	-	35
Southeast (Volusia-Dade)	4	407	48	2	461
Monroe County	4	242	36	-	282
West (Collier-Wakulla)	-	112	24	-	136
Northwest (Franklin-Escambia)	-	115	66	3	184
Non-coastal	2	204	23	1	230
TOTAL BOATS	10	1,106	206	6	1,328

In total, there are about 956 (69%) commercial vessels, 177 (70%) charter vessels, and 8 (80%) headboats with federal permits for king mackerel that likely fish for Atlantic migratory group Spanish mackerel. The majority of the commercial permits are registered to vessels homeported on the east coast of Florida and Monroe County. About 14% of commercial permits and 29% of the charter permits are homeported in North Carolina. Most of the headboat permits are registered to vessels homeported in North Carolina and points north.

Table 5.2.4-19. Boats with federal permits for commercial fishing for Spanish mackerel by region, January 2006.

Home State or Region	Not Specified	Commercial	Charter	Headboat	All
Northeast (Maine-Virginia)	3	84	7	2	96

North Carolina	5	135	51	4	195
South Carolina	-	10	3	-	13
Georgia	2	3	1	-	6
Florida east coast	7	385	45	1	438
Florida west coast	13	475	123	1	612
Florida non-coastal	5	203	16	1	225
Alabama	-	11	-	-	11
Mississippi	-	7	2	-	9
Louisiana	1	64	1	-	66
Texas	-	6	3	1	10
Other states	2	8	-	-	10
TOTAL BOATS	38	1,391	252	10	1,691
FLORIDA					
Northeast (Nassau-Flagler)	-	19	5	-	24
Southeast (Volusia-Dade)	7	366	40	1	414
Monroe County	5	262	42	1	310
West (Collier-Wakulla)	8	140	31	-	179
Northwest (Franklin-Escambia)	-	73	50	-	123
Non-coastal	5	203	16	1	225
TOTAL BOATS	25	1,063	184	3	1,275

5.2.4.3 Social and cultural environment

Most fishermen who participate in the mackerel fishery also participate in other fisheries. Even if mackerel fishing only accounts for a portion of the income earned by a fisherman, it is an important part and may mean the difference in someone being able to continue to fish, and the necessity to seek other types of employment. If the mackerel fishery were to experience further reductions in the catch, there could be ramifications for fishermen, fish processors, marinas, and other fishing-related businesses that draw part of their income from the mackerel fishery. If there are changes made to the current regulations for the mackerel fishery, it is assumed that the regulations would have the most impact in communities where the most mackerel are landed, the most income from mackerel earned, and the most boats are permitted for mackerel. That is, regulations will likely have the greatest impact on the communities that are most dependent on the mackerel resource. The above mentioned data can act as indicators of mackerel dependence. By comparing all of the data, it is possible to determine which counties/communities may be most impacted by changes in regulations that may affect mackerel-dependent fishermen, fishing-dependent businesses, and communities.

Measures of Fishing Dependence

Jepson et al. (2006) conducted community profiles for the South Atlantic region. These community profiles provide a snapshot of the community and its involvement in fishing using 2001 as a base year. The profiles provide historical background about the community and its involvement in fisheries or fisheries related industries. The profiles provide information on community involvement in commercial and recreational fishing as evidenced through various indicators (federal commercial permits, state commercial licenses, federal charter permits, seafood landings, fish processors and wholesale fish houses, recreational docks/marinas, and recreational fishing tournaments). Demographic information on a community basis is also provided to the extent that the data were gathered in a Federal Census.

Mackerel Fishing Communities
In general, the community profiles do not provide fishery specific information other than the number of federal and state permits associated with each community. Because not all communities profiled are likely relevant to the actions under consideration in this document, profiles that outline homeports for vessels with at least five federal commercial king mackerel, federal commercial Spanish mackerel, and federal charter/headboat permits for coastal pelagics combined, have been included. The last subsection under each state heading summarizes community engagement in that state based on several indicators that data was gathered for. These community profiles have been included in Appendix A of Draft Mackerel Amendment 18.

5.2.4.4 Bycatch

Bycatch data in the commercial CMP fisheries are primarily collected via logbooks, and recreational bycatch is collected by the Marine Recreational Fisheries Statistics Survey (MRFSS). Bycatch from commercial gill nets has recently been collected via the supplementary discard program, which was implemented in August 2001. A stratified, random sample (20% coverage) of commercial permit holders was selected each year and required to record their discards for each trip they made. For the first survey period (8/01-7/02), 15 vessels with gill-net gear were selected to fill out discard report forms. For the second survey period (8/02 to 7/03), 14 vessels with gill-net gear were selected to report. Overall, menhaden, smooth dogfish sharks, and spiny dogfish sharks were the three most frequently discarded species. There were no interactions of sea turtles or marine mammals reported (Poffenberger 2004).

5.2.5 Spiny Lobster

5.2.5.1 Description of fishing practices, vessels and gear

Commercial fishery (See Appendix A)

Private recreational fishery

Recreational landings are estimated using mail surveys. Recipients of FWC mail surveys are randomly selected from the state's saltwater fishing license database of individuals who purchased a lobster permit that was valid during the survey period. To ensure that this selection process does not over- or under- sample any geographic region, these selections were stratified based upon license sales in each of 10 residence areas defined by postal codes. The number of lobster license holders that have been attempted to survey each season has ranged from 4,000 to 5,000.

Fishing effort during the Special Two-Day Sport Season from the 1992 through the 2003fishing seasons, expressed in terms of person-days has ranged from c. 60,000 to 112,000 person-days. Fishing effort was concentrated in the Florida Keys, where effort has ranged from 39,000 to 79,000 and accounted for 64% or more of the statewide fishing effort estimate each season. Most of the remaining fishing effort occurred along the SE coast of the state, where effort ranged from 16,000 to 36,000 person-days. Fishing effort throughout the remaining areas of the state ranged from 2000 to 10,000 person-days. Annual landings during the Special Season have ranged from 249,000 to 568,000 lbs. The largest proportion of landings occur in the Florida Keys and have ranged from 163,000 to 397,000 lbs, or 60% to 70% of the annual statewide total. Landings along the SE coast during the Special Season ranged from 70,000 to 151,000 lbs, and those throughout the remainder of the state ranged from 5,000 to 58,000 lbs.

To obtain a coarse estimate of lobster fishing effort after the Labor Day holiday, mail surveys from 1993 through 1996 included questions that asked respondents about which month they intended to fish for lobsters after the survey period. Nearly 60% of respondents to the regular season survey had fished for lobsters before Labor Day, but only 37% of respondents to both surveys indicated they intended to do so during the remainder of September, and that percentage progressively decreased during the subsequent months. However, an end-of-season mail survey that was conducted after the conclusion of the 1994 lobster fishing season indicated that lobster fishing effort during those months was even lower than that indicated by respondents of the former surveys. Only 13% of those survey recipients indicated that they actually fished for lobsters after Labor Day, and no more than 10% of those respondents fished for lobster in any single month during the survey period. From that same survey, we estimated that statewide there were only 50,673 (±1SD = 9,163) person-days of lobster fishing during that period and that 148,000 (± SD = 39,000) lbs of lobsters were landed. Because of the small number of surveys from which these estimates were derived (n = 52), regional landings were not estimated. Comparing this estimate to estimates from the Special Two-Day Season and regular season during 1994 indicated that less than 7 % of lobster landings that season occurred after Labor Day.

Allowable gear

Authorized gear includes trap, pot, dip net, bully net, snare and hand harvest.
There is a 5% by catch limit by weight (of all fish lawfully aboard) for incidental harvest of spiny lobster by trawls in the EEZ. No poisons or explosives are allowed. No spear, hooks or piercing devices are allowed. A degradable panel is required on non-wooden traps. Traps may not be tended at night. Buoy and trap identification is required.

5.2.6 Live Rock Aquaculture and Allowable Octocoral

5.2.6.1 Octocoral Fishery

Description of fishing practices, vessels and gear

History of the Commercial Fishery

The commercial live octocoral fishery probably dates back to the late 1950s or early 1960s when salt water aquariums first started to become popular and the supply of marine specimens began to appear in major cities in the United States. In the early days, filtration systems tended to be crude and the average marine aquarist stocked his aquarium with fish and a few common invertebrates such as crabs, shrimp, and starfish. As the hobby grew and filtration systems improved, more and more aquarists began to stock their aquariums with difficult-to-keep invertebrates such as clams, snails, stony corals, and octocorals. By 1980 the octocoral fishery was becoming well established, and a handful of the more hardy octocoral species collected off the Florida coasts could be found in most large marine aquarium stores throughout the U.S. The demand for Florida octocorals has continued to grow, as has the list of species harvested and successfully kept in the average marine aquarium. Florida-collected octocorals dominate the U.S. market as well as some of the European and Asian markets.

The South Atlantic Council, together with the Gulf of Mexico Council, became the first fishery management councils to describe the octocoral fishery in 1982 in the original Fishery Management Plan for Coral, Coral reefs and Live/Hard Bottom Habitat (SAFMC 1982). Amendment 1 to the Coral FMP was developed in 1990. This plan set an annual harvest limit of 50,000 octocoral colonies from federal waters, allowed for a minimal bycatch of substrate around the holdfast, set allowable gears, and defined the area where harvest is permitted.

Subsequent to this, the Florida Marine Fisheries Commission ruled that octocoral harvest in Florida waters would be unlimited. If the EEZ yearly quota was reached before September 30, then harvest would be closed in Florida until the following October 1.

Over the years there has been occasional interest in collecting octocorals for use in biomedical research. Past work has mostly focused on sampling a wide variety of species and looking for chemical compounds that might be of interest to this type of research. Compounds of interest were eventually synthesized in the lab, eliminating the need to continue harvesting a specific species of octocoral for the extraction. No large-scale octocoral harvests are presently taking place in the South Atlantic EEZ.

Although octocoral harvest in the South Atlantic EEZ is legal in almost all areas from Cape Canaveral south, the overwhelming bulk of the commercial octocoral harvest is located primarily in the Florida Keys. Harvest of octocorals from state waters occurs as far north as Jupiter inlet, but it is also mostly a Florida Keys based fishery. A limited harvest also occurs in the Gulf of Mexico EEZ off Florida's southwest coast.

Licenses and Permits

Commercial harvest of octocorals in federal waters is restricted to individuals or corporations holding a federal octocoral permit or a valid Florida Saltwater Products license (SPL) with a marine life (ML) endorsement. Federal permits are available through NOAA Southeast Regional Center in St Petersburg, FL, and are not restricted in any way. Saltwater products licenses from Florida's Fish and Wildlife Commission (FWC) are unrestricted, but the ML endorsement necessary to land commercial quantities of any organism designated as a "marine life" species, which includes all octocorals, is restricted. The commercial marine life fishery in Florida waters and the adjacent federal waters is managed by a limited entry program administered by the State of Florida's

FWC, and only a limited number of the licenses currently issued are transferable and valid for harvesting octocorals.

The state of Florida also has a Special Activities License (SAL) that can be issued to researchers, public aquariums, and educational institutions that allows the harvest of octocorals in state and federal waters. The permit holder must state in the application how many and what species of octocorals they wish to harvest, and the request is reviewed by FWC staff before being issued. Requests for any substantial amounts of octocoral harvest in federal waters are referred to NOAA Fisheries for review and approval.

Recreational harvest of gorgonia is permitted with a State of Florida saltwater fishing license and is restricted to 6 specimens per day, and the harvest is considered part of the aggregate recreational bag limit of marine life, which is no more than 20 total marine specimens per license holder per day.

Reporting requirements
All octocorals harvested commercially by marine life fishermen must be reported monthly to the Florida Fish and Wildlife Research Institute (FWRI). Landings must be identified as coming from specific zones along the coast, and within each zone it must be specified as coming from state or federal waters. The FWRI has accurate state and federal landing data for octocorals going back as far as about 1990.

Octocorals harvested under a Federal Fisheries Permit must be reported to NOAA Fisheries.

Octocorals harvested by SAL holders must be reported to FWRI.

Octocorals harvested by recreational fishermen are not reported.

Harvest Methods
Almost all commercial harvest of octocorals is done by marine life fishermen for the live aquarium trade, so harvest is by hand and is done in small numbers on any given day. Because it is listed as a marine life species by the state of Florida, fishermen harvesting octocorals using a Florida SPL with ML endorsement must transport and land them in a live and healthy condition.

As many as 50 different species of octocorals are harvested off the coasts of Florida, but only about a dozen species make up the majority of the harvest. Water depth ranges from 5' to 150', but most specimens from federal waters are photosynthetic specimens from shallow waters (less than 80'). Sea fans, *Gorgonia ventalina,* and *Gorgonia flabellum* as well as all black corals of the genus Antipathes are protected in state and Federal waters and there is no allowable harvest from any state or federal waters.

The aquarium trade has specific size and shape requirements that force marine life fishermen to be very selective in their harvest. Small specimens are passed by for the most part, and few specimens larger than about 20 inches are collected because they are too big for most aquariums and are difficult to ship. The standard shipping box used by Florida shippers has an inside dimension of 15" x 15", so although a 20 inch specimen could fit diagonally in a standard box or could be bent, most wholesale shippers and purchasers prefer specimens less than 15' long. Shape and quality are other factors that fishermen must consider when selecting specimens. The ideal specimen is one that has several lateral branches and no dead spots or odd growths.

The South Atlantic Coral FMP states that harvest by non-powered hand tools is permitted, so although there are many hand tools that could be used, the majority of the harvest is done using either a dive knife, a mason's hammer, or a hammer and wood chisel. The FMP allows for the harvest of a minimal amount of substrata (1" around the base of the octocoral), and most harvesters harvest much less than this amount. Allowing the substrate around the holdfast to be harvested reduces the chance of injuring the specimen and also makes it easier for the final consumer, the aquarist, to attach it to a rock in their aquarium or place it upright in the sand.

Most marine life fishing vessels are less than 25' and are usually trailerable, open fishing boats with outboard motors, and most fishermen either work alone or with just one other person on the boat. Most divers use standard SCUBA gear, but a few use boat mounted surface supplied air systems. Marine life vessels are required to have some sort of aeration system on board to aerate the livestock both on the water and during transport to an onshore holding facility.

Harvest by SAL requires all of the above considerations, but the SAL permit may have additional requirements or exemptions that are issued by the state of Florida on a case-by-case basis.

Recreational harvest is most likely done in the same way that the commercial harvest is done and uses the same types of vessels and gear. Recreational harvesters are not required to aerate their catch, but the catch must be landed live.

The recreational Federal permit is also limited to a daily catch of 6 octocorals. This permit must adhere to the most stringent of Federal or State criteria.

Allowable gear
Hand harvest is the only allowable method. A toxic chemical may not be used or possessed in a coral area in the EEZ. A power-assisted tool may not be used to take prohibited coral, allowable octocoral or live rock. Possession in the EEZ of coral resources harvested with a power assisted tool is prohibited.

Economic description of the fishery

The FWRI collects and maintains fishery landing data for this fishery and has provided the following landing data and ex-vessel value of the catch. However, the total economic value of the catch is many times greater as the product moves from the collector to the final consumer. The traditional chain of possession of the product is collector to wholesaler to pet shop to aquarist, and traditionally the price is at least doubled at each step of the process, so a $4 octocoral reported to the FWRI will sell for at least $16 to the final aquarist, and most likely much more than that. Most of this income comes into Florida from the rest of the United States and from other parts of the world (primarily Europe).

Landing data collected by FWRI for the 2006 calendar year indicated that a total of 39,404 colonies were harvested from the South Atlantic EEZ, for an approximate ex-vessel value of $157, 616 (based on an average landed price of $4 per colony). FWRI probably has a better number than this. Harvest levels have risen and fallen over the last five years, from a low of 29,420 in 2002 to 39,404 in 2006. Harvest in 2004 and 2005 was below the level for 2003, most likely reflecting the disruptive impacts of hurricanes on the ability of the fishermen to get out and harvest. Hurricanes not only disrupt the lives of the fishermen, but they also tend to scour many areas and in many cases the scouring removes all octocorals from that habitat, further disrupting the fishermen's ability to harvest. Re-growth of a completely scoured area to a level that will sustain a harvest varies from two years to four, depending on the habitat type and the targeted species. FWRI data also indicates that there were 26 fishermen reporting landings from the South Atlantic EEZ from 2002 to 2006, and 103 fishermen reporting state landings during that same time period.

Social and cultural environment

Although the area where octocoral harvest is permitted extends from the Florida Keys north to Cape Canaveral, the entire harvest from the South Atlantic EEZ comes from the Keys with most of the harvesters either living in the Keys or in Southeast Florida. Within the Florida Keys, there is no harvest in Key Largo National Marine Sanctuary or in Biscayne National Park, and within the Florida Keys National Marine Sanctuary there are several closed areas where all consumptive harvest is prohibited.

Most fishermen that land octocorals also land other marine life specimens on the same trip, and usually multiple species of octocorals can be harvested on the same dive. Octocoral communities are always associated with hardbottom habitats, and densities vary greatly. Harvest volume is governed by demand and by the amount of holding capacity available on the fishing vessel and at the shore based holding facility.

Bycatch

Because the octocorals are almost exclusively harvested one at a time by divers, there is very little bycatch. On most of shallow water, photosynthetic species, there is no visible bycatch at all on the octocoral itself; on the substrate that surrounds the base there may be an occasional attached macro alga or sponge. Experienced harvesters usually collect octocorals in areas where the target species are abundant and they can quickly and easily remove a specimen without damaging any surrounding benthic communities.

Bycatch is slightly more common on some of the deepwater, non-photosynthetic specimens, very little of which is collected in the federal waters of the Florida Keys (most of the deepwater octocorals are collected off Broward and Palm Beach counties in state waters). Bycatch on these deepwater octocorals usually consists of small brittle stars and basket stars, and the amount and the species composition varies greatly from location to location, from species to species, and from season to season.

All octocorals most likely have communities of tiny, almost microscopic invertebrates living on them that may be specially adapted to live on each of the different species of octocorals. These invertebrates may include different shrimps, amphipods, nudibranchs, and starfish. Some of these organisms are occasionally seen on the specimens in the wild or at the bottom of containers used to transport freshly harvested specimens, but the amount per colony is generally very small. Accurate bycatch species identification and counts can only be done in a laboratory with a dissecting scope, and it is unlikely that this information is available for most of the species harvested by marine life fishermen.

The impact of harvesting octocorals is most likely not discernable. Few fish feed directly on octocorals, octocoral communities are not considered prime habitat for most fish, the selective nature of the harvest has very little impact on the overall community, and because of the rapid growth of octocorals and their short natural lifespan, there is a rapid population replacement cycle in hardbottom habitats.

5.2.6.2 Live Rock Aquaculture

Description of fishing practices, vessels, and gear

The federal live rock aquaculture fishery for the South Atlantic EEZ takes place exclusively in the Florida Keys, mostly due to the narrow continental shelf off Southeast Florida and unsuitable conditions north of there. In the Florida Keys, most of the federal aquaculture sites are in 30 to 50' of water along the outer reef edge.

Federal live rock aquaculture permits are managed by the NOAA Fisheries Southeast regional office in St Petersburg Florida. Applicants must select a suitable site in federal waters, have the site surveyed and approved by a biologist from the Florida Keys National Marine Sanctuary, provide a geologic description of the seed rock to be used, and complete all the necessary paperwork required by NOAA Fisheries. Permitting from start to finish can be accomplished in less than three months if the applicant is well prepared, but most applications take longer to be approved.

Development of an approved site requires lots of hard work both above the water and below the water. Collecting and depositing suitable rock is tedious and must be done by hand. Upland rocks, generally purchased from limestone quarries in South Florida, must be transported to the site by boat and then lowered to the bottom in baskets and placed within the designated site boundaries. The average rock size is about 5 pounds and is somewhere between the size of a soft ball and a football. High quality rocks are irregular in shape and have numerous holes in them. Low quality rocks lack the irregular shape, have few if any holes, and are a denser type of limestone.

Most aquaculturists employ off-season commercial crawfish boats to transport the rock to the site and lower it to the bottom. A medium to large sized trap boat can haul 10,000 pounds of rock, and if the rock site is close to the dock, they can take two or more trips a day to the site. Most of the big rock deposits and underwater stacking activities take place in the late spring, summer, and fall when the commercial boats are available, the weather is consistently favorable, and the water is warm and clear.

To date, all federal sites have been located in sand, so most individuals have opted to lay a foundation of larger, less desirable rocks on the sand, and then build mounds on top of these foundations. Most work is done with SCUBA gear, but some operations use surface supplied air systems which consist of low pressure, high volume air compressors, filters, pressure tanks, and long hoses that have regulators on the ends.

The time required to "grow" a high quality live rock is about two years, but there is a market for one year old "base" rock, and there are maintenance steps that can be taken to produce high quality rock in under two years. The quality of the seed rock used will also have an impact on how soon it can be harvested and what its market value will be, so hand selected seed rocks will have a higher yield than machine sorted seed rocks.

Vessel types for live rock aquaculture depend on the size of the operation and the type of business. Individuals that are selling more than a thousand pounds a week generally operate 25 to 35' vessels ranging from open, center console skiffs, with outboard motors to traditional, closed cabin vessels with inboard diesel engines. Operations of this size usually have crews of two or three people, and use mechanical lifting devices such as davits and hydraulic hoists. Individuals selling less than a thousand pounds a week tend to operate out of boats less than 25', have a crew of just two people, and pull the rock by hand. These small operators also tend to participate in the marine life fishery, and often mix marine life collecting trips with live rock harvesting stops.

After the rock is harvested, it is usually transported submerged in water to a shore based facility where it is stored prior to being shipped out. Most of the rock is shipped by airfreight out of Miami or Ft. Lauderdale FL, but some is transported by truck to wholesalers in Tampa where it is then flown out of the Tampa area airports. A limited amount of rock is also shipped by FedEx, UPS, DHL, and the United States Postal service, and some is even trucked into the southeast U.S.

Economic description of the fishery

According to data collected by the Florida Wildlife Research Institute (FWRI), 36 different license holders reported a total of 3,136,819 pounds of aquacultured live rock harvested from the South Atlantic EEZ from 2002 to 2006. These license holders were not necessarily all different fishermen and not all of them owned their own aquaculture sites.

The landings data show a clear upward trend until 2005, after which landings drop from over a million pounds in 2004 to roughly 370,000 pounds in 2005 and to just over 13,000 pounds in 2006. This precipitous drop was a direct result of two very active hurricane seasons topped off by a disastrous late season hurricane Wilma in October of 2005. Only one Upper Keys live rock site remained in production following hurricane Wilma. Landings are expected to go back up in 2007, but for many, the risks of trying to grow live rock in the exposed offshore waters of the Florida Keys far outweigh the potential benefits.

The ex vessel price for high quality live rock is around $2.00 a pound, but the price can vary from market to market and season to season. There is a considerable amount of price pressure from cheap imports coming from Haiti and Southeast Asia, which has kept the price at or below the $2.00 per pound value for the last 15 years. Aquacultured live rock is generally denser and less porous than imported wild live rock, which detracts from its value. However, aquacultured live rock also tends to have more living organisms on it, which increases its value. Other positive selling points for the aquacultured rock are that it is domestically produced, may contain live stony corals, and it is not harvested from a natural reef.

Social and cultural environment

Live rock aquaculture is primarily a Florida based fishery with state and federal aquaculture sites on both coasts of Florida. Along the East Coast of Florida in the South Atlantic EEZ, all of the aquaculture sites are in the Florida Keys from about Tavernier to Key West. Most of the permit holders are also marine life fishermen, and the live rock is one of many products that they harvest for the marine ornamental trade. Most live rock producers operate small business with less than 5 employees, and most sell their product out of the state to wholesalers and pet shops, or directly to hobbyists. Prior to the active hurricane seasons of 2004 and 2005, there were several companies based outside of the Keys that were almost exclusively dependent on live rock for their income, but after losing everything to multiple hurricanes, they have moved their operations out of the Keys or have gotten out of the business completely. The surviving live rock operations are ones that do not depend on live rock for much more than 20% of their gross income.

Bycatch

Bycatch associated with live rock harvest is varied and often sold as part of the product. Macro algae, sponges, bryozoans, octocorals, and stony corals that attach to the rock are what add value to the rock and determines what type of rock it can be sold as. Not all of these sessile organisms are desirable, so the rocks are sometimes “cleaned” on the bottom or on the boat so that these undesirable organisms are not taken back to the holding facilities.

Another type of bycatch associate with live rock harvest is the numerous crabs, shrimps, snails, worms, and tiny fish that cling to the rocks or hide in the crevices of the rocks. Often times a quick shake on the bottom loosens up a lot of these small fish and invertebrates, but many remain attached to the rock and are brought to the surface. Once on the boat, most producers sort the rock and place it into holding tanks for transport to shore, so the sorting process also releases some of the attached organisms, which are then dumped back overboard. Whatever remains on the rock at this point is taken to shore and ends up in the shore based holding facilities, and some is actually shipped to the buyer still attached to the rock.

All of the bycatch associated with live rock aquaculture is inherently created by this method of harvest. Although there is bycatch associated with this industry, it is a bycatch that is essentially produced in conjunction with the production live rock. In many ways, offshore live rock aquaculture is a type of polyculture, because many different organisms are raised at the same time on the same site. Live rock aquaculture operations are net producers of marine life because whole communities of fish and invertebrates establish themselves around the live rock site and although the harvest operations disturb these communities, they continue to thrive there from year to year.

5.2.7 Sargassum

5.2.7.1 Description of fishing practices, vessels and gear

Only one company, Aqua-10 Laboratories, harvested pelagic *Sargassum* offshore of North Carolina from 1976 to 1997; no harvest has occurred since 1997. A total of approximately 448,000 pounds wet weight of pelagic *Sargassum* has been harvested to date. Pelagic *Sargassum* was originally collected with unweighted shrimp trawls or 3' x 4' and 4' x 8' beam trawls constructed of iron pipe with 1.5 inch and 2 inch mesh bags that were 6'- 8' deep. The average capacity of the beam trawl is 200 pounds of *Sargassum*. Initially, harvest was conducted during the months of June and September by Aqua-10 contracting with a shrimp, snapper grouper, or longline vessel to harvest pelagic *Sargassum* in conjunction with their regular fishing trip. No harvest occurred from 1991 through 1994. The company reinitiated harvest activities in 1995 and had purchased a former snapper grouper vessel to conduct directed trips harvesting pelagic *Sargassum* in the South Atlantic EEZ off North Carolina. The company anticipated growth in demand and projects an increase from an average annual harvest of 1,723 pounds dry weight or 17,230 pounds wet weight, to 50,000 dry weight or 500,000 pounds wet weight annually between 1999 and 2005 to meet demand. The company is no longer in operation and , no harvest has occurred since 1997.

Pelagic *Sargassum* was sun dried, powdered, fermented, and extracted to provide a processed liquid used by Aqua-10 in plant and yield stimulants (soil and foliar), fertilizer concentrate (soil and foliar), poultry feed supplement, and livestock feed supplement.

For a summary of previous harvest activities see, "Commercial harvest of pelagic *Sargassum*: A summary of landings since June 1995 (Settle, 1997)" and a NMFS SEFSC *Sargassum* harvest report - June 13 1996. In addition, reference the thesis prepared by Lawrence Settle (Settle, 1993) titled "Spatial and Temporal Variability in the Distribution and Abundance of Larval and Juvenile Fishes Associated with Pelagic Sargassum".

William E. Campbell, owner of Aqua-10 Laboratories, provided information on the harvest and processing of pelagic *Sargassum* during the informal review and public hearing process which is contained in the Administrative record. Additional comments were provided during the September 1998 Council meeting in Charleston, S.C. and are included in a supplemental comment package compiled for the December 1998 Council meeting. Mr. Campbell gave written permission for his confidential landings data to be used. In his comments to the Council on December 3, 1998, Mr. Campbell indicated he used 4-inch stretched mesh to harvest *Sargassum*.

Allowable gear

Harvest and possession of Sargassum is prohibited south of the latitude line representing the North Carolina/South Carolina border (34º North latitude). All harvest is prohibited within 100 miles of shore between the 34º North latitude line and the line representing the North Carolina/Virginia border. Harvest is limited to the months of November through June. Official observers are required on any harvesting trip. An annual quota of 5,000 pounds landed wet weight. Nets used to harvest Sargassum be constructed of 4" stretch mesh or larger fitted to a frame no larger than 4 x 6 feet.

5.2.8 Dolphin and Wahoo

5.2.8.1 Description of fishing practices, vessels and gear

The fishery for dolphin and wahoo is prosecuted along the Atlantic coast predominately south of Virginia into the Caribbean Sea and the Gulf of Mexico. The fishery is seasonal with catches from the Atlantic occurring mainly between April and September, catches from the Caribbean primarily occurring January through June, and catches in the Gulf of Mexico mainly occurring between May and October (Table 5.2.8-1).

Historically, Atlantic recreational fishermen have landed greater than 90% of the total harvest of dolphin. In 2007, estimates of total catch indicate the commercial fishery harvested 8% of the over 9 million pounds landed. Fishermen harvested 1.96 million pounds of wahoo in 2007 of which 92% were harvested by the recreational fishery, primarily in the private/rental mode.

Commercial fishery

Dolphin

In the Atlantic, commercial fisheries for dolphin consist primarily of longline and hook and line (which includes hand line, troll, rod and reel and electric reel). The hook and line portion of the commercial fishery is conducted similarly to the recreational hook and line segment, which is described under the recreational fisheries section. The longline component of the fishery consists of longliners that primarily target highly migratory species but may also catch dolphin and longliners that target dolphin directly.

Table 5.2.8-1. Summary of locations and approximate seasonality of commercial and/or sport fisheries for dolphin (*Coryphaena hippurus*) within the western central Atlantic (Oxenford 1997). References are found in Oxenford (1997).

Area	Location	Approximate seasonality	Selected References
Southeastern USA	North Carolina South Carolina Georgia East Florida	April-Sept	Ellis 1957 Iversen 1962 Beardsley 1967 Rose & Hassler 1969 Hassler & Hogarth 1977 Gentle 1977 Brusher & Palko 1985 Oxenford & Hunte 1986 Palko *et al.* 1989
Southern USA (Gulf of Mexico)	West Florida Alabama Mississippi Louisiana Texas	May-Oct	Baughman 1941 Springer & Pirson 1958 Fable 1981 Bentivoglio 1988 Palko *et al.* 1989
Central America (Caribbean coast)	Mexico	?	FAO 1996
Northern Caribbean	Bahamas Hispaniola Puerto Rico US Virgin Islands	Jan-June	Erdman 1956 Olsen & Wood 1982 Appeldoorn & Meyers 1993 Perez & Sadovy 1991 Perez *et al.* 1992 Rivera Betancourt 1994
Eastern Caribbean	Guadeloupe Martinique Dominica St. Lucia Barbados St. Vincent Grenada Tobago	Dec-June	Mahon *et al.* 1981 Sacchi *et al.* 1981 Murray 1985 Oxenford & Hunte 1986 Hunte 1987 Mahon *et al.* 1990 Mahon 1993 FAO 1996 Mohammed 1996
Southern Caribbean	Curacao	Dec-July	Zaneveld 1961
South America	Northeast Brazil	?	Monteiro *et al.* 1996
Atlantic	Bermuda	March-Dec	Oxenford & Hunte 1986

In development of the Dolphin Wahoo FMP, NMFS provided the Council with a characterization of the directed commercial longline fishery for dolphin in the Atlantic as consisting of approximately 3 or 4 longline vessels that direct effort on dolphin on a regular basis off the coasts of North and South Carolina and longliners who catch dolphin and wahoo but primarily target highly migratory species, mainly swordfish and shark. In the mid to late 1990s, there was an increase in longline landings of dolphin in the South

Atlantic with the participation of swordfish and shark longliners who have been adapting their gear to simultaneously target dolphin. They also focus more effort on dolphin after shark and swordfish quotas have been met. This increased participation by these other longliners may alter the makeup of this fishery as those vessels that participated in the directed fishery for dolphin withdraw for a variety of reasons. According to reports by NMFS (1995 & 1996), there may be as many as 20 longline vessels that participated in this fishery. With implementation of the FMP, federal dolphin wahoo commercial permits are required and now over 1,196, 11, 452, and 75 permits are held by applicants in Florida, Georgia, North Carolina and South Carolina respectively.

The directed fishery begins the last part of April and continues for about 3 weeks initially off the coast of South Carolina then north to Morehead City, North Carolina where dolphin become more scattered and difficult to catch near the middle of July. Most fishing occurs on either side of the Gulf Stream where eddies spin-off with early concentrations on the western side.

Vessels in the directed longline fishery make sets during the daytime using gear that is from 2 to 6 miles in length. The mainline is often 700 pound monofilament with leaders of 400 pound monofilament. There are ordinarily a total of 75 to 80 hooks per mile with a maximum of 480 hooks total. The standard No. 5 circle hooks that are used for dolphin are smaller than those normally used for conventional longline fishing. Leaders of around 18 inches are also shorter than normal with one hook per leader. No drop lines are used in this fishery and haul back is immediate. Fish are located using hook and line gear along weed lines or temperature breaks. Gear may be set in a circular pattern to facilitate haulback and as many as six sets may be made daily. Trips may average 2 days in length (NMFS, 1995 & 1996).

Longline vessels in the shark and swordfish fisheries target dolphin simultaneously by attaching small leaders to their float buoys. There is usually only one leader per buoy with approximately 100-150 such rigs employed at one time. These dolphin rigs are retrieved at the same time as the main longline which is often set overnight (NMFS, 1995 & 1996).

In addition to longlines primary commercial gear include hand lines and rod and reel (Table 5.2.8.2). The commercial dolphin fishery in New England has fluctuated with average landings for 1984-97 of 10,701 pounds. Average landings over 1994-97 were up slightly to 13,570 pounds then back down to 9,403 over 1997-2000. Commercial landings have increased between 2000-2007 reaching 23,300 with an all time high of 40,140 pounds being landed in 2007 (table 5.2.8-2). In the Mid-Atlantic, landings averaged 70,761 pounds for 1984-97, increased to 131,933 over 1994-97, and then decreased to 82,342 pounds over 1997-2000. The decrease continued through 2000-2007 reaching 45,041 as an average for the period (Table 5.2.8.3). South Atlantic landings averaged 920,870 pounds over 1984-97, increased to 1,428,484 over 1994-97, and then decreased to 1,018,863 pounds over 1997-2000. Between 2000-2007 landings in the South Atlantic averaged 492,557.

South Atlantic commercial landings are shown by state in Table 5.2.8-4. Average landings were highest in Florida followed by North Carolina, South Carolina, and Georgia; however, in 2004 and 2007 landings from North Carolina exceeded Florida. For the most recent time period (2007) landings were 290,811 pounds in Florida, 369,462 pounds in North Carolina, 56,856 pounds South Carolina, and 6,925 pounds in Georgia.

Table 5.2.8-2. Commercial landings of dolphin (pounds) in the Atlantic by primary gear type for 2002-2007 (Data Source: NMFS ALS 2008).

Gear Type	2002	2003	2004	2005	2006	2007
Not Coded	50	135	7,665	13,082	12,667	22,051
Lines Hand, Other	149,525	143,216	95,835	167,626	71,917	88,024
Rod and Reel	16,266	11,171	18,291	29,790	24,224	33,013
Reel, Electric or Hydraulic	6,325	3,187	11,624	18,664	6,752	13,102
Lines Troll, Other	53,766	30,694	37,976	67,083	23,902	68,555
Lines Long Set With Hooks	299,557	325,728	359,350	624,533	264,482	500,688
Lines Long, Reef Fish	6,010	7,827	36,150	70,139	28,298	68,032
Lines Long, Shark	1,302	106	67	94	41,921	
Diving Outfits, Other	283	1,121	326	732	304	619
Lines Long Drift With Hooks					55,836	24,676

New England commercial landings of dolphin are shown by state in Table 5.2.8-3

Table 5.2.8-3. Commercial landings of dolphin (pounds) in New England by state for 2000-2007 (Source: NMFS ALS 2007, non confidential).

	Connecticut	Delaware	Massachusetts	Rhode Island
2000	30	225	4,619	1,896
2001	583	258	3,863	24,654
2002	2,529	173	-	12,307
2003	406	-	9,327	11,542
2004	-	438	16,667	17,958
2005	-	317	12,931	5,547
2006	-	348	7,928	11,717
2007	-	-	25,230	14,910

Mid-Atlantic commercial landings are shown by state in Table 5.2.8-4.

Table 5.2.8-4. Commercial landings of dolphin (pounds) in the Mid-Atlantic by state for 1984-2007 (Source: NMFS and Goodyear, 1999, NMFS, 2000 and NMFS ALS 2007, non confidential).

	Maryland	New Jersey	New York	Virginia
2000	4,668	20,567	10,588	-
2001	5,276	28,187	17,621	-

2002	848	58,408	24,105	-
2003	-	30,350	15,790	1,089
2004	-	26,807	2,535	-
2005	2,851	12,969	5,993	620
2006	5,258	18,100	3,421	627
2007	-	59,595	4,052	-

South Atlantic commercial landings of dolphin are shown by state in Table 5.2.8-5.

Table 5.2.8-5. Commercial landings of dolphin (pounds) in the South Atlantic by state for 2000-2007 (Source: NMFS ALS 2007, non confidential).

	North Carolina	South Carolina	Georgia	Florida East Coast
2000	197,249	66,721	6,648	266,459
2001	160,537	95,816	8,442	206,102
2002	168,427	88,310	-	179,735
2003	186,250	63,058	-	210,043
2004	255,801	74,572	-	178,140
2005	139,759	66,632	-	169,585
2006	159,573	61,468	-	212,080
2007	369,462	51,856	6,923	290,811

Wahoo

The commercial fishery for wahoo is incidental to fishing for dolphin or other pelagic species. In New England landings while being sporadic, peaked at 16,720 pounds in 1994 and dropped off to 110 and 163 pounds for 1995 and 1996 respectively. Landings for 1997 through 1999 were 75 pounds or less. Landings between 2000-2007 have averaged 222 pounds. In the Mid-Atlantic, annual commercial landings from 1984 through 1997 averaged 1,840 pounds (Table 5.2.8-6). Landings increased to an average of 3,890 pounds in 1994 through 1997 and declined slightly to 3,104 pounds for 1997-2000. In the South Atlantic annual commercial landings ranged from 25,137 pounds in 1984 to 102,277 pounds in 1995. Average landings were 85,264 pounds in 1994-97 and declined slightly to 80,486 pounds in 1997-2000 and between 2001 and 2007, further declined to an average of 45,382 (Table 5.2.8-7).

Table 5.2.8-6. Commercial landings of wahoo by New England and Mid-Atlantic state 2000-2007 (Data Source: NMFS ALS).

	Rhode Island	Mass.	Delaware	New York	New Jersey	Maryland	Virginia
2000	339	-	-	672	1,267	1,186	-
2001	405	-	-	283	962	-	-
2002	299	-	-	525	757	35	-
2003	-	342	-	212	602	-	-
2004	-	771	-	-	2,350	-	-
2005	-	650	-	173	-	1,232	-

2006	-	-	58	246	1,427	-	-
2007	393	356	-	405	3,048	-	56

Table 5.2.8-7. Commercial landings of wahoo by South Atlantic state 2000-2007 (Data Source: NMFS ALS).

	North Carolina	South Carolina	Georgia	Florida East Coast
2000	19,906	7,753	-	17,723
2001	20,512	5,840	-	20,638
2002	19,957	3,938	-	24,279
2003	17,221	3,981	-	21,746
2004	22,011	3,911	-	20,846
2005	14,988	4,935	-	12,884
2006	16,544	2,752	-	10,390
2007	24,311	3,189	-	14,330

Recreational fishery

Dolphin

The recreational dolphin fishery in New England has been sporadic with the average landings from 1984-97 at 19,524 pounds to 5,588 in the period 2000-2007 (Table 5.2.8-8). The dolphin fishery in the Mid-Atlantic had average landings of 477,655 pounds for the 1984-97 period. The more recent landings average 61,903 pounds for the time period 2000-2007. Recreational landings of dolphin in the South Atlantic have increased over time but have shown wide fluctuation in catches from year to year; landings for the South Atlantic peaked at just over 12 million pounds in 1995; average landings for 2000-2007 were 8,430,861 pounds (Table 5.2.8-14).

Florida and North Carolina account for the bulk of landings. Average landings in Florida for 1994-97 were 6,398,917 pounds and declined to 4,731,124 pounds for 1997-99. Average landings 2000-2007 were 4,471,990 pounds Table 5.2.8-14). The trend was reversed in North Carolina with average landings increasing from 3,403,370 pounds to 4,243,769 pounds for the same time periods. Average landings remained fairly constant at 3,341,205 for 2000-2007. Average landings increased in South Carolina to 611,475 with a high of 2,268,963 pounds in 2007. Landings in Georgia for these same time periods was fairly constant at almost 6,000 pounds.

Recreational landings by state and mode within the Atlantic are shown in Tables 5.2.8-8 and 5.2.8-12. data through 2007. Recreational landings by state in the Mid-Atlantic are shown in Table 5.2.8-9. Landings have been variable and spread amongst the States of Maryland, New Jersey, New York, and Virginia. Over the 2000-2007 time period, Virginia and Maryland accounted for the majority of landings. Landings from the recreational sector by state and mode within the Atlantic are presented in Table 5.2.8-8 through 5.2.8-10. These tables provide more detail by State but follow the general trends described above.

The overall trend by mode within the New England, Mid-Atlantic and South Atlantic are shown in Tables 5.2.8-8, through 5.2.8-10 and 5.2.8-5; data provided through 2007. In New England (Table 5.2.8-8) private/rental now exceeds charter. Florida (Table 5.2.8-15) the private/rental catch greatly exceeds the charter catch. South Atlantic charter fleet has accounted for more of the recent landings (Table 5.2.8-10).

Table 5.2.8-8. Comparison of recreational landings of dolphin (pounds) in New England by primary harvest mode 2000-2007 (Data Source: MRFSS 2008).

	MRFSS Charter	MRFSS Private
2000	-	-
2001	-	363
2002	-	21,202
2003	-	7,643
2004	-	-
2005	-	14,211
2006	-	1,285
2007	-	-

Table 5.2.8-9. Comparison of recreational landings of dolphin (pounds) in the Mid-Atlantic by primary harvest mode 2000-2007 (Data Source: MRFSS 2008).

	MRFSS Charter	MRFSS Private
2000	-	155,134
2001	-	33,827
2002	-	41,151
2003	-	63,481
2004	-	27,293
2005	15,419	44,462
2006	38,445	50,455
2007	9,587	15,968

Table 5.2.8-10. Comparison of recreational landings of dolphin (pounds) in the South Atlantic by primary harvest mode 2000-2007 (Data Source: MRFSS 2008).

	MRFSS Charter	MRFSS Private
2000	610,544	1,249,853
2001	423,329	1,102,382
2002	518,981	777,666
2003	208,418	929,608
2004	348,612	541,927
2005	567,349	566,276
2006	441,095	680,375
2007	443,571	770,163

Note: no recorded headboat landings 2000-2007

Table 5.2.8-11. Recreational landings of dolphin (pounds) in the Atlantic by mode 2000-2007 (Data Source: MRFSS and NMFS Headboat Survey).

	Headboat	MRFSS Charter	MRFSS Private	Rec. Total
2000	31,701	4,291,309	7,151,982	11,474,992
2001	32,897	3,349,390	8,895,620	12,277,907
2002	17,798	4,319,966	5,584,374	9,922,137
2003	7,505	1,639,730	6,270,811	7,918,046
2004	12,235	2,699,631	3,852,428	6,564,294
2005	10,731	4,637,952	4,129,963	8,778,647
2006	443,275*	3,858,555	4,332,240	8,634,071
2007	21,319	3,941,133	5,155,273	9,117,724

Table 5.2.8-12. Recreational landings of dolphin by New England and Mid-Atlantic state 2000-2007 (Data Source: MRFSS 2008).

	Rhode Island	Mass.	Delaware	New York	New Jersey	Maryland	Virginia
2000	-	-	19,438	503,352	29,883	5,141	98,532
2001	-	-	50,876	17,359	-	32,513	80,856
2002	123,339	-	29,202	-	20,020	181,522	343,038
2003	-	-	5,626	203,899	16,061	75,497	7,028
2004	-	-	10,187	5,712	178,676	83,704	109,906
2005	-	-	6,550	12,963	89,494	30,379	4,429
2006	-	-	90,228	30,296	168,630	159,095	70,349
2007	-	4,266	1,475	-	54,469	49,246	124,743

Note: no recorded headboat landings 2000-2007

Table 5.2.8-13. Recreational landings of dolphin (pounds) by South Atlantic State for 1984-2007 (Source: MRFSS, 2008).

	North Carolina	South Carolina	Georgia	Florida East Coast
1984	2,526	71,755	0	3,231,309
1985	444,355	1,226,930	5,915	3,669,896
1986	1,449,289	2,268,963	390	3,065,732
1987	761,841	10,064	1,493	3,573,442
1988	907,151	142,234	0	5,248,659
1989	1,898,646	97,265	0	7,779,449
1990	1,553,099	57,000	0	5,717,045
1991	1,535,740	119,176	7,992	9,533,120
1992	997,262	44,544	2,809	4,108,846
1993	2,348,073	343,968	120,724	2,551,424
1994	2,939,585	92,205	3,382	6,583,804
1995	3,638,181	89,489	1,803	8,531,897
1996	2,168,491	148,288	3,338	5,035,966

1997	4,886,057	174,479	606	5,456,469
1998	3,466,778	123,473	0	3,652,416
1999	4,397,882	193,630	17,196	5,171,410
2000	5,757,355	85,715	21,753	6,546,941
2001	6,141,218	682,430	7,273	6,594,534
2002	6,355,915	192,863	556	4,067,630
2003	3,615,079	165,627	9,131	4,850,585
2004	2,963,900	199,728	2,297	3,749,295
2005	2,526	71,755	0	3,231,309
2006	444,355	1,226,930	5,915	3,669,896
2007	1,449,289	2,268,963	390	3,065,732

Table 5.2.8-14. Recreational landings of dolphin (pounds) on the Florida East Coast by mode for 1981-2007 (Source: FWRI, 2008).

Year	Shore	Charter Boats	Private Vessels	Headboat (not available)	Total
1981			2,848,522		2,848,522
1982			3,406,674		3,406,674
1983			5,328,944		5,328,944
1984			3,231,309		3,231,309
1985			3,669,896		3,669,896
1986		667,176	2,398,556		3,065,732
1987		328,377	3,245,065		3,573,442
1988		565,544	4,683,115		5,248,659
1989	18,150	1,452,697	6,308,602		7,779,449
1990		342,041	5,375,004		5,717,045
1991		713,492	8,819,628		9,533,120
1992	48,711	1,206,104	2,854,031		4,108,846
1993	66,612	537,623	1,947,189		2,551,424
1994	8,527	1,930,998	4,644,279		6,583,804
1995		2,932,043	5,599,854		8,531,897
1996		1,305,053	3,730,913		5,035,966
1997		1,274,078	4,182,391		5,456,469
1998		1,642,418	2,009,998		3,652,416
1999		924,960	4,246,450		5,171,410
2000		834,558	5,712,383		6,546,941
2001		1,005,414	5,589,120		6,594,534

2002		542,446	3,525,184		4,067,630
2003		314,244	4,536,341		4,850,585
2004		379,857	3,369,438		3,749,295
2005		299,656	2,892,232		3,191,888
2006		290,941	3,917,905		4,208,846
2007		228,639	3,778,299		4,006,938

Wahoo

Wahoo are primarily caught using the same fishing methods as dolphin, i.e., trolling. The recreational fishery for wahoo mainly operates off North Carolina and the east coast of Florida. Annual recreational landings in the South Atlantic ranged from a low of 282,967 pounds in 1990 to a high of 2,470,098 pounds in 1986; landings in 1999 were 1,172,886 pounds and 991,559 in 2000. Average South Atlantic landings for the period 1994-1997 were 866,327 pounds and increased to 992,224 for 1997-2000. More recent information data shows (Table 5.2.8-15). In the Mid-Atlantic, for the period 1994-1997, average landings were 16,239 pounds and increased to 76,433 pounds in the 1997-2000 period (Table 5.2.8-16). In New England there were only landings in 1993 (5,738 pounds) and 1998 (5,355 pounds) (Table 5.2.8-16).

Recreational landings by state and mode (Florida) are shown in Tables 5.2.8-15 through 5.2.8-17. The charterboat sector in North Carolina landed the largest quantity of wahoo for the period 1994-1997, with an average annual landings of 363,386 pounds during this period. Total recreational landings from North Carolina averaged 502,523 pounds for the same time period. Landings from the more recent time period 2000-2007 have increased averaging 587,430 pounds with an all time high of 1,025,379 pounds recorded in 2007 (Table 5.2.8.16). The private/rental sector on Florida's East Coast accounted for the next highest average landings of 204,098 pounds during the period 1994-1997, then the private/rental fleet in North Carolina at 138,906 pounds (Table 5.2.9-16), and the charter fleet on the east coast of Florida averaging 132,349 pounds (Table 5.2.8-16) for the same period. Average annual recreational landings of wahoo for the period 2000-2007 for recreational fishermen in South Carolina were 81,512pounds (Table 5.2.8-16).

Table 5.2.8-15. Recreational landings of wahoo (pounds) by New England and Mid-Atlantic State 2000-2007 (Data Source: MRFSS 2008).

	Delaware	New Jersey	Maryland	Virginia
2000	-	-	-	44,275
2001	-	-	-	-
2002	-	-	-	-
2003	-	-	-	-
2004	-	-	21,665	-
2005	-	-	1,689	-
2006	-	-	3,448	-
2007	311	80,598	7,721	5,534

Table 5.2.8-16. Recreational landings of wahoo (pounds) by South Atlantic State for 2000-2007 (Source: FWRI, 2008).

	North Carolina	South Carolina	Georgia	Florida East Coast
2000	470,832	113,517	8,245	441,385
2001	425,596	62,827	-	561,340
2002	642,894	79,714	-	517,365
2003	540,879	265,903	1,556	290,297
2004	700,353	11,751	-	211,130
2005	502,629		-	305,736
2006	390,880	20,675		345,141
2007	1,025,379	97,710	14,116	682,701

Table 5.2.8-17. Recreational landings of wahoo (pounds) on the Florida East Coast by mode for 2000-2007 (Source: FWRI, 2008).

Year	**Shore**	**Charter Boats**	**Private Vessels**	**Headboat (not available)**	**Total**
2000		93,881	347,504		441,385
2001		75,014	486,326		561,340
2002		97,126	420,239		517,365
2003		22,613	267,685		290,298
2004		16,806	194,324		211,130
2005		45,152	260,584		305,736
2006		19,617	325,522		345,139
2007		36,546	646,153		682,699

Allowable gear

Allowable gear in the Atlantic EEZ: Pelagic longline*, hook and line gear including manual, electric, or hydraulic rod and reels, bandit gear, handline and spearfishing gear (including powerheads).

*Surface and pelagic longline gear for dolphin and wahoo is prohibited within any "time area closure" in the Atlantic EEZ which is closed to the use of pelagic gear for highly migratory pelagic species (HMS).

5.2.8.2 Economic description of the fishery

Commercial fishery

Prior to the 1970s, most dolphin landings occurred in Florida; however, by the mid-70s there were significant landings in other areas within the South Atlantic region. During the late 1970s, landings increased in the northeast from Maine to Virginia (Thompson, 1999). Commercial landings of dolphin increased from 7% of total harvest in 1985 to about 19% by 1996 (Table 5.2.8-18). In 1995, commercial landings in the Atlantic exceeded 2.2 million pounds. This sector's landings exceeded one million pounds in 1989, and doubled in 1995. During the period 1997 to 1999 the proportion of commercial landings have dropped to around 11% of the total harvested in the Atlantic. The commercial harvest between 2000 and 2007 has ranged from 5% in 2001 and 10% in 2004 of the total Atlantic harvest. Recreational harvest has conversely run between 95% in 2001 to 90% in 2004.

Dolphin are caught off North and South Carolina mainly from May through July. Off Florida's east coast the main season occurs between April and June (Thompson, 1999).

Table 5.2.8-18. Proportion of total Atlantic recreational and commercial dolphin landings 1994-2007 (Data Source: MRFSS, NMFS ALS and NMFS Headboat Survey).

	Headboat	ALS	MRFSS Charter	MRFSS Private	Rec. Total	Comm. Total	% Rec	% Comm
1994	11,275	1,112,571	2,557,377	3,143,233	5,711,886	1,112,571	84%	16%
1995	23,996	1,963,370	3,703,519	4,698,248	8,425,762	1,963,370	81%	19%
1996	21,435	1,149,556	3,050,665	3,719,142	6,791,242	1,149,556	86%	14%
1997	20,150	1,464,594	5,276,326	4,420,613	9,717,089	1,464,594	87%	13%
1998	9,668	726,641	4,482,453	2,405,513	6,897,634	726,641	90%	10%
1999	22,587	944,183	3,601,592	5,530,947	9,155,127	944,183	91%	9%
2000	31,701	948,127	4,291,309	7,151,982	11,474,992	948,127	92%	8%
2001	32,897	698,239	3,349,390	8,895,620	12,277,907	698,239	95%	5%
2002	17,798	610,411	4,319,966	5,584,374	9,922,137	610,411	94%	6%
2003	7,505	679,482	1,639,730	6,270,811	7,918,046	679,482	92%	8%
2004	12,235	755,222	2,699,631	3,852,428	6,564,294	755,222	90%	10%
2005	10,731	541,321	4,637,952	4,129,963	8,778,647	541,321	94%	6%
2006	443,275	594,050	3,858,555	4,332,240	8,634,071	594,050	94%	6%
2007	21,319	844,990	3,941,133	5,155,273	9,117,724	844,990	92%	8%

Ex-vessel value of dolphin captured in the Atlantic between 2000 and 2007 are presented in Tables 5.2.8-19 through 5.2.8-23. Based on information from fishermen, the bulk of this recreational sale can be attributed to the for-hire sector.

Table 5.2.8-19. Commercial landings of dolphin (ex-vessel value in dollars) in New England by state for 2000-2007 (Source: NMFS ALS 2007, non confidential).

	Connecticut	Delaware	Massachusetts	Rhode Island
2000	$53	$450	$8,501	$3,860
2001	$1,166	$336	$6,090	$25,259
2002	$2,085	$286	-	$18,092
2003	$734	-	$16,410	$22,604
2004	-	$1,009	$28,499	$38,444
2005	-	$671	$24,953	$10,531
2006	-	$789	$15,437	$18,742
2007	-	-	$49,357	$27,751

Table 5.2.8-20. Commercial landings of dolphin (ex-vessel value in dollars) in the Mid-Atlantic by state for 1984-2007 (Source: NMFS and Goodyear, 1999, NMFS, 2000 and NMFS ALS 2007, non confidential).

	Maryland	New Jersey	New York	Virginia
2000	$8,075	$36,810	$19,669	-
2001	$6,694	$30,670	$18,830	-
2002	$740	$102,034	$36,017	-
2003	-	$62,178	$33,146	$1,089
2004	-	$51,779	$4,625	-
2005	$4,958	$24,846	$13,049	$1,136
2006	$9,555	$34,664	$6,051	$1,002
2007	-	$128,337	$8,534	-

Table 5.2.8-21. Commercial landings of dolphin (ex-vessel value in dollars) in the South Atlantic by state for 2000-2007 (Source: NMFS ALS 2007, non confidential).

	North Carolina	South Carolina	Georgia	Florida East Coast
2000	$306,692	$105,363	$8,360	$401,328
2001	$220,795	$120,943	$6,608	$273,191
2002	$243,520	$122,431	-	$253,748
2003	$329,379	$108,149	-	$320,108
2004	$452,584	$129,542	-	$295,498
2005	$258,628	$145,889	-	$297,828
2006	$307,502	$121,130	-	$371,303
2007	$762,110	$105,107	$9,971	$552,178

Table 5.2.8-22. Commercial landings of wahoo (ex-vessel value in dollars) by New England and Mid-Atlantic state 2000-2007 (Data Source: NMFS ALS).

	Rhode Island	Mass.	Delaware	New York	New Jersey	Maryland	Virginia
2000	$714	-	-	$1,150	$3,028	$2,973	-
2001	$718	-	-	$491	$2,298	-	-

2002	$611	-	-	$1,133	$1,241	$18	-
2003	-	$585	-	$444	$1,530	-	-
2004	-	$1,433	-	-	$5,566	-	-
2005	-	$1,415	-	$280	-	$2,927	-
2006	-	-	$129	$467	$3,557	-	-
2007	$782	$817	-	$1,018	$7,731	-	$112

Table 5.2.8-23. Commercial landings of wahoo (ex-vessel value in dollars) by South Atlantic state 2000-2007 (Data Source: NMFS ALS).

	North Carolina	South Carolina	Georgia	Florida East Coast
2000	$46,483	$16,893	-	$42,487
2001	$41,718	$11,458	-	$47,871
2002	$38,299	$7,980	-	$59,004
2003	$42,239	$8,361	-	$54,691
2004	$50,028	$7,651	-	$53,210
2005	$32,819	$10,262	-	$32,234
2006	$38,140	$5,749	-	$26,447
2007	$55,649	$7,598	-	$37,640

Price Fluctuations in the Dolphin Fishery

Dolphin prices are similar to that of king mackerel. Even though landings increased significantly during the early and mid 1980s, real prices continued to increase. This trend continued until 1989 when landings doubled from the previous year and prices declined. In the 1990s price reached an all time high in 1994 despite the increase in landings during this period. Rhodes (1998) speculated that this phenomenon was the result of unmet demand for other seafood products that could be substituted with dolphin products such as mahi-mahi steaks. This increasing price trend did not continue when landings reached 2.6 million pounds in 1995. Prices declined in 1995 reaching a seven year low in 1997. Rhodes (1998) also analyzed monthly price data and surmised that in the South Atlantic region, prices are at their lowest in the first half of the year, usually May to June.

It is difficult to determine what factors are responsible for the decrease in price in the years following 1995. Part of this effect may be due to increased landings that peaked in 1995 at 2.57 million pounds. Also, imports may have played a role in this price decline, however import data on dolphin are only available from 1997. Furthermore, The Fisheries Statistics & Economics Division of the National Marine Fisheries Service (NMFS) report only imports of frozen dolphin fillets. A total of 15.75 million pounds of frozen dolphin fillets were imported at a value of $20.23 million dollars in 1997. In 1998 imports were 16.72 million pounds at a value of $23.95 million dollars. However, these figures may be underestimates of dolphin imports. Information from seafood distributors indicate that fresh, de-headed, and gutted dolphin, as well as other product forms, are also imported by U.S. buyers (Rhodes, 1998). Given the lack of historical and complete import data it is difficult to speculate on the influence of imports on domestic prices. A survey of U.S. buyers to collect data on all dolphin product forms imported into the U.S. by country of origin, time of year, and port of entry will provide some of the necessary information for market analysis.

Price Fluctuations in the Wahoo Fishery

In the United States fisheries for wahoo exist off North and South Carolina, primarily from April to September and off Florida's East Coast. The National Marine Fisheries Service first recorded landings of wahoo in the commercial catch in 1974 when they amounted to 1,000 pounds caught primarily off Florida. Landings during the period 1987 to 1993 ranged between 160,000 to 370,000 pounds (Vondruska, 1999). Recently Louisiana has landed the most. In fact in 1997 more than 50% of total wahoo commercial landings came from Louisiana (Vondruska, 1999). Price per pound was less than $1.00 until 1985. During the period from 1985 to 1994 real price fluctuated but remained below $1.23 per pound. From 1995 to 1997 the price per pound increased above $1.30 per pound.

Recreational fishery

The preceding section provides a detailed account of the historical recreational catch of dolphin in the Atlantic by mode of fishing. In summary, the total 1999 recreational harvest accounted for 91% (10,127,970 pounds total recreational harvest and 1,050,090 pounds commercial harvest) of the total U.S. harvest in 1999. Most of this recreational activity occurs in the summer months, and charter boat and private boat modes take the majority of the recreational catch of this species.

The size distribution of the catch from the recreational sector differs depending on the mode of fishing (Goodyear, 1999). Headboats harvest smaller fish compared to the other two modes. Just over 55% of the headboat catch are fish below 22 inches (550 mm) fork length. For the most part, the size distribution of fish harvested by private/rental boats and party/charter boats are fairly similar for both groups (Goodyear, 1999). Both size of fish caught and catch success rates are important determinants of the quality of the recreational experience, and thus the value of these recreational trips.

Information on the value of the dolphin recreational fishery in the Atlantic is not yet available. Apart from the economic value (consumer surplus) anglers derive from the resource, they generate significant economic impact through expenditures for recreational fishing which are important to coastal communities in the Atlantic. Data on economic impact of recreational fishing for dolphin are not available.

Like dolphin, the recreational landings of wahoo account for a larger proportion of the total harvest in the Gulf and Atlantic. In 1999 the total commercial harvest amounted to 99,159 pounds, compared to 1.41 million pounds harvested by recreational anglers. Information on the value of the wahoo recreational fishery and data on economic impact of recreational fishing for wahoo are not available.

The charterboat sector in the South Atlantic and the Gulf of Mexico depend on dolphin as one of the main attractions for their clientele. Available data indicates that this species is less important to the headboat sector (Holland et al., 1999). Of all charterboat owners surveyed as part of a study to document the characteristics and economics of the for-hire sector in the State of Florida, 26% target dolphin. This species was much more important to the charter fleet operating in the Florida Keys and Florida's Atlantic Coast. Results from this study also revealed that 53% of charterboats in North Carolina and 60% of charterboats in South Carolina target dolphin (Holland et. al., 1999).

In their study Holland et al. (1999) measured capital investment, average annual expenses, and average revenue in the for-hire sector. A summary of this data is contained in Table 5.2.8-24. On average it appears that investment in equipment is much higher in Florida compared to the rest of the South Atlantic.

In terms of fixed costs, it is unclear as to whether these expenditures were apportioned to charters and other revenue earning activities for the vessel. Some charterboats are full-time operations while others may only operate charters on a seasonal basis and could be commercial harvesters for part of the fishing year. For part-time operations the total annual fixed costs can be attributed to several activities including commercial fishing.

Table 5.2.8-24. Summary of Capital Investment, Average Annual Expenses, and Average Annual Revenue on Charterboats. Data on Florida includes information for the entire State of Florida (Source: Holland et. al., 1999).

Item	Florida	North Carolina	South Carolina	Georgia	Average for NC, SC, GA
Average Capital Investment:					
Hull and Superstructure	$90,989				$39,445
Engine	$40,518				$14,586
Electronics	$5,568				$5,900
Other Equipment and Tackle	$5,878				$4,463
Average Annual Expenditures					
Wages and Salaries	$25,810				$17,298
Fuel and Oil	$8,224				$7,575
Engine	$6,334				$2,738
Maintenance and Repair	$5,720				$4,991
Docking Fees	$4,604				
Hull and Superstructure	$3,020				
Insurance	$2,970				
Other Equipment and Tackle	$2,404				
Advertising	$2,041				
Average Total Exp.	**$68,574**	**$46,888**	**$23,235**	**$41,688**	
Average Annual Revenue	**$68,816**	**$60,135**	**$26,304**	**$56,851**	

Crew wages may be underestimates in that they do not reflect the "tips" left by customers. Out of state anglers typically give the fish they catch to the crew members on these charter vessels in lieu of a tip. Crew members, and sometimes vessel owners, sell these fish. The frequency of this practice varies by state within the South Atlantic region and may be more common in Georgia and the Florida Keys. Income derived from bag limit caught fish is not reflected in these revenue estimates or crew salaries. As a result it could be misleading to use this information to determine profitability of the charterboat fleet in each state under current operating procedures. However, these data provide a first step in describing the economic characteristics of this sector.

5.2.8.3 Social and cultural environment

There are little data available that are directly applicable to dolphin and wahoo recreational and commercial fishing communities in the U.S. Atlantic. The data that are available are only partial for some communities and then, in many cases, only some sectors in those communities (commercial, charter, and/or recreational). Until complete and comparative social research is carried out in these regions, the following overview must be considered the best available data on the social characteristics of these fishing communities.

However, the community profiles that are included in Section should be viewed as representative of fishing communities throughout the various geographic regions of the dolphin wahoo fishery. All of the communities profiled count dolphin and wahoo as a fishery that is exploited at least for a portion of the year and at least among one or more user groups. This lack of complete data should not be seen as necessarily detrimental to the analysis of possible social impacts accruing from this proposed fishery management plan. Rather, the data that are available allows for reasonable predictions of social outcomes due to management measures. What social impacts that occur in one community can then be reasonably expected to occur in other communities that are either somewhat larger or smaller, older or less historical, and with somewhat different demographic, cultural, and economic mixes. This is stated as an acceptable procedure in the CFR Sec.1502.22 when one must proceed with less than complete data.

5.2.8.4 Bycatch

Observer data and vessel logbooks indicate that pelagic longline fishing for Atlantic swordfish and tunas results in catch of non-target finfish species such as bluefin tuna, billfish, and undersized swordfish, and of protected species, including threatened and endangered sea turtles. Also, this fishing gear incidentally hooks marine mammals and sea birds during tuna and swordfish operations. The bycatch of animals that are hooked but not retained due to economic or regulatory factors contributes to overall fishing mortality. Such bycatch mortality may significantly impair rebuilding of overfished finfish stocks or the recovery of protected species. Atlantic blue marlin, white marlin, sailfish, bluefin tuna, and swordfish are overfished. The concurrent closure in this FMP was deemed necessary by NMFS to reduce bycatch and incidental catch of overfished and protected species by pelagic longline fishermen who target highly migratory pelagic species (HMS).

Appendix C of the Final Supplemental Environmental Impact Statement (FSEIS) for HMS Regulatory Amendment 1 contains data on dolphin-wahoo pelagic longline fishery analysis. The data presented on page C-66 and in Table C-4 indicate that pelagic longlines targeting dolphin do in fact result in a bycatch of HMS species.

Implementation of regulations in the SAFMC's 2003 Dolphin Wahoo FMP addressed the Magnuson-Stevens Act requirements to reduce bycatch and the mortality of bycatch. Additional detailed data on bycatch in the directed dolphin/wahoo fisheries will be provided through full implementation of ACCSP (which includes observer coverage).

5.2.9 Calico Scallop

5.2.9.1 Description of fishing practices, vessels and gear

Commercial Fishery

The commercial fishery for calico scallops has developed slowly and catches have fluctuated widely in all areas where commercial concentrations have been located. This is usually attributed to a combination of factors: yearly variations in the location and productivity of beds and problems of economically sorting, shucking, and eviscerating scallops because of their shape and small size.

Lack of knowledge by industry and resource agencies on the distribution and abundance of the calico scallop resource is one reason for the slow development of a commercial fishery until the late 1950s. Calico scallops had been taken by trawl fishermen sporadically since 1949, but no directed fishery developed from these early observations. Part of the slow development of the fishery was because trawlers were primarily equipped for shrimp fishing in different areas and depths and part was because of the absence of an established market for calico scallops.

Exploratory fishing by private organizations from 1954 to 1958 located concentrations of calico scallops in the northeastern Gulf of Mexico in the general area of Cape San Blas, Florida (Bullis and Ingle 1959; Carpenter 1967). Exploratory fishing by the Bureau of Commercial Fisheries from 1957 to 1960 revealed extensive beds of scallops in 19 to 46 m (62.3 to 150.9 ft) between Carrabelle, Florida, and Mobile, Alabama.

Beginning in March 1958, a large bed of scallops in 13 to 37 m (42.7 to 121.4 ft) northwest of Cape San Blas was fished commercially, at first using shrimp trawls and later with four-foot wide dredges (Bullis and Ingle 1959). The catch was shucked by hand and during the spring and summer of 1958, four boats produced 1,200 to 2,000 gallons of shucked meats per week. By September 1958, the yield of meat per scallop had declined to the point that fishing was no longer profitable.

Between 1959 and 1975, the commercial fishery for calico scallops in the northeastern Gulf of Mexico operated sporadically. Over this 16-year period, maximum production of approximately 16,000 pounds of shucked meats (adductor muscles) occurred in 1962 and again in 1969. In 1975, landings increased significantly and peak production in this area occurred in 1976 when 1.8 million pounds of meat valued at approximately $1.2 million was produced by the 54 vessels operating in the fishery.

In 1959, calico scallops were discovered near Cape Lookout, North Carolina, by exploratory vessels of the Bureau of Commercial Fisheries (Cummins 1971). This discovery stimulated development of a commercial fishery off Carteret County which continued sporadically to 1973. The principal scallop grounds have been located northeast and southwest of Cape Lookout in 19 to 31 m (62.3 to 101.7 ft). Commercial production of calico scallops from North Carolina waters has fluctuated widely since 1959 when three boats produced 6,500 pounds of meat valued at $2,600 (computed as ex-vessel or dockside price of meats). Peak landings occurred in 1966 when 20 vessels operating in the fishery produced 1.86 million pounds of meat valued at $369,000.

As had been the case in 1962, 1963, and 1964, scallop production from the North Carolina grounds did not exist in 1968 and 1969. While the fishery resumed again in 1970, production was below 1966 levels and from 1974 to 1978, no production came from this area. In 1979 a productive bed was again located; harvesting occurred in 1979 and 1981.

In January 1960, large quantities of calico scallops were discovered off Daytona Beach, Florida, by the Bureau of Commercial Fisheries (Taylor 1967). Further explorations conducted by the Bureau from 1960 to 1968 defined a 3,108 square kilometer (1,200 square mile) scallop bed lying in 19 to 74 m (62.3 to 242.8 ft) of water from the St. Johns River south to Ft. Pierce (Cummins 1971). Publication of these observations also stimulated development of a commercial fishery in this area which is referred to as the Cape Canaveral beds.

Since 1973 trawls have been the only gear employed in the fishery. Commercial production has generally increased since 1967 when four shrimp-type scallop vessels produced approximately 21,000 pounds of meat from the Cape Canaveral beds. In 1975, production of approximately 1.4 million pounds of meat valued at $900,000 was produced by 13 vessels trawling on the Cape Canaveral grounds. In October 1980, harvesting began on a new viable bed located about 8.1 to 9.7 km (5 to 6 mi) offshore of New Smyrna at a depth of approximately 20 m (66 ft). However, mass mortality of this bed caused fishing to cease by January 1981, and the fishery moved to other productive beds located in the Cape Canaveral area. Peak production occurred in 1984 when approximately 43 million pounds of meat valued at $23.5 million were produced by about 75-150 vessels trawling on the Cape Canaveral grounds.

South Carolina's first commercial scallop bed (Anderson and Lacey 1979) was located in June of 1977 approximately 97 km (60 mi) offshore of the South Carolina-Georgia border. In early January of 1978, seven scallop trawlers moved up from Florida and began harvesting scallops from the South Carolina beds in depths of 37 to 45 m (121 to 148 ft). By March of 1978, approximately 45 major vessels from Florida, North Carolina, Georgia, and South Carolina were actively involved in this fishery. Numerous other fishermen, particularly shrimpers, entered the fishery toward the end of the harvest, attracted by the size and quality of the beds. A total of 611,000 pounds of meat valued at $803,000 were harvested during 1978. Commercial activity continued through mid-May until production was drastically reduced due to meat size reductions during spawning. In the fall of 1981, another bed of scallops was located off South Carolina.

Three boats landed over a thousand bushels in two days during January 1982. Scallop explorations have historically been very limited offshore of Georgia, although small numbers of calico scallops have occasionally been found by shrimp trawlers and during research cruises. During 1979, large amounts of calico scallops were harvested off Key West adjacent to the Dry Tortugas shrimp grounds, shifting some activity from the Cape Canaveral beds.

Participating User Groups

The domestic fishery for calico scallops is entirely commercial. Natural fluctuations in the abundance of the resource have precluded development of a long-term, directed fishery for calico scallops in many areas where concentrations have been located. Consequently, much of the commercial production has been by shrimp fishermen who have fished for scallops, when they are available, as an alternative to shrimp fishing during poor seasons or as means of supplementing their income during the off season. (R. Cummins, Fishery Management, NMFS, S.E. Center, Charleston, S.C.; pers. comm.) has estimated that between 40-50 shrimp vessels engaged in the calico scallop fishery on a part-time basis in the early 1980s.

An exception to this is off the east coast of Florida where, due to the large size of the Cape Canaveral beds, commercial production has occurred fairly consistently since 1967. In this area, up to 10 factory-type vessels, which were specially equipped for processing calico scallops, have been engaged in the fishery intermittently since 1969. During 1980, one factory-type vessel was fishing in the area and plans were made for two more to enter the fishery in the spring of 1982. Currently there are no at-sea processing vessels in the fishery.

During 1980 and 1981, the number of vessels harvesting scallops increased to between 75 and 150. These numbers included 15 processor owned shrimp vessels which had been rigged for use in the calico scallop fishery out of Cape Canaveral. As of this writing, there were no vessels operating in the fishery.

The fishery is unusual because most boats fish for only about 12 hours per trip, and are usually away from the dock no more than 24 hours. The entire catch remains on deck unsorted. On-shore the catch is culled; shell, shell fragments, and other by-catch are removed. The clean shell stock can then be processed with very little human contact using shakers, steam, rollers (evicerators), chillers, and packaging equipment. Fresh meat can thus reach the market within 24-48 hrs of harvest (Blake and Moyer 1991). This type of fishery has been labeled a Type I processor (Anonymous 1998). In this type of processing all by-catch and waste is buried in landfills. A Type II processor culls, shucks, and packages the entire harvest at-sea, and can thus remain on the fishing ground for extended periods. Type II fishers also return all bycatch and waste to the sea.

Most of the harvest has been conducted by modified shrimp trawlers. At the peak of the fishery, about 70 vessels and 7 processing plants were active (Rockwood and Pompe 1988). North Carolina's fishing fleet peaked at around 20 vessels, and during one brief period, a fleet of about 45 vessels harvested along the South Carolina-Georgia border (Anonymous 1981). In each case, most of the vessels are shrimp boats that convert their gear for scallop harvest when the stock becomes plentiful and resources are put in place to process the catch on-shore. At present, no vessels are harvesting calico scallops, and none of the processing plants remain in operation. The most common point for landing calico scallops, Port Canaveral, Florida, has increasingly converted dock space previously used for commercial fishing to tourist related industries - marinas and cruise ship terminals.

Vessels and Gear

Three basic types of vessels have been used in the calico scallop fishery. They, in turn, have used three types of gear with some interchange of gear between vessel types. These are shrimp trawlers, scallop vessels designed for use in the sea scallop fishery, and specialized calico scallop vessels with processing equipment aboard. The first two vessel types have basically sought to land shellstock (i.e., intact scallops including shell, viscera, and edible adductor muscle meat after sorting from debris) for processing ashore. The specialized calico scallop vessels are designed to produce scallop meats with the shucking and evisceration done at sea.

Almost all of the calico scallops harvested commercially in recent years have been taken by shrimp vessels using modified otter trawls. These offshore shrimp trawlers have wood, aluminum, steel or fiberglass hulls and generally range from 15.2 to 25.9 m (50 to 85 ft) in length. Many of the newer, larger offshore vessels (22.9-27.4 m; 75-90 ft in length) are double-rigged for towing two nets simultaneously. Typically, the vessels are diesel-powered with pronounced variations between length and horsepower in single and double-rigged vessels. Generally, the vessels in the 15.2-21.3 m (50-70 ft) class are powered by 100-200 horsepower diesels. A large portion of the vessels are equipped with electronic navigational and fish finding aids. Cost of vessels depends upon size, date of purchase, and amount of equipment on board.

Calico scallop landings by vessel size category from 1994, 1995, and 1997 were provided by Martha Norris, FL FWC (Table 5.2.9-1); there were no landings in 1996. Data were provided for vessels less than 50 feet, 50-59.9 feet, 60-69.9 feet, 70-79.9 feet, and 80-89.9 feet. In order to not show confidential data, landings were combined into the two vessel size categories shown in Table 5.2.10-1. The "Unknown" category includes landings by Florida Salt Water Products Licenses (SPLs) with no associated vessel information. Vessels in the 70-89.9 foot category harvested approximately half of calico scallops landed between 1994 and 1997. In 1994 there were two vessels under 50 feet, one in 1995, and none in 1997. In fact the smallest vessels harvesting calico scallops during 1997 were in the 60-69.9 foot category.

Table 5.2.9-1. Calico Scallop Landings by Vessel Size Category. Source: Martha Norris, Department of Environmental Protection, Florida Marine Research Institute, Division of Marine Resources. July 29, 1998. Note: Pounds are in meat weight.

VESSEL SIZE CATEGORY	YEAR					
	1994		1995		1997	
	POUNDS	# DEALERS	POUNDS	# DEALERS	POUNDS	# DEALERS
UNKNOWN	1,411,480	27	252,784	8	604,768	12
<70 FT	1,319,384	11	161,416	6	67,424	4
70-89.9 FT	2,258,736	17	530,893	10	873,100	11
TOTAL	4,989,600	55	945,093	24	1,545,292	27

<u>Trawls</u>

Scallops were first caught with sea scallop dredges. During the early exploratory phase of this fishery, 1950s to early 1970s, the main gear was a 6-8 foot “tumbler” dredge - a heavy frame with a net made of 2" steel rings. This dredge could be fished with either side up (Cummins 1971). Dredges began to be replaced (in 1966) with scallop trawls. Despite higher maintenance and repair costs, trawls proved to be a more efficient means of harvest (Cummins 1971). Beginning about 1973, all harvest was conducted with modified shrimp otter trawls (Anonymous 1998). The otter trawl used in the shrimp fishery basically consists of: 1) a cone-shaped bag in which the shrimp catch is gathered in the tail or codend, and 2) trawl doors or otter boards at the extreme end of each wing for holding the wings apart and the mouth of the net open. The trawl doors are attached to the net by top and bottom leg lines on each wing of the trawl.

The following description of a scallop trawl is from Rivers (1962). The otter trawl net commonly employed in the calico scallop fishery is similar to the two-seam, semi-balloon design used in the shrimp fishery with modifications to maximize contact with the substrate while minimizing damage to the net’s webbing. Unlike the otter trawl nets used in the shrimp fishery, the scallop trawl net was designed so that it fishes with either side down, i.e., there is no overhang, and top and bottom sections are identical. This feature increases the longevity of the equipment in that when the original bottom section becomes worn, the trawl may be turned over so that the relatively unworn top becomes the new bottom. The 7.6 to 10.7 m (25 to 35 ft) scallop trawl nets are fitted with a “Texas drop chain” on the footrope and one to three “tickler chains.” The latter chains are stretched across the mouth of the trawl and attached near the trailing bottom corner of each door. The Texas chain, similar to that used on shrimp trawl nets, consists of a length of chain cut one foot shorter than the length of the leadline and fastened to it at regular intervals by 2, 4, or 6-link chain drops. The extra “tickler” chains used on the scallop trawl are designed to increase the scraping and digging action of the trawl.
The belly sections of the scallop trawl are short so that the amount of webbing exposed to wear is as small as possible. Both the nets belly and the tail-bag are reinforced with heavy chafing gear of polyethylene strands or automobile inner-tube strips in order to decrease the shearing and abrasive effects of the calico scallops on the nets. For added protection, a false belly of heavy webbing is often laced over the bottom belly of the

trawl. In addition, the leg lines between the doors and net wings are relatively short in order to facilitate the funneling effect of the doors. The complete scallop rig (boards, trawl, and accessories) is fished from a single cable that is connected to the boards by a 18.3 m (60 ft) bridle of 9.52 mm (3/8-in) wire rope.

The trawl is usually set and dragged from outrigger booms in the familiar shrimp-boat fashion. Owing to its light weight and small size, the trawl is easily handled. At the end of a drag, the splitting strap is brought to the rail of the boat and hooked to the hoisting tackle. The codend is brought aboard, and the catch dumped on deck. The trawl is then reset. Any scallops that might be in the webbing above the splitting-strap beckets are left in the net until the end of the next drag, or are allowed to spill back into the water. The time that would be consumed in making a second lift of the net to shake the scallops down into the codend and bring them aboard is used more profitably in making an additional drag. By limiting drags to 15-30 minutes or less, the catches usually fit well within the codend, and little loss is experienced.

Dredges

Dredges landed significant amounts of calico scallops from Florida beds between 1968 and 1972. While some of the vessels which have employed this gear include New England sea scallopers using 10-foot Georges Bank-type scallop dredges, most of the vessels were shrimp trawlers using scallop trawls and experimenting with tumbler dredges. A typical calico scallop dredge consists essentially of a rectangular frame measuring approximately 2.4 m wide by 0.46 m high (8 ft by 1.5 ft). The bag is made up of 50.8 mm (2 in) inside diameter rings held together with dredge links and attached to the rectangular frame. The dredge is towed on three flexible bridles (of chain or wire rope) attached at each end and center of the frame. This feature allows the dredge to “roll over” obstructions which would otherwise damage a trawl (Bullis and Cummins, 1961; Rivers, 1962). Dredges are no longer used in the fishery.

Assessment and Specifications of U.S. Harvesting Capacity

U.S. harvesting capacity is largely determined by the location and availability of scallops which vary constantly. For example, if scallops are located near a suitable port for short vessel runs to and from the grounds during cold weather periods, the shellstock would be landed and trucked to all available processing machinery presently located from North Carolina to the Florida west coast. Another example is when scallops are located many miles from the nearest suitable port during warm weather. Because shellstock is normally transported on deck, operations must be conducted at night in order to preserve quality; actual fishing time is reduced by vessel running time to port. Still another example is when scallops are located near a port such as Key West where weather is warm all year and trucks are weight limited to 36,000 pounds over the Keys bridges, thus increasing freight cost and at the same time causing a reduction in the amount of sellable finished product.

During the 1990s, some 40 to 50 vessels were involved sporadically on a part-time basis, the number depending upon conditions in the shrimp industry. About 25 vessels worked the scallop beds on a full-time basis, which includes time spent in locating new scallop beds. During late 1981 and early 1982, the number of vessels fishing the Cape Canaveral grounds varied from 75 to 150. Some processors in North Carolina and Florida offered a sizable reward to shrimpers who located a commercial size bed of scallops.

Scallop production and meat yield is so variable that the only meaningful measure is the pounds of finished product (edible meats) produced. Double-rigged shrimp-type vessels typically make four or five single-day trips per week, weather permitting. Drags are normally of short duration (10 minutes or less). Vessels are paid on a yield basis (i.e., on the amount of meats processed from landed shellstock) which reportedly ranges from two pounds to as much as six pounds per bushel. When large amounts of “trash” (old, broken, or empty shells) are encountered the yield is much lower. At the height of the fishery in the 1980s, most of the fishermen would process the entire catch dockside. No culling of the catch occurred at sea, meaning all bycatch had to be disposed of in landfills, in addition to any shell and viscera from the harvested scallops. For a time, processors were grading according to size (meat count) with larger meats commanding high prices. It was possible for a good shellstock vessel to produce several hundred 8-pound gallons per day. When scallops are found in abundance, harvesting capacity in the U.S. has been greater than processing capacity to date. The introduction of several new processing lines in 1981 (North Carolina and Florida) brought processing capacity equal to or greater than harvesting capacity. Since 2000, the loss of processing capacity has created a situation where the ability to harvest, through conversion of shrimp boats, could readily exceed the processing capacity, which is probably near zero as of 2006.

Assessment and Specifications of U. S. Processing Capacity

In 1978 there were some 16 scallop processing lines located in the southeastern U.S. and in 1979 and 1980 more were being built. However, much of the older equipment is outdated and some is not in operational condition. In 1980, two at-sea processing vessels were being outfitted with one or more processing lines. With the most effective updated shore-based processing equipment, steam is utilized in lieu of hot water for shucking. Some equipment is capable of sustained production rates well in excess of 100 gallons of meats per hour depending upon the size and condition of the meats and the amount of barnacle encrustation on the shells. Patent rights are held on most of the processing equipment and there was patent infringement litigation on a continuing basis during the 1980s. When large increases in scallop abundance occur, temporarily processing capacity is less than available shellstock. Currently, there is no active fishing, and no known processing plants for calico scallops.

The development of machine processing greatly changed the amount of effort required to process stock in relation to harvest effort. This has been referred to as the Processing/Harvesting Ratio (PHR) (Maiolo 1982). The PHR is based on Paredes et al. (1976). Prior to machine processing, hand shuckers were reluctant to process calicos because of the size which limited financial remuneration. When they did hand shuck, it is estimated that it took 13 units of effort to process stock that took one unit of effort to harvest. This ratio was reversed to 1:5, or one unit of effort to process what it took five to produce (the estimates were made in terms of hours) (Maiolo 1982). Presumably, this type of mechanized processing could be rebuilt, but significant capital would likely be needed.

Processing

Early in 1969 four factory-type processing vessels were engaged in the calico scallop fishery off Cape Canaveral, Florida. Two of these vessels, owned by a single firm, were steel hulled, and 26.2 m (86 ft) in length. They were powered by 335 horsepower diesels and had a cruising speed of ten knots. These vessels, and two similar ones, were equipped with culling, shucking, and eviscerating equipment capable of processing the catch as it was brought aboard by trawl or dredge (for a complete description of this on-board processing equipment see Cummins and Rivers 1970.) The processing time from culler to "ready for packing" required about 6 to 7 minutes. Three of the four vessels were "ice boats" which landed processed scallop meats in 10-pound containers packed in ice.

The seagoing processing machines were removed from these vessels after a few years and the reasons given are varied: the machine made the vessel unstable, the machinery was not designed for shipboard use in rough seas, and problems in maintaining constant hot water and steady temperatures (96°C; 205°F) necessary in the shucking procedure.

One processing vessel engaged in the calico scallop fishery persisted until 2003. This vessel was owned by Mr. William H. Burkhardt who served on the Council's Calico Scallop Advisory Panel. Mr. Burkhardt provided a detailed description and diagrams of the separation and evisceration process (Anonymous 1998). Mr. Burkhardt reported that "when scallops are harvested from a typical bed, shell percentages can vary from approximately 90/10 to 10/90. On the average one half of shell stock is unwanted old dead shell. The other half becomes clean new shell once the meats are removed in steam process." Mr. Burkhardt designed the adjustable separator to do the following: "(A) Select the targeted scallop size. Adjust to varying shell size/meat size with a simple mechanical adjustment. (B) Immediately return to the sea alive, small scallops under the targeted size, attached spat and other species bycatch. Research has shown that most will live if quickly returned to the sea. (C) Separate the clean scallops and immediately discharge overboard the mud, shell and bycatch." In Mr. Burkhardt's opinion, at-sea processing has the following advantages: "1. Reduces weight improving vessel safety. 2. Improves product quality by removing bacteria in the washing process. 3. Reduces or eliminates same species and other species bycatch. 4. Return shell to the original bed."

Recreational Fishery

There is no recreational fishery for the calico scallop due to the depth of water where calico scallops occur and the gear necessary to harvest calico scallops.

Allowable gear

Calico scallops may be harvested commercially in the EEZ using trawl and dredge. Hand harvest is the only allowable means to harvest calico scallops recreationally.

5.2.9.2 Economic description of the fishery

The best economic analysis of the calico scallop fishery was produced by Rockwood and Pompe (1988) and pertained only to the Brevard County harvest - most of the scallops harvested from the Cape Canaveral beds. This report was produced just after the peak fishing years of 1984-1987. The authors estimated that the industry should be able to support 500 jobs and generate 77.6 million dollars (in 1988) of total economic output for the region. The total local expenditures were around $2 for every pound of meat harvested. Total employment (fishing and related support industries) ranged from 278 to 2616 jobs over a four year period. This translates into about 1 job for every 5500 pounds of meat harvested. Expenses ranged 28 - 43% for vessel operations, 35 - 60 % for processing, and 11 - 21% for office and overhead. Total labor accounted for about 35% of expenses. At that time fuel was a very minor expense, 0.6 - 2.5% of total expenses. The increased costs of diesel fuel would certainly need to be reanalyzed. Anecdotal reports from fishers indicate that when the price of one gallon of diesel surpasses the value of one pound of scallops, the fishery is no longer profitable.

5.2.9.3 Social and cultural environment

Employment

Employment in the harvesting sector of the calico scallop fishery depends, to a large extent, on the distribution/abundance of the resource which fluctuates widely on a year-to-year basis.

Since 1970, the number of fishermen employed on vessels which have participated in the scallop fishery has ranged from 32 (in 1974) to 350-450 (in 1981) over the region as a whole, including the mid-Atlantic and New England areas. The industry peaked in the early 1980s at 2,616 jobs. For many, if not most, of these fishermen, scalloping is a part-time and/or seasonal activity which provides a means of supplementing the income they derive from other fisheries. However, with the discovery of new beds, and the opening of new processing lines, the proportion of total income derived from calico scalloping has increased significantly. For many fishermen, during 1981, income obtained from fishing for scallops represented as much as 75 percent of the total for the year. As of 2005 there were no active calico scallop fishermen.

Machine processing has generated a sizable increase in the number of laborers in the processing houses. As of December 1981, the number was estimated to be over 200 people working nearly full time at an average of $5 per hour. Previously only a portion of total income had been derived from scalloping. During 1981, however, especially in North Carolina where shrimping was poor, a greater proportion of income was derived from processing calico scallops. In regard to total wages for processing all types of shellfish and finfish, calico scallop processing shifted from playing a minor role to one which is fairly significant, and back to non-existent by 2004.

Fishing and Landing Areas

Concentrations of calico scallops and principal fishing areas are located off North Carolina, northeast and southwest of Cape Lookout; off the east coast of Florida from Ft. Pierce northward to the St. Johns River; and in the northeastern Gulf of Mexico between

Carrabelle, Florida and Mobile, Alabama (Cummins 1971). It should be noted that the location and productivity of beds within these three principal fishing grounds fluctuate annually and, to a lesser extent seasonally, and consequently, so does the distribution of fishing effort both within these areas and over the region.

In addition to the three traditional fishing areas identified above, some commercial scalloping activity has occurred offshore of Tampa and Key West, Florida, and offshore of the South Carolina/Georgia border.

Calico scallops are generally landed at ports where suitable shore-based processing facilities are located or at ports in reasonably close proximity to fishing grounds where the scallops can be quickly unloaded and transported to processing facilities. Basically, landing ports are chosen for having four criteria: 1) a sufficient depth of water on all tides, 2) a strong dock for offloading with turning space for tractor trailers, 3) adequate fuel facilities, and 4) processing plants to handle the scallops. Ports within the management area where scallops have been landed are listed below.

North Carolina:
Beaufort/Morehead City
Sneads Ferry

South Carolina:
Georgetown
McClellanville
Mt. Pleasant

Georgia:
Brunswick
Darien
Savannah

Florida:
Apalachicola
Carrabelle
Ft. Myers
Ft. Pierce
Key West
Mayport
Port Canaveral
Port St. Joe
St. Augustine
Tampa
St. Marys

Increasingly, available dock space has been converted to uses other than commercial fisheries. In Port Canaveral, FL, the primary use has become the cruise ship industry. In other areas of Florida, such as Apalachicola, seafood processing houses have been bought out and the real estate converted for use in luxury, waterfront condominiums.

Conflicts among Domestic Fishermen

The calico scallop fishery of the South Atlantic and Gulf coast has been free of competition from foreign fleets and sport fishermen. However, during late 1981, the number of boats and vessels fishing the Cape Canaveral grounds increased dramatically. Estimates of the number of boats and vessels vary from 75 to 150. In addition, these boats and vessels hailed from home ports along the Gulf of Mexico and the entire East Coast of the U.S. This large increase in number of boats and vessels, combined with the diverse makeup of the new entrants, resulted in stress and controversy. Competition became intense leading to near collisions, fishing in areas with large concentrations of small scallops, and fishing in areas with parasite infested scallops. Recriminations among fishermen and processors became common. During the 1990s, the number of vessels in the fishery was reported to be around 25 (Calico Scallop Advisory Panel and Scoping Meetings). By 2005, there were no active calico scallop vessels in either North Carolina or Florida.

5.2.9.4 Bycatch

In the 1980s, the State of Florida commissioned a study of the bycatch associated with the calico scallop fishery (Nelson 1992). The findings indicate a similar composition to the community structure found in earlier studied in the State of North Carolina (Stephan 1989). Most of the bycatch was not composed of commercial or recreationally valuable species. The most common fishes were small flounders (family Bothidae), blue spotted searobin (*Prionotus roseus*), and scorpionfishes (Family Scorpaenidae). Other common fauna were Portunid crabs and echinoderms. In current studies, common associated fauna include imperial venus (*Chione latilirata*), sea stars of the genus *Astropecten*, Venus clams, and gastropods (*Distorsio* spp.). Sand dollars (*Encope* spp.) can be common in nearby sandy bottom, which may be interspersed in the shelly habitat where scallops are more common.

One issue that developed in the 1990s was the elimination of any on-board culling. This practice meant that the entire catch was processed dockside meaning all bycatch was disposed of in landfills rather than at-sea. A concern had developed that disposal of viscera and discards was actually attracting predators and encouraging development of disease on the fishing ground. The effect of the practice was that millions of pounds of shell were removed from the habitat. The shell is believed to be the primary settlement substrate for juvenile scallops, so in effect, the practice was removing an essential fishery habitat for calico scallops. Wells and Wells (1964) had already shown that at least 112 species of fauna utilized scallop shells as settlement habitat - including juvenile scallops. Often, the weight of the epifauna can exceed that of the host shell. The effect is that the large volume of shell creates a valuable benthic community, one that is removed from the ocean when bycatch is not culled at-sea. This practice also eliminates attached juveniles and eliminates any possibility for survival of organisms present in bycatch. The potential that this large-scale removal of potential prey impacts nearby reef fish communities should be considered.

5.3 Other Managed Fisheries in the South Atlantic

5.3.1 Atlantic Menhaden

5.3.1.1 Description of fishing practices, vessels and gear

Atlantic menhaden have supported one of the United States' largest fisheries since colonial times. Landings records indicate that over 18 million mt of Atlantic menhaden have been caught by fishing fleets operating from Maine to Florida since 1940 (ASMFC 2001).

Native Americans were the first to use menhaden, primarily for fertilizer. During the 1940s, the primary use changed to high protein animal feeds and oil production.

Menhaden meal was mixed into poultry, swine, and cattle feeds as the amount used for fertilizer was decreasing. The oil was used in the manufacture of soap, linoleum, waterproof fabrics, and certain types of paint(ASMFC 2001).

Following World War II, the industry grew rapidly, reaching peak production during 1953-62. Sharp declines in landings thereafter resulted in factory closings and fleet reductions through the 1960s and into the early 1980s. Since that time, the menhaden industry has experienced major changes in processing capacity, resource accessibility, and development of new product markets.

Vessels and Domestic Harvesting Capacity (ASMFC 2001)
The early menhaden purse seine fishery utilized sailing vessels, while coal-fired steamers were introduced after the Civil War. In the 1930s, diesel-powered vessels began to replace the steamers, although a few sailing vessels were still in use. Reintjes (1969) described modern menhaden vessels and purse seines and summarized the significant technological advancements since World War II as follows:

- 1946 -- Use of spotter aircraft. Setting on a school is now directed by the spotter pilot via radio communication with the purse boats.
- 1946 -- Use of pumps to transfer fish from the nets to the carrier vessel resulted in shorter transfer time and more fishing time.
- 1954 -- Use of synthetic net material rather than cotton twine resulted in increased net life.
- 1957 -- Use of hydraulic power blocks in the purse boats to haul in the net permitted a reduction in crew size and reduced net retrieval time. Strong synthetic net material was able to withstand the increased strain from the new haul technique.
- 1958 -- Introduction of lighter, stronger, and faster aluminum purse boats to replace wooden boats.

The refrigeration of vessel holds in the 1960s and 1970s was crucial for the industry to maintain its viability. Despite restricted access to a number of traditional grounds and a reduced fleet size, refrigerated holds enabled the fleet to maximize the harvest during peak resource availability.

Refrigeration also allowed the fleet to range over a larger area and stay out longer, greatly improving the ability to catch fish when and where they are available. Currently, commercial menhaden purse seine fishing operations utilize spotter aircraft to locate schools of menhaden and direct vessels to the fish. When a school is located, two purse boats with a net stretched between them are deployed. The purse boats encircle the school and close the net to form a purse or bag. The net is then retrieved to concentrate the catch, and the mother ship comes along-side and pumps the catch into refrigerated holds.

Individual sets can vary from 10 to more than 100 mt, and large vessels can carry 400-600 mt of refrigerated fish. Over the years, vessels participating in the Atlantic menhaden purse seine fishery have varied considerably in size, fishing methods, gear type, and intensity of effort. During the early 1960s, the commercial menhaden fleet experienced significant changes as larger, faster vessels replaced outdated models. Today, the 12 vessels operating in North Carolina and Virginia range from 166 ft (51 m) to 200 ft (61 m) in length. Typical menhaden vessels generally carry two purse boats approximately 39 ft (13 m) in length. A few small vessels have only one purse boat and are called “snapper rigs.” These small boats have the ability to fish in shallow areas not available to the larger vessels. The catches of the snapper rigs (a small fraction of the total) are mostly sold for bait (sport fishery, crab pots, etc.) with minor quantities processed into meal, oil, and solubles.

The typical purse seine net has a bar mesh of 3/4 in (1.9 cm) to 7/8 in (2.2 cm). The net length ranges from about 1,000 ft (305 m) to about 1,400 ft (427 m) and the depth from about 65 ft (20 m) to about 90 ft (27 m).

Historically, the total number of vessels fishing for menhaden was generally related to the availability of the resource. Greer (1915) reported 147 vessels in 1912. During 1955 to 1959, about 115-130 vessels fished during the summer season, while 30-60 participated in the North Carolina fall fishery. As the resource declined during the 1960s, fleet size decreased more than 50%. Through the 1970s, approximately 40 vessels fished during the summer season, while nearly 20 were active in the fall fishery.

During 1980-1990, 16-33 vessels fished the summer season, and the level of effort in the fall fishery ranged from a low of 3 vessels in 1986 to a maximum of 25. During the 1990 season, the mid-Atlantic fleet, based in Virginia was composed of 20 vessels, and the south Atlantic fleet, based in North Carolina, consisted of one large vessel and two smaller vessels, each using two purse boats. One of the smaller vessels, however, fished exclusively for bait. An additional 3-4 large vessels from Virginia and/or the Gulf of Mexico fished in the south Atlantic during the fall fishery.

Due to company consolidation in 1997, there are presently 10 vessels in the mid-Atlantic fleet (at Reedville, Virginia) and two vessels in the south Atlantic (at Beaufort, North Carolina). Changes in fleet size since the 1980s are attributable to a number of factors. Reductions in effort during the mid-1980s were related largely to world commodity markets and economic considerations. The addition of vessels participating in the Gulf of Maine Internal Waters Processing (IWP) ventures reflected resource availability in Maine. Reduction of the Chesapeake fleet by several vessels was accompanied by improved operating efficiency. Vessels from the Gulf of Mexico fishery were added to the Atlantic fleet for the fall fishery in order to maximize harvest when weather and fish migratory behavior provided opportunities for large catches. In November 1997, Omega Protein purchased its competitor in Reedville, AMPRO Fisheries. For the 1998 fishing season, Omega dismantled the AMPRO factory and reduced the Virginia reduction fleet from 20 to 13 vessels. Further reductions in fleet size occurred during 1999.

All twelve vessels in the menhaden fleet currently utilize refrigerated fish holds, compared to only 60% of the fleet in 1980. Refrigeration enables vessels to deliver better quality raw material and serves to increase vessel range and extend time on the fishing grounds. This ability to maximize peak resource availability was critical in the 1970s and 1980s for the maintenance of the industry in the face of restricted access to traditional grounds and a reduced number of vessels landing at fewer plants.

Average hold capacity of menhaden vessels in the summer fishery declined from 1,101,000 standard fish (737,670 lb or 334.6 mt) in 1980, to 997,000 standard fish (667,990 lb or 303 mt) in 1990, a decrease of 9.4%. The total hold capacity of the current twelve vessel menhaden fleet is well below that of the late 1950s.

During peak landing years (1953-1962), an average of 112 vessels with a mean vessel capacity of about 678,000 standard fish (representing a total fleet capacity of approximately 76,000,000 standard fish) supplied the industry (Nicholson 1971). The fleet landed daily catches at 20 menhaden reduction plants from New York to Florida. In comparison, the 1990 fleet of 33 vessels, which operated within a more restrictive and regulated environment, landed their catch at five plants, including the foreign processing vessel. As previously noted, the current fleet of twelve vessels unloads menhaden at only two ports, Reedville, Virginia and Beaufort, North Carolina.

Fishing and Landing Areas
The Chesapeake Bay area (including the mid-Atlantic area) accounted for about 77% of the Atlantic menhaden landings in 1990 and about 73% during the 1980-1990 period. Plants in the north and south Atlantic areas, including one plant active during the fall fishery, processed about 27% of the annual landings. Three plants located in Virginia and North Carolina processed about 90% of the harvest.

In 1991, Chesapeake Bay, including the mid-Atlantic area, accounted for about 74% of the menhaden landings. The North Atlantic area contributed most of the balance of the landings, while the south Atlantic area contributed the remainder. The catch was landed at shoreside processing plants in Beaufort, North Carolina; Reedville, Virginia (2 plants); and Blacks Harbour, N.B., Canada. A Russian factory ship anchored at various locations within the territorial waters of southern Maine also processed menhaden under an IWP arrangement.

As no menhaden landings for reduction have occurred in New England since the summer of 1993,and the plant in Beaufort North Carolina closed in 2005, landings of Atlantic menhaden for reduction have been made exclusively by the Virginia vessels at Reedville, Virginia.

Between 1994 and 1997, the factories at Reedville processed an average 89% of the Atlantic menhaden catch for reduction; the remainder was unloaded at Beaufort.
Smith (1999b) summarized catch estimates of menhaden vessel captains in the Virginia and North Carolina fleets (excluding New England vessels) from Captains Daily Fishing Reports (CDFR's) during 1985-96. On average, over the twelve year study period, 52% of the catch by the Virginia and North Carolina fleets came from the Virginia portion of Chesapeake Bay, 17% was caught in North Carolina coastal waters, 16% in Virginia ocean waters, and 15% in ocean waters of Rhode Island, New York, New Jersey,

Delaware, and Maryland and Delaware Bay combined. However, the New Jersey portion of Delaware Bay has been closed to the reduction fishery since mid-1989, the Delaware portion in mid-1992, and most of Long Island Sound has now been closed to the reduction fishery.

Fishing Seasons

The directed menhaden purse seine fishery for reduction is seasonal. The presence of menhaden schools is dependent on the temperature of coastal waters. Two fairly distinct fishing seasons occur, the "summer fishery" and the "fall fishery". The summer fishery begins in April with the appearance of schools of menhaden off the North Carolina coast. The fish migrate northward, appearing off southern New England in May-June. The fishery in the Gulf of Maine may extend into early October, although menhaden may not appear in the Gulf of Maine at all in some years. Menhaden stratify by age along their migration route as smaller, younger fish remain in the southern area, while larger, older fish travel farther to the north. Peak landings occur during June-September.

The fall fishery begins about 1 November as migratory fish appear off Virginia. In early fall, this southward migration is initiated by cooling ocean temperatures. Menhaden vessels based in Reedville, Virginia harvest these fish during the fall fishery. Fishing may continue into January (and sometimes February), but is highly weather dependent. Menhaden generally leave the nearshore coastal fishing grounds in January, dispersing in ocean waters off the south Atlantic states.

Commercial Reduction Fishery

Atlantic menhaden have supported one of the United State's largest fisheries since colonial times. Menhaden have repeatedly been listed as one the nation's most important commercial fisheries species in terms of quantity. Total menhaden landings (Gulf of Mexico and Atlantic) in 1998 were 1.7 billion lb (816,467 mt) valued at $103.8 million (NMFS 1999). Preliminary Atlantic menhaden landings in 1999 totaled 416 million lb (188,662 mt) with an estimated ex-vessel value of $33.2 million (NMFS 2000).

The last reduction plant located in Beaufort, North Carolina closed in 2005 subsequently there is no longer a reduction fishery in North Carolina or the South Atlantic region.

Commercial Bait Fishery

Information on the harvest and use of menhaden for bait is difficult to obtain because of the nature of the bait fisheries and data collection systems. Harvest comes from directed fisheries, primarily small purse seines, pound nets, and gill nets, and bycatch in various food-fish fisheries, such as pound nets, haul seines, and trawls. Menhaden are taken for bait in almost all Atlantic coast states and are used for bait in crab pots, lobster pots, and hook and line fisheries (both sport and commercial). A specialized use involves live menhaden as bait for coastal pelagic species.

Reported annual landings of Atlantic menhaden for bait along the Atlantic coast averaged about 33.7 mt (about 70.0 million pounds) for the period 1985-99. Reported bait landings usually accounted for approximately 10% of the total Atlantic menhaden landings each year from 1985-97. In 1998 and 1999, reported bait landings accounted for 13.7% and 17.3%, respectively, of the total Atlantic menhaden landings. The increase in percent of coastal landings are attributed to better data collection in the Virginia snapper rig bait seine fishery and a decline in coastal reduction landings due to reductions in processing plants and fleet size.

Closure of reduction plants in New England and the mid-Atlantic may have influenced growth in the bait fishery, making more product available for the lobster and crab pot fisheries, as well as bait and chum for sport fishermen. Additionally, the passage of a net ban in Florida in November 1994 reduced the availability of bait and chum in that state, which opened up new markets for menhaden bait caught in Virginia and the mid-Atlantic states. The appearance of growth in the Atlantic coast bait fishery must be tempered by the knowledge that reporting systems for bait landings, particularly for Atlantic menhaden, have historically been incomplete at best. In most cases, recent landings estimates are more accurate, but for some states, bait landings continue to be underestimated. The nature of the fishery and its unregulated marketing are causes of the under-reporting problem. There are some well-documented, large-scale, directed bait fisheries for menhaden using gears such as purse seines, pound nets, and gill nets. There are also many smaller-scale directed bait fisheries and bycatch fisheries supplying large quantities of bait with few, if any reporting requirements. Menhaden taken as bycatch in other commercial fisheries is often reported as "bait" together with other fish species. The “over-the-side” sale of menhaden for bait among commercial fishermen is under-reported (and often unreported). Common practices, such as utilizing menhaden for bait or chum in sportfishing tournaments is difficult to estimate when quantity sales are made to individual marinas and fishing clubs.

Despite problems associated with estimating menhaden bait landings, data collection has improved in many areas. Some states license directed bait fisheries and require detailed landings records. Catch-per unit-of-effort (CPUE) data, pounds caught per hour set and pounds caught per yard of net set are also reported for directed gill net fisheries in some states.

(paragraph below form the 2005 update to the ASFMC FMP)
Landings of Atlantic menhaden by the bait fisheries (all gears combined) in 2004 amounted to 34,743 mt; this was 16% of the combined (reduction and bait) total Atlantic menhaden landings in 2004. The majority of the bait landings are from purse-seine gear operating in Virginia and New Jersey waters. Through the period 1985-1997, bait landings generally comprised about 10% or less of the total Atlantic menhaden harvest. With the decline in the reduction landings in recent years, the relative importance of the bait fishery has increased. More comprehensive reporting of bait landings has also contributed to this trend.

South Atlantic Bait Fisheries

Part of North Carolina’s landings are reported directly, while the rest are estimated from fishery-dependent sampling. The principal use for menhaden as bait in North Carolina is in the blue crab pot fishery. South Carolina and Georgia have no directed menhaden fisheries, shrimp trawl bycatch and cast netting supply menhaden to crab potters and sport fishermen in those states. Florida's east coast had substantial menhaden landings for bait from gill nets and purse seines prior to the implementation of a net ban in 1994.

Domestic Processing Activities and Products

Menhaden reduction plants, through a process of heating, separating, and drying, produce fish meal, fish oil, and fish solubles from fresh menhaden. Meal is a valuable ingredient in poultry and livestock feeds because of its high protein content (at least 60%). The broiler (chicken) industry is currently the largest user of menhaden meal, followed by the turkey, swine, pet food, and ruminant industries. The aquaculture industry has recently demonstrated an increased demand for fish meal as well.

Menhaden oil has been used for many years as an edible oil in Europe. The oil is refined and used extensively in cooking oils and margarine. In 1989, the United States Food and Drug Administration (FDA) concluded that fully and partially hydrogenated menhaden oil is a safe ingredient for human consumption. In 1990, the FDA proposed an amendment, based on an industry petition, to the standard of identity for margarine to permit the use of marine oils. It was approved in 1997 and could provide a significant new market for omega-3 rich menhaden oil.

Solubles are the aqueous liquid component remaining after oil removal. In general, most meal producers add the soluble component to the meal to create a product termed “full meal.” The use of solubles as an export product is limited because most companies in the feed industry are not equipped with the necessary storage tanks, pumps, and meters to handle a liquid product.

The world fish meal industry is in the process of adopting low temperature meal technology, a process which yields significantly higher protein content than previous technologies and produces feed components particularly valuable to aquaculturists. Investment in these new processes represents an opportunity for the U.S. industry to broaden its market base and add value to its products. Public sector support, in the form of research on markets, technology development, and new products, will be a key factor in maintaining the domestic menhaden industry’s global competitive status.

Recreational Fishery

No significant directed recreational fisheries exist for menhaden. However, menhaden are an important bait in many recreational fisheries; some recreational fishermen employ cast nets to capture menhaden or snag them with hook and line for use as bait, both dead and live.

Current status of the fishery

The 2006 coastwide harvest (bait and reduction) of Atlantic menhaden was 183,583 metric tons (ASMFC 2007). This is slightly down from 185,030 metric tons in 2005. The 2006 harvest for reduction purposes only was 157,385 metric tons. This is up 7% from the 2005 landings of 146,860 metric tons, but down 13% from the previous 5-year average of 180,833 metric tons; declines in landings during 2005 and 2006 mainly reflect the decision by Beaufort Fisheries Inc., to no longer participate in the reduction fishery. Reduction landings generally have gone down since the early 1990s (Figure 5.3.1-3). The coastwide bait harvest for 2006 was 26,198 metric tons, down 31.4% from the 2005 harvest of 38,170 metric tons, and down 28% from the average harvest of the previous five years (2001-2005)(Figure 5.3.1-1).

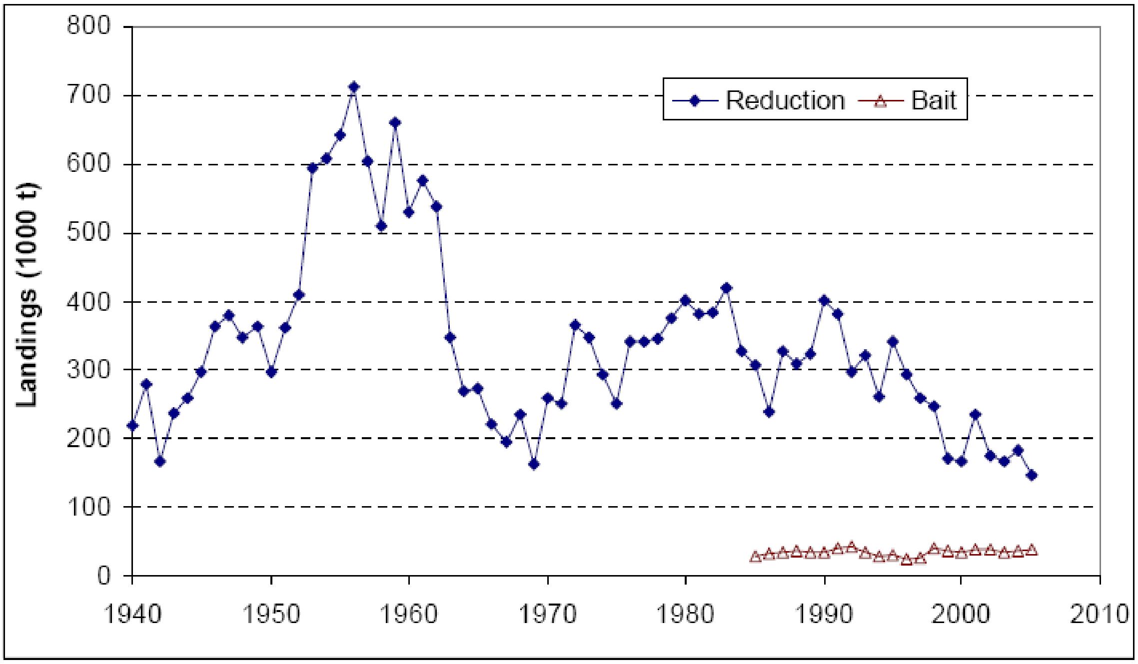


Figure 5.3.1-1. Landings from the reduction purse seine fishery (1940–2005) and bait fishery (1985–2005) for Atlantic menhaden (ASMFC 2006)

The largest percentage decrease in bait landings from 2005 to 2006 occurred in Maryland and Virginia, 59% and 51% respectively; this trend mirrors removals from Chesapeake Bay by the reduction fishery. All states from New Jersey and north reported an increase in 2006 landings over 2005. Potomac River Fisheries Commission and Florida also reported increased harvest.

The bait fishery appears to be expanding in the northern range of the species, i.e., New England, based on reported landings in recent years (Table 5.3.1-1).

Omega Protein's plant in Reedville, Virginia, is the only active menhaden reduction factory on the Atlantic coast. Eleven vessels fished out of this plant in 2006. Beaufort Fisheries Inc. has been closed since the 2004 fishing season.

Table 5.3.1-1. Menhaden Bait Landings by Region (1985 – 2006) [in 1,000s of metric tons] (ASMFC 2006, B. Muffley pers. comm. 2007)

Year	New England (ME – CT)	Mid-Atlantic (NY – MD Coast)	Chesapeake Bay (MD Bay, VA, PRFC)	South Atlantic (NC – FL)	Total (ME – FL)
1985	6.15	1.82	18.05	2.27	28.30
1986	13.75	1.31	13.64	2.44	31.15
1987	13.28	1.28	16.99	2.56	34.11
1988	19.73	1.20	12.38	2.88	36.19
1989	9.54	1.52	20.30	3.41	34.77
1990	11.19	4.38	13.98	4.07	33.61
1991	14.47	7.98	13.90	3.38	39.74
1992	12.44	12.73	14.15	3.10	42.43
1993	11.64	13.37	7.84	2.10	34.94
1994	0.43	17.79	5.76	3.17	27.15
1995	4.08	17.19	7.62	1.57	30.46
1996	0.04	16.21	6.47	0.58	23.29
1997	0.14	17.61	7.50	1.66	26.91
1998	0.21	15.17	23.71	1.33	40.42
1999	0.15	12.68	22.92	1.32	37.07
2000	0.19	14.25	19.68	0.93	35.05
2001	0.08	12.17	23.79	1.37	37.41
2002	0.69	11.29	24.11	1.13	37.22
2003	0.12	8.00	26.07	0.79	34.98
2004	0.03	9.59	25.20	0.50	35.32
2005	1.01	8.25	28.26	0.66	38.18
2006	1.49	9.87	14.35	0.50	26.21

Allowable gear

Atlantic menhaden may be harvested commercially in the EEZ using purse seine, trawl, gillnet and hook-and-line. Menhaden may be harvested recreationally using hook-and-line, snagging and cast nets.

5.3.1.2 Economic and social description

No recent studies have been conducted to assess the economic characteristics of the menhaden fisheries. The most recent information is included in the 1992 FMP (ASMFC 1992).

(text below excerpted from "Collection of Baseline Sociological Data to Describe The Atlantic Menhaden (Brevoortia tyrannus) Fishery by Dr. Brian Cheuvront, NCDMF)

As part of the ongoing effort to document changes in the menhaden fishery over time, Dr. Brian Cheuvront was contracted by the Atlantic States Marine Fisheries Commission (ASMFC) to conduct interviews with persons in Virginia and North Carolina who participate in the menhaden fishery. This section is directly out of Dr. Cheuvront's report to the ASMFC.

Menhaden (*Brevoortia* spp.) have repeatedly been listed as one the nation's most important commercial fisheries species in terms of quantity. Total menhaden landings (Gulf of Mexico and Atlantic) in 2002 were 1.4 billion pounds (633,985 metric tons) valued at $83.6 million. Atlantic menhaden (*Brevoortia tyrannus*) landings in 2002 totaled 385.5 million pounds (174,870 metric tons) with an estimated ex-vessel value of $22.1 million (NMFS, 2003). In North Carolina, Atlantic menhaden alone accounted for 62.4% of all finfish landed, and 13.5% of the value of all finfish landed in 2002 (NC DMF).

Historically, menhaden had many uses. It is thought Native Americans may have used menhaden for fertilizer. Colonists soon recognized the value of whole menhaden for fertilizer, and local seine fisheries gradually developed from New York to Maine. The use of whole fish as fertilizer continued into the nineteenth century. A southern fishery developed after the Civil War (Menhaden Resource Council, 2003).

The menhaden oil industry began in Rhode Island in 1811. It grew steadily, with significant mechanization, including boilers for rendering raw fish and presses for removing oil. Oil was initially used for fuel and industrial processes, while the remaining solids (scrap) were used for fertilizer. Numerous small factories were located along the coasts of the northeastern states. However, their supply was limited to fish that could be captured by the traditional shore-based seines. In 1845, the purse seine was introduced, and an adequate supply of raw material was no longer a problem. By 1870, the industry had expanded southward, with several plants in the Chesapeake Bay and North Carolina areas.

The primary use of menhaden changed from fertilizer to animal feed and other products during the period following World War I. At that time, menhaden oil was used in the manufacture of soap, linoleum, waterproof fabrics, and certain types of paints.

Following World War II the industry grew rapidly. Sharp declines in landings thereafter resulted in factory closings and fleet reductions through the 1960s and into the early 1970s. Since that time, the menhaden industry has experienced major changes in processing capacity, resource accessibility, and access to new product markets.

Nine menhaden reduction plants on the Atlantic coast closed permanently during the 1980s while two new operations began. In 1990, five reduction plants with 37 vessels processed Atlantic menhaden for fishmeal and oil. In the United States, land-based plants are currently located at Beaufort, North Carolina and Reedville, Virginia. Upper Chesapeake Bay in Maryland and the coast of New Jersey are closed to menhaden fishing operations. Most Atlantic states, however, remain open to menhaden fishing.

Currently there are only two menhaden processing plants working on the east coast of the United States. Omega Protein is located in Reedville, Virginia and Beaufort Fisheries is located in Beaufort, North Carolina. Of the two, Omega Protein processes about four to five times more menhaden than does Beaufort Fisheries. There are also a few smaller operations that fish for menhaden to be used primarily as bait for recreational fishermen and commercial crab pots.

In-person interviews were conducted involving 21 people from September to December of 2003. The in-person interviews took place in Beaufort, NC and Reedville, VA.

People interviewed included: two plant general managers, one plant bookkeeper, one oils reduction plant supervisor, one oils reduction plant machine operator, seven menhaden fishing boat crew members (captains, mates, engineer, deck hands, etc.), two commercial pound netters, two bait fishery boat captains, two recreational fishermen who target menhaden using commercial gear and three people from the Reedville community involved in community affairs, but not directly involved in the menhaden fishery (including the Fisherman's Museum director). Topics of discussion included (as appropriate) work history, fishing effort, labor, race relations, current state of the industry, fishing communities, fisheries management, conflicts between user groups, and perceptions about the future. The interviews were recorded on standard cassette tapes. Once all were completed, they were transcribed verbatim.

Work History
Nearly all of the people interviewed for this study and who were currently worked in menhaden have done so for an average of about 25 years. Several of the people interviewed in Reedville were retired from some aspect of the menhaden industry. Menhaden processing is a field where most workers come up through the ranks, including general managers, beginning as either a crewmember or as an apprentice machine operator. All found the work to be hard, but rewarding. Several respondents said they had little formal education and found working in menhaden to be as financially lucrative as any job they could expect. Most expected to remain working in the fishery until they retired or the factory ceased operations.

Only the general managers and few others in working at the reduction facilities were able to work 12 months a year. They did not work in menhaden when there were no fish to catch or process. The fishing season typically lasts longer in Reedville than in Beaufort. Many of the workers at Omega Protein are able to work 10 to 11 months of the year. Aside from some maintenance and net repair workers, most employees at Beaufort Fisheries work about 6 months of the year.

Fishing Effort
Omega Protein currently has 10 boats that fish for menhaden. Beaufort Fisheries has two. There are 4 menhaden bait fishery operations using nets that work the Chesapeake Bay. All the people interviewed said their used to be a lot more effort targeting menhaden. Pictures of the Beaufort waterfront from the 1950's show as many as 30 or so boats tied up at the docks. The last couple of decades have seen the closure of a processing plant in Southport, NC and the consolidation of American Protein in Reedville by Omega Protein.

According to one informant, Omega Protein had about 13 boats actively working about 25 years ago and American Protein had a similar number. Crews were also larger in past years.

Comparatively speaking, the boats targeting menhaden today are more successful than their predecessors. Reliance on spotter planes has increased individual trip catches. But still, as one general manager put it, “it’s not unheard of for us to travel 30 miles in one direction to get two fish.”

Labor

Much of the heavy work on menhaden boats is now mechanized. Early crews consisted of a captain, pilot, mate, one or two engineers, a cook, and as many as two dozen crewmembers to haul nets (Garrity-Blake, 1994). Nowadays, crews average approximately 14 with only 8 crew members.

Availability of labor seemed to more of an issue for Beaufort Fisheries than Omega Protein. The working season tends to be shorter and workers need additional sources of employment that they can easily leave when the fish are present. Most jobs that allow this kind of movement are low paying. So as soon as menhaden workers find better paying jobs, they leave the menhaden fishery altogether. Finding quality replacements for them is difficult.

Omega Protein employees work for most of the year and can survive financially during the periods they are not fishing. Also, a major factor is that workers in Reedville have very few options for other employment. Omega Protein is the largest employer in Northumberland County, Virginia (2001 population: 12,412). Workers in the Beaufort area (Carteret County, 2001 population: 59,901) have more alternatives for employment.

Race Relations

Garrity-Blake (1994) addressed racial issues in the menhaden industry. At that time she stated that earlier vestiges of racism were beginning to change. The general managers interviewed both said that race is not a factor in who gets hired for any position. The most important factors are experience and skill. However, in both communities, African-Americans, on average have lower level of educational achievement and occupy a large percent of the lower level positions.

The African Americans interviewed expressed that they felt no different in terms of discrimination on their jobs. One African-American man who was interviewed worked in a reduction facility for twenty years. He had an 8th grade education. He was clear that he did not have the skills for doing other work and was happy to have the job that he does because it paid well. He saw the job as an opportunity in a living environment that was short of job opportunities for most people.

Both general managers spoke highly of African-American employees and insisted that all workers in their plants were more like family than employees, regardless of race. One spoke of company sponsored and financed programs to help any employee (“black, white, or green – it doesn’t matter”) who wished to advance through the ranks, including getting any necessary boating licenses.

There were three main categories of concerns expressed regarding the current state of the industry. The first concern was largely business related. The two reduction facilities were worried about staying profitable and staying competitive. The second concern was regarding fisheries management and affected all who worked the fishery. Harvesters and general managers alike were extremely concerned regarding conflicts between user groups particularly between commercial fishery interests and the interests of recreational fishermen who are concerned that there are not enough menhaden to feed the available striped bass and other prized sport fish populations.

Business Concerns

The two plant general managers spoke about some of the larger business concerns they have. Typical business concerns such as supply and demand of product were understandably important to them. But they were also concerned about markets for their products. One of the plants will shortly be undergoing a $16-17 million expansion program designed to be able to reduce menhaden oil for human consumption as Omega-3 fatty acids. Other competitors for their products include soybeans. For these businesses, they are not just concerned with fish stocks and ability to land them, but also competition from other products.

Other business concerns include pressure from outside development, and the previously mentioned labor issues. Outside development is increasing the property values where these plants are located. There is concern that newly arrived people in the community do not understand the history, nor appreciate the positive impact the industry has had on the surrounding community.

Fisheries Management and Environmental Regulation

All harvesters and plant managers who were aware of the stock status emphasized that they were pleased that the stocks are healthy. They are resigned to having to cope and react with regulations that limit their fishing activities. One spoke of his tremendous disappointment at the fact that industry representatives were no longer on the management boards. "…they kicked us off. It must have been about three years ago because we were involved in the menhaden business and hired a couple of sports fishermen to take our place."

The reduction facilities agree with the way the fishery is currently being managed, however, they fear what they see as increasing influence from recreational interests. Menhaden pound net fishermen were not as happy with fisheries management. They were unhappy because they must remove their nets from the water because of sea turtle encounters. "They found three dead turtles out of three hundred in pound nets so they decided to have an industry wide closure. They had a mandatory closure on the pound net fishery for two weeks [in 2003] and this year coming up [2004] they're talking like six weeks of closure."

Menhaden processors must not only deal with fisheries regulatory bodies, but also with air and water quality authorities. Depending on the actions of those government agencies, they are viewed as being benign or harassment. One processor said they specifically worked with the Environmental Protection Agency on smoke stack issues and did not feel they were overly hassled. On the other hand, one general manager complained about fish kills that occurred near his processing plant had the state division of water quality visiting him “11 straight days, Saturday and Sunday included, raising hell about that [leaking] raw box. It’s been there over 100 years and never had a fish kill.”

Conflicts Between User Groups

User group conflicts represented the most salient issue for many of the people interviewed. No one interviewed stated that they ever had conflicts with other commercial fishing interests. Currently, there are 14 vessels (10 from Omega Protein, 4 independent bait vessels) whose home ports are on the Chesapeake Bay, in or near Reedville. Vessels that target menhaden tend to be larger than most other nearby fishing vessels and the commercial vessels tend to stay away from each other.

Everyone interviewed was concerned about the ongoing conflicts with groups representing recreational fishing interests. Most were seriously worried that recreational interests would win out over commercial interests. They cited the larger number of people who fish recreationally and their lobbying power. Some expressed a feeling that there is a conspiracy against commercial fishing and recreational groups are using tactics to shut down commercial fishing altogether, especially in fisheries where there is significant recreational interest. Tactics mentioned included getting persons sympathetic to their issues appointed to management boards, lobbying state and federal legislators, misrepresenting facts, and fabricating stories to implicate commercial fisheries in the demise of recreationally valued species.

Some respondents said they have heard recreational groups feel that commercial menhaden harvest, particularly from the Chesapeake Bay, is removing a vital food source for striped bass, a fish whose numbers had been greatly reduced in the past, but now is back in record numbers. The commercial fishermen point to the stock assessment that says that Chesapeake Bay harvest of menhaden largely targets age 2 and 3 fish; however, the majority of striped bass are eating age 0 and 1 fish, along with some age 2 fish. They also pointed out that even though the striped bass are now back in record numbers, the harvest of this recovered fish stock clearly favors recreational fishermen. A commercial fisherman who sometimes uses a gill net said that the only way he could keep two striped bass for his own consumption was to go out and get a recreational fishing license, because as a commercial fisherman he was not allowed to keep any striped bass.

A few people interviewed stated the reason why the recreational fishermen are targeting menhaden is because they want to end commercial fishing altogether and will use any means to do so. There were some reports of conflicts on the water with recreational fishermen, as well. Both processing plant general managers expressed that there had been occasions when a recreational vessel would see purse seine boats heading for a school of fish, a recreational vessel would speed through the school of fish trying to break them up. However, these were represented as relatively rare occurrences.

The commercial menhaden fishermen feel as if they are the underdogs in this conflict. As one commercial fisherman put it, “the [recreational] industry and big dollar businesses are behind them pushing for this. They have all their magazines. They've got a lot of people with a lot of money."

Fishing Communities

Menhaden fishing was seen as being very important to the history of both the Beaufort and Reedville communities. Elijah Reed founded the town of Reedville after the Civil War. He came to Virginia's Northern Neck with the expressed purpose of finding a place to locate a menhaden processing plant. Beaufort was settled nearly two hundred years prior to the emergence of the commercial menhaden fishery in North Carolina. One town owes its identity to menhaden; the other considers menhaden to be an important part of its history.

Omega Protein is the largest employer in all of Northumberland County, Virginia, with about 250 employees most of the year. Beaufort Fisheries employs approximately 70 individuals when there are fish to harvest and process. There are many employers in Carteret County that have more workers than Beaufort Fisheries.

The employment differences between the communities have a large effect on the current role menhaden has locally. In Reedville, Omega Protein is highly visible and the company works hard to be perceived as a good community partner. All the people interviewed in Reedville, including a few who were not directly involved in the commercial harvest of menhaden perceived Omega Protein as a good corporate citizen. For example, several years ago Omega Protein made significant changes to their infrastructure to help reduce the smell from the reduction facility in response to community concerns.

One person interviewed mentioned that sometimes when new people (known locally as "come heres") arrive in Reedville they complain about the processing facility. Over time, they realize the facility doesn't present a problem. Some people said that if Omega Protein was to close down, Reedville would cease to exist.

Beaufort Fisheries has a different relationship with its local community. Long time residents are aware of the role of menhaden in the community, but the local importance of commercial fishing to the economy was long ago supplanted by tourism and coastal gentrification. Additionally, Beaufort Fisheries is located on a property primely situated for waterfront home development.

Tourism and coastal gentrification are issues for both communities. Many of the older fishermen used to come to Beaufort years ago as part of the menhaden fleet that followed the fish. These people, especially, look at recent developments of Beaufort with disdain. One fisherman stated that the last thing he wanted for Reedville was for it to become like Beaufort with all the expensive houses and fancy restaurants.

Perceptions About the Future

Many of the people interviewed were asked whether they would recommend to a young person a career working in menhaden. Most of the respondents were too worried about the future of the commercial fishery to recommend it. Their biggest concerns were about the outcomes of brewing user group conflicts and being able to keep competitive in the markets where menhaden are used. For most, the work is hard and the outcome is uncertain. One processor general manager said, "I've got two boys and I told both of them I'm not going to allow them to come down here. I want something better for them than this." Exceptions to this feeling were among land-based workers with steady employment working at the processing plants.

Conclusions
The people who work in the menhaden industry have many things to worry about. Like all fishermen, they have to be able to find and catch the fish. But they also have to worry about competition, sometimes from non-fishery related products such as soybeans. Because menhaden are an industrial product rather than a seafood product, processors worry about additional issues such as compliance with environmental regulations of water and air quality. However, the long-term survivability of the industry may depend on the outcome of its current battles with recreational fishing interests.

Commercial menhaden harvesters and processors view the stocks as being more than adequate for the needs of both themselves and as forage food for striped bass and other fish. However, they are concerned that attacks on the menhaden industry are really attempts to eliminate commercial harvesting altogether. There is a sense that without some outside intervention their way of live may be lost in favor of recreational fishing interests. Whether or not this prophecy will be true remains to be seen.

5.3.1.3 Bycatch

(from 2001 ASMFC FMP)
Incidental bycatch of other finfish species in menhaden purse seines has been a topic of interest and concern for many years to the commercial and recreational fishing industry, as well as the scientific community (Smith 1896; Christmas et al. 1960; Oviatt 1977). Numerous past studies have shown that there is little or no bycatch in the menhaden purse seine fishery. Some states restrict bycatch to 1% or less of the total catch on a vessel by regulation.

A study of bycatch of other species in the Atlantic menhaden fishery was recently completed through funding provided by the Federal Saltonstall-Kennedy grant program (Austin et al. 1994). The Virginia Institute of Marine Science studied bycatch levels of finfish, turtles, and marine mammals in the Atlantic menhaden fishery. Results from that study indicated that bycatch in the 1992 Atlantic menhaden reduction fishery was minimal, comprising about 0.04% by number. The maximum percentage bycatch occurred in August (0.14%) and was lowest in September (0.002%). Among important recreational species, bluefish accounted for the largest bycatch, 1,206 fish (0.0075% of the total menhaden catch). No marine mammals, sea turtles, or other protected species were killed, captured, entangled or observed during sampling. A concurrent study was conducted by Louisiana State University for the Gulf of Mexico menhaden fishery (de Silva and Condrey 1997).

Additional data are available from the Gulf of Maine IWP fishery in 1991. Every catch unloaded onto the processing vessel was inspected by a state observer. A total of 93 fish were taken as bycatch along with about 60,000,000 individual menhaden (D. Stevenson, Maine DMR, pers. comm.; as cited in ASMFC 1992).

5.3.2 Striped Bass

5.3.2.1 Description of fishing practices, vessels and gear

Current status of the fishery

Total striped bass harvest (commercial and recreational) comprised 3.32 million fish in 2005, a 33.7% increase from 2002 (2.48 million fish) but only a 0.9% increase from 2004 (3.29 million fish) (ASMFC 2006). This increase in total harvest from 2004 to 2005 is attributable to the commercial harvest (1.0 million fish), which rose by 11.25% from 2004, rather than the recreational fishery (2.31 million fish), which fell by 3.0% from 2004. On the other hand, discard losses in the recreational fishery (1.52 million fish) rose by 17.5% from 2004 to 2005, meaning that the total recreational catch (harvest plus discard losses) rose by 2.0% from 2004. An estimate of commercial discard losses for 2005 is unavailable at this time. In 2004, commercial discard losses measured 0.52 million fish, or 36.38% of the total commercial catch for the year.

Recreational harvest (2.31 million fish) and discard losses (1.52 million fish) account for 60.3% and 39.7%, respectively, of the total 2005 recreational loss. Maryland recreational fisheries harvested 21.4% of total recreational landings in number, followed by Massachusetts (17.0%), Virginia (16.1%), New Jersey (13.8%), New York (10.9%), and North Carolina (6.8%). The remaining states each landed 5% or less of the total recreational landings in number.

The commercial harvest (1.0 million fish) was dominated by Maryland’s commercial fisheries, which made up 56.5% of the total commercial landings by number in 2005. Virginia accounted for 11.8% of the commercial landings by number, followed by PRFC (8.0%), New York (7.0%), North Carolina (6.6%), and Massachusetts (5.9%). The remaining states each landed 3% or less of the total commercial landings in number.
A reliable estimate for commercial discards is unavailable at the writing of this report. Thus, the 2004 data are used to portray the proportion of the total catch attributable to recreational harvest and discards and commercial harvest and discards (Figure 5.3.2-1).

Table 2. Striped Bass Landings and Discards (numbers of fish) from 2002-2005

	Recreational		Commercial	
	Harvest	Discard Losses	Harvest	Discard Losses
2002	1,828,367	1,118,538	654,062	168,201
2003	2,405,707	1,168,907	865,689	262,078
2004	2,381,823	1,373,430	907,328	518,847
2005	2,309,670	1,520,854	1,009,437	N/A

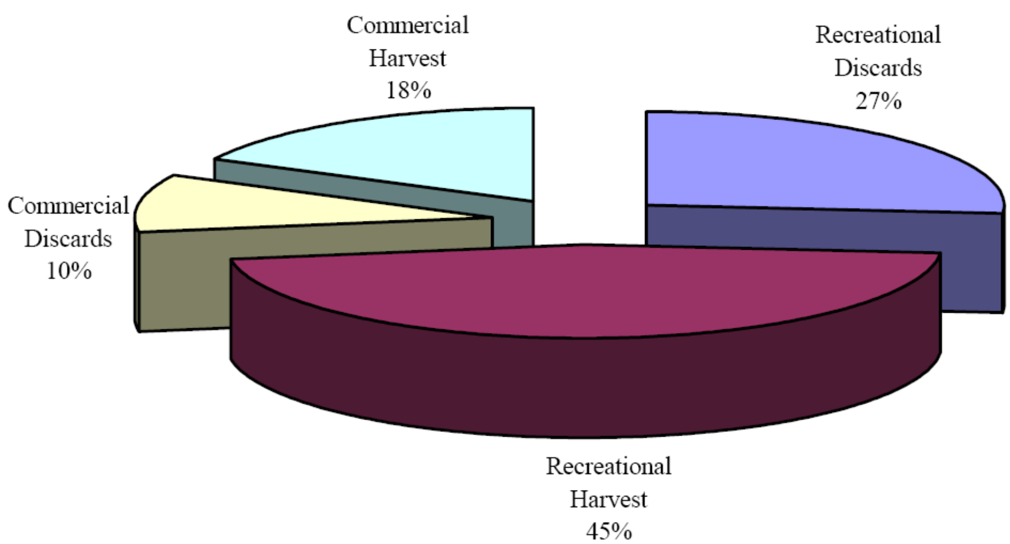


Figure 5.3.2-1. 2004 Striped Bass Total Catch (5.2 million fish)

Allowable gear

No harvest or possession in the EEZ. In state waters, the predominant gear types in the commercial fisheries are gillnets, pound nets, and hook and line. Commercial fisheries operate in 8 of the 14 jurisdictions regulated by the Atlantic States Marine Fisheries Commission FMP. Commercial fishing for striped bass is prohibited in New Jersey, Pennsylvania, Connecticut, New Hampshire, Maine and the District of Columbia. Massachusetts allows commercial fishing with hook and line gear only, while other areas allow net fisheries.

5.3.2.2 Bycatch

Studies are currently being conducted to evaluate the interactions between striped bass, bluefish, weakfish and prey species, such as Atlantic menhaden. ASMFC has contracted out for the development of a dynamic trophic model or a multispecies model to determine the effect of the abundance for a suite of species has on each other (see Section 1.4.4.2

Multispecies Management as an Element of Ecosystem Management of ASMFC's Amendment 6 to the Striped Bass FMP). As the abundance of striped bass has increased striped bass are more frequently encountered as bycatch in other fisheries, but the data on discard and frequency of interactions is limited. Amendment 6 creates a bycatch and discard mortality monitoring program to determine which fisheries are catching striped bass as bycatch and to evaluate the discard mortality associated with the gear used in these fisheries (see below). As more information becomes available, Atlantic States Marine Fisheries Commission intends to incorporate the data into the Atlantic striped bass management program.

Under Amendment 6 to the Striped Bass FMP, the Management Board will be developing a bycatch data collection and management program. However, if prior to the completion of this work the Board identifies a significant discard problem, the Board may require the state/jurisdictions to make management changes to reduce the impacts of discards.

In general, states shall undertake every effort to reduce or eliminate the loss of striped bass from the general population due to bycatch discard mortality. The Technical Committee shall examine trends in estimated by-catch annually.

Bycatch Monitoring and Research Program
The issue of striped bass discards from the commercial and recreational fisheries has increased in importance as the population has rebuilt through the 1990's. However, the data on the magnitude of discards and the mortality associated with these discards is limited. In order to increase the accuracy of the discard data, the Striped Bass Management Board will, through the adaptive management program, develop a mandatory data collection program. The program will be developed during the first two years of implementation of this amendment.

The following two paragraphs generally describe the data collection program and research projects that need to be established to address the discard data deficiencies.

The MRFSS collects information on the number of striped bass released alive from recreational fishermen, however, the mortality of these released fish has been the source of debate for a number of years. Currently, the Technical Committee applies an 8% mortality rate to all released striped bass. To further refine this mortality estimate, there are two additional pieces of information that need to be determined. First, recreational fishermen need to be surveyed to determine the proportional use of different gear type and fishing practices (e.g. fly fishing, live bait fishing, circle hooks, treble hooks, etc). The second piece of information that needs to be determined is the mortality rate associated with each of the particular gear types and fishing practices.
The latest stock assessment for striped bass (2001) noted that there is considerable uncertainty in the estimate of discard mortality from commercial fisheries. As in recreational fishing, two data elements need to be collected to increase the accuracy of the commercial discard estimates; (1) at-sea observers need to be placed on commercial vessels that are targeting striped bass as well as vessels that may encounter striped bass to

collect information on the number of fish that are being discarded from the various commercial gear types and (2) scientific studies need to be conducted to determine the discard mortality associated with all of the commercial gear types that are currently encountering striped bass.

Bycatch Management Program
Following the implementation of the discard data collection program, the Management Board will develop a bycatch management program. This program will be designed to implement penalties for "excessive" bycatch problems and/or incentives to states/jurisdictions that implement measures to minimize the impact of discards.
This program will be developed through the adaptive management process and should be ready for implementation four years after the implementation of Amendment 6 to the Striped Bass FMP.

5.3.3 Anadromous and Catadromous Species

5.3.3.1 Description of fishing practices, vessels and gear

Current status of the fisheries

American Eel (ASMFC 2006)
American eel currently support important commercial fisheries throughout their range. Fisheries are executed in rivers, estuaries, and ocean. Commercial fisheries for glass eel/elver exist in Maine, South Carolina, and Florida (though in Florida, no commercial glass eel/elver landings were recorded in 2005), whereas yellow/silver eel fisheries exist in all states/jurisdictions with the exception of Pennsylvania and the District of Columbia (though in New Hampshire, Rhode Island, South Carolina and Georgia, no commercial yellow/silver eel landings were recorded in 2005).

Commercial
Commercial landings decreased from the high of 1.8 million pounds in 1985 to a low of 641 thousand pounds in 2002. Landings of yellow/silver eels in 2005 totaled 867,861 pounds.1 New Jersey, Delaware, Maryland, and the Potomac Rivers Fisheries Commission each reported landings over 100,000 pounds of eel, and together accounted for 83% of the coastwide commercial total landings in 2005. Landings data for 2005 comes from the 2006 State Compliance Reports.

Recreational
Few recreational anglers directly target eel. For the most part, hook and line fishermen catch eel incidentally when fishing for other species. The NMFS Marine Recreational Fisheries Statistics Survey (MRFSS), which has surveyed recreational catch in ocean and coastal county waters since 1981, shows a declining trend in the catch of eel during the latter part of the 1990's. According to MRFSS2, 2005 recreational total catch was 94,119 fish, which represents a slight decrease in number of fish from 2004 (112,001 fish). Florida and Georgia combined, represent 53% of the recreational American eel catch; Florida, Georgia, Delaware, and Maryland combined, represent 78% of the recreational American eel harvest in 2005. About 87% of the eel caught were released alive by the

anglers (MRFSS 2005 total recreational harvest was 12,100 fish). Eel are often purchased by recreational fishermen for use as bait for larger gamefish such as striped bass, and some recreational fishermen may catch their own eels to utilize as bait.

Shad and River Herring

(Source: ASMFC 2006)

American shad, hickory shad, and river herring formerly supported important commercial and recreational fisheries throughout their range. Fisheries are executed in rivers (both freshwater and saltwater), estuaries, tributaries, and oceans. Although recreational harvest data are scarce, most harvest is believed to come from the commercial industry. Commercial landings for all these species have declined dramatically from historic highs. Following is a summary of fisheries by species:

American Shad

Total combined river and ocean commercial landings decreased from a high of 2,364,263 pounds in 1985 to a low of 1,390,512 pounds in 1999, but increased in 2000 to 1,816,979 pounds. Based upon landings data provided in Compliance Reports from individual states and jurisdictions, an all-time low has been reached in 2005 with landings of 680,061 pounds. This new low is likely a direct result of the closure of all ocean-intercept fisheries. Combined landings from New Jersey, Delaware, North Carolina and South Carolina accounted for 84.3% of the commercial harvest in 2005. No directed shad harvest was reported in state Compliance Reports from Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, Pennsylvania, Maryland, the District of Columbia, and Florida. The National Marine Fisheries Service reported no harvest from Massachusetts, Pennsylvania, the District of Columbia, South Carolina, Georgia, and Florida.

Shad bycatch landings from ocean waters in 2005 decreased greatly from 2004 levels, comprising 7,411 pounds, or about 1% of the coastwide total. Only five states—Maine, New Hampshire, New York, New Jersey, and North Carolina—reported landings of ocean bycatch. Substantial shad sport fisheries occur on the Connecticut (CT and MA), the Hudson (NY), the Delaware (NY, PA and NJ), the Susquehanna (MD), the Santee and Cooper (SC), the Savannah (GA), and the St. Johns (FL) Rivers. Shad sport fisheries are also pursued on several other rivers in Massachusetts, Virginia, North Carolina, South Carolina, and Georgia. In 2005, recreational creel limits ranged from zero to 10 fish per day. The exception to this is the Santee River (SC), which is permitted to have a 20 fish per day creel limit due to the approval of a conservation equivalency plan in 2000. Tens of thousands of shad are caught by hook and line from large East Coast rivers each year but detailed creel surveys are generally not available. Actual harvest (catch and removal) may amount to only about 20-40% of total catch, but hooking mortality could boost this "harvest" value substantially. Several comprehensive angler use and harvest surveys are planned or have been recently completed.

MRFSS Data for American Shad are unreliable due to the design of MRFSS that focuses on active fishing sites along coastal and estuarine areas. For 2005, MRFSS does not report the harvest or catch of any American shad.

Several creel surveys were completed in 2005 including the Hudson River (NY), the Connecticut River (CT), the Susquehanna River below the Conowingo Dam (MD), the Tar-Pamlico River (NC), the Tailrace Canal of the Cooper River (SC), the Ogeechee River (GA), and the St. John's River (FL). Of the 6,582 shad caught on the Hudson, anglers harvested only 508, a retention rate of 8%. Catch per unit effort ranged from 0.123 fish/hour in early spring to 0.585 fish/hour in late spring. Anglers in Connecticut that targeted shad were successful 32% of the time when fishing from shore and boats were successful 41.2% of the time. Total effort in Connecticut has declined 75% since the last creel survey conducted in 2000, while total catch shows a similar decline of 73.2%. In Maryland, the catch and release fishery for American shad reported a catch rate of 0.49 American shad per hour. Anglers on the Tar-Pamlico River had a total catch of 7,575 shad (combined American and hickory) with an estimated harvest of 1,212 fish (American shad = 1,192 fish), and a success rate of 1.6 fish caught per angling hour. The estimated harvest for the Cooper River recreational fishery was 14,629 fish, 65% of which were males. Fishermen surveys report that catch per hour as 1.60 shad and that 22% of fish caught were released on the Cooper River. The harvest on the Ogeechee River from January 30 through April 2, 2005, was 442 fish (379.9 pounds) with effort estimated to be 1754 hours. The creel survey on the St. John's River in Florida for the 2004-2005 season reported 1,270 shad caught with an estimated harvest rate of 21% (269 fish).

Hickory Shad

The Potomac River Fisheries Commission, North Carolina, South Carolina, and Georgia reported hickory shad commercial landings in 2005. North Carolina reported the highest landings with 173,779 pounds. In 2005, the coast-wide commercial landings for hickory shad were 179,919 pounds (from 2006 State Compliance Reports). This is a decrease from the 2004 total preliminary landings of 187,464 pounds.

MRFSS Data for hickory shad are unreliable due to the design of MRFSS that focuses on active fishing sites along coastal and estuarine areas. For 2005, MRFSS does not report the harvest or catch of any hickory shad.

River Herring (Blueback Herring and Alewife)

Commercial landings of river herring declined 90% from over 13 million pounds in 1985 to about 1.33 million pounds in 1998. In 2005, river herring landings were reported from Maine, New Hampshire, Massachusetts, New York, New Jersey, Delaware, PRFC, and North Carolina, totaling 692,827 pounds, down from 2004's total of 2,120,881 (from 2006 State Compliance Reports). MRFSS Data for river herring are unreliable due to the design of MRFSS that focuses on active fishing sites along coastal and estuarine areas. For 2005, MRFSS does not report the harvest or catch of any river herring.

5.3.4 Red Drum

5.3.4.1 Description of fishing practices, vessels and gear

Commercial

There is no directed commercial fishery for Atlantic red drum in state waters, and the EEZ was closed to harvest by the SAFMC in 1990 to prevent any directed fishery for red drum, especially for adults, from developing in these waters (ASMFC 2002) . Traditionally, landings have occurred almost exclusively in state waters as prior to the EEZ closure landings in federal waters were a bycatch of other fisheries and did not exceed 2,000 lbs in any year since 1985 (Table 5.3.4-1). Commercial landings of red drum along the Atlantic coast were high during the early 1950's and have generally fluctuated from 150,000 to 400,000 lbs since (Table 5.3.4-2).

Currently, North Carolina is the only state along the Atlantic coast with any significant annual landings of red drum and has accounted for greater than 95% of the coastwide landings since 1989. Landings of red drum in North Carolina are primarily a bycatch in other fisheries, particularly those targeting flounder, striped mullet, spotted seatrout and weakfish. Virginia consistently reports annual landings but has only exceeded 10,000 lbs in three of the last 10 years. Landings north of Virginia are less frequent. Florida has had a no sale provision on native caught red drum since January 1, 1989. In 1987, South Carolina declared red drum a gamefish and established a no sale provision except for mariculture grown fish with the appropriate documentation. Landings in Georgia are limited to hook and line captured fish and typically do not exceed 3,000 lbs. Overall Atlantic landings for the period of 1989 through 2000 were dominated by anchored and runaround gill nets followed by long hauls, pound nets and beach seines. Georgia allows the sale of red drum as long as they are within the state's regulations (size & bag limits) and the individual has their equivalent of a land and sell license – fish must be taken with hook and line

Table 5.3.4-1. EEZ commercial red drum bycatch harvested in the Atlantic (Source: NMFS SEFC).

Year	Pounds	Ex-vessel Value (1982 Dollars)
1979	679	108
1980	19,992	3,621
1981	3,985	992
1982	3,913	887
1983	4,920	1,244
1984	11,778	2,882
1985	1,832	488
1986	1,883	707
1987	1,149	428
1988	991	248

Table 5.3.4-2. Total commercial landings of red drum in the Atlantic (Source: NMFS Annual Reports).

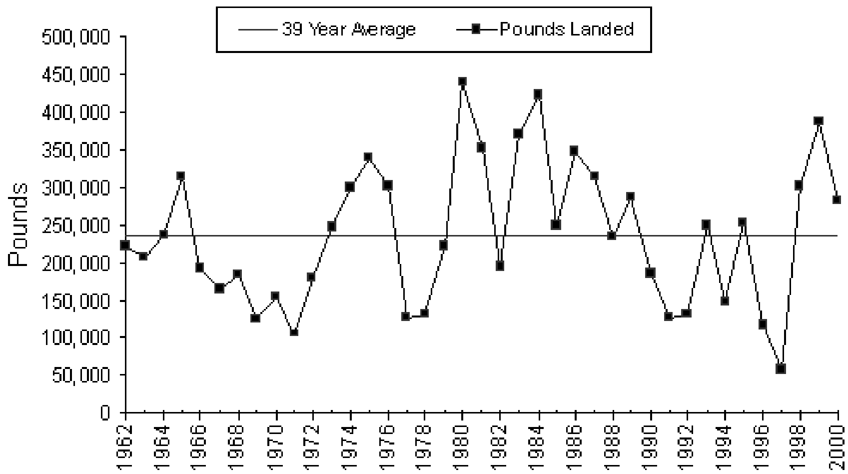
Year	Commercial	Recreational
1950	189,200	
1951	135,500	
1952	130,100	
1953	127,400	
1954	138,800	
1955	96,200	
1956	106,700	
1957	108,000	
1958	102,300	
1959	131,200	
1960	129,000	
1961	114,500	
1962	149,300	
1963	134,200	
1964	119,000	
1965	146,300	
1966	153,000	
1967	147,100	
1968	167,000	
1969	119,000	
1970	146,800	
1971	85,200	
1972	128,400	
1973	166,500	
1974	137,300	

1975	83,300	
1976	106,000	
1977	103,500	
1978	104,696	
1979	92,684	
1980	191,222	
1981	258,374	317,963
1982	139,170	480,676
1983	105,164	675,924
1984	130,885	976,971
1985	88,929	414,176
1986	77,070	360,725
1987	42,993	227,222
1988	284	12,507
1989		146,064
1990		258,569
1991		516,999
1992		396,555
1993		290,930
1994		578,412
1995		525,231
1996		596,483
1997		345,390
1998		487,091
1999		540,310
2000		885,447
2001		853,714
2002		551,128
2003		729,445
2004		677,736
2005		791,709
2006		644,920
2007		833,817

Note: East Florida – commercial harvest prohibited since late 1980s

Historic landings data along the Atlantic coast are from the period prior to when Florida and South Carolina prohibited the sale of native red drum. Commercial landings and nominal value can be subdivided into five major gear categories: gill nets, pound nets, seines, hand gear and trawls.

Figure 5.3.4-1. Red Drum Commercial and Recreational Harvest (pounds). (Source: NMFS Office of Science and Technology, 2006; state compliance reports, 2006).



North Carolina

Red drum are commercially harvested in North Carolina with a variety of gears and constitute a bycatch fishery and historically have not been a major component of commercial landings. Prior to the imposition of a possession limit on red drum greater than 32 inches TL (changed to 27 inches TL in 1992) by North Carolina, Outer Banks fishermen occasionally targeted large red drum with long haul seines in Pamlico Sound. The increase in the legal minimum size in 1991 limit for red drum from 14 to 18 inches TL reduced mortality of immature red drum. This resulted in an increase in the age of entry into the commercial fishery of about 8 months. Due to current size restrictions (18-27 inches TL), commercially harvested red drum are generally from a single year class. Therefore, catches vary annually and depend on year class strength. Age-1 and age-2 fish presently dominate the landings and the harvest of adults is prohibited.

Historically, annual landings of red drum have been highly variable from year to year. These ranged from 7,500 to 214,000 lbs during the 1970's with an average of 83,009 lbs per year whereas landings from the 1980's were greater than in the 1970's, averaging 203,813 lbs per year with a range of 52,561 to 283,020 lbs.

Landings averaged 186,932 lbs per year and ranged from 52,548 to 372,749 lbs during the 1990's. The majority of these originated from fishing operations in Pamlico and Core sounds and the Atlantic Ocean. No commercial gear dominated landings in the 1970's, although long haul and common haul seines generally were the most productive with gill and pound nets, and fish trawls occasionally contributing larger catches. During the 1980's and 1990's, anchored and run-around gill nets accounted for greater than 70% percent of annual commercial landings. Most of these net fisheries are seasonal, and target spotted seatrout, (southern and/or summer) flounder, and striped mullet along the barrier islands and mainland shorelines.

They catch red drum incidentally and make an important contribution to the overall catch.

A directed fishery used run-around gill nets to encircle schools of red drum developed in the mid-1990s. This gear accounted for 31% of the commercially catch from 1994-1998.

Prior to the implementation of trip limits in 1998, nearly half of the total annual commercial harvest of red drum was taken by a few trips which landed large amounts of red drum. Slightly more than 1% (1.1%) of the trips that landed red drum accounted for 48.5% of the total harvest. For this period, the largest landings of red drum primarily occurred behind the 'Outer Banks' from Oregon Inlet to Ocracoke during the spring and fall. Gears that typically had large landings of red drum were runaround gill and long haul nets. These were effective in circling large schools of red drum. Participation in the run-around gill net fishery increased during this period as many of these fishers actively pursued schools of red drum., A typical catch for a run-around gill net trip would range from 100 to 1000 pounds whereas a few exceptional long haul sets caught up to 10,000 pounds.

Implementation of a 100-pound trip limit on the commercial harvest of red drum in October of 1998 effectively eliminated any large-scale directed fishery for red drum. Some fishers still actively targeted this species even at these reduced harvest limits. This resulted in reduction of the daily commercial trip limit to levels ranging from 10 to 5 red drum. Also, at least 50% of the landings by weight for an individual trip consist of edible finfish other than red drum. The intent of the rule is to make this exclusively a bycatch fishery.

South Carolina

South Carolina designated red drum a gamefish in 1987. They can be sold only when transported into the State with proper documentation showing legal capture, or if the fish are produced by a bonafide mariculture operation. Red drum landings never exceeded 14,000 lbs with a nominal value of $12,000 in the last 30 years.

Georgia

Georgia had a small commercial gill net fishery prior to the 1950s, but presently there is no directed commercial fishery for red drum. Landings enter the market through recreational fishermen who sell their catch, often directly to restaurants. This is not illegal as long as they were not harvested with net gear. As a result, many red drum are not recorded in official commercial statistics.

Florida

Commercial landings on the east coast of Florida fluctuated annually between 85,000 lbs and 250,000 lbs from 1962 to 1987. Most of the catch was taken by either as bycatch of the mullet gill net fishery or by a directed fishery utilizing trammel nets. Commercial landings ceased when regulations prohibiting their sale became effective in 1988. The existence and potential red drum harvest in the EEZ off the east coast of Florida is recognized by both commercial and recreational fishermen.

Recreational

Recreational fishing for red drum along the Atlantic coast historically extended farther north than at present. Red drum was a prized sport fish as far north as Barnaget Light, New Jersey. There, surf fishermen commonly landed large adult fish (25-45 lb). This fishery no longer exists; only an occasional large red drum is caught.

The recreational fishery for trophy red drum along the South Atlantic is primarily a surf fishery along the outer beaches of barrier islands. The largest (94 lbs 2 oz) red drum ever caught by recreational angler was taken in the surf on the Outer Banks of North Carolina. Fishing in estuaries from Chesapeake Bay to Florida catch small red drum. Salt-water angling surveys indicate that 88% of red drum caught in the Mid-Atlantic region in 1965 came from sounds, rivers and bays. In 1970, only 47% were caught in estuarine waters. Along the southeastern Atlantic coast, more red drum (59%) were caught in the ocean in 1965; however, in 1970, 79% were caught in sounds, rivers and bays. Catch data for red drum on the eastern shore of Virginia from 1955 to 1965 showed small catches. Highest rates occurred during 1957 and 1962 (0.14 fish per man-hour). More fish were landed during May and September, but catch rates were highest for April, June and September. A low of 0.01 fish per man-hour occurred in 1959. A 1963 sport fishery survey in the Cape Canaveral area of Florida found that catch per unit effort was highest in October and April.

<u>Seasonality</u>

Along the barrier beaches and inlets of the North Carolina coast, surf fishing is best from March to June and mid-September to November. Large red drum are available from mid-May through early October around river mouths and high shoals in Pamlico Sound. Small fish are caught along barrier island beaches during a seven month period (June through December) with a peak period from September through December. During these months, red drum are also caught in estuarine waters, particularly around grass flats and shorelines. Red drum fishing occurs throughout the year from South Carolina to southeastern Florida with the best fishing for small fish from August to December inshore. Large fish are targeted from March to May and September to December along the beach and shoal areas. Best fishing for small red drum from St. Lucie Inlet to southern Florida is from April to August and from August to November for large ones. Adult red drum generally remain in coastal waters during spring and fall months and during late summer move offshore, presumably to spawn. Generally, adult drum move offshore during the coldest months.

<u>Fishing Gear</u>

Red drum are caught by bottom fishing, jigging and casting from shore, as well as, bottom fishing, casting, live-lining and trolling from boats. Baits include soft or shedder crabs, shrimp, clams, squid, cut or whole mullet, spot, herring or menhaden, as well as artificial lures such as spoons, jigs, weighted bucktails, feathers, plugs and streamer flies. Red drum have been harvested by gill nets and gigs for home consumption in North and South Carolina. In South Carolina, 94% of the individuals using gill nets in 1978, fished recreationally. This fishery no longer exists since the State of South Carolina declared red drum a gamefish and harvest is restricted to hook and line and, during designated months, gigs.

For-Hire Fishery (ASFMC 2002)
The for-hire fishery for red drum is charter boat fishery, concentrated on the Atlantic Coast from North Carolina to Florida, with a substantial fishery in the Gulf of Mexico as well. A head boat fishery for red drum is virtually nonexistent (ASMFC 1994b). NMFS headboat survey data from 1981 to 1997 estimated headboat landings of red drum to be far less than 1% of total recreational fishery landings (Holiman 1999).

Whitmore (1994) looked at relative directed effort in the South Atlantic charter fishery. Relative effort was based on the product of the number of boats and the number of months/12 fished. Directed red drum effort ranked 9th out of 16 species, well behind black sea bass, groupers, and king mackerel, but ahead of summer flounder, Spanish mackerel, and sharks. Nearly 50% of the relative effort occurred in Georgia, with the remaining effort distributed fairly evenly between North Carolina and South Carolina. Florida did not have a charter fishery directed at red drum in 1994 and 1995.

From 1983 to 1998, estimated red drum harvest in the South Atlantic charter fishery fluctuated between 3,348 fish (8,868 lbs.) in 1989 and 119,067 fish (283,813 lbs.) in 1995. Harvest declined annually from 1995 to 1998. The 1998 harvest of 14,769 fish (91,303 lbs.) comprised 39% of the catch and 5% (7% by weight) of the total recreational harvest. From 1983 to 1998, the percentage of party/charter boat trips targeting red drum has fluctuated between 0.20% in 1985 to 5.22% in 1995. This peak of 5.22% in 1995 coincides with peak catch and landings over the same time period. This percentage has declined annually from 1995 to 1.15% in 1998. In contrast, the percentage of anglers targeting red drum in the shore and private/rental boat fisheries in 1998 was 3.19% and 5.10%, respectively (Holiman 1999). Comparing the charter boat fisheries by state, the highest percentage of charter boat anglers targeting red drum in 1998 was South Carolina (4.4%), followed by Georgia (2.4%), Florida East Coast (0.9%), North Carolina (0.2%), and Virginia (0.0%).

Popularity of fishing for red drum by charter boat anglers has increased from 1998 to 2000 in Florida (0.9% to 3.9%) and Georgia (2.4% to 8.7%), while decreasing in South Carolina (4.4% to 2.2%) and essentially remaining very low in North Carolina (0.2% to 0.1%). In South Carolina, red drum has been the most sought-after species in the inshore charter-boat fishery from 1995 to 1999. In 1999, of 2,900 inland boat trips, 1,476 (51%) were targeted at red drum, followed by anglers targeting any species (16%), and spotted seatrout (15%). The number of permitted boats fishing in inland waters (where the majority of the effort is directed at red drum) has increased nearly annually from 39 boats in 1993 to 98 boats in 1999. Directed effort for red drum increased significantly from 1,359 angler-hours in 1993 to 12,875 angler-hours in 1999. Catch has shown an increasing trend similar directed effort from 1993 to 1999, while CPUE has fluctuated between 0.5 and 0.7 fish per angler-hour. By comparison, private boat CPUE showed the same trend though was consistently lower than charter CPUE. Of the reported 10,656 red drum caught by the charter fishery, 85% were released (Low 2001).

Seasonality

A 1994 ASMFC survey of Atlantic seaboard charter and headboat fisheries showed that the charter boats fish year-round for red drum in South Carolina and Georgia, and fish 9 months for red drum in North Carolina (data indicated no red drum charter fishery in 1994) (ASMFC 1994b). In South Carolina prior to 1998, the charter-boat effort for red drum peaked in April and during September - November. The fishery has since evolved into a year-round fishery, with substantial effort each month in 1999 (Low 2001). Charter boats near Brunswick, Georgia, will target red drum year-round, with peak the season from September through December in the saltwater marshes surrounding St. Simons Island.

Fishing Gear

Charter boats are generally not exclusive to red drum, turning to target other species when the bite is hot and at different times of the year. Fly fishing charters are gaining popularity. Fishing is for red drum is predominantly inshore and estuarine. In 1993, 15% of charter trips in South Carolina were in estuarine waters. These estuarine charters sought red drum and spotted seatrout as the principal species. The majority (70%) of South Carolina charter trips was offshore and not targeting red drum. Common fishing techniques include bottom fishing from North Carolina through Georgia, with additional live lining in North Carolina and trolling in South Carolina (ASMFC 1994). Charter boats near Cape Canaveral, Florida, will pole flat-bottom boats in estuarine waters and fish with spinning gear on light line (6-10 lbs.). In the fall near Morehead City, North Carolina, charter boats fish the estuarine waters for red drum using cut bait. Historically, Matlock (1978) indicated that charter boats were still, troll, and drift fishing in the open ocean and bays.

In South Carolina, 98% of red drum effort, and 95% of the catch is concentrated in inland waters. The remaining effort is concentrated in open ocean waters from 0-3 miles, with some effort in ocean waters >3 miles. Open ocean effort is typically bottom fishing over natural structure, but does include some manmade structure. Inland trips are typically made with smaller boats with an average of 2 anglers. Ocean trips are typically larger boats carrying an average of 4 anglers.

Current status of the fishery

Commercial Fishery

(ASMFC 2006)

Few commercial landings of red drum have been recorded in states north of Maryland since 1960 (Table 4.3.4-3). Only Rhode Island, New York, and New Jersey have reported any commercial landings since 1980. Coastwide commercial landings show no particular temporal trends, ranging from approximately 55,000 to 422,000 pounds annually between 1960 and 2005 (Figure 5.3.4-2). The greatest harvest was reached in 1980, while the lowest was reached in 2004. In 2005, coastwide commercial harvest increased to 129,980 pounds, the majority (~99%) from North Carolina (Table 4.3.4-3). Landings in Georgia (<500 lbs), Virginia (656 lbs), Maryland (37 lbs), and New Jersey (517 lbs) comprise the remaining 1% of the commercial landings for red drum.

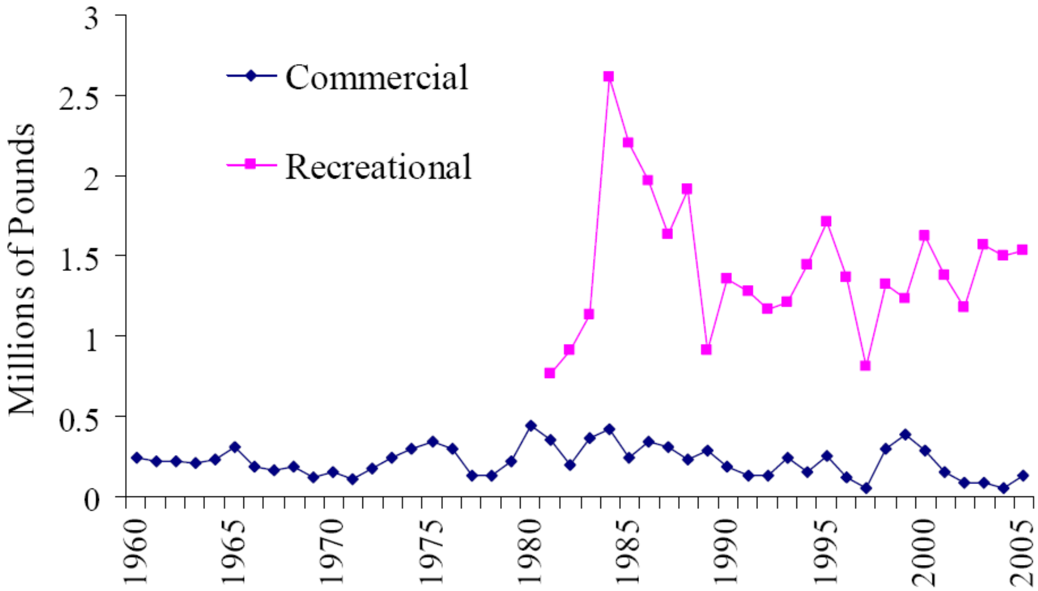


Figure 5.3.4-2. Red Drum Commercial and Recreational Harvest (pounds). (Source: NMFS Office of Science and Technology, 2006; state compliance reports, 2006).

Historically, the major commercial harvesters were North Carolina and Florida. However, commercial harvest has been prohibited in Florida under state regulations, since January 1988. South Carolina has also banned the commercial harvest or sale of native caught red drum since 1987. In North Carolina, an annual cap of 250,000 pounds limits the commercial harvest of red drum. In 1999, the North Carolina Marine Fisheries Commission implemented rules through the development of a state red drum FMP that: prohibited the possession or sale of red drum larger than 27 inches; reduced the recreational bag limit to 1 fish per day between 18-27 inches; imposed a commercial daily trip limit of seven (7) fish with a 250,000 pound annual cap; and required fishermen to attend gill nets less than five-inch stretched mesh from May 1-October 31 in order to reduce regulatory discards. In 2003, the South Atlantic State/Federal Fisheries Management Board approved a motion to allow the North Carolina Fisheries Director to raise or lower the seven fish commercial trip limit while maintaining the 250,000 pound harvest cap.

Table 4.3.4-3. Commercial landings (in pounds) of red drum along the Atlantic coast, 1960-2005 (1960-2004 Data: NMFS Fish. Stats. & Econ. Division, 2006; 2005 Data: state compliance reports, 2006).

Year	RI	NY	NJ	DE	MD	VA	NC	SC	GA	FLEC	Total
1960					200	29,400	79,300	4,200	400	129,000	242,500
1961						12,000	89,700	900	1,000	114,500	218,100
1962						12,900	60,900			149,300	223,100
1963						2,700	71,200			134,200	208,100
1964						4,600	101,500	11,500		119,000	236,600
1965					1,200	94,900	71,400			146,300	313,800
1966					200	3,100	35,200	200	2,700	153,000	194,400
1967						1,100	12,800	900	5,800	147,100	167,700
1968						100	12,500		5,500	167,000	185,100
1969					400	700	3,900	700	2,700	119,000	127,400
1970						100	7,500	400	2,200	146,800	157,000
1971						700	17,200	1,300	1,200	85,200	105,600
1972						5,900	42,900	1,200	3,400	128,400	181,800
1973				900		6,200	70,300	600	3,700	166,500	248,200
1974						15,700	142,000	2,300	3,100	137,300	300,400
1975				200		19,600	214,000	12,400	10,000	83,300	339,500
1976						18,600	168,200	2,600	7,300	106,000	302,700
1977				200		300	19,700	800	5,000	103,500	129,500
1978				300		2,100	21,774	4,325	328	104,696	133,523
1979					100	1,900	126,517	1,767	935	92,684	223,903
1980						400	243,223	4,107	1,493	191,222	440,445
1981						200	93,420		261	258,374	352,255
1982						1,700	52,561	2,228	251	139,170	195,910
1983					100	41,700	219,871	2,274	1,126	105,164	370,235
1984						2,600	283,020	3,950	1,961	130,885	422,416
1985						1,100	152,676	3,512	3,541	88,929	249,758
1986					1,000	5,400	249,076	12,429	2,939	77,070	347,914
1987						2,600	249,657	14,689	4,565	42,993	314,504
1988					8,100	4,000	220,271		3,281	284	235,936
1989					1,000	8,200	274,356	165	3,963		287,684
1990					29	1,481	183,216		2,763		187,489
1991					7,533	24,771	96,045		1,637		129,986
1992					1,087	2,352	128,497		1,759		133,695
1993					55	8,637	238,099		2,533		249,324
1994	5,094				859	4,080	142,160		2,141		154,334
1995		668			6	2,992	248,200		2,578		254,444
1996		8			215	2,073	113,401		2,271		117,968
1997	43				22	4,049	52,548		1,395		58,057
1998	165	57	311		336	6,436	294,415		672		302,392
1999		47	241	6	504	12,368	372,996		1,115		387,277
2000		1,215			843	11,457	271,013		707		285,235
2001		58	14		727	5,318	149,674				155,791
2002		116			1,161	7,752	79,767				88,796
2003		43			631	2,716	81,364				84,754
2004					12	638	54,086				54,736
2005			517		37	656	128,770				129,980
Total	5,302	2,212	1,083	1,606	26,357	398,276	6,040,873	89,446	98,215	3,566,871	

Recreational Fishery

(ASMFC 2006)

The number of red drum harvested by recreational fishermen ranged between approximately 175,000 and 1,000,000 fish from 1981 to 1988; since then, the number has been in the 250-530,000 range (Figure 5.3.4-3). Over a million fish were taken in both 1984 and 1985, but this was exceptional. The recreational harvest for 2005 was 498,761 fish (~1.5 million pounds) (Table 5.3.4-4). By number of fish, Florida takes approximately 38% of the catch, but takes over 50% by weight. South Carolina, Georgia, and Florida are responsible for 88% of the catch by number of fish (Table 5.3.4-5). The number of red drum released by recreational fishermen was approximately 2.4 million in 2005, an increase from the previous year, and the second highest for the time series (Table 5.3.4-6).

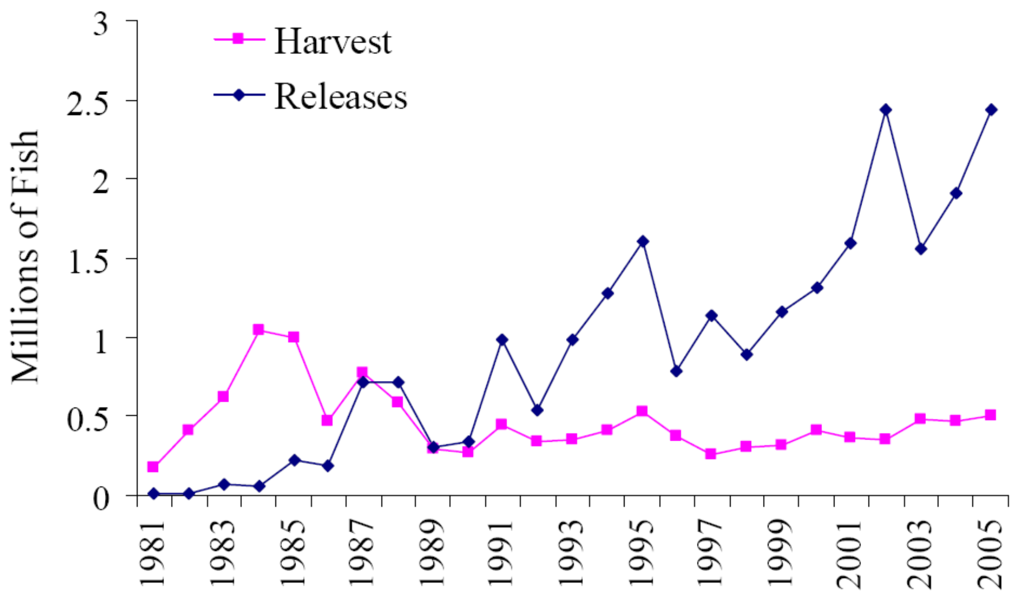


Figure 5.3.4-3. Recreational harvest of red drum in number of fish (A + B1 fish) (Source: NMFS Office of Science and Technology, 2006).

Table 5.3.4-4. Recreational harvest (pounds of A + B1 fish) of red drum along the Atlantic coast, 1981-2005 (Source: NMFS Office of Science & Technology, 2006).

Year	DE	MD	VA	NC	SC	GA	FLEC	Total
1981		4,370	347,939	31,519	50,230	9,442	317,963	761,463
1982				37,511	340,686	52,150	480,676	911,023
1983		3,018	51,299	109,540	222,691	67,298	675,924	1,129,770
1984			1,285	1,160,539	183,282	294,583	976,971	2,616,660
1985				70,677	1,532,316	185,887	414,176	2,203,056
1986		754,161	145,517	31,594	498,586	173,837	360,725	1,964,420
1987			44,332	200,729	913,639	250,795	227,222	1,636,717
1988			9,030	451,974	1,050,049	385,860	12,507	1,909,420
1989		2,348	27,236	214,849	396,771	127,245	146,064	914,513
1990		2,679		302,994	631,819	161,712	258,569	1,357,773
1991		5,635	30,582	108,268	284,290	337,207	516,999	1,282,981
1992			55,324	109,134	411,484	198,751	396,555	1,171,248
1993			45,505	266,459	282,614	328,245	290,930	1,213,753
1994			3,684	192,060	314,632	353,616	578,412	1,442,404
1995			66,270	405,620	417,595	300,337	525,231	1,715,053
1996			1,512	204,556	396,394	164,756	596,483	1,363,701
1997			1,810	39,077	296,155	129,836	345,390	812,268
1998			34,861	591,428	129,619	84,348	487,091	1,327,347
1999			92,794	326,303	103,777	166,630	540,310	1,229,814
2000			95,596	316,029	93,043	228,965	885,447	1,619,080
2001	860		51,890	132,578	188,198	155,854	853,714	1,383,094
2002	* 860	15,154	155,213	182,226	103,830	170,572	551,128	1,178,123
2003			57,214	118,808	449,399	234,865	729,445	1,589,731
2004			31,748	114,434	402,789	286,486	668,179	1,503,636
2005			7,366	242,019	318,882	194,706	773,480	1,536,453
Total	1,720	787,365	1,358,007	5,960,925	10,012,770	5,043,983	12,609,591	

*Weight estimated from same number of fish (275) caught in previous year

Table 5.3.4-5. Recreational harvest of red drum along the Atlantic coast, 1981-2005 (Source: NMFS Office of Science & Technology, 2006).

Year		DE	MD	VA	NC	SC	GA	FLEC	Total
1981	Harvest		601	49,630	15,054	27,319	6,323	75,244	174,171
	PSE (%)		48	60.2	38.7	45.7	37.2	36.7	
1982	Harvest				16,445	160,760	30,757	204,401	412,363
	PSE (%)				34.7	18.2	37.2	27.5	
1983	Harvest		2,413	32,940	81,528	104,806	56,854	344,513	623,054
	PSE (%)		51.8	48.2	55.6	37.8	27.7	19.1	
1984	Harvest			1,457	108,787	129,547	258,188	549,381	1,047,360
	PSE (%)			100	67.8	30.7	21.9	16.1	
1985	Harvest			0	22,077	530,110	183,837	265,185	1,001,209
	PSE (%)			0	32.7	30.6	18.6	22.2	
1986	Harvest		12,804	28,139	17,501	193,188	102,279	113,440	467,351
	PSE (%)		67.4	22.4	65.7	19.8	18.8	19.8	
1987	Harvest			2,186	61,100	522,420	138,062	51,225	774,993
	PSE (%)			58.8	19.9	17.7	18.4	30.9	
1988	Harvest			4,311	142,626	287,916	147,042	9,542	591,437
	PSE (%)			70.7	18.3	20.2	28.4	72.6	
1989	Harvest		1,014	12,007	62,359	127,492	51,557	34,748	289,177
	PSE (%)		90.9	32.2	16.3	20.8	21.9	24.3	
1990	Harvest		1,279	0	33,149	118,666	76,304	44,280	273,678
	PSE (%)		100	0	28.2	22.4	22.5	22.7	
1991	Harvest		2,745	17,119	38,658	125,833	162,802	102,727	449,884
	PSE (%)		51.6	39.4	15.3	22.6	23.2	15.7	
1992	Harvest			13,275	23,593	112,534	83,861	104,265	337,528
	PSE (%)			38.3	19.3	15.6	16.7	14.1	
1993	Harvest			14,005	49,493	119,189	105,710	65,140	353,537
	PSE (%)			50	12	16.9	17.9	10.5	
1994	Harvest			1,378	28,953	129,515	134,214	120,938	414,998
	PSE (%)			60.8	16.4	21.5	17.5	9.9	
1995	Harvest			3,665	88,593	202,430	134,915	96,927	526,530
	PSE (%)			53.6	12.3	25.4	17.1	10.7	
1996	Harvest			572	36,746	130,649	60,251	146,823	375,041
	PSE (%)			99.2	15	14.9	20	16.1	
1997	Harvest			1,920	8,749	129,022	39,041	75,235	253,967
	PSE (%)			62.3	25.7	12.7	19.2	14.1	
1998	Harvest			13,070	114,638	46,509	24,929	107,982	307,128
	PSE (%)			30.2	12.1	15.9	20.3	10.3	
1999	Harvest			12,425	64,739	44,069	67,283	126,180	314,696
	PSE (%)			38.7	14.5	18.3	23.7	7.8	
2000	Harvest			22,603	61,618	37,217	94,144	191,070	406,652
	PSE (%)			27.8	12.9	23.3	19.7	8.4	
2001	Harvest	275		6,967	23,142	61,420	90,376	177,633	359,813
	PSE (%)	100.1		39.8	15.9	26.8	30.3	8.2	
2002	Harvest	275	5,521	49,795	42,541	41,190	90,993	119,010	349,325
	PSE (%)	99.8	71.2	22.8	15.4	21.6	19.1	8.7	
2003	Harvest			13,607	25,481	162,484	122,259	159,331	483,162
	PSE (%)			38.1	16.5	23.1	16.9	8.5	
2004	Harvest			4,975	30,165	134,079	139,074	162,016	470,309
	PSE (%)			65.6	18.9	15.2	22.2	8.5	
2005	Harvest			2,673	53,154	143,769	108,286	190,879	498,761
	PSE (%)			100.1	20.5	18.7	18.6	9.0	
Total Harvest		550	26,377	308,754	1,249,550	3,818,598	2,506,777	3,634,716	

Table 5.3.4-6. Recreational releases of red drum by state, 1981-2005 (Source: NMFS Office of Science & Technology, 2006).

Year		NH	NJ	DE	MD	VA	NC	SC	GA	FLEC	Total
1981	Released	1,334					2,230	417	0	9,042	13,023
	PSE (%)	100					100	100	0	70.8	
1982	Released						0	2,496	3,377	10,172	16,045
	PSE (%)						0	80.2	65.4	66.9	
1983	Released						1,866	6,751	1,417	54,723	64,757
	PSE (%)						100	63	60	40.2	
1984	Released						2,931	0	4,232	47,196	54,359
	PSE (%)						100	0	52.9	38.1	
1985	Released					1,115		16,688	6,315	193,399	217,517
	PSE (%)					73.4		31.3	31.3	29.1	
1986	Released					7,595		24,018	56,045	100,095	187,753
	PSE (%)					68.1		32.4	23	22.4	
1987	Released						18,499	82,595	234,676	377,959	713,729
	PSE (%)						36.7	26.6	19.7	21.1	
1988	Released					3,958	24,874	269,176	177,319	233,988	709,315
	PSE (%)					71	57.8	23.6	24.6	27.6	
1989	Released				2,918	7,038	7,566	42,824	71,162	172,303	303,811
	PSE (%)				75.5	57.3	34	40.8	27	21.3	
1990	Released				0	934	12,452	102,611	156,263	68,667	340,927
	PSE (%)				0	100	38.2	39.2	38.9	18.3	
1991	Released				4,432	14,461	121,178	99,968	92,803	645,773	978,615
	PSE (%)				66.6	76.1	14.4	42	31.2	23.3	
1992	Released		301			15,383	60,230	46,269	128,066	284,893	535,142
	PSE (%)		99.9			43.5	17.9	27.5	21.4	11.5	
1993	Released					50,434	182,301	146,324	140,386	465,656	985,101
	PSE (%)					44	20.1	27	27.7	11.8	
1994	Released					10,684	107,662	324,706	146,039	691,261	1,280,352
	PSE (%)					34.7	14.3	17.2	24.6	10.4	
1995	Released					33,560	164,520	362,844	356,618	683,706	1,601,248
	PSE (%)					40.4	10.5	14.9	23.9	9.1	
1996	Released					2,424	35,752	176,517	71,983	500,374	787,050
	PSE (%)					46.3	17.9	15.9	24.1	9.3	
1997	Released			2,571		109,754	259,570	175,772	22,736	560,559	1,130,962
	PSE (%)			80.6		36.1	10.6	25	29.7	9.7	
1998	Released				2,768	93,660	199,701	84,274	33,882	481,009	895,294
	PSE (%)				79.7	22.3	11.3	14.6	21.3	8.7	
1999	Released				2,148	232,893	247,146	87,776	18,586	565,981	1,154,530
	PSE (%)				73.5	31.4	10.3	14.9	50	8	
2000	Released				1,458	196,541	203,967	94,050	129,190	693,152	1,318,358
	PSE (%)				100	35.7	14.2	18.6	22.4	7.3	
2001	Released					30,365	238,552	221,045	249,892	850,044	1,589,898
	PSE (%)					31.1	13.7	18.5	25.2	7.5	
2002	Released			1,388	18,412	801,239	640,857	142,931	168,902	663,879	2,437,608
	PSE (%)			45.8	36.7	14.7	10.7	18.6	18.6	9.1	
2003	Released			731	2,935	43,379	75,561	430,052	272,897	732,141	1,557,696
	PSE (%)			100	75.2	40.1	15	17.5	16.5	8.5	
2004	Released			68		33,148	191,593	403,591	167,146	1,117,636	1,913,182
	PSE (%)			100		29.5	10.1	16.9	18	7.9	
2005	Released					31,146	327,859	498,537	330,193	1,247,109	2,434,844
	PSE (%)					33.2	15.1	12.7	19.9	7.4	
Total	Released	1,334	301	4,758	35,071	1,719,521	3,120,275	3,830,066	3,034,992	11,413,838	

Allowable gear
There is no harvest or possession of red drum allowed in the EEZ.

5.3.4.2 Economic and social description

Commercial fishery
Reported annual red drum commercial landings (i.e. pounds) in the Atlantic states had averaged about 322,000 pounds with an average, deflated (i.e. 1982 dollars) total value of $140,00 during the 1980's (Table 5.3.4-7), a 61% increase in the total value compared to 1970's. In contrast, the average reported landings in the Atlantic states in the 1990's were only 61% of 1980's average landings, and the total deflated ex-vessel value declined to an average of about $100,000 (Table 5.3.4-7) even though the highest nominal ($412,000) and deflated ($215,000) total ex-vessel value was recorded in 1999. In general, the overall ex-vessel prices, nominal and deflated, in the Atlantic states have generally increased since the 1970's (Table 5.3.4-7).

These trends in red drum landings and values in the Atlantic states mainly reflect the interaction of regulatory actions and market demand. Before the 1980's, commercial red drum landings in both the Atlantic and Gulf states were generally associated with commercial fishing effort in near-shore and estuarine waters and catches of juvenile red drum. In the early 1980's, the ex-vessel price of red drum began to increase significantly as Cajun-style blackened redfish was introduced to restaurant menus (Martin 1986) throughout the country. Commercial fishermen in the Gulf began targeting schooling adult red drum in the EEZ (GMFMC 1987) and concern grew in the Atlantic states that large-scale purse seine fishing would begin developing along the Atlantic coast which could lead to recruitment over fishing (ASMFC 1984). Recreational fishing lobbying efforts to assign the red drum "gamefish" status also began developing in the Atlantic states, especially Florida (e.g. Thunberg et al. 1993). In 1987, the red drum was given gamefish status in South Carolina, and Florida began taking management actions to remove red drum as a commercially targeted species. In 1988, the ISFMP (ASMFC 2001) requested that all states from Maine to Florida implement red drum regulations "...to prevent development of northern markets for southern fish." By January 1989, Florida had implemented a one-fish bag limit for recreational and commercial fishermen and a ban on sale of native red drum.

Table 5.3.4-7. Commercial red drum landings (lbs) and ex-vessel value in Atlantic states including North Carolina, 1970-2000 (Pers. Comm. NMFS, Fish. Stats. and Econ. Div.).

	All Atlantic States					North Carolina			NC percent of:	
Year	**Pounds Landed**	**Nominal Value**	**Defl. Value**	**Nom. Price/lb**	**Defl. Price/lb**	**Pounds Landed**	**Nominal Value**	**Defl. Value**	**Atlantic Pounds**	**Defl. Value**
1970	157,000	$ 30,061	$ 94,830	$ 0.19	$ 0.60	7,500	$ 648	$ 2,044	4.8%	2.2%
1971	105,600	20,068	64,115	0.19	0.61	17,200	1,718	5,489	16.3%	8.6%
1972	181,800	35,992	91,350	0.20	0.50	42,900	5,228	13,269	23.6%	14.5%
1973	248,200	54,651	115,297	0.22	0.46	70,300	7,775	16,403	28.3%	14.2%
1974	300,400	57,606	115,443	0.19	0.38	142,000	15,777	31,617	47.3%	27.4%
1975	339,500	57,007	112,885	0.17	0.33	214,000	21,537	42,648	63.0%	37.8%
1976	302,700	62,522	90,743	0.21	0.30	168,200	21,700	31,495	55.6%	34.7%
1977	129,500	43,487	55,117	0.34	0.43	19,700	2,672	3,387	15.2%	6.1%
1978	133,523	51,458	58,542	0.39	0.44	21,774	2,480	2,821	16.3%	4.8%
1979	223,903	72,609	71,890	0.32	0.32	126,517	21,728	21,513	56.5%	29.9%
1980	440,445	155,134	170,103	0.35	0.39	243,223	47,133	51,681	55.2%	30.4%
1981	352,255	158,851	168,096	0.45	0.48	93,420	18,817	19,912	26.5%	11.8%
1982	195,910	123,912	123,912	0.63	0.63	52,561	12,273	12,273	26.8%	9.9%
1983	370,235	142,161	148,704	0.38	0.40	219,871	51,958	54,349	59.4%	36.5%
1984	422,216	187,111	164,421	0.44	0.39	283,020	82,458	72,459	67.0%	44.1%
1985	249,758	122,950	101,277	0.49	0.41	152,676	50,384	41,502	61.1%	41.0%
1986	349,669	190,776	169,721	0.55	0.49	249,076	106,808	95,025	71.2%	56.0%
1987	314,814	206,651	142,322	0.66	0.45	249,657	148,205	102,070	79.3%	71.7%
1988	235,936	132,658	76,814	0.56	0.33	220,271	125,289	72,547	93.4%	94.4%
1989	287,684	182,552	134,924	0.63	0.47	274,356	173,755	128,422	95.4%	95.2%
1990	187,489	110,658	77,819	0.59	0.42	183,216	106,450	74,859	97.7%	96.2%
1991	129,986	73,696	54,109	0.57	0.42	96,045	56,989	41,842	73.9%	77.3%
1992	133,350	93,072	59,738	0.70	0.45	128,497	86,859	55,750	96.4%	93.3%
1993	249,390	210,566	124,008	0.84	0.50	238,099	203,955	120,115	95.5%	96.9%
1994	154,626	108,270	61,727	0.70	0.40	142,159	102,322	58,336	91.9%	94.5%
1995	254,437	228,609	132,297	0.90	0.52	248,193	223,413	129,290	97.5%	97.7%
1996	117,753	117,013	63,080	0.99	0.54	113,392	112,915	60,871	96.3%	96.5%
1997	58,059	61,285	36,986	1.06	0.64	52,548	56,950	34,369	90.5%	92.9%
1998	302,475	294,590	172,578	0.97	0.57	294,415	288,429	168,968	97.3%	97.9%
1999	387,227	411,656	214,740	1.06	0.55	372,749	397,974	207,603	96.3%	96.7%
2000	285,269	308,437	169,099	1.08	0.59	271,013	294,864	161,658	95.0%	95.6%
Ten Year Averages:										
1970	212,213	$ 48,546	$ 87,021	$ 0.24	$ 0.44	83,009	$ 10,126	$ 17,069	32.7%	18.0%
1980	321,912	160,275	140,029	0.52	0.44	203,813	81,708	65,024	63.5%	49.1%
1990	197,479	170,942	99,708	0.84	0.50	186,931	163,626	95,200	93.3%	94.0%

The deflated ex-vessel price of red drum has generally increased between 1994 and 2000, while the ex-vessel price index of edible fish has displayed a downward trend during the same time period (NMFS 2001a). The red drum ex-vessel price increase during this time period compared to the edible fish index would suggest that the demand for red drum has outpaced the overall demand for fish in the U.S. To make definitive statements on how changes in demand and supplies, including imported red drum products, over time have affected red drum prices would require an extensive econometric analysis and an understanding the market structure. Regardless, it appears that the increase in red drum ex-vessel prices during the 1990's probably included regulatory constraints on U.S. caught red drum commercial fishing (supplies), as well as an increase in the demand for red drum. It should also be noted that harvesting of adult red drum with a lower ex-vessel price compared to estuarine-oriented juveniles complicates the analysis of price trends during the 1970's and 1980's (SAFMC 1990b) compared to the 1990's, but other factors may moderate this complication. Specifically, the harvest of adults was obviously constrained by regulatory actions in the Atlantic states starting in the 1980's, and the higher market prices for juvenile created a strong incentive for targeting juvenile fish compared to adults.

Commercial landings of red drum in North Carolina have represented the most consistent and nearly sole source of red drum landings and related ex-vessel values in the Atlantic states. During the 1990's, North Carolina commercial harvest has annually averaged about 93% and 94%, respectively, of the total landings and deflated ex-vessel value for the Atlantic states (Table 5.3.4-7) while in the 1970's the deflated value of North Carolina landings only averaged 18% of the Atlantic total. During the 1990's, nominal total ex-vessel value for red drum landings in North Carolina averaged $163,600 fluctuating between approximately $57,000 in 1991 to $398,000 in 1999. The deflated total ex-vessel value averaged about $95,200 (Table 5.3.4-7) during the 1990's and also reached a high in 1999, about $208,000 and a low of approximately $34,400 in 1997. Both the nominal and deflated ex-vessel price of red drum in North Carolina has shown a generally increasing trend during the 1990's with the nominal price reaching a low of $0.58 in 1990 to a high of $1.08 in 1999 (Figure 5.3.4-4). The deflated ex-vessel price fluctuated between $0.65 in 1997 and $0.41 in 1990 (Figure 5.3.4-3). As previously discussed, the upward increase in North Carolina ex-vessels was probably influenced by the decline in red drum supplies due to regulatory actions in the Southeast, especially in the Gulf states.

Trends in the total annual ex-vessel value by major gear groups in the Atlantic states during the 1980's reflect the decline in Florida landings and the increase in North Carolina landings. Before 1985, red drum catches from the "Combined Gear" category, as reported for the east coast of Florida, comprised more than 50% of the total nominal ex-vessel value of Atlantic red drum landings (Table 5.3.4-8). With a decline in Florida landings after 1985, gill net catches, mostly from North Carolina, represented over 50% of the total nominal ex-vessel of Atlantic red drum landings (Table 5.3.4-8) by 1988. Seine catches also accounted for a significant portion of the total ex-vessel value during the 1986-98 period (Table 5.3.4-8).

Annual average, deflated ex-vessel prices for red drum by gear groups have been the highest from hand gears and lowest for pound nets and incidental trawl catches (Table 5.3.4-8) plus trawl prices had the lowest deflated minimum price during the 1980-2000 period. Fish size may account for the higher prices for hand gear catches compared to other gears because hand gear catches are often composed of one or two year old fish which usually fetch a higher price per pound than large adult fish which were historical caught by trawls or other gear used in the EEZ (SAFMC 1990b).

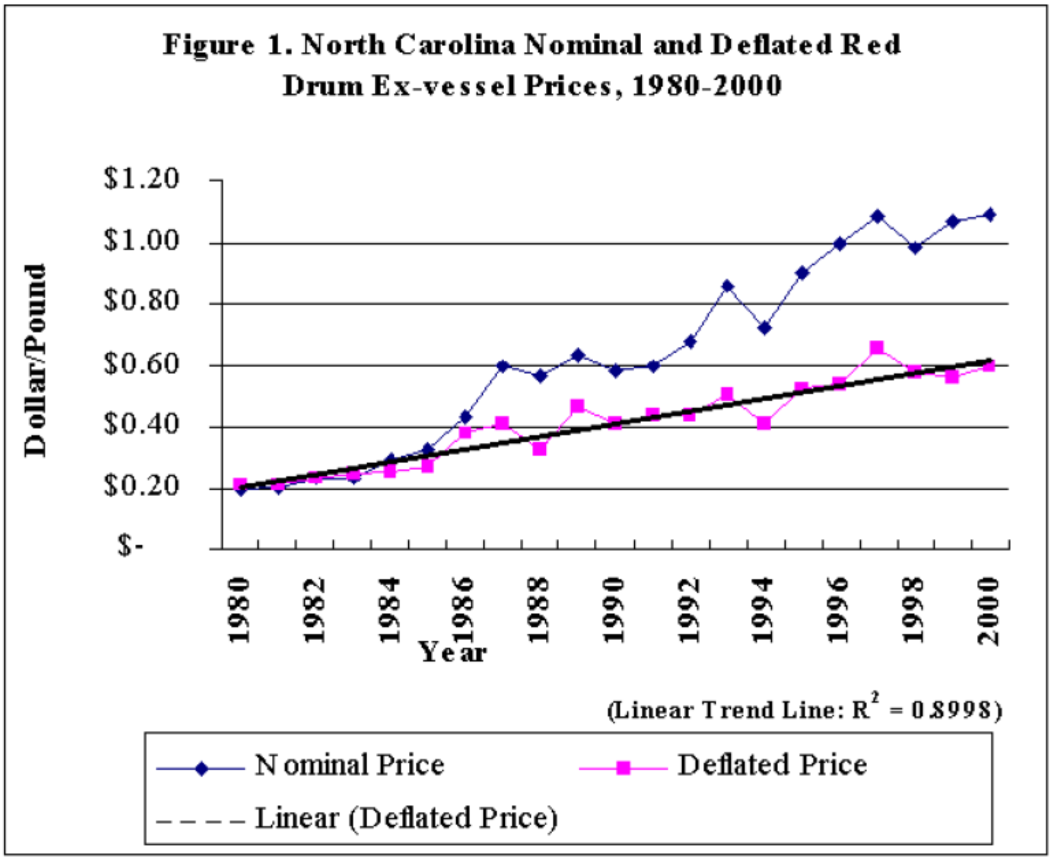


Figure 5.3.4-4. North Carolina nominal and deflated red drum ex-vessel prices, 1980-2000.

There is no recent research on the red drum marketing (e.g. retail price trend analysis, import trends, market structure, etc) in the United States. Except for commercial aquaculture operations, the lack of available market studies on red drum is partly indicative of the lack of interest in developing markets for red drum due to current regulatory constraints on directly harvesting and/or marketing red drum in the U.S. It does appears that there is at least a regional demand for red drum in the Gulf states because anecdotal information indicates that some of the red drum caught in North Carolina are sold in the Gulf states. A small amount of red drum is still landed in the Gulf states, about 38,000 pounds in 2000 at a nominal ex-vessel price of $1.52.

Table 5.3.4-8. Average deflated ex-vessel prices of red drum landings by gear in the Atlantic states, 1980-2000.

Gear Group	Average	Maximum	Minimum
"Combined Gear"*	0.69	0.79	0.57
Gill Nets	0.42	0.65	0.22
Seines	0.40	0.65	0.22
Hand Gear	0.70	1.05	0.47
Other	0.51	0.71	0.18
Pots & Traps	0.53	0.78	0.37
Pound Nets	0.38	0.54	0.18
Trawl	0.35	0.79	0.13

"Combined Gear" - category used for all Florida red drum landings in the 1980s; * Commercial harvesting was disallowed in
Florida after 1988
Gill nets - includes runaround, anchor and other gill nets
Seines - includes beach, common and long haul seines
Hand Gear - includes hand lines, spears (gigs), rakes and rod and reel
Other - all other gear
Pots & Traps - includes fish and crab traps
Trawls - includes shrimp, finfish and crab otter trawls

Recreational fishery

Starting in 1999, a recreational fishing expenditure survey was conducted in the Southeast region as an "add-on" to the NMFS Marine Recreational Fisheries Statistics Survey (MRFSS) (Genter et al. 2001).

Angler daily trip expenditures were estimated for each fishing mode by resident group (i.e. non-resident and state resident) within each state including North Carolina, South Carolina, Georgia, and Florida. For example, resident private boat anglers fishing in North Carolina, South Carolina, Georgia, and on the east coast of Florida, averaged $71, $36, $161, and $37, respectively. Non-resident anglers averaged $92, $67, $78, and $141, when saltwater fishing in North Carolina, South Carolina, Georgia, and along the east coast Florida, respectively (Genter et al. 2001).

Expenditures related to anglers targeting a given species such as red drum were not estimated in the above study. Southwick Associates (2001) did prepare a preliminary estimate of red drum expenditures by red drum anglers in Virginia, the Carolinas, Georgia, and Florida by applying the average expenditure to the number of red drum targeting trips in a given state (Table 5.3.4-9). On a per-trip basis, largest expenditures are reported for resident activity in Florida, South Carolina and North Carolina (Table 5.3.4-9). The average expenditures are significantly higher when equipment items are included compared to trip-related costs only. Equipment expenditures are primarily comprised of boat and tackle costs. The large difference between trip-related and equipment expenditures is also seen in the U.S. Fish and Wildlife Service's 1996 National Survey (USFWS 1997), but was not as prevalent in the 1991 National Survey when the general economy was not as robust as in 1996 and 1999. It can be speculated that increased expenditures for equipment by red drum and other anglers may be driven in part by a strong economy as well as other factors such as fish population, changing angler preferences (i.e. flats boats), etc.

Based upon these preliminary estimates, 1999 expenditures by all anglers was over $1.3 billion, and resident and non-resident anglers targeting red drum in 1999 were $75.7 million and $1.26 billion, respectively. Within the South Atlantic states, Florida had the highest estimated total expenditure by non-resident anglers, $59.2 million, followed by North Carolina, $10.4 million; South Carolina, $4.0 million; and Georgia, $111,000. Estimated resident angler expenditures within the South Atlantic states were $1.1 billion, $78.8 million, $32.1 million, and $11.1 million for Florida, South Carolina, North Carolina, and Georgia, respectively. For the South Atlantic states, estimated red drum angler expenditures represented over 20 % of all marine angler expenditures in the South Atlantic states as reported by Genter et al. 2001. The economic "importance" and impacts of these angler expenditures and related implications will be discussed in Sections 1.5.3.1 and 1.5.3.2. (sections reference ASMFC Red Drum Amendment 2)

The NMFS also conducted an add-on survey to the MRFSS in the southeast region during 1997. The purpose of the add-on survey was to obtain socio-demographic, economic and fishing behavioral information on recreational anglers throughout the southeastern United States (Holiman 2000).

Summarized information on the demographic and economic characteristics of the recreational fishery in North Carolina was also provided in the FMP (NCDMF 2001) for 1997-1998. The majority (95.4%) of recreational anglers targeting red drum in North Carolina waters in 1997 were white and predominantly male (83.5%) and averaged 18.2 years of experience in recreational fishing. The majority (68%) of North Carolina red drum anglers surveyed was between 26 and 55 years of age and about 73% of them were employed, earning between $15,000 to over $175,000 per year. Slightly more than half reported earning over $45,000 per year.

Table 5.3.4-9. Red drum target effort trips in the South Atlantic by state for the period 1985-2000. Figures are thousands of trips (Source: MRFSS data as reported by Holiman 1999 and Southwick 2001).

Year	North Carolina	South Carolina	Georgia	East Florida	Total
1985	3,380.36	1,571.87	438.86	9,926.71	15,317.80
1986	2,977.06	1,447.73	639.43	9,840.15	14,904.37
1987	3,861.94	1,648.12	751.35	10,686.78	16,948.19
1988	4,762.89	1,906.13	666.72	11,485.19	18,820.93
1989	3,848.90	1,080.63	625.89	10,805.93	16,361.35
1990	3,867.93	931.06	705.44	8,067.60	13,572.03
1991	3,762.39	1,796.21	740.82	11,086.64	17,386.06
1992	4,372.00	1,457.23	572.15	10,340.03	16,741.41
1993	4,716.08	1,776.21	673.46	9,630.11	16,795.86
1994	5,170.14	1,987.30	955.82	11,815.06	19,928.32
1995	5,106.67	1,530.25	781.72	11,617.80	19,036.44
1996	4,741.82	1,434.08	617.36	10,525.86	17,319.12
1997	4,891.51	1,606.38	575.87	11,298.96	18,372.72
1998	4,461.46	1,714.09	571.86	10,089.81	16,837.22
1999	4,555.04	1,213.32	472.58	8,194.17	14,435.11
2000	6,090.99	1,276.87	763.93	11,162.94	19,294.73
Total	70,567.18	24,377.50	10,553.26	166,573.72	272,071.66

Although marine angler expenditures at the state and county level are useful, economists do not consider expenditures and related economic impacts to be the best approach for determining the economic value of the recreational fishing experience. From an economic perspective, the appropriate approach to quantifying the economic value of recreational fishing is based upon consumer surplus (Edwards 1991).

In general, consumer surplus or welfare is the value of the trip over and above the actual expenditure on the trip. For non-market goods, like shore or private boat fishing, consumer surplus can be directly estimated by asking anglers what they are willing to pay or be compensated for changes in quantity or quality of their fishing experience (SAFMC 1990b). Consumer surplus can also be indirectly approximated using a specialized travel cost model, Random Utility Models (RUMs), which is used to estimate angler site selection patterns based on individual trip costs and other site characteristics including fish catch rates. A RUM oriented valuation of marine recreational fishing for private boat angler was done by Haab et al. (2000) using data collected during the 1997 MRFSS add-on in the Southeastern states. Controlling for other site selection characteristics, they estimated the marginal value of an increase in historical catch and keep (harvest) by one additional fish harvested in a given state. In the South Atlantic states, the estimated value of one additional red drum caught per trip was the highest for South Carolina ($5.13), followed by Florida's east coast ($3.39), Georgia ($1.88), and North Carolina ($.36). It is assumed that a reduction in the number of red drum that could be caught and retained by the angler due to more stringent bag limits would have a similar magnitude in value change per fish for an angler. The loss of red drum fishing opportunities per trip for the following South Atlantic states was also estimated: South Carolina ($20.79), Florida's east coast ($8.73), Georgia ($3.04), and North Carolina ($1.87). For example, if "elimination of access" to North Carolina's red drum recreational fishery occurred, it would result in a consumer surplus or welfare loss of almost $232,000 based upon 124,053 annual red drum targeting trips, i.e. the value of red drum above angler expenditures (Haab et al. 2000).

Besides the specifics of eliminating "access", there are other qualifiers to this estimate. The RUM analysis will tend to overestimate losses from reduction in catch and keep rates because it does not account for switching to other species by anglers (Haab et al. 2000). In addition, values associated with catch and releases vs. retention were not addressed, although the importance of red drum catch and retention in fishing success has been debated by researchers (e.g., Duda 1993).

Non-Consumptive Factors

Non-consumptive considerations include non-consumptive use values and non-use values. Consumptive use values are associated with capture fisheries including catch-release fishing while non-consumptive use values are usually associated with "eco-tourism." A field trip to view the schooling of juvenile red drum in their estuarine habitat or a fish-watching hobbyist visiting an aquarium to watch large adult red drum in a tank are examples of activities that generate non-consumptive use value related to red drum. In contrast, "non-users" may also derive benefits of some part of the environment, such as red drum, based upon the knowledge that actions have been or will be taken to enhance and/or preserve a portion of the environment (Russell 2001). Economists also divide non-use value into two categories, bequest value and "pure" existence value. As the name implies, bequest value is based upon concern for future generation use or non-use of natural resources while existence value is oriented toward current generations. Consequently, total value (TV) of a resource from an economic perspective can be categorized into the three components as adapted from Hanley & Spash (1993):

$$TV = CS + XV + BV$$

where CS is consumer surplus (i.e. use value) including expected CS, XV is existence value, and BV is bequest value. Estimating total value and/or component values can be problematic, but in general, these values can be estimated two major methods. The indirect methods attempt to analyze markets or other behavioral information (e.g. fishing access site selection by anglers) in order to estimate willingness to pay (WTP) and/or willingness to accept (WTA) changes in environmental quality like catch and retention rates (Russell 2001). Random Utility Models or RUMs are one example of an indirect method, which can be used to estimate changes in consumer surplus related to red drum fishing. In contrast, the direct method is limited to one methodology, the Contingent Valuation Method (CVM).

CVM is based upon directly asking a relevant sample of consumers, not necessarily users of a resource, carefully constructed hypothetical questions about environment goods (e.g. red drum) in order to estimate WTP or WTA related to changes in a portion of the environment (Russell 2001). Both approaches have strengths and weaknesses, but the CVM approach is the only method for estimating nonuse values (Hanley & Spash 1993).

Pace (1995) estimated the total value of stocking or "enhancing" red drum stocks in South Carolina (SC) by surveying a sample of SC anglers and respondents in sample of all SC households using a CVM oriented mail questionnaire in 1994. Pace (1995) pooled angler and non-angler household, but the weighting of the sample results are skewed toward many of the non-angler respondents which have little or no interest in recreational fishing or other uses (e.g. "fish watching"). Consequently, it is assumed that their responses are a rough approximation of nonuse values (benefits) related to stocking red drum in South Carolina. Pace (1995) reported that the average, annual WTP per household (1994 dollars) was $1.73 for red drum stocking with annual aggregate value of about $2.2 million based on total SC households in 1994. The average of the WTP value seems reasonable because it has similar magnitude as reported by Haab et al. (2000) for red drum anglers as approximated using RUMs. Regardless, the preservation and enhancement of red drum stocks can also generate benefits for non-users, not just anglers.

5.3.5 Weakfish and other Sciaenids

5.3.5.1 Description of fishing practices, vessels and gear

Current Status of the Weakfish Fishery

The majority of commercially and recreationally caught weakfish are landed from state waters. The dominant commercial gears used include gill nets, pound nets, haul seines, and trawls. The majority of commercial landings occur in the fall and winter months, presumably as the fish congregate to migrate. The recreational fishery catches weakfish using live or cut bait, jigging, trolling, and chumming. Recreational harvests typically peak in the warmer months (May through October) when effort tends to be greatest.

Typically recreational landings are recorded in numbers and commercial landings are recorded in pounds. However, Table 5.3.5-2uses recreational landings in pounds to compare the landings of the fisheries. Both commercial and recreational landings fell consistently from 2000 to 2004, reaching all-time lows. In 2005, commercial landings continued to decrease, while recreational landings increased 84% from 2004.

Commercial Fishery

The NMFS compiles commercial weakfish landings. The data are cooperatively collected by the NMFS and state fishery agencies from state mandated trip-tickets, landing weigh-out reports from seafood dealers, federal logbooks, shipboard and portside interviews, and biological sampling of catches. The NMFS data were not available for 2005 at the time of this report, thus the 2005 landings rely on preliminary data from annual state compliance reports. Massachusetts had no preliminary data to report and no estimate is included in the total.

The commercial weakfish fishery occurs during the fall and winter as the species migrates from estuaries to over-wintering grounds in the South Atlantic (Hogarth et al. 1995). Weakfish are taken primarily by trawls, pound nets, gill nets, and haul seines. Weakfish landings were dominated by the trawl fishery from the 1950's through the mid - 1980's, when gill net landings began to account for the majority of the landings. Gill net landings in the latter half of the 1990's were about double that of the trawl fishery.

From 2000 to 2003, there was an increasing trend of the commercial fishery accounting for a higher percentage of the total catch (Table 5.3.5-1). However, this trend appears to have stopped in 2004. In 2005, commercial landings contributed less than 50% of the total landings for the first time in the time series (1982-present). Coastwide commercial weakfish landings have ranged from a time series high of 21.2 million pounds in 1986 to a low of 1.3 million pounds in 2005.

Table 5.3.5-1. Amendment 4 Control Rule

	Fishing Mortality Rate	Female Spawning Stock Biomass
Target	$F_{30\%} = F = 0.31$	X
Threshold	$F_{20\%} = F = 0.50$	$SSB_{20\%}$ = 31.8 million pounds

Table 5.3.5-2. Comparison of Atlantic coast commercial and recreational weakfish landings

Year	Recreational Landings (pounds)	Commercial Landings (pounds)	Total Pounds	% Total as Commercial
1982	8,285,323	19,478,274	27,763,597	70%
1983	11,730,620	17,475,003	29,205,623	60%
1984	7,013,779	19,773,587	26,787,366	74%
1985	5,489,027	16,953,357	22,442,384	76%
1986	10,141,785	21,187,973	31,329,758	68%
1987	6,749,894	17,072,159	23,822,053	72%
1988	6,331,649	20,526,402	26,858,051	76%
1989	2,177,234	14,162,178	16,339,412	87%
1990	1,347,259	9,438,190	10,785,449	88%
1991	2,130,564	8,692,760	10,823,324	80%
1992	1,398,977	7,453,788	8,852,765	84%
1993	1,102,338	6,853,579	7,955,917	86%
1994	1,795,515	6,190,522	7,986,037	78%
1995	1,855,546	7,098,658	8,954,204	79%
1996	2,925,391	6,940,038	9,865,429	70%
1997	3,692,716	7,297,783	10,990,499	66%
1998	4,044,973	8,419,604	12,464,577	68%
1999	3,143,428	6,905,158	10,048,586	69%
2000	4,154,793	5,400,529	9,555,322	57%
2001	2,722,629	4,999,539	7,722,168	65%
2002	2,192,603	4,772,978	6,965,581	69%
2003	864,960	2,001,271	2,866,231	70%
2004	860,086	1,523,919	2,384,005	64%
2005	1,584,547	1,315,859	2,900,406	45%

*Commercial landings for 2005 are preliminary. Massachusetts landings are not included in the coastwide total. One hundred pounds was included for Georgia's commercial landings; the state reported "confidential but no more than 100 lbs."

North Carolina, Virginia, and New Jersey have dominated commercial weakfish landings since 1950. North Carolina has annually landed the most weakfish since 1982 and Virginia has consistently landed the second most since 1993. North Carolina has accounted for over half of all the weakfish commercially landed since 1982.

Recreational Fishery

Recreational catch statistics are collected by the NMFS in the Marine Recreational Fisheries Statistics Survey (MRFSS). Effort data is collected through telephone interviews. Catch expansions are based on angler interviews and biological sampling conducted by trained interviewers stationed at fishing access sites.

Recreational landings hit a time series high of 11.7 million pounds in 1983. Landings were relatively high from 1983-1988, but abruptly fell in 1989. Annual recreational landings fluctuated between 1.1 million and 4.1 million pounds from 1993 to 2002, but fell to approximately 864,000 pounds in 2003. The lowest recreational landings on record occurred in 2004 (860,065 pounds). Recreational landings rebounded to over 1.5 million pounds in 2005, with New Jersey taking over 1.1 million pounds (~72% of recreationally landed weakfish). North Carolina is a distant second at 157,018 pounds (~10% of recreationally landed weakfish). The number of fish released alive by anglers has remained above 1 million fish since 1993, peaking at over 5 million in 1996, and decreasing to ~1.8 million fish in 2005.

Recreational landings from the EEZ account for only about 13% of the total coastwide recreational landings by pounds since 1982. From 1995 to 2005, recreational harvest in the EEZ has contributed less than 5.3% to each year's recreational landings, and only 1.8% in 2005.

Since 1982, over half of the total recreational harvest in pounds has come from inshore saltwater and brackish water bodies such as bays, estuaries, and sounds. In 2005, these areas contributed 73.6% of the recreational landings.

Current Status of the Spot Fishery

Spot support commercial fisheries along the Atlantic coast, particularly from the Chesapeake southward. They are harvested by a variety of commercial gear including haul seines, pound nets, gillnets, and trawls. Commercial catches have fluctuated widely since 1930 with no apparent long-term trends. Landings peaked in 1952 at 14.5 million pounds, and have since ranged between 3.9 and 12.7 million pounds. Since 1983, commercial landings on the Atlantic coast have remained steady, ranging from four to nine million pounds. Commercial landings were 4.37 million pounds in 2005.

Spot is a popular recreational species that is sought by anglers from Delaware Bay to northern Florida. Most of the Atlantic recreational harvest is taken within three miles of the coast, from shore or by private or rental boats rather than by party or charter boats. The recreational catch of spot has fluctuated from a high of 6.9 million pounds in 1981 to a low of 1.6 million pounds in 1999. In 2005, 3.6 million pounds were landed, the highest number in almost a decade.

Spot are short-lived and year-to-year fluctuations in landings can be expected since the catch in most years consists of a single year class. Moreover, year class abundance is thought to be determined by environmental conditions that prevail on the spawning and nursery areas in any particular year. Changes in fishing effort, habitat degradation, and economic conditions may also affect the quantities of fish caught in any year.

2006 ASMFC FMP update
Total landings of spot in 2005 were estimated at 7,924,737 pounds. The commercial fishery removed approximately 55 percent of this total, and the recreational fishery removed 45 percent.

The commercial fishery has consistently landed more pounds of spot than the recreational fishery since at least 1981; however, the proportion attributable to the commercial fishery in 2005 was the lowest in the time series.

Commercial landings of spot have fluctuated between 3.8 and 14.5 million pounds from 1950-2005. During this time series, landings have been over 10 million pounds thirteen times, four of those occurring during the peak of landings from 1972-75, and the last occurring in 1982. The 2005 landings were approximately 4.4 million pounds, the lowest since 1969 (Figure 5.3.5-1). Small spot are a major component of the bycatch in seine, fish/shrimp trawl, and pound net fisheries in the Chesapeake and in North Carolina, as well as a part of the bycatch of the South Atlantic shrimp trawl fishery.

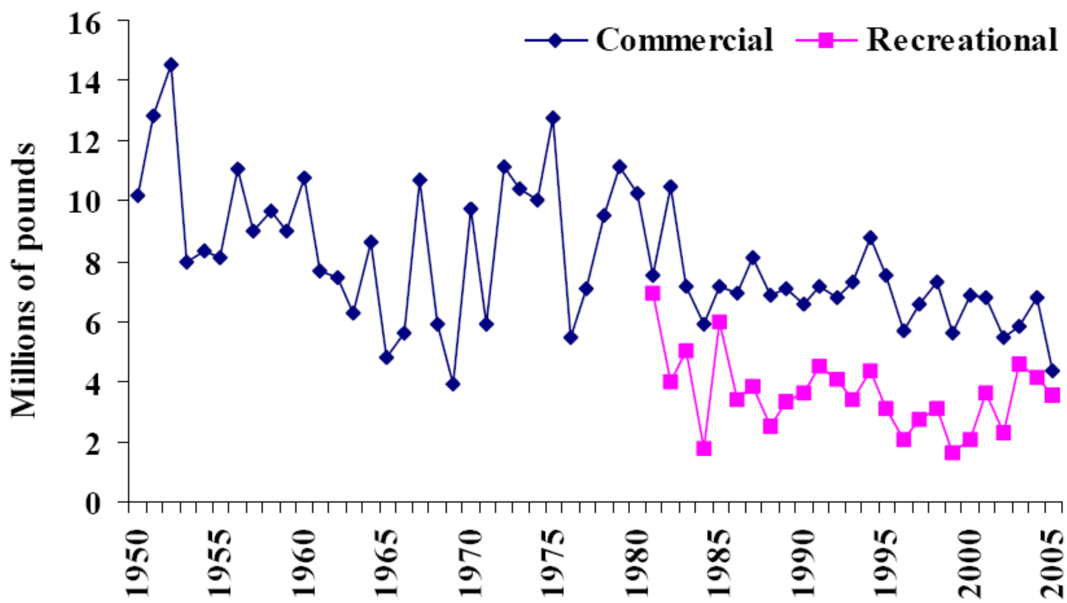


Figure 5.3.5-1. Spot commercial and recreational landings (pounds), 1950-2005

Between 1981 and 2005, the recreational harvest (A + B1 fish) of spot from along the Atlantic coast has varied between 3.6 million fish and 20.1 million fish, but has not exceeded 10 million fish since 1994. From there, spot landings declined steadily to the low point in 1999, after which landings increased gradually (Figure 5.3.5-2). The recreational harvest in 2005 was 8.8 million fish (3.5 million pounds), an increase in the number of fish, yet a decrease in pounds from 2004. The estimated number of spot released annually by recreational anglers from 1981 has remained relatively constant, ranging from 2.0 to 6.3 million fish with the exception of 1981 (11.1 million fish), 1990 (7.3 million fish), and 1991 (10.6 million fish). The number released alive in 2005 was

5.9 million fish, a nearly two-fold increase from the 3.1 million fish released alive in 2004.

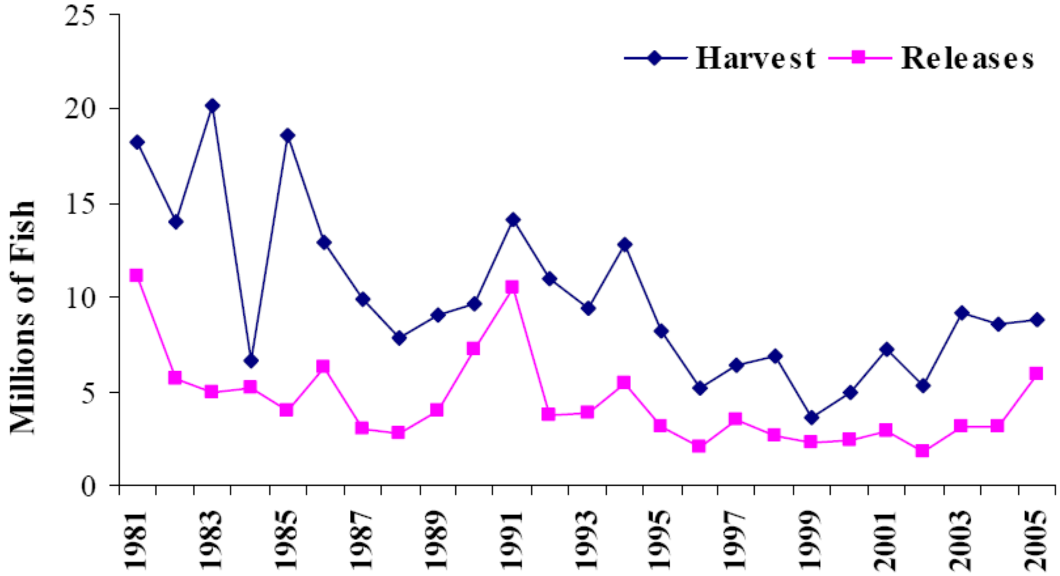


Figure 5.3.5-2. Spot recreational harvest and releases (numbers of fish), 1981-2005

Current Status of the Atlantic Croaker Fishery

Atlantic coast commercial landings of croaker have varied from one million pounds in 1970 to 64 million pounds in 1945. Commercial landings increased steadily each year from a low of 3.7 million pounds in 1991 to more than 28 million pounds in 2003. Commercial landings decreased in 2004 to approximately 25.5 million pounds coastwide, and again in 2005 to 22.5 million pounds; however, coastwide commercial landings have remained above 20 million pounds since 1996 (Figure 5.3.5-3). While commercial fishermen from New Hampshire south have landed Atlantic croaker in at least one year since 1960, the majority of landings come from the mid-Atlantic states (New Jersey through North Carolina) and Florida. Commercial landings from the remaining states are small and sporadic or only a recent component. Virginia and North Carolina have dominated the commercial harvest since 1960.

Atlantic croaker is the major component of the North Carolina and Virginia “scrap fishery”. A number of regulations instituted by North Carolina, such as banned flynet fishing south of Cape Hatteras, the introduction of BRDs in shrimp trawls, incidental finfish limits taken by shrimp and crab trawls in inside waters, minimum mesh size restrictions in trawls and culling panels in long haul seines may have indirectly reduced catches of juvenile croaker and changed the size and age distributions of the harvest. In the last stock assessment, aggregate, unculled (“scrap”) bait fisheries landings data were included for North Carolina and Virginia, and at-sea discard data was included from gill net and trawl fisheries. Scrap landings and discards were combined in the model. Between 1973 and 1995, scrap/discards accounted for an average 20% of removals, and from 1996 to 2002, an average 3% of removals. In Georgia, trawl-caught croaker is sold as unsorted mixed fish along with spot, whiting, and small flounder, therefore, commercial landings are a tenuous measurement of croaker landings there. Small croaker were previously a major part of the bycatch of the south Atlantic shrimp trawl fishery, however the use of TEDs and BRDs has reduced this bycatch.

Recreational landings are from the National Marine Fisheries Service Marine Recreational Fishery Statistics Survey (MRFSS). From 1981-2005, recreational landings of Atlantic croaker (Type A+B1 in numbers) from New Jersey through North Carolina have varied between 1.3 million pounds (1981) and 11 million pounds (2001), with landings showing a strong linear increase over this period (Figure 5.3.5-4).The recreational harvest in 2005 was 11.6 million fish (10.6 million pounds) (Tables 4 and 5). By number of fish, this is the third highest recreational landings for the time series, and the second highest by pounds. The majority of the landings are from Virginia (~68% by pounds). The increased landings in recent years have been at the northern range of the fishery (New Jersey to Virginia). The number of recreational releases in 2005 was estimated at 13.3 million fish, an increase from 2004 (Figure 5.3.5-4).

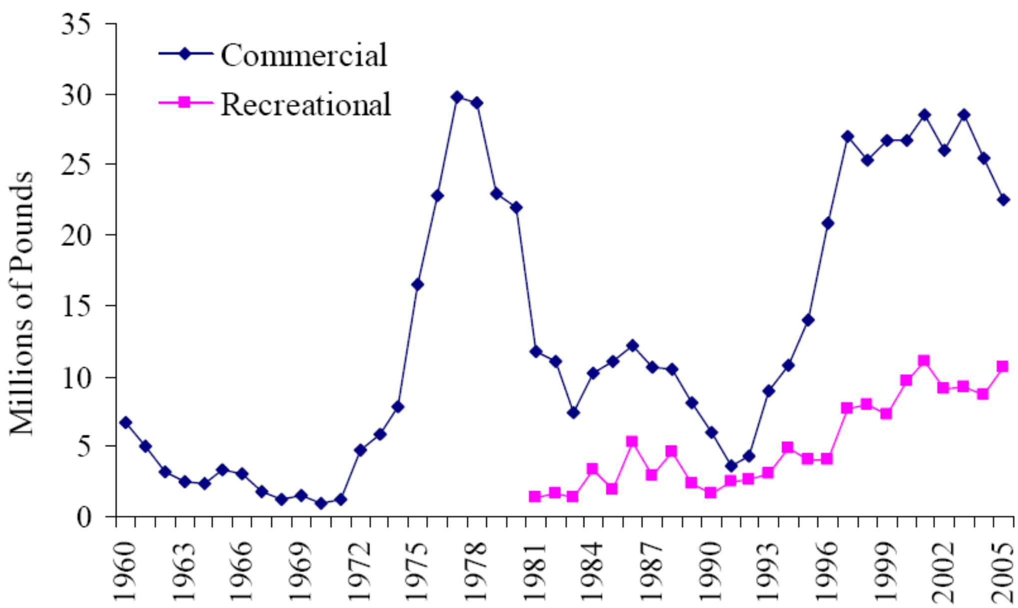


Figure 5.3.5-3. Atlantic croaker commercial and recreational harvest (pounds) (NMFS Office of Science & Technology 2006; State Fishery Agencies, pers. com. 2006).

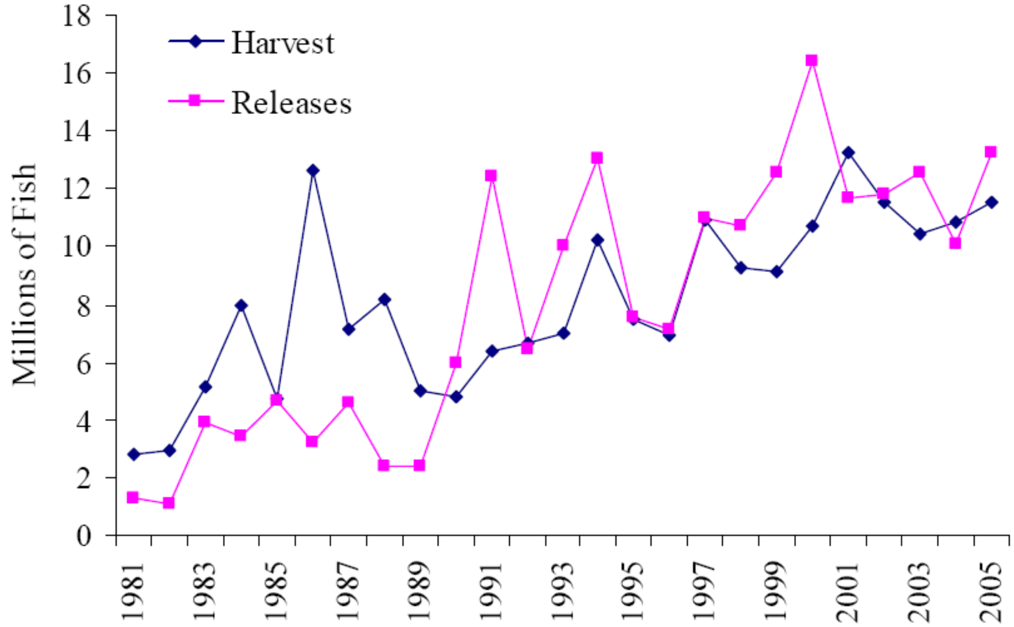


Figure 5.3.5-4. Atlantic croaker recreational harvest (A+B1 fish) and releases (B2 fish), 1981-2005 (NMFS Office of Science & Technology 2006).

Allowable gear

Allowable gear for the commercial harvest of weakfish in the EEZ includes trawl, gillnet, hook-and-line and rod and reel. Weakfish may be harvested recreationally using hook-and-line and spear.

5.3.5.2 Economic and social description

Weakfish Fishery

The Atlantic commercial weakfish fishery is prosecuted between Massachusetts and Florida. There are, however, limited commercial landings in the states of Maine, South Carolina, and Georgia. Maine reported landings of five pounds in 1995; South Carolina had reported landings in 1982 and 1989; and Georgia reported landings, except for 1988 and 1989, between 1982 and 1990. There are no reported landings for New Hampshire. Between 1950 and 2000, total Atlantic Coast landings (Maine through east coast of Florida) declined by 51,021 pounds per year or at the annual rate of 0.64% per year. In 1950, total landings equaled 7.99 million pounds; in 2000, landings equaled 5.38 million pounds ((Figure 5.3.5-4). During the 1970s, however, landings dramatically increased and exceeded 10.0 million pounds in each year until 1990. Between 1990 and 2000 landings decreased from 9.44 to 5.38 million pounds or by nearly 43.0 percent.

The ex-vessel value or first sale value (also referred to as dockside value) followed the same pattern as landings ((Figure 5.3.5-4). In 1950, the ex-vessel value equaled $5.74 million (in 2001 constant dollar values), but declined to $3.78 million in 2000. The decline represented an annual decrease of $38,486 or an annual rate of 0.67 percent.

Between 1978 and 1989, the annual ex-vessel value regularly exceeded $10.0 million per year.
North Carolina has traditionally had the highest level of landings of weakfish (Table 6). On an average annual basis, New Jersey ranks second in terms of landings, and Virginia ranks third. Landings of weakfish in the three states, combined, accounted for 87.9% of the total landings of weakfish between 1980 and 2000 (Table 6). In terms of total ex-vessel or dockside value, North Carolina has traditionally ranked first; Virginia and New Jersey rank second and third, respectively (Table 10). Between 1980 and 2000, all states, except Rhode Island and Connecticut experienced declines in ex-vessel value.

The ex-vessel prices of weakfish have varied substantially over time and among the states (Tables 10 and 11). Between 1980 and 2000, the lowest constant dollar price occurred in 1980. Connecticut, Rhode Island, and New York have generally had the highest ex-vessel prices per pound. North Carolina has typically received the lowest ex-vessel price per pound. The price differences are likely related to product size, market demand, and seasonality of product. Weakfish are generally locally marketed, and prices, therefore, likely reflect local market conditions. In addition, weakfish are highly perishable, and thus, cannot easily be processed and shipped to distant markets.

In describing the economic aspects of a commercial fishery, it is common to describe the size of the fishery, the number of vessels involved, the number of individuals engaged in the fishery, and economic returns. In the case of the weakfish fishery, data necessary for providing a detailed economic description are not available. For the most part, the weakfish fishery is prosecuted in state waters, and few states collect the information required for an extensive economic overview.
Commercial fishermen indicate that there is a varying degree of dependence on weakfish based on the location/port and the gear type used. For some gillnet fishermen in the northern states, weakfish represents one third of the economic value of their total annual catch, while others state that it is one of the three primary species they target during the year. Others suggested that it only represents 10% of their annual catch in terms of value. However, these fish are targeted and caught at a time that helps them “make it through the year.”

Some fishermen have suggested that while they currently target weakfish only minimally, historically it was a sought-after species. This follows a reported trend among fishermen who vary their targeted species based on environmental changes or reductions in the number of fish they see when on the water. The fact that 10 years ago some fishermen targeted weakfish only minimally was more a reflection on the condition of the stock and not the desire for the species.

5.3.6 Bluefish

5.3.6.1 Description of fishing practices, vessels and gear

(MAFMC, 2006)
Bluefish have been commercially harvested in the U.S. for centuries. Bigelow and Schroeder (1953) concluded bluefish were plentiful at the time that New England was

first settled based on the accounts by an author in 1672. However, the abundance of bluefish in southern New England waters has fluctuated periodically since then. An interesting recent account describes the "mosquito fleet" which operated out of Charleston, South Carolina, throughout the nineteenth and first half of the twentieth century (Bishop et al. 1994). This fleet of vessels 20 to 35 feet in length sailed daily from Charleston, out of sight of land with no navigational aids, and provided fresh bluefish, among other species, to the residents, a feat which won the respect and admiration of the community.

In more recent times, total coastwide bluefish landings (commercial and recreational) have averaged 86 million lbs (1981-1989), with commercial landings comprising roughly 17% of the total landings during that time. Since 1981, commercial landings have averaged about 13 million lbs. However, commercial landings declined 44% from a peak of 16.5 million lbs in 1981 to only 9.3 million lbs in 1996.

Bluefish are pursued in both state and EEZ waters by a variety of commercial gears. Coastwide (1987-1996 combined) most bluefish (48%) were landed by gill nets (all types combined) followed by otter trawls (19%). Fish pound nets accounted for 7% of the commercial catch followed by hand and troll lines (6%) and haul seines (3%) during the same time period.

During the period 1976-1987, beach haul seines harvested a significant portion of bluefish in New York and South Carolina. The quantities of bluefish harvested by this gear during 1987-1996 declined considerably relative to earlier years, with measurable landings only in New York, Maryland, Virginia, and North Carolina. The states of Maryland and South Carolina had more bluefish landed commercially by hand lines from 1987 to 1996 than any other gear type. Fish otter trawls were predominant in Rhode Island, Connecticut, and New York. Some type of gill net caught significant amounts of bluefish in all states except Connecticut, South Carolina, Georgia and Florida. Almost all of the bluefish in Maine and New Hampshire were caught by gill nets and this gear type was also predominant in Delaware waters. Runaround gill nets were predominant in New Jersey.

Since 1985, gill nets (all types combined) and otter trawls have been the predominant gear types while the other major gear types (haul seines, paired trawls, purse seines, pound nets, troll and hand lines) has remained relatively consistent at low levels or have declined in importance

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Seasonally, most bluefish were harvested commercially from May through October. Average monthly landings for the period 1987-1996 peaked at 1.2 million lbs in October. Most bluefish were caught during the fall months from September through November.

Bluefish are very important in the Atlantic coast recreational fishery. Wilk (1980) noted that no other species on the Atlantic coast is as abundant throughout such a wide range and variety of habitats as bluefish. MRFSS data indicate that since 1981 recreational bluefish landings averaged 50 million lbs, ranging from 95 million lbs in 1981 to 14 million lbs in 1995. In 1996, bluefish recreational landings were approximately 15 million lbs. In 1987, bluefish were the fish most sought by marine anglers in the North Atlantic, second only to summer flounder in the Mid-Atlantic, and fourth in preference for anglers in the South Atlantic (MAFMC 1990a). During 1987, bluefish comprised 34% by weight of all species caught by recreational fishermen along the Atlantic coast (MAFMC 1990a). The 1979 to 1987 recreational catch represented a substantial increase over the 1960 to 1970 recreational harvest when bluefish averaged approximately 10% of all species caught by marine anglers along the Atlantic coast.

Bluefish were the predominant species (by number) harvested by anglers in 1987. After reaching a secondary peak in 1986, recreational bluefish landings began to decline. The decline in bluefish recreational catch and landings continued over the last decade. MRFSS data indicate that anglers caught an estimated total of 27.6 million bluefish in 1987, with the numbers declining to a low of 9.9 million in 1993. Numbers increased to approximately 12 million in 1994, but then decreased to 10.5 million in 1995 and, in 1996, decreased again to a low of 9.9 million. The weight of bluefish landed by anglers declined from about 77 million lbs in 1987 to just less than 15 million lbs in 1996. The average weight of the bluefish landed has fluctuated during the years 1987 through 1996 between a low of 2.7 pounds (1994) and a high of 4.9 pounds (1988). The percent of the catch released by anglers has continued to increase from the 24 % reported for 1987 to 54 % in 1996.

An analysis of the recreational landings by subregion indicates more bluefish by weight were landed in the Mid-Atlantic than in the North and South Atlantic every year from 1987 to 1996, except for 1993 and 1994 when North Atlantic landings were highest. In most years, and on average, the weight of the Mid-Atlantic landings (average 55.7%) exceeded those from the North Atlantic (average 33.1%) and South Atlantic (average 11.2%) regions.

Current status of the fishery (Source: ASMFC, 2006)

Recreational catch of bluefish has averaged over 41 million pounds since 1981 although catch declined steadily over the time period. In 2004, recreational anglers along the Atlantic Coast landed 6,939 bluefish. Most of the recreational activity occurs from July to October, when almost 70% of the bluefish harvest is taken. Most of the recreational catch of bluefish is taken in the North and Mid-Atlantic states (New York to Virginia). Recreational landings hit a low of 3,682 fish in 1999 but has averaged over 5,900 fish since 1999 (Table 5.3.6-1).

Table 5.3.6-1. Estimated number of bluefish caught and the estimated number of bluefish landed by marine recreational fishermen each year, 1981 to 2004.

Year	Catch ('000)	Landings ('000)
1981	31,261	23,888
1982	27,220	23,724
1983	30,137	24,884
1984	26,508	20,798
1985	22,474	19,246
1986	30,411	24,441
1987	27,603	21,076
1988	13,365	9,905
1989	18,637	13,600
1990	16,446	11,365
1991	18,292	11,943
1992	11,440	7,158
1993	9,925	5,725
1994	11,920	5,768
1995	10,494	5,168
1996	9,521	4,205
1997	12,574	5,413
1998	9,204	4,202
1999	11,488	3,682
2000	16,260	4,897
2001	20,412	6,663
2002	15,217	5,300
2003	14,679	5,888
2004	18,679	6,939

Commercial landings decreased from 16.5 million pounds (lbs) in 1981 to 7.3 million lbs in 1999. Commercial landings have been regulated by quota since implementation of Amendment 1 in 2000. Since implementation of Amendment 1, landings have varied with a low of 6.8 million pound landed in 2002. Preliminary landing estimates for 2004 increased to 7.2 million pounds.

Allowable gear

Allowable gear for the commercial harvest of bluefish in the EEZ includes Trawl, gillnet, longline, handline, hook and line, rod and reel, bandit gear, cast net, pot, trap, lampara net and spear. Allowable recreational gear includes rod and reel, handline, spear, hook and line, hand harvest, bandit gear, powerhead, gillnet, cast net.

5.3.6.2 Economic and social description

(sections below from the 2007 bluefish specifications document – except as indicated from Amendment 1 to the Bluefish FMP)

Commercial fishery

In 2005, the value of bluefish landings was approximately $2.3 million. Average ex-vessel price of bluefish was $0.33/lb in 2005. On average (1985-1994), the ex-vessel value of bluefish commercial landings from state waters was about twice that from the Exclusive Economic Zone (EEZ) waters.

Bluefish comprised 0.17% and 0.59% of the total ex-vessel value and pounds of all finfish and shellfish species landed along the Atlantic coast of the U.S. in 2004, respectively. The contribution of bluefish to the total value of all finfish and shellfish vary by state, ranging from less than 0.01% in Maine, South Carolina, and Georgia to approximately 1% in New York. The contribution of bluefish to the total pounds landed of all finfish and shellfish vary by state, ranging from less than 0.01% in each Maine, South Carolina, and Georgia to approximately 4% in New York. Relative to total landings value, bluefish were most important in North Carolina and New York, contributing the largest percentage of ex-vessel value of all commercial landings in those states (Table 5.3.6-2). This contribution has not changed considerably from the previous fishing year (i.e., 2004), and it is not expected to change considerably in 2007.

Table 5.3.6-2. The percentage contribution of bluefish to the commercial landings and value of all species combined from Maine through East Coast of Florida, 2005 (Source: NMFS Dealer Weighout data and South Atlantic General Canvass data).

State	Pounds of Bluefish as a Percentage of all Species	Value of Bluefish as a Percentage of all Species
ME	< 0.01%	< 0.01%
NH	0.11%	0.10%
MA	0.14%	0.06%
RI	0.54%	0.20%
CT	0.23%	0.04%
NY	4.17%	1.01%
NJ	0.57%	0.27%
DE	0.63%	0.17%
MD	0.27%	0.12%
VA	0.10%	0.07%

NC	6.60%	1.10%
SC	< 0.01%	< 0.01%
GA	< 0.01%	< 0.01%
FL (East Coast)	0.42%	0.11%
Total	0.59%	0.17%

The economic impact of the commercial bluefish fishery relative to employment and wages is difficult to determine. According to NMFS, commercial fishermen in the western Atlantic landed approximately 1.62 billion lb of fish and shellfish in 2004. Those landings have been valued at approximately $1.33 billion. Total landed value ranged from approximately $14 million in Georgia to $367 million in Maine. However, it can be assumed that only a small amount of the region's fishing vessel employment, wages, and sales are dependent on bluefish since the relative contribution of bluefish to the total value and poundage of all finfish and shellfish is very small.

NMFS VTR data indicate that a total of 11,786 commercial trips targeting bluefish (bluefish ≥ 50% of total catch) resulted in landings of 4.3 million lb from Maine to North Carolina in 2005. Landings from directed trips are approximately 60% of total commercial landings for 2005 (i.e., 7.026 million lb in Table 5.3.6-3). Two major gear types accounted for over 90.3% of the total commercial catch: gillnets and bottom otter trawls. Gillnets comprised 35.0% of the total trips that landed bluefish and 60.2% of the catch, while bottom otter trawls comprised 41.6% of the trips and 30.1% of the catch.

Table 5.3.6-3. Bluefish commercial and recreational landings (‘000 lb), 1981-2005.

Year	Comm	Rec	Total	% Comm	% Rec
1981	16,454	95,288	113,725	15	85
1982	15,430	83,006	98,436	16	84
1983	15,799	89,122	104,921	15	85
1984	11,863	67,453	79,316	15	85
1985	13,501	52,515	66,016	20	80
1986	14,677	92,887	107,564	14	86
1987	14,504	76,653	91,157	16	84
1988	15,790	48,222	64,012	25	75
1989	10,341	39,260	49,601	21	79
1990	13,779	30,557	44,336	31	69
1991	13,581	32,997	46,578	29	71
1992	11,477	24,275	35,753	32	68
1993	10,122	20,292	30,414	33	67
1994	9,495	15,541	25,036	38	62

1995	8,009	14,307	22,316	36	64
1996	9,301	11,746	21,047	44	56
1997	9,063	14,302	23,366	39	61
1998	8,247	12,334	20,581	40	60
1999	7,307	8,253	15,338	48	54
2000	8,036	10,606	18,642	43	57
2001	8,689	13,230	21,919	40	60
2002	6,864	11,371	18,235	38	62
2003	7,403	13,136	20,376	36	64
2004	8,041	15,203	22,839	35	67
2005	7,026	16,162	23,188	30	70
Avg 81-05	10,992	36,349	47,309	23	77
Avg 95-05	7,999	12,786	20,713	39	62
Avg 00-05	7,677	13,285	20,867	37	64

Description of the Areas Fished

The Northeast Region is divided into 46 statistical areas for Federal fisheries management. Eight of these areas comprised at least 5 percent of the total commercial bluefish catch in 2005, and collectively accounted for 71.41% of the commercial trips that caught bluefish and 77.1% of the bluefish catch. These eight areas include 635, 611, 636, 613, 612, 614, 615, 623; the percentages associated with each area are provided in Table 5.3.6-4. It may be noted that the vessel log database used to characterize the distribution of commercial harvest does not extend outside of the Northeast Region (i.e., to SC, GA, FL).

Table 5.3.6-4. Statistical areas that accounted for at least 5 percent of the bluefish catch and/or trips in 2005, NMFS VTR data.

Statistical Area	Catch (percent)	Trips (percent)
635	14.0%	2.3%
611	11.9%	26.7%
636	11.8%	1.0%
613	11.5%	14.2%
612	11.2%	12.3%
614	5.7%	4.8%
615	5.5%	2.6%
623	5.5%	0.2%

Processing sector, marketing and consumption (from MAFMC Am 1 to the bluefish FMP)
Bluefish is primarily a fresh fish product. It is generally iced both on board the vessel and at the dock during unloading before it is shipped to market. The limited extent of the fresh fish market has been one of the major factors constraining the commercial harvest of bluefish. Should methods become available to maintain a quality product over longer periods of time, and current efforts to develop markets in the central portions of the country prove successful, the demand for bluefish and bluefish products could increase. At a local level, demand for bluefish by processors is relatively low, and the market can be saturated quickly. When this occurs, the price for bluefish drops to a low level and, consequently, fishermen target other species (MAFMC 1990a).

A relatively small amount of bluefish is filleted and smoked each year. Slightly more than 2% of bluefish landed in 1983 were processed in this manner (MAFMC 1990a). A number of inquires to NMFS indicated interest in processing bluefish increased in 1986 and 1987 (R. Ross pers. comm.). Most of these inquires concern cured bluefish or bluefish pate rather than fillets. A decrease in New England groundfish stocks and an increase in consumer demand for fish may explain this increased interest.

The price per pound of processed bluefish varies by product type. A telephone survey conducted in 1987 (MAFMC 1990a) indicated that fresh fillets were the most common form of processed bluefish product along the Atlantic coast (averaged $1.43 per pound, wholesale, in constant 1985 dollars). Frozen fillets averaged $0.96 per pound whereas smoked bluefish averaged $3.62 per pound. Smoked bluefish comprised an average of 14% of the total value of the output from the plants that processed them while the fresh and frozen fillets averaged 2% and 1%, respectively.

Along the Atlantic coast between 1992 and 1996, an average of 307,410 lbs of bluefish was processed with an average value of $649,973 (in nominal dollars) (Koplin pers. comm.). The largest volume of bluefish was processed in 1992 at 481,274 lbs ($732,302), and the smallest amount processed was in 1995 (186,591 lbs valued at $493,417). The bulk of the bluefish processing from 1987 to 1996 took place in the New England area. The number of processing plants handling bluefish between 1992 and 1996 along the Atlantic coast averaged 13; total employment at these plants averaged 324 people, and bluefish comprised an average of 2.5% of the total output value and 1.7% of the total output weight.

Recreational fishery

The fishery for bluefish is one of the most important recreational fisheries on the Atlantic Coast. For example, during the period 1981 to 1996, bluefish accounted for 29% of the Atlantic coast recreational harvest of finfish by weight (the greatest of any species), ranging from 42% in 1981 to 11% in 1995. From 1996 to 2004, bluefish comprised an average of 10% of total recreational landings, with a low of 7% in 2000 and a high of 12% in both 1998 and 2004. In 2005, bluefish accounted for over 13% of the Atlantic coast recreational harvest of finfish by weight. MRFSS data indicate that the average number of overall recreational fishery participants was relatively constant (~ 5 million) from 1985 – 1999 but has shown a positive trend in recent years, topping off at a little less than 8 million in 2005. This positive trend is consistent with the recent increases in bluefish recreational landings.

During the 1980s, a significant portion of Mid-Atlantic recreational participants depended upon bluefish, particularly those fishing from party/charter vessels. For example, in 1985 party/charter boats in the Mid-Atlantic region landed a total of 22.2 million lb of fish, over half of which were bluefish (12.3 million lb). In 1990, a Council survey was conducted of party and charter boat owners between Maine and Virginia. The survey indicated that bluefish ranked first in the catch and was the second most desired species for party boat owners, while for charter boats, bluefish ranked third in terms of desirability and second in terms of success rate. No survey exists for the more recent time-frame; however, from 1996 – 2005, the proportion of party and charter trips that targeted bluefish has remained relatively constant.

MRFSS catch data by mode indicates that 51% of bluefish were caught by private and rental boats between 1995 and 2004 (Table 5.3.6-5). In addition to private and rental boats, 43% of bluefish were caught from shore and 6% from party and charter boats (Table 5.3.6-5) from 1995 to 2004.

Table 5.3.6-5. The percentage (%) of bluefish caught and landed by recreational fishermen for each mode, Maine through Florida, 1995-2004 (Source: MRFSS).

Mode	Catch (Number A+B1+B2)	Landing (Weight A+B1)
Shore	43	20
Party/Charter	6	21
Private/Rental	51	59

Trends in directed fishing for bluefish from 1991 to 2006 are provided in Table 5.3.6-6. The lowest annual estimate of directed trips was 1.3 million in 2000; the highest annual estimate of directed trips was 5.8 million trips in 1991. In 2003, anglers targeted bluefish in 2.1 million trips bluefish. MRFSS estimates of directed effort since 2003 are not yet available.

Table 5.3.6-6. Number of bluefish recreational fishing trips, recreational harvest limit, and recreational landings from 1991 to 2006.

Year	Number of Fishing Trips[a]	Recreational Harvest Limit ('000 lb)	Recreational Landings ('000 lb)[b]
1991	5,811,446	None	32,997
1992	4,261,811	None	24,275
1993	3,999,487	None	20,292
1994	3,414,337	None	15,541
1995	3,409,966	None	14,307
1996	2,523,984	None	11,746
1997	2,021,713	None	14,302
1998	1,838,525	None	12,334
1999	1,316,939	None	8,253
2000	1,279,035	25,745	10,606
2001	1,914,480	28,258	13,230
2002	1,880,539	16,365	11,371
2003	2,099,771	26,691[c]	13,136
2004	n/a	21,150[c]	15,146
2005	n/a	20,157[c]	16,162
2006	n/a	16,473[c]	n/a

[a]Number of fishing trips as reported by anglers in the intercept survey indicating that the primary species sought was bluefish, North Atlantic, Mid-Atlantic, and South Atlantic regions combined. Estimates are not expanded. MRFSS Data.
[b]Atlantic coast from Maine through Florida's east coast.
[c]Adjusted for RSA.
n/a = Data not available.

Because of the importance of bluefish to recreational anglers, a change in expenditures by bluefish anglers would be expected to impact the sales, service, and manufacturing sectors for the overall recreational fishing industry. The total value recreational anglers place on the opportunity to fish can be divided into actual expenditures and a non-monetary benefit associated with satisfaction. In other words, anglers incur expenses to fish (purchases of gear, bait, boats, fuel, etc.), but do not pay for the fish they catch or retain nor for the enjoyment of many other attributes of the fishing experience (socializing with friends, being out on the water, etc.). Despite the obvious value of these fish and other attributes of the experience to anglers, no direct expenditures are made for them, hence the term "non-monetary" benefits. In order to determine the magnitude of non-monetary benefits, a demand curve for recreational fishing must be estimated. In the case of bluefish, as with many recreationally sought species, a demand curve is not available. Part of the problem in estimating a demand curve is due to the many and diverse attributes of a recreational fishing experience: socializing, weather, ease of access and site development, catch rates, congestion, travel expenditures, and costs of equipment and supplies, among others. A recreational angler's willingness-to-pay for bluefish must be separated from the willingness-to-pay for other attributes of the experience. Holding all other factors constant (expenditures, weather, etc.), a decrease in the catch (or retention rate) of bluefish would decrease demand and an increase in the catch (or retention rate) should increase demand. Each change will have an associated decrease/increase in expenditures and non-monetary benefits.

Recreational fishing contributes to the general well being of participants by affording them with opportunities for relaxation, experiencing nature, and socializing with friends. The potential to catch and ultimately consume fish is an integral part of the recreational experience, though studies have shown that non-catch related aspects of the experience are often as highly regarded by anglers as the number and size of fish caught. Since equipment purchase and travel-related expenditures by marine recreational anglers have a positive effect on local economies, the maintenance of healthy fish stocks is important to fishery managers.

Economic impact of the recreational fishery

Anglers' expenditures generate and sustain employment and personal income in the production and marketing of fishing-related goods and services. In 1998, saltwater anglers from Maine through Virginia spent an estimated $903.3 million on trip-related goods and services (Steinback and Gentner 2001). Private/rental boat fishing comprised the majority of these expenditures ($561.8 million), followed by shore fishing ($259.8 million) and party/charter fishing ($81.7 million). Survey results indicate that the average trip expenditure in 1998 was $47.42 for anglers fishing from a private/rental boat, $32.48 for shore anglers, and $67.12 for anglers that fished from a party/charter boat. Adjusted average expenditures in 2005 dollars are $81.93 for party/charter boat trips, $57.80 for private/rental boat trips, and $39.64 for shore trips.1 Trip-related goods and services included expenditures on private transportation, public transportation, food, lodging, boat fuel, private boat rental fees, party/charter fees, access/boat launching fees, equipment rental, bait, and ice. Unfortunately, estimates of trip expenditures specifically associated with bluefish were not provided in the study. However, if average trip expenditures are assumed to be constant across fishing modes, estimates of the expenditures associated with bluefish can be determined by multiplying the proportion of total trips that targeted bluefish by mode (expanded estimates) by the total estimated trip expenditures from the Steinback and Gentner study. According to this procedure, anglers fishing for bluefish from Maine through Virginia spent an estimated $104.69 million on trip-related goods and services in 2005. Approximately $37.26 million was spent by anglers fishing aboard private/rental boats, $60.50 million by those fishing from shore, and $6.93 million by anglers fishing from party/charter boats. Apart from trip-related expenditures, anglers also purchase fishing equipment and other durable items that are used for many trips (i.e., rods, reels, clothing, boats, etc.). Although some of these items may be purchased with the intent of targeting/catching specific species, the fact that these items can be used for multiple trips creates difficulty when attempting to associate durable expenditures with particular species. Therefore, only trip-related expenditures were used in this assessment.

The bluefish expenditure estimates can be used to reveal how anglers' expenditures affect economic activity such as sales, income, and employment from Maine through Virginia. During the course of a fishing trip, anglers fishing for bluefish purchase a variety of goods and services, spending money on transportation, food, boat fuel, lodging, etc. The sales, employment, and income generated from these transactions are known as the direct effects of anglers' purchases. Indirect and induced effects also occur because businesses providing these goods and services also must purchase goods and services and hire employees, which in turn, generate more sales, income, and employment. These ripple effects (i.e., multiplier effects) continue until the amount remaining in a local economy is negligible. A variety of analytical approaches are available for determining these impacts, such as input-output modeling. Unfortunately, a model of this kind was not available. Nonetheless, the total sales impacts can be approximated by assuming a multiplier of 1.5 to 2.0 for the Northeast Region. Given the large geographical area of the Northeast Region, it is likely that the sales multiplier falls within those values. As such, the total estimated sales, income and employment generated from anglers that targeted bluefish in 2005 was likely to be between $157.04 million ($104.69 million * 1.5) and $209.38 million ($104.69 million * 2.0) from Maine through Virginia. A similar procedure could be used to calculate the total personal income, value-added, and employment generated from bluefish anglers' expenditures, but since these multiplier values have been quite variable in past studies, no estimates were provided here.

For-hire recreational fishery

(from MAFMC Amendment 1 to the bluefish FMP)
Vessel trip report data (VTR) has been collected by NMFS since 1994 for the recreational and commercial fisheries. In the recreational fishery, this data is collected from party/charter vessels that have permits to operate in federal waters as required by the FMPs or amendments for Summer Flounder, Scup, Black Sea Bass, Northeast Multispecies, and Atlantic Mackerel, Butterfish, and Squids.

Party and charter vessels with a federal permit are required to report all their activities regardless of location (e.g., federal or state waters) when they engage in a fishery for one or more of the species mentioned above. As such, these vessels are required to report all their catches, including bluefish. If a party/charter vessel does not have federal permit as specified above and operates exclusively in nonfederal waters, it is exempt from reporting and this activity is not included in the VTR data system (Power pers. comm.).

Vessel trip reporting data indicate that bluefish contributed over 13% of the total catch (by number) made by party/charter vessels in 1996. The contribution of bluefish to the total catch of party/charter vessels fluctuated throughout the year, ranging from 0% in January, February, March, April, and December to 20% in August, with the largest proportion of bluefish caught to other species caught occurring from June through

August. Analysis of the recreational landings by state indicates that bluefish contributed with less than 1% of the total catch of party/charter vessels in Delaware and Maryland, and over 67% in Connecticut.

Social Description
Ports and communities that are dependent on bluefish are fully described in the 2002 Bluefish Specification Document (section 4.3; MAFMC 2001) and are available via the internet at http://www.nero.noaa.gov/ro/doc/nr02.htm.

NMFS dealer data from 2005 were used to rank fishing ports in order of importance for bluefish commercial landings. Ten ports qualified as "top bluefish ports", i.e., those ports where 100,000 pounds or more of bluefish were landed. Wanchese, NC was by far the most important commercial bluefish port with over 2.1 million lb landed, which is more than four times the landings from the second ranked port (Belford, NJ; 493 thousand lb).

The ranking of recreational fisheries landings (numbers of fish) by state in 2005 is provided in Table 5.3.6-7.

Table 5.3.6-7. MRFSS preliminary estimates of 2005 recreational harvest and total catch for bluefish.

State	Harvest (A+B1)		Catch (A+B1+B2)
	Pounds of Fish	Number of Fish	Number of Fish
ME	81,284	18,662	68,150
NH	63,437	11,296	50,024
MA	2,289,770	568,294	2,330,056
RI	738,839	296,618	829,977
CT	1,072,452	354,276	1,303,606
NY	2,471,381	2,275,304	5,514,409
NJ	5,843,489	1,879,237	4,472,785
DE	288,260	157,676	364,029
MD	618,443	240,906	585,699
VA	595,392	366,226	959,138
NC	1,108,237	1,243,669	3,365,739
SC	234,979	292,507	651,688
GA	2815	3,256	27,926
FL	752,878	547,891	958,157

Wanchese, North Carolina (this section excerpted from the MAFMC's Am. 1 to the Bluefish FMP, 1998)
"Wanchese has traditionally been a fishing community with commercial fishing operations since the late 1800s. Many of the current residents of Wanchese are descendants of people who settled here in the late 1600s and early 1700s." Many of the fishers are small, independent owner operators. "Informants have estimated that fifty percent of the men in Wanchese are in a marine related career." Wanchese has never developed the strong tourism sector seen in nearby areas. Because of the periodic shallowness of Oregon Inlet, many of its larger trawlers stay in Hampton, Virginia or New Bedford, Massachusetts during the winter. "Wanchese is also the site of the Wanchese Seafood Industrial Park (WSIP) which was developed in the 1970s to be a major site for seafood processing activities. However, because of the uncertain nature of Oregon Inlet and the general decline in fisheries since the 1970s, very few businesses actually operate in WSIP. The catch is either sold at retail markets locally or it is packed in ice and sent to other markets. At least one of the Wanchese commercial fishing and packing operations has expanded to other ports such as Hampton, Virginia and New Bedford, Massachusetts." In recent years, some New Bedford vessels have moved south to base in Wanchese in response to shortages of groundfish and scallops in New England.

Much of Wanchese ocean fishing occurs in the winter months (November-April). However, the boats in Wanchese fish all year round. Bluefish is predominantly caught with ocean gill nets which fish up to ten miles offshore and in the area of Ocracoke to Currituck Light. Other species include weakfish, dogfish and Atlantic croaker between the first of November and the end of April. There are a half dozen fish houses and other marine-related businesses that handle species other than crabs, and a couple that handle crabs exclusively. McCay et al. (1993) reported that summer flounder (21%) was the most important species in Dare County in terms of landed value in 1991. The value of all species landed in Dare County was over $11 million in 1991. Blue crabs (hard) are second in importance (11%), followed by weakfish (9%). Other species of volume in Dare County in 1991 were bluefish (4.02%), sea basses (3.41%), dogfish (1.00%), tilefish (0.53%), scup (0.41%), butterfish (0.31%), squid (0.29%), and Atlantic mackerel (0.12%).

Generally, the boats that are owned by local companies are operated by hired captains. However, these boats may be operated by a relative in some instances. Independent boats are usually owner-operated, with family members often serving as crew. "The crew on these vessels are mostly local; 75-80% are from within the area. All are paid with some variation of a share system." The crews are mostly 18 to 40 years of age; captains are usually older, with some over 65. Most crew members are white, though there are some black fishers including black captains. Sometimes, members of a family will own boats and fish houses. In the fish houses, most of the work force are black women, except for the crab houses where Latino workers are more common."

Recreational fishers use the inshore, offshore, and sound waters around Wanchese in Dare County. Those fishing from boats do not predominantly target bluefish. Bluefish are targeted by pier and surf fishers, who are primarily local residents and residents of nearby counties. Other species targeted by pier and surf fishers are flounder, Kingfish or sea mullet, triggers, puffers, skates, rays, spot, pigfish, and pinfish.

Federally Permitted Vessels (from the 2007 bluefish specifications document)
NMFS Federal permit data indicate that a total of 3,441 commercial and 900 recreational (party/charter) bluefish permits were issued in 2005. Among these, 478 vessels had both commercial and recreational bluefish permits.

A subset of federally-permitted vessels was active in 2005. Dealer reports indicate that 669 vessels with commercial bluefish permits actually landed bluefish (19.4% of the permitted fleet); and VTR data show 233 party/charter vessels catching bluefish (25.9% of the permitted fleet).

Dealers (from the 2007 bluefish specifications document)
According to NMFS permit data, 417 dealers had Federal bluefish permits in 2005. Dealer reports, however, indicate that only 156 of these dealers (37.4%) actually bought bluefish. The distribution of permitted and active dealers by state is provided in Table 17. While employment data for these dealers are not available, dealer reports indicate that gross revenues from the purchase of bluefish in 2005 were $2.27 million.

5.3.7 Summer Flounder

5.3.7.1 Description of fishing practices, vessels and gear

Summer flounder support an extensive commercial fishery along the Atlantic Coast, principally from Massachusetts through North Carolina. Landings from Maine through North Carolina, have fluctuated widely over the last six decades (Table 38), increasing from slightly less than 10 million pounds per year prior to World War II to an average of around 20 million pounds during the 1950's and early 1960's. Landings consistently decreased during the 1960's to a low of 6.7 million pounds in 1969. Commercial landings increased in the mid 1970's until 1989, due to increased levels of effort in the southern winter trawl fishery (MAFMC 1993). Landings of summer flounder from Maine to North Carolina peaked in 1979 at nearly 40 million pounds (Table 38). Reported landings were 32.3 million pounds in 1988 and less than 18 million pounds in 1989, and further decreased in 1990 to about 9 million pounds, a decline of 71% from 1988 (Table 38).

In 1993, the first year that a coastwide quota was implemented, commercial landings were 12.8 million pounds, slightly in excess of the quota for that year. Commercial landings increased to 15.4 million pounds in 1995 and then dropped to 8.8 million pounds in 1997. Commercial landings were 10.7 million pounds in 1999.

From 1990 to 1999 the state of North Carolina had the highest commercial landings of summer flounder, accounting for 25% of the 1990 to 1999 mean, followed by Virginia (24%), New Jersey (17%), and Rhode Island (15%; Table 38). The states of Maine,

Delaware, and Maryland, accounted for less than 1% each of the 1990 to 1999 mean. The state of New Hampshire had no summer flounder landings from 1990 to 1999.
Most commercial landings are made from otter trawl vessels (93%) and sea scallop dredges (2%), as based on 1990 to 1999 NMFS Weighout Data (Table 39). From 1990 to 1999 combined, otter trawls caught 117 million pounds of summer flounder, while sea scallop dredges caught 2.5 million pounds. Hand lines, pound nets, and unknown combined gears were the only other gear that averaged more than 1 million pounds for the time period. Small catches of summer flounder were also made with haul seines, floating traps, gillnets, pots/traps, and midwater/pair trawls (Table 39).
From 1990 to 1999, the majority of the summer flounder were landed annually by commercial fishermen using otter trawls in all states except Delaware (Table 40). Three gear types accounted for 97% of the Delaware landings, pots/traps, gillnets, and hand lines.

Due to a change in reporting requirements, the reporting of commercial landings by distance from shore is inconsistent from 1994-1998. Therefore, only 1999 landings are presented by distance from shore in this document. Earlier landings by distance from shore are presented in Amendment 10. In 1999, 73.8% of the commercial landings of summer flounder came from the EEZ (Table 12). Delaware had the lowest landings (12.5%) in the EEZ, while Virginia had the highest landings (92.3%) in the EEZ. The remainder of the states caught the majority of their landings in the EEZ (Table 12).

Approximately 37% of the commercial summer flounder landings from 1990 to 1999 were caught in January and February (Table 41). Less than 10% of the landings for this time period were caught in each month from March through December. The lowest landings occurred April through August.

Summer flounder is one of the mainstays of the sport fishery along the Atlantic coast. The use of live bait is common, but summer flounder are also taken on jigs, small spoons, and spinners. Although not as strong a fighter per pound as some other sport fishes, the summer flounder provides lively action, especially on light tackle (MAFMC 1993). From 1980 to 1989 summer flounder landings ranged from a high of 38.2 million pounds in 1980 to a low of 3.2 million pounds in 1989. Recreational landings of summer flounder in 1999, at about 8.4 million pounds, were 36% below the historical 1980-1999 average of 17.4 million pounds and only slightly below the 1990-1999 average of 8.6 million pounds (Table 42). In 1999 the recreational sector accounted for 44% of the total landings. Historically recreational summer flounder landings accounted for 61% of the average total landings from 1980-1999, and 59% of the average total landings from 1990 to 1999 (Table 42).

Recreational catch and landings have fluctuated since recreational harvest limits were implemented under Amendment 2 regulations in 1993 (Table 43). Landings increased to 8.8 million pounds in 1993 from the 1992 level of 7.15 million pounds (Table 43). From 1994 to 1999, recreational landings ranged from 5.4 million pounds (1995) to 12.5 million pounds (1998). Recreational landings in 1999 were estimated to be 8.4 million pounds. In 1980 summer flounder recreational catch was at its highest with 28.4 million fish. It declined to a low of 2.7 million fish in 1989 and has been increasing since. In 1999 summer flounder recreational catch totaled 21.4 million fish.

Summer flounder recreational data indicate that in only two of the last eight years (1994 and 1995) have recreational landings been less than the recreational harvest limits (Table 44). In 1998 and 1999, recreational landings of summer flounder were 12.5 million lb and 8.4 million lb, respectively. The summer flounder recreational landings in 1998 and 1999 were 5.07 million lb and 0.96 million lb over the recreational harvest limit for those years, respectively.
The method of estimating trips for specific species is potentially biased since MRFSS interviewers ask anglers, upon completion of their trip, which species they targeted. This approach may cause anglers to report the species they caught, regardless of the species they originally sought. Over the past 10 years, recreational trips directing for summer flounder in the Mid-Atlantic, New England, and South Atlantic Regions, have fluctuated between a low of 3.6 million trips in 1990 to a high of 5.8 million trips in 1994, the second year with a recreational harvest limit (Table 44). In 1999, there was an estimated 4.2 million trips directing for summer flounder.

From 1990 to 1999, New Jersey landed the largest percentage of catch by number (42.9%), followed by New York (18.8%), Virginia (14.8%), and North Carolina (5.8%). The remaining states all caught less than 5% each (Table 45).

MRFSS estimates from 1990 to 1999 indicate that more than 90% of the recreational summer flounder landings occurred in state waters (inland waters and ocean water <= 3 miles combined) in the North Atlantic and Mid-Atlantic subregions and in North Carolina (Table 46).

From 1990 to 1999, recreational fishermen in private/rental boats, accounted for 92.2%, 84.0%, and 75.9% of the landings in the New England Region, Mid-Atlantic Region, and North Carolina, respectively. The party/charter boat industry accounted for the second highest percent (11.6%) of recreational summer flounder landings in the Mid-Atlantic Region, as compared to only 2.4% and 0.4% of the landings in the New England Region and North Carolina (Table 47). Fishermen fishing from shore were the second highest in both the New England Region (54.9%) and North Carolina (23.7%; Table 47).

VTR data for party/charter boats is only available from 1996 and later, when the requirement for a federal permit holder to submit a vessel logbook was implemented. VTR data indicate that summer flounder contributed almost 13% of the total catch (by number) made by party/charter vessels for the 1996-1999 period (Table 48). The contribution of summer flounder to the total catch of party/charter vessels fluctuated throughout the year, ranging from less than 1% in January, February, March, April, and December to 24% in July. The largest proportion of summer flounder was caught from May through September (Table 48). Analysis of the VTR party/charter data by state indicates that the proportion of summer flounder in the total catch ranged from less than 1% in Maine, New Hampshire, Massachusetts, and Maryland to 34% in New York (Table 48).

Current status of the fishery

(Source: ASMFC 2006)
During the late 1980's landings declined dramatically, reaching a low of 9.3 million pounds in the commercial fishery in 1990 and 3.2 million pounds in the recreational fishery in 1989. Following this record low, the commercial landings showed an increasing trend through 1995, but have varied without trend through 2005. For the past four years commercial landings have been over 13.8 million pounds, with 2005 landings at 17.14 million pounds.

Recreational landings in 1997 were 11.9 million pounds, double the estimate for 1995). The landings continued to increase through 2000, 16.5 million pounds. In 2002 landings dropped to 8.0 million pounds, but then increase to 11.6 million pounds in 2003. Landings have since declined to 10.02 million pounds in 2005. New York, New Jersey, and Virginia dominated the recreational fishery by landings again in 2005.

Combined commercial and recreational landings were 27.16 million pounds in 2005.

Allowable gear

Summer flounder may be harvested commercially in the EEZ using trawl, longline, handline, rod and reel, pot, trap, gillnet and dredge. They may be harvested recreationally using rod and reel, handline, pot, trap and spear.

5.3.7.2 Economic and social description

Commercial fishery

Commercial landings of summer flounder have decreased approximately 75% from 37.8 million pounds in 1984 to 9.3 million pounds in 1990. Commercial landings in 1992 were 16.6 million pounds, and then decrease to 8.8 million pounds in 1997. In 1998 and 1999, commercial landings were above the 1997 landings. In 1999, commercial landings were 10.7 million pounds or 4% below the 1998 level and 15% below the 1990-1999 mean. The commercial share averaged about 60% of the combined total landings of summer flounder from 1990-1999 (Table 42). Preliminary landings data indicates that 11.2 million pounds of summer flounder were landed in 2000.

The ex-vessel value of summer flounder landings has increased from about $19 million in 1991 to a peak $28 million in 1995 (Table 69). Ex-vessel value dropped to $21.1 and $16.5 million in 1996 and 1997, respectively. The sharp decrease in summer flounder value in 1996 and 1997 from the 1995 level was the result of a sharp decline in landings of approximately 7 and 12 million pound, respectively. Between 1998 and 2000, summer flounder ex-vessel value has ranged from $18.4 to $19.8 million. Inflation adjusted prices (2000 dollars) have ranged from $1.57 to $1.96 per pound for the 1991 to 2000 period (Table 69).

The value of summer flounder landings relative to the value of total landings in 1999 and 2000 are presented in Table 70. In 2000, the contribution of summer flounder landings to the value of total landings varied for each state from 1% or less (Maine, New Hampshire, Massachusetts, Delaware, and Maryland) to about 12% in North Carolina. The overall contribution of summer flounder landings to the total ex-vessel value from Maine to North Carolina was about 1.6%.

While some states experienced small percentage changes in the contribution of summer flounder value to the value of total landings from 1999 to 2000, the aggregate contribution associated with this species from Maine to North Carolina was virtually unchanged. At $1.96/lb, the average price (all sizes) of summer flounder reached a record high in inflation adjusted (2000) dollars in 1995 (Table 69). Adjusted prices for summer flounder have ranged from $1.57 to $1.96 per pound for the 1991 to 2000 period. In 2000, highest prices were received in the northern States with Maine, Connecticut and New York as the leaders at $3.12, $2.63, and $2.47 per pound, respectively. Coastwide, the average price of summer flounder was $1.65 per pound in 2000 (Table 71).

Monthly landing and price data for flounder indicates that a supply - price relationship is observable on a monthly basis. Months with highest average ex-vessel prices tend to coincide with months of lowest landings, normally in June, July, and August (Table 72). Prices received for summer flounder originating in state waters for the 1999-2000 period were generally higher than for EEZ waters (Table 73) and tracked the seasonal supply relationship for 1991-2000 (Table 72). The 2000 coastwide average ex-vessel price per pound for jumbo was $2.07, $1.67 for large, $1.39 for medium, $1.40 for small, and $2.08 for unclassified landings (Table 74). The average price per pound for peewees was $3.86 in 2000, however, only a few hundred pounds of summer flounder belonging to this category were landed and this does not represent a typical price pattern. As a general rule, price premiums for larger flounder reflect higher yielding fillet weight.

Processing, marketing, and consumption

Almost all summer flounder are sold in fresh form. The catch is generally iced at the dock and then shipped to market. The major central wholesale market for fresh fish in the Mid-Atlantic region is the Fulton Fish Market.

The number of processing plants handling summer flounder from Maine through North Carolina has varied from 10 in 1990 to 4 in 1999. The value of the summer flounder processed by these plants has varied from $2.1 million in 1990 to over $2.5 million in 1999. In addition, 91 plants reported handling unclassified flounders in 1990 (valued at $42.3 million) and 35 plants in 1999 (valued at $30.8 million) from Maine through North Carolina. The bulk of the plants handling unclassified flounders in 1999 were located in Massachusetts (20) followed by North Carolina (5), and Maine (4). Maryland, New Jersey, Pennsylvania, Rhode Island, and Virginia had a combined total of 6 plants handling unclassified summer flounder in 1999 (NMFS Unpublished processing survey data).

Summer flounder prices per pound for each size category vary from processor to processor and from day to day for each processor. The prices react to the market supply of summer flounder, other flounders available, imports, and wholesale/retail demand. The size categories of summer flounder are likewise not fixed. In the areas where more summer flounder less than 14" are landed there, is a greater tendency to refer to smaller fish as mediums, than in areas where fewer summer flounder less than 14" are landed. The exact lengths which comprise a size category are known to vary from processor to processor and day to day. This variation in price leaves the fisherman with some sense of uncertainty in terms of what he will receive for his catch. Such uncertainty, however, is common in the fishing business.

A study conducted in New England in 1982 (Hu et al. 1983) showed that labor costs would be reduced approximately $0.05 per pound by filleting large flounder instead of small flounder. This is the result of more fillet weight per flounder and the reduced time involved in the fillet process. The species of flounder examined and the size differences were not mentioned.

Economic impact of the commercial fishery

A study by the National Fisheries Education and Research Foundation estimated sales, employment, and wage impacts for flounder harvesting, processing and distribution in the Mid-Atlantic region for 1986 (NFERF 1989). Since summer flounder comprised 84% of the total flounder landings in this region in 1986, specific estimates for summer flounder can be derived from the estimates for total flounders.

Cumulative direct impacts of the Mid-Atlantic summer flounder fishery (Table 104) amounted to 2,290 person-years of employment, $21.6 million in income, and $50.2 million in output (sales). Over 60% of the employment was generated in the food service sector. Harvesting and processing made up most of the remainder, each accounting for just under 15%. Income per person-year was highest in the harvesting and distribution sectors and lowest for processing and food service, probably related to the labor intensive nature of the two latter sectors. Value of output was high for harvesting, processing and food service, indicating the large markup in these sectors. In 2000, summer flounder contributed 1.6% of the total value of all finfish and shellfish landed from Maine to North Carolina (Table 70).

International trade

No summer flounder are imported into the US since the species occurs primarily along the US Atlantic coast. However, imports of several other species of flatfish are substitutes for summer flounder in the market place. These imports compete with and affect the price of summer flounder, winter flounder, yellowtail flounder, and other domestic flatfish species (Wang 1984).

Flat fish imports (excluding halibut) for all product forms decreased from 68.2 million pounds in 1995 to 35.0 million in 2000. However, the value of those imports increased from $139.0 in 1995 to $147.4 in 2000 (NMFS trade data).

Imports of summer flounder have slightly increased for the 1995 to 2000 period. The quantity of summer flounder (all product forms) that entered the US increased from 9.4 million pounds ($42.4 million) in 1995 to 9.7 million pounds ($44.3 million) in 2000. By product type, “frozen fillets” contributed to the bulk of the imports in 2000 with over 52% of the total poundage and 63% of the total value, followed by “whole fresh” (29%, 12%), “fresh fillets” (11%, 17%), “frozen fillet blocks >4.5 kg” (6%, 7%), and “whole frozen” (2%, 1%). Canada and Argentina contributed with the bulk of the summer flounder shipped into the US in 2000. Canada contributed with 50% of the total volume and 37% of the total value of all summer flounder that entered the US last year, and Argentina contributed with 27% of the total volume and 36% of the total value.

The value of imported flatfish products can vary widely depending on the species, whether fresh or frozen, overall quality, and the level of value added through filleting, etc. Belgium and the Netherlands in particular specialize in high value species and products. The average value of Belgium’s and Netherlands' flatfish exports to the US was $10.65/lb and 6.83/lb in 2000, versus Pakistan $1.01/lb, and $4.21 per lb. for all countries combined. The value of summer flounder that enters the US also varies by product form. The average value of summer flounder (all product forms) that entered the country in 2000 was $4.56/lb. In 2000, the most valuable summer flounder product form was “fresh fillets” at $7.23/lb, followed by “frozen fillets” ($5.56/lb), “frozen fillet blocks >4.5 kg” ($5.11/lb), “whole frozen” ($2.02/lb), and “whole fresh” $1.88/lb.

Total US commercial production flounders was estimated at 331 million pounds in 1999, with an average ex-vessel value of $0.27/lb (Fisheries of the USA, 2000). Slightly more than 3.2% (10.6 million pounds) of this domestic harvest was made up of summer flounder, with an average price of $1.83/lb: more than six times the nation's average. When compared with just the more valuable Atlantic coast flounders (winter, summer, and yellow tail flounders), summer flounder comprised 35% of the 1999 landings and 44% of the value.

Japan continues to be the most important export market for summer flounder. Exports of summer flounder are difficult to determine as summer flounder gets lumped under a variety of export codes and it is impossible to identify in the U.S. export data (Ross pers. comm.). However, export of US summer flounder to Japan has been reported to vary from approximately 800 to 1,800 mt in 1993-1997 (Asakawa pers. comm.). Fresh whole U.S. fluke or summer flounder is generally exported to Japan for raw (sashimi) consumption. Fresh U.S. summer flounder is used as a substitute for Japanese “hirame” (bastard halibut – *Paralichthys olivaceus*), and normally imported whole fresh and sold through seafood auction markets to restaurants. They are usually consumed raw for sashimi or sushi toppings in Japan. While U.S. summer flounder is well established in some major action markets, daily prices may fluctuate depending on the total quantity of domestic and imported hirame (including U.S. summer flounder) delivered to auction on a given day. Depending on quality, auction prices for fresh U.S. summer flounder may vary from around 1,000 to 3,000 yen/kilo ($3.13 to 9.40/lb at 145 yen/$ 1.00) depending on size, quality and market conditions (Asakawa pers. comm.). Frozen summer flounder may not be considered to be of the same quality, and is unlikely to become substitute for unfrozen summer flounder. Nevertheless, properly handled frozen summer flounder may receive wholesale prices of 400-900 yen/kilo ($1.73-3.90/lb) or higher (Asakawa pers. comm.). The recent economic crisis in Japan could potentially hamper exports of seafood commodities to that country. Furthermore, future devaluation of the yen would result in reduced revenues for exporters of summer flounder to Japan.

Activity at the port level indicate that 54% of the total fluke commercial landings occurred in seven ports: Point Judith, Rhode Island; Cape May and Point Pleasant, New Jersey; Newport News and Hampton, Virginia; and Wanchese and Beaufort, North Carolina. The contribution of summer flounder to ports with 10% or more summer flounder dependence (value) is presented in Table 90. Of the seven ports accounting for the bulk of the summer flounder landings in 1999, only Beaufort (18.95%), Wanchese (13.26%), and Hampton (10.87%) had 10% or more revenue dependence on summer flounder (Table 90).

Recreational fishery

Recreational fishermen caught over 24 million summer flounder in 2000, the highest annual level of the past decade (Table 105). Landings in 2000 were also substantially higher than the ten year average in terms of numbers (7.5 million fish) and weight (15.8 million pounds). However, recreational fishermen released a slightly lower proportion of summer flounder alive (31%) than the 10 year average of 32%.

In 2000, over 90% of the summer flounder landed by weight in the North and Mid-Atlantic were caught in state waters (Table 106). Landings by North and Mid-Atlantic fishermen fishing in state waters have consistently exceeded EEZ landings throughout the past decade, accounting for over 93% of total landings, on average, during the past 10 years.

The participation of summer flounder anglers by region and mode indicates that from 1991 to 2000, 8% of the summer flounder (by number) were caught from party or charter vessels (Table 107). Anglers' expenditures aboard party and charter boats benefits the party and charter industry as well as other businesses in the coastal communities.
In addition to party and charter vessels, 10% of the summer flounder were caught from shore, and 82% from private/rental boats (Table 107). Furthermore, private and rental boat fishermen also accounted for over 80% of the summer flounder landings (by number) and over 80% of the summer flounder released alive, on average, during the past decade. Ownership of a private vessel involves sizable investment and maintenance costs, thus contributing greatly to measures of economic impact. Private vessels are also used for non-fishing purposes; and are used to fish for many different species. Expenditure and cost data must be prorated for summer flounder trips to account for multipurpose use.

Anglers fishing in New Jersey were responsible for over 45% of the average annual total summer flounder landings from Maine to North Carolina during the past decade (Table 108). Recreational landings in New Jersey, New York, and Virginia accounted for 76% of the total annual landings (by number) during this time period.

NMFS estimated that in 2000, a total of 33.228 million day trips were taken by marine recreational anglers along the Atlantic coast from Maine to North Carolina (Personal communication from NMFS, Fisheries Statistics and Economics Division). An estimated 16.7% of these anglers indicated that they preferred or sought summer flounder as the primary target species. That is, an estimated 5.56 million angler trips (all modes) were nominally directed at summer flounder from Maine to North Carolina in 2000.

Economic impact of the recreational fishery

Anglers' expenditures generate and sustain employment and personal income in the production and marketing of fishing-related goods and services. In 1998, saltwater anglers from Maine to Virginia spent an estimated $1.136 billion on trip-related goods and services (Steinback and Gentner 2001). Trip-related goods and services included expenditures on private transportation, public transportation, food, lodging, boat fuel, party/charter fees, access/boat launching fees, equipment rental, bait, and ice.

Unfortunately, estimates of trip expenditures specifically associated with summer flounder were not provided in the study. However, if average trip expenditures are assumed to be constant across all fishing trips, an estimate of the expenditures associated with summer flounder can be determined by multiplying the proportion of total trips that targeted summer flounder (16.7%) by the total estimated trip expenditures from the Steinback and Gentner study ($1.136 billion). According to this procedure, anglers fishing for summer flounder from Maine to Virginia spent an estimated $200.412 million on trip-related goods and services in 2000.1 Apart from trip-related expenditures, anglers also purchase fishing equipment and other durable items that are used for many trips (i.e., rods, reels, clothing, boats, etc.).

Although some of these items may be purchased with the intent of targeting/catching specific species, the fact that these items can be used for multiple trips creates difficulty when attempting to associate durable expenditures with particular species. Therefore, only trip-related expenditures were used in this assessment.

The summer flounder expenditure estimate can be used to reveal how anglers' expenditures affect economic activity such as sales, income, and employment from Maine to Virginia. During the course of a fishing trip, summer flounder anglers purchase a variety of goods and services, spending money on transportation, food, boat fuel, lodging, etc. The sales, employment, and income generated from these transactions are known as the direct effects of anglers' purchases.
Indirect and induced effects also occur because businesses providing these goods and services also must purchase goods and services and hire employees, which in turn, generate more sales, income, and employment. These ripple effects (i.e., multiplier effects) continue until the amount remaining in a local economy in negligible. A variety of analytical approaches are available for determining these impacts, such as input-output modeling. Unfortunately, a model of this kind was not available. Nonetheless, the total sales impacts can be approximated by assuming a multiplier of 1.5 to 2.0 for the Northeast Region. Given the large geographical area of the Northeast Region, it is likely that the sales multiplier falls within those values. As such, the total estimated sales

generated from anglers that targeted summer flounder in 2000 was likely to be between $300.618 million ($200.412 million * 1.5) and $400.824 million ($200.412 million * 2.0) from Maine to Virginia. A similar procedure could be used to calculate the total personal income and employment generated from summer flounder anglers' expenditures, but since these multiplier values have been quite variable in past studies, no estimates were provided here.

Value of the fishery to anglers

The value that anglers place on the recreational fishing experience can be divided into actual expenditures and non-monetary benefits associated with satisfaction (consumer surplus). Anglers incur expenses for fishing (purchase of gear, bait, boats, fuel, etc.), but do not pay for the fish they catch or for the enjoyment of many other attributes of the fishing experience (socializing with friends, contact with nature, etc.). Despite the obvious value of these attributes of the experience to anglers, no direct expenditures are made for them, hence the term "non-monetary" benefits.

Behavioral models that examine travel expenditures, catch rates, accessibility of fishing sites, and a variety of other factors affecting angler enjoyment can be used to estimate the "non-monetary" benefits associated with recreational fishing trips. Unfortunately, a model of this kind does not exist for summer flounder. Data constraints often preclude researchers from designing species-specific behavioral models. However, a recent study by Hicks, et. al. (1999) estimated the value of access across states in the Northeast region (that is, what people are willing to pay for the opportunity to go marine recreational fishing in a particular state in the Northeast) and the marginal value of catching fish (that is, what people are willing to pay to catch an additional fish). Table 117 shows, on average, the amount anglers in the Northeast states (except for North Carolina which was not included in the study) are willing to pay for a one-day fishing trip. The magnitude of the values in Table 117 reflect both the relative fishing quality of a state and the ability of anglers to choose substitute sites. The willingness to pay is generally larger for larger states, since anglers residing in those states may need to travel significant distances to visit alternative sites. Several factors need to be considered when examining the values in Table 117.

First, note that Virginia has relatively high willingness to pay estimates given its relative size and fishing quality characteristics. In this study, Virginia defines the southern geographic boundary for a person's choice set, a definition that is arbitrary in nature. For example, an angler in southern Virginia is likely to have a choice set that contains sites in North Carolina. The regional focus of the study ignores these potential substitutes and therefore the valuation estimates may be biased upward (Hicks, et. al. 1999). Second, the values cannot be added across states since they are contingent upon all of the other states being available to the angler. If it was desirable to know the willingness to pay for a fishing trip within Maryland and Virginia, for example, the welfare measure would need to be recalculated while simultaneously closing the states of Maryland and Virginia.

Assuming the average willingness to pay values shown in Table 117 are representative of trips that targeted summer flounder, these values can be multiplied by the number of trips that targeted summer flounder by state (from the MRFSS data) to derive welfare values for summer flounder.

Table 118 shows the aggregate estimated willingness to pay by state for anglers that targeted summer flounder in 2000 (i.e., the value of the opportunity to go recreational fishing for summer flounder). New York, New Jersey, and Virginia were the states with the highest estimated willingness to pay for summer flounder day trips. Once again, note that the values cannot be added across states since values are calculated contingent upon all of the other states being available to the angler.

In the Hicks et. al. (1999) study the researchers also estimated welfare measures for a one fish change in catch rates for 4 different species groups by state. One of the species groups was "flat fish," of which summer flounder is a component. Table 119 shows their estimate of the welfare change associated with a one fish increase in the catch rate of all flat fish by state. For example, in Massachusetts, it was estimated that all anglers would be willing to pay $5.03 (the 1994 value adjusted to its 2000 equivalent) extra per trip for a one fish increase in the expected catch rate of all flat fish. The drawback to this type of aggregation scheme is that the estimates relate to the marginal value of the entire set of species within the flat fish category, rather than for a particular species within the grouping. As such, it is not possible to estimate the marginal willingness to pay for a one fish increase in the expected catch rate of summer flounder from the information provided in Table 119.

However, it is possible to calculate the aggregate willingness to pay for a 1 fish increase in the catch rate of flat fish across all anglers. Assuming that anglers will not adjust their trip taking behavior when flat fish catch rates at all sites increase by one fish, the estimated total aggregate willingness to pay for a one fish increase in the catch rate of flat fish in 2000 was $154.843 million (total trips (33.228 million) x average per trip value ($4.66)). This is an estimate of the total estimated welfare gain (or loss) to fishermen of a one fish change in the average per trip catch rate of all flat fish. Although it is unclear how much of this welfare measure would be attributable to summer flounder, the results show that flat fish in general, in the Northeast, are an extremely valuable resource.

Although not addressed here, recreational fishing participants and non-participants may also hold additional intrinsic value out of a desire to be altruistic to friends and relatives who fish or to bequeath a fishery resource to future generations. A properly constructed valuation assessment would include both use and intrinsic values in the estimation of total net economic value. Currently, however, there have been no attempts to determine the altruistic value (i.e., non-use value) of summer flounder in the Northeast.

5.3.8 Horseshoe Crab

5.3.8.1 Description of fishing practices, vessels and gear

(Source: http://www.dnr.state.md.us/education/horseshoecrab/fhistory.html)

A commercial fishery for horseshoe crabs has existed since the 19th century. Early on, horseshoe crabs were harvested primarily for fertilizer and animal feed. Typically, crabs were collected by hand on beaches during the spawning season or by pound nets. Huge numbers were collected during the spawning season as the crabs became concentrated on mid-Atlantic beaches. In fact, between the 1870's and 1920's, annual harvests in the Delaware Bay averaged over one million crabs.

This fishery eventually declined for several reasons. First, competition from chemical fertilizers developed starting in the 1930s. Second, the horseshoe crab population declined. And lastly, the public complained about the odor caused by large numbers of dead horseshoe crabs processed at fertilizer and animal feed factories. In the 1950s to the 1980s, reported commercial harvests were almost non-existent. However, no mandatory reporting requirements existed for horseshoe crabs during this period. Commercial harvesting of the crabs continued throughout this time period but not reported. These harvests appear to have been localized and limited because horseshoe crab populations steadily recovered.

Since the 1980s several new fisheries have developed for horseshoe crabs. Horseshoe crabs are harvested as bait to catch American eel (*Anguilla rostrata*), channel whelk (*Busycotypus canaliculatus*) and knobbed whelk (*Busycon carica*) in Maryland and the rest of the mid-Atlantic region. Increased demand in these fisheries led to a dramatic increase in the horseshoe crab harvest during the 1990s and led to coast-wide management of horseshoe crabs.

In the American eel fishery unique chemical odors emitted by egg-laden female horseshoe crabs strongly attract the eels to an eel pot. It is because of this strong attraction that eels prefer female horseshoe crabs to other types of bait. The eel pot fishery only uses female horseshoe crabs as bait. Male crabs do not emit the same chemical odors as the females and are not used. To catch the whelk, the horseshoe crab is used as bait, divided into quarters, placed in a conch trap and placed offshore on the bottom. Whelks smell the horseshoe crab bait and enter the trap to feed. Periodically, the waterman will check each trap and harvest the whelks he finds. This fishery uses both male and female crabs as bait to catch whelk. The fishery for whelk grew out of increasing overseas demand for this mollusk. Starting in the 1990s, expansion of the whelk fishery led to dramatic increases in horseshoe crab harvests. The whelk harvest goes primarily to regional processing plants or is directly exported to European food markets.

(excerpt for the ASMFC's species profile factsheet for horseshoe crab):
Horseshoe crabs are also collected by the biomedical industry to support the production of Limulus Amoebocyte Lysate (LAL), a clotting agent that aids in the detection of human pathogens in patients, drugs, and intravenous devices. No other procedure has the same accuracy as the LAL test. The current estimate of medical usage is between 250,000 and 300,000 horseshoe crabs per year on the Atlantic coast. While crabs are bled and released live generally within 72 hours of capture, up to 15 percent do not survive the procedure.

Current status of the fishery

Bait Fishery (ASMFC 2006)
Reported coastwide bait landings in 2006 remained below the quota established under Addendum III and IV (Table 1, Figure 1). Bait landings increased for the third consecutive year, but also remained below one million crabs for the third consecutive year.

An alternative bait/gear workshop conducted under the auspices of ASMFC in 1999 introduced the concept of using bait savings devices (bait bags) in whelk (conch) pots. Free bait bags were distributed to whelk potters in the Mid Atlantic and southern New England regions through a state, federal, and NGO partnership. National Marine Fisheries Service funded the acquisition of the bait bags. The Ecological Research and Development Group (ERDG), Delaware, Maryland, New Jersey, Virginia, New York, Connecticut, Rhode Island and Massachusetts assisted in the distribution of the bags. The reductions in reported bait landings in excess of the 25% reductions required under Addendum I were largely attributed to the success of this program, with the widespread use of the devices by the commercial fishery. Massachusetts fishermen have been using bait cups in conch traps with success. The cups use about a 10th of a crab and can be fished for 2-3 days the relatively cold waters.

Reported coastwide landings since 1998 showed more male than female horseshoe crabs were annually harvested; though, a large proportion of the reported landings in 1998 and 1999 were unclassified. Unclassified landings accounted for less than 12% of the reported landings since 2000. The American eel pot fishery prefers egg-laden female horseshoe crabs as bait, while the whelk (conch) pot fishery is less dependent on females. The hand, trawl and dredge fisheries accounted for over 90% of the 2006 reported commercial horseshoe crab bait landings by gear type. This is consistent with the distribution of landings by gear since 1998. Although the hand fishery accounted for most of the coastwide harvest and was typically the most prominent method of take in most states, the trawl and dredge fisheries accounted for over 45% of the reported landings by gear in 2006. The dredge fishery accounted for 52% of the Delaware landings and 82% of the Virginia landings. The trawl fishery accounted for over 99% of Maryland's horseshoe crab bait landings.

The dominance of the hand fishery was reflected in the seasonal distribution of landings. Most of the coastwide harvest since 1998 came during May and June as crabs come ashore to spawn and, thus, were readily available to the fishery. There is typically a secondary mode I monthly landings during the late summer or fall. This secondary peak coincides with an increased demand for horseshoe crabs in the conch pot fishery.

Biomedical Fishery
The horseshoe crab is an important resource for research and manufacture of materials used for human health. There are four companies along the Atlantic Coast that process

horseshoe crab blood for use in manufacturing Limulus Amoebocyte Lysate (LAL): Associates of Cape Cod, Massachusetts; Cambrex Bioscience, Maryland; Wako Chemicals, Virginia; and Endosafe, South Carolina. There is one company that bleeds horseshoe crabs but does not manufacture LAL: Limuli Labs, New Jersey. Addendum III requires states where horseshoe crabs are collected for biomedical use to collect and report harvest data and characterize mortality.

The Plan Review Team annually calculates total coastwide harvest and estimates mortality. It was reported that 367,914 crabs (including crabs harvested as bait) coastwide were brought to biomedical companies for bleeding in 2006 (see table below). A total of 58,625 crabs were harvested as bait and counted against state quotas. These crabs were not included in the mortality estimates below. It was reported for 2006 that 309,289 crabs were harvested for biomedical purposes only. Crabs were rejected prior to bleeding because of mortality, minor injuries, and slow movement. Based on state reports, approximately 1.5% of crabs harvested and brought to bleeding facilities were rejected because of death or serious injury. The PRT estimates a mortality of 4,639 crabs prior to bleeding.

Table 5.3.8-1. Number of crabs harvested for biomedical purposes.

Year	*2004*	*2005*	*2006*
Number of crabs brought to biomedical facilities (bait and biomedical crabs)	343,126	323,149	367,914
Number of biomedical-only crabs harvested (not counted against state bait quotas)	292,760	283,720	309,289
Estimated mortality of biomedical-only crabs prior to bleeding	4,391	4,256	4,639
Number of biomedical-only crabs bled	275,194	270,496	296,958
Estimated mortality of biomedical-only crabs during or after bleeding	41,279	40,574	44,543
Total estimated mortality on biomedical crabs not counted against state bait quotas	45,670	44,830	49,182

The highest estimate of crab mortality from the bleeding process in the literature is 15% (Thompson 1998). Using the number of biomedical-only crabs and the estimated mortality rate during or after the bleeding process, the PRT calculated an estimated mortality of 44,543 crabs. The total coastwide mortality estimate of crabs not counted against state quotas is 49,182 crabs for 2006.

The 1998 FMP establishes a mortality threshold of 57,500 crabs, where if exceeded the Board is required to consider action. The PRT recommends that the Board not consider action at this time but that it continues to monitor biomedical use of crabs closely. It appears that use of horseshoe crabs has increased slightly since the original FMP was approved. However, more crabs that were harvested for bait were bled in biomedical facilities in 2006, thereby keeping mortality under the threshold. While monitoring of biomedical harvest and use of crabs has improved under Addendum III to the FMP, inconsistencies remain in reporting among the states. The PRT plans to work with the states that report biomedical landings to continue to standardize reporting.

Allowable gear

5.3.8.2 Economic and social description

Commercial Fishery

Between the 1850s and the 1920s, over 1 million horseshoe crabs were harvested annually for fertilizer and livestock feed (Shuster 1982; Shuster and Botton 1985). Reported harvests in the 1870s were 4 million horseshoe crabs annually, and 1.5 to 1.8 million horseshoe crabs annually between 1880s and 1920s (Finn et al. 1991). Shuster (1960) reports that in the late 1920s and early 1930s 4 to 5 million crabs were harvested annually. Shuster (1960) reports over 1 million crabs were harvested during the 1940s and 500,000 to 250,000 horseshoe crabs were harvested in the 1950s. By the 1960s, only 42,000 horseshoe crabs were reported to be harvested annually (Finn et al., 1991).

Early harvest records are suspect due to under-reporting. The period of time between 1950 and 1960 is considered the nadir of horseshoe crab abundance. The substantial commercial-scale harvesting of horseshoe crabs ceased in the 1960s (Shuster, 1996).

Bait Fishery

Currently, horseshoe crabs are commercially harvested for use as American eel, conch (or whelk), and catfish bait along certain portions of the Atlantic coast. The horseshoe crab fishery is unique in that crabs can be easily harvested during their spawning season and can be caught with a minimal financial expense. The eel fishery is highly dependent on sustained populations of horseshoe crabs and prefers female horseshoe crabs with eggs.

The conch fishery also is dependent on horseshoe crabs, but uses both male and female horseshoe crabs. Commercial landings data for horseshoe crabs (i.e., metric tons, pounds, and price) are collected by the NMFS by state, year, and gear type. Commercial landings data may include harvest for both the bait and biomedical fisheries.

However, the NMFS data are relatively incomplete and disjunct. For example, in several years that NMFS reports no landings in states such as Delaware, state biologists report that landings did occur (Michels, pers. comm., 1997). In 1994 and 1995, the NMFS reported Maryland's harvest at 232,000 and 117,000 pounds, respectively. Based on State landing records, actual Maryland harvest was approximately 1 million pounds during these years (O'Connell, pers. comm., 1998). In many cases, horseshoe crabs are harvested and used directly by eel fishers, whelk fishers, or catfish fishers without going through a dealer (where NMFS gets much of its information) or arrangements are made for harvesters to sell directly to such fisheries without going to dealers. Since such private sales are not reported, NMFS fishery statistics underestimate the catch. Based on NMFS data, commercial harvest from the northeastern Atlantic coast has ranged between 10,000 pounds (in 1969) to over 5.0 million pounds (in 1996) (NMFS, 1998).

Since 1988, commercial landings have averaged 1,436,808 pounds. Botton and Ropes (1987b) estimated the total number of horseshoe crabs harvested by comparing the total number of pounds landed with the average weight of an adult horseshoe crab, which is approximately 4 pounds. However, the NMFS used a different conversion factor to estimate the number of pounds landed (e.g., 2.6 pounds per crab). The total average horseshoe crab catch (animals/year) for the Atlantic Coast (assuming an adult horseshoe crab is 4 pounds) has increased from 476,515 in 1993 to 1,288,408 in 1996 (NMFS, 1998). This increase is similar to increases reported by Michels (unpublished data, 1997) for the Delaware Bay harvest, which ranged from 330,333 in 1993 to 896,540 in 1996. However, Michels (unpublished data, 1997) did not include the Maryland harvest (which can be substantial). These statistics provide further evidence that the NMFS data represent an underestimate of actual harvest. Regardless of the data set used, all data show a significant increase in harvest between 1990 and 1996.

The SAS and the PRP concluded that commercial landings data show a substantial increase in reported harvest during the 1990s (Atlantic States Marine Fisheries Commission, 1998a; 1998b). This increase could be, in part, a function of increased harvest reporting efficiency. The states of Delaware, Maryland, New Jersey, and New York represent the largest harvest of horseshoe crabs recently. Estimates in Delaware, Maryland, New Jersey, New York, and Rhode Island indicate a rapid increase in fishery growth, based primarily on use as bait for the American eel and whelk fisheries and the shift in pressure from declining traditional fisheries (Michels, unpublished data, 1997; NMFS, 1998; Thompson, 1998). However, the States of Connecticut, Massachusetts, North Carolina, and Virginia indicate declines in current harvest compared with harvest in the late 1970s and early 1980s (NMFS, 1998).

Based on reported landings in New Jersey alone, horseshoe crab harvests have increased in the last three years from approximately 250,000 in 1993 to over 600,800 in 1996. The Delaware Division of Fish and Wildlife (1997) reports increases in landings between 1990 (under 250,000 pounds) and 1997 (over 1,500,000 pounds). The Delaware Division of Fish and Wildlife (1997) also reports increases in effort as represented by issuance of beach collection permits, which increased from 18 in 1991 to 131 in 1997.

However, prior to 1991 little or no reporting occurred within the Delaware Bay. Thus, the increase in horseshoe crab harvest during the 1990s may be partly related to mandatory reporting requirements. Primary harvest was identified in Rhode Island, New Jersey, Delaware, Maryland, and Virginia. Little to no harvesting of horseshoe crabs was reported in Maine, New Hampshire, or Connecticut (Botton and Ropes, 1987b).

The Chesapeake Bay in Maryland and Virginia likely has a substantial harvest, but without quantitative studies, the catch remains under-reported. Maryland has been responsible for 23 to 78 percent of the total commercial catch of horseshoe crabs from the northeastern Atlantic coast since 1980 (NMFS, 1998). Maryland averaged 357,000 pounds between 1981 and 1991 from a small directed ocean fishery and bycatch from the clam fishery. Since 1992, harvest has increased significantly in Maryland with 2.6 million pounds landed in 1996. Maryland's fishery is primarily an offshore trawl fishery;

more than 95 percent of the harvest occurs from July through November. In 1996, 96 percent of Maryland's harvest was from waters outside of 1 mile (52 percent from State waters [1-3 miles] and 44 percent from federal waters [3+ miles]), 3 percent from the coastal bays, and <1 percent from the Chesapeake Bay (O'Connell, pers. comm., 1998).

In Virginia, horseshoe crab harvest averaged 190,000 pounds between 1980 and 1988. With a ban on trawling in state waters since 1989, horseshoe crab landings have decreased considerably, averaging 22,000 pounds (Butowski 1994) and only increasing to 86,294 pounds in 1996 (NMFS 1998). Demand has increased in Virginia as indicated by whelk landings, which have increased from 75,000 pounds in 1994 to 750,000 pounds in 1995 (Petrocci 1997).

Reported dockside value from the northeastern Atlantic coast has ranged between $289 (1967) and $1,541,260 (1996). Fishery statistics (Table 5.3.8-2) for the period 1970 through 1997 indicate a variable fishery. As previously identified, fishery statistics probably underestimate the catch of horseshoe crabs, because the sale of crabs for bait is often arranged between private individuals (i.e., unreported in NMFS landing statistics) rather than through centralized dealers (Botton and Ropes 1987b).

In 1997, the majority (85 percent) of horseshoe crabs in Delaware were landed by hand harvest, while dredge harvest made up approximately 15 percent (Delaware Division of Fish and Wildlife, 1997). Between 1991 and 1996 the majority of the horseshoe crabs were landed by hand-harvest (63 percent) compared to dredging (37 percent) (Delaware Division of Fish and Wildlife, 1997), except for 1991 when the dredge harvest dominated the catch (56 percent). The increased harvest noted in Delaware mirrored increases in the number of hand-collection permits issued (Delaware Division of Fish and Wildlife, 1997). NMFS data compiled by Delaware Division of Fish and Wildlife (1997) identified that among the northeastern and mid-Atlantic States, Maryland, New Jersey, and

Delaware harvest the majority of horseshoe crabs (36, 31, and 14 percent, respectively). The shrimp trawl fishery in the South Atlantic Bight may contribute to horseshoe crab mortality via bycatch (Thompson, 1998), but the amount of bycatch harvest remains unreported. The amount of horseshoe crab bycatch has become very small, since the use of turtle excluder devices became mandatory in the shrimp trawl fishery (Cupka, pers. comm., 1998).

Table 5.3.8-2. Atlantic states landings for horseshoe crab for the period 1970 - 1997. Source: National Marine Fisheries Service (1998). Note: National Marine Fisheries Service data is an underestimate of the true coastwide harvest due to the lack of mandatory reporting in all states. Note: All dollars are 1992 dollars, adjusted by the implicit price deflator (GDP). All life stages are included.

ATLANTIC STATES LANDINGS (MAINE - FLORIDA)		
Year	Pounds	Value (in $1000s)
1970	15,900	7.79
1971	11,900	3.01
1972	42,000	2.63
1973	88,700	5.54
1974	16,700	6.90
1975	62,800	18.90
1976	2,043,100	63.96
1977	473,000	16.58
1978	728,500	45.59
1979	1,215,630	148.24
1980	566,447	79.02
1981	326,695	55.97
1982	510,060	44.95
1983	440,959	35.83
1984	152,392	15.36
1985	522,199	41.46
1986	507,814	47.82
1987	462,663	67.82
1988	636,252	71.23
1989	1,087,912	131.72
1990	908,130	101.81
1991	1,089,045	121.50
1992	1,000,619	109.71
1993	1,906,059	207.22
1994	1,401,656	228.60
1995	2,547,987	378.99
1996	5,156,126	1541.26
1997	6,146,487	1228.56

Biomedical Fishery
Scientists have used horseshoe crabs in eye research, surgical sutures wound dressing development, and detection of bacterial endotoxins in drugs and intravenous devices (Hall 1992). Limulus Amoebocyte Lysate (LAL), a clotting agent in horseshoe crab blood, has made it possible to detect human pathogens such as spinal meningitis and gonorrhea in patients, drugs, and all intravenous devices. In 1964, researchers discovered that horseshoe crab blood coagulates in the presence of minute quantities of gram-negative bacterial endotoxin and the LAL industry was initiated. By 1979, the U.S. Food

and Drug Administration (FDA) issued draft guidelines for the use of LAL as an end-product pyrogen test for endotoxin in medical devices and injectable drugs. The LAL test is currently the worldwide standard for screening medical equipment for bacterial contamination; any drug produced by a pharmaceutical company must pass an LAL screening. No other known procedure has the same accuracy as the LAL test. If LAL became unavailable, it could take years to find a universally accepted replacement. To obtain LAL, manufacturing companies catch primarily adult horseshoe crabs, collect a portion of their blood, and then release them alive.

In 1989, the FDA reported that 130,000 horseshoe crabs were used in the biomedical industry. The current estimate of medical usage is between 200,000 and 250,000 horseshoe crabs per year on the Atlantic Coast (Swan pers. comm. 1998; McCormick pers. comm. 1998). The FDA mandates conservation by requiring the return of horseshoe crabs to the environment. Most labs return bled crabs to their habitat within 72 hours of capture, but may or may not release crabs at the collection site (Botton 1995).

Approximately 10 percent of the crabs do not survive the bleeding procedure, which comprises a source of mortality that is not included in the commercial catch statistics (Rudloe 1983). Based on a tagging and controlled mortality study, Thompson (1998) reported similar post-processing mortality of horseshoe crabs (10 to 15 percent). Mortality due to the bleeding procedure may be lower (e.g., 0 to 4 percent), depending on the biomedical facility (Swan pers. comm. 1998), but the mortality associated with collection, shipping, and handling remains unknown. This mortality is minimal compared to that from the commercial bait fishery.

In South Carolina, live horseshoe crabs may be taken only for use in LAL production, with animals returned to natural habitat after bleeding. Landings in South Carolina by hand-harvest and trawl have increased since the late 1980s. The annual reported harvest in South Carolina has increased over 300 percent since reporting requirements were established in 1991 (Thompson 1998). Presumably, this increase in harvest was driven by the biomedical industry’s demand for more horseshoe crabs.

Horseshoe crabs are used also to make chitin filament for suturing (Hall 1992). Since the mid-1950s medical researchers have known that chitin-coated suture material enhanced healing time by 35-50 percent. Currently, horseshoe crabs are harvested on a limited basis to manufacture chitin-coated suture material and chitin wound dressings (Hall 1992). Horseshoe crab blood is also beneficial in cancer research; the LAL could lead to controlled cancer therapy. Endotoxins and other substances in horseshoe crab blood may have the potential for diagnosing leukemia.

Social environment

(excerpt from Horsheshoecrab.org)

Horseshoe crabs are the primary bait for the American eel and conch fisheries in many mid-Atlantic States. In Maryland, the estimated value of the horseshoe crab fishery in 1996 for 10 horseshoe crab harvesters was $398,596 (Maryland Department of Natural Resources 1998). Also in 1996, one Maryland seafood dealer, supplying horseshoe crabs to 20 American eel and 25 conch harvesters, estimated that the value of horseshoe crabs for these fisheries was $151,200. Horseshoe crab prices vary and are reported to be between $0.65 to $0.75 per animal (Maryland Department of Natural Resources 1998).

In 1997, American eel and conch harvesters in Delaware used an average of 4,714 and 20,502 horseshoe crabs per season per harvester, respectively. In New Jersey, American eel and conch harvesters used an average of 4,005 and 22,654 horseshoe crabs per season per harvester, respectively (Munson 1998). Many conch and American eel harvesters in New Jersey and Delaware harvest their own bait, supplying 18 to 65 percent of their bait needs (Munson 1998). While only nine percent of the fishing income (of respondents in the Delaware Bay Watermen's study) is attributable to the direct sale of horseshoe crabs, an average of 58 percent of the eel and conch fishing income depends on using horseshoe crabs as bait (Munson 1998). American eel harvesters in the Delaware Bay area report that approximately 21 percent of their total fishing income is attributable to eeling, while conch harvesters report that an average of 53 percent of their total fishing income depends on the conch fishery (Munson 1998). In 1996, the commercial harvest of horseshoe crabs was estimated to be a $1.5 million industry.

Horseshoe crabs are vital to medical research and the pharmaceutical products industry. The worldwide market for LAL is currently estimated to be approximately $50 million per year. This estimate is based on bleeding 250,000 horseshoe crabs per year, generating approximately $200 in revenue per crab for the biomedical industry. The biomedical industry either directly collects horseshoe crabs on spawning beaches or purchases horseshoe crabs for as much as $3.00 per crab. The biomedical industry pays approximately $375,000 per year for horseshoe crabs based on an estimate of 250,000 horseshoe crabs harvested at an average price of $1.50 per crab.

Eco-tourism is critical to the economies of many states, including New Jersey and Delaware, and it depends on the abundance and health of the ecosystems within the region. In 1988, over 90,000 “birders” spent $5.5 million in Cape May, New Jersey (Kerlinger and Weidner 1991) to watch the interaction between spawning horseshoe crabs and migrating shorebirds. In 1996, approximately 606,000 people in New Jersey and Delaware took trips away from their residence (traveling more than one mile) for the primary purpose of watching wildlife. Of these people, 409,000 individuals specifically stated that they were watching shorebirds (U.S. Bureau of Census and USFWS, 1998).

In 1996, New Jersey and Delaware wildlife watchers spent between nine and 12 days per year (on average) away from home (traveling more than one mile) watching wildlife (U.S. Bureau of Census and USFWS, 1998). In New Jersey and Delaware, total expenditures, including food, lodging, transportation, and equipment in 1996 for the primary purpose of wildlife watching was $639,992,000 (USFWS, 1998). The type of wildlife watched was not identified in this survey. The 1996 regional economic impact resulting from expenditures by wildlife watchers in New Jersey and Delaware was the creation of 15,127 jobs and the generation of a total household income of $399 million (USFWS, 1998).

5.3.8.3 Bycatch

Little is known about bycatch in the horseshoe crab trawl fishery. Although bycatch monitoring programs have been developed for many fisheries (NOAA 2003), to date no studies have attempted to identify or quantify bycatch in the horseshoe crab trawl fishery. The gear used in the horseshoe crab trawl fishery is much different than that used in other fisheries; the benthic gear is equipped with heavy ground gear to effectively catch horseshoe crabs. Therefore, monitoring programs developed for other fisheries may not accurately portray bycatch in the horseshoe crab trawl fishery.

In 2001, a benthic trawl survey was developed and initiated by the Horseshoe Crab Research Center (HCRC) at Virginia Tech (Hata and Berkson 2004). Species composition data were collected aboard the HCRC trawl survey in the fall of 2005 and 2006 to identify species that are susceptible to the trawl gear used in the horseshoe crab trawl fishery (Graham et al., in review). Sites between the eastern tip of Long Island, New York, USA (71° 50'W and 41° 04'N) and the southern tip of the Delmarva Peninsula, Virginia, USA (75° 55'W and 37° 05'N) were sampled using the trawl gear that is commonly used in the commercial fishery (n = 156 sites) (Graham et al., in review).

Over two fall seasons, 76 different taxa were identified as susceptible to the trawl gear (n = 60 taxa in 2005, n = 69 taxa in 2006), including 47 finfish species from 33 families (Table 5.3.8-3) (Graham et al., in review). The majority of biomass was comprised of skates (49%) and horseshoe crabs (33%) (Graham et al., in review). Catch per unit effort was greatest for little/winter skate (*Leucoraja* spp.), horseshoe crab, and clearnose skate (*Raja eglanteria*) (Graham et al. in review). Clearnose skate, horseshoe crab, summer flounder (*Paralichthys dentatus*), spider crab (*Libinia* spp.), and windowpane flounder (*Scophthalmus aquosus*) were most commonly caught throughout the study area (Graham et al., in review). Of the 76 taxa caught, some taxa may be especially sensitive to removal as bycatch (Table 5.3.8-4) (Graham et al., in review). Some species that were caught have low population sizes and life history characteristics do not allow quick recovery of their populations (Graham et al., in review). Other species are currently unmanaged, possibly allowing populations to decline without detection (Graham et al., in review). The majority of species have potential to exhibit heavy harvest elsewhere, as most support commercial and recreational fisheries (Graham et al., in review). It is important to quantify bycatch of all species in the horseshoe crab trawl fishery so management strategies can be adapted accordingly (Graham et al., in review).

Species composition among sites differed based on location and bottom water temperature, suggesting that these variables can be used to predict potential bycatch species during other seasons (Graham et al., in review). Species composition shifted at Atlantic City, New Jersey with species composition at northern sites (i.e., sites north of Atlantic City) being much different than at southern sites (i.e., sites south of Atlantic City, New Jersey) (Table 5.3.8-3(Graham et al., in review). Species caught during the HCRC trawl survey were also common to their preferred temperature ranges; therefore, researchers may be able to use species' preferred temperature ranges in conjunction with water temperature data to determine which bycatch species will be caught throughout the year (Graham et al., in review).

This study provides crucial information about bycatch in the horseshoe crab trawl fishery; however, it is important to point out the differences between collection methods of the HCRC trawl survey and the commercial fishery. The HCRC trawl survey sites were randomly selected (based on the methods of Hata and Berkson, 2004), whereas commercial fishers often target sites that are high in horseshoe crab abundance. HCRC survey sites were also only sampled in the fall, while commercial fishing has potential to occur year round depending on current regulations. Also, HCRC survey sites were only towed for fifteen minutes, unlike commercial tows which may last for much longer (i.e., > 1 hour). Due to these differences between the HCRC survey and the commercial fishery, data should be collected aboard commercial fishing vessels to confirm these results and further identify and quantify bycatch in the horseshoe crab trawl fishery. Lastly, it is important to emphasize that commercial fishers use trawl gear to collect horseshoe crabs for bait and biomedical companies. Many times, biomedical companies are given more lenient harvest regulations because horseshoe crabs are returned to the water after they are bled, and experience relatively low mortality. Although mortality of horseshoe crabs is relatively low, harvest methods still have potential to catch many individuals as bycatch and regulations should be set accordingly to minimize bycatch.

Table 5.3.8-3. (from Graham et al., in review). Catch per unit effort (CPUE) and percent occurrence for all taxa caught during the Horseshoe Crab Research Center trawl survey (2005 and 2006).

		Catch per Unit Effort (ind/km)		Percent occurrence	
Fishes (Common name)	Scientific name	Southern sites	Northern sites	Southern sites	Northern sites
Atlantic angel shark	*Squatina dumeril*	0.18	0.00	7.8	0.0
Atlantic croaker	*Micropogonias undulatus*	11.16	0.05	42.2	3.0
Atlantic sharpnose shark	*Rhizoprionodon terraenovae*	0.01	0.00	1.1	0.0
Atlantic sturgeon	*Acipenser oxyrinchus*	0.03	0.15	3.3	4.5
Atlantic thread herring	*Opisthonema oglinum*	0.01	0.00	1.1	0.0
Black drum	*Pogonias cromis*	0.03	0.00	3.3	0.0
Black sea bass	*Centopristis striata*	0.03	0.07	3.3	9.1
Bluefish	*Pomatomus saltatrix*	0.05	0.14	3.3	16.7
Bullnose/Southern eagle ray	*Myliobatis freminvillei/goodei*	0.56	0.00	28.9	0.0
Butterfish	*Peprilus triacanthus*	0.51	0.13	7.8	10.6
Clearnose skate	*Raja eglanteria*	40.68	1.92	95.6	78.8
Cobia	*Rachycentron canadum*	0.02	0.00	1.1	0.0
Conger eel	*Conger oceanicus*	0.02	0.00	1.1	0.0
Cownose ray	*Rhinoptera bonasus*	0.40	0.02	10.0	1.5
Dusky shark	*Carcharhinus obscurus*	0.02	0.00	2.2	0.0
Fourspot flounder	*Paralichthys oblongus*	0.00	0.01	0.0	1.5
Gray triggerfish	*Balistes capriscus*	0.00	0.01	0.0	1.5
Hogchoker	*Trinectes maculatus*	0.01	0.00	1.1	0.0
Little/Winter Skate	*Leucoraja erinacea/ocellata*	26.15	213.82	31.1	100.0
Monkfish	*Lophiodes americanus*	0.00	0.01	0.0	1.5

Northern Puffer	*Sphoeroides maculatus*	0.05	0.08	4.4	10.6
Northern searobin	*Prionotus carolinus*	0.51	0.53	15.6	25.8
Northern stargazer	*Astroscopus guttatus*	0.17	0.02	7.8	3.0
Pigfish	*Orthopristis chrysoptera*	0.02	0.00	1.1	0.0
Red drum	*Sciaenops ocellatus*	0.01	0.00	1.1	0.0
Red hake	*Urophycis chuss*	0.00	0.10	0.0	6.1
Scup	*Stenotomus chrysops*	0.58	1.25	15.6	37.9
Seahorse	*Hippocampus spp.*	0.00	0.03	0.0	3.0
Sheepshead	*Archosargus probatocephalus*	0.02	0.00	2.2	0.0
Silver hake	*Merluccius bilinearis*	0.00	0.14	0.0	4.5
Smallmouth flounder	*Etropus microstomus*	0.00	0.01	0.0	1.5
Smooth butterfly ray	*Gymnura micrura*	0.63	0.00	20.0	0.0
Smooth dogfish	*Mustelus canis*	0.23	0.30	6.7	25.8
Southern kingfish	*Menticirrhus americanus*	0.41	0.00	20.0	0.0
Southern stingray	*Dasyatis americanus*	1.88	0.00	40.0	0.0
Spiny butterfly ray	*Gymnura altavela*	0.20	0.00	14.4	0.0
Spiny dogfish	*Squalus acanthias*	0.21	0.73	7.8	21.2
Spot	*Leiostomus xanthurus*	0.94	0.00	30.0	0.0
Spotted hake	*Urophycis regia*	0.00	0.01	0.0	1.5
Striped bass	*Morone saxatilis*	0.06	0.20	3.3	9.1
Striped burrfish	*Chilomycterus schoepfii*	0.12	0.00	10.0	0.0
Striped searobin	*Prionotus evolans*	0.50	4.33	16.7	74.2
Summer flounder	*Paralichthys dentatus*	2.72	3.46	62.2	65.2
Weakfish	*Cynoscion regalis*	0.47	0.04	16.7	6.1
Windowpane flounder	*Scophthalmus aquosus*	3.65	5.59	47.8	92.4
Winter flounder	*Pseudopleuronectes americanus*	0.00	0.34	0.0	18.2
Witch flounder	*Glyptocephalus cynoglossus*	0.00	0.02	0.0	1.5
Invertebrates					
American lobster	*Homarus americanus*	0.02	0.09	2.2	6.1
Asteriid sea star	*Asteriid* spp.	11.54	25.80	27.8	66.7
Blue crab	*Callinectes sapidus*	1.90	0.34	34.4	16.7
Blue mussel	*Mytilus edulis*	0.00	0.47	0.0	4.5
Channeled whelk	*Busycotypus canaliculatus*	5.29	0.00	78.9	0.0
Deep-sea scallop	*Placopecten magellanicus*	0.22	4.96	0.0	16.7
Green sea urchin	*Strongylocentrotus droebachiensis*	0.00	0.01	0.0	1.5
Hairy sea cucumber	*Sclerodactyla* spp.	1.24	0.00	5.0	0.0
Hermit crab	*Pagurus* spp.	1.27	4.09	32.2	69.7
Horseshoe crab	*Limulus polyphemus*	87.61	7.52	93.3	60.6
Jellyfish (unknown)	Phylum Cnidaria	0.06	0.20	3.3	10.6
Jonah crab	*Cancer borealis*	0.08	2.39	3.3	16.7
Knobbed whelk	*Busycon carica*	11.85	0.00	77.8	0.0
Lady crab	*Ovalipes ocellatus*	0.12	0.05	7.8	6.1
Lesser blue crab	*Callinectes similis*	0.02	0.00	2.2	0.0
Lightning whelk	*Busycon contrarium*	0.04	0.00	3.3	0.0
Long-finned squid	*Loligo pealei*	0.42	0.31	14.4	19.7
Margined sea star	*Astropecten* spp.	0.00	1.14	0.0	4.5
Moon snail	*Polinices heros*	0.04	1.19	2.2	36.4
Mud crab	*Panopeus* spp.	0.01	0.00	1.1	0.0

Octopus	Order Octopoda	0.01	0.01	1.1	1.5
Purple sea urchin	*Arbacia punctulata*	1.13	0.71	5.6	7.6
Quahog	*Mercenaria mercenaria*	0.00	0.02	0.0	1.5
Rock crab	*Cancer spp.*	0.38	1.42	25.6	57.6
Sand dollar	*Echinarachnius parma*	0.18	0.25	1.1	15.2
Sea anemone	Phylum Cnidaria	0.02	0.00	1.1	0.0
Sea mouse	*Aphrodita aculeata*	0.01	0.13	0.0	7.6
Spider crab	*Libinia* spp.	3.62	4.52	65.6	59.1
Surf clam	*Spisula solidissima*	0.05	1.55	4.4	47.0

Table 5.3.8-4. (from Graham et al., in review). A measure of occurrence and abundance (Occur; Abund) during the HCRC trawl survey, resilience, and fishery, management, and conversation (IUCN Listing) statuses are listed for each species caught as bycatch during the Horseshoe Crab Research Center (HCRC) trawl survey (2005 and 2006). Information could not be found for species that were caught but are not listed.

Fishes	Occur; Abund[a]	Resilience[b]	Fishery status worldwide[c]	Mgmt status[d]	IUCN listing[e]
Atlantic angel shark	R; VL	Low	Closed (U.S.)	Mng[3]	DD
Atlantic croaker	C; L	Medium	Comm/Rec	Mng[2,6]	None
Atlantic sturgeon	R; VL	Very Low	Comm/Rec; Closed (U.S.)	Mng; Moratorium[8]	NT
Black drum	R; VL	Medium	Comm/Rec	Mng[5]	None
Black sea bass	U; VL	Medium	Comm/Rec	Mng[2,6]; OF’ing = Unknown	None
Bluefish	U; VL	Medium	Comm/Rec	Mng[2,6]	None
Bullnose ray	U; L	Very Low	Comm	No info	None
Butterfish	U; VL	High	Comm/Rec	Mng[8]; OF’ing = Unknown	None
Clearnose skate	A; H	Low	Comm	Mng[8]	None
Cownose ray	U; VL	Low	Comm; None (U.S.)	n/a	NT
Dusky shark	R; VL	Very Low	Comm; Closed (U.S.)[9]	Mng; "Species of concern"[10]	NT
Little skate	A; H	Low	Comm	Mng[8]	None
Northern Puffer	U; VL	High	No info	Umng	None
Northern searobin	U; VL	Medium	Comm	No info	None
Northern stargazer	U; VL	Medium	Rec	No info	None
Red hake	R; VL	Medium	Comm/Rec	Mng[8]	None
Scup	C; VL	Medium	Comm/Rec	Mng[2]; OF’ing = Unknown	None
Silver hake	R; VL	Medium	Comm	Mng[8]	None
Smooth butterfly ray	U; L	Very Low	Comm; None (U.S.)	n/a	DD
Smooth dogfish	U; L	Low	Comm/Rec	Unmng	NT
Southern eagle ray	U; L	Very Low	Comm	No info	None
Southern kingfish	U; VL	Medium	Comm/Rec	Mng[4]	None

Southern stingray	C; M	Very Low	Comm/Rec	n/a	DD
Spiny butterfly ray	U; L	Very Low	Comm/Rec	No info	None
Spiny dogfish	U; L	Very Low	Comm	Mng[8]	VUL
Spot	U; VL	High	Comm	Mng[2] Of'ed; Of'ing = Unknown	None
Striped bass	U; VL	Low	Comm/Rec	Mng[6,8]; OF'ing \= Unknown	None
Striped burrfish	U; VL	No info	Rec	No info	None
Striped searobin	C; L	Medium	Comm/Rec	No info	None
Summer flounder	A; M	Medium	Comm/Rec	Mng[6,8]; Of'ing = Occurring	None
Weakfish	U; VL	High	Comm	Mng[8]	None
Windowpane flounder	A; L	Medium	Comm	Mng[8]	None
Winter flounder	U; VL	Medium	Comm/Rec	Mng[8]	None
Winter skate	A; H	Low	Comm	Mng[8]; OF'ing = Occurring	None

Invertebrates	Occur; Abund[a]	Resilience[b]	Fishery status[c]	Mgmt status[d]	IUCN listinge
American lobster	R; VL	Unknown[1]	Comm/Rec	Mng[2]	None
Blue crab	C; VL	High[1]	Comm/Rec	Mng[6]	None
Blue mussel	R; VL	No info	Comm[7]	Mng[7]	None
Deep-sea scallop	U; L	Medium1	Comm	Mng[8]	None
Jonah crab	U; VL	Unknown5	Fished[5]	Umng[5]	None
Knobbed whelk	C; M	No info	Comm/Rec[5]	Mng[11]	None
Long-finned squid	U; VL	High1	Comm	Mng[8]	
Spider crab	A; VL	No info	No info	No info	None
Long-finned squid	U; VL	High1	Comm[7]	Mng[8]	None
Surf clam	C; VL	No info	Comm[7]	Mng[8]	None

a. Occurrence (Occur; percent of tows in which species was present): Abundant (A) > 50%, Common (C) = 21-50%, Uncommon (U) = 6-20%, Rare (R) < 5% of tows; Abundance (Abund; percent of total biomass): High (H) > 10%, Medium (M) = 2-10%, Low (L) = 1%, Very low (VL) < 1% of biomass (Data from present study); b. Population doubling time; High < 15 months, Medium = 1.4-4.4 years, Low = 4.5-14 years, Very low > 14 years (FishBase 2007 unless noted otherwise); c. Fishery status; Commercial fishery (Com), Recreational fishery (Rec) (FishBase 2007 unless noted otherwise); d. Management status of species: Managed (Mng), Unmanaged (Umng), Overfished (OF'ed), Overfishing (OF'ing); e. IUCN Listing: Vulnerable (VUL) = facing high risk of extinction in the wild, Near threatened (NT) = close to qualifying for threatened category in the future, Data deficient (DD) = appropriate data are lacking (IUCN 2006). Footnotes: 1. BOI 2005; 2. ASMFC 2007; 3. Fishbase 2007; 4. GA DNR 2007; 5. MBA 2007; 6. MD DNR 2007; 7. ME DMR 2007; 8. NEFSC 2007; 9. NMFS 2007a; 10. NMFS 2007b; 11. VA MRC 2007.

5.3.9 Highly Migratory Pelagics

5.3.9.1 Description of fishing practices, vessels and gear

Pelagic longline fishery

The U.S. pelagic longline fishery for Atlantic HMS primarily targets swordfish, yellowfin tuna, and bigeye tuna in various areas and seasons. Secondary target species include dolphin, albacore tuna, pelagic sharks (including mako, thresher, and porbeagle sharks), as well as several species of large coastal sharks. Although this gear can be modified (e.g., depth of set, hook type, etc) to target swordfish, tunas, or sharks, it is generally a multi-species fishery. These vessel operators are opportunistic, switching gear style and making subtle changes to target the best available economic opportunity of each individual trip. Pelagic longline gear sometimes attracts and hooks non-target finfish with little or no commercial value, as well as species that cannot be retained by commercial fishermen due to regulations, such as billfish. Pelagic longlines may also interact with protected species such as marine mammals, sea turtles, and seabirds. Thus, this gear has been classified as a Category I fishery with respect to the Marine Mammal Protection Act. Any species (or undersized catch of permitted species) that cannot be landed due to fishery regulations is required to be released, whether dead or alive. Pelagic longline gear is composed of several parts (see Figure 5.3.9-1) (NMFS, 1999).

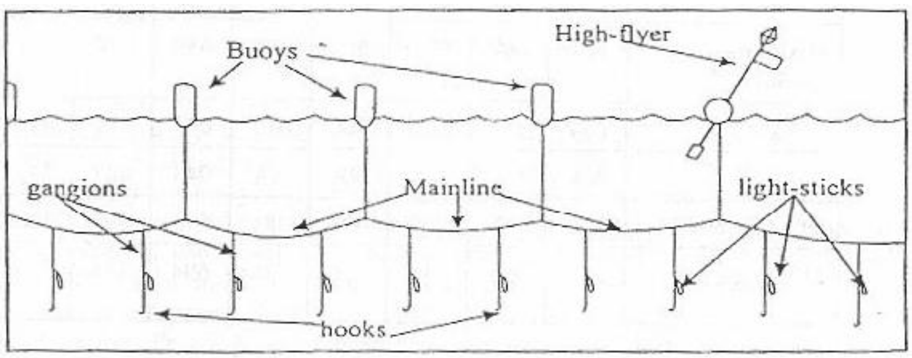

Figure 5.3.9-1. Typical U.S. Pelagic Longline Gear. Source: Arocha 1996 Note: As of April 1, 2001, (66 FR 17370) a vessel is considered to have pelagic longline gear on board when a power-operated longline hauler, a mainline, floats capable of supporting the mainline, and leaders (gangions) with hooks are on board.

The primary fishing line, or mainline of the longline system, can vary from five to 40 miles in length, with approximately 20 to 30 hooks per mile. The depth of the mainline is determined by ocean currents and the length of the floatline, which connects the mainline to several buoys, and periodic markers which can have radar reflectors or radio beacons attached.

Each individual hook is connected by a leader, or gangion, to the mainline. Lightsticks, which contain chemicals that emit a glowing light, are often used, particularly when targeting swordfish. When attached to the hook and suspended at a certain depth, lightsticks attract baitfish, which may, in turn, attract pelagic predators (NMFS, 1999).

When targeting swordfish, pelagic longline gear is generally deployed at sunset and hauled at sunrise to take advantage of swordfish nocturnal near-surface feeding habits (NMFS, 1999). In general, longlines targeting tunas are set in the morning, deeper in the water column, and hauled in the evening. Except for vessels of the distant water fleet, which undertake extended trips, fishing vessels preferentially target swordfish during periods when the moon is full to take advantage of increased densities of pelagic species near the surface. The number of hooks per set varies with line configuration and target species (Table 5.3.9-1) (NMFS, 1999). The pelagic longline gear components may also be deployed as a trolling gear to target surface feeding tunas. Under this configuration, the mainline and gangions are elevated and actively trolled so that the baits fish on or above the water's surface. This style of fishing is often referred to as "green-stick fishing," and reports indicate that it can be extremely efficient compared to conventional fishing techniques.

Table 5.3.9-1. Average Number of Hooks per Pelagic Longline Set, 1999-2004. Source: Data reported in pelagic longline logbook.

Target Species	1999	2000	2001	2002	2003	2004
Swordfish	521	550	625	695	712	701
Bigeye Tuna	768	454	671	755	967	400
Yellowfin Tuna	741	772	731	715	723	696
Mix of tuna species	NA	638	719	767	764	779
Shark	613	621	571	640	970	1,046
Dolphin	NA	943	447	542	692	1,033
Other species	781	504	318	300	865	270
Mix of species	738	694	754	756	750	777

Figure 5.3.9-2 illustrates basic differences between swordfish (shallow) sets and tuna (deep)longline sets. Swordfish sets are buoyed to the surface, have few hooks between floats, and are relatively shallow. This same type of gear arrangement is used for mixed target sets. Tuna sets use a different type of float placed much further apart. Compared with swordfish sets, tuna sets have more hooks between the floats and the hooks are set much deeper in the water column. It is believed that because of the difference in fishing depth, tuna sets hook fewer turtles than the swordfish sets. In addition, tuna sets use bait only, while swordfish fishing uses a combination of bait and lightsticks. Compared with vessels targeting swordfish or mixed species, vessels specifically targeting tuna are typically smaller and fish different grounds.

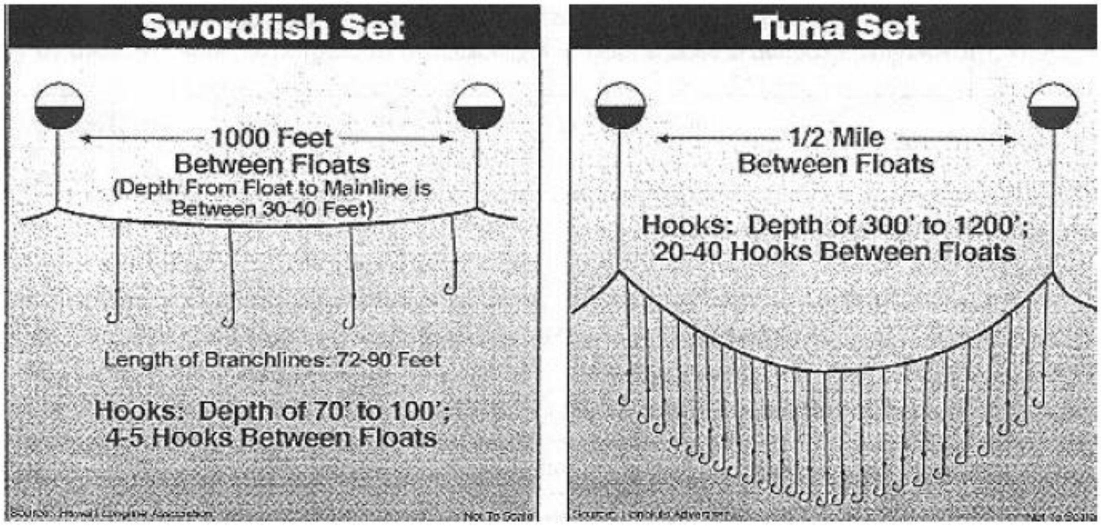

Figure 5.3.9-2 . Different Pelagic Longline Gear Deployment Techniques. Source: Hawaii Longline Association and Honolulu Advertiser. NOTE: This figure is only included to show basic differences in pelagic longline gear configuration and to illustrate that this gear may be altered to target different species.

<u>The South Atlantic – Florida East Coast to Cape Hatteras Swordfish Fishery</u>
Historically, South Atlantic pelagic longline vessels targeted swordfish year-round, although yellowfin tuna and dolphin fish were other important marketable components of the catch. In 2001 (65 FR 47214, August 1, 2000), the Florida East Coast closed area (year-round closure) and the Charleston Bump closed area (February through April closure) became effective.

Prior to these closures, smaller vessels used to fish short trips from the Florida Straits north to the bend in the Gulf Stream off Charleston, South Carolina (Charleston Bump). Midsized and larger vessels migrate seasonally on longer trips from the Yucatan Peninsula throughout the West Indies and Caribbean Sea, and some trips range as far north as the Mid-Atlantic coast of the United States to target bigeye tuna and swordfish during the late summer and fall. Fishing trips in this fishery average nine sets over 12 days. Home ports (including seasonal ports) for this fishery include Georgetown, South Carolina; Charleston, South Carolina; Fort Pierce, Florida; Pompano Beach, Florida; and Key West, Florida. This sector of the fishery consists of small to mid-size vessels, which typically sell fresh swordfish to local high-quality markets (NMFS 1999).

<u>Management of the U.S. Pelagic Longline Fishery</u>
The U.S. Atlantic pelagic longline fishery is restricted by a limited swordfish quota, divided between the North and South Atlantic (separated at 5°N. Lat). Other regulations include minimum sizes for swordfish, yellowfin, bigeye, and bluefin tuna, limited access permitting, bluefin tuna catch requirements, shark quotas, protected species incidental take limits, reporting requirements (including logbooks), and gear and bait requirements. Current billfish regulations prohibit the retention of billfish by pelagic longline vessels, or the sale of billfish from the Atlantic Ocean. As a result, all billfish hooked on pelagic

longlines must be discarded, and are considered bycatch. This is a heavily managed gear type and, as such, is strictly monitored.

Because it is difficult for pelagic longline fishermen to avoid undersized fish in some areas, NMFS has closed areas in the Gulf of Mexico and along the east coast. The intent of these closures is to decrease bycatch in the pelagic longline fishery by closing those areas with the highest rates of bycatch. There are also time/area closures for pelagic longline fishermen designed to reduce the incidental catch of bluefin tuna and sea turtles. In order to enforce time/area closures and to monitor the fishery, NMFS requires all pelagic longline vessels to report positions on an approved vessel monitoring system (VMS).

In June 2004, NMFS conditionally re-opened the Northeast Distant Statistical Reporting Area (NED)to pelagic longline fishing. NMFS limited vessels with pelagic longline gear onboard in that area, at all times, to possessing onboard and/or using only 18/0 or larger circle hooks with an offset not to exceed ten degrees. Only whole mackerel and squid baits may be possessed and or utilized with allowable hooks. In August of 2004, NMFS limited vessels with pelagic longline gear onboard, at all times, in all areas open to pelagic longline fishing, excluding the NED, to possessing onboard and/or using only 16/0 or larger non-offset circle hooks and/or 18/0 or larger circle hooks with an offset not to exceed ten degrees. Only whole finfish and squid baits may be possessed and/or utilized with allowable hooks. All pelagic longline vessels must possess and use sea turtle handling and release gear in compliance with NMFS careful release protocols.

Permits

The 1999 FMP established six different limited access permit types: (1) directed swordfish, (2) incidental swordfish, (3) swordfish handgear, (4) directed shark, (5) incidental shark, and (6) tuna longline. To reduce bycatch in the pelagic longline fishery, these permits were designed so that the swordfish directed and incidental permits are valid only if the permit holder also holds both a tuna longline and a shark permit.

Similarly, the tuna longline permit is valid only if the permit holder also holds both a swordfish (directed or incidental, not handgear) and a shark permit. This allows limited retention of species that might otherwise have been discarded.

As of February 1, 2006, approximately 214 tuna longline limited access permits had been issued. In addition, approximately 191 directed swordfish limited access permits, 86 incidental swordfish limited access permits, 240 directed shark limited access permits, and 312 incidental shark limited access permits had been issued. Vessels with limited access swordfish and shark permits do not necessarily use pelagic longline gear, but these are the only permits that allow for the use of pelagic longline gear in HMS fisheries.

Monitoring and Reporting

Pelagic longline fishermen and the dealers who purchase HMS from them are subject to reporting requirements. NMFS has extended dealer reporting requirements to all swordfish importers as well as dealers who buy domestic swordfish from the Atlantic.

These data are used to evaluate the impacts of harvesting on the stock and the impacts of regulations on affected entities.

Commercial HMS fisheries are monitored through a combination of vessel logbooks, dealer reports, port sampling, cooperative agreements with states, and scientific observer coverage. Logbooks contain information on fishing vessel activity, including dates of trips, number of sets, area fished, number of fish, and other marine species caught, released, and retained. In some cases, social and economic data such as volume and cost of fishing inputs are also required.

Recent Catch and Landings

U.S. pelagic longline catch (including bycatch, incidental catch, and target catch) is largely related to these vessel and gear characteristics, but is summarized for the whole fishery in Table 5.3.9-2. U.S. pelagic longline landings of Atlantic tunas and swordfish for 1999 – 2004 are summarized in Table 5.3.9-3. Additional information related to landings can be found in Section 3.4.6 of the Consolidated Atlantic Highly Migratory Species Fishery Management Plan.

From May 1992 through December 2000, the Pelagic Observer Program (POP) recorded a total of 4,612 elasmobranchs (15 percent of the total catch) caught off the southeastern U.S. coast in fisheries targeting tunas and swordfish (Beerkircher et al. 2004). Of the 22 elasmobranch species observed, silky sharks were numerically dominant (31.4 percent of the elasmobranch catch), with silky, dusky, night, blue, tiger, scalloped hammerhead, and unidentified sharks making up the majority (84.6 percent) (Beerkircher et al. 2004).

Table 5.3.9-2. Reported Catch of Species Caught by U.S. Atlantic Pelagic Longlines, in Number of Fish, for 1999-2004. Source: Pelagic Longline Logbook Data.

Species	1999	2000	2001	2002	2003	2004
Swordfish Kept	67,120	62,978	47,560	49,320	51,835	46,440
Swordfish Discarded	20,558	17,074	13,993	13,035	11,829	10,675
Blue Marlin Discarded	1,253	1,443	635	1,175	595	712
White Marlin Discarded	1,969	1,261	848	1,438	809	1,053
Sailfish Discarded	1,407	1,091	356	379	277	424
Spearfish Discarded	151	78	137	148	108	172
Bluefin Tuna Kept	263	235	177	178	273	475
Bluefin Tuna Discarded	604	737	348	585	881	1,031
Bigeye, Albacore, Yellowfin, Skipjack Tunas Kept	114,438	94,136	80,466	79,917	63,321	76,962
Pelagic Sharks Kept	2,894	3,065	3,460	2,987	3,037	3,440
Pelagic Sharks Discarded	28,967	28,046	23,813	22,828	21,705	25,355
Large Coastal Sharks Kept	6,382	7,896	6,478	4,077	5,326	2,292
Large Coastal Sharks Discarded	5,442	6,973	4,836	3,815	4,813	5,230
Dolphin Kept	31,536	29,125	27,586	30,384	29,372	38,769
Wahoo Kept	5,136	4,193	3,068	4,188	3,919	4,633
Turtles Discarded	631	271	424	465	399	369
Number of Hooks (X 1,000)	*7,902*	*7,976*	*7,564*	*7,150*	*7,008*	*7,276*

Table 5.3.9-3. Reported Landings in the U.S. Atlantic Pelagic Longline Fishery (in mt ww) for 1999-2004. Source: NMFS, 2004a; NMFS, 2005.

Species	1999	2000	2001	2002	2003	2004
Yellowfin Tuna	3,374	2,901	2,201	2,573	2,154	2,489
Skipjack Tuna	2.0	1.8	4.3	2.5	4.2	0.7
Bigeye Tuna	929.1	531.9	682.4	535.8	284.9	308.7
Bluefin Tuna	73.5	66.1	37.5	49.9	81.4	96.1
Albacore Tuna	194.5	147.3	193.8	155	110.9	117.4
Swordfish N.*	3,362.4	3,315.8	2,483	2,598.8	2,772.1	2,551
Swordfish S.*	185.2	143.8	43.2	199.9	20.9	15.7

* Includes landings and estimated discards from scientific observer and logbook sampling programs.

Purse seine fishery

Purse seine gear consists of a floated and weighted encircling net that is closed by means of a drawstring; know as a purseline, threaded through rings attached to the bottom of the net.

The efficiency of this gear can be enhanced by the assistance of spotter planes used to locate schools of tuna. Once a school is spotted, the vessel, with the aid of a smaller skiff, intercepts and uses the large net to encircle it. Once encircled, the purseline is pulled, closing the bottom of the net and preventing escape. The net is hauled back onboard using a powerblock, and the tunas are removed and placed onboard the larger vessel.

Vessels using purse seine nets have participated in the U.S. Atlantic tuna fishery continuously since the 1950s; although a number of purse seine vessels did target and land bluefin tuna off the coast of Gloucester, MA as early as the 1930s. In 1958, continued commercial purse seining effort for Atlantic tunas began with a single vessel in Cape Cod Bay and expanded rapidly into the region between Cape Hatteras and Cape Cod during the early 1960s. The purse seine fishery between Cape Hatteras and Cape Cod was directed mainly at small and medium bluefin tuna, yellowfin tuna, and at skipjack tuna, primarily for the canning industry. North of Cape Cod, purse seining was directed at giant BLUEFIN TUNA. High catches of juvenile BLUEFIN TUNA were sustained throughout the 1960s and into the early 1970s. These high catch rates by U.S. purse seine vessels are believed to have played a role in the decline in abundance during subsequent years. Currently these purse seine vessels focus their effort on giant bluefin tuna, versus other tunas, due to the international market that developed for giant bluefin tuna in the late 1970s. These fresh caught bluefin tuna are primarily flown directly to Japan for processing into sushi or sashimi. By the late 1980s, high ex-vessel prices and the increased importance of the Japanese market had increased effort on all size classes of bluefin tuna. In 1992, NMFS responded by banning the sale of school, large school, and small medium bluefin tuna (27 inches to less than 73 inches curved fork length).

A limited entry system with non-transferable individual vessel quotas (IVQs) for purse seining was established in 1982, effectively excluding any new entrants into this category. Equal baseline quotas of bluefin tuna are assigned to individual vessels by regulation; the IVQ system is possible given the small pool of ownership in this sector of the fishery. Currently, only five vessels comprise the Atlantic tuna purse seine fleet and in 1996 the quotas were made transferable among the five vessels.

Vessels that are participating in the Atlantic tunas purse seine fishery are required to target the larger size class bluefin tuna, more specifically the giant sized class (81 inches or larger) and are granted a tolerance limit of 15 percent by weight, of the total amount of giant bluefin tuna landed during a season. These vessels may commence fishing starting on July 15 of each year and may continue through December 31, provided the vessel has not fully attained its IVQ. Over the last few years, the purse seine category has not fully harvested its allocated quota. This can be attributed to a number of different reasons outside of the industry's or NMFS' control, such as lack of availability or schools being comprised of mixed size classes. NMFS has issued several Exempted Fishing Permits (EFPs) to this sector of the fishery and will continue to assess current regulations and their impact on providing reasonable opportunities to harvest available quota.

Recent Catch and Landings

Table 5.3.9-4 shows purse seine landings of Atlantic tunas from 1999 through 2004. Purse seine landings typically make up approximately 20 percent of the total annual U.S. landings of bluefin tuna (about 25 percent of total commercial landings), but account for only a small percentage, if any, of the landings of other HMS. In the 1980s and early 1990s, purse seine landings of yellowfin tuna were often over several hundred metric tons. Over 4,000 mt ww of yellowfin tuna were recorded landed in 1985. In recent years, via informal agreements with other sectors of the tuna industry, the purse seine fleet has opted not to direct any effort on HMS other than bluefin tuna.

Table 5.3.9-4. Domestic Atlantic Tuna Landings for the Purse Seine Fishery: 1999-2004 (mt ww). Northwest Atlantic Fishing Area. Source: U.S. National Report to ICCAT: 2005.

Species	1999	2000	2001	2002	2003	2004
Bluefin Tuna	247.9	275.2	195.9	207.7	265.4	31.8
Yellowfin Tuna	0	0	0	0	0	0
Skipjack Tuna	0	0	0	0	0	0

Commercial handgear fishery

Commercial handgears, including handline, harpoon, rod and reel, and bandit gear are often used to fish for Atlantic HMS by fishermen on private vessels, charter vessels, and headboat vessels. Rod and reel gear may be deployed from a vessel that is at anchor, drifting, or underway (i.e., trolling). In general, trolling consists of dragging baits or lures through, on top of, or even above the water's surface. While trolling, vessels often use outriggers, kites, or green-sticks to assist in spreading out or elevating baits or lures and to prevent fishing lines from tangling. Operations, frequency and duration of trips, and distance ventured offshore vary widely. Most of the vessels are greater than seven meters in length and are privately owned by individual fishermen.

The handgear fisheries are typically most active during the summer and fall, although in the South Atlantic and Gulf of Mexico fishing occurs during the winter months. Fishing usually takes place between eight and 200 km from shore and for those vessels using bait, the baitfish typically includes herring, mackerel, whiting, mullet, menhaden, ballyhoo, butterfish, and squid.

The commercial handgear fishery for bluefin tuna occurs mainly in New England, and more recently off the coast of southern Atlantic states, such as Virginia, North Carolina and South Carolina, with vessels targeting large medium and giant bluefin tuna. The

majority of U.S. commercial handgear fishing activities for bigeye, albacore, yellowfin, and skipjack tunas take place in the northwest Atlantic. Beyond these general patterns, the availability of Atlantic tunas at a specific location and time is highly dependent on environmental variables that fluctuate from year to year.
Currently the U.S. Atlantic tuna commercial handgear fisheries are managed through an open access vessel permit program. Vessels that wish to sell their Atlantic tunas must obtain a commercial handgear permit in one of the following categories: General (rod and reel, harpoon, handline, bandit gear), Harpoon (harpoon only), or Charter/Headboat (rod and reel and handline).

These vessels may also need permits from the states they operate out of in order to land and sell their catch. All commercial permit holders are encouraged to check with their local state fish/natural resource management office regarding these requirements.

Permitted vessels are also required to sell their Atlantic tunas to federally permitted Atlantic tuna dealers. As the Atlantic tunas dealer permits are issued by the Northeast Region Permit Office, vessel owner/operators are encouraged to contact the permitting office directly, either by phone at (978) 281-9438 or via the web at http://www.nero.noaa.gov/ro/doc/vesdata1.htm, to obtain a list of permitted dealers in their area.

Vessels that are permitted in the General and Charter/Headboat categories commercially fish under the General category rules and regulations. For instance, regarding bluefin tuna, vessels that possess either of the two permits mentioned above have the ability to retain a daily bag limit of zero to three bluefin tuna, measuring 73 inches or greater curved fork length per vessel per day while the General category bluefin tuna fishery is open. The General category bluefin tuna fishery opens on June 1 of each year and remains open until January 31 of the subsequent year, or until the quota is filled. Vessel owner/operators should check with the agency via websites (www.hmspermits.gov) or telephone information lines (1-888-872-8862) to verify the bluefin tuna retention limit on any given day. The General category bluefin tuna quota is approximately 47 percent of the U.S. quota and equates to a base line allocation of approximately 690 mt.

Vessels that are permitted in the Harpoon category fish under the Harpoon category rules and regulations. For instance, regarding bluefin tuna, vessels have the ability to keep two bluefin measuring 73 inches to less than 81 inches curved fork length per vessel trip per day while the fishery is open. There is no limit on the number of bluefin tuna that measure longer than 81 inches curved fork length, as long as the Harpoon category season is open. The Harpoon category season also opens on June 1 of each year and remains open until November 15, or until the quota is filled. The Harpoon category bluefin tuna quota is approximately 3.9 percent of the U.S. quota and equates to a base line allocation of approximately 57 mt.

U.S. commercial swordfish fishing in the Atlantic Ocean is reported to have begun in the early 1800s as a harpoon fishery off the coast of New England. This fishery traditionally consisted of harpoon vessels operating out of Rhode Island and Massachusetts where they took extended trips for swordfish north and east of the Hudson Canyon and particularly off Georges Bank, and could land as many as 20 to 25 large swordfish over a ten-day period. These fish primarily consisted of large fish that finned on the surface and were available to the harpoon gear, some weighing as much as 600 lbs dw, but averaging about 225 to 300 lbs dw at the turn of the century. Because of the limited effort directed towards large fish, the stock was sufficient to support a sustainable seasonal swordfish fishery for more than 150 years. Most swordfish caught in the United States in the early 1900s were harvested with harpoons; harpoon landings declined from the 1940s through the 1960s. Due to a decreased availability of the large swordfish in the northeast this fishery has essentially ceased to exist. However, a recently emerging swordfish handgear fishery, both commercial and recreational, has appeared to develop off the east coast of Florida. This fishery is essentially prosecuted at night with rod and reel or handline gear. Some vessels participating in this fishery are currently utilizing individual handlines attached to free-floating buoys. This fishery has been operating under the current regulations, which require that handlines be restricted to no more than two hooks and be released and retrieved by hand. The current regulations do not limit the number of individual handlines/buoys that may be possessed or deployed.

Currently the U.S. commercial swordfish fishery is managed through limited access vessel permits. Vessels that possess a limited access handgear permit must abide by the minimum size limits for swordfish (i.e., 29 inches form cleithrum to caudal keel; 47 inches lower jaw fork length; or 33 lbs dressed weight) and seasonal retention limits. When the directed swordfish fishery is open, permitted handgear vessel do not have a possession limit. However, during a directed fishery closure, permitted handgear vessels may land two swordfish per trip, provided these two fish were not taken with harpoon gear. Fishermen with a commercial handgear swordfish permit are required to report fishing activities in an approved logbook within 48 hours of each day’s fishing activities for multi-day trips, or before offloading for one-day trips, and submit the logbook within seven days of offloading.

The shark commercial handgear fishery plays a very minor role in contributing to the overall shark landing statistics. For further information regarding the shark fishery refer to Section 3.4.5. Economic and social aspects of all the domestic handgear fisheries are described later in this document (Section 3.5 and Chapter 9.0 respectively).

<u>Recent Catch and Landings</u>

The proportion of domestic HMS landings harvested with handgear varies by species, with Atlantic tunas comprising the majority of commercial landings. Commercial handgear landings of all Atlantic HMS (other than sharks) in the United States are shown in Table 5.3.9-5.

In 2004, bluefin tuna commercial handgear landings accounted for approximately 42 percent of the total U.S. bluefin tuna landings, and almost 75 percent of commercial bluefin tuna landings. Also in 2004, four percent of the total yellowfin catch, or nine percent of the commercial yellowfin catch, was attributable to commercial handgear. Commercial handgear landings of skipjack tuna accounted for approximately ten percent of total skipjack landings, or about 30 percent of commercial skipjack landings. For albacore, commercial handgear landings accounted for approximately one percent of total albacore landings, or about six percent of commercial albacore landings. Commercial handgear landings of bigeye tuna accounted for approximately one percent of total bigeye landings and one percent of total commercial bigeye landings. Updated tables of landings for the commercial handgear fisheries by gear and by area for 1999 – 2004 are presented in the following tables.

Table 5.3.9-5. Domestic Landings for the Commercial Handgear Fishery, by Species and Gear, for 1999-2004 (mt ww). Source: U.S. National Report to ICCAT: 2005

Species	Gear	1999	2000	2001	2002	2003	2004
Bluefin Tuna	Rod and Reel	643.6	590.9	889.7	878.5	529.2	331.4
	Handline	15.5	3.2	9.0	4.5	2.6	1.3
	Harpoon	115.8	184.2	102.1	55.6	75.5	41.2
	TOTAL	**774.9**	**778.3**	**1,000.8**	**938.6**	**607.3**	**373.9**
Bigeye Tuna	Troll	0.0	0.0	0.0	0.0	0.0	0.0
	Handline	12.3	5.7	33.7	14.4	6.3	3.1
	TOTAL	**12.3**	**5.7**	**33.7**	**14.4**	**6.3**	**3.1**
Albacore Tuna	Troll	0.0	0.0	0.0	0.0	0.0	0.0
	Handline	4.4	7.9	3.9	6.6	3.4	5.6
	TOTAL	**4.4**	**7.9**	**3.9**	**6.6**	**3.4**	**5.6**
Yellowfin Tuna	Troll	0.0	0.0	0.0	0.0	0.0	0.0
	Handline	220.0	284.0	300.0	244.0	216.0	234.0
	TOTAL	**220.0**	**284.0**	**300.0**	**244.0**	**216.0**	**234.0**
Skipjack Tuna	Troll	0.0	0.0	0.0	0.0	0.0	0.0
	Handline	6.4	9.7	10.5	12.7	9.4	10.4
	TOTAL	**6.4**	**9.7**	**10.5**	**12.7**	**9.4**	**10.4**
Swordfish	Handline	5.0	8.9	8.9	11.7	20.6	20.0
	Harpoon	0.0	0.6	7.4	2.8	0.0	0.5
	TOTAL	**5.0**	**9.5**	**16.3**	**14.5**	**20.6**	**20.5**

Table 5.3.9-6. Domestic Landings for the Commercial Handgear Fishery by Species and Region for 1999- 2004 (mt ww). Source: U.S. National Report to ICCAT: 2005

Species	Region	1999	2000	2001	2002	2003	2004
Bluefin Tuna	NW Atl	774.4	778.3	1,000.8	938.3	607.3	373.9
Bigeye Tuna	NW Atl	11.9	4.1	33.2	13.8	6.0	3.0
	GOM	0.2	0.1	0.5	0.6	0.3	0.1
	Caribbean	0.2	1.5	0.0	0.0	0.0	0.0
Albacore Tuna	NW Atl	0.6	2.9	1.7	3.9	1.4	5.4
	GOM	≤ .05	0.0	0.0	0.0	≤ .05	0.0
	Caribbean	3.8	5.0	2.2	2.7	2.0	2.1
Yellowfin Tuna	NW Atl	192.0	235.7	242.5	137.0	148.0	208.0
	GOM	12.7	28.6	43.4	100.0	59.0	19.0
	Caribbean	14.5	19.4	14.3	7.0	9.0	7.0
Skipjack Tuna	NW Atl	0.2	0.2	0.2	0.2	0.2	0.6
	GOM	0.4	0.7	0.0	0.0	0.0	0.2
	Caribbean	5.8	8.8	10.3	12.5	9.2	9.6
Swordfish	NW Atl	5.0	8.3	16.0	11.6	10.8	18.9
	GOM	≤ .05	1.2	0.3	2.9	9.8	1.6

Bottom longline

In 1993, NMFS implemented the FMP for Sharks of the Atlantic Ocean, which established three management units: large coastal sharks (LCS), small coastal sharks (SCS), and pelagic sharks. At that time, NMFS identified LCS as overfished, and implemented commercial quotas for LCS and established recreational harvest limits for all sharks. In 2003, NMFS amended the measures enacted in the 1999 FMP based on the 2002 LCS and SCS stock assessments, litigation, and public comments. Implementing regulations for Amendment 1 to the 1999 FMP were published on December 24, 2003 (68 FR 74746). Management measures enacted in the amendment included: re-aggregating the large coastal shark complex, using maximum sustainable yield (MSY) as a basis for setting commercial quotas, eliminating the commercial minimum size restrictions, establishing three regional commercial quotas (Gulf of Mexico, South Atlantic, and North Atlantic) for LCS and SCS management units, implementing trimester commercial fishing seasons effective January 1, 2005, imposing gear restrictions to reduce bycatch, and a time/area closure off the coast of North Carolina effective January 1, 2005.

As a result of using MSY to establish quotas, and implementing a new rebuilding plan, the overall annual landings quota for LCS in 2004 was established at 1,017 metric tons (mt) dressed weight (dw). The overall annual landings quota for SCS was established at 454 mt dw and the pelagic, blue, and porbeagle shark quotas were established at 488 mt dw, 273 mt dw, and 92 mt dw, respectively.

The regional quotas which were established in Amendment 1 to the 1999 HMS FMP for LCS and SCS were intended to improve overall management of the stocks by tailoring quotas to specific regions based on landings information. These quotas were based upon average historical landings (1999 – 2001) from the canvass and quota monitoring databases. The canvass database provides a near-census of the landings at major dealers in the southeast United States (including state landings) and the quota monitoring database collects information from dealers in the South Atlantic and Gulf of Mexico.

On November 30, 2004, NMFS issued a final rule (69 FR 69537), which established, among other things, new regional quotas based on updated landings information from 1999 –2003. This final rule did not change the overall quotas for LCS, SCS, and pelagic sharks established in Amendment 1 to the 1999 HMS FMP, but did revise the percentages allocated to each of the regions. The updated information was based on several different databases, including the canvass and quota monitoring databases, the Northeast Commercial Fisheries Database (CFDBS), and the snapper grouper logbook.

The new regional quotas and trimester seasons for the commercial Atlantic shark fishery became effective January 1, 2005. Commercial shark fishing effort is generally concentrated in the southeastern United States and Gulf of Mexico (Cortes and Neer, 2002). During 1997 – 2003, 92 – 98 percent of LCS, 38 – 49 percent of pelagic sharks, and nearly all SCS (80 – 100 percent) came from the southeast region (Cortes, pers. comm.). McHugh and Murray (1997) found in a survey of shark fishery participants that the largest concentration of bottom longline fishing vessels is found along the central Gulf coast of Florida, with the John’s Pass - Madeira Beach area considered the center of directed shark fishing activities. Consistent with other HMS fisheries, some shark fishery participants move from their homeports to other fishing areas as the seasons change and fish stocks move.

The Atlantic bottom longline fishery targets both LCS and SCS. Bottom longline is the primary commercial gear employed in the LCS and SCS fisheries in all regions. Gear characteristics vary by region, but in general, an approximately ten-mile long bottom longline, containing about 600 hooks, is fished overnight. Skates, sharks, or various finfishes are used as bait. The gear typically consists of a heavy monofilament mainline with lighter weight monofilament gangions. Some fishermen may occasionally use a flexible 1/16 inch wire rope as gangion material or as a short leader above the hook.

Recent Catch and Landings Data

The following section provides information on shark landings as reported in the shark bottom longline observer program. For recent catch and landings data for the shark fishery as a whole, which includes landings from bottom longline and other gears combined, please refer to Section 3.4.7.

In January 2002, the observer coverage requirements in the shark bottom longline fishery changed from voluntary to mandatory participation if selected. NMFS selects approximately 40 - 50 vessels for observer coverage during each season. Vessels are randomly selected if they have a directed shark limited access permit, have reported landings from sharks during the previous year, and have not been selected for observer coverage during each of the three previous seasons.

The U.S. Atlantic commercial shark bottom longline fishery has been monitored by the University of Florida and Florida Museum of Natural History, Commercial Shark Fishery Observer Program (CSFOP) since 1994. In June 2005, responsibility for the observer program was transferred to the Southeast Fisheries Science Center's Panama City Laboratory. The observer program trains and places the observers aboard vessels in the directed shark bottom longline fishery in the Atlantic and Gulf of Mexico to collect data on the commercial shark fishery and thus improve overall management strategies for the fishery. Observers provide baseline characterization information, by region, on catch rates, species composition, catch disposition, relative abundance, and size composition within species for the large coastal and small coastal shark bottom longline fisheries.

During 2003, six observers logged 263 sea days on shark fishing trips aboard 20 vessels in the Atlantic from North Carolina to Florida and in the eastern Gulf of Mexico off Florida. The number of trips taken on each vessel ranged from one to five and the number of sea days each observer logged ranged from nine to 35. Observers documented the catches and fishing effort on approximately 150 longline sets that fished 103,351 hooks.

During 2004, five observers logged 196 sea days on 56 shark fishing trips aboard 11 vessels. Observers documented the catches and fishing effort during 120 longline sets that fished 90,980 hooks.

Data from the shark observer program between 2000 and 2002 show that LCS comprised 66.2 percent of the total catch (Burgess and Morgan, 2002). During 2003, LCS comprised 68.4 percent of the total catch, and in 2004 LCS comprised 66.7 percent of the total catch. Sandbar sharks dominated the observed catches with 30.6 percent of total LCS catch in 2003 and 26.6 percent in 2004 (Table 3.52). The overall catch and disposition of species for 2004 is listed in Table 3.53. Regional differences in sandbar shark abundance were evident. For example, in the Carolina region, sandbar sharks comprised 67.4 percent of the total catch and 77.2 percent of the large coastal shark catch. In the Florida Gulf region, sandbar sharks comprised 62.0 percent of the total catch and 66.5 percent of the large coastal catch, whereas in the Florida East Coast region, sandbar sharks comprised only 17.2 percent of the total observed catch, and 37.1 percent of the large coastal shark catch (Burgess and Morgan, 2003). Blacktip sharks comprised 13.9 percent of total observed catch and 20.3 percent of the large coastal catch (Burgess and Morgan, 2002). Tiger sharks comprised 7.5 percent of the total observed catch and 11.0 percent of the large coastal shark catch. A majority of tiger sharks (71.7 percent) and nurse sharks (98.8 percent) were tagged and released.

During 2003, shark observer program data indicate that SCS comprised 28.0 percent of the total observed catch (Burgess and Morgan, 2003; Burgess and Morgan 2004). Atlantic sharpnose shark dominated the SCS catch (80.3 percent). The remainder of the small coastal catch consisted of blacknose sharks (5.5 percent), bonnethead (0.03 percent), and finetooth (0.02 percent)(Table 3.52). In previous seasons, the Atlantic sharpnose shark was the most frequently caught shark in the Florida East Coast region and accounted for 51.6 percent of the total observed catch, and 96.0 percent of the small coastal catch in that region (Burgess and Morgan, 2002).

Bottom longlining for sharks has relatively low observed bycatch rates. Historically, finfish bycatch has averaged approximately five percent in the bottom longline fishery. Finfish bycatch for the bottom longline fishery includes, but is not limited to, skates, rays, cobia, redfish, bluefish, and great barracuda. During the second semi-annual season of 2003, observer data indicate that approximately 4,320 sharks were caught compared to 432 other fish, four invertebrates, and three sea turtles (Burgess and Johns, 1999). In terms of bycatch rates, observed shark catches constitute 91 percent of the 4,759 total animals caught, with other fish comprising 10 percent, invertebrates less than .01 percent, and sea turtles less than .01 percent. For more information on bycatch see Section 3.8.

Gillnet fishery

The southeast shark gillnet fishery is comprised of several vessels based primarily out of ports in northern Florida (South Atlantic Region) that use nets typically 456 to 2,280 meters long and 6.1 to 15.2 meters deep, with stretched mesh from 12.7 to 22.9 cm. This fishery is currently prohibited in the state waters off South Carolina, Georgia, and Florida, thereby forcing some of these vessels to operate in deeper waters under Federal jurisdiction, where gillnets are less effective. The entire process (set to haulback) takes approximately 9 hours (Carlson and Baremore 2002a).

The 2005 Directed Shark Gillnet Fishery Observer Program report described the gear and soak time deployed by drift gillnet, strike gillnet, and sink gillnet fishermen. Set duration was generally 0.3 hours and haulback averaged 2.9 hours. The average time from setting the net through completion of haulback was 10.2 hours. The most frequently used mesh size for drift gillnets was 12.7 cm. Strikenetters use the largest mesh size (22.9 cm) and the set times were 2.7 hours. Sink gillnets used to target sharks generally use 17.8 cm mesh size and were soaked for approximately 0.8 hours. This gear was also observed being deployed to target non-HMS (kingfish or Spanish mackerel); using a stretched mesh size of 7.6 cm, to comply with mesh size regulations for the Spanish mackerel fishery, and soaked for approximately 5.9 hours (Carlson and Bethea 2006).

In the southeast shark gillnet fishery, NMFS modified the requirement to have 100 percent observer coverage at all times on March 30, 2001 (66 FR 17370), by reducing the level required to a statistically significant level outside of right whale calving season (100 percent observer coverage is still required during the right whale calving season from November 15 through March 31). This modification of observer coverage reduced administrative costs while maintaining statistically significant and adequate levels of coverage to provide reasonable estimates of sea turtle and marine mammal takes outside the right whale calving season. The level of observer coverage necessary to maintain statistical significance will be reevaluated annually and adjusted accordingly.

Additionally, in 2001, NMFS established a requirement to conduct net checks every two hours to look for and remove any protected species.

Recent Catch and Landings

The following section provides information on shark landings as reported in the shark gillnet observer program. For recent catch and landings data for the shark fishery as a whole, which includes landings from gillnet, bottom longline, and other gears combined, please refer to Section 3.4.7. A total of 24 driftnet sets were observed on five vessels from February through September, 2004. Driftnet vessels carried nets ranging in length from 547.2 – 2736 m; depths from 7.6 – 13.7 m and stretched mesh sizes from 12.7 – 22.9 cm. The most frequently used mesh size was 12.7 cm. For all observed driftnet sets, set duration averaged 0.4 hrs. Sets were made in seawater averaging 15.4 m deep.

Haulback and processing of the catch averaged 3.4 hrs. Average soak time for the driftnet (time net was first set minus time haulback began) was 10.8 hrs. The observed driftnet catch consisted of nine species of sharks. Three species of sharks made up 92.9 percent (by number) of the observed shark catch (Table 3.57). These species were the Atlantic sharpnose shark, blacknose shark, and finetooth shark. By weight, the shark catch was made up of Atlantic sharpnose shark, (55.3 percent), blacknose shark (17.1 percent), blacktip shark (10.7 percent), and finetooth shark (10.3 percent). Total observed catch composition (percent of numbers caught) was 79.0 percent sharks, 20.7 percent teleosts, 0.3 percent rays, and 0.03 percent protected species (i.e., marine mammals, sea turtles, sawfish).

Recreational fishery

Atlantic tunas, sharks, swordfish, and billfish are all targeted by domestic recreational fishermen using rod and reel gear. The recreational swordfish fishery had declined dramatically over the past twenty years, but recent information indicates that the recreational swordfish fishery is rebuilding in the Mid-Atlantic Bight, and off the east coast of Florida. Effective March 1, 2003, an HMS Angling category permit has been required to fish recreationally for any HMS managed species (Atlantic tunas, sharks, swordfish, and billfish) (67 FR 77434, December 18, 2002). Prior to March 1, 2003, the regulations only required vessels fishing recreationally for Atlantic tunas to possess an Atlantic Tunas Angling category permit.

Recreational fishing for Atlantic HMS is managed primarily through the use of minimum size limits and bag limits. Recreational tuna fishing regulations are the most complex and include a combination of minimum sizes, bag limits, limited season-based quota allotment for bluefin tuna, and reporting requirements (depending upon the particular species and vessel type).

The recreational swordfish fishery has been managed through the use of a minimum size requirement and landings requirement (swordfish may be headed and gutted but may not be cut into smaller pieces). However, regulations effective March 2003 (68 FR 711) established a recreational retention limit of one swordfish per person up to three per vessel per day. Regardless of the length of a trip, no more than the daily limit of North Atlantic swordfish can be possessed onboard a vessel.

The recreational shark fishery is managed using bag limits, minimum size requirements, and landing requirements (sharks must be landed with head and fins attached). Additionally, the possession of 19 species of sharks is prohibited.

Atlantic blue and white marlin have a combined landings limit (i.e., a maximum of 250 fish that can be landed per year); however, the primary management strategy for the recreational billfish fishery is through the use of minimum size limits. There are no recreational retention limits for Atlantic sailfish, blue marlin, and white marlin. Recreational anglers may not land longbill spearfish.

ICCAT has made several recommendations to recover billfish resources throughout the Atlantic Ocean that are discussed in detail in Section 3.1.2 of the Consolidated Atlantic Highly Migratory Species Fishery Management Plan (2006).

Recent Catch and Landings Data

The recreational landings database for HMS consists of information obtained through surveys including the Marine Recreational Fishery Statistics Survey (MRFSS), Large Pelagic Survey (LPS), Southeast Headboat Survey (HBS), Texas Headboat Survey, and Recreational Billfish Survey Tournament Data (RBS). Descriptions of these surveys, the geographic areas they include, and their limitations, are discussed in Section 2.6.2 of the 1999 FMP and Section 2.3.2 of the 1999 Billfish Amendment (REF?).

Reported domestic landings of Atlantic bluefin tuna (1983 through 1998) and BAYS tuna (1995 through 1997) were presented in Section 2.2.3 of the 1999 FMP. As landings figures for 1997 and 1998 were preliminary in the 1999 FMP, updated landings for recreational rod and reel fisheries are presented in Table 3.41 through 2004. Recreational landings of swordfish are monitored by the LPS and the MRFSS. However, because swordfish landings are considered rare events, it is difficult to extrapolate the total recreational landings from dockside intercepts.

An ad hoc committee of NMFS scientists reviewed the methodology and data used to estimate recreational landings of Atlantic HMS during 2004. The Committee was charged with reviewing the 2002 estimates of U.S. recreational landings of bluefin tuna, white marlin and blue marlin reported by NMFS to ICCAT. The committee was also charged with recommending methods to be used for the estimation of 2003 recreational fishery landings of bluefin tuna and marlin. Although the Committee discovered and corrected a few problems with the raw data from the LPS and the estimation program used to produce the estimates, the Committee concluded that the estimation methods for producing the 2002 estimates were consistent with methods used in previous years. The report of the Committee is available at: http://www.nmfs.noaa.gov/sfa/hms/Tuna/2002-2003_Bluefin-Marlin_Report-120304.pdf.

Atlantic Billfish Recreational Fishery

Due to the rare nature of billfish encounters and the difficulty of monitoring landings outside of tournament events, reports of recreational billfish landings are sparse. However, the Recreational Billfish Survey (RBS) provides a preliminary source for analyzing recreational billfish landings. Table 5.3.9-7 documents the number of billfish landed in 1999 – 2004, as reported by the RBS.

Table 5.3.9-7. Preliminary RBS Recreational Billfish Landings in numbers of fish (calendar year). Source: NMFS Recreational Billfish Survey.

Species	1999	2000	2001	2002	2003	2004
Blue Marlin	172	117	75	84	96	110
White Marlin	36	8	22	33	20	25
Sailfish	30	18	11	14	24	9
Swordfish	-	-	0	16	48	168

In support of the sailfish assessment conducted at the 2001 SCRS billfish species group meeting, document SCRS/01/106 developed indices of abundance of sailfish from the U.S. recreational billfish tournament fishery for the period 1973 – 2000. The index of weight per 100 hours fishing was estimated from numbers of sailfish caught and reported in the logbooks submitted by tournament coordinators and NMFS observers under the RBS, as well as available size information. Document SCRS/01/138 estimated U.S. sailfish catch estimates from various recreational fishery surveys.

All recreational, non-tournament landings of billfish, including swordfish, must be reported within 24 hours of landing to NMFS by the permitted owner of the vessel landing the fish. This requirement is applicable to all permit holders, both private and charter/headboat vessels, not fishing in a tournament. In Maryland and North Carolina, vessel owners should report their billfish landings at state-operated landings stations. A landed fish means a fish that is kept and brought to shore. Due to large-scale non-compliance with the call-in requirement, the landings in Table 5.3.9-8 are considered a minimum estimate of the non-tournament landings of billfish.

Table 5.3.9-8. Number of billfish reported to NMFS via call-in system by fishing year, 2002-2005. Source: G. Fairclough pers. comm.

Species	2002*	2003	2004	2005**
Blue Marlin	0	7	2	5
White Marlin	0	1	0	2
Sailfish	3	16	57	58
Swordfish	28	188	314	381

Based on a fishing year of June 1 – May 31.
* Reporting requirement did not go into effect until March 1, 2003
** 2005 landings as of May 16, 2006

Swordfish Recreational Fishery

The recreational swordfish fishery in the North Atlantic Ocean has been steadily expanding in recent years, probably due to increased availability of small swordfish and an increased interest in the sport. Fishermen typically fish off the east coast of Florida and off the coasts of New Jersey and New York. Fish have also occasionally been encountered on trips off Maryland and Virginia. In the past, the New York swordfish fishery occurred incidental to overnight yellowfin tuna trips. During the day, fishermen targeted tunas, while at night they fished deeper for swordfish. This appears to have evolved into a year-round directed fishery off Florida and a summer fishery off of New Jersey. The Florida fishery occurs at night with fishermen targeting swordfish using live or dead bait and additional attractants such as lightsticks, LED lights, and light bars suspended under the boat.

Historically, fishery survey strategies have not captured all landings of recreational handgear-caught swordfish. Although some handgear swordfish fishermen have commercial permits, many others land swordfish strictly for personal consumption. Therefore, NMFS published regulations to improve recreational swordfish monitoring and conservation. A trip limit of one swordfish per person, up to three per vessel, and mandatory reporting of all recreationally-landed swordfish and billfish via a toll-free call-in system became effective on March 2, 2003 (68 FR 711). Accordingly, all reported recreational swordfish landings are counted against the incidental swordfish quota.

Recreational fishing tournaments allow for the collection of a large volume of fishery-dependent data in a relatively short time period. Tournaments also provide a “snapshot” of the recreational fishery at a particular time and location. Analysis of tournament data collected over a period of years could provide valuable information regarding trends in the recreational swordfish fishery. A recent study documented recreational handgear-caught swordfish in three south Florida tournaments (J. Levesque, pers. comm.). The tournaments occurred from July through September 2002, two in Lighthouse Point and the other in Ft. Lauderdale. Data was obtained through direct at-sea observation, dockside interviews with anglers landing swordfish, and a telephone interview with a tournament organizer. A total of 156 vessels and between 468 – 624 individuals participated in the three tournaments.

Tournament caught swordfish reported to the RBS have increased in recent years. There were none reported in 2001, 16 in 2002, 48 in 2003, and 168 in 2004. While total tournament landings of swordfish are still low in terms of numbers of fish, it appears that as swordfish have recovered in the past few years, tournament landings of swordfish have increased.

Shark Recreational Fishery

Recreational landings of sharks are an important component of HMS fisheries. Recreational shark fishing with rod and reel is a popular sport at all social and economic levels, largely because the resource is accessible. Sharks can be caught virtually anywhere in salt water, depending upon the species. Recreational shark fisheries are oftentimes exploited in nearshore waters by private vessels and charter/headboats. However, there is also some shore-based fishing and some offshore fishing. The following tables provide a summary of landings for each of the three species groups.

Amendment 1 to the 1999 Atlantic Tunas, Swordfish, and Shark FMP limited the recreational fishery to rod and reel and handline gear only.

Table 5.3.9-9. Estimates of Total Recreational Harvest of Atlantic Sharks: 1998-2004 (numbers of fish in thousands). Source: 1998-2000 (Cortés, pers. comm.); 2001-2004 (Cortés, 2005a; 2005b). Estimates for 2001-2004 do not include prohibited species.

Species Group	1998	1999	2000	2001	2002	2003	2004
LCS	169.6	92.3	131.5	127.9	76.3	86.1	66.3
Pelagic	11.8	11.1	13.3	3.8	4.7	4.3	5.1
SCS	175.1	125.7	197.8	211.6	154.6	134.7	128.5
Unclassified	8.0	6.9	11.0	22.2	5.3	18.1	27.3

Table 5.3.9-10. Recreational Harvest of Atlantic Large Coastal Sharks (LCS) by Species, in number of fish: 1998-2004. Sources: 1998-2000 (Cortés, pers. comm.); 2001-2004 (Cortés, 2005a; 2005b). Total estimates for 2001-2004 do not include prohibited species.

LCS Species	1998	1999	2000	2001	2002	2003	2004
Basking**	0	0	0	0	0	0	0
Bignose*	0	0	0	0	0	0	71
Bigeye sand tiger**	0	0	0	0	0	0	0
Blacktip	83,045	35,585	69,668	48,757	38,237	40,442	31,197
Bull	1,663	3,150	6,116	4,151	1,893	3,344	4,885
Caribbean Reef*	74	3	122	0	741	0	692
Dusky*	4,499	5,570	2,501	5,583	1,047	2,731	0
Galapagos*	0	0	0	0	0	0	0
Hammerhead, Great	476	388	925	3,382	4	68	9
Hammerhead, Scalloped	2,052	1,367	3,433	1,087	1,061	2,816	714
Hammerhead, Smooth	375	1	2	703	2	1	0
Hammerhead, Unclassified	390	75	3,675	0	5,293	0	0
Lemon	2,161	173	2,785	5,488	3,454	4,879	5,710
Night*	133	50	24	0	0	0	0
Nurse	2,455	1,503	2,233	3,672	2,680	647	3,594
Sandbar	35,766	20,602	10,878	36,094	8,324	5,185	3,843
Sand tiger**	0	0	0	604	0	0	0

LCS Species	1998	1999	2000	2001	2002	2003	2004
Silky	5,376	3,863	5,120	3,808	1,780	1,998	502
Spinner	10,805	6,361	5,402	3,651	3,835	4,460	3,380
Tiger	1,380	153	1,480	758	170	110	1
Whale**	0	0	0	0	0	0	0
White**	0	0	0	0	0	0	0
Large Coastal Unclassified	18,979	13,444	17,102	16,211	9,535	22,086	12,466
Total:	169,62	92,288	131,466	134,045	76,294	86,036	66,301

* indicates species that were prohibited in the recreational fishery as of July 1, 1999.

Table 5.3.9-11. Recreational Harvest of Atlantic SCS by Species, in number of fish: 1998-2004. Source: 1998-2000 (Cortés, pers. comm.); 2001-2004 (Cortés, 2005a; 2005b). Total estimates for 2001-2004 do not include prohibited species.

SCS Species	1998	1999	2000	2001	2002	2003	2004
Atlantic Angel*	110	0	0	0	0	0	0
Blacknose	10,523	6,049	9,795	15,179	11,416	6,705	15,126
Bonnethead	29,147	38,835	56,142	58,511	50,903	39,863	42,354
Finetooth	139	78	1,438	6,701	2,942	1,774	581
Sharpnose, Atlantic	135,137	80,694	130,371	131,165	89,365	86,340	70,469
Sharpnose, Caribbean*	0	0	0	0	0	0	0
Smalltail*	0	4	26	26	0	0	11
Total:	175,056	125,660	197,772	211,582	154,626	134,682	128,530

* indicates species that were prohibited in the recreational fishery as of July 1, 1999.

Allowable gear

5.3.9.2 Economic and social description

Commercial fisheries

In 2003, the total commercial landings at ports in the 50 states by U.S. fishermen were 9.5 billion pounds valued at $3.3 billion. In 2004, the total commercial landings at ports in the 50 states by U.S. fishermen were 9.6 billion pounds and were valued at $3.7 billion. The overall value of landings between 2003 and 2004 had increased by nine percent. The total value of commercial HMS landings in 2004 was $43.9 million (Table 3.77). The 2004 ex-vessel price index indicated that 12 of the 17 finfish species tracked had increasing ex-vessel prices and five species had decreasing ex-vessel prices since 2003. The total edible finfish ex-vessel price index for 2004 was up eight percent from 2003.

The estimated value of the 2004 domestic production of all fishery products was $6.6 billion. This is $909 million less than the estimated value in 2003. The total import value of fishery products was $22.9 billion in 2004. This is an increase of $1.7 billion from 2003. The total import value in 1996 was $13.1 billion. The total export value of fishery products was $13.6 billion in 2004. This is an increase of $1.6 billion from 2003. The total export value in 1996 was $8.7 billion.

Consumers spent an estimated $61.9 billion for fishery products in 2004 including $42.8 billion at food service establishments, $18.9 billion in retail sales for home consumption, and $213.3 million for industrial fish products. The commercial marine fishing industry contributed $31.6 billion to the U.S. Gross National Product in 2004. In 1996, consumers spent an estimated $41.2 billion including $27.8 billion at food service establishments, $13.2 billion for home consumption, and $283.9 billion for industrial fish products. The commercial marine fishing industry contributed $21.0 billion to the U.S. Gross National Product in 1996.

Ex-Vessel Prices

The ex-vessel price depends on a number of factors including the quality of the fish (e.g., freshness, fat content, method of storage), the weight of the fish, the supply of fish, and consumer demand.

Average ex-vessel prices for bigeye tuna have generally increased since 1996. Prices from 2003 to 2004 have increased in all four regions. The gears used also influenced the average price of bigeye tuna.

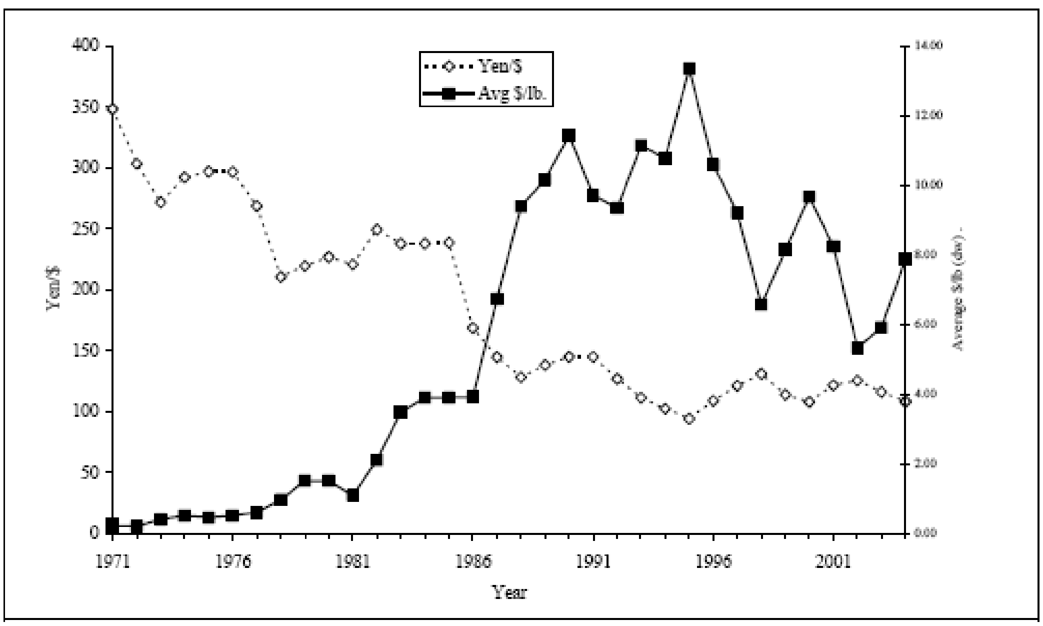

Figure 5.3.9-3. Average Annual Yen/$ Exchange Rate and Average U.S. bluefin tuna. Ex-vessel $/lb (dw) for all gears: 1971-2003. Source: Federal Reserve Bank (www.stls.frb.org) and Northeast Regional Office.

Average ex-vessel prices for bluefin tuna have generally declined since 1996. Since 2002, however, prices increased in all regions except the North Atlantic. The gear used also made a difference in the ex-vessel price. In the North Atlantic and Mid-Atlantic, bluefin tuna caught with handgear had higher average prices than those caught with longline. This trend has been fairly consistent over the years between 1996 and 2004. The ex-vessel prices for bluefin tuna can be influenced by many factors, including market supply and the Japanese Yen/U.S. Dollar (¥/$) exchange rate. Figure 5.3.9-3 shows the average ¥/$ exchange rate, plotted with average ex-vessel bluefin tuna prices, from 1971 to 2003.

The average ex-vessel prices for yellowfin tuna have increased in 2004 in the Gulf of Mexico, Mid-Atlantic and North Atlantic while increasing slightly in the South Atlantic. Yellowfin tuna caught with longline gear had higher average ex-vessel prices than fish caught with other gear types in 2004. The average ex-vessel price for other tunas decreased in all regions except the Gulf of Mexico in 2004. The average price of other tunas is lowest in the South Atlantic compared to other regions. The type of gear used did not appear to consistently influence the average ex-vessel prices of other tuna.

Average ex-vessel prices for swordfish increased in 2004 in all regions. Swordfish caught using handline gear had higher average ex-vessel prices than other gear types, except in the Mid-Atlantic where it was trawls.

The average ex-vessel price for LCS slightly decreased in the Gulf of Mexico in 2004 and North Atlantic. However, prices for LCS increased in the Mid-Atlantic and South Atlantic (Table 5.3.9-14).

The average ex-vessel prices for pelagic sharks increased in the Mid-Atlantic and North Atlantic regions in 2004 (Table 5.3.9-14), while prices decreased in Gulf of Mexico and South Atlantic. The 2004 prices for pelagic sharks are not significantly different than 1996 prices and are actually lower than 1996 when adjusting for inflation. The average ex-vessel prices for small coastal sharks (SCS) rebounded in all regions in 2004 (Table 5.3.9-14). Gear type did not consistently affect ex-vessel price of small coastal sharks in 2004 (Table 5.3.9-14).

<u>Revenues</u>

Table 5.3.9-14 summarizes the average annual revenues of the Atlantic HMS fishery based on average ex-vessel prices and the weight reported landed as per the U.S. National Report (NMFS 2005), the Shark Evaluation Reports, information given to ICCAT (Cortes, 2005), as well as price and weight reported to the NMFS Northeast Regional Office by Atlantic bluefin tuna dealers. These values indicate that the estimated total annual revenue of Atlantic HMS fisheries has decreased 34 percent from approximately $66.4 million in 1996 to approximately $43.9 million in 2004. From 2003 to 2004, the tuna fishery's total revenue decreased significantly. A majority of that decrease can be attributed to reduced commercial landings of bluefin tuna and yellowfin tuna. From 2003 to 2004, the annual revenues from shark decreased by over 21 percent. In contrast, the annual revenues from swordfish from 2003 to 2004 increased by five percent after having been in decline for several years.

<u>Wholesale Market</u>

Currently, NMFS does not collect wholesale price information from dealers. However, the wholesale price of some fish species is available off the web (http://www.st.nmfs.gov/st1/market_news/index.html). As with ex-vessel prices, wholesale prices depend on a number of factors including the quality of the fish, the weight of the fish, the supply of fish, and consumer demand.

As reported by the Fulton Fish Market, Table 5.3.9-12 indicates that the average wholesale price of HMS sold in Atlantic and Gulf of Mexico states generally decreased from 1996 to 2003, except for blacktip shark. Prices have appeared to have rebounded in 2004, breaking from the declining trend. During that same period, the wholesale price of swordfish weighing over 100 pounds decreased 19 percent, swordfish weighing between 50 and 99 pounds decreased 25 percent, and swordfish cuts decreased 15 percent. The wholesale price of blacktip shark increased 27 percent from 1996 to 2003, with most of the increase occurring in 2003. The wholesale price of mako shark decreased 14 percent from 1996 to 2003, however 2003 wholesale prices were up from 2002. The wholesale price of thresher shark has decreased 22 percent from 1996 to 2003. Wholesale yellowfin tuna prices have remained relatively stable from 1996 to 2003. The yellowfin tuna wholesale price of #2 quality fish had decreased eight percent while the price of #2 cuts has increased seven percent from 1996 to 2003. Bigeye tuna wholesale prices from 1999 to 2003 have increased significantly for both high grade cuts and fish.

Table 5.3.9-12. The overall average wholesale price per lb of fresh HMS sold in Atlantic and Gulf of Mexico states as reported by the Fulton Fish Market. Source: NMFS, 2004.

Species	Description	1996 Price/lb	1999 Price/lb	2000 Price/lb	2001 Price/lb	2002 Price/lb	2003 Price/lb	2004 Price/lb
Blacktip	-	$1.05	$1.04	$1.04	$1.05	$1.00	$1.33	$1.08
Mako	-	$2.77	$2.74	$3.18	$3.00	$2.00	$2.37	$2.24
Thresher	-	$1.00	$0.91	$0.82	$1.25	$1.25	$0.78	$1.24
Swordfish	100# and up	$6.28	$5.26	$5.26	$5.42	$5.19	$5.08	$5.66
	50-99#	$6.02	$4.54	$4.72	$4.81	$4.59	$4.50	$5.15
	26-49#	$5.50	$3.36	$3.58	$4.05	$3.50	-	$3.25
	Cuts	$7.74	$6.55	$6.54	$6.73	$6.84	$6.55	$7.13
Yellowfin tuna	#1: BTF	$7.00	$5.97	$5.69	$5.50	$7.42	-	$6.00
	#1: Cuts	$9.38	$8.23	$8.00	$8.23	$10.67	-	$8.50
	#2: BTF	$5.00	$4.24	$4.36	$3.97	$4.92	$4.60	$4.62
	#2: Cuts	$6.52	$6.22	$6.20	$6.00	$7.29	$6.98	$7.32
	#3: BTF	-	$3.00	-	-	-	$2.50	-
	#3: Cuts	-	$4.50	-	-	-	-	$3.00
Bigeye tuna	#1: BTF	-	$4.00	-	-	-	$6.50	$7.75
	#1: Cuts	-	$5.50	-	-	-	$8.50	$11.00
	#2: BTF	-	$4.26	-	-	-	-	-
	#2: Cuts	-	$6.00	-	-	-	-	-

Note: #'s indicate quality (1 is highest, 3 is lowest); BTF is by the fish.

Recreational fisheries

Although NMFS believes that recreational fisheries have a large influence on them economies of coastal communities, NMFS has only recently been able to gather additional information on the costs and expenditures of anglers or the businesses that rely on them.

An economic survey done by the U.S. Fish and Wildlife Service2 in 2001 found that for the entire United States 9.1 million saltwater anglers (including anglers in state waters) went on approximately 72 million fishing trips and spent approximately $8.4 billion (USFWS, 2001). Expenditures included lodging, transportation to and from the coastal community, vessel fees, equipment rental, bait, auxiliary purchases (e.g., binoculars, cameras, film, foul weather clothing, etc.), and fishing licenses (USFWS, 2001). Saltwater anglers spent $4.5 billion on trip-related costs and $3.9 billion on equipment (USFWS, 2001). Approximately 76 percent of the saltwater anglers surveyed fished in their home state (USFWS, 2001). The next USFWS survey was conducted in 2006.

Specific information regarding angler expenditures for trips targeting HMS species was extracted from the recreational fishing expenditure survey add-on (1998 in the Northeast, 1999 – 2000 in the Southeast) to the National Marine Fisheries Service's Marine Recreational Fisheries Statistics Survey (MRFSS). These angler expenditure data were analyzed on a per-person per trip-day level and reported in 2003 dollars. The expenditure data include the costs of tackle, food, lodging, bait, ice, boat fuel, processing, transportation, party/charter fees, access/boat launching, and equipment rental. The overall average expenditure on HMS related trips is estimated to be $122 per person per day. Specifically, expenditures are estimated to be $686 per person per day on billfish directed trips (based on a low sample size), $85 on pelagic shark directed trips, $95 on large coastal shark directed trips, $81 on small coastal sharks, and $106 on tuna trips.

The American Sportfishing Association (ASA) also has a report listing the 2001 economic impact of sportfishing on specific states. This report states that all sportfishing (in both Federal and state waters) has an overall economic importance of $116 billion dollars (ASA, 2001). Florida, Texas, North Carolina, New York, and Alabama are among the top ten states in terms of overall economic impact for both saltwater and freshwater fishing (ASA, 2001). Florida is also one of the top states in terms of economic impact of saltwater fishing with $2.9 billion in angler expenditures, $5.4 billion in overall economic impact, $1.5 billion in salaries and wages related to fishing, and 59,418 fishing related jobs (ASA, 2001). California followed Florida with $0.8 billion in angler expenditures, $1.7 billion in overall economic impact, $0.4 billion in salaries and wages, and 15,652 jobs (ASA, 2001). Texas and New Jersey were the next highest states in terms of economic impact (ASA, 2001).

At the end of 2004, NMFS began collecting market information regarding advertised charterboat rates. This preliminary analysis of the data collected includes 99 observations of advertised rates on the internet for full day charters. Full day charters vary from six to 14 hours long with a typical trip being 10 hours. Most vessels can accommodate six passengers, but this also varies from two to 12 passengers. Table 3.79 summarizes the average charterboat rate for full day trips on vessels with HMS Charter/Headboat permits. The average price for a full day boat charter was $1,053 in 2004. Sutton et al., (1999) surveyed charterboats throughout Alabama, Mississippi, Louisiana, and Texas in

1998 and found the average charterboat base fee to be $762 for a full day trip. Holland et al. (1999) conducted a similar study on charterboats in Florida, Georgia, South Carolina, and North Carolina and found the average fee for full day trips to be $554, $562, $661, and $701, respectively. Comparing these two studies conducted in the late 1990s to the average advertised daily HMS charterboat rate in 2004, it is apparent that there has been a significant gain in charterboat rates.

Table 5.3.9-13. Average Atlantic HMS charterboat rates for day trips. Source: NMFS searches for advertised daily charter rates of HMS Charter/Headboat permit holders. (Observations=99)

State	2004 Average Daily Charter Rate
AL	$1,783
CT	$1,500
DE	$1,060
FL	$894
LA	$1,050
MA	$777
MD	$1,167
ME	$900
NC	$1,130
NJ	$1,298
NY	$1,113
RI	$917
SC	$1,300
TX	$767
VA	$825
Overall Average	**$1,053**

In 2003, Ditton and Stoll published a paper that surveyed the literature regarding what is currently known about the social and economic aspects of recreational billfish fisheries. It was estimated that 230,000 anglers in the United States spent 2,136,899 days fishing for billfish in 1991. This is approximately 3.6 percent of all saltwater anglers over age 16.

The states with the highest number of billfish anglers are Florida, California, North Carolina, Hawaii, and Texas in descending order. Billfish anglers studied in the U.S. Atlantic, Puerto Rico, and Costa Rica fished between 39 and 43 days per year.

Billfish recreational anglers tend to spend a great deal of money on trips. Ditton and Stoll (2003) report that a 1990 study of U.S. total trip costs for a typical billfish angler estimated a mean expenditure of $2,105 per trip for the Atlantic and $1,052 per trip for Puerto Rico. The aggregate economic impact of billfish fishing trips in the U.S. Atlantic is conservatively estimated to be $22.7 million annually.

In addition to the economic impact of recreational billfish angling, Ditton and Stoll (2003) report that using a contingent valuation method they estimated consumer's surplus or net economic benefit to maintain current billfish populations in the U.S. Atlantic to be $497 per billfish angler per year in the U.S. Atlantic and $480 in Puerto Rico. They also estimate that the number of annual billfish anglers in the U.S. Atlantic to be 7,915 and 1,627 in Puerto Rico. The aggregate willingness-to-pay for maintaining current billfish populations is $3.93 million in the U.S. Atlantic and 0.78 million in Puerto Rico. The aggregate direct impact of billfish expenditures is estimated to be $15.13 million for the U.S. Atlantic and $32.40 million for Puerto Rico. Thus, the total aggregate economic value of billfish angler fishing is $19.06 million per year for the U.S. Atlantic and $33.18 million per year for Puerto Rico.

Generally, HMS tournaments last from three to seven days, but lengths can range from one day to an entire fishing season. Similarly, average entry fees can range from approximately $0 to $5,000 per boat (average approximately $500/boat – $1,000/boat), depending largely upon the magnitude of the prize money that is being awarded. The entry fee would pay for a maximum of two to six anglers per team during the course of the tournament. Additional anglers can, in some tournaments, join the team at a reduced rate of between $50 and $450. The team entry fee did not appear to be directly proportional to the number of anglers per team, but rather with the amount of money available for prizes and, possibly, the species being targeted. Prizes may include citations, T-shirts, trophies, fishing tackle, automobiles, boats, or other similar items, but most often consists of cash awards. In general, it appears that billfish and tuna tournaments charge higher entry fees and award more prize money than shark and swordfish tournaments, although all species have a wide range.

Cash awards distributed in HMS tournaments can be quite substantial. Several of the largest tournaments, some of which are described below, are part of the World Billfish Series Tournament Trail whereby regional winners are invited to compete in the World Billfish Series Grand Championship for a new automobile and a bronze sculpture. Other tournament series include the International Game Fish Association (IGFA) Rolex Tournament of Champions, and the South Carolina Governor’s Cup. White marlin is a top billfish species from Cape Hatteras, North Carolina to the eastern tip of Georges Bank from June through October each year. The White Marlin Open in Ocean City, Maryland, which is billed as the “world’s richest fishing tournament,” established a new world record payout for catching a fish when it awarded $1.32 million in 2004 to the vessel catching the largest white marlin. The 21st Annual Pirates Cove Billfish Tournament in North Carolina awarded over $1 million in prizes in 2004, with the top boat garnering over $400,000 for winning in six categories. Total prize money awarded in the Big Rock Tournament in North Carolina has exceeded $1 million since 1998.

Blue marlin, sailfish, and tunas are also often targeted in fishing tournaments, including those discussed above. In 2004, blue marlin was the HMS most frequently identified as a prize category in registered HMS tournaments. Forty-five teams participated in the 2004 Emerald Coast Blue Marlin Classic at Sandestin, Florida, with over $482,000 in cash prizes and the top boat receiving over $58,000. The 34th Annual Pensacola (Florida) International Billfish Tournament indicated that it would award over $325,000 in cash and prizes in 2004. The World Sailfish Championship in Key West, Florida has a

$100,000 guaranteed first prize for 2005. In South Carolina, the Megadock Billfishing Tournament offers a $1,000,000 prize for any boat exceeding the current blue marlin state record. The 2004 Florida Billfish Masters Tournament in Miami, Florida awarded over $123,000 in prize money, with the top boat receiving over $74,000. Sixty-two boats competed in the 2003 Babylon Tuna Club Invitational in Babylon, New York for over $75,000 in cash prizes, and the Mid-Atlantic Tuna Tournament sponsored by the South Jersey Marina in Cape May, New Jersey anticipates awarding over $25,000 in prizes in 2005.

Several tournaments target sharks. Many shark tournaments occur in New England, New York, and New Jersey, although other regions hold shark tournaments as well. In 2004, the 24th Annual South Jersey Shark Tournament hosted over 200 boats and awarded over $220,000 in prize money, with an entry fee of $450 per boat. The "Mako Fever" tournament, sponsored by the Jersey Coast Shark Anglers, in 2004 awarded over $55,000 in prizes, with the first place vessel receiving $25,000. In 2004, the 18th Annual Monster Shark Tournament in Martha's Vineyard, Massachusetts was broadcast on ESPN, and featured a new fishing boat valued at over $130,000 awarded to the winner.

Swordfish tournaments have gained increased popularity in recent years, especially on the east coast of Florida, as the swordfish population has recovered. Events include the Islamorada Swordfish Tournament that began in 2004, and the Miami Swordfish Tournament that began in 2003. Both of these tournaments anticipated awarding over $30,000 in total cash and prizes, assuming that 50 boats would participate.

In addition to official prize money, many fishing tournaments may also conduct a "calcutta" whereby anglers pay from $200 to $5,000 to win more money than the advertised tournament prizes for a particular fish. Tournament participants do not have to enter calcuttas. Tournaments with calcuttas generally offer different levels depending upon the amount of money an angler is willing to put down. Calcutta prize money is distributed based on the percentage of the total amount entered into that Calcutta. Therefore, first place winner of a low level calcutta (entry fee ~$200) could win less than a last place winner in a high level calcutta (entry fee ~$1000). On the tournament websites, it was not always clear if the total amount of prizes distributed by the tournament included prize money from the calcuttas or the estimated price of any equipment. As such, the range of prizes discussed above could be a combination of fish prize money, Calcutta prize money, and equipment/trophies.

Fishing tournaments can sometimes generate a substantial amount of money for surrounding communities and local businesses. Besides the entry fee to the tournament and possibly the calcutta, anglers may also pay for marina space and gas (if they have their own vessel), vessel rental (if they do not have their own vessel), meals and awards dinners (if not covered by the entry fee), hotel, fishing equipment, travel costs to and from the tournament, camera equipment, and other miscellaneous expenses. Fisher and Ditton (1992) found that the average angler who attended a billfish tournament spent $2,147 per trip (2.59 days), and that billfish tournament anglers spent an estimated $180 million (tournament and non-tournament trips) in 1989. Ditton and Clark (1994) estimated annual expenditures for Puerto Rican billfish fishing trips (tournaments and non-tournaments) at $21.5 million. More recently, Ditton, et al., (2000) estimated that the total expenditure (direct economic impact) associated with the 1999 Pirates Cove Billfish Tournament, not including registration fees, was approximately $2,072,518.

The total expenditure (direct economic impact) associated with the 2000 Virginia Beach Red, White, and Blue Tournament was estimated at approximately $450,359 (Thailing et al. 2001). These estimated direct expenditures do not include economic effects that may ripple through the local economy leading to a total impact exceeding that of the original purchases by anglers (i.e., the multiplier effect). Less direct, but equally important, fishing tournaments may serve to generally promote the local tourist industry in coastal communities. In a survey of participants in the 1999 Pirates Cove Billfish Tournament, Ditton, et al., (2000) found that almost 80 percent of tournament anglers were from outside of the tournament's county. For this reason, tourism bureaus, chambers of commerce, resorts, and state and local governments often sponsor fishing tournaments.

Social and cultural environment

This section consolidates all of the community profiles from previous HMS management plans or amendments and updates the community information, where possible. To ensure continuity with the 1999 HMS FMP and previous amendments, if a community was selected and described as being involved with an HMS fishery, the same community was included in this assessment. The communities profiled were originally selected due to the proportion of HMS landings, the relationship between the geographic communities and the fishing fleets, the existence of other community studies, and input from the HMS and Billfish Advisory Panels. The communities selected for detailed study are Gloucester and New Bedford, Massachusetts; Barnegat Light and Brielle, New Jersey; Wanchese, and Hatteras Township, North Carolina; Pompano Beach, Fort Pierce, Madeira Beach, Panama City Beach, and Islamorada, Florida; Boothville/Venice and Dulac, Louisiana; and Arecibo, Puerto Rico. These communities are not intended to be an exhaustive list of every HMS-related community in the United States; rather the objective is to give a broad perspective of representative areas.

The demographic profiles found in the 2006 Consolidated Atlantic Highly Migratory Species FMP have been modified to include the same baseline information for each community profiled; as a result, most of the tables include more information than portrayed in the 1999 HMS FMP and its amendments. The demographic tables still use both 1990 and 2000 Bureau of the Census data for comparative purposes. The descriptive community profiles include the same information provided by the Wilson, et al. (1998) and Kirkley (2005) analyses with some new information provided by Impact Assessment, Inc (2004) on the Gulf of Mexico communities. Unlike the Wilson, et al., (1998) study used in the 1999 HMS FMP, it was not possible to undertake field research for this assessment.

This assessment also reviewed the HMS permit databases to incorporate information about residence. This information was also used to identify additional HMS-related fishing communities that should be profiled in the future. Six GIS maps were generated to identify the communities where angler, charter/headboat, HMS dealers (tunas, shark, and swordfish combined), commercial tuna (all gear categories combined), directed and incidental shark, and swordfish (directed, incidental, and handgear combined) permit holders reside (Figure 9.1 to Figure 9.6 in the 2006 Consolidated FMP). In past community profile and social impact analyses, it was difficult to identify where recreational HMS fishermen were located because no data were available for the number of recreational fishermen, as well as recreational landings by community. Previous social impact assessments report on charter fishing operations, fishing tournaments, and related activities to identify the scope of recreational fishing for each of the communities described. The information provided by the HMS permit databases should facilitate the identification of recreational HMS communities that should be profiled in the future.

For future social impact analyses, the HMS permit databases, landings information, and HMS APs should be consulted to determine the most appropriate community profiles for HMS-related fisheries. The 2005 HMS permit data indicate that several new community profiles should be developed and some of the previously profiled communities may no longer be as significantly involved in the fishery as they were in the past.

Wakefield, Rhode Island should be considered due to the number of commercial tuna and swordfish permit holders in the area. Montauk, New York has a large concentration of charter/headboat, commercial tuna, and HMS dealer permit holders in the community. A large number of Cape May, New Jersey residents hold an HMS angling, charter/headboat, shark and/or swordfish permits. Morehead City, North Carolina is home to a number of HMS angling, charter/headboat, and commercial tuna permit holders. Each of these towns is actively involved with more than one sector of the HMS fisheries and therefore be impacted be any changes to HMS regulations.

5.3.9.3 Bycatch

Pelagic Longline Fishery

NMFS collects data on the disposition (released alive or dead) of bycatch species from logbooks submitted by fishermen in the pelagic longline fishery. Observer reports also include disposition of the catch as well as information on hook location, trailing gear and injury status of protected species interactions. These data are used to estimate post-release mortality of sea turtles and marine mammals based on guidelines for each (Angliss and DeMaster 1998, Ryder et al. 2006).

Marine Mammals

Of the marine mammals that are hooked by U.S. pelagic longline fishermen, many are released alive, although some animals suffer serious injuries and may die after being released. The observed and estimated marine mammal interactions for 1992 – 2005 are summarized in Table 5.3.9-17 and Table 5.3.9-18. Marine mammals are caught primarily during the third and fourth quarters in the Mid-Atlantic Bight (MAB) and Northeast Coastal (NEC) areas (Table 5.3.9-18). In 2005, the majority of observed interactions were with pilot whales in the MAB area (Walsh and Garrison, 2006).

In 2000, there were 14 observed takes of marine mammals by pelagic longlines. This number has been extrapolated based on reported fishing effort to an estimated 403 mammals fleet-wide (32 common dolphin, 93 Risso's dolphin, 231 pilot whales, 19 whales, 29 pygmy sperm whales) (Yeung 2001). In 2001 and 2002, there were 16 and 24 observed takes of marine mammals, respectively. The majority of these interactions were observed in the MAB, followed by the Northeast Distant (NED) research experiment. In 2001, there were an estimated total of 84 Risso's dolphin and 93 pilot whale interactions in the pelagic longline fishery. In 2002, there were an estimated 87 Risso's dolphin and 114 pilot whale interactions in the pelagic longline fishery. In the NED research experiment, an additional four Risso's dolphin and one northern bottlenose whale were recorded with serious injuries during 2001, as well as three Risso's dolphin, one unidentified dolphin, and one unidentified marine mammal in 2002. One striped dolphin was recorded as released alive during the NED experiment in 2001, as well as one Risso's dolphin, one common dolphin, one pilot whale, and one unidentified dolphin in 2002 (Garrison, 2003).

In 2003, there were 28 observed takes of marine mammals in the pelagic longline fishery. The majority of these interactions were observed in the MAB, followed by the NED experimental fishery, and the NEC area. This number has been extrapolated based on reported fishing effort to an estimated 300 mammals fleet wide (49 beaked whales, 16 dolphin, 30 Atlantic spotted dolphin, 46 common dolphin, 105 Risso's dolphin, 32 pilot whales, 22 minke whales). In addition, five Risso's dolphin, one striped dolphin, and one baleen whale were observed captured in the 2003 NED research experiment, with one Risso's dolphin recorded as dead (Garrison and Richards 2004).

There were a total of 12 observed interactions with marine mammals in the pelagic longline fishery in 2004. The majority of these interactions was with pilot whales and was observed in the MAB area. During 2004, the pelagic longline fishery was estimated to have interacted with 108 pilot whales, 49 Risso's dolphins, and seven common dolphins (Garrison, 2005). In 2005, there were a total of 24 observed interactions with marine mammals in the pelagic longline fishery. The majority of these interactions was with pilot whales and was observed in the MAB area. During 2005, the pelagic longline fishery was estimated to have interacted with 294 pilot whales, 42 Risso's dolphin, six common dolphin, five bottlenose dolphin, four Atlantic spotted dolphin, one beaked whale, 13 unidentified marine mammals, three unidentified whales, and three unidentified dolphin (Walsh and Garrison, 2006). NMFS monitors observed interactions with sea turtles and marine mammals on a quarterly basis and reviews data for appropriate action, if any, as necessary. In June 2005, NMFS convened the Pelagic Longline Take Reduction Team (PLTRT) to assess and reduce marine mammal takes, specifically pilot whales and Risso's dolphins, by the pelagic longline fishery. At the time of writing, the Pelagic Longline Take Reduction Plan (PLTRP) was expected to be finalized soon.

Table 5.3.9-14. Summary of Marine Mammal Interactions in the Pelagic Longline Fishery, 1992-1998. Source: Yeung, 1999a; Yeung, 1999b.

Year	Species	Total		Mortality		Alive	
		Obs	Est	Obs	Est	Obs	Est
1992	Risso's Dolphin	3	121	2	74	1	47
	Common Dolphin	1	24			1	24
	Dolphin	1	17			1	17
	Pilot Whale	12	420	3	105	9	319
1993	Risso's Dolphin	3	62	1	36	2	26
	Bottlenose Dolphin	2	29			2	29
	Pilot Whale	16	193	1	15	15	178
	Spotted Dolphin	1	11			1	11
1994	Atlantic Spotted Dolphin	1	17	1	17		
	Pantropical Spotted Dolphin	1	20			1	20
	Killer Whale	1	16	1	16		
	Pilot Whale	14	161	12	137	2	26
	Risso's Dolphin	7	87	7	87		
1995	Risso's Dolphin	5	101	4	85	1	16
	Unidentified Marine Mammal	1	22			1	22
	Pilot Whale	13	252	11	200	2	53
	Shortfin Pilot Whale	2	58	2	58		
1996	Risso's Dolphin	4	99	2	52	2	47
	Unidentified Marine Mammal	1	43			1	43
1997	Pilot Whale	1	29			1	29
	Short-Beaked Spinner Dolphin	1	16			1	16
1998	Beaked Whale	1	88			1	88
	Bottlenose Dolphin	2	46	1	31	1	15
	Risso's Dolphin	2	47	1	23	1	24
	Pilot Whale	1	24			1	24

Table 5.3.9-15. Summary of Marine Mammal Interactions in the Pelagic Longline Fishery, 1999-2005. Sources: Yeung, 2001; Garrison, 2003; Garrison and Richards, 2004; Garrison, 2005; Walsh and Garrison, 2006.

Year	Species	Total		Mortality		Serious Injury		Alive	
		Obs	Est	Obs	Est	Obs	Est	Obs	Est
1999	Risso's Dolphin	1	23			1	23		
	Unidentified Marine Mammal	1	14					1	14
	Pilot Whale	5	385	1	94	4	291		
2000	Common Dolphin	1	32					1	32
	Risso's Dolphin	3	93	1	41	1	23	1	29
	Pilot Whale	8	231	1	24	4	109	3	98
	Whale	1	19			1	19		
	Pygmy Sperm Whale	1	28			1	28		
2001	Risso's Dolphin	8	83.6	1	24.4	6	48.9	1	14.3
	Pilot Whale	6	92.9	1	19.8	4	50.2	1	22.7
	Striped Dolphin	1	1					1	1
	Northern Bottlenose Whale	1	1			1	1		
2002	Risso's Dolphin	10	87.2			4	11	6	59.6
	Pilot Whale	10	113.5			4	49.9	6	67.8
	Common Dolphin	1	1					1	1
	Unidentified Dolphin	2	2			1	1	1	1
	Unidentified Marine Mammal	1	1			1	1		
2003	Beaked Whale	2	48.8			1	5.3	1	43.5
	Dolphin	1	16.2			1	16.2		
	Atlantic Spotted Dolphin	1	29.8			1	29.8		
	Bottlenose Dolphin	1	2					1	2
	Common Dolphin	2	45.6					2	45.6
	Risso's Dolphin	14	109.5	1	1	3	40.1	10	68.4
	Striped Dolphin	1	1					1	1
	Pilot Whale	4	32.1			2	21.4	1	11.3
	Baleen Whale	1	1					1	1
	Minke Whale	1	22.3					1	22.3
2004	Pilot Whale	8	107.5			6	74.1	2	33.8
	Common Dolphin	1	6.8					1	6.8
	Risso's Dolphin	3	49.4			2	27.5	1	21.9
2005	Pilot Whale	18	294.4			9	211.5	9	79.5
	Risso's Dolphin	2	42.1				2.9	2	39.2
	Common Dolphin		5.7						5.7
	Bottlenose Dolphin	1	5.2					1	5.2
	Beaked Whale		1				1		
	Atlantic Spotted Dolphin	1	4.3					1	4.3
	Unidentified Marine Mammal	1	13.2			1	13.2		
	Unidentified Whale		3.4				3.4		
	Unidentified Dolphin	1	2.6					1	2.6

Sea Turtles

Currently, many sea turtles are taken in the GOM and NEC areas (Table 5.3.9-16) and most are released alive. In the past, the bycatch rate was highest in the third and fourth quarters.

Loggerhead and leatherback turtles dominate the catch of sea turtles. In general, sea turtle captures are rare, but takes appear to be clustered (Hoey and Moore 1999).

The estimated take levels for 2000 were 1,256 loggerhead and 769 leatherback sea turtles (Yeung, 2001). The estimated sea turtle takes for regular fishing and experimental fishing effort for 2001 - 2005 are summarized in Table 5.3.9-19. The majority of leatherback interactions have occurred in the Gulf of Mexico. Loggerhead interactions are more widely distributed, however, the NEC, FEC, and Gulf of Mexico appear to be areas with high interaction levels each year.

In 2005, the pelagic longline fishery interacted with an estimated 351 leatherback sea turtles and 275 loggerhead sea turtles outside of experimental fishing operations. During 2005, the interactions with leatherback sea turtles were highest in the Gulf of Mexico (179 animals). The majority of loggerhead sea turtle interactions occurred in the NEC, MAB, CAR, SAR, and SAB areas (Walsh and Garrison, 2006). NMFS monitors observed interactions with sea turtles and marine mammals on a quarterly basis and reviews data for appropriate action, if any, as necessary.

Table 5.3.9-16. Estimated number of leatherback and loggerhead sea turtle interactions in the U.S. Atlantic pelagic longline fishery, 2001-2005 by statistical area. Sources: Walsh and Garrison, 2006; Garrison, 2005; Garrison and Richards, 2004; Garrison 2003.

	Leatherback					**Loggerhead**				
Area	**2001**	**2002**	**2003**	**2004**	**2005**	**2001**	**2002**	**2003**	**2004**	**2005**
CAR	61	0	0	17	2	27	43	36	61	40
GOM	393	695	838	780	179	0	170	135	45	19
FEC	313	100	27	64	62	0	99	137	99	0
SAB	241	93	75	164	7	39	22	52	194	34
MAB	139	70	94	184	11	43	94	18	92	54
NEC	30	5	76	33	6	117	147	241	150	67
NED	32	0	0	98	63	72	0	0	52	20
SAR	0	0	0	18	20	0	0	70	41	38
NCA	1	0	2	0	0	13	0	39	0	3
TUN	0	0	0	0	0	0	0	0	0	0
TUS	0	0	0	0	0	0	0	0	0	0
Total	1208	962	1113	1359	351	312	575	728	734	275
NED exp'tal fishery (2001-03)	77	158	79	--	--	142	100	92	--	--
Exp'tal fishery (2004-05)	--	--	--	3	17	--	--	--	0	8
Total	1285	1120	1192	1362	368	454	675	820	734	283

As a result of the increased sea turtle interactions in 2001 and 2002, NMFS reinitiated consultation for the pelagic longline fishery and completed a new BiOp on June 1, 2004. The June 2004 BiOp concluded that long-term continued operation of the Atlantic pelagic longline fishery is not likely to jeopardize the continued existence of loggerhead, green, hawksbill, Kemp's ridley, or olive ridley sea turtles, but is likely to jeopardize the continued existence of leatherback sea turtles. The BiOp included a reasonable and prudent alternative (RPA) and an incidental take statement (ITS) for the combined years 2004 – 2006, and for each subsequent three-year period (NMFS, 2004b).

A final rule published in July 2004 (69 FR 40734) prohibited the possession of "J"-style hooks in the pelagic longline fishery and required the possession and use of specific sea turtle release and disentanglement gears, handling and release protocols, as well as requiring the use of specific circle hooks and baits.

NED Research Experiment
Consistent with the conservation recommendation of an earlier, 2001 BiOp, NMFS initiated a research experiment in the Northeast Distant (NED) area in consultation and cooperation with the domestic pelagic longline fleet. The goal was to develop and evaluate the efficacy of new technologies and changes in fishing practices to reduce sea turtle interactions. In 2001, the experiment attempted to evaluate the effect of gangions placed two gangion lengths from floatlines, the effect of blue-dyed bait on target catch and sea turtle interactions, and the effectiveness of dipnets, line clippers, and dehooking devices. Eight vessels participated, making 186 sets, between August and November.

During the course of the research experiment, 142 loggerhead and 77 leatherback sea turtles were incidentally captured and no turtles were released dead. The data gathered during the 2001 experiment were analyzed to determine if the tested measures reduced the incidental capture of sea turtles by a statistically significant amount. The blue-dyed bait parameter decreased the catch of loggerheads by 9.5 percent and increased the catch of leatherbacks by 45 percent. Neither value is statistically significant. In examining the gangion placement provision, the treatment sections of the gear (with gangions placed 20 fathoms from floatlines) did not result in a statistically significant reduction in the number of loggerhead and leatherback sea turtle interactions than the control sections of the gear (with a gangion located under a floatline). The treatment section of the gear recorded an insignificant increase in the number of leatherback interactions. Following an examination of the data, NMFS discovered that the measures had no significant effect upon the catch of sea turtles (Watson et al., 2003).

Dipnets and line clippers were examined for general effectiveness. The dipnets were found to be adequate in boating loggerhead sea turtles. Several line clippers were tested, with the La Force line clipper having the best performance. Several types of dehooking devices were tested, with the work on these devices continuing in the 2002 and 2003 NED research experiment.

In the summer and fall of 2002, NMFS conducted the second year of the research experiment. The use of circle and "J"-hooks, whole mackerel bait, squid bait, and shortened daylight soak time were tested to examine their effectiveness in reducing the capture of sea turtles. The data indicate there were 501 sets made by 13 vessels with 100 percent observer coverage. During the course of the experiment, 100 loggerhead and 158 leatherback sea turtles were captured and 11 were tagged with satellite tags. In addition to the sea turtles, the vessels interacted with one unidentified marine mammal, one unidentified dolphin, one common dolphin, one longfin pilot whale, and four Risso's dolphins; all were released alive (Watson et al. 2003).

In 2003, the research experiment tested a number of treatments to verify the results of the 2002 experiment in addition to testing additional treatments. Data indicate that there were 539 sets made by 11 vessels with 100 percent observer coverage. During the course of the experiment, one olive ridley, 92 loggerhead, and 79 leatherback sea turtles were captured; all were released alive (Foster et al., 2004; Watson et al., 2004). In addition to the sea turtles, the vessels interacted with one striped dolphin, one baleen whale, and five Risso's dolphin resulting in one mortality (Garrison and Richards, 2004).

From 2001 through 2003, NMFS worked with the commercial fishing industry to develop new pelagic longline fishing technology to reduce interaction rates and bycatch mortality of threatened and endangered sea turtles. The cooperative gear technology research investigated line configurations, setting and retrieving procedures, hook types, hook sizes, bait types, and release and disentanglement gears. Ultimately, specific hook designs and bait types were found to be the most effective measures for reducing sea turtle interactions. Large circle hooks and mackerel baits were found to substantially reduce sea turtle interactions over the use of the industry standard "J"-hooks and squid baits. The gears developed to remove hooks and line from hooked and entangled sea turtles are anticipated to reduce post-hooking mortality associated with those interactions not avoided. Since the conclusion of the NED research experiment, NMFS has continued to investigate pelagic longline bycatch mitigation techniques in the Gulf of Mexico, Atlantic Ocean and the Caribbean Sea.

Additionally, NMFS held a series of voluntary workshops for U.S. pelagic longline fishermen providing outreach and training in sea turtle handling and release techniques. NMFS believes that the transfer of this information to other fishing countries will result in significant reductions in interaction rates and post-release mortalities of threatened and endangered sea turtles throughout their ranges.

Seabirds

Gannets, gulls, greater shearwaters, and storm petrels are occasionally hooked by Atlantic pelagic longlines. These species and all other seabirds are protected under the Migratory Bird Treaty Act. Seabird populations are often slow to recover from excess mortality as a consequence of their low reproductive potential (one egg per year and late sexual maturation). The majority of longline interactions with seabirds occur as the gear is being set. The birds eat the bait and become hooked on the line. The line then sinks and the birds are subsequently drowned.

The United States has developed a National Plan of Action in response to the Food and Agriculture Organization of the United Nations (FAO) International Plan of Action to reduce the incidental takes of seabirds (www.nmfs.gov.gov/NPOA-S.html). Although Atlantic pelagic longline interactions will be considered in the plan, NMFS has not identified a need to implement gear modifications to reduce seabird takes by Atlantic pelagic longlines. Takes of seabirds have been minimal in the fishery, most likely due to the setting of longlines at night and/or fishing in areas where birds are largely absent. Observer data from 1992 through 2005 indicate that seabird bycatch is relatively low in the U.S. Atlantic pelagic longline fishery (Table 5.3.9-17). Since 1992, a total of 129 seabird interactions have been observed, with 95 observed killed (73.6 percent). In 2005, a total of four seabirds were observed taken.

Observed bycatch has ranged from one to 18 seabirds observed dead per year and zero to 15 seabirds observed released alive per year from 1992 through 2003. Half of the seabirds observed were not identified to species (n = 59). Of the seabirds identified, gulls represent the largest group (n = 35), followed by greater shearwaters (n = 23), and northern gannets (n = 8) (Table 5.3.9-21). Greater shearwaters experienced the highest mortality (96.2 percent), followed by gulls (80 percent), and unidentified seabirds (67.8 percent). Northern gannets had the lowest mortality rate (12.5 percent).

Preliminary estimates of expanded seabird bycatch and bycatch rates from 1995 – 2004, varied by year and species with no apparent pattern. The estimated number of all seabirds caught and discarded dead ranged from zero to 468 per year, while live discards ranged from zero to 292 per year. The annual bycatch rate of birds discarded dead ranged from zero to 0.0486 birds per 1,000 hooks, while live discards ranged from zero to 0.0303 birds per 1,000 hooks.

Table 5.3.9-17. Seabird Bycatch in the U.S. Atlantic Pelagic Longline Fishery, 1992-2005. Source: NMFS, 2004a; NMFS PLL fishery observer program (POP) data.

Year	Month [1]	Area	Type of Bird	Number observed	Status
1992	10	MAB	GULL	4	dead
1992	10	MAB	SHEARWATER GREATER	2	dead
1993	2	SAB	GANNET NORTHERN	2	alive
1993	2	MAB	GANNET NORTHERN	2	alive
1993	2	MAB	GULL BLACK BACKED	1	alive
1993	2	MAB	GULL BLACK BACKED	3	dead
1993	11	MAB	GULL	1	alive
1994	6	MAB	SHEARWATER GREATER	3	dead
1994	8	MAB	SHEARWATER GREATER	1	dead
1994	11	MAB	GULL	4	dead
1994	12	MAB	GULL HERRING	7	dead
1995	7	MAB	SEA BIRD	5	dead
1995	8	GOM	SEA BIRD	1	dead
1995	10	MAB	STORM PETREL	1	dead
1995	11	NEC	GANNET NORTHERN	2	alive
1995	11	NEC	GULL	1	alive
1997	6	SAB	SEA BIRD	11	dead
1997	7	MAB	SEA BIRD	1	dead
1997	7	NEC	SEA BIRD	15	alive
1997	7	NEC	SEA BIRD	6	dead
1998	2	MAB	SEA BIRD	7	dead
1998	7	NEC	SEA BIRD	1	dead
1999	6	SAB	SEA BIRD	1	dead
2000	6	SAB	GULL LAUGHING	1	alive
2000	11	NEC	GANNET NORTHERN	1	dead
2001	6	NEC	SHEARWATER GREATER	7	dead
2001	7	NEC	SHEARWATER GREATER	1	dead
2002	7	NEC	SEABIRD	1	dead
2002	8	NED	SHEARWATER GREATER	1	dead
2002	8	NED	SEABIRD	1	dead
2002	9	NED	SHEARWATER GREATER	3	dead
2002	9	NED	SEABIRD	3	alive
2002	9	NED	SHEARWATER SPP	1	dead
2002	10	NED	GANNET NORTHERN	1	alive

Year	Month [1]	Area	Type of Bird	Number observed	Status
2002	10	NED	SHEARWATER SPP	1	dead
2002	10	NED	SEABIRD	2	dead
2002	10	MAB	GULL	3	alive
2002	10	MAB	GULL	1	dead
2002	11	MAB	GULL	3	dead
2003	1	GOM	SEABIRD	1	alive
2003	8	NED	SEABIRD	1	dead
2003	9	MAB	SEABIRD	1	dead
2004	1	MAB	GULL	5	dead
2004	3	MAB	GREATER SHEARWATER	1	alive
2004	3	MAB	GREATER SHEARWATER	4	dead
2004	4	NED	SEABIRD	1	dead
2005	1	SAB	HERRING GULL	1	dead
2005	1	SAB	SHEARWATER	1	dead
2005	3 [2]	NEC	GREATER SHEARWATER	1	alive
2005	3 [2]	NEC	GREATER SHEARWATER	1	dead

1 Beginning in 2004, reports based on Quarters not month.
2 Experimental fishery takes.

Table 5.3.9-18. Status of Seabird Bycatch in the U.S. Atlantic Pelagic Longline Fishery, 1992-2005. Source: NMFS PLL fishery observer program (POP) data.

Species	Release Status		Total	Percent Dead
	Dead	Alive		
GULLS (incl. Blackback, Herring, Laughing, and unid. gulls)	28	7	34	80%
UNIDENTIFIED SEABIRD	40	19	59	67.8%
GREATER SHEARWATER	22	1	23	95.6%
SHEARWATER SPP	3	0	3	100%
NORTHERN GANNET	1	7	8	12.5%
STORM PETREL	1	0	1	100%
TOTAL ALL SEABIRDS	95	34	129	73.6%

Finfish

In the U.S. pelagic longline fishery, fish are discarded for a variety reasons. Swordfish, yellowfin tuna, and bigeye tuna may be discarded because they are undersized or unmarketable (e.g., shark bitten). Blue sharks, as well as other species, are discarded because of a limited markets (resulting in low prices) and perishability of the product. Large coastal sharks are discarded during times when the shark season is closed. Bluefin tuna may be discarded because target catch requirements for other species have not been met. Also, all billfish are required to be released. In the past, swordfish have been discarded when the swordfish season was closed.

Reported catch from 1999 – 2004 for the U.S. pelagic longline fishery (including reported bycatch, incidental catch, and target catch) is summarized in Table 5.3.9-2**.** Additional U.S. landings and discard data are available in the 2005 U.S. National Report to ICCAT (NMFS, 2005).

At this time, direct use of observer data with pooling for estimating dead discards in this fishery represents the best scientific information available for use in stock assessments. Direct use of observer data has been employed for a number of years to estimate dead discards in Atlantic and Pacific longline fisheries, including billfish, sharks, and undersized swordfish. Furthermore, the data have been used for scientific analyses by both ICCAT and the Inter- American Tropical Tuna Commission (IATTC) for a number of years.

Bycatch mortality of marlins, swordfish, and bluefin tuna from all fishing nations may significantly reduce the ability of these populations to rebuild, and it remains an important management issue. In order to minimize bycatch and bycatch mortality in the domestic pelagic longline fishery, NMFS implemented regulations to close areas to this gear type (Figure 5.3.9-4) and has banned the use of live bait by pelagic longline vessels in the Gulf of Mexico.

As part of the bluefin tuna rebuilding program, ICCAT recommends an allowance for dead discards. The U.S. annual dead discard allowance is approximately 68 mt ww. The estimate for the 2004 calendar year was used as a proxy to calculate the amount to be added to, or subtracted from, the U.S. bluefin tuna landings quota for 2005. The 2004 calendar year preliminary estimate of U.S. dead discards, as reported per the longline discards calculated from logbook tallies, adjusted as warranted when observer counts in quarterly/geographic stratum exceeded logbook reports, totaled 72 mt ww. Estimates of dead discards from other gear types and fishing sectors that do not use the pelagic longline vessel logbook are unavailable at this time, and thus, are not included in this calculation. As U.S. fishing activity is estimated to have exceeded the approximate 68 mt ww dead discard allowance by approximately 4.0 mt, the ICCAT recommendation and U.S. regulations state that the United States must account for this excess. Therefore, NMFS shall subtract the amount in excess (approximately 4.0 mt) from the amount of bluefin tuna that can be landed in the subsequent fishing year by those categories accounting for the dead discards.

The 2005 calendar year preliminary dead discard estimate is not yet available. The 2004 calendar year preliminary dead discard estimate, as reported in pelagic longline vessel logbooks and published in 2005 Final Initial Quota Specifications (70 FR 33033, June 7, 2005), totaled 71.8 mt ww. This preliminary estimate has been revised using the longline discards calculated from logbook tallies, adjusted as warranted when observer counts in stratum exceeded logbook reports. The revised 2004 calendar year dead discard estimate is 72.0 mt ww.

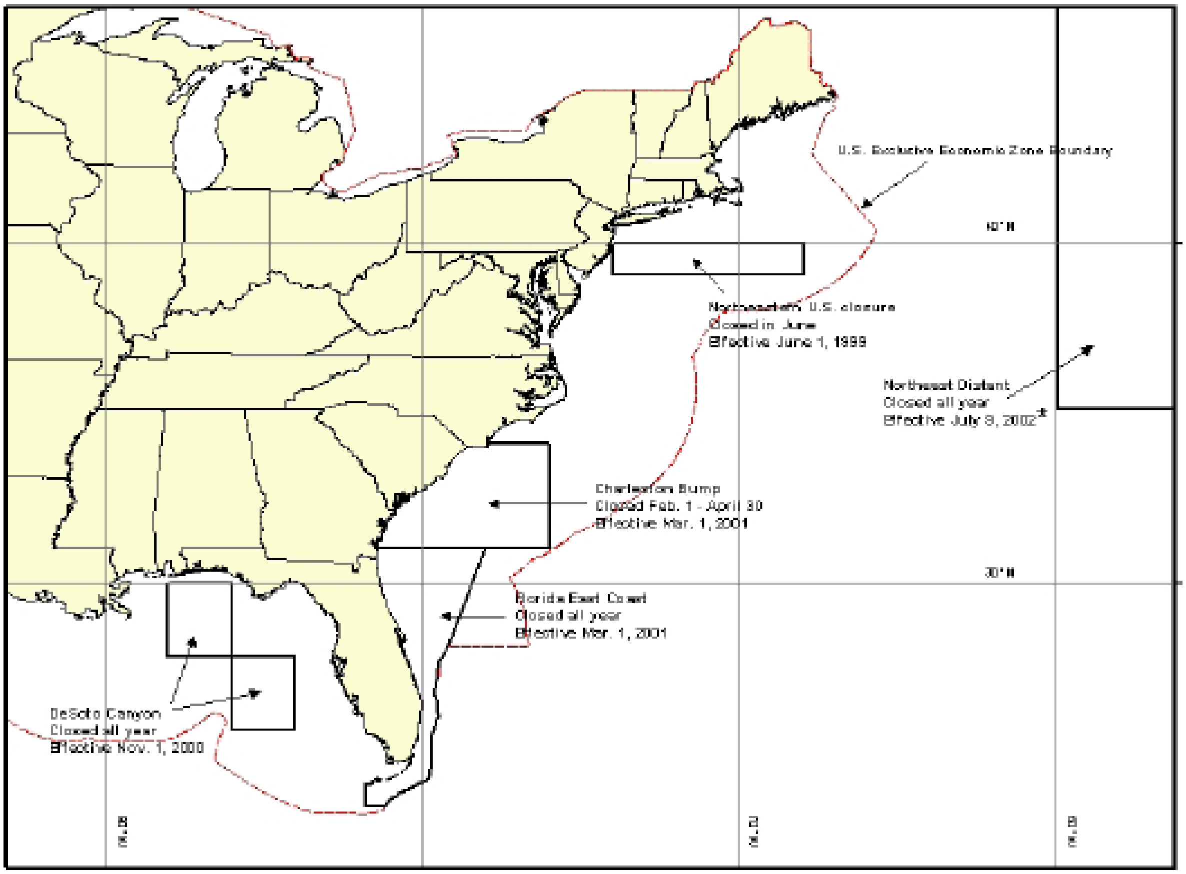

Figure 5.3.9-4. Areas Closed to Pelagic Longline Fishing by U.S. Flagged Vessels

Purse Seine Fishery

NMFS has limited observer data on the bluefin tuna purse seine fishery. There are no recorded instances of non-tuna finfish, other than minimal numbers of blue sharks, caught in tuna purse seines. Anecdotal evidence indicates that if fish are discarded, they are easily released out of the net with minimal bycatch mortality.

Commercial Handgear Fishery

Vessels targeting bluefin tuna with harpoon gear have not been selected for observer coverage since the deliberate fishing nature of the gear is such that bycatch is expected to be low. Therefore, there are no recorded instances of non-target finfish caught with harpoons and NMFS cannot quantify the bycatch of undersized bluefin tuna in this fishery. Bycatch in the swordfish harpoon fishery is virtually if not totally, non-existent. Since bycatch approaches zero in this fishery, it follows that bycatch mortality is near zero. Disposition of bycatch reported in logbooks is used to estimate mortality of bycatch in the hook and line handgear fisheries.

Bottom longline fishery

Under the Marine Mammal Protection Act (MMPA) (16 U.S.C. 1361 et seq.) the Atlantic shark gillnet fishery is classified as Category II (occasional serious injuries and mortalities), and the shark bottom longline as Category III (remote likelihood or no known serious injuries or mortalities) (July 20, 2004, 69 FR 43338). On October 29, 2003, NMFS issued a biological opinion (BiOp) pursuant to the Endangered Species Act (ESA) regarding Atlantic shark fisheries. This BiOp concluded that the level of anticipated take in the Atlantic shark fishery resulting from measures implemented in Amendment 1 to the 1999 FMP (68 FR 74746), were not likely to jeopardize the continued existence of endangered green, leatherback, and Kemp's ridley sea turtles, the endangered smalltooth sawfish, or the threatened loggerhead sea turtle. Furthermore, it concluded that the actions in the rule were not likely to adversely affect marine mammals. As a result of this conclusion, NMFS (NMFS 2003) anticipates that the continued operation of the shark bottom longline fishery will result in a five year total incidental take of the following numbers of sea turtles: Leatherback – 172; loggerhead – 1,370; a total of 30 in any combination of hawksbill, green, and Kemp's ridley sea turtles. NMFS also anticipates a five year take of 261 smalltooth sawfish, of which no lethal takes are expected. If the actual calculated incidental captures or mortalities exceed the incidental take statement, a formal consultation for that gear type must be re-initiated immediately. More information is available in Amendment 1 to the 1999 FMP and the October 2003 BiOp and is not repeated here.

Loggerhead Sea Turtles

In the bottom longline fishery, a total of 65 sea turtles were observed caught from 1994 through 2006 (Table 5.3.9-25, 5.3.9-26). Seasonal variation indicates that most of the sea turtles were caught early in the year. Of the 65 observed sea turtles, 50 were loggerhead sea turtles, of which 26 were released alive. Another nine loggerheads were released in an unknown condition and eight were released dead. Based on extrapolation of observer data in Amendment 1 to the 1999 FMP, it was estimated that a total of 2,003 loggerhead sea turtles were taken in the shark bottom longline fishery from 1994 through 2002 (NMFS, 2003a). An additional 503 unidentified sea turtles were estimated to have been taken. On average, 222 loggerhead sea turtles and 56 unidentified sea turtles were estimated to have been taken annually during this time period in the shark bottom longline fishery.

Leatherback Sea Turtles

Of the 65 observed sea turtle interactions in the bottom longline fishery from 1994 – 2006, six were leatherback sea turtles of which one was dead and three were released with their condition unknown. Based on extrapolation of observer data done for Amendment 1 to the FMP, it was estimated that 269 leatherback sea turtles were taken in the shark bottom longline fishery from 1994 through 2002 (NMFS, 2003a). On average, 30 leatherback sea turtle interactions occurred each year in the shark bottom longline fishery during this period. This analysis only estimates takes without discriminating between live and dead releases. Of the observed leatherback takes, approximately 25 percent were lethal.

Applying the observed mortality rate of 25 percent to the total leatherback takes and an additional 42 percent post-release mortality estimate due to hook ingestion to the remaining, results in an estimated total number of leatherbacks killed as a result of the interaction with bottom longline gear at 17 per year. The leatherback mortality is very conservative because it is known that leatherbacks rarely ingest or bite hooks, but are usually foul hooked on their flippers or carapaces, reducing the likelihood of post-hooking release mortality. However, leatherback-specific data for this fishery is not available and therefore the most conservative estimate is used.

Smalltooth Sawfish
As of April 1, 2003, NMFS listed smalltooth sawfish as an endangered species (68 FR 15674) under the ESA. After reviewing the best scientific and commercial information, the status review team determined that the continued existence of the U.S. Distinct Population Segment of smalltooth sawfish was in danger of extinction throughout all or a significant portion of its range from a combination of the following four listing factors: the present or threatened destruction, modification, or curtailment of habitat or range; overutilization for commercial, recreational, scientific, or educational purposes; inadequacy of existing regulatory mechanisms; and other natural or manmade factors affecting its continued existence. NMFS is working on designating critical habitat for smalltooth sawfish.

Sawfish have been observed caught (12 known interactions, 11 released alive, one released in unknown condition) in shark bottom longline fisheries from 1994 through 2006 (Morgan pers. comm., Burgess and Morgan, 2004; Carlson). Based on these observations, expanded sawfish take estimates for 1994 – 2002 were developed for the shark bottom longline fishery (NMFS, 2003a). A total of 466 sawfish were estimated to have been taken in this fishery from 1994 – 2002, resulting in an average of 52 per year. All but one of the observed sawfish was released alive.

Marine Mammals
Four delphinids have been observed caught and released alive between 1994 and 2004 (G. Burgess, pers. comm.). Bycatch estimates for the shark bottom longline fishery have not been extrapolated for marine mammals.

Seabirds
Bycatch of seabirds in the shark bottom longline fishery has been virtually non-existent. A single pelican has been observed killed from 1994 through 2005. The pelican was caught in January 1995 off the Florida Gulf Coast (between 25° 18.68 N, 81° 35.47 W and 25° 19.11 N, 81° 23.83 W) (G. Burgess, University of Florida, pers. comm., 2001). No expanded estimates of seabird bycatch or catch rates are available for the bottom longline fishery.

Table 5.3.9-19. Species composition of observed bottom longline catch during 2003. Source: Burgess and Morgan, 2004.

Species	Total Number Caught	% Total Catch	% Management Category
Dusky shark	108	1.22	1.78
Silky shark	105	1.18	1.73
Lemon shark	60	0.68	0.99
Great hammerhead	55	0.62	0.91
Bignose shark	8	0.09	0.13
Night shark	8	0.09	0.13
White shark	3	0.03	0.05
Caribbean shark	1	0.01	0.02
Total	6072	68.41	100
Small Coastal Sharks			
Atlantic sharpnose shark	1996	22.49	80.32
Blacknose shark	484	5.45	19.48
Bonnethead	3	0.03	0.12
Finetooth	2	0.02	0.08
Total	2485	28.00	100.00
Pelagic Sharks			
Sevengill	5	0.06	45.45
Shortfin mako	2	0.02	18.18
Bigeye sixgill	2	0.02	18.18
Bigeye thresher shark	1	0.01	9.09
Sixgill shark	1	0.01	9.09
Total	11	0.12	100.00
Dogfish/Other Sharks			
Smooth dogfish	298	3.36	
Unidentified sharks	10	0.113	

Species	Total Number Caught	% Total Catch	% Management Category
Large Coastal Sharks			
Sandbar shark	2719	30.63	44.78
Blacktip shark	1232	13.88	20.29
Tiger shark	665	7.49	10.95
Spinner shark	309	3.48	5.09
Scalloped hammerhead	259	2.92	4.27
Bull shark	257	2.90	4.23
Nurse shark	175	1.97	2.88
Sand tiger	108	1.22	1.78

Table 5.3.9-20. Species composition of observed bottom longline catch during 2004.

Species	Total Number Caught	% Total Catch	% Management Category
Dusky shark	54	0.7	1.0
Night shark	42	0.5	0.8
Lemon shark	17	0.2	0.3
Sandtiger shark	12	0.1	0.2
Bignose shark	5	0.1	0.1
Total	5415	66.7	100
Small Coastal Sharks			
Atlantic sharpnose shark	2231	27.5	85.8
Blacknose shark	353	4.3	13.6
Bonnetheat shark	10	0.1	0.4
Finetooth shark	5	0.1	0.2
Total	2599	32.0	100
Pelagic Sharks			
Sevengill shark	2	0.02	25.0
Sixgill shark	1	0.01	12.5
Shortfin mako shark	3	0.01	37.5
Bigeye thresher shark	2	0.02	25.0
Total	8	0.1	100
Dogfish Sharks			
Smooth dogfish	85	1.0	97.7
Spiny dogfish	2	0.02	2.3
Total	87	1.1	100
Other Sharks			
Unidentified	5	0.1	71.4
Carcharhinus sp.	2	0.02	28.6
Total	7	0.1	100

Species	Total Number Caught	% Total Catch	% Management Category
Large Coastal Sharks			
Sandbar shark	2157	26.6	39.8
Blacktip shark	1107	13.6	20.4
Tiger shark	972	12.0	18.0
Nurse shark	440	5.4	8.1
Silky shark	254	3.1	4.7
Scalloped hammerhead	155	1.9	2.9
Bull shark	108	1.3	2.0
Great hammerhead	92	1.1	1.7

Table 5.3.9-21. Total number of Observed Sea Turtle Interactions by Species by Month for Years 1994-2006 in the Shark Bottom Longline Fishery. Source: Shark Bottom Longline Observer Program.

Month	Leatherback Sea Turtle	Loggerhead Sea Turtle	Other Sea Turtles	Total
Jan	1	12	1	14
Feb	3	10	6	19
Mar		7		7
Apr		4		4
May	1			1
Jun				
July		11		11
Aug		3		3
Sept	1	2	1	4
Oct		1	1	2
Nov				
Dec				
Total	6	50	9	65

Table 5.3.9-22. Total number of Observed Sea Turtle Interactions by Year for Years 1994-2006 in the Shark Bottom Longline Fishery. Source: Shark Bottom Longline Observer Program. Letters in parentheses indicate whether the sea turtle was released alive (A), dead (D), or in an unknown (U) condition.

Year	Leatherback Sea Turtle	Loggerhead Sea Turtle	Other Sea Turtle	Total
1994	1 (1U)	5 (5U)	6 (6U)	12
1995		4 (3A, 1D)		4
1996	1 (1U)	6 (3A, 2D, 1U)		7
1997	1 (1U)	5 (3A, 2U)		6
1998		2 (1A, 1D)	1 (1A)	3
1999		2 (2A)		2
2001	1 (1D)	2 (2A)		3
2002		5 (3A, 1D, 1U)		5
2003		7 (6A, 1D)	1 (1U)	8
2004		5 (3A, 2D)		5
2005	2 (1A, 1D)	4 (1A, 3D)	1 (1U)	7
2006		2 (1D, 1U)		3
Total	6	50	9	65

Gillnet fishery

On September 23, 2002, NMFS implemented a restricted area to reduce bycatch of right whales from November 15 through March 31 (67 FR 59471). In this area, only gillnets used in a strikenet fashion can operate during times when right whales are present.

Operation in this area at that time requires 100 percent observer coverage. Vessels fishing in a strikenet fashion used nets 364.8 meters long, 30.4 meters deep, and with mesh size 22.9 cm. Observed catch in the strikenet fishery consisted of 6 species of sharks (96.7 percent of total number caught) and seven species of teleosts and rays (3.3 percent of total number caught). No marine mammals or sea turtles were observed caught. The blacktip shark made up 97.5 percent of the number of sharks caught, and 86 percent of the overall catch. Bycatch included crevalle jack, red drum, and great barracuda (Table 5.3.9-27).

There were 23 species of teleosts, two species of rays, and one species of marine mammal observed caught during the driftnet season (Table 5.3.9-29). Four species of teleosts and rays made up 90.8 percent by number of the overall non-shark species in observed strikenet catches. These species were little tunny (45.6 percent); king mackerel (23.3 percent); great barracuda (11.8 percent); and red drum (10.2 percent). For incidental driftnet catch species, the highest proportion discarded dead (with observed catch greater than 10 specimens) was Atlantic sailfish, (100.0 percent), king mackerel (78.3 percent), and cobia (28.7 percent). Red drum had the highest discard proportion alive (98.1 percent) (Carlson and Baremore, 2003). Observed driftnet sets caught 23 species of teleosts and rays and no sea turtles or marine mammals. Only the great barracuda were retained, with all remaining bycatch discarded alive (Carlson, 2002).

Outside of right whale calving season, observed drift gillnet catch consisted of 26 species of teleosts and rays and one species of marine mammal, which was discarded dead. Five species of teleosts and one species of ray made up 90.6 percent by number of the overall non-shark catch. Little tunny (44.1 percent), king mackerel (20.8 percent), great barracuda (12.5 percent), Atlantic moonfish (9.4 percent), and cobia (3.8 percent) dominated the bycatch (Carlson and Baremore, 2002). During drift gillnet fishing, the highest proportion of species discarded dead (for species with greater than 10 individuals) was for tarpon, crevalle jack, king mackerel, and red drum. Cownose rays and red drum had the highest proportion of discarded alive with 78.1 percent and 50.0 percent, respectively (Carlson and Baremore, 2002).

On January 22, 2006, a dead right whale was spotted offshore of Jacksonville Beach, Florida. The survey team identified the whale as a right whale calf, and photos indicated the calf as having one large wound along the midline and smaller lesions around the base of its tail. The right whale calf was located at 30°14.4’ N. Lat., 81° 4.2’’ W. Long., which was approximately 1nautical mile outside of the designated right whale critical habitat, but within the Southeast U.S. Restricted Area. NMFS determined that both the entanglement and death of the whale occurred within the Southeast U.S. Restricted Area, and all available evidence suggested the entanglement and injury of the whale by gillnet gear ultimately led to the death of the animal.

On February 16, 2006, NMFS published a temporary rule (71 FR 8223) to prohibit, through March 31, 2006, any vessel from fishing with any gillnet gear in the Atlantic Ocean waters between 32°00’ N. Lat. (near Savannah, GA) and 27°51’ N. Lat. (near Sebastian Inlet, FL) and extending from the shore eastward out to 80°00’ W. long under the authority of the Atlantic Large Whale Take Reduction Plan (ALWTRP) (50 CFR 229.32 (g)) and the Endangered Species Act. NMFS took this action based on its determination that a right whale mortality was the result of an entanglement by gillnet gear within the Southeast U.S. Restricted Area.

The regulations at 50 CFR 229.32(g)(1) also require NMFS to close the Southeast U.S. Restricted Area for the rest of the time period, and for the time period November 15 through March 31 in each subsequent year, unless NMFS revises the restricted period or unless other measures are implemented. NMFS plans to seek assistance and recommendations from the ALWTRT at their next meeting in order to evaluate whether permanent closures within the Southeast U.S. Restricted Area are necessary.

Loggerhead Sea Turtles
Loggerhead sea turtles are rarely caught in the shark gillnet fishery. During the 1999 right whale calving season, no loggerhead sea turtles were observed caught in this fishery (Carlson and Lee 1999), and no loggerheads were observed caught with strikenets during the 2000 – 2002 right whale calving seasons (Carlson 2000; Carlson and Baremore 2001; Carlson and Baremore 2002a). However, three loggerhead sea turtles were observed caught with drift gillnets during right whale calving season, one each year from 2000 to 2002 (Carlson 2000; Carlson and Baremore 2001; Carlson and Baremore 2002a; Garrison 2003). In 2004 there were no observed sea turtle interactions in either the strikenet or drift gillnet fisheries.

No loggerhead sea turtles were caught outside of the right whale calving season in 2002 (Carlson and Baremore 2002b), and no loggerhead turtles were observed caught during or after the right whale calving season in 2003 or 2004 in the directed shark gillnet fishery (Carlson and Baremore 2003; Carlson pers. comm). In 2005 five loggerheads were observed caught, and in 2006 three loggerheads were observed caught (Table 5.3.9-30). All but two were released alive. One loggerhead sea turtle mortality was reported in abandoned fishing gear in January 2004, and was not considered part of normal fishing operations.

Leatherback Sea Turtles
In the shark gillnet fishery, leatherback sea turtles are sporadically caught. During the 1999 right whale calving season, two leatherback sea turtles were caught in this fishery, and both were released alive (Carlson and Lee 1999). No leatherback sea turtles were observed caught with strikenets during the 2000 – 2002 right whale calving seasons (Carlson 2000; Carlson and Baremore 2001; Carlson and Baremore 2002a). Leatherback sea turtles have been observed caught in shark drift gillnets including 14 in 2001 and two in 2002 (Carlson 2000; Carlson and Baremore 2001; Carlson and Baremore 2002a; Garrison 2003). NMFS temporarily closed the shark gillnet fishery (strikenetting was allowed) from March 9 to April 9, 2001, due to the increased number of leatherback interactions that year (66 FR 15045, March 15, 2001). From 2003 – 2004, no leatherback sea turtles were observed caught in gillnets fished in strikenet or driftnet methods (Carlson and Baremore 2003; Carlson pers. comm.).

Smalltooth Sawfish

To date there has been only one observed catch of a smalltooth sawfish in shark gillnet fisheries. The sawfish was taken on June 25, 2003, in a gillnet off southeast Florida and was released alive (Carlson and Baremore, 2003). The set was characteristic of a typical drift gillnet set, with gear extending 30 to 40 feet deep in 50 to 60 feet of water. Prior to this event it was speculated that the depth at which drift gillnets are set above the sea floor may preclude smalltooth sawfish from being caught. Although sometimes described as a lethargic demersal species, smalltooth sawfish feed mostly on schooling fish, thus they would occur higher in the water column during feeding activity. In fact, smalltooth sawfish and Atlantic sharks may be attracted to the same schools of fish, potentially making smalltooth sawfish quite vulnerable if present in the area fished. The previous absence of smalltooth sawfish incidental capture records is more likely attributed to the relatively low effort in this fishery and the rarity of smalltooth sawfish, especially in Federal waters. These factors may result in little overlap of the species with the gear. The sawfish was cut from the net and released alive with no visible injuries. This indicates that smalltooth sawfish can be removed safely if entangled gear is sacrificed.

Given the high rate of observer coverage in the shark gillnet fishery, NMFS believes that smalltooth sawfish takes in this fishery are very rare. The fact that there were no smalltooth sawfish caught during 2001 when 100 percent of the fishing effort was observed indicates that smalltooth sawfish takes (observed or total) most likely do not occur on an annual basis. Based on this information, the 2003 BiOp estimated that one incidental capture of a sawfish (released alive) over the next five years, will occur as a result of the use of gillnets in this fishery (NMFS, 2003a).

Marine Mammals

Observed takes of marine mammals in the Southeast Atlantic shark gillnet fishery during 1999 – 2004, totaled 12 bottlenose dolphins and four spotted dolphins. Extrapolated observations from these data suggest serious injury and mortality of 25 bottlenose dolphin and one Atlantic spotted dolphin in the shark gillnet fishery from 1999 through 2002 (Garrison, 2003).

Table 5.3.9-23. Total Strikenet Shark Catch and Bycatch by Species in order of Decreasing Abundance for all Observed Trips, 2003. Source: Carlson and Baremore, 2003.

Species	Total Number Caught	Kept (%)	Discarded Alive (%)	Discarded Dead (%)
Blacktip shark	6,401	97.5	.6	1.9
Blacknose shark	343	100.0	0	0
Crevalle jack	215	96.2	3.3	.5
Red Drum	18	0	100	0
Great barracuda	13	92.3	0	7.7
Manta ray	10	0	100	0
Bull shark	8	75	12.5	12.5
Permit	8	50	37.5	12.5
Nurse shark	1	0	100	0
Spinner shark	1	100	0	0
Finetooth shark	1	100	0	0
Cobia	1	100	0	0
Atlantic bonito	1	0	0	100
Total	**7,021**			

Table 5.3.9-24. Total Shark Catch by Species and Species Disposition in Order of Decreasing Abundance for all Observed Driftnet Sets, 2003. Source: Carlson and Baremore, 2003.

Species	Total Number Caught	Kept (%)	Discarded Alive (%)	Discarded Dead (%)
Atlantic sharpnose	6,917	99.8	0	.2
Blacknose	799	100	0	0
Finetooth	620	100	0	0
Blacktip	375	45	24	31
Bonnethead	168	100	0	0
Scalloped Hammerhead	62	3.2	0	96.8
Spinner	20	5	0	95
Great Hammerhead	6	100	0	0
Lemon	1	0	100	0
Total	**8,968**			

Table 5.3.9-25. Total bycatch in NMFS observed drift gillnet sets in order of decreasing abundance and species disposition for all observed trips, 2003. Source: Carlson, 2003.

Species	Total Number Caught	Kept (%)	Discard Alive (%)	Discard Dead (%)
Little tunny	1169	92.6	0	7.4
King mackerel	596	21.5	.2	78.3
Barracuda	300	100	0	0
Red drum	262	0	98.1	1.9
Cobia	80	70	1.3	28.7
Blackfin tuna	36	100	0	0
Atlantic sailfish	30	0	0	100
Cownose ray	22	0	59.1	40.9
Spanish mackerel	11	100	0	0
Remora	9	0	33.4	66.6
Crevalle jack	8	0	0	100
Blue runner	8	87.5	0	12.5
Tarpon	5	0	0	100
Manta ray	5	0	100	0
Dolphin	5	100	0	0
Tripletail	4	100	0	0
Spotted eagle ray	2	0	100	0
Blue marlin	2	0	0	100
Balloonfish	2	0	0	100
Wahoo	1	100	0	0
Pompano	1	100	0	0
Rainbow runner	1	100	0	0
Black drum	1	0	100	0
Bluefish	1	0	0	100

Table 5.3.9-26. Total number of Observed Sea Turtle Interactions by Year from 2000-2006 in the Shark Gillnet Fishery. Source: Directed Shark Gillnet Observer Program. Letters in parentheses indicate whether the sea turtle was released alive (A), dead (D), or unknown (U).

Year	Leatherback Sea Turtle	Loggerhead Sea Turtle	Total
2000		1 (U)	1
2001		1 (U)	1
2002		1 (U)	1
2003			0
2004			0
2005	1(A)	5 (4A, 1D)	6
2006		3 (2A, 1D)	3
Total	1	11	12

Table 5.3.9-27. Protected Species Interactions in Drift Gillnet Sets During the Directed Shark Gillnet Fishery for All Observed Trips, 2003. Source: Carlson, 2003.

Species	Total Number Caught	Released Alive	Discarded Dead	Released Condition Unknown or Comatose
Bottlenose dolphin	2	0	1	1
Smalltooth sawfish	1	1	0	0

Recreational fishery

Bycatch in the recreational rod and reel fishery is difficult to quantify because many fishermen value the experience of fishing and may not be targeting a particular pelagic species. Recreational "marlin" or "tuna" trips may yield dolphin, tunas, wahoo, and other species, both undersized and legal sized. Bluefin tuna trips may yield undersized bluefin, or a seasonal closure may prevent landing of a bluefin tuna above a minimum or maximum size. In some cases, therefore, rod and reel catch may be discarded. The Magnuson-Stevens Act (16 USC 1802 (2)) stipulates that bycatch does not include fish under recreational catch-and-release.

The 1999 Billfish Amendment established a catch-and-release fishery management program for the recreational Atlantic billfish fishery. As a result of this program, all Atlantic billfish that are released alive, regardless of size, are not considered bycatch. NMFS believes that establishing a catch-and-release fishery in this situation will further solidify the existing catch-and-release ethic of recreational billfish fishermen, and thereby increase release rates of billfish caught in this fishery. Current billfish release rates range from 89 to 99 percent. The recreational white shark fishery is by regulation a catch-and-release fishery only and white sharks are not considered bycatch.

Bycatch can result in death or injury to discarded fish. Therefore, bycatch mortality should be incorporated into fish stock assessments, and into the evaluation of management measures. Rod and reel discard estimates from Virginia to Maine during June – October could be monitored through the expansion of survey data derived from the LPS (dockside and telephone surveys). However, the actual numbers of fish discarded for many species are so low that presenting the data by area could be misleading, particularly if the estimates are expanded for unreported effort in the future.

Discard mortality

Post-release mortality studies have been conducted on few HMS at this time. Immediate mortality in recreational hook and line-caught juvenile bluefin tuna can be high (29.2 percent) due to injuries or predation (Belle, 1997). This is thought to be a conservative estimate because scientific personnel in the study were professionally trained and had extensive experience in fish handling techniques designed to reduce mortality. Mortality often occurs ten minutes or longer after the fish is released under normal circumstances. Injuries may not be readily apparent to the angler and seemingly minor capture injuries may be related to substantial internal injuries. Forty percent of sampled tuna that died during that study did not have injuries that would be apparent to the angler in the boat. Skomal and Chase (1996) provided evidence that the stress of rod and reel angling did not cause immediate post-release mortality in larger bluefin tuna (50 to 150 kg). However, they did document metabolic and pH disturbances in bluefin tuna sampled off Cape Hatteras, NC. The physiological consequences of angling stress are poorly understood for several species of large pelagic fishes (Skomal and Chase, 1996).

A study by Graves et al. (2002), investigated short-term (five days) post-release mortality of Atlantic blue marlin using pop-up satellite tag technology. A total of nine recreationally caught blue marlin were tagged and released during July and August of 1999. All hooks employed in the study were “J” hooks. The attached tags were programmed to detach from the fish after five days and to record direct temperature and inclination of the buoyant tag to determine if the fish were actively swimming after being released. After detachment, the tags floated to the surface and began transmitting recorded position, temperature and inclination data to satellites of the ArgosTM system. Three different lines of evidence provided by the tags (movement, water temperature, and tag inclination) suggested that at least eight of the nine blue marlin survived for five days after being tagged and released. One of the tags did not transmit any data which precluded the derivation of a conclusion regarding the tagged marlin’s survival.

The study was continued in 2003 to evaluate post release survival and habitat use of white marlin using pop-up satellite archival tags (PSATs) caught and released from four locations in the western North Atlantic recreational fishery (Horodysky and Graves 2005). Forty-one tags were attached to white marlin caught using dead baits rigged on straight shank (“J”) hooks (n = 21) or circle hooks (n = 20) offshore of the U.S. Mid-Atlantic, the Dominican Republic, Mexico, and Venezuela. Survival was significantly higher ($p<0.01$) for white marlin caught on circle hooks (100 percent) relative to those caught on straight-shank (“J”) hooks (65 percent). These results, along with previous studies on circle hook performance, suggest that a change in hook type can significantly increase the survival of white marlin released from recreational fishing gear. Data from these short term deployments also suggest that white marlin strongly associate with warm, near surface waters. However, based on the frequency, persistence, and patterns of vertical movements, white marlin appear to direct a considerable proportion of foraging effort well below surface waters, a behavior that may account for relatively high catch rates of white marlin on some pelagic longline sets. NMFS continues to support studies on recreational post-release mortality and intends to account for this source of mortality when additional information becomes available.

Outreach programs to address bycatch were included in the 1999 FMP and the Billfish Amendment. These programs have not yet been implemented, but the preparation of program designs is currently in progress. One of the key elements in the outreach program will be to provide information that leads to an improvement in post-release survival from both commercial and recreational gear. Additionally, an outreach program to encourage the use of circle hooks to increase post-release survival within HMS fisheries was introduced in a proposed rule published in 2001 (66 FR 66386, December 26, 2001). The final rule to promote the voluntary use of circle hooks published in 2003 (68 FR 711, January 7, 2003). Initial implementation of the outreach program began in 2004 with workshops conducted on the proper handling and release of sea turtles.

5.4 Spatial Presentation of Commercial Landings for South Atlantic Species 1990-2006 (ACCSP)

Maps of catch by area for the following species presented in Appendix B.

Common Name	**Species Name**
Almaco Jack	Seriola rivoliana
Atlantic Spadefish	Chaetodipterus faber
Banded Rudderfish	Seriola zonata
Bank Sea Bass	Centropristis ocyurus
Bar Jack	Caranx ruber
Bigeye Tuna	Thunnus obesus
Blackfin Snappper	Lutjanus buccanella
Black Grouper	Mycteroperca bonaci
Black Margate	Anisotremus surinamensis
Black Sea Bass	Centropristis striata
Black Snapper	Apsilus dentatus
Bluefin Tuna	Thunnus thynnus
Bluefish	Pomatomus saltatrix
Blueline Tilefish	Caulolatilus microps
Bluetripe Grunt	Haemulon sciurus
Blue Runner	Caranx crysos
Blue Marlin	Makaira nigricans
Blue Stripe Grunt	Haemulon sciurus
Brown Shrimp	Farfantepenaeus aztecus
Cero	Scomberomorus regalis
Cobia	Rachycentron canadum
Coney	Epinephelus fulvus
Cottonwick	Haemulon melanurum
Crevale Jack	Caranx hippos
Croaker	Micropogonias undulatus
Cubera Snapper	Lutjanus cyanopterus
Dog Snapper	Lutjanus jocu
Common Dolphin	Coryphaena hippurus
Pompano Dolphin	
French Grunt	Haemulon flavolineatum
Gag Grouper	Mycteroperca microlepis
Golden Crab	Chaceon fenneri
Golden Tilefish	Lopholatilus chamaeleonticeps
Goliath Grouper	Epinephelus itajara
Grass Porgy	Calamus arctifrons
Graysby	Epinephelus cruentatus
Gray Snapper	Lutjanus griseus

Gray Triggerfish	Balistes capriscus
Greater Amberjack	Seriola dumerili
Hogfish	Lachnolaimus maximus
Jolthead Porgy	Calamus bajonado
King Mackerel	Scomberomorus cavalla
Knobbed Porgy	Calamus nodosus
Lane Snapper	Lutjanus synagris
Lesser Amberjack	Seriola fasciata
Little Tunny	Euthynnus alletteratus
Longspine Porgy	Stenotomus caprinus
Mahogany Snapper	Lutjanus mahogoni
Margate	Haemulon album
Menhaden	Brevoortia tyrannus
Misty Grouper	Epinephelus mystacinus
Mutton Snapper	Lutjanus analis
Nassau Grouper	Epinephelus striatus
Ocean Triggerfish	Canthidermis sufflamen
Pink Shrimp	Farfantepenaeus duorarum
Porkfish	Anisotremus virginicus
Puddingwife	Halichoeres radiatus
Queen Snapper	Etelis oculatus
Queen Triggerfish	Balistes vetula
Red Drum	Sciaenops ocellatus
Red Grouper	Epinephelus morio
Red Hind	Epinephelus guttatus
Red Porgy	Pagrus pagrus
Red Snapper	Lutjanus campechanus
Rock Hind	Epinephelus adscensionis
Rock Sea Bass	Centropristis philadelphica
Rock Shrimp	Sicyonia brevirostris
Royal Red Shrimp	Pleoticus robustus
Sailfish	Istiophorus platypterus
Sailors choice	Haemulon parrai
Sand Tilefish	Malacanthus plumieri
Saucereye Porgy	Calamus calamus
Scamp	Mycteroperca phenax
Schoolmaster	Lutjanus apodus
Scup	Stenotomus chrysops
Sharks (Several species)	
Sheepshead	Archosargus probatocephalus
Silk Snapper	Lutjanus vivanus
Smallmouth Grunt	Haemulon chrysargyreum
Snowy Grouper	Epinephelus niveatus
Spadefish	Chaetodipterus faber
Spanish Grunt	Haemulon macrostomum
Spanish Mackerel	Scomberomorus maculatus

Speckled Hind	Epinephelus drummondhayi
Spiny Lobster	Panulirus argus
Spot	Leiostomus xanthurus
Swordfish	Xiphias gladius
Tiger Grouper	Mycteroperca tigris
Tomtate	Haemulon aurolineatum
Vermilion Snapper	Rhomboplites aurorubens
Wahoo	Acanthocybium solanderi
Warsaw Grouper	Epinephelus nigritus
Weakfish	Cynoscion regalis
Whiteboned Porgy	Calamus leucosteus
White Grunt	Haemulon plumieri
White Shrimp	Litopenaeus setiferus
White Marlin	Tetrapturus albidus
Wreckfish	Polyprion americanus
Yellow Jack	Caranx bartholomaei
Yellowfin Tuna	Thunnus albacares
Yellowedge Grouper	Epinephelus flavolimbatus
Yellowfin Grouper	Mycteroperca venenosa
Yellowmouth Grouper	Mycteroperca interstilitialis
Yellowtail Snapper	Ocyrus chrysurus

10/08/08

FINAL AMENDMENT 4 TO THE FISHERY MANAGEMENT PLAN FOR THE SPINY LOBSTER FISHERY OF PUERTO RICO AND THE U.S. VIRGIN ISLANDS AND AMENDMENT 8 TO THE JOINT SPINY LOBSTER FISHERY MANAGEMENT PLAN OF THE GULF OF MEXICO AND SOUTH ATLANTIC

(Including the Final Environmental Impact Statement, Regulatory Impact Review, and Initial Regulatory Flexibility Analysis)

October 8, 2008

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ACRONYMS/ABBREVIATIONS

ABC	acceptable biological catch
ACOE	Army Corps of Engineers
ADCNR, MRD	Alabama Department of Conservation and Natural Resources, Marine Resources Division
AFS	American Fisheries Society
ALK	Age Length Key
APA	Administrative Procedure Act
AP	advisory panel
ASA	American Soybean Association
ASAP	Age Structured Assessment Program
ASMFC	Atlantic States Marine Fisheries Commission
ASPIC	Stock Production Model
ATCA	Atlantic Tuna Convention Act
B	Biomass
$B_{CURRENT}$	current biomass of stock
B_{MSY}	Biomass at MSY
BOD	Biological Oxygen Demand
BRD	bycatch reduction device
CFMC	Caribbean Fishery Management Council
CFR	Code of Federal Regulations
COE	Corps of Engineers (Same as ACOE)
ComFIN	Commercial Fisheries Information Network
Council	Gulf of Mexico Fishery Management Council
CPUE	catch per unit effort
CL	Carapace Length
CSL	Caribbean Spiny Lobster
CWA	Clean Water Act
CZMA	Coastal Zone Management Act
DEIS	draft environmental impact statement
DO	dissolved oxygen
DOC	U. S. Department of Commerce
DOI	Department of Interior
DPS	distinct population segment
DQA	Data Quality Act
EA	environmental assessment
EEC	European Economic Community
EEZ	Exclusive Economic Zone
EFH	Essential Fish Habitat
EFP	exempted fishing permit
EIS	Environmental Impact Statement
ELMR	Estuarine Living Marine Resources
E.O.	Executive Order
EPA	Environmental Protection Agency
EPIRB	Emergency Position Indication Radio Beacon
ESA	Endangered Species Act

F	instantaneous fishing mortality rate
FACA	Federal Advisory Committee Act
FAO	Food and Agriculture Organization (United Nations)
FCZ	fishery conservation zone (is now called EEZ)
FDACS	Florida Department of Agricultural and Consumer Services
FDEP	Florida Department of Environmental Protection
FDCA	Federal Drug and Cosmetic Act
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FKNMS	Florida Keys National Marine Sanctuary
FL	fork length
FMP	fishery management plan
FMRI	Florida Marine Research Institute
F_{MSY}	Fishing Mortality Rate Yielding MSY
FMU	fishery management unit
FWC	Florida Fish and Wildlife Conservation Commission
FWRI	Fish and Wildlife Research Institute
GC	general counsel
GCSE	General Counsel Southeast Region
GLM	general linear model
GMFMC	Gulf of Mexico Fishery Management Council
HAPC	Habitat Areas of Particular Concern
HMS	Highly Migratory Species
HPUE	Harvest per unit effort
HSI	Habitat Suitability Index
ICCAT	International Commission on Conservation of Atlantic Tunas
IFQ	Individual Fishing Quotas
IPT	Inter-Disciplinary Project Team
IRFA	initial regulatory flexibility analysis
ITQ	individual transferable quota
LE	Law Enforcement
LEAP	Law Enforcement Advisory Panel
M	instantaneous natural mortality rate
MARFIN	Marine Fisheries Initiative
MDMR	Mississippi Department of Marine Resources
MFMT	Maximum Fishing Mortality Threshold
MMPA	Marine Mammal Protection Act
MMS	Minerals Management Service
MP	million pounds
MPA	Marine Protected Area
MRAG	Marine Resources Assessment Group Americas Corporation
MRFSS	Marine Recreational Fishery Statistics Survey
MSAP	Mackerel Stock Assessment Panel
MSFCMA	Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act)
MSST	Minimum Stock Size Threshold
MSY	maximum sustainable yield

MT	million metric tons
MYPR	maximum yield per recruit
NEPA	National Environmental Policy Act
NGO	non-governmental organization
NMFS	National Marine Fisheries Service
NMSA	National Marine Sanctuaries Act
NOAA	National Oceanic and Atmospheric Administration
NOAA Fisheries	Same as NMFS
NOS	National Ocean Service
NPDES	National Pollutant Discharge Elimination System
OIE	Office of International Epizooties
OMB	Office of Management and Budget
OCSLA	Outer Continental Shelf Lands Act
OSP	OptimumSustainable Population Level
OY	optimum yield
PBR	potential biological removal level
PEIS	Programmatic Environmental Impact Statement
ppm	parts per million (e.g., oxygen)
ppt	parts per thousand (salinity)
RA	Regional Administrator of NMFS
RDSAP	Red Drum Stock Assessment Panel
RecFIN	Recreational Fisheries Information Network
RFA	Regulatory Flexibility Act
RFSAP	Reef Fish Stock Assessment Panel
RIR	regulatory impact review
RSW	running sea water system
SAFMC	South Atlantic Fishery Management Council
SAP	stock assessment panel
SARP	Southeast Aquatic Resources Partnership
SAV	Submerged Aquatic Vegetation
SBA	Small Business Administration
SEAMAP	Southeast Area Monitoring and Assessment Program
SEDAR	Southeast Data Assessment Review (stock assessment)
SEFSC	Southeast Fisheries Science Center of NMFS
SEIS	supplemental environmental impact statement
SEP	Socioeconomic Panel
SERO	Southeast Regional Office (NMFS)
SFA	Sustainable Fisheries Act
SMZ	special management zone
SOPPs	Statement of Organization Practices and Procedures
SPL	saltwater products license (FL)
SPR	spawning potential ratio
SSB and SS	spawning stock biomass
SSB/R	spawning stock biomass per recruit
SSC	Scientific and Statistical Committee
TAC	total allowable catch

TED	turtle excluder device
TEWG	turtle expert working group
TL	Tail Length
TOC	total organic carbon
TSV	Taura Syndrome Virus
TW	Tail Weight
USCG	United States Coast Guard
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
VPA	virtual population analysis
WSSV	white spot syndrome virus
YPR	yield per recruit
Z	instantaneous total mortality rate

FINAL ENVIRONMENTAL IMPACT STATEMENT (FEIS) COVER SHEET

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Name of Action

Amendment 4 to the Spiny Lobster Fishery Management Plan of Puerto Rico and the U.S. Virgin Islands and Amendment 8 to the Spiny Lobster Fishery Management Plan of the Gulf of Mexico and South Atlantic.

Type of Action

(X) Administrative	( ) Legislative
() Draft	(X) Final

Abstract

The United States is a major importer of spiny lobster, importing over 88,000 tons (over 194 million lbs) over the past 10 years, worth an estimated $2.27 billion dollars. The United States imports over 90% of the spiny lobster harvested in South and Central America and the Caribbean countries. The major exporters to the United States are the Bahamas, Brazil, Honduras and Nicaragua. All of these exporting countries have some form of minimum size requirement, but they are not standardized and enforcement is severely lacking. Therefore, NOAA Fisheries Service in coordination with the Caribbean, South Atlantic, and Gulf of Mexico Fishery Management Councils is considering minimum conservation standards on imports to curtail the flow of undersized lobster harvested in foreign countries. Eliminating the primary market for undersized lobster is expected reduce the harvest of undersized animals and increase the spawning stock biomass and long-term potential yield within the pan-Caribbean spiny lobster fishery.

FISHERY IMPACT STATEMENT

This integrated document contains all elements of the Plan Amendment, Final Environmental Impact Statement (FEIS), Initial Regulatory Flexibility Analysis (IRFA), Regulatory Impact Review (RIR), and Social Impact Assessment (SIA)/Fishery Impact Statement (FIS).

Actions within this Amendment/EIS will improve the status of the spiny lobster stock pan-Caribbean by providing an incentive for foreign nations to implement conservation standards designed to protect the spawning stock and therefore the reproductive ability of the spiny lobster population. Additionally, further protections will be provided to undersized lobsters, and berried (egg-bearing) females.

The combined economic benefits of this Amendment would be larger minimum-sized imported lobsters with greater market value and enhanced long-run domestic and foreign revenues, profits and incomes that derive from a biologically and economically improved resource. Further, economic benefits of this Amendment would be improved domestic and foreign revenues, profits and incomes that derive from a biologically and economically improved resource.

This Amendment is expected to adversely affect cultural traditions and social networks of organized groups and communities that engage in the illegal importation of Caribbean spiny lobster. Furthermore, the same combination of actions is expected to beneficially affect cultural traditions and social networks of groups and communities that engage in the legal importation of Caribbean spiny lobsters.

1.0 EXECUTIVE SUMMARY

Fisheries for spiny lobster (*Panulirus argus*) exist throughout its range in the Caribbean and tropical western Atlantic. Foreign and U.S. scientists and fisheries managers all concur the Caribbean spiny lobster is fully exploited or over-exploited in much of its range (Cochrane and Chakalall 2001). Spiny lobsters are being harvested below the respective Continental and Caribbean U.S. minimum size limits; this is adversely impacting recruitment throughout Florida and the Caribbean because of the distribution and dispersal of larvae during their long larval phase. A reduction of effort on undersized lobster and a more comprehensive enforcement tool would increase spawning stock biomass and increase potential yield. The lobster seafood industry has even recognized this fact and has asked respective governments to address the illegal harvest and exportation of undersized lobster tails to the United States.

This Amendment/EIS will examine two actions with various alternatives to restrict imports of spiny lobster into the United States to minimum conservation standards to achieve an increase in the spawning biomass of the spiny lobster stock and increase long-term yields from the fishery. Limiting Caribbean spiny lobster imports to a uniform minimum size that protects juvenile spiny lobsters would help stabilize the reproductive potential of the Caribbean spiny lobster by reducing the amount of juvenile spiny lobster mortality in foreign fisheries. Such action would result in the harvest of larger lobsters in exporting countries and approximately 50 percent of these larger lobsters will be capable of spawning, thus increasing the probability of dispersal of Caribbean spiny lobster larvae throughout the species' range. Scientists state that the harvest of juvenile tails in other Caribbean countries impacts the sustainability of U.S. lobster stocks because these harvesting countries produce the parental stocks and larvae for the U.S. stocks. In other words, if you destroy brood stock off the coast of Latin America, you effectively destroy the fisheries of other countries, regardless of the management schemes in those countries. This animal is an example of a shared resource in that it has no national boundaries because of its dependency on the ocean currents for its larval distribution.

Action 1 is intended to improve the status of the spiny lobster stock pan-Caribbean by providing an incentive for foreign nations to implement conservation standards designed to protect the spawning stock and therefore the reproductive ability of the spiny lobster population. The most effective means for creating this incentive is to improve NOAA law enforcement's (LE) capabilities in preventing undersized lobster from being imported to the United States and eliminating the market for undersized lobster tails. By implementing an import restriction on size, LE will be more capable of tracking undersized lobster shipments and developing criminal cases against suspected importers of undersized lobster, thus eliminating the market for undersize lobster tails.

Action 2 is designed to: 1) provide further protections to undersized lobsters, and 2) protect berried (egg-bearing) females. If any importation conservation standards are to have the desired effect, then the trade in "lobster meat" must be stopped to close the potential loophole of harvesting undersize lobster, processing it into meat, and then making it available in the market. Unshelled lobster tail meat shipped in its bulk raw form cannot be accurately measured and this practice has been performed by unscrupulous lobster exporters / importers to thwart law enforcement's efforts to regulate a minimum size. The protection of berried females (or those that were, prior to being stripped) is imperative if the minimum conservation sizes are implemented in order to protect the spawning stock biomass; if no protections are afforded to the females as they are actively reproducing, then all benefits from increasing the spawning stock biomass have been lost. Both of these actions will aid in increasing the spawning stock biomass and protecting the spiny lobster resource.

2.0 INTRODUCTION

This FEIS/Amendment 4 to the Spiny Lobster Fishery Management Plan (FMP) of Puerto Rico and the U.S. Virgin Islands, and Amendment 8 to the Spiny Lobster Fishery Management Plan of the Gulf of Mexico and South Atlantic will modify all three Councils' FMPs to restrict spiny lobster imports into the United States to minimum conservation standards to achieve an increase in spawning stock biomass and increase long-term yield from the fishery.

2.1 Background

The Caribbean spiny lobster (*Panulirus argus*) has a relatively long planktonic larval phase, which is referred to as the puerulus stage. Planktonic larvae are widely dispersed by ocean currents before they settle and recruit to a specific habitat. The long larval duration for spiny lobsters accounts for connectivity from their source areas to their settlement areas. Recruitment is dependent on environmental conditions, such as temperature and salinity, and on the availability of spawning adults, which is influenced by fishery factors, such as fishing pressure and minimum size limit compliance. These fishery factors can be affected by having an adequate regulatory program to protect spiny lobster (e.g., size limits and protections for berried females) and having adequate enforcement of the program. Studies also have shown local gyres or loop currents in certain locations could influence the retention of locally spawned larvae. In addition, benthic structures such as coral reefs may disturb the flow of water and lead to the settlement of larvae in a particular location (Lee et. al. 1994).

Most of the Caribbean spiny lobster research has been conducted on the Florida population, but the interconnectivity issue also has been studied in the Caribbean region and is recognized and discussed in the Caribbean Council's Spiny Lobster Fishery Management Plan. Caribbean spiny lobster ranges throughout the western Atlantic Ocean from North Carolina to Brazil, including Bermuda, the Bahamas, and all of the Caribbean and Central American areas in between (Herrnkind 1980). DNA analysis indicates a single stock structure for the Caribbean spiny lobster (Lipcius and Cobb, 1994; Silberman and Walsh 1994) throughout its range.

Some Caribbean spiny lobster fisheries managed by other countries (i.e., Brazil, Nicaragua, and Ecuador) are reportedly heavily exploited. These countries export millions of pounds of lobsters to the United States that are at or below their mean size at reproduction. Overexploiting spiny lobster stocks in foreign fisheries could jeopardize the abundance and structure of U.S. stocks because the larval recruitment of U.S. stocks is dependent on the reproductive potential of stocks managed by other countries. The potential for overfishing the Caribbean spiny lobster is relatively high because a lucrative market exists for all sizes of this species. Approximately 90 percent of the Caribbean spiny lobster marketed in the United States is harvested by foreign fisheries managed by Central and South America countries.

Limiting Caribbean spiny lobster imports to a uniform minimum size that protects juvenile spiny lobsters would help stabilize the reproductive potential of the Caribbean spiny lobster by reducing the amount of juvenile spiny lobster mortality in foreign fisheries. Such action is expected to result in the harvest of larger lobsters in exporting countries and approximately 50 percent of these larger lobsters will be capable of spawning, thus increasing the probability of dispersal of Caribbean spiny lobster larvae throughout the species' range. Scientists state that the harvest of juvenile tails in other Caribbean countries impacts the sustainability of U.S. lobster stocks because these harvesting countries produce the parental stocks and larvae for the U.S. stocks. In other words, if you destroy brood stock off the coast of Latin America, you effectively destroy the fisheries of other countries, regardless of the management schemes in those countries. This animal is an example of a shared resource in that it has no national boundaries because of its dependency on the ocean currents for its larval distribution.

There are two main issues associated with addressing the importation of undersize lobsters. First is the importation of lobsters which are below the domestic size limits, and concurrently the mean size at sexual maturity, which were legally harvested in another nation's waters. Second is the importation of lobsters below the domestic size limit, which were illegally harvested in violation of harvest restrictions in other nations. This second activity is already illegal, as the Lacey Act prohibits the importation of lobster harvested in violation of the laws of another nation.

Establishing a minimum size for imports would address both of these issues. By restructuring the importation of lobsters smaller than the domestic size limit, it will severely limit, if not eliminate, the market for legally and illegally harvested undersized lobster. This is expected to serve as an incentive for countries that do not currently have such measures to implement consistent size limits in order to protect juvenile lobster.

Establishment of a uniform minimum size for spiny lobsters imported to the U.S. would assist law enforcement officers in restricting illegal product in the market. The "big four" exporters to the United States are the Bahamas, Brazil, Honduras, and Nicaragua. All these countries have some form of minimal size limit for the Caribbean spiny lobster, but unfortunately this size limit is not standardized. Furthermore, exporting countries do not have the law enforcement resources to effectively monitor shipments to the United States.

The United States imports millions of dollars of undersized lobster each year. Most of these imports go undetected because of the enforcement loopholes that exist for international poachers. These loopholes include: (a) the lack of a U.S. minimal size limit that is applicable for all imports; (b) the use of secretive codes to disguise the undersized lobster tail shipments; (c) the increased use of "trans-shipments through countries of convenience" (i.e. shipping illegal product thru countries that have weaker lobster laws and changing the country of origin to avoid investigators); and (d) shipping the illegal tails to U.S. ports, where inspectors are not as savvy to the lobster smuggling issues.

Minimum size limits are typically used to protect the breeding stock in a fishery, and are often defined at a size that will allow individuals in a population the opportunity to breed at least once before being subject to harvest. The 3 inch (7.6 cm) carapace length (CL) minimum size limit restriction on imports that is currently being considered by the three regional Fishery Management Councils and NOAA Fisheries Service would provide about 50 percent of spiny lobsters the opportunity to spawn at least once before they can be landed by a fishery (Lyons et al. 1981). As an indication of the importance of establishing a minimum import size close to the size at maturity for spiny lobster, each Caribbean spiny lobster measuring 3" CL typically produces about 300,000 eggs per clutch. However, a more recent study demonstrates the potential difficulty in determining the size at maturity for spiny lobster. Bertelsen and Matthews (2001) compared spiny lobster fecundity between adjoining populations of spiny lobster in Florida. The authors found those lobsters in the heavily fished Florida Keys fishery reproduced at a smaller size than those in the sanctuary of the Dry Tortugas National Park. Lobsters from the fishery less than 70 mm (2.75 inches) were found to produce eggs, whereas very few lobsters less than 80 mm (3.15 inches) CL and none less than 70 mm CL produce eggs in the sanctuary population.

Current U.S. regulations for the Caribbean, established in 1983, prohibit the possession of egg-bearing females, and established a minimum size limit (3.5 inches) in terms of carapace length. The Caribbean Fishery Management Council rejected a minimum weight limit because of difficulty of weighing spiny lobsters at sea.

NOAA's Office of Law Enforcement strongly recommends an import restriction include a minimum size limit that utilizes a tail weight measured in ounces (using carapace and tail length conversions). All spiny lobsters will be required to be landed with the shell attached. The landing limit will be converted to a minimum weight limit range (in ounces and grams), noting that Florida Fish and Wildlife Commission scientists have published conversion tables that could be used to determine the most applicable length and weight requirements. The implementation of a minimum weight in ounces is critical for NOAA law enforcement as the seafood industry, processes, packs, ships, exports, imports, and sells lobster tails by weight. In addition, U.S. Customs' entry documents and the seafood industry's sales, storage and bills of lading documents typically include the tail weights (in ounces), making this measurement an effective enforcement tool to track undersized lobster, even after it enters the U.S. port.

Preliminary discussions with all three regional Fishery Management Councils and the state of Florida indicate broad support for a minimum size landing limit restriction on Caribbean spiny lobster imports. The intent is to maintain an open line of dialogue with all parties throughout the fishery management plan amendment process to ensure any problems or issues that surface as the proposed action is developed are satisfactorily addressed.

Since 2003, an effort has been underway to establish a U.S. minimal size limit that would be applicable to spiny lobster imports. This effort has been supported by the U.S. Department of Justice, NOAA's Office of Law Enforcement, Southeast Region, three regional Fishery Management Councils and, recently, by some leading seafood industry corporations, which realize the spiny lobster fishery is being decimated throughout the Caribbean basin. The United States has other existing restrictions on seafood imports involving American lobster, imported swordfish and imported tuna.

There are about 45 species of spiny lobsters species (commonly called rock lobster) in the family Palinuridae throughout the world with several occurring in the Caribbean basin. The Caribbean spiny lobster (*P. argus*; aka red lobster tail and Florida spiny lobster) is the predominant species making up approximately 95 percent of the lobster harvested and marketed in the Caribbean basin countries (i.e., Florida, Central America (Atlantic side), Bahamas, and Brazil). Symmetrical spots on the tail segments and unique markings on the tail fins of this species make it morphologically distinguishable from other species.

Spiny lobsters that originate from the Caribbean basin are tailed, sorted by weight, packed in 10-pound boxes, and shipped to the United States for consumption. Based on law enforcement officer's experiences in inspecting these boxes, the contents are exclusively one species (Caribbean spiny lobster). This is true for the Central American countries (Atlantic side), the Caribbean Island countries and Florida. Brazil poses a slight problem because it mixes Caribbean spiny lobster with *P. lauvicauda* in some shipments that are exported to the United States. However, Brazilian authorities have identified the problem and are attempting to implement a rule that would change this practice and would require species to be isolated before packing.

NOAA's Office of Law Enforcement, Southeast Region, has made several significant Lacey Act cases involving undersized lobster (w/ Honduras, Nicaragua, Bahamas, and an ongoing one with Brazil). These cases typically are criminal and are rather complex in nature due to the need for cooperation with foreign governments, poorly written foreign laws, and the millions of dollars of illegal proceeds. A U.S. minimum restriction applicable to spiny lobster imports would greatly assist law enforcement and federal prosecutors to stem the illegal and profitable flow of undersized imports into the U.S. markets.

<u>International</u>
In an international fishery like that of spiny lobster, "consensus" on addressing concerns is important, as are U.S. efforts to engage other countries in negotiations/agreements. FAO/WECAFC has organized five workshops on spiny lobster in cooperation with most regional agencies and institutions, dealing with various projects: Belize City, Belize (1997); Merida, Mexico (1998, 2000, and 2006); and Havana, Cuba (2002). A representative from the Caribbean Council attended all the workshops. A staff member of NOAA Fisheries Service's Southeast Region attended the 2006 workshop in Merida.

The 2006 Merida workshop was divided into two parts. The first part occurred September 19- 27, and was attended by senior scientists from lobster producing nations. The second part occurred September 28-29, and was attended by senior fishery managers, senior scientists, representatives from the fishing and processing industry, and selected lobster importers. The objectives of the workshop were: (1) to review and update the assessments of the status of Caribbean spiny lobster at national and regional levels and to consider the current levels of exploitation and recent trends in the fishery; and (2) to evaluate the nature and severity of current problems in the fishery, including the number of undersized lobster being caught and exported.

The workshop sought regional agreement by senior fishery managers on strategies to address problems and to ensure optimal and sustainable use of the resource. Senior scientists and senior decision makers of the following lobster producing nations participated in the workshop: Antigua and Barbuda, Bahamas, Belize, Brazil, Colombia, Costa Rica, Cuba, Dominican Republic, France on behalf of Guadeloupe and Martinique, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Turks and Caicos, United States, and Venezuela. The senior fishery managers carefully considered and adopted the report of the senior scientists. In keeping with the recommendation to allow about 50 percent of the stock to reach maturity, the national representatives agreed to a minimum harvest size of 74 mm (2.91 inches) cephalothorax length. Nations with minimum size limits greater than 76 mm were encouraged to retain the larger minimum size limits because of the additional conservation and economic benefits they provide. In addition to the minimum size limit, it was agreed that managing fishing mortality also is necessary to achieve sustainable use of the resource. It was further agreed that countries that already have minimum size limits in place should take action to implement and enforce them effectively to reduce the currently high catches of juveniles in order to protect and allow the species to rebuild throughout its range.

More recently, at a Regional workshop on the lobster fisheries in Central America held in Managua, Nicaragua, December 10-11, 2007, sponsored by OSPESCA, the delegates representing Central American fishery management agencies, artisanal fishers, industry, and other institutions developed an 18 point workshop accord, which addressed, among other things, a minimum harvest size for lobster tails of 140 mm (5.5 inches). The accord also recognized industry practices and determined for commercial purposes, each box must have an average tail weight of five ounces with a range of 4.5 to 5.5 ounces. A 5.5 inch tail length and 4.5 oz weight equate to a 3.0 inch carapace length.

2.2 Management History

Gulf of Mexico and South Atlantic

The original Fishery Management Plan (FMP) from the Gulf of Mexico and South Atlantic Fishery Management Councils was written in 1982. It states “The Fishery Conservation and Management Act (FCMA) requires that stocks be managed throughout their range to the extent practicable” and “There may be a relationship between spiny lobster stocks in the Caribbean, South Atlantic and Gulf of Mexico regions" (pg. 7-1). A definition of the fishery is also provided:

> "The spiny lobster fishery consists of the spiny lobster, *Panulirus argus*, and other incidental species of spiny lobster (spotted spiny lobster, *P. guttatus*; smooth tail lobster *P. laevicauda*; Spanish lobster, *Scyllarides aeguinoctialis* and *S. nodifer*), which inhabit or migrate through the coastal waters of and the Fishery Conservation Zone (now known as the exclusive economic zone (EEZ)) of the Gulf of Mexico and South Atlantic Fishery Management Council areas and which are pursued by commercial and recreational fishermen" (pg. 12-1).

The original FMP analyzed several different potential minimum sizes, ranging from 2.75 to greater than 3 inches CL. Ultimately, the smaller minimum sizes were not used for biological reasons as they would not protect the spawning stock. The larger sizes were deemed to cost the fishery too much economically and socially, therefore, the 3 inch CL was chosen.

In multiple places within the FMP, the importation of undersized lobster was noted as a concern. Under the description of alternative optimum yields it was noted:

> "The characteristics of demand for lobster indicate preferences for the smaller-sized animals; in fact, market forces would endanger spiny lobster stocks because the greatest preference in the New York wholesale market (Exhibit 9-3) is for animals less than 3.0 inches CL, sizes at which reproduction has not yet occurred. (All of these smaller-sized lobsters are imported)" (pg. 12-4).

Further, under the possible alternatives that were not preferred, a prohibition on the import of undersized spiny lobster is listed. The rationale for not proposing the ban was two-fold. First, there was concern that changes in the import market, which supplies approximately 90% of the lobsters consumed in the United States, could have significant affects on the price-size relationship, though the magnitude of the change on the retail market could not be estimated. Second, the nations harvesting Caribbean spiny lobster were uncomfortable about the impact of import restrictions on international relationships (pg. 12-35).

Since the 1980's the FMP has been amended consistent with new requirements of the Magnuson-Stevens Act, but those amendments have not affected the Caribbean nations regarding the minimum import size for spiny lobster.

Caribbean
The original FMP for the Caribbean was written in 1981. It acknowledges the need to manage spiny lobster throughout its range and interrelated stocks could be managed as a unit or in close coordination. The plan further acknowledges that "conclusive data regarding genetics between various geographic areas…not available…establishment of an international coalition will eventually be necessary to effectively manage this migratory species throughout its range" (pg. 5). The plan addresses only the species *P.*

argus where it is limited to the geological platforms of Puerto Rico and the Virgin Islands essentially inside the 100-fathom isobath. It continues "these shelf areas include not only the Commonwealth of Puerto Rico and the territory of the Virgin Islands, but also the entire chain of the British Virgin Islands. The lobster population recognizes none of these political entities nor the limits of territorial seas" (pg. 6).

The stock unit is defined as:

> "The question of whether or not biologically distinct stocks of *P. argus* may be identified is not resolved. For purposes of this plan three biological assessment areas (distinguished by their user groups and geography) were assumed; (1) Puerto Rico, (2) St. Thomas and St. John, and (3) St. Croix. A single optimum yield is established. There is nominally one species and the source(s) of recruitment are not verified" (Section 4.2)".

The original FMP analyzed several different potential minimum sizes, ranging from 2.75 to greater than 3.5 inches CL. As in the Gulf of Mexico and S. Atlantic FMP, the smaller minimum sizes were eliminated because they would not protect the spawning stock. The larger sizes were deemed to cost the fishery too much economically and socially, therefore, the 3.5 inch CL was chosen (see below for rationale for differences in minimum size between the 2 FMPs).

Similar to the Gulf of Mexico and S. Atlantic FMP, the Caribbean FMP mentions the use of an import ban of undersized lobster as a method to improve the stocks status. Under "Recommendations to the Secretary of Commerce" the FMP states:

> "It is recommended that the Secretary of Commerce undertake whatever action may be necessary and appropriate to immediately prohibit the importation into the U.S. Virgin Islands and Puerto Rico of undersized (less than 3.5 inches CL) or berried spiny lobsters and of spiny lobster tails of less than 6 oz. total weight" (Section 5.1).

In addition, under this section, the Secretary of Commerce is asked to adopt an action plan to work with other Caribbean nations to enact conservation and management measures consistent with those adopted by the Caribbean FMC with regard to spiny lobster and other species.

As with the S. Atlantic and Gulf of Mexico FMP, since the 1980's the Caribbean FMP has been amended consistent with new requirements of the Magnuson-Stevens Act, but those amendments have not affected the above definitions or the minimum size regulations of the spiny lobster fishery.

3.0 PURPOSE AND NEED

Foreign and U.S. scientists and fisheries managers all concur the Caribbean spiny lobster is fully exploited or over-exploited[1] in much of its range (Cochrane and Chakalall 2001). Spiny lobsters are being harvested below the respective Continental and Caribbean U.S. minimum size limits and below the size at first maturity; this is adversely impacting recruitment throughout Florida and the Caribbean because of the distribution and dispersal of larvae during their long larval phase. A reduction of effort on undersized lobster and more comprehensive enforcement would increase spawning stock biomass and increase potential yield. The lobster seafood industry has even recognized this fact and has asked respective governments to address the harvest and exportation of undersized lobster tails to the United States.

This Amendment/EIS will examine various alternatives to restrict imports[2] of spiny lobster into the United States to minimum conservation standards to achieve an increase in the spawning biomass of the spiny lobster stock and increase long-term yields from the fishery.

4.0 MANAGEMENT ALTERNATIVES

The management alternatives section is divided into two actions. The first action will examine various morphometric values that imported spiny lobster would be required to meet. The morphometric values in Action 1 provide an easily measurable requirement that can be used by fishermen, importers, and law enforcement to ensure compliance. The second action examines other import restrictions, which will further protect the spiny lobster stock and close any potential loopholes that may be exploited in an effort to circumvent minimum size restrictions.

4.1 Action 1: Minimum Size Limits for Spiny Lobster (*Panulirus argus)* Imported into the United States

A. <u>Alternative 1 (No Action Alternative) – Do not establish minimum size limit restrictions on spiny lobster imported into the U.S.</u>

Under the no action alternative, imports would be subject to the management and regulations of the exporting country and violations of those regulations would be pursued through the Lacey Act.

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[1] Fully exploited means the act of employing to the greatest possible advantage; over-exploited means exploited to the point of diminishing returns

[2] For the purpose of this amendment/EIS the term “import” (A) means to land on, bring into, or introduce into, or attempt to land on, bring into, or introduce into, any place subject to the jurisdiction of the United States, whether or not such landing, bringing, or introduction constitutes an importation within the meaning of the customs laws of the United States; but
(B) does not include any activity described in subparagraph (A) with respect to fish caught in the U.S. exclusive economic zone by a vessel of the United States" (16 U.S.C. 1802 (22)).

B. **Preferred Alternative 2** – No person in the U.S. would be allowed to import a spiny lobster (*Panulirus argus*), as follows:

1. Any spiny lobster of less than 5 ounces tail weight (5 ounces is defined as a tail that weighs 4.2 – 5.4 ounces). If the imported product does not meet this minimum weight requirement, the person importing the lobster can demonstrate compliance by showing that the product imported satisfies the tail length requirement, or that it was harvested from an animal that satisfied the minimum carapace length requirement of:
   a. Greater than 3.0 inches (7.62 cm) carapace length if the animal is whole.
   b. Greater than or equal to 5.5 inches (13.97 cm) tail length if only the tail is present.

2. *In Puerto Rico and the U.S. Virgin Islands:* Any spiny lobster of less than 6.0 ounces tail weight (6 ounces is defined as a tail that weighs 5.9 – 6.4 ounces). If the imported product does not meet this minimum weight requirement, the person importing the lobster can demonstrate compliance by showing that the product imported satisfies the tail length requirement, or that it was harvested from an animal that satisfied the minimum carapace length requirement of:
   a. Greater than or equal to 3.5 inches (8.89 cm) carapace length if the animal is whole.
   b. Greater than or equal to 6.2 inches (15.75 cm) tail length if only the tail is present.

C. Alternative 3 – No person would be allowed to import into the U.S., including Puerto Rico and the U.S. Virgin Islands, any spiny lobster (*Panulirus argus*) of less than 5 ounces tail weight (5 ounces is defined as a tail that weighs 4.2 – 5.4 ounces).
If the imported product does not meet this minimum weight requirement, the person importing the lobster can demonstrate compliance by showing that the product imported satisfies the tail length requirement, or that it was harvested from an animal that satisfied the minimum carapace length requirement of:
   a. Greater than 3.0 inches (7.62 cm) carapace length if the animal is whole.
   b. Greater than or equal to 5.5 inches (13.97 cm) tail length if only the tail is present.

Comparison of Action 1 Alternatives

Fisheries for spiny lobster (*Panulirus argus*) exist throughout its range in the Caribbean and tropical western Atlantic. The Western Central Atlantic Fishery Commission (WECAFC) held workshops in 2000 and 2002 regarding the management of the spiny lobster fisheries in the WECAFC region and the scientific committee from that workshop concluded that spiny lobster are fully exploited to over-exploited throughout its entire range. [NOTE: WECAFC is part of the Food and Agriculture Organization (FAO) and was established pursuant to FAO's Constitution. It is advisory only and has no regulatory powers, unlike other Regional Fisheries Management Organizations such as the International Commission for the Conservation of Atlantic Tunas (ICCAT).]

Several genetic studies have been conducted on spiny lobster in the Caribbean since the 1990's. The consensus from these experiments is that the spiny lobster population appears to be interconnected throughout the Caribbean with the possibility of a semi-isolated subpopulation in part of Brazil. Despite the somewhat limited information regarding the Caribbean as a whole, based on scientific studies, the U.S. population is very likely dependent on recruitment from other areas (Lyons et al. 1981, Acosta et. al. 1997).

The alternatives in Action 1, other than the status quo, are intended to eliminate the largest market for undersize spiny lobster (the U.S.) and provide an incentive for foreign nations that do not have minimum conservation standards to implement conservation standards which will improve the status of the spiny lobster stock in the U.S. and throughout the Caribbean. The most effective means for creating this incentive is to improve law enforcement (LE) capabilities for preventing undersized lobster from being imported to the United States. By implementing an import restriction on size, LE will be more capable of tracking undersized lobster shipments and developing cases against suspected importers of undersized lobster. Under existing laws (most notably the Lacey Act), LE must develop an extensive record and work in coordination with foreign nations when attempting to develop a case against an importer. This is often a very complicated and difficult process to coordinate. By changing the domestic laws to place conservation standards on imported lobster, this amendment/EIS will help protect lobster stocks, as well as provide a better tool for LE officials to deter the importation of undersized lobster.

Due to the complexity of the spiny lobster industry and the high volume of international trade, the alternatives provide a number of means for determining whether an individual lobster is indeed undersized. **Preferred Alternative 2** and **Alternative 3** are structured the same, but alter the minimum size depending on the location of importation (i.e., into the U.S. or the U.S. Caribbean). Table 4.1.1 lists each alternative and the associated minimum possession limits for the alternative. The multiple minimum size morphometrics (i.e., carapace length, tail length, and tail weight) provided in each alternative are intended to provide an understandable and practical size restriction for each component of the industry. For example, the use of carapace length (CL) is currently what fishermen, while at sea, use to verify if an individual lobster is indeed legal (Figure 4.1.1). Tail length (TL) is used by some fishermen while at sea; for example, Gulf of Mexico and South Atlantic fishermen in the EEZ who possess a tailing permit. The tail weight (TW) is used by processors, importers, and exporters. Law enforcement agents would use CL and TL for inspections at sea and dockside as is the current practice, while TW would be used in examining imports if either **Preferred Alternative 2** or **Alternative 3** were chosen.

Importers would be required to meet the minimum weight conservation standard identified in the alternatives. However, if the imported product does not meet the minimum weight requirement, the person importing the lobster can demonstrate compliance by showing that the product imported satisfies the equivalent tail length requirement, or that it was harvested from an animal that satisfied the equivalent minimum carapace length requirement.

Figure 4.1.1. A measurement of the carapace length on a spiny lobster.

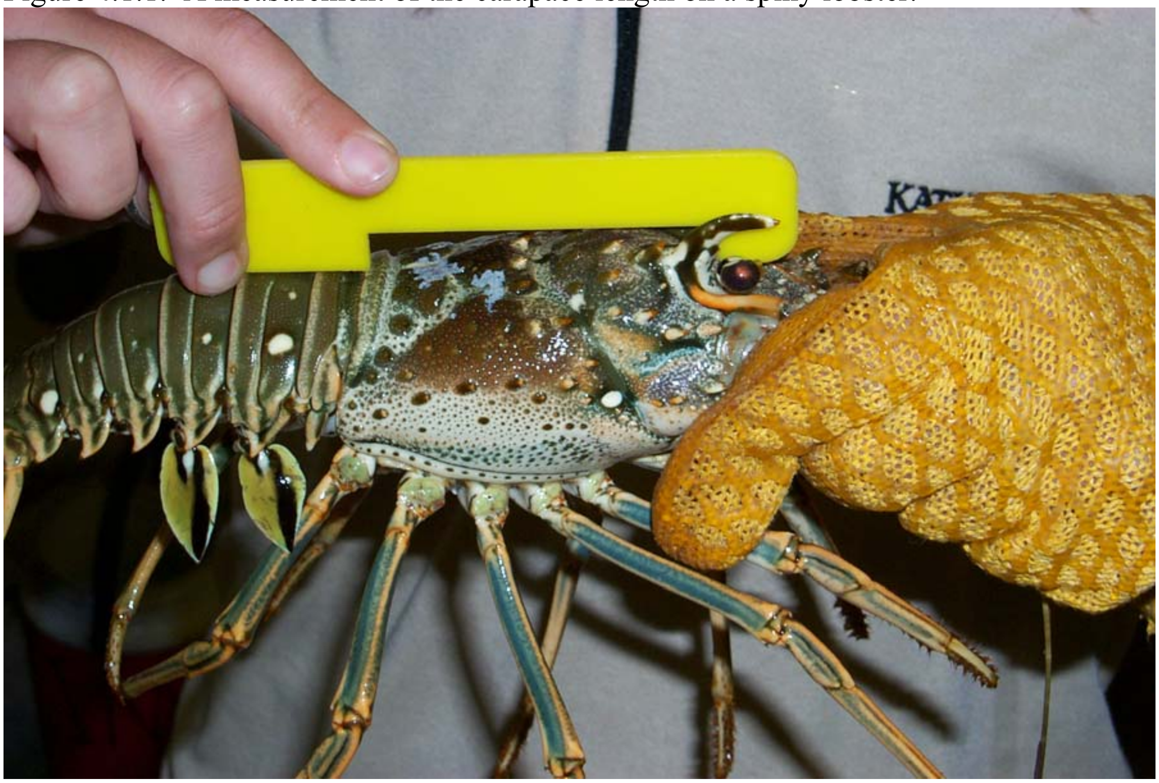

Table 4.1.1. Alternatives with respective morphometric requirements for spiny lobster importation.

Alternative	Carapace Length	Tail Length	Tail Weight/ Industry Allowances
1	N/A	N/A	N/A
2	> 3.0 inches U.S.; ≥ 3.5 inches in the Caribbean	≥ 5.5 inches U.S.; ≥ 6.2 inches Caribbean	≥ 4.2 oz U.S.; ≥ 5.9 oz Caribbean/ U.S - 5 oz weights = 4.2 - 5.4 oz; Caribbean - 6 oz weights = 5.9 - 6.4 oz.
3	> 3.0 inches	≥ 5.5 inches	≥ 4.2 oz/ 5 oz weights = 4.2 - 5.4 oz

The intent of this amendment is to utilize the tail weight in deterring under-sized lobster imports as that is the unit of measure the industry utilizes as it markets, imports, stores, transports, and sells this product. Spiny lobster is rarely, if ever, imported or marketed in the U.S. as a whole animal, but instead as frozen tails. Standard industry practice for overseas spiny lobster processing is to separate, sort, and box the tails by their tail weight prior to shipping. In addition, U.S. Customs' entry documents and the seafood industry's sales, storage and bills of lading documents typically include the tail weights (in ounces), making this measurement an effective enforcement tool to track undersized lobster, even after it enters the U.S. port. It is estimated over 99% of spiny lobster product enters the U.S. in this fashion (P. Raymond, NOAA OLE, pers. comm.).

Additionally, there was a December 2007 workshop with delegates from Central American fishery management agencies, artisanal fishers, and industry held in Managua, Nicaragua (OSPESCA). The delegates developed an 18 point workshop accord which contained recommendations for minimum conservation standards including a minimum harvest size for tails of 140 mm and a minimum tail weight of 4.5 ounces. For the commercial industry, this translates into each shipping box having an average tail weight of 5 ounces with a range from 4.5 to 5.5 ounces.

However, the 4.5 ounce tail weight recommendation was not based on scientific conversions from the recommended 140 mm tail length, but was instead based on industry practice of sorting and shipping. Tables 4.1.2 and 4.1.3 provide conversions from carapace length to tail length and tail weight based on Matthews et al. (2003). If we examine the 140 mm (5.5 inch) tail length recommendation, we see it is derived from one standard deviation of the mean for a 3.0 inch (76.2 cm) carapace length animal (table 4.1.3, in green). Therefore, if a tail length recommendation is based on one set of scientific standards, all conversions from the carapace length should be based on that same standard. Therefore, the appropriate tail weight to be used for a 3.0 inch carapace length animal would be a 4.15 ounce tail weight (Table 4.1.3, in yellow). This, like the tail length recommendation is based on one standard deviation from the mean for the measurements of a 3.0 inch carapace length animal. For the purpose of simplifying this requirement, the weight has been rounded to one decimal place to make the requirement a 4.2 ounce tail weight. For imports to the U.S. Caribbean, similar conversions from a 3.5 inch CL animal yield a minimum TW of 5.9 ounces and a TL of 6.2 inches (Table 4.1.3, in turquoise).

Therefore, in an effort to accommodate industry practices this amendment defines the 5 ounce tail as ranging from 4.2 to 5.4 ounces and a 6 ounce tail as ranging from 5.9 to 6.4 ounces. This allows industry to maintain their sorting and packaging practices while instituting the minimum tail weight conservation standard based on scientific conversions.

The use of this scientific standard has already been applied in the current regulations for the Gulf and South Atlantic joint FMP for spiny lobster. The Gulf and South Atlantic FMP allows lobsters to be tailed while at sea if the vessel has the appropriate tailing permit. The minimum size for tails to be legal is 5.5 inches, which is derived from one standard deviation of tail length for a 3.0 inch carapace length animal (Table 4.1.3 in yellow). Using the one standard deviation approach, it is expected that 84.13% of all 3.0 inch carapace length animals would be legal based on their tail length and tail weight measurements at 5.5 inches and 4.2 ounces, respectively.

Table 4.1.2. CL and average TL and TW conversions (metric and English conversions; Matthews, pers. Comm.)

Carapace length (mm)	Tail weight (g)	Tail length (mm)		Carapace length (in)	Tail weight (oz)	Tail length (in)
76.2	122.8	142.5		3.00	4.34	5.61
82.6	153.5	153.4		3.25	5.42	6.04
88.9	188.0	164.2		3.50	6.64	6.46

Table 4.1.3. CL measurements with converted TL and TW for animals minus 1 SD (metric and English conversions; Matthews, pers. Comm.)

Carapace length (mm)	Tail weight (g)	Tail length (mm)		Carapace length (in)	Tail weight (oz)	Tail length (in)
76.2	117.6	139.9		3.00	4.15	5.51
82.6	143.2	149.6		3.25	5.06	5.89
88.9	168.3	158.4		3.50	5.94	6.24

Alternative 1 would not establish restrictions on spiny lobster imports. **Preferred Alternative 2** would require all imported lobster to have a TW of 4.2 ounces or greater if imported to the U.S.; for those lobsters imported to the U.S. Caribbean, a lobster must have a TW of 5.9 ounces or greater. Because weighing tails at sea is difficult, fishermen would continue to use the CL and TL measurements as appropriate for their region or country to ensure compliance with the legal requirements. Law enforcement officials would have the ability to use those same measurements for at sea and dockside enforcement while utilizing the appropriate TW measurement for enforcement of imported lobster tails. Due to the scientific variation of lobster tail weight, an importer may demonstrate compliance with the minimum conservation standards by providing documentation that an animal that does not meet the TW requirement meets the TL or CL measurement.

Alternative 3 would require all imported lobster to have a TW of 4.2 ounces or greater regardless of the port of entry into the U.S. This alternative would function similarly to **Preferred Alternative 2** with fishermen using the CL and TL measurements and LE utilizing those measurements plus the TW. However, there is some concern in the U.S. Caribbean that there may be a loss of the conservation standards with the use of this single size approach. The U.S. Caribbean has a more restrictive conservation standard on spiny lobster (i.e., a minimum landing size of 3.5 inches) than does the continental U.S. The loss in conservation would be seen through the creation of a loophole where products may be claimed as imports even if they are not in an effort to circumvent local laws. Similarly, law enforcement may lose some of its ability in enforcing local laws because of the allowance of smaller lobster through the import market. In weighing these differences between **Preferred Alternative 2** and **Alternative 3**, it appears that requiring imports to meet the minimum conservation standards of the domestic port of entry would provide more benefits than one standard set of standards. Therefore, **Preferred Alternative 2** would be more beneficial than **Alternative 1** or **Alternative 3**.

4.2 Action 2: Implement Other Import Restrictions on Spiny Lobster

A. Alternative 1 (No Action Alternative) – Do not have other restrictions on the importation of spiny lobster.

   Under the no action alternative for Action 2, imports would be subject to the management and regulations of the exporting country and violations of those regulations would be pursued through the Lacey Act.

B. **Preferred Alternative 2** - Do not allow the importation of spiny lobster tail meat which is not in whole tail form with the exoskeleton attached; and do not allow the importation of spiny lobster with eggs attached or importation of spiny lobster where the eggs, swimmerets, or pleopods have been removed or stripped.

C. Alternative 3 - Do not allow the importation of spiny lobster tail meat which is not in whole tail form with the exoskeleton attached

D. Alternative 4 - Do not allow the importation of spiny lobster with eggs attached or importation of spiny lobster where the eggs, swimmerets, or pleopods have been removed or stripped.

Comparison of Action 2 Alternatives

If no protections are afforded to the females as they are actively reproducing, then all benefits from increasing the spawning stock biomass have been lost. The alternatives considered in Action 2, other than the no action alternative, are designed to: 1) provide further protections to undersized lobsters, and 2) protect berried (egg-bearing) females. Both of these actions will aid in accomplishing the purpose of this amendment/EIS, to increase the spawning stock biomass of the spiny lobster population.

Appendix A of this document provides copies of documents obtained from LE officials used in their investigations of undersize spiny lobster imports. Of particular interest to this action is the document on page 2 of the appendix dated 8/16/2000. In this document the seller inquires whether a buyer is interested in “approx 800-900 lbs of lobster meat.” This inquiry is made one day after the seller informs the buyer of a “lot of pressure on tails under 5 oz.” (page 1 Appendix A). Likely, there was intent to circumvent the laws regarding minimum sizes for any country and to continue bringing in illegal product regardless of how that was achieved. If any importation conservation standards are to have the desired effect, then the trade in “lobster meat” must be stopped to close the potential loophole of harvesting undersize lobster, processing it into meat, and then making it available in the market. Figure 4.2.1 illustrates what is meant by “lobster meat.”

Figure 4.2.1. An example of lobster tail meat without the exoskeleton attached.

The protection of berried females (or those that were, prior to being stripped) is also imperative if the minimum conservation sizes are implemented in order to protect the spawning stock biomass (Figure 4.2.2 and 4.2.3). Action 1 will help achieve an increase in the spawning stock biomass of spiny lobsters; if no protections are afforded to the females as they are actively reproducing, then all benefits from increasing the spawning stock biomass have been lost. Therefore, the alternatives in Action 2 are supportive of those in Action 1 and will further the conservation of the spiny lobster population.

Figure 4.2.2. A berried (egg-bearing) female.

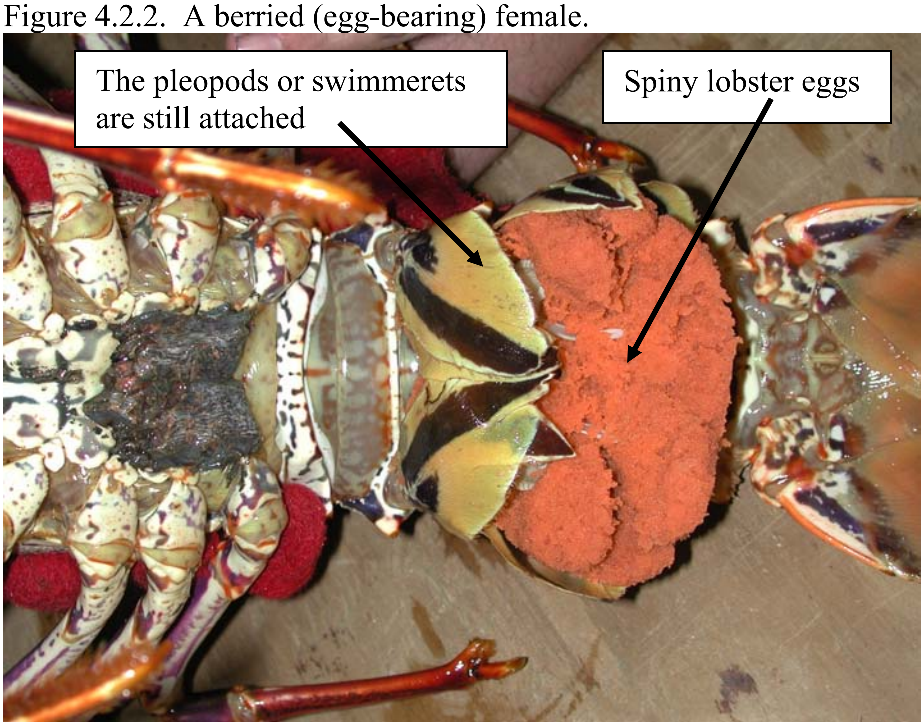

Figure 4.2.3. Examples of lobster tails that have been clipped to remove the pleopods or swimmerets and a stripped tail.

Alternative 1, No Action, would not implement any further conservation standards for imported lobster. **Preferred Alternative 2** would prohibit the importation of lobster tail meat. For the purposes of this action, lobster tail meat means that meat which is not in whole tail form with the exoskeleton attached or still part of a whole lobster. If this alternative is selected, significant loopholes with the minimum size limit would be eliminated. **Preferred Alternative 2** also prohibits importation of berried females or those females who have been obviously stripped of their eggs by removing the eggs, clipping the swimmerets, or removing the pleopods. Individual animals that have been stripped of their eggs or who have had their swimmerets or pleopods removed are easily identified by law enforcement officials once the tail is thawed and the underbelly inspected (P. Raymond, NOAA OLE, pers. comm.). Thus, a restriction on their importation would further the goal of this amendment/EIS in increasing the spawning stock biomass of the spiny lobster population.

Alternatives 3 and **4** would achieve similar goals as **Preferred Alternative 2**, but not to the same extent. These two alternatives are obviously derivatives of **Preferred Alternative 2** and would implement only one or the other restriction of prohibiting lobster tail meat or berried females. While both are viable alternatives for achieving an increase in the spawning stock biomass of spiny lobster, **Alternative 3** and **4** are not as comprehensive as **Preferred Alternative 2**.

Alternative 1 would maintain the regulations that exist under the Caribbean FMP and the South Atlantic/Gulf of Mexico FMP. **Preferred Alternative 2** would require all imported lobster to comply with domestically equivalent regulations such that no berried lobsters, or stripped (clipped) lobsters or lobster meat would be allowed for importation into the U.S. **Alternative 3** and **4** are some derivation of **Preferred Alternative 2**, but not as comprehensive. Therefore, **Preferred Alternative 2** would be more beneficial than **Alternatives 3** and **4**, and all would be more beneficial than **Alternative 1** in increasing the spawning stock biomass and protecting the spiny lobster resource.

4.3 Alternatives Considered but Rejected

During the development of this Amendment /EIS no alternatives were considered and then rejected. However, there were modifications to the alternatives as various iterations of the Amendment/EIS were developed.

Action 1 Modifications

Action 1 has maintained various morphometric size limit restrictions for imports throughout the development of the document. There were changes in the exact measurements of these limits based on insight provided by spiny lobster biologists and the peer-reviewed literature of spiny lobster. Specifically, the changes occurred to the minimum weight limit required for lobsters and the language used to delineate the 2 different sets of morphometrics used in the alternatives.

The minimum weight limit has been identified in various iterations as 4.15, 4.5, and the current 4.2 ounces. Using the Matthews et al. (2003) paper, the direct derivative for tail weight from a 3 inch carapace length animal rounded to 2 decimal places is 4.15 ounces, hence that measurements use in the original document. However, industry practice is to sort tails based on whole ounce categories plus or minus 0.5 ounces. Therefore, it was deemed most appropriate to use a minimum tail weight of 4.5 ounces based on the 4.15 ounce conversion for industry’s ease. It was later determined that it would be more appropriate to use the direct conversion based on best available science, while rounding to a single decimal place, hence the current 4.2 ounce minimum weight.

The other change in Action 1 was in regards to the language used to identify the 2 differing sets of morphometrics to be used for spiny lobster imports. The Caribbean FMC has a different minimum carapace length requirement for the spiny lobster fishery of Puerto Rico and the USVI (3.5”). There was very strong opinion in the US Caribbean that any import should meet those same requirements in the U.S. Caribbean. Therefore, a different set of morphometric minimum size limits were developed based on the 3.5 inch carapace length.

In an effort to delineate what size limit an imported lobster would be required to meet, language was developed to include the U.S. Caribbean (Puerto Rico and the USVI) and the continental U.S. A number of issues were identified in using the wording of “Continental U.S.” as this created a loophole for importers to trans-ship spiny lobster products through Hawaii, Alaska, and other U.S. territories, thereby bypassing the minimum import requirements. Therefore, the language now used in the alternatives includes **all of the U.S. except Puerto Rico and the USVI** where the minimum import sizes are based on the 3.5 inch carapace length.

5.0 AFFECTED ENVIRONMENT

5.1 Physical Environment

The Caribbean Sea is an interior sea formed by a series of basins lying to the east of Central America and separated from the North American Basin of the Atlantic by an island arc 2,500 nautical miles long which joins the Florida Peninsula to the north coast of Venezuela. This arc is demarcated by the Greater Antilles (Cuba, Jamaica, Hispaniola, and Puerto Rico) and the Lesser Antilles (the Virgin Islands, Guadeloupe, Martinique, St. Lucia, Barbados, and Trinidad).

Contained between the 10^{th} and 30^{th} degrees of north latitude, this interior sea has an elliptical form. The long northwest-southeast axis is 2,200 nautical miles and the short axis is 900 nautical miles. The total area of the Caribbean Basin is 4,320,000 km^2, divided into two unequal parts: 1) the Gulf of Mexico (1,700,000 km^2) and 2) the Caribbean Sea (2,600,000 km^2); separated by the Yucatan Peninsula and Cuba between which flows the Yucatan Channel (60 nautical miles wide and 2000 m deep).

The Gulf of Mexico is a simple depression including an extended peripheral continental shelf representing more than one-third of the surface area of the Gulf, and a central basin whose maximum depth is 3800 m. The continental shelf is rich in oil-bearing strata. The Gulf of Mexico opens on the North American Basin by the single opening of the Straits of Florida, between the tip of Florida, the north coast of Cuba, and the Bahamas Archipelago. The width of the channel is 30-50 nautical miles and its greatest depth is 800 m.

As a seismic and volcanic region, the Caribbean has a much more complex topography and has numerous openings into the North American Basin. The Jamaican Ridge, running from Cape Gracias a Dios to Jamaica and Hispaniola, divides the Caribbean into two sections-one in the northwest, the other southeast, communicating across a 1500 m sill which is 20 nautical miles wide at 100m. The northwest basin is itself divided in two by the Cayman Ridge, which from the southwest point of Cuba runs toward, without reaching it, the Gulf of Honduras. Between the Gulf of Mexico and the Cayman Ridge lies the Yucatan Basin, of which the central part is 4700 m deep. At its western extremity it communicates freely at depth of more than 5000 m with the second basin, the Cayman Basin. In the eastern part of the Cayman Basin, between the southwest point of Cuba and against the Cayman Ridge lies a narrow trench 7680 m deep.

The southeast basin, more extensive than the northwest, is in turn subdivided into three by two ridges (Beata and the Aves), having a mostly north-south orientation, parallel to the general direction of the Lesser Antilles. Between the Jamaica and Beata Ridges lies the Colombian Basin, more than 4000 m deep. Between the Beata and Aves Ridges is the Venezuelan Basin which has depths between 4000 and 5000 m; and the Grenada Basin, with a depth of more than 3000 m, is held between the Aves Ridge and the chain of the Lesser Antilles. Because the Beata Ridge does not reach the north coast of Colombia, the Colombian and Venezuelan Basins exchange freely at depths of 1600 m. The main exchanges between the Caribbean and the North American Basin are: 1) the

Windward Passage between the southeast of Cuba and the northwest part of Haiti, with a depth of 1650 m and a width of 12 nautical miles; and 2) the Anegada Passage, prolonged by the Virgin Islands Passage, with a depth of 1800 m and a length of 8 nautical miles, enabling the Atlantic to communicate with the Venezuelan Basin.

The channels between the islands of the Lesser Antilles are all of the order of a depth of 1000 m. Outside of the Greater Antilles chain, to the north of Puerto Rico and Hispaniola, lies the Puerto Rico trough, which has a maximum depth of 8648 m. This maximum depth is found no more than 200 km from a peak in Hispaniola, which reaches 3175 m for a relief of about 11,823 m in less than 200 km.

The Caribbean Basin is entirely in the tropical Atlantic. The mean annual temperature is near 25° C and seasonal variations are small. The winds, the eastern sector predominating, are tied to the trade wind system of the Northern Hemisphere. In the Gulf of Mexico in winter there is a rather marked northern component. Precipitation is 500 mm annually in the east and southeast Caribbean, 500-1000 mm annually over the Gulf of Mexico, and 2000 mm annually in the southwest part of the Caribbean (Tchernia 1980).

5.2 Biological Environment

5.2.1 Spiny Lobster (*Panulirus* argus)

The Caribbean spiny lobster (*P. argus*) populates the western Atlantic Ocean, Caribbean Sea, and Gulf of Mexico ranging from Bermuda down to Brazil (Herrnkind 1980; Figure 5.2.1). Distribution and dispersal of *P. argus* is determined by the long planktonic larval phase, called the puerulus, during which time the infant lobsters are carried by the currents until they become large enough to settle to the bottom (Davis and Dodrill 1989). As the lobsters begin metamorphosis from puerulus to the juvenile form, the ability to swim increases and they move into shallow, near shore environments to grow and develop.

Figure 5.2.1. Distribution of spiny lobster (*P. argus*)

Young benthic stages of *P. argus* will typically inhabit branched clumps of red algae (*Laurencia sp.*), mangrove roots, seagrass banks, or sponges where they feed on invertebrates found within the microhabitat. In contrast to the social behavior of their older counterparts, the juvenile lobsters are solitary and exhibit aggressive behavior to ensure they remain solitary. The inhabitation of macroalgae by the juvenile lobsters provides protection to the vulnerable individuals from predators while providing easy access to food sources (Marx and Herrnkind 1985).

Individuals two to four years old exhibit nomadic behavior emigrating out of the shallows and moving to deeper, offshore reef environments. Once in the adult phase, Caribbean spiny lobsters are thigmotactic and tend to enter social living arrangements aggregating in enclosed dens. Shelter environments may include natural holes in a reef, rocky outcrops, or artificially created environments (Lipcius and Cobb 1994).

As adults in the offshore environment, Caribbean spiny lobsters support commercial, recreational, and artisanal fisheries throughout their geographic range (Davis and Dodrill 1989). Given the wide distribution of *Panulirus argus* from Bermuda down to Brazil, it is hard to determine a definitive stock structure for this species. There are a multitude of currents and other factors that influence the movement of water throughout the range of *P. argus*. The long duration that lobsters spend in the larval stage, traveling by the currents severely impairs the ability of scientists to determine a stock structure. More recent work with DNA may be useful in determining some sort of stock structure for the Caribbean spiny lobster (Lipcius and Cobb, 1994), however the extensive larval phase may also limit this tool as it takes few successful migrants to homogenize the gene pool (Silberman and Walsh 1994). Studies have also shown that the presence of local gyres or loop currents in certain locations could influence the retention of locally spawned larvae. In addition, benthic structures such as coral reef may disturb the flow of water and lead to the settlement of larvae in a particular location (Lee, et al. 1994).

The general anatomy of *Panulirus argus* conforms to the typical decapod body plan consisting of five cephalic and eight thoracic segments fused together to form the cephalothorax. The carapace, a hard shield- like structure, protects this portion of the body and is often the part of the lobster measured and used as a standard to determine organism length. All the segments bear paired appendages that serve in locomotion, sensory, or both (Phillips, Cobb and George, 1980). From the head of the lobster, the appendages are ordered starting with the first antennae, second antennae, mandibles, first maxillae, and second maxillae. There are five pairs of walking legs called pereiopods and a six-segmented tail. The antennae function primarily to obtain sensory information by chemoreception, as do the dactyls of the walking legs and the mouthparts involved in handling food. Lobsters have great visual ability, achieved through the use of their paired, lateral compound eyes. In addition, highly distributed superficial hairs detect water movements (Ache and Macmillan, 1980).

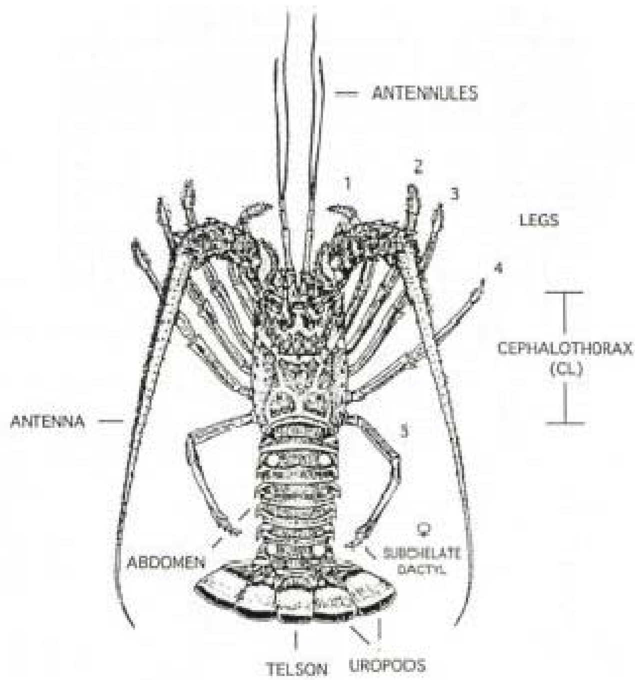

Figure 5.2.2: Morphology of *Panulirus argus* (Lipcius and Cobb, 1994).

Gills are the main organs used by lobsters for respiration. The rate of oxygen consumption in *P. argus* is dependent upon the temperature, the degree of crowding within the den, feeding and size of the lobster; oxygen consumption is not determined by the concentration of the oxygen in the water as some studies show that oxygen uptake remained the same in both hypoxic and aerated water (Phillips, Cobb and George, 1980).

Food Habits

Once *P. argus* settles out from the planktonic phase and enters the seagrass and macroalgae nursery habitat, their diet consists of small gastropod mollusks, isopods, amphipods and ostracods, most of which can be found in or within close proximity to the lobster's algal shelter. Studies suggest that as the abundance of food declines in and around their algae habitat, lobsters forage more frequently and thus have more frequent contact with conspecifics. Aggressive behavior in the juvenile lobsters, which at this time live solitarily, has been observed as a means of enforcing territoriality. The consequence of increased aggressive interactions as well as a declining food source is thought to induce the nomadic emigration from the algal nursery environment to off shore reef environments (Marx and Herrnkind, 1985).

During the adult and juvenile phases, the Caribbean spiny lobster will rest in shelters during daylight hours and emerge in the evening to forage for food. Adult lobsters are key predators in many benthic habitats with their diets consisting of slow-moving or stationary bottom-dwelling invertebrates including sea urchins, mussels, gastropods, clams and snails (Lipcius and Cobb, 1994). Juvenile lobsters also forage at night and will eat a similar diet of invertebrates, only smaller individual prey. During feeding, prey organisms are seized and maneuvered using the anterior periopods or maxillipeds, while the mandibles carry out mechanical digestion and are capable of crushing hard mollusk shell (Herrnkind, et. al. 1975). Little is known about the dietary requirements of the larval phase, plankton sized lobsters.

Larger animals such as sharks and finfish frequently prey upon adult Caribbean spiny lobsters. Studies indicate that Caribbean spiny lobsters are highly selective of the dens they choose to live in and the location of these crevices. Their evening movements away from and subsequent return to their dens illustrates the spatial orientation they have to their immediate habitats (Herrnkind, 1980).

Reproduction

Reproduction in the Caribbean spiny lobster occurs almost exclusively in the deep reef environment once mature individuals have made the permanent transition from the shallow seagrass nursery to the ocean coral reef system. Spawning season is in the spring and summer, however autumnal reproduction has been known to occur in some situations (Kanciruk and Herrnkind, 1976). The gestation period for eggs is about a month. Eggs are orange when they are fresh and brown when they are close to hatching. Studies have found that the initiation of spawning is related to water temperature with an optimal water temperature for mating of 24 degrees centigrade (Lyons, et. al., 1981).

Reproductive fecundity is dependent upon the size of the individual as well as the geographic area in which the lobster lives. Reproductive efficiency for a given size in a given area can be determined using the relationship between fecundity and carapace length. A study conducted in South Florida found that differences exist between the fecundity/carapace length relationships of individuals living in the Dry Tortugas from individuals living in the Upper and Middle Florida Keys. Based on data provided from each location, an Index of Reproductive Potential was calculated using the model developed by Kanciruk and Herrnkind (1976):

$$\text{Index} = (A \times B \times C)/D$$

Where:
A = number of females in size class/total females
B = propensity of size class to carry eggs
C = egg carrying capacity of size class female
D = constant (31.27) – present to set the 76-80 mm size class index to 100 as the standard.

Choice of mate is determined by the female as well as inter-male aggression, where larger males will prevent a smaller male from courting a female (Lipcius and Cobb, 1994).

Females mate only once during a season, while males can fertilize multiple females. During mating, the male will flick his antennules over the anterior of the female and scrape at her with the third walking legs. The male follows the female around continually trying to lift the female up and embrace her. This pattern continues until the female acquiesces and they each stand on their walking legs while the male deposits the spermatophore mass on the female sternum (Atema and Cobb, 1980). Females bearing eggs will usually live in solitary dens and infrequently forage for food (Lyons, et. al., 1981). Large adult females will produce more broods, as well as spawn eggs earlier in the reproductive period than younger females since younger individuals molt earlier in the reproductive period.

Growth and Molting

The life cycle of the Caribbean spiny lobster provides larvae with the potential to travel long distances for periods ranging from a few months to almost two years. During this time, the larval lobsters remain near the surface of the water. Maximum potential dispersal distances differ from one region to another and are primarily dependent on the currents in the area. A gyre in an area where lobster eggs have hatched may keep the larva in the same geographic area, however most of the time the larva are transported out of the area, sometimes hundreds of miles (Lee, et. al., 1994). Once the planktonic lobsters reach about 35 mm they are large enough to settle down as post larval pueruli in shallow benthic environments to grow. Growth in juveniles is rapid with most reaching a carapace length of 60-70 mm within about two years (Herrnkind, 1980). Once the lobsters reach about 70 mm and begin to sexually mature, the young *P. argus* emigrate from the nursery to deeper offshore reef environments.

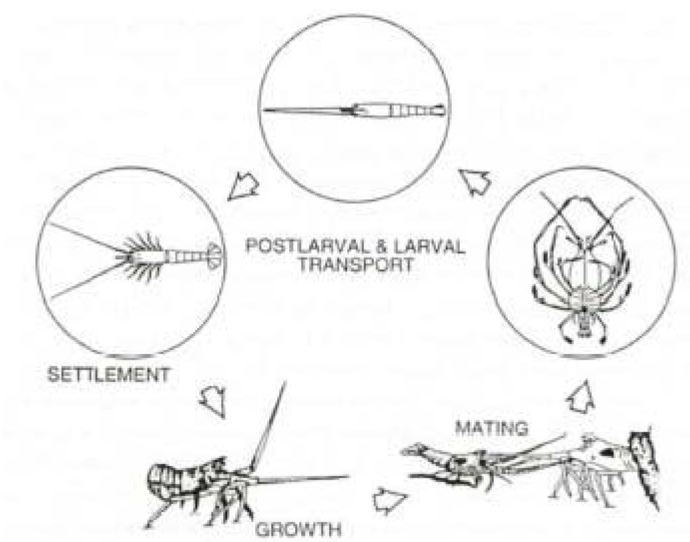

Figure 5.2.3: The Life Cycle of *Panulirus argus* (Lipcius and Cobb, 1994).

Physical growth of lobsters is achieved through molting. A thorough understanding of the molt cycle of the Caribbean spiny lobster is an important component to the management of this fishery because the catchability and captive behavior of crustaceans is directly related to the animal's proximity to molting. The molt cycle begins with the intermolt period, the time when a new cuticle is being created, tissue growth is rapid and the lobster actively forages. This period of time culminates in ecdysis, which is shedding the old cuticle or molting (Lipcius and Herrnkind, 1982).

Molting occurs primarily at night. Possible reasons for nocturnal ecdysis include decreasing the risk of cannibalism by other members of this gregarious species, and decreasing diurnal predation risks. The first action to occur during molting is the rupture of the thoracoabdominal membrane followed by a rising of the dorsal part of the cephalothorax; this action frees the eyes, bases of antennae and antennules. A series of peristaltic contractions causes the removal of the abdomen from the old cuticle, while writhing motions free the cephalothorax and attached structures. A few final wriggles and contractions terminating in a tail flip completely segregates the lobster from its old cuticle. Once molted, the lobster seeks immediate shelter, as they are especially vulnerable until their new cuticle becomes hardened (Lipcius and Herrnkind, 1982). For adult lobsters, molts average about two and a half times each year. The entire molting event takes approximately ten minutes. The new exoskeleton will take about 12 days from the start of the molt to harden such that it cannot be dented; however the shell is not completely formed until the 28^{th} day (Williams, 1984).

Studies found that feeding rates significantly increase in the time preceding a molt to accommodate the increasing metabolic needs associated with new cuticle formation. About a week before ecdysis, daily food intake for the Caribbean spiny lobster decreases rapidly, in correlation with a reduction in demanding activities such as locomotion and foraging. In the few days before and the time during ecdysis, feeding ceases altogether and the lobster becomes socially reclusive. Within a week of the molting event, *P. argus* will display maximal feeding, foraging and locomotor activity rates to accommodate for the active tissue growth that occurs (Lipcius and Herrnkind, 1982). The dramatic swings in feeding and foraging behavior associated with the molting cycle influences the success of fishermen when capturing this species. The highest catchability of spiny lobster is expected immediately following molting because lobsters are actively foraging at this time and are therefore more likely to accept bait. Conversely, the lowest catachability of spiny lobster is expected before molting when foraging decreases and the lobster becomes less mobile (Lipcius and Herrnkind, 1982).

Growth and Mortality Rates

Despite the wide body of literature on this species, limited information is available on the growth and aging of the Caribbean spiny lobster due in part to the molting habits of lobsters interfering with tagging efforts. Consequently, length data, which is substantially easier and less costly to collect, has been the dominant source of information used to estimate growth in *P. argus.* The limited quantitative information that exists on growth for this species at various locations has been compiled in a doctoral thesis by Jaime Manuel Gonzalez-Cano (1991) and was graphed below using the von Bertalanffy growth model.

$$L = Linf\,[1-e(-k(t-to))]$$

Where:
L = length of the organism at time t
Linf = asymptotic average length achieved
K = growth rate with units 1/time

T_0 = time when the length of the organism would be zero

As with any fished population, especially one with poor aging information, natural mortality rates for Caribbean spiny lobster populations have been difficult to isolate from fished rates of mortality.

Locomotion and Migration

The Caribbean spiny lobster achieves locomotion by using the five pairs of walking legs attached to the cephalothorax and can swim (backward) for brief periods using its tail for propulsion (Lipcius and Cobb, 1994). Patterns of movement in *Panulirus argus* fall into the following categories: homing, nomadism and migration. Throughout most of their life, *P. argus* is a shelter dweller during the day and forages at night. Evening movements within the home range are directed; lobsters are apparently aware of their location at all times and can find the way back to the den of origin even if detours are caused by predators or divers. Nomadism is the movement that occurs in juvenile lobsters away from the nursery habitat and to the offshore reefs. Migration is the direct movement of an entire population or sub-population over a long distance for a given period of time (Herrnkind, 1980).

Mass movements (2-60 individuals) of Caribbean spiny lobsters occur annually throughout the geographic range of the species and are dependent on latitude and climactic factors. Observed locations for the migration include Bermuda in October, the Bahamas and Florida in late October and early November, and the Yucatan and Belize in December (Herrnkind, 1985). This mass migratory behavior is thought to have evolved in response to deteriorating conditions that resulted from the periods of glaciations that occurred over the past several 100,000 years. Thus, the migration and queuing behavior became specialized by the natural selection on individuals of the harsh winters during periods of glaciations. Gonads during the migration in the fall are inactive, as they don’t begin to mature until the late winter (Herrnkind, 1985).

The first autumn storm in the tropics usually brings a severe drop in water temperature of about five degrees centigrade, as well as high northerly winds of up to 40 km/h and large sea swells. The shallow regions that the lobsters exploit during the summer months become turbid and cold, initiating the diurnal migration of thousands of lobsters to evade these conditions. The Caribbean spiny lobster is highly susceptible to severe winter cooling and will exhibit reduced feeding and locomotion at temperatures 12-14 degrees centigrade; molting individuals usually perish under these conditions. According to Herrnkind (1985), the behavioral changes observed in *P. argus* as well as the known biological information about the species lends credence to the idea that individuals migrate to evade the stresses of the cold and turbidity in the winter.

Caribbean spiny lobster initiate the migratory behavior by queuing, the single file formation of migrating individuals initiated by visual or tactile stimuli. Queuing is maintained by establishing contact between the antennules of one individual and anterior walking legs of another. Biologically, the queuing behavior is an important hydrodynamic drag reduction technique for the migration of individuals over long distances (Bill and Herrnkind, 1976). Studies done by tagging individuals found that during the migration, individuals tended to move distances of 30-50 km (Herrnkind, 1985).

Migratory movement lasts for variable periods of time and is believed to be dependent on the total number of migratory lobsters. One study in the Bahamas in 1971 found the migration to take six hours while another study in the same location in 1969 found the migration to take five days. It is thought that the more lobsters present, the longer the migration will last in order to avoid over crowding of shelters at their final destination (Kanciruk and Herrnkind, 1978). Once individuals reach sheltered habitats located in deeper water, such as a deep reef site, the migratory queuing behavior ends and the lobsters disperse.

5.2.2 Protected Species

There are 32 different species of marine mammals that may occur in the EEZ of the Gulf of Mexico, South Atlantic, and Caribbean. All 32 species are protected under the MMPA and six are also listed as endangered under the ESA (i.e., sperm, sei, fin, blue, humpback and North Atlantic right whales). There are no known interactions between spiny lobster fisheries and marine mammals. Other species protected under the ESA occurring in the Gulf of Mexico, South Atlantic, and Caribbean include five species of sea turtle (green, hawksbill, Kemp's ridley, leatherback, and loggerhead); the smalltooth sawfish, and two *Acropora* coral species (elkhorn [*Acropora palmata*] and staghorn [*A. cervicornis*]). A discussion of these species is below. Designated critical habitat for the North Atlantic right whale also occurs within the South Atlantic region. Critical habitat has been designated for green, hawksbill, and leatherback sea turtles in the Caribbean region, however, 99% or more of these areas are contained within state waters.

5.2.2.1 ESA-Listed Sea Turtles

Green, hawksbill, Kemp's ridley, leatherback, and loggerhead sea turtles are all highly migratory and travel widely throughout the South Atlantic. The following sections are a brief overview of the general life history characteristics of the sea turtles found in the South Atlantic region. Several volumes exist that cover more thoroughly the biology and ecology of these species (i.e., Lutz and Musick (eds.) 1997, Lutz et al. (eds.) 2002).

Green sea turtle hatchlings are thought to occupy pelagic areas of the open ocean and are often associated with *Sargassum* rafts (Carr 1987, Walker 1994). Pelagic stage green sea turtles are thought to be carnivorous. Stomach samples of these animals found ctenophores and pelagic snails (Frick 1976, Hughes 1974). At approximately 20 to 25 cm carapace length, juveniles migrate from pelagic habitats to benthic foraging areas (Bjorndal 1997). As juveniles move into benthic foraging areas a diet shift towards herbivory occurs. They consume primarily seagrasses and algae, but are also know to consume jellyfish, salps, and sponges (Bjornal 1980, 1997; Paredes 1969; Mortimer

1981, 1982). The diving abilities of all sea turtles species vary by their life stages. The maximum diving range of green sea turtles is estimated at 110 m (360 ft) (Frick 1976), but they are most frequently making dives of less than 20 m (65 ft.) (Walker 1994). The time of these dives also varies by life stage. The maximum dive length is estimated at 66 minutes with most dives lasting from 9 to 23 minutes (Walker 1994).

The **hawksbill's** pelagic stage lasts from the time they leave the nesting beach as hatchlings until they are approximately 22-25 cm in straight carapace length (Meylan 1988, Meylan and Donnelly 1999). The pelagic stage is followed by residency in developmental habitats (foraging areas where juveniles reside and grow) in coastal waters. Little is known about the diet of pelagic stage hawksbills. Adult foraging typically occurs over coral reefs, although other hard-bottom communities and mangrove-fringed areas are occupied occasionally. Hawksbills show fidelity to their foraging areas over several years (van Dam and Diéz 1998). The hawksbill's diet is highly specialized and consists primarily of sponges (Meylan 1988). Gravid females have been noted ingesting coralline substrate (Meylan 1984) and calcerous algae (Anderes Alvarez and Uchida 1994), which are believed to be possible sources of calcium to aid in eggshell production. The maximum diving depths of these animals are not known, but the maximum length of dives is estimated at 73.5 minutes. More routinely dives last about 56 minutes (Hughes 1974).

Kemp's ridley hatchlings are also pelagic during the early stages of life and feed in surface waters (Carr 1987, Ogren 1989). Once the juveniles reach approximately 20 cm carapace length they move to relatively shallow (less than 50m) benthic foraging habitat over unconsolidated substrates (Márquez-M. 1994). They have also been observed transiting long distances between foraging habitats (Ogren 1989). Kemp's ridleys feeding in these nearshore areas primarily prey on crabs, though they are also known to ingest mollusks, fish, marine vegetation, and shrimp (Shaver 1991). The fish and shrimp Kemp's ridleys ingest are not thought to be a primary prey item but instead may be scavenged opportunistically from bycatch discards or from discarded bait (Shaver 1991). Given their predilection for shallower water, Kemp's ridleys most routinely make dives of 50 m or less (Soma 1985, Byles 1988). Their maximum diving range is unknown. Depending on the life stage a Kemp's ridleys may be able to stay submerged anywhere from 167 minutes to 300 minutes, though dives of 12.7 minutes to 16.7 minutes are much more common (Soma 1985, Mendonca and Pritchard 1986, Byles 1988). Kemp's ridleys may also spend as much as 96% of their time underwater (Soma 1985, Byles 1988).

Leatherbacks are the most pelagic of all ESA-listed sea turtles and spend most of their time in the open ocean. However, they will enter coastal waters and are seen over the continental shelf on a seasonal basis to feed in areas where jellyfish are concentrated. Leatherbacks feed primarily on cnidarians (medusae, siphonophores) and tunicates. Unlike other sea turtles, leatherbacks' diets do not shift during their life cycles. Because leatherbacks' ability to capture and eat jellyfish is not constrained by size or age, they continue to feed on these species regardless of life stage (Bjorndal 1997). Leatherbacks are the deepest diving of all sea turtles. It is estimated that these species can dive in excess of 1000 m (Eckert et al. 1989) but more frequently dive to depths of 50 m to 84 m

(Eckert et al. 1986). Dive times range from a maximum of 37 minutes to more routine dives of 4 to 14.5 minutes (Standora et al. 1984, Eckert et al. 1986, Eckert et al. 1989, Keinath and Musick 1993). Leatherbacks may spend 74% to 91% of their time submerged (Standora et al. 1984).

Loggerhead hatchlings forage in the open ocean and are often associated with Sargassum rafts (Hughes 1974, Carr 1987, Walker 1994, Bolten and Balazs 1995). The pelagic stage of these sea turtles are known to eat a wide range of things including salps, jellyfish, amphipods, crabs, syngnathid fish, squid, and pelagic snails (Brongersma 1972). Stranding records indicate that when pelagic immature loggerheads reach 40-60 cm straight-line carapace length they begin to live in coastal inshore and nearshore waters of the continental shelf throughout the U.S. Atlantic (Witzell 2002). Here they forage over hard- and soft-bottom habitats (Carr 1986). Benthic foraging loggerheads eat a variety of invertebrates with crabs and mollusks being an important prey source (Burke et al. 1993). Estimates of the maximum diving depths of loggerheads ranges from 211 m to 233 m (692-764ft.) (Thayer et al. 1984, Limpus and Nichols 1988). The lengths of loggerhead dives are frequently between 17 and 30 minutes (Thayer et al. 1984, Limpus and Nichols 1988, Limpus and Nichols 1994, Lanyan et al. 1989) and they may spend anywhere from 80 to 94% of their time submerged (Limpus and Nichols 1994, Lanyan et al. 1989).

5.2.2.2 ESA-Listed Marine Fish

The historical range of the **smalltooth sawfish** in the U.S. ranged from New York to the Mexico border. Their current range is poorly understood but believed to have contracted from these historical areas. In the South Atlantic region, they are most commonly found in Florida, primarily off the Florida Keys (Simpfendorfer and Wiley 2004). Only two smalltooth sawfish have been recorded north of Florida since 1963 (the first was captured off of North Carolina in 1999 (Schwartz 2003) and the other off Georgia 2002 [Burgess unpublished data]). Historical accounts and recent encounter data suggest that immature individuals are most common in shallow coastal waters less than 25 m (Bigelow and Schroeder 1953, Adams and Wilson 1995), while mature animals occur in waters in excess of 100 meters (Simpfendorfer pers comm. 2006). Smalltooth sawfish feed primarily on fish. Mullet, jacks, and ladyfish are believed to be their primary food resources (Simpfendorfer 2001). Smalltooth sawfish also prey on crustaceans (mostly shrimp and crabs) by disturbing bottom sediment with their saw (Norman and Fraser 1937, Bigelow and Schroeder 1953).

5.2.2.3 ESA-Listed Marine Invertebrates

Elkhorn (*Acropora palmata)* and staghorn (*A. cervicornis*) coral were listed as threatened under the ESA on May 9, 2006. The Atlantic *Acropora* Status Review (*Acropora* Biological Review Team 2005) presents a summary of published literature and other currently available scientific information regarding the biology and status of both these species.

Elkhorn and **staghorn** corals are two of the major reef-building corals in the wider Caribbean. In the Gulf of Mexico, South Atlantic, and Caribbean they are found most commonly in the Florida Keys and U.S. Virgin Islands, though colonies exist in Puerto Rico and Flower Gardens National Marine Sanctuary in the Gulf of Mexico. The depth range for these species ranges from <1 m to 60 m. The optimal depth range for elkhorn is considered to be 1 to 5 m depth (Goreau and Wells 1967), while staghorn corals are found slightly deeper, 5 to 15 m (Goreau and Goreau 1973).

All Atlantic *Acropora* species (including elkhorn and staghorn coral) are considered to be environmentally sensitive, requiring relatively clear, well-circulated water (Jaap et al. 1989). Optimal water temperatures for elkhorn and staghorn coral range from 25° to 29°C (Ghiold and Smith 1990, Williams and Bunkley-Williams 1990). Both species are almost entirely dependent upon sunlight for nourishment, contrasting the massive, boulder-shaped species in the region (Porter 1976, Lewis 1977) that are more dependent on zooplankton. Thus, Atlantic *Acropora* species are much more susceptible to increases in water turbidity than some other coral species.

Fertilization and development of elkhorn and staghorn corals is exclusively external. Embryonic development culminates with the development of planktonic larvae called planulae (Bak et al. 1977, Sammarco 1980, Rylaarsdam 1983). Unlike most other coral larvae, elkhorn and staghorn planulae appear to prefer to settle on upper, exposed surfaces, rather than in dark or cryptic ones (Szmant and Miller 2006), at least in a laboratory setting. Studies of elkhorn and staghorn corals indicated that larger colonies of both species[3] had higher fertility rates than smaller colonies (Soong and Lang 1992).

5.3 Description of the Economic and Social Environment

5.3.1 Introduction

In September 2006, the Working Group on Caribbean spiny lobster of the Western Central Atlantic Fishery Commission (WECAFC) met in Merida, Mexico, to attend the Regional Workshop on the Assessment and Management of Caribbean Spiny Lobster. The primary objective of the workshop was to "review and update the status of Caribbean spiny lobster resource at national and regional levels to seek regional agreement on strategies to address management problems" (WECAFC 2007, p. 2). At the workshop were representatives from The Bahamas, Belize, Brazil, Colombia, Costa Rica, Cuba, Dominican Republic, France (Martinique and Guadeloupe), Haiti, Honduras, Jamaica, Mexico, Nicaragua, the Turks and Caicos Islands, United States of America (also representing Puerto Rico and the U.S. Virgin Islands), and Venezuela, as well as the Caribbean Fishery Management Council (CFMC) and Caribbean Regional Fishery Mechanism (CRFM). The estimated status of the national populations of Caribbean spiny lobster of the participating countries is presented in the Table 5.3.1.

In keeping with the recommendation to allow about 50 percent of the stock to reach maturity, the national representatives at the workshop agreed to a minimum harvest size of 74 mm (2.91 inches) cephalothorax length. Nations with minimum size limits greater than 76 mm were encouraged to retain the larger minimum size limits because of the additional conservation and economic benefits they provide.

Table 5.3.1. Estimated status of national populations of Caribbean spiny lobster of participating countries. *Source*: WECAFC 2007).

Status of Stock	Countries
Under-exploited	Venezuela (some areas)
Fully-exploited or stable	Antigua & Barbuda, Belize, Costa Rica, Cuba, Mexico, Puerto Rico & U.S. Virgin Islands, Turks & Caicos, USA (Florida), Venezuela (some areas)
Over-exploited	Nicaragua, Jamaica, Dominican Republic, Brazil, Colombia, Honduras
Unknown	Bahamas, Guadeloupe, Haiti, Martinique, other Less Antilles countries

5.3.2. Global Commercial Production of Lobster & Caribbean Spiny Lobster

Since 1962, average annual global harvest of Caribbean spiny lobster has been less than such harvest for American and rock lobster (*Jasus* spp.). See Table 5.3.2. Annual global production of Caribbean spiny lobster averages about 54 percent of all spiny lobster production (*Panulirus* spp. and *Palinurus* spp.) and about 17 percent of global production of all lobster.

Table 5.3.2. Global Production of Lobster, including Caribbean Spiny Lobster (CSL), 1962 through 2003. *Source*: FAO Fishstats, reported landings.

	Metric Tons Landed									
Year	CSL (Panulirus argus)	Spiny Lob (Panulirus & Palinurus).	Am Lob (Homarus americanus)	Eur Lob (Homarus gammanus)	Rock Lob. (Jasus)	Norway Lob (Nephrops norvegicus)	Other Lob	Total Lob	% CSL of Total Lob	% CLS of Spiny Lob
1962	16,324	34,859	34,479	3,100	26,700	23,500	0	122,638	13.31%	46.83%
1963	15,426	33,591	33,833	2,600	25,600	27,700	0	123,324	12.51%	45.92%
1964	15,347	32,050	32,915	4,800	30,100	29,900	0	129,765	11.83%	47.88%
1965	18,658	35,876	32,119	2,500	30,400	28,300	0	129,195	14.44%	52.01%
1966	17,827	35,449	30,400	2,300	32,800	30,700	100	131,749	13.53%	50.29%
1967	16,502	34,506	28,029	2,300	28,900	31,100	100	124,935	13.21%	47.82%
1968	19,497	37,939	31,755	2,300	33,600	33,000	100	138,694	14.06%	51.39%
1969	25,239	42,979	33,513	2,000	26,200	37,600	100	142,392	17.73%	58.72%
1970	25,400	43,949	33,100	2,172	24,400	35,716	1,801	141,138	18.00%	57.79%
1971	24,500	44,445	32,600	2,307	20,856	37,574	1,702	139,484	17.56%	55.12%
1972	25,600	48,931	29,700	2,108	20,457	42,010	1,802	145,008	17.65%	52.32%
1973	25,500	47,016	29,200	1,915	20,062	42,025	1,602	141,820	17.98%	54.24%
1974	28,759	50,459	27,203	1,889	19,548	37,916	1,831	138,846	20.71%	56.99%
1975	26,184	49,866	31,185	1,864	17,044	41,293	1,855	143,107	18.30%	52.51%

Year	Metric Tons Landed									
	CSL (Panulirus argus)	Spiny Lob (Panulirus & Palinurus).	Am Lob (Homarus americanus)	Eur Lob (Homarus gammanus)	Rock Lob. (Jasus)	Norway Lob (Nephrops norvegicus)	Other Lob	Total Lob	% CSL of Total Lob	% CLS of Spiny Lob
1976	24,573	52,586	30,308	1,885	16,667	43,314	1,795	146,555	16.77%	46.73%
1977	24,449	49,755	32,215	1,950	16,823	44,666	3,315	148,724	16.44%	49.14%
1978	30,020	54,979	34,790	1,810	17,123	45,947	2,750	157,399	19.07%	54.60%
1979	32,855	58,778	38,447	1,739	17,459	45,625	2,491	164,539	19.97%	55.90%
1980	29,165	54,860	36,851	1,844	17,288	44,271	1,683	156,797	18.60%	53.16%
1981	29,353	52,845	38,703	1,844	18,863	47,193	2,143	161,591	18.16%	55.55%
1982	29,655	51,016	40,698	2,041	17,663	50,146	1,856	163,420	18.15%	58.13%
1983	28,704	52,820	47,707	2,287	17,501	54,008	1,230	175,553	16.35%	54.34%
1984	34,820	58,167	48,637	2,442	18,571	53,531	1,708	183,056	19.02%	59.86%
1985	36,994	62,128	53,574	2,229	18,971	61,724	2,220	200,846	18.42%	59.54%
1986	34,637	63,503	58,861	1,971	16,937	58,832	2,419	202,523	17.10%	54.54%
1987	33,303	61,380	60,095	2,285	17,650	60,826	2,821	205,057	16.24%	54.26%
1988	32,535	63,640	62,576	2,575	17,132	61,566	2,395	209,884	15.50%	51.12%
1989	34,340	65,886	67,964	2,916	12,176	56,699	3,014	208,655	16.46%	52.12%
1990	32,881	62,327	75,534	2,823	11,308	56,162	3,446	211,600	15.54%	52.76%
1991	40,240	66,666	77,222	2,527	9,119	57,708	3,244	216,486	18.59%	60.36%
1992	36,805	65,502	67,134	2,259	11,366	55,825	3,796	205,882	17.88%	56.19%
1993	36,206	62,439	66,552	2,276	11,418	59,238	4,695	206,618	17.52%	57.99%
1994	39,066	65,953	71,663	2,851	10,627	61,468	4,726	217,288	17.98%	59.23%
1995	39,833	65,359	70,631	2,981	11,266	63,774	5,863	219,874	18.12%	60.94%
1996	38,468	62,826	71,866	2,589	10,625	58,990	6,055	212,951	18.06%	61.23%
1997	36,756	69,990	78,146	3,219	12,582	61,596	7,848	233,381	15.75%	52.52%
1998	34,165	61,887	77,155	2,933	10,227	57,379	7,545	217,126	15.74%	55.21%
1999	38,098	66,051	83,105	3,285	10,396	61,770	3,995	228,602	16.67%	57.68%
2000	37,631	69,134	83,062	2,600	10,280	56,628	5,892	227,596	16.53%	54.43%
2001	31,863	62,144	83,803	2,781	9,944	56,317	6,760	221,749	14.37%	51.27%
2002	38,344	64,952	82,422	2,727	10,672	57,228	6,882	224,883	17.05%	59.03%
2003	33,327	64,545	83,682	2,801	10,741	55,210	7,095	224,074	14.87%	51.63%
Ave	*29,758*	*54,382*	*51,510*	*2,443*	*17,811*	*48,238*	*2,873*	*177,257*	*16.71%*	*54.27%*

According to the Food and Agriculture Organization of the United Nations (FAO), world capture of Caribbean spiny lobster has greatly increased from 1950 through 2005, starting at a low of 2,957 metric tons in 1950 to 35,540 metric tons in 2005 (http://www.fao.org/fishery/species/3445). Twice annual global production has exceeded 40,000 metric tons; and since 1984, annual global production has varied between 30,000 and 41,000 metric tons. See Figure 5.3.2.

Among the countries that harvested Caribbean spiny lobster from 1996 through 2005 and reported those landings to the FAO, the Bahamas had the largest average annual landings, followed by Cuba, Brazil, Nicaragua, and the United States. See Figure 5.3.3 and Table 5.3.3. U.S. imports of frozen spiny lobster represented an average of 87 percent of reported annual Caribbean spiny lobster landings from countries other than the U.S. and Cuba. See Figure 5.3.4.

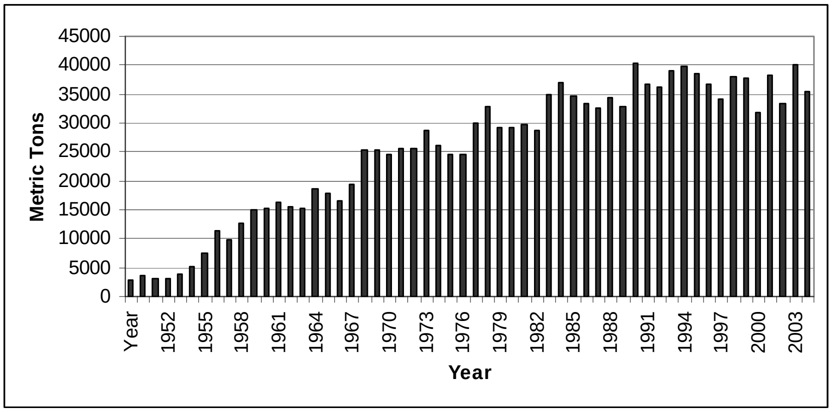

Figure 5.3.2. World Capture of Caribbean Spiny Lobster. *Source*: FAO Fishstats data.

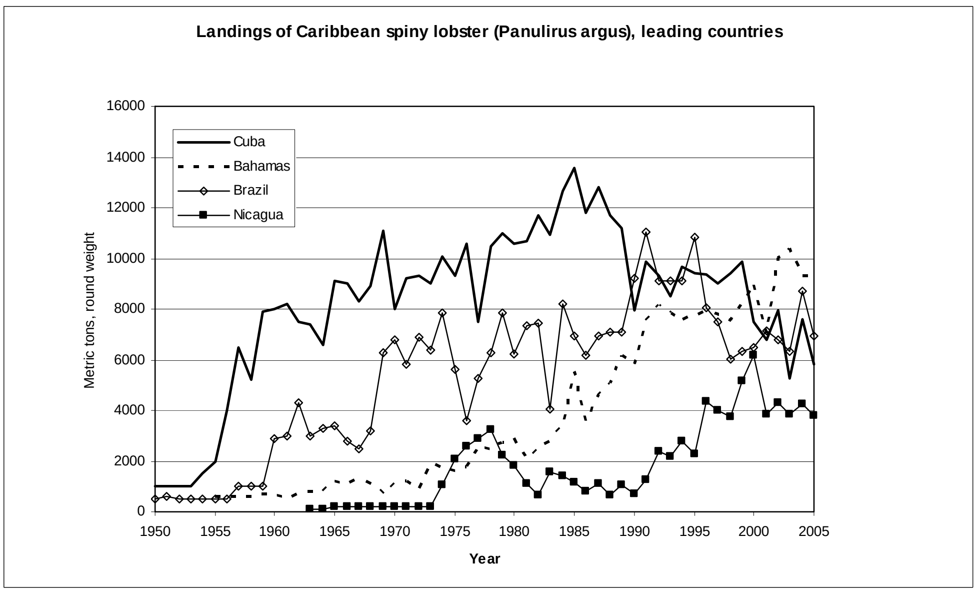

Figure 5.3.3. Top 4 Producers of Caribbean Spiny Lobster, 1950 – 2005. *Source*: FAO Fishstats.

Table 5.3.3. Reported Landings of Caribbean Spiny Lobster, Metric Tons, 1996 – 2005.[4] *Source*: FAO Fishstats.

Country	10-yr Ave	% Total
Anguilla	60	0.16%
Antigua and Barbuda	254	0.69%
Bahamas	8,660	23.61%
Belize	496	1.35%
Bermuda	28	0.08%
Brazil	7,022	19.14%
British Virgin Islands	57	0.16%
Colombia	439	1.20%
Costa Rica	111	0.30%
Cuba	7,859	21.43%

[4] Panama was among the countries that did not report its landings.

Country	10-yr Ave	% Total
Dominican Republic	1,089	2.97%
Grenada	31	0.08%
Haiti	499	1.36%
Honduras	1,054	2.87%
Jamaica	373	1.02%
Martinique	156	0.43%
Mexico	797	2.17%
Nicaragua	4,350	11.86%
Puerto Rico	183	0.50%
Saint Kitts and Nevis	25	0.07%
Trinidad and Tobago	7	0.02%
Turks and Caicos Is.	269	0.73%
USA	2,308	6.29%
US Virgin Islands	106	0.29%
Venezuela, Boliv Rep of	507	1.38%
Total	36,681	100.00%
Total, excluding USA	34,373	
Total, ex. USA & Cuba	26,514	
U.S. imports froz spiny	22,982	86.68%

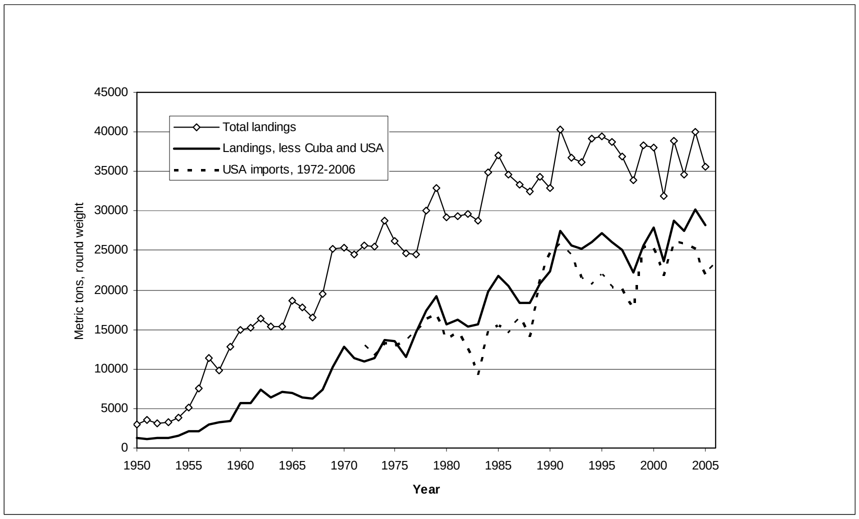

Figure 5.3.4. Global Landings of Caribbean Spiny Lobster and U.S. Imports of Frozen Spiny Lobster. Source: FAO Fishstats.

In 2003, the top five countries with landings of *Panulirus*, *Palinurus*, and *Janus* species were Australia (21.83 percent), The Bahamas (13.78 percent), which combined to produce approximately 35 percent of the world metric ton capture, Indonesia (8.80 percent), Brazil (8.27 percent), and Cuba (8.16 percent) (FAO Fishstats).

Five species of lobster are both commercially and recreationally harvested in U.S. waters. These species are: American lobster (*Homarus americanus*), California spiny lobster (*Panulirus interruptus*), Caribbean spiny lobster (*Panulirus argus*), banded or Hawaiian spiny lobster (*Panulirus marginatus*), and Spanish slipper lobster (*Scyllarides aequinoctialis*). The American lobster is a "true" lobster, whereas the others are members of the spiny/rock lobster group. In the southeast, spotted lobster[5] (*Panulirus guttatus*), ridged slipper lobster (*Scyllarides nodifer*), and smooth tail lobster (*Panulirus laevicauda*) are taken by recreational fishermen only. Since 2000, commercial landings of Hawaiian spiny lobster, which is also known as banded spiny lobster (*Panulirus marginatus*), have declined from 10,394 pounds in 2000 to 4,870 pounds in 2004.

All of the domestic catch of California spiny lobster is taken in California; however, most of the catch has been marketed in Asia and France because dealers from foreign markets have paid lobster fishers prices ranging from $6.75 to $8.00 per pound (California Department of Fish & Game, 2003; Cascorbi, 2004).[6] However, since 2000, California lobster fishers have attempted to reestablish domestic markets for California spiny lobster because of depressed overseas markets.

From 1962 through 2003, continental U.S. commercial landings of Caribbean spiny lobster have ranged from a low of 1,424 metric tons in 1962 to a high of 5,358 metric tons in 1972. See Table 4. Since 1992, an average of 2,626 metric tons has been landed in the continental U.S. annually. Puerto Rico had no reported commercial landings of Caribbean spiny lobster from 1962 through 1998 and the U.S. Virgin Islands had no such landings from 1962 through 1974. Prior to 1999, over 95 percent of commercial landings occurred in the contiguous U.S.; however, since 1999 landings in Puerto Rico have increased resulting in its productive share rising from zero up to a high of over 10 percent in 2001. See Table 5.3.4.

Commercial landings of Caribbean spiny lobster in the contiguous United States have been reported in Alabama, Georgia, Florida, Mississippi, South Carolina, and Texas since 1962; however, Florida dominates. In 35 of the 45 years from 1962 through 2006, Florida landings accounted for all of the annual commercial landings; and in each of the other 10 years, annual landings in Florida represented at least 94 percent of the total pounds commercially landed that year. This explains why the species is also called the Florida spiny lobster. See Table 5.3.5.

Table 5.3.4. U.S., U.S. Virgin Islands and P.R. Commercial Production of Caribbean Spiny Lobster, 1962 – 2003. *Source*: FAO Fishstats.

Year	Metric Tons			Pounds			% of Landings		
	US	USVI	PR	US	USVI	PR	US	USVI	PR
1962	1,424	0	0	3,139,383	0	0	100.00%	0.00%	0.00%
1963	1,626	0	0	3,584,717	0	0	100.00%	0.00%	0.00%
1964	1,647	0	0	3,631,014	0	0	100.00%	0.00%	0.00%
1965	2,608	0	0	5,749,657	0	0	100.00%	0.00%	0.00%
1966	2,427	0	0	5,350,620	0	0	100.00%	0.00%	0.00%
1967	2,002	0	0	4,413,655	0	0	100.00%	0.00%	0.00%
1968	3,247	0	0	7,158,411	0	0	100.00%	0.00%	0.00%

[5] *Panulirus guttatus* is also called a spotted spiny lobster, Guinea lobster, rock lobster, and spotted crawfish.
[6] The species is also harvested along Mexico's west coast; however, most of the catch occurs in California.

Year	Metric Tons			Pounds			% of Landings		
	US	USVI	PR	US	USVI	PR	US	USVI	PR
1969	3,839	0	0	8,463,548	0	0	100.00%	0.00%	0.00%
1970	4,600	0	0	10,141,266	0	0	100.00%	0.00%	0.00%
1971	3,900	0	0	8,598,030	0	0	100.00%	0.00%	0.00%
1972	5,400	0	0	11,904,964	0	0	100.00%	0.00%	0.00%
1973	5,100	0	0	11,243,577	0	0	100.00%	0.00%	0.00%
1974	4,938	0	0	10,886,428	0	0	100.00%	0.00%	0.00%
1975	3,363	22	0	7,414,147	48,502	0	99.35%	0.65%	0.00%
1976	2,430	39	0	5,357,234	85,980	0	98.42%	1.58%	0.00%
1977	2,318	59	0	5,110,316	130,073	0	97.52%	2.48%	0.00%
1978	2,080	71	0	4,585,616	156,528	0	96.70%	3.30%	0.00%
1979	2,699	74	0	5,950,277	163,142	0	97.33%	2.67%	0.00%
1980	2,959	49	0	6,523,479	108,027	0	98.37%	1.63%	0.00%
1981	2,463	42	0	5,429,986	92,594	0	98.32%	1.68%	0.00%
1982	2,649	58	0	5,840,046	127,868	0	97.86%	2.14%	0.00%
1983	2,053	29	0	4,526,091	63,934	0	98.61%	1.39%	0.00%
1984	2,369	35	0	5,222,752	77,162	0	98.54%	1.46%	0.00%
1985	1,667	35	0	3,675,107	77,162	0	97.94%	2.06%	0.00%
1986	2,362	54	0	5,207,320	119,050	0	97.76%	2.24%	0.00%
1987	2,169	30	0	4,781,827	66,139	0	98.64%	1.36%	0.00%
1988	2,438	48	0	5,374,871	105,822	0	98.07%	1.93%	0.00%
1989	2,438	57	0	5,374,871	125,664	0	97.72%	2.28%	0.00%
1990	2,606	60	0	5,745,248	132,277	0	97.75%	2.25%	0.00%
1991	2,878	74	0	6,344,905	163,142	0	97.49%	2.51%	0.00%
1992	1,792	*70*	0	3,950,684	154,324	0	96.24%	3.76%	0.00%
1993	2,548	*70*	0	5,617,379	154,324	0	97.33%	2.67%	0.00%
1994	3,420	*70*	0	7,539,811	154,324	0	97.99%	2.01%	0.00%
1995	2,934	*80*	0	6,468,364	176,370	0	97.35%	2.65%	0.00%
1996	3,373	*80*	0	7,436,193	176,370	0	97.68%	2.32%	0.00%
1997	2,783	*80*	0	6,135,466	176,370	0	97.21%	2.79%	0.00%
1998	2,343	*90*	0	5,165,432	198,416	0	96.30%	3.70%	0.00%
1999	2,749	*94*	209	6,060,509	207,235	460,766	90.07%	3.08%	6.85%
2000	2,571	*100*	212	5,668,086	220,462	467,380	89.18%	3.47%	7.35%
2001	1,527	*110*	190	3,366,459	242,509	418,878	83.58%	6.02%	10.40%
2002	2,047	*120*	158	4,512,863	264,555	348,330	88.04%	5.16%	6.80%
2003	1,887	130	196	4,160,124	286,601	432,106	85.27%	5.87%	8.86%

Table 5.3.5. Commercial Landings of Caribbean Spiny Lobster, 1962 – 2006, in Pounds. *Source*: NMFS Accumulated Landings System.

Year	**Pounds Landed by State**						**TOTAL**
	FL	**GA**	**MS**	**AL**	**SC**	**TX**	
1962	3,107,000	32,200	0	0	0	0	3,139,200
1963	3,585,200	0	0	0	0	0	3,585,200
1964	3,631,100	0	0	0	0	0	3,631,100
1965	5,714,100	35,000	0	0	0	0	5,749,100
1966	5,350,200	0	0	0	0	0	5,350,200
1967	4,413,600	0	0	0	0	0	4,413,600

Year	Pounds Landed by State						TOTAL
	FL	GA	MS	AL	SC	TX	
1968	6,154,900	1,004,200	0	0	0	0	7,159,100
1969	7,581,200	882,200	0	0	0	0	8,463,400
1970	9,869,500	0	212,700	0	33,000	0	10,115,200
1971	8,206,000	0	373,500	132,600	0	0	8,712,100
1972	11,416,800	0	191,000	39,000	165,100	0	11,811,900
1973	11,171,700	0	21,000	1,500	0	0	11,194,200
1974	10,882,600	0	0	800	0	0	10,883,400
1975	7,408,400	0	0	100	0	0	7,408,500
1976	5,345,600	0	0	0	0	0	5,345,600
1977	6,344,100	0	0	0	0	0	6,344,100
1978	5,601,903	0	0	0	0	0	5,601,903
1979	7,828,269	0	0	0	0	0	7,828,269
1980	6,694,842	0	0	0	0	0	6,694,842
1981	5,894,005	0	0	0	0	0	5,894,005
1982	6,496,804	0	0	0	0	0	6,496,804
1983	4,317,000	0	0	0	0	0	4,317,000
1984	6,251,917	0	0	0	0	0	6,251,917
1985	5,739,393	0	0	0	0	0	5,739,393
1986	5,006,704	0	0	0	0	0	5,006,704
1987	6,082,439	0	0	1,141	0	67	6,083,647
1988	6,308,430	0	0	0	0	0	6,308,430
1989	7,673,159	0	0	0	0	0	7,673,159
1990	5,986,170	0	0	0	0	0	5,986,170
1991	7,022,809	0	0	0	0	0	7,022,809
1992	4,486,421	0	0	0	0	0	4,486,421
1993	5,378,807	0	0	0	0	0	5,378,807
1994	7,104,204	0	0	0	0	0	7,104,204
1995	7,023,938	0	0	0	0	0	7,023,938
1996	7,868,547	0	0	0	0	0	7,868,547
1997	7,107,518	0	0	0	0	0	7,107,518
1998	5,829,132	0	0	0	0	0	5,829,132
1999	7,529,605	0	0	0	0	0	7,529,605
2000	5,772,670	0	0	0	0	0	5,772,670
2001	3,411,253	0	0	0	0	0	3,411,253
2002	4,484,598	0	0	0	0	0	4,484,598
2003	4,269,831	0	0	0	0	0	4,269,831
2004	5,006,383	0	0	0	0	0	5,006,383
2005	3,369,856	0	0	0	0	0	3,369,856
2006	4,773,995	0	0	0	0	0	4,773,995

The commercial value of a Caribbean spiny lobster is found entirely in its tail. As such, most international trade of the species has been in frozen lobster tails. However, whole cooked frozen lobsters, live lobsters, and meat are traded as well. Although there is a small live market in the U.S., most is sold as frozen tails. Spiny lobsters imported into the U.S. that originate from the Caribbean basin are typically tailed, sorted by weight, packed in 10-pound boxes, and shipped frozen to the U.S. for consumption. Size is the critical element in the pricing of lobster tails. Caribbean lobster tails are sorted by the industry into the following sizes: 4 oz, 5 oz, 6 oz, 7 oz, 8 oz, 9 oz, 10 oz, 11 oz, 12 – 14 oz, 14 – 16 oz, 16 – 20 oz, and 20 – 24 oz. A 5-oz tail weighs from 4.5 to 5.4 oz, while a 6-oz tail weighs from 5.5 to 6.4 oz.

The Harmonized Commodity Description and Code System (HS) defines rock lobster as lobster within the family *Palinuridae*, which includes *Jasus* species (spp.), *Justitia* spp., *Linuparus* spp., *Palinurus* spp., *Palinustus* spp., *Panulirus* spp., *Projasus* spp., and *Puerulus* spp. The experiences of NOAA law enforcement officers suggest that boxes of frozen lobster that originate from the Caribbean basin are almost exclusively Caribbean spiny lobster (*Panulirus argus*) tails, with the exception being boxes from shipped from Brazil. Brazil also exports Brazilian spiny lobster (*Panulirus lauvicauda*), and some shipments have contained both Caribbean and Brazilian spiny lobsters. The Government of Brazil is acting to implement a rule that would not allow the two species to be exported in the same box.

Caribbean spiny lobster, Cape rock lobster (*Jasus lalandii*) and Australian spiny lobster (*Panulirus cygnus*) make up most, but not all, of the spiny and rock lobster found on the U.S. mainland market. California spiny lobster makes up about 2 percent of U.S. landings of spiny lobster. From 1997 through 2006 imports of spiny lobster have comprised more than 90 percent of U.S. supply. See Table 5.3.6.

Table 5.3.6. U.S. Supply of Spiny Lobsters, 1997 – 2006. *Source*: Fisheries of the United States 2006.

Year	U.S. Commercial Landings, in lbs	Imports(1), in lbs	Total, in lbs	Exports(2), in lbs	Total Supply, in lbs	Imports as % Supply	Net Imports, in lbs
	Round weight						
1997	7,240,000	74,120,000	81,360,000	5,842,000	75,518,000	91.10%	68,278,000
1998	5,935,000	95,801,000	101,736,000	1,802,000	99,934,000	94.17%	93,999,000
1999	6,692,000	86,240,000	92,932,000	2,346,000	90,586,000	92.80%	83,894,000
2000	6,463,000	94,433,000	100,896,000	1,571,000	99,325,000	93.59%	92,862,000
2001	4,082,000	76,667,000	80,749,000	2,158,000	78,591,000	94.94%	74,509,000
2002	5,188,000	86,923,000	92,111,000	4,890,000	87,221,000	94.37%	82,033,000
2003	4,863,000	94,423,000	99,286,000	6,047,000	93,239,000	95.10%	88,376,000
2004	5,938,000	94,720,000	100,658,000	7,506,000	93,152,000	94.10%	87,214,000
2005	4,144,000	86,987,000	91,131,000	7,766,000	83,365,000	95.45%	79,221,000
2006	5,605,000	85,752,000	91,357,000	14,670,000	76,687,000	93.86%	71,082,000

From 2002 through 2007, total U.S. imports of frozen rock lobster and other sea crawfish (*Palinurus* spp., *Panulirus* spp. and *Jasus* spp.) averaged 12,374.2 metric tons with a value of about $355.5 million, annually.[7] The top 5 countries of origin of those imports by volume (metric tons) are Brazil, The Bahamas, Australia, Honduras and Nicaragua,

[7] Harmonized import code HS 03 includes fish, crustaceans, mollusks, and aquatic invertebrates. HS 0306 includes crustaceans only. HS 030611000 includes rock lobster and other sea crawfish, frozen. HS 0306210000 includes rock lobster and other sea crawfish, not frozen.

who collectively represent about 68 percent of the total volume of those imports. See Table 5.3.7. Those same countries account for about 78 percent of the total dollar value of those imports. Of the top 10 countries of origin by volume of frozen rock lobster and other sea crawfish imports, 6 of those countries (Brazil, The Bahamas, Honduras, Nicaragua, Colombia and Belize) export Caribbean spiny lobster to the U.S.

Rock lobster and other sea crawfish are also imported not frozen; however, frozen imports dominate. From 2002 through 2007, U.S. imports of not frozen rock lobster (HS 0036210000) averaged 164 metric tons with a value of $2.9 million annually, as compared with about 12,372 metric tons with a value of $355.5 million for frozen. The top five countries of origin during those years by volume were Mexico (122 metric tons), Australia (10 metric tons), Peoples Republic of China (5.5 metric tons), Taiwan (4.6 metric tons), and the United Kingdom (3.3 metric tons). Mexico is exporting increasing numbers of live Caribbean spiny lobster, and it is assumed that the bulk of its exports of not frozen rock lobster are these live specimens.

Table 5.3.7. Top 20 Countries of Origin for Imports of Frozen Rock Lobster and Other Sea Crawfish (HS 0036110000), 6-Year Average, 2002 – 2007. Source: U.S. Customs Data.

Trading Partner	MT	% Total	Combined %	1000s $	% Value	Combined %
BRAZIL	2,926.6	23.65%	23.65%	75,739	21.30%	21.30%
BAHAMAS, THE	1,518.1	12.27%	35.92%	50,135	14.10%	35.41%
AUSTRALIA(*)	1,492.6	12.06%	47.99%	64,635	18.18%	53.59%
HONDURAS	1,281.4	10.36%	58.34%	42,124	11.85%	65.44%
NICARAGUA	1,239.2	10.02%	68.36%	39,101	11.00%	76.44%
CHINA, PEOPLES REPUB	626.6	5.06%	73.42%	3,741	1.05%	77.49%
SOUTH AFRICA, REPUBL	520.6	4.21%	77.63%	16,250	4.57%	82.06%
UNITED ARAB EMIRATES	484.0	3.91%	81.54%	10,374	2.92%	84.98%
COLOMBIA	320.2	2.59%	84.13%	8,700	2.45%	87.43%
BELIZE	222.3	1.80%	85.93%	7,488	2.11%	89.53%
MEXICO	194.1	1.57%	87.50%	6,039	1.70%	91.23%
OMAN	190.8	1.54%	89.04%	4,329	1.22%	92.45%
THAILAND	184.9	1.49%	90.53%	2,486	0.70%	93.15%
TAIWAN	133.0	1.07%	91.61%	1,771	0.50%	93.65%
PANAMA	131.7	1.06%	92.67%	2,615	0.74%	94.38%
NEW ZEALAND(*)	118.5	0.96%	93.63%	3,175	0.89%	95.27%
JAMAICA	113.3	0.92%	94.55%	3,496	0.98%	96.26%
DOMINICAN REPUBLIC	85.5	0.69%	95.24%	1,803	0.51%	96.76%
CHILE	67.7	0.55%	95.78%	979	0.28%	97.04%
SPAIN	66.1	0.53%	96.32%	494	0.14%	97.18%

*: denotes a country that is a summarization of its component countries. Australia(*) includes Australia, Christmas Island, Cocos (Keeling) Island, Heard Island and McDon, and Norfolk Island. New Zealand(*) includes Cook Islands, New Zealand, Niue, and Tokelau.

5.3.3 Federal Management of Caribbean Spiny Lobster under the MSA

The Caribbean spiny lobster in the U.S. Exclusive Economic Zone (EEZ) of the Atlantic Ocean and Gulf of Mexico is jointly managed by the South Atlantic and Gulf of Mexico Fishery Management Councils through the Fishery Management Plan for Spiny Lobster (Spiny Lobster FMP) in the Gulf of Mexico and South Atlantic. In the U.S. EEZ of the Caribbean Sea surrounding Puerto Rico and the U.S. Virgin Islands, the resource is managed by the Caribbean Fishery Management Council (Caribbean FMC) through its Spiny Lobster FMP. In the Gulf and South Atlantic, the commercial fishery and, to a large extent, the recreational fishery occurs off South Florida, primarily in the Florida Keys. In order to streamline a management process that involves both state and federal jurisdictions, the Gulf and South Atlantic Spiny Lobster FMP basically extends the Florida Fish and Wildlife Commission's rules regulating the state fishery to the southeastern U.S. EEZ from North Carolina to Texas.

The Gulf and South Atlantic Spiny Lobster FMP was implemented on July 26, 1982 (47 *Federal Register (FR)* 29203). The FMP, for the most part, extended Florida's rules of regulating the fishery to the EEZ throughout the range of the fishery; and since 1982, it has been amended seven times.

The Gulf and South Atlantic Spiny Lobster FMP was first amended on July 15, 1987 (52 *FR* 22659) with certain rules deferred and implemented on May 11, 1998 (53 *FR* 17196) and on July 30, 1990 (55 *FR* 26448). This amendment (Amendment 1) updated the rules to be more compatible with Florida law. Amendment 1 required a commercial permit, limited possession of undersized lobsters as attractants, required a live well, modified recreational possession and seasonal regulations, modified closed season regulations, required the immediate release of egg-bearing lobsters, modified the minimum size limit, required a permit to separate the tail at sea and prohibited possession or stripping of egg-bearing slipper lobsters.

Amendment 2 was approved on October 27, 1989 (54 *FR* 48059) and provided a regulatory amendment procedure for instituting future compatible state and federal rules without amending the Spiny Lobster FMP to ensure federal-state compatibility. Amendment 2 modified the problems/issues and objectives of the FMP, modified the statement of optimum yield, established a protocol and procedure for an enhanced cooperative management system, and added to the vessel safety and habitat sections of the FMP.

Amendment 3 was implemented on March 25, 1991 (56 *FR* 12357) and contained provisions for adding a scientifically measurable definition of overfishing; an action plan to prevent overfishing, should it occur, as required by the National Standards of the Magnuson-Stevens Fisheries Conservation and Management Act (50 *CFR* Part 600); and the requirement for collection of fees for the administrative cost of issuing permits.

The first Regulatory Amendment to the Spiny Lobster FMP was implemented on December 30, 1992 (Regulatory Amendment 1). Regulatory Amendment 1 addressed: 1) the extension of the Florida spiny lobster trap certificate system for reducing the number of traps in federal waters off Florida, 2) the revision of the FMP's commercial permitting requirements, 3) the limitation of the number of live undersize lobster used as attractants for baiting traps, 4) the specification of gear allowed for commercial fishing in the U.S. EEZ off Florida, 5) the specification of the possession limit of spiny lobsters by persons diving at night, 6) the requirement of lobsters harvested by divers to be measured without removing from the water, and 7) the specification of uniform trap and buoy numbers for federal waters off Florida. All of these changes were implemented through the framework procedure of the FMP as established by Amendment 2.

The second Regulatory Amendment (Regulatory Amendment 2) was approved in March 1993 and implemented in August 1993 (58 *FR* 38978). Regulatory Amendment 2 addressed: 1) a change in the days for the special recreational season in federal waters off Florida, 2) a prohibition on night-time harvest off Monroe County, Florida, during that season, 3) specifies allowable gear during that season, and 4) provides for different bag limits during that season off the Florida Keys and federal waters off other areas of Florida.

Amendment 4 was implemented on September 13, 1995 (60 *FR* 41828). It provided a bag limit of 2 lobsters per day for all fishers in federal waters off North Carolina, South Carolina, and Georgia (50 *CFR* §640.23).

Amendment 5 of the Spiny Lobster FMP was part of the Comprehensive Amendment Addressing Essential Fish Habitat in Fishery Management Plans of the South Atlantic Region, which the National Marine Fisheries Service (NMFS) approved on June 3, 1999. Amendment 6 was part of the Comprehensive Amendment Addressing Sustainable Fishery Act Definitions and Other Required Provisions in FMPs of the South Atlantic Region. NMFS approved the Comprehensive Amendment in October 1998 and it was implemented on December 2, 1999 (64 *FR* 59126). Similarly, the Gulf of Mexico Fishery Management Council developed Generic Amendments to address Essential Fish Habitat and Sustainable Fishery Act. The former described the distribution and relative abundance of juvenile and adult spiny lobster for offshore, near-shore, and estuarine habitats of the Gulf; and the latter updated the description of the spiny lobster fisheries and provided fishing community assessment information for Monroe County, Florida.

Amendment 7 was implemented under a Generic Amendment that created the two Tortugas Marine Reserves: Tortugas North (120 square nautical miles) and Tortugas South (60 square nautical miles). This amendment prohibits fishing for or possession of spiny lobster in either of the two reserves. It was implemented on July 19, 2002 (67 *FR* 47467).

Currently, harvest or possession of spiny lobsters in the U.S. South Atlantic EEZ is regulated in 50 CFR 640. According to 50 CFR 640.4, anyone who sells, trades, or barters or attempts to sell, trade, or barter spiny lobster that was harvested or possessed in the EEZ off Florida, or harvested in the EEZ other than off Florida and landed in Florida must have licenses and certificates specified to be a commercial harvester, as defined in

Rule 46-24.002(a), Florida Administrative Code. Similarly, any person who sells, trades, or barters or attempts to sell, trade, or barter a Caribbean spiny lobster harvest in the U.S. EEZ other than off Florida, a Federal vessel permit must be issued and on board the harvesting vessel (50 CFR §640.4(a)(1)(ii)).

The commercial and recreational fishing season for spiny lobster in the EEZ off Florida and the EEZ off the Gulf States, other than Florida, begins on August 6 and ends on March 31 (50 CFR §640.20(b)). No person may possess a Caribbean spiny lobster in or from the Gulf and South Atlantic EEZ with a carapace length of 3.0 inches (7.62 cm) or less or a separated tail with a length less than 5.5 inches (13.97 cm) (50 CFR §640.21(b)). Current regulation prohibits the possession of a spiny lobster or parts thereof in or from the Gulf and South Atlantic EEZ from which the eggs, swimmerettes or pleopods have been removed (50 CFR §640.21(a)); and requires any berried spiny lobster to be returned immediately to the water (50 CFR §640.7(g)).

The Caribbean Fishery Management Council manages the Caribbean spiny lobster fishery in the U.S. Caribbean EEZ and territorial seas of Puerto Rico and the U.S. Virgin Islands through the FMP for the Spiny Lobster Fishery of Puerto Rico and the U.S. Virgin Islands. The Caribbean Spiny Lobster FMP was implemented in 1985. The associated regulations include that no person may possess a Caribbean spiny lobster in or from the Caribbean EEZ with a carapace length less than 3.5 inches (8.9 cm) (50 CFR §622.37(b)).

On July 26, 2007, a Notice of Intent was published in the *Federal Register* (72 *FR* 41063) announcing the Caribbean Fishery Management Council's intent to prepare a draft environmental impact statement to describe and analyze management alternatives to be included in an amendment to its Spiny Lobster FMP and the Gulf and South Atlantic Spiny Lobster FMP. The Caribbean, Gulf and South Atlantic Fishery Management Councils have expressed concern about the effects of imports of spiny lobster that are smaller than the size limits in the U.S. spiny lobster FMPs. In many instances, imports are also undersized based on size limits established in the country of origin. The Caribbean FMC has expressed intent to amend its Spiny Lobster FMP of a minimum size limit on imported spiny lobster. NOAA Fisheries believes amendment of the Gulf and South Atlantic Spiny Lobster FMP should be addressed concurrently.

5.3.4 Other Federal Laws and Regulations that Protect Spiny Lobster

Lacey Act

The Lacey Act, as amended in 1981 (16 USC §§ 3372 et seq.) prohibits any person from importing, exporting, transporting, selling, receiving, acquiring, or purchasing in interstate or foreign commerce any fish or wildlife taken, possessed, transported, or sold in violation of any law or regulation of any state or in violation of any foreign law. For example, it is a violation of the Lacey Act to import Caribbean spiny lobster that is in violation of the exporting country's minimum harvest-size standard. Many of the countries that harvest Caribbean spiny lobster have minimum harvest size standards. See Table 5.3.8.

NOAA's Office of Law Enforcement, Southeast Region, has made several significant Lacey Act cases against individuals involved in importing undersized lobsters from Honduras, Nicaragua, The Bahamas, and Brazil.

In July 2003, a Miami man pleaded guilty to importing more than $2.8 million worth of undersized spiny lobster from Nicaragua. The man and others illegally shipped into the U.S. about 190,000 pounds of frozen spiny lobsters below Nicaragua's minimum legal size of 5 ounces (Associated Press July 3, 2003).

Table 5.3.8. Minimum Size Restrictions of Caribbean Spiny Lobster for Harvesting Countries. *Source*: FAO.

Country	Carapace Length	Tail Length	Tail Weight	Total Weight	Total Length	CRFM Member	% 2003 World Harvest	Agreed to 74 mm (2.91 in.) cephalothorax length*
Anguilla	95 mm					Yes	0.18	
Antigua and Barbuda						Yes	0.73	
Bahamas	82.5 mm[a]	5.5 in. or 139.7 mm				Yes	31.14	Yes
Barbados						Yes	0.00	
Belize	76.2 mm or 3 in.	113 mm[a]	4 oz.			Yes	1.63	Yes
Bermuda	3 5/8 in. or 92 mm		12 oz. or 340 g			No	0.09	
Brazil	75 mm[a]	130 mm[a]					16.02	Yes
British Virgin Islands	3.5 in.			1 lb.		Yes	0.01	
Colombia-San Andres	80.1 mm[a,c]	140 mm[a]				No	0.8	Yes
Colombia-Guajira	68.9 mm[a]	210 mm[a]		385 g[a]		No		
Costa Rica						No	0.08	Yes
Cayman						No	0.00	
Cuba	69 mm[a]	150 mm[a]			210 mm[a]		15.80	Yes
Dominica						Yes	0.00	
Dominican Republic	80.5 mm[a]	120 mm[a,b]			240 mm[a]	No	2.41	Yes
Grenada	3.7 in.					Yes	0.08	
Guadaleupe						No	0.00	
Gautemala						No	0.00	
Guyana						Yes	0.00	
Haiti						Yes	0.60	Yes
Honduras	80.1mm[a]	145 mm[a]	142 g[a]			No	3.06	Yes
Jamaica	7.62 cm or 3 in.					Yes	1.50	Yes
Martinque						No	0.57	Yes
Mexico	74.6 mm[a]	135 mm[a]			223 mm[a]	No	3.15	Yes
Monserrat						Yes	0.00	
Nicaragua	75 mm[a]	135 mm[a]	142 g[a]		230 mm[a]	No	11.56	Yes
Panama						No	0.00	
Puerto Rico	3.5 in.					No	0.59	Yes
St. Kitts & Nevis	9.5 cm or 3.75 in.					Yes	0.03	
St. Lucia	95[a]		340 g[a]			Yes	0.00	
Saint Vincent and the Grenadines	95 mm or 3.75 in.			1.5 lb.	9 in.	Yes	0.00	
Turks and Caicos	3.57 in. or 83 mm		7 oz. or 142 g			Yes	0.74	Yes

Country	Carapace Length	Tail Length	Tail Weight	Total Weight	Total Length	CRFM Member	% 2003 World Harvest	Agreed to 74 mm (2.91 in.) cephalothorax length*
Trinidad and Tobago						Yes	0.01	
USA (Florida)	3 in. or 76 mm	5.5 in.				No	5.66	Yes
U.S. Virgin Islands	3.5 in.					No	0.39	Yes
Venezuela	120 mm[a]			900 - 1,000 g[a]		No	3.18	Yes

a: FAO Fisheries Report No. 715, page 257.
b: Without telson.
c: Converted from another measurement.
*: At the September 2006 Regional Workshop on the Assessment and Management of Caribbean Spiny Lobster of the Working Group on Caribbean spiny lobster of the WECAFC.

In December 2003, a Norfolk, Virginia-based seafood company and its vice president pleaded guilty in federal court in Miami to conspiracy to import more than $2 million worth of undersized spiny lobster from Nicaragua to the United States. The company purposely mislabeled boxes of frozen undersized lobster to conceal that the boxes held 2-, 3-, and 4-ounce tails, all of which were below Nicaragua's legal 5-ounce limit for lobster processing and trade (South Florida Business Journal, December 15, 2003).

In May 2006, Winn-Dixie, Inc. pleaded guilty to illegal possession, transportation, and sale of undersized Caribbean spiny lobster contrary to Florida laws and regulations and the Lacey Act. On October 29, 2002, Winn-Dixie received a shipment at one of its Florida facilities of about 6,000 pounds of Caribbean spiny lobster imported from Brazil that it purchased through a broker in Illinois. It was determined that about 4,600 pounds of lobster tail failed to meet Florida and Brazil size standards (States News Service; May 22, 2006).

Florida Keys National Marine Sanctuary and Protection Act

In November 1990, Congress passed the Florida Keys National Marine Sanctuary and Protection Act that established the Florida Keys National Marine Sanctuary (FKNMS) (Pub.L 101-605).[8] The FKNMS is comprised of 9,660 square kilometers (about 2,900 square nautical miles) of coastal waters off the Florida Keys. It extends approximately 220 miles southwest of the southern tip of the Florida peninsula and includes the world's third largest coral barrier reef. Within the Sanctuary are 24 no-take zones. Fifty-eight percent of the Sanctuary resides in Florida waters and 42 percent is in federal waters. Both NOAA and the State of Florida manage the Sanctuary. The waters of the FKNMS are within the jurisdiction of both the South Atlantic and Gulf of Mexico fishery management councils.

[8] The National Marine Sanctuary System was created in 1972. Two areas in the Florida Keys were designated as sanctuaries, the first in 1975 and the second in 1981. These areas were included in the Florida Keys National Marine Sanctuary in November 1990.

Biscayne Bay National Park

Originally established as a national monument by Congress in 1968, Biscayne Bay National Park was re-designated as a national park in 1980. The Park's purpose is to preserve and protect its rare combination of terrestrial and aquatic natural resources. The Park includes approximately 173,000 acres in Miami-Dade County, and is about 22 miles long. The park extends from shore about 14 miles to the 60-foot contour and contains about 72,000 acres of coral reefs. Under existing Supervisor's rules for the Park, several areas are closed year-round to public entry to protect sensitive resources and wildlife. This also means not taking Caribbean spiny lobster in those areas.

Buck Island Reef National Monument

Buck Island Reef National Monument (Buck Island NM) in St. Croix was established in 1961 and expanded more than twenty times in size in 2001, from 880 acres to over 19,000 acres. Its area is mostly underwater and it encompasses 7 percent of the shelf around St. Croix. Federal regulation prohibits the harvest or collection of Caribbean spiny lobster within the boundaries of the national monument (36 CFR § 7.73(a)). Virgin Islands Coral Reef National Monument (Virgin Islands NM) in St. John was established in 2001 and its area encompasses 3 percent of the St. John/St. Thomas shelf. Harvest or collection of Caribbean spiny lobster is prohibited (36 CFR § 7.46(a)). The National Park Service manages both of these national monuments.

Virgin Islands National Park

Virgin Islands National Park on St. John was established by Congress in 1956 and today is managed by the National Park Service. It comprises more than half of the island of St. John and almost 9 square miles of water surrounding the island. Virgin Islands National Park attracts almost one million visitors a year, most of them arriving on cruise ships or smaller boats. Caribbean spiny lobster may be taken by hand or hand held hook within the park (36 CFR § 7.74(e)(3)).

Dry Tortugas National Park

The Dry Tortugas National Park was established by Congress in 1992 (Public Law 102-525). Possession of Caribbean spiny lobster is prohibited within boundaries of the park unless the individual took the lobster outside the park waters and the person in possession has proper State/Federal licenses and permits (36 CFR § 7.27(b)(4)(i)). The presence of lobster aboard a vessel in park waters, while one or more persons from such vessel are overboard constitutes prima facie evidence that the lobsters were harvested from park waters in violation of the above regulation.

Past Federal Actions

Indirect, but related, past federal actions that greatly affected the Caribbean spiny lobster fishery were the Migration and Refugee Assistance Act of 1962 and Cuban Refugee

Adjustment Act of 1966. The Migration and Refugee Assistance Act authorized assistance to or in behalf of refugees in the United States, which included business loans. The Cuban Refugee Adjustment Act adjusted the status of Cuban refugees to that of lawful permanent residents, which enabled them to acquire commercial fishing vessels.[9] According to Moe (1991), many of the 300,000 Cubans who fled Cuba used those government loans to obtain boats to fish lobster in Bahamian waters.[10] When Bahamian waters were closed to U.S. fishermen, those lobster fishermen moved their operations into U.S. waters.

5.3.5 State & Territory Spiny Lobster Laws and Fisheries Histories

5.3.5.1 Florida

Up until the twentieth century, landings of spiny lobster were low because the fishery was largely a bait fishery that supported Florida's finfish industry (Labisky et al., 1980).[11] However, at the turn of the century a spiny lobster commercial fishery began to develop due to the construction of the Overseas Railroad in 1912, which allowed dealers to ship spiny lobsters to northern hotels and restaurants (ibid., p. 30). The first legislation enacted by the State of Florida (State) to conserve the supply of spiny lobster in response to the growing commercial retail trade was in 1919 when it implemented a seasonal closure from March 1 to June 1, but which allowed the taking of lobster for research, fish bait, or propagation throughout the year. Two years later the closed season was changed to March 21 to June 21.

In the nineteenth century and up until the early twentieth century, spiny lobsters were typically harvested in shallow waters of Key West with cast nets, gill nets, haul seines, and grains (Labisky et al., 1980). Continuous increases in commercial demand in the early 1900s, however, stimulated expansion of the fishery so that by 1922 the primary fishing grounds extended from the shallow waters surrounding Key West to a "25-mile linear zone that encompassed the southern shores of the lower Florida Keys and the shallow Atlantic reef area both east and west of Key West" (Labisky et al., 1980). The expansion of the fishery into deeper waters necessitated gear changes from cast nets, gill nets, haul seines and grains to increasing use of bully nets and wire traps.

From 1925-26 to 1927-28 total landings increased from 88,000 pounds to 873,000 pounds, an almost 900 percent increase. The State amended its lobster regulations in 1929 to increase the length of the closed season from three to four months (March 21 to July 21) and set, for the first time, a minimum legal size limit, which was one pound (Labisky *et* al., 1980; Prochaska and Baarda, 1975).

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[9] As of August 1, 1966, there were 165,000 refugees from Cuba in the U.S. without legal permanent resident status (Immigration Information, vol. 19, Interim Decision #3069).

[10] The Bartlett Act of 1964 excluded foreign fishing vessels from fishing within the United States's territorial sea, which was defined as all ocean waters within 3 miles from the coast of the United States, its territories and possessions and the Commonwealth of Puerto Rico" (Public Law 88-308). Two years later Congress passed the Contiguous Fisheries Zone Act (Public Law 89-658), which created a 9-mile contiguous zone extending out from the 3-mile limit from which foreign fishing vessels would be excluded.

[11] According to Moe (1991, p. 39), spiny lobsters are "excellent bait for large snapper and grouper".

Despite declines in landings and prices per pound during the 1930s, the development of deep-freeze processing techniques enabled further expansion of the commercial retail market for spiny lobster in the 1940s. From 1940 to 1949 total commercial landings increased from 0.4 million pounds to 3.58 million pounds and price per pound increased from $0.07 to $0.22. By the 1940s, the most popular commercial fishing gears were wooden slat-traps, bully nets, and ice-can traps in that order. Slat-traps were used primarily in deeper waters "associated with the offshore reef on the Atlantic side of the Keys; bully nets were used in the shallow waters of Florida Bay; and … ice cans were used in shallow inshore waters" (Labisky *et* al., 1980, p. 33). Traps were still pulled by hand, however, which limited their numbers and use in deep waters (Moe, 1991). Also in the 1940s, there was an increase in imports of spiny lobster tails from the Caribbean, South Africa, and Australia (Labisky *et* al., 1980).

The south Florida spiny lobster fishery continued to grow in the 1950s. From 1952 to 1959 the number of boats/vessels in the fishery expanded from 102 to 254; the price per pound increased from $0.18 per pound in 1950 to $0.30 per pound in 1959; the number of traps increased from 17,000 in 1951 to approximately 52,000 in 1959; and commercial landings increased from 1.56 million pounds in 1950 to 3.18 million pounds in 1959.[12] With that growth came more State action to protect the supply of spiny lobster. In 1953, the Florida Legislature changed the timing of the closed season from the period of March 21 to July 21 to the period of April 15 to August 15, and redefined the legal size limit from one pound to a minimum tail size of 6 inches; however, in 1955, it reestablished the closed season from March 31 to August 1 (Labisky et al., 1980). In 1954, the State began to require lobster permits and fishers to report the number of traps fished (Florida Marine Fisheries Commission, December 5, 1991).

Moe (1991) notes three developments in the 1950s that had a significant impact on the spiny lobster fishery. First, the development of skin and SCUBA diving, especially around the Florida Keys, provided easy opportunities to hunt lobster with spear guns, which was legal at that time. Second, the development of hydraulic systems to haul traps eventually eliminated pulling traps in by hand. Third, lobster fishers began to keep 2 or 3 undersized lobsters, known as "shorts", in traps as attractants because the use of shorts increased catches significantly.[13] In a short period of time, "every fisherman used shorts whenever possible as well as the standard cowhide bait" (Moe, 1991, p. 385.).

According to Labisky *et al.*, the south Florida spiny lobster fishery radically changed in the1960s with the influx of thousands of Cubans into the country. Many of the approximately 300,000 Cuban immigrants obtained U.S. government loans and bought boats to fish for lobster in Bahamian waters (Moe, 1991; Labisky *et al.*, 1980). Most of

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[12] According to Labisky et al., there were 376 boats/vessels in 1950 and 319 boats/vessels in 1951 that were engaged in spiny lobster fishing. It is unclear why the number of boats/vessels fell to 102 in 1952, or if the 1950 and 1951 figures are questionable estimates. A boat is a watercraft with carrying capacity less than 5 tons, whereas a vessel is a watercraft with a carrying capacity of 5 tons or greater.

[13] Experiments have shown that traps baited with short lobsters catch approximately three times more lobster than traps baited with any other method (Moe, 1991; Heatwole *et al.*, 1988).

these immigrants' boats were Miami based. In 1975 when Bahamian waters were closed to foreign fishing, these Miami-based boats began to fish locally.

The first gear restriction occurred in 1965, which specified the types of gear that could be used to harvest lobster (Prochaska and Baarda, 1975; Williams, 1976). Wood traps could be used, provided that they were not greater than 3 x 2 x 2 feet or the equivalent in cubic feet.[14] Permit numbers had to be placed permanently on each trap or other device used to catch lobsters, as well as on the buoy that was used to mark the traps (Prochaska and Baarda, 1975). Also, traps and buoys had to be color-coded; and up to 20 traps could be attached to a trot-line. That same year the State set the minimum carapace size to 3 inches and minimum tail measurement to 5.5 inches.

In 1968 the minimum carapace length was reduced to 3 inches. About the same time, the fishery in the Florida Keys had expanded from the Key West area to the middle keys (FWRI 2007). A 1969 act allowed a 6-inch minimum on tails separated under special permit.

In 1971, the State changed its regulations to establish a $50 permit fee and allow landings of spiny lobsters harvested from international waters during the State's closed season (Labisky *et al*., 1980). By this time there were increasing conflicts between commercial fishers and recreational divers who harvested spiny lobster, so in 1975 the State enacted legislation that created the special 2-day sport season that is scheduled the last consecutive Wednesday and Thursday of July each year, one week before the start of the commercial season. During the special 2-day sport season, recreational lobster fishers are allowed up to 6 lobsters per person per day in the Monroe County and Biscayne Bay National Park and up to 12 lobsters per person per day in other areas of the state. The bag limit during the regular lobster-fishing season is 6 lobsters per person per day, or 24 per boat per day, whichever is greater.[15]

The Florida Marine Fisheries Commission (FMFC) adopted its first fisheries management plan (FMP) for spiny lobster on July 2, 1987. For the most part, the management plan continued existing practices; however, among the new requirements was the provision of having on board live wells with re-circulating water when transporting short lobsters (Florida Marine Fisheries Commission (FMFC), December 5, 1991). In 1988, a three-year moratorium on the issue of new permits was established in an effort to limit total commercial effort. In July 1990, the FMP was amended, and among its changes was the designation of spiny lobster as a restricted species (RSE) after July 1993. The following year the Florida legislature enacted laws, which prohibited the

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[14] As stated by Prochaska and Baarda (p. 26): The 1965 law "requires that the constructed traps be of wood slats so that when a trap is lost it will be broken up with time and thus will not continue to catch lobsters which would then be lost for both breeding stock or human consumption. The wood slat traps can be protected on the sides by reinforcement with 16 gauge, one inch poultry wire, though the bottom and top cannot be so reinforced. Partial wire reinforcing is allowed to protect the trap from the 'ravages of turtles'. Ice cans, drums and other similar devices are permitted provided that they are not equipped with grains, spears, grabs, hooks or similar devices."

[15] Recreational fishers are not allowed to use traps to capture lobster. Bully nets and diving (breath-hold, SCUBA, or hookah) are the only legal recreational fishing methods.

FMFC from adopting rules that would prohibit the possession of undersized lobsters or require traps to have escape gaps before April 1998.

In 1991, Florida instituted a recreational spiny lobster license (also known as a crawfish permit), which was purchased as an additional endorsement to the state's recreational saltwater fishing license. Also that year the State began to use two annual mail surveys of persons with a lobster license/permit to estimate the number and landings of lobsters harvested by recreational fishers who take lobsters during the special 2-day sport season and from opening day to the first Monday in September of the regular fishing season.[16]

The number of traps increased greatly from the mid 1970s through the 1980s, rising from 219,100 in 1970 to 979,766 in 1991. This rapid growth resulted in increased user conflicts on the water, excessive mortality of shorts, declining yield per trap, and concerns about trap debris (FFWCC 2007). See Figure 5.3.5.

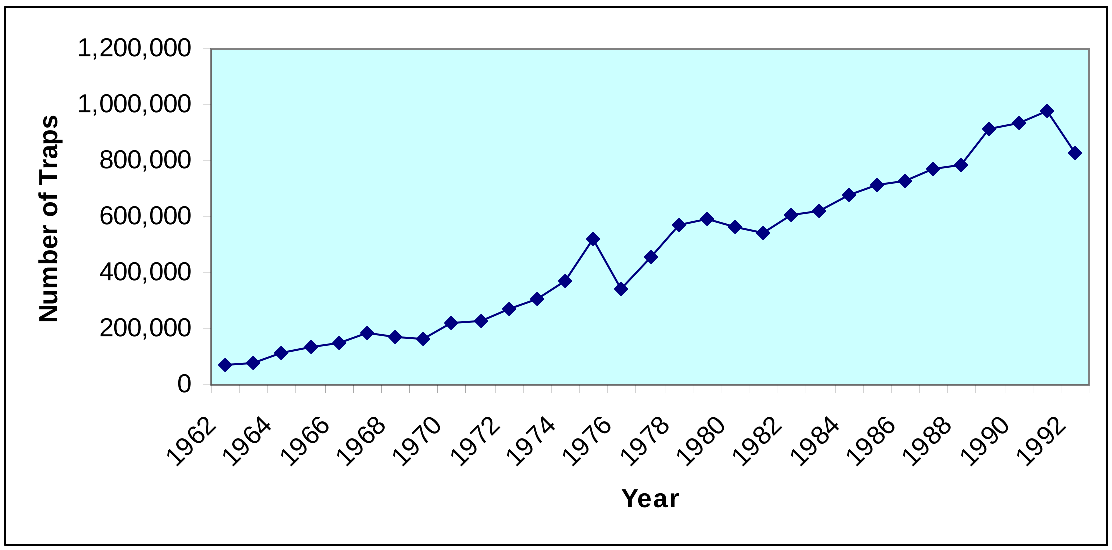

Figure 5.3.5. Annual Numbers of Traps, 1962 – 1993.

In 1992, Florida implemented the spiny lobster Trap Certificate Program (TCP), which regulated the total number of traps by requiring a certificate for each trap and setting a limit on the number of certificates. When first implemented, the initial certificate allocation was based on the trap use that had been reported for the three preceding years (Larkin and Milon).

The FFMFC is authorized to reduce the total number of certificates by decreasing the number of each individual's traps by no more than 10 percent annually. In 1993, Caribbean spiny lobster fishermen set 704,234 traps. That same year, the Florida Fish and Wildlife Commission (FFWCC) implemented the Lobster Trap Certificate Program to reduce the number of lobster traps allowed in the fishery. Since the initial allocation of

[16] The survey of recreational fishers who harvest during the regular fishing season focuses on the first month of the season because the majority of fishing effort occurs during the first month of the season (Sharp *et al.*, 2005).

certificates, the Florida Fish and Wildlife Conservation Commission (FFWCC or FWC) has decreased the number of certificates four times at 10 percent reductions: 1994, 1995, 1996, and 1999. In 2001, the FFWCC set the target number of spiny lobster traps at 400,000 and implemented a 4 percent annual reduction in traps. The FFWCC suspended the annual trap reduction in 2003; nonetheless, the program has resulted in a significant reduction in the annual numbers of traps set. During the 2005 - 2006 season, 497,042 trap tag certificates were issued; followed by 473,943 for the 2006 - 2007 season and as of December 21, 2007, there were a total of 475,320 trap tag certificates for the 2007 - 2008 season.

No one who owns one or more lobster trap certificates can be issued a commercial dive permit (68B-24.0055(2)(b)). As of January 1, 2005, and until January 1, 2010, no new commercial dive permits will be issued and no commercial dive permit will be renewed or replaced except those that were active during the 2004 – 2006 fishing season. Existing permits may only be issued to a single saltwater products license with a valid crawfish endorsement and a valid restricted species endorsement (68B-24.005(2)(c)). Failure to renew the commercial dive permit by September 30 of each year results in forfeiture of the permit.

A crawfish endorsement or crawfish license, also known as a trap number, is required for any person to use traps to harvest spiny lobster or take spiny lobster in commercial quantities (68B-24.0055(1)). The number of Crawfish Endorsements issued has declined since the 1998 -1999 season. See Figure 5.3.6. The number of individuals holding Crawfish Endorsements has also declined. During the 2005 – 2006 season, there were 1,402 endorsement holders, followed by 1,303 for 2006 – 2007, and as of December 1, 2007, there were 1,241 endorsement holders for the 2007 – 2008 season.

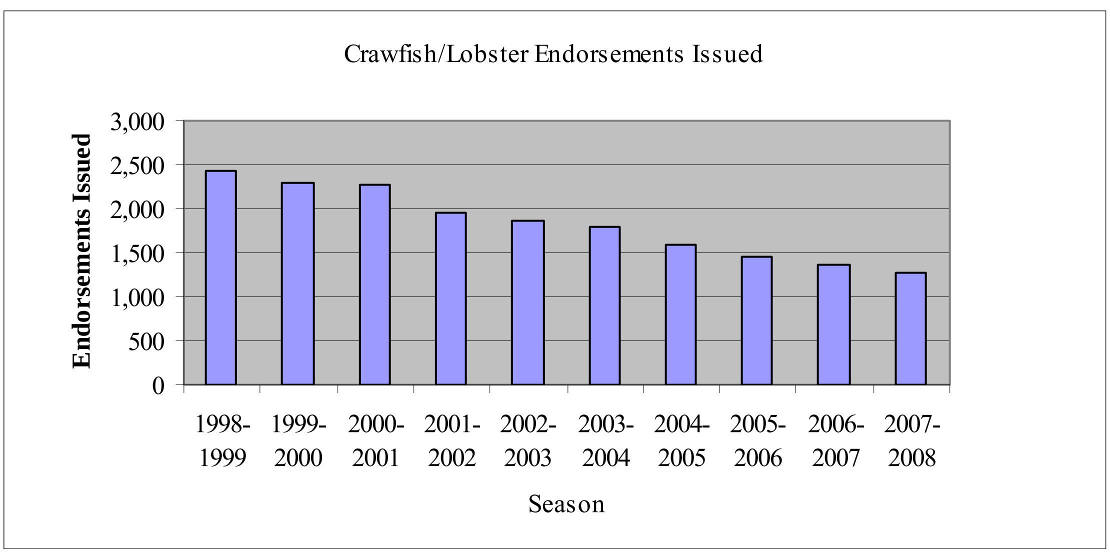

Figure 5.3.6. Number of Crawfish/Lobster Endorsements Issued. Source: Florida Fish and Wildlife Conservation Commission, Marine Fisheries Information System.

On August 5, 1994, the Special Recreational Crawfish License (SRCL) was issued after the implementation of the commercial spiny lobster trap certificate program (68B-

24.0035, Florida Administrative Code). The SRCL was intended to reduce the adverse impact on recreational fishers who were commercially licensed and using traps, but were prohibited from using lobster traps because they did not meet the qualifications that were established from the commercial lobster trap certificate program.[17] SRCLs are not issued to persons who did not possess a crawfish trap number (Crawfish Endorsement) and a Saltwater Products License during the 1993 – 1994 license year (68B-24.0035(2)(b), F.A.C.). No person issued a SRCL may also possess a Crawfish Endorsement. An SRCL is not valid unless the holder also possesses a valid Recreational Crawfish Permit required by Section 372.57(8)(d), Florida Statutes. Moreover, if the SRCL is not renewed every year, the holder loses the license. The SRCL applies to recreational fishers in state, not federal, waters, and does not permit harvesting lobsters during the 2-day sport season. License holders are required to file quarterly reports with the Florida Fish and Wildlife Conservation Commission detailing the amount of spiny lobster harvested in the previous quarter together with the amount harvested by other recreational harvesters aboard the license holder's vessel (68B-24.0035(2)(e), F.A.C.).

The number of SRCLs has declined since the 1998 – 1999 season. See Figure 5.3.7. Beginning with the 2012 – 2013 license year and every year thereafter, no SRCL will be issued or renewed (68B-24.0035(2)(g), F.A.C.).

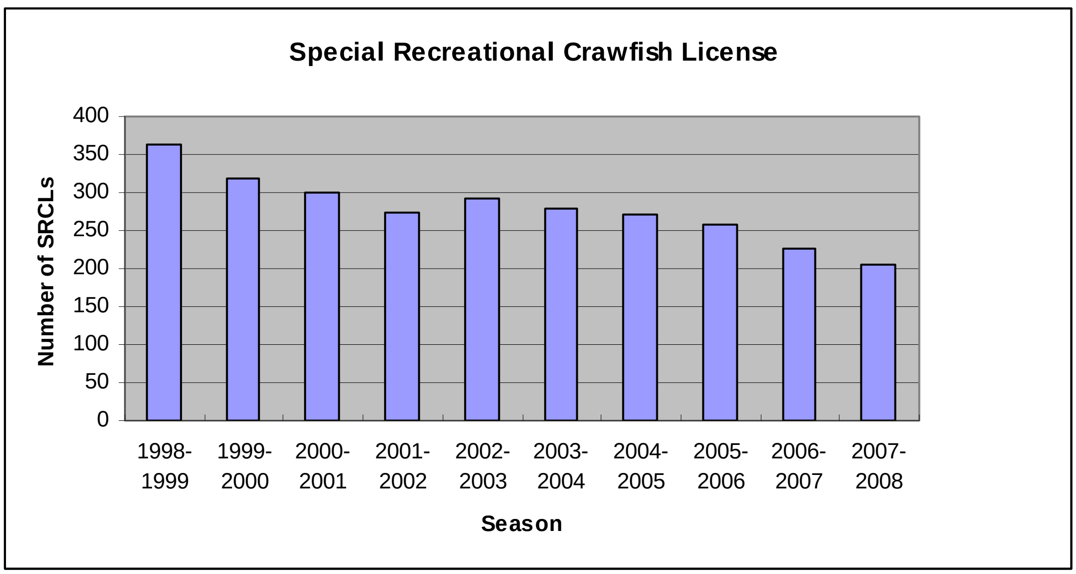

Figure 5.3.7. Number of Special Recreational Crawfish Licenses, 1998 – 1999 to 2007 – 2008 season. Source: Florida Fish and Wildlife Conservation Commission, Marine Fisheries Information System.

Currently, Florida law requires anyone who commercially harvests or sells spiny lobster to have a Saltwater Products License (SPL).[18] An SPL may be issued in the name of an individual or a valid vessel registration number issued in the name of the licensed

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[17] A commercial license was/is required because traps were/are not legally acceptable gear in the recreational spiny lobster fishery.

[18] A Saltwater Products License (SPL) is required to harvest saltwater species in excess of the recreational bag limits, with the intent to sell, or with certain gears. For species that have no established bag limit, the bag limit is 100 pounds or 2 fish per person per day or whichever is greater.

applicant. The State also requires anyone who sells spiny lobster to have a Restricted Species Endorsement (RS) and Crawfish Endorsement.[19]

Spiny lobster harvested in Florida waters must remain in a whole condition while on or below state waters and the practice of separating the tail from the body is prohibited (68B-24.003(4)). Possession of spiny lobster tails that have been separated lobster tails on or below state waters is prohibited unless the spiny lobster is being imported pursuant to 68B-24.0045, F.A.C., or were harvested outside state waters and the separation was pursuant to a federal permit allowing such separation. If tails are separated from the body, tails must be at least 5.5 inches in length,[20] otherwise, if whole, the carapace must be greater than 3 inches long (68B-24.003(1), F.A.C.).

In Florida, the harvest or possession of egg-bearing spiny lobster is prohibited and any egg-bearing lobster found in traps must be immediately returned to the water free, alive and unharmed (68B-24.007 *F.A.C.*). The practice of stripping or otherwise molesting egg-bearing spiny lobster in order to remove the eggs is prohibited and the possession of spiny lobster or spiny lobster tails from which the eggs, swimmerets or pleopods have been removed or stripped is prohibited (68B-24.007 *F.A.C.*).

Possession of undersized lobster is prohibited, except in the spiny lobster trap fishery, where fishermen use undersized lobsters to attract legally sized ones.[21] Allowable gears are traps, hand-held net, hoop net (diameter no larger than 10 feet), bully net (diameter no larger than 3 feet), and by diving. The vessel limit for harvest with a bully net is 250 lobsters per vessel per day, for the trap fishery there is no bag or trip limit, and limits for the dive fishery are regional. Additional restrictions and requirements depend on the method of harvest.

For those in the spiny lobster trap fishery, trap certificates and tags are required for all traps. A tag must be securely attached to each trap; spiny lobster trap specifications and trap, buoy, and vessel marking requirements apply; and traps, buoys, and vessels must display the Crawfish endorsement.[22] Florida law authorizes FWC to retrieve traps left in the water after the close of the season and fines the traps' owners to cover the costs of retrieving the traps.

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[19] Species designated as Restricted include African pompano, amberjack, black drum, black (striped) mullet, bluefish, blue crab, clams (Brevard County only), crawfish/lobster, cobia, Florida pompano, flounder, grouper, hogfish, king mackerel, permit, red porgy, cobia, sea bass, sheepshead, shrimp, snapper, Spanish mackerel, spotted sea trout, stone crab, triggerfish, tripletail, and tropical marine fish and plants including ornamental sponges.

[20] No less than 5.5 inches not including any protruding muscle tissue.

[21] A person aboard a vessel with a Crawfish endorsement and trap certificates may harvest and possess while on the water 50 undersized spiny lobster (shorts) and one short per trap aboard the boat. Shorts must be released alive and unharmed upon leaving trap lines.

[22] Traps must be constructed of wood or plastic and be no larger than 3 feet by 2 feet or the volumetric equivalent (12 cubic feet) with the entrance located on top of the trap. Each plastic trap must have a degradable panel. Traps must be baited and placed in the water beginning August 1. Traps may be worked during daylight hours only. Traps may not be placed within 100 feet of the intercoastal waterway or any bridge or seawall. Traps must be removed from the water by April 5 each year. Harvest is prohibited in designated areas of John Pennekamp Coral Reef State Park.

All vessels used by persons commercially harvesting lobster by diving, scuba, or snorkel must display the Commercial Dive Permit on the vessel SPL. A person with a Commercial Dive Permit cannot have a trap certificate. After January 1, 2005, no diver permits were issued, renewed or replaced except those that were active in 2004-05. Dive permits that are not renewed by September 30 of each year are forfeited. A 250-lobster daily vessel limit applies in Broward, Dade, Monroe, Collier, and Lee counties and adjoining federal waters.[23]

The commercial CSL and regular recreational CSL season starts on August 6 and ends on March 31 (68B-24.005(1). No person can harvest, attempt to harvest, or have in his possession, regardless or where taken, any spiny lobster during the closed season of April 1 through August 5 of each year, except during the 2-day sport season, for storage and distribution of lawfully possessed inventory stocks or by special permit issued by the Florida Fish and Wildlife Conservation Commission (68B-24.005(1)). During the 2-day sport season no person can harvest spiny lobster by any means other than by diving or with the use of a bully net or hoop net.

A Wholesale Dealer License is required for any person, firm or corporation that sells spiny lobster to any person, firm, or corporation except to the consumer and who may buy spiny lobster from any person pursuant to section 370.06(2) of the Florida Statutes or any licensed wholesale dealer.

Each spiny lobster imported into Florida must comply with the minimum size requirements and the prohibitions relating to eggbearing spiny lobster (68B-24.0045(3) F.A.C.). During the open season (August 6 through March 31), a person may possess wrung spiny lobster tails or possess spiny lobster in excess of the bag limit while on state waters if such person also possesses appropriate receipt(s), bill(s) of sale, or bill(s) of lading to show that the spiny lobster were purchased in a foreign country and are entering the state in international commerce (68B-24.0045(1)).

5.3.5.1.2 Florida County Ordinances

Zoning laws have indirectly affected the spiny lobster fishery in south Florida. In August 1986, Monroe County changed its zoning laws by implementing the Monroe County Land Use Plan (Plan). Under the Plan, commercial fishers must store, build, repair, and dip traps in industrial or commercially zoned areas, within areas designated as commercial fishing villages or in areas termed specific fishing districts (Johnson & Orbach, 1990).[24] Prior to the zoning change, fishers could store and work on traps on

[23] Divers must permanently and conspicuously display a 'divers down flag' placard on the vessel and affix the Commercial Dive Permit to the diagonal stripe with 10-inch numbers visible from the air and 4-inch numbers visible from the water. Harvest from artificial habitat is prohibited. Divers must possess a carapace measuring device and measure lobster in the water. The use of bleach or chemical solutions or simultaneous possession of spiny lobster and any plastic container capable of ejecting liquid is prohibited.

[24] Traps used to be dipped in recycled oil to protect them from the marine environment. However, that practice was prohibited beginning in 1995. Now fishermen soak traps in a brine solution to extend the life of their traps.

residential property. Under Article V, Section 9.5 – 143(f) of the Monroe County Ordinances, where a nonconforming use of land or structure is discontinued or abandoned for 6 months or 1 year in the case of stored lobster traps, then such use may not be reestablished or resumed, and subsequent use must conform to provisions detailed in the chapter of the ordinances.

5.3.5.2 Puerto Rico

Puerto Rico law requires commercial lobster fishermen to have a Common Lobster Fishing Permit (12 L.P.R.A § 25e(b)(2)). Regulation 6768, Article 8(o) states no person can fish, possess, sell or offer for sale the common lobster (P. argus) with a carapace length less than 3.5 inches."

Most spiny lobster are taken by scuba diving and fish pots. See Table 5.3.9.

Table 5.3.9. Puerto Rico Commercial Lobster Fishery Gear Types. *Source*: SEDAR 2005.

Gear Type	Landings (1000s lbs)	Percent
Scuba Diving	2,110.40	43.3
Fish Pot	1,859.00	38.1
Lobster Pot	442.7	9.1
Trammel Net	162.2	3.3
Bottom Line	78.7	1.6
Spear Fishing	77.4	1.6
Skin Diving	58.3	1.2
Gill Net	52.6	1.1
Other	34	0.7

5.3.5.3 U.S. Virgin Islands

Title 12, Chapter 9A, §319(b) of the Virgin Islands Code (V.I.C.) states "No person, firm, or corporation shall take or have in his possession at any time, regardless of where taken, any spiny lobster (crawfish or crayfish) of the species Panulirus Argus unless such spiny lobster … shall have a carapace length of more than three and one-half (3 ½) inches." According to 12 V.I.C. §319(c), lobsters must remain in a whole condition at all times while being transferred on, above or below the waters of the territory and the practice of wringing or separating the tail from the body is prohibited on the waters of the territory. Egg-bearing lobsters of any species shall not be taken, possessed or sold at any time, except that egg-bearing lobsters may be returned to pots and traps in which they have been captured, provided such egg-bearing lobsters are returned to such pots or traps in a live or unharmed condition, are provided with adequate food, and are immediately returned into the water (12 V.I.C. §319(c)). Such egg-bearing lobsters as are returned to pots or traps as aforementioned, shall not be taken or possessed or sold until the eggs have been naturally released into the water; provided they are of at least the minimum size forth in §319(b). The practice of stripping, shaving, scraping, clipping, or otherwise molesting egg-bearing lobsters in order to remove the eggs is prohibited (12 V.I.C. §319(e)).

It is unlawful for any person to spear, hook or otherwise impale any lobster in the process of capture. Lobsters may only be captured by hand, snare, pot or trap, so that short or egg-bearing lobsters may be released unharmed or returned to the pot or trap as permitted (12 V.I.C. §319(f)). The great majority of spiny lobster landings are taken by scuba gear and traps and lines. See Table 5.3.10.

Table 5.3.10. U.S. Virgin Islands Spiny Lobster Percent Landings by Gear Category, 1994 – 2003. *Source*: SEDAR 2005.

Gear Type	Percent Reported Landings
Scuba	61.51
Traps/Lines	33.23
Free Diving	2.24
Gillnets	1.16
Seine Nets	0.46
Scuba/Free Diving	0.31
Unknown	0.29
Line Fishing	0.24

Title 12, Chapter 9A, §324 of the V.I.C. states that no person shall sell, or represent for the purpose of sale, in any form, any seafood as local or native seafood unless the same shall have been originally caught or taken in this territory; nor shall any person so sell, or represent for the purpose of sale, in any form, any crustacean as local or native lobster unless the same is the species known as *Panulirus argus*; nor shall any person so sell, or represent for the purpose of sale, in any form, any meat as local or native lobster meat unless such meat is wholly from crustaceans of *Panulirus argus*.

5.3.6 Foreign Laws and International Agreements

On August 1, 1975, the Commonwealth of The Bahamas enacted a law that declared spiny lobster a creature of its Continental Shelf, which is similar to the U.S. law (16 U.S.C. 1857(2)(B)) that considers American lobster a part of our Continental Shelf (Vanderbilt Television News Archive, September 11, 1975). Consequently, Bahamian territorial waters were closed to U.S. spiny lobster fishers on and after that date. The closure had a dramatic impact on landings of spiny lobster in the southeast: pounds landed in 1975 were 32 percent less than the previous year's landings, and pounds landed in 1976 were 28 percent less than 1975 landings.[25] In Florida, pounds landed on the east

[25] According to Labisky et al. (1980), less than half of the spiny lobster landed was harvested in domestic waters and most of the foreign catch was taken from Bahamian waters. Noetzel & Wojnowski report that in 1973, about one-fifth of landings on Florida's west coast came from spiny lobsters that were harvested in

coast in 1975 were 44 percent less than pounds landed in 1974, and pounds landed in 1976 were about 57 percent less than pounds landed in 1975.[26] Pounds of spiny lobster landed on the west coast declined from approximately 6.7 million in 1974 to about 4.4 million in 1976. East coast Florida fishers have landed less spiny lobster annually since the closure of Bahamian waters in 1975; however, landings on the west coast of the state have exceeded those landed in 1974, before the closure, for four years. To mitigate the losses caused by the closure of Bahamian waters, domestic fishers began to increase the number of traps after 1975 (Shivlani & Milon, 2000).

In 1972, the Treaty between the Government of the United States of America and the Government of the Republic of Colombia Concerning the Status of Quita Sueño, Roncador and Serrana was signed, which allowed U.S. fishing vessels to operate in Colombian waters. As a result of that treaty, U.S. vessels fishing in Colombian Treaty Waters are prohibited from possessing Caribbean spiny lobster smaller than 5.5 inches (19.97 cm) tail length (50 CFR 300.126(m)). Also, a berried (egg-bearing) spiny lobster caught in treaty waters cannot be retained on board, and a berried lobster may not be stripped, scraped, shaved, clipped or in any manner molested to remove the eggs (50 *CFR* §300.132).

In an international fishery like that of spiny lobster, "consensus" on addressing concerns is important, as are U.S. efforts to engage other countries in negotiations/agreements. FAO/WECAFC has organized five workshops on spiny lobster in cooperation with most regional agencies and institutions, dealing with various projects: Belize City, Belize (1997); Merida, Mexico (1998, 2000, and 2006); and Havana, Cuba (2002). A representative from the Caribbean Council attended all the workshops. A staff member of NOAA Fisheries Service's Southeast Region attended the 2006 workshop in Merida.

The participating countries of the September 2006 workshop of the Working Group on Caribbean spiny lobster of the WECAFC agreed that there were management problems across the region, which included growth of fishing effort; weak enforcement and compliance; illegal, unreported and unregulated fishing; increasing use of artificial habitats (casitas); conflicts between trap fishers and dive fishers; open access fisheries; and reports that in some Central American countries of leaving lobster traps in the water during the countries' closed seasons. The countries also agreed that countries that did not have a minimum harvest-size in their regulations that is equal to or greater than 74 millimeters carapace-length should make efforts to do so (WECAFC 2007, p. 3).

The WECAFC member countries who attended the Merida Workshop in 2007 agreed. According to the United Nations' Food and Agricultural Organization (FAO), Belize, Bermuda, Colombia, Guyana, and Jamaica did not have minimum size-regulations as of December 31, 2007.

Caribbean waters off the coasts of Nicaragua and Honduras (1975, p. 25). According to Williams (1975), the closing of Bahamian waters to U.S. spiny lobster fishers represented a loss of approximately 90 percent of foreign water landings.

[26] On the east coast of Florida, 4,147,200 pounds were landed in 1974; 2,319,300 pounds were landed in 1975; and 987,300 pounds were landed in 1976.

5.3.7 Florida Commercial and Recreational Harvest

Caribbean spiny lobsters are harvested by both commercial and recreational fishermen. Florida law allows commercial fishermen to harvest spiny lobster by diving or using wooden, plastic or metal traps, or bully or hoop nets (68B-24.006(1)); however, wooden traps are the most popular gear type.[27] These traps are weighted with cement and include a self-deteriorating escape panel that degrades over time. Fishermen commonly string traps along a trap line, with each end of the trap line marked by a buoy. All traps must be removed by April 5 of each year (68B-24.005(4) F.A.C.). Strong coastal storms can damage and destroy the traps.

The predominant gear type used to catch spiny lobster in Florida is a pot or trap. From 1997 through 2006, about 90 percent of annual total state landings have been caught in pots and traps. See Figure 5.3.8. Diving is the second most popular gear type and takes about 9 percent of the total pounds landed annually.

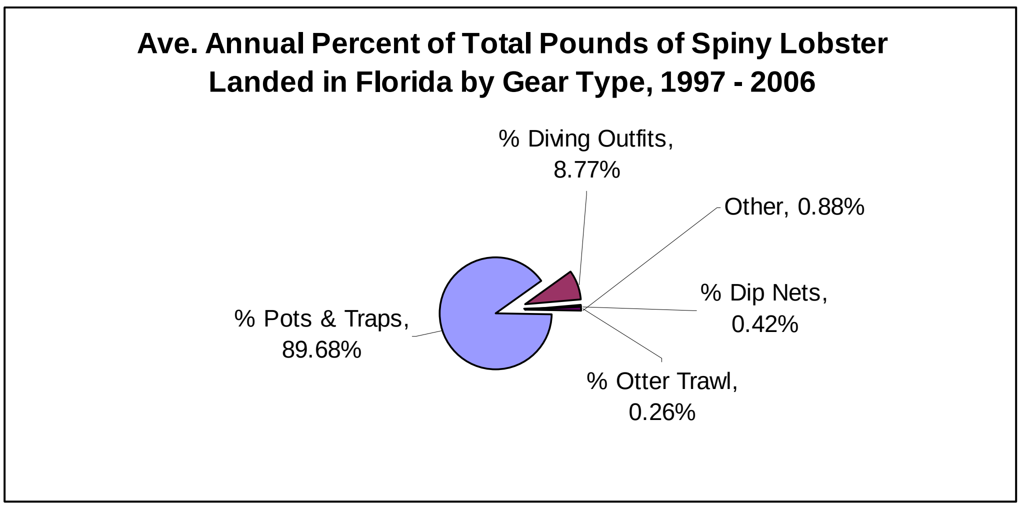

Figure 5.3.8. Average Annual Percent of Total Pounds of Spiny Lobster Landed in Florida by Gear Type, 1997 – 2006. *Source*: National Marine Fisheries Service, Accumulated Landings System.

Commercial fishermen use live undersized CSL, commonly known as "shorts", instead of cowhide or fish heads as bait to attract CSL into their traps. Florida law allows the holder of a valid Crawfish Endorsement, lobster trap certificates, and valid saltwater products license to harvest and possess, while on the water, undersized spiny lobster not exceeding 50 per boat and 1 per trap aboard each boat is used exclusively for luring, decoying, or otherwise attracting noncaptive spiny lobster into traps. Such undersized spiny lobster must be kept alive while in possession, in a shaded continuously circulating live well

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[27] A bully net used to directly harvest spiny lobster can not have a diameter greater than 3 feet and similarly, a hoop net can not have a diameter larger than 10 feet (68B-24.007(5)). Spiny lobster taken by the use of any non-hand-held net or trawl as incidental bycatch of legally harvested targeted species is allowed if the combined whole weight of all spiny lobster does not exceed 5 percent of the total whole weight of all species legally possessed at the time.

with a pump capacity to totally replace the water at least every 8 minutes and large enough to provide at least 0.75 gallon of seawater per lobster (68B-24.003(3) F.A.C.).

Usually each season's landings peak in August then sharply decrease thereafter. See Figure 5.3.9. Effort and landings also decrease after the opening of the stone crab claw fishery on October 5 (FWRI 2007).[28] See Figure 5.3.10.

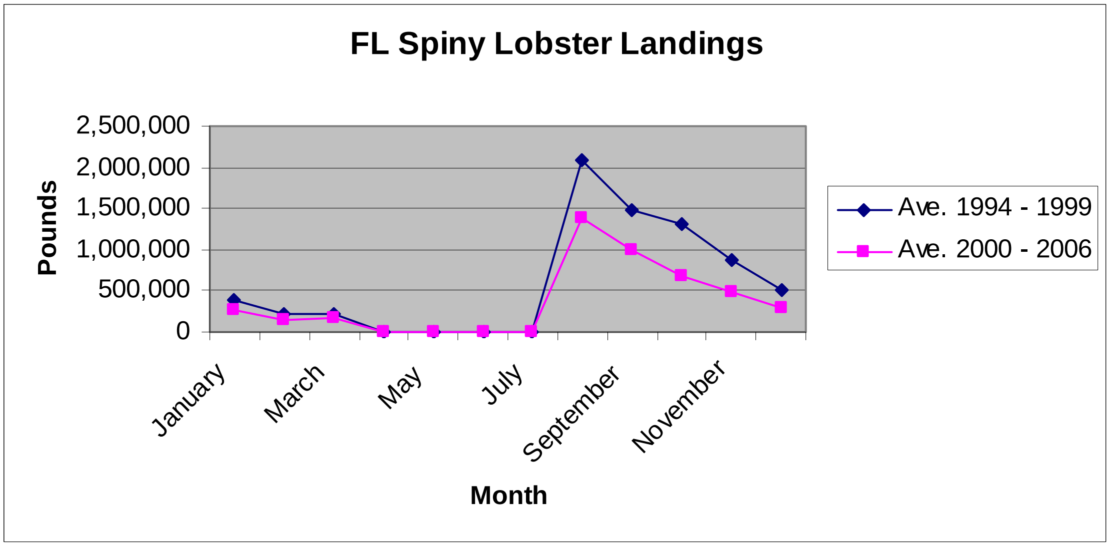

Figure 5.3.9. Florida Landings of Spiny Lobster, 1994 – 2006. *Source*: Florida Fish and Wildlife Conservation Commission, Marine Fisheries Information System.

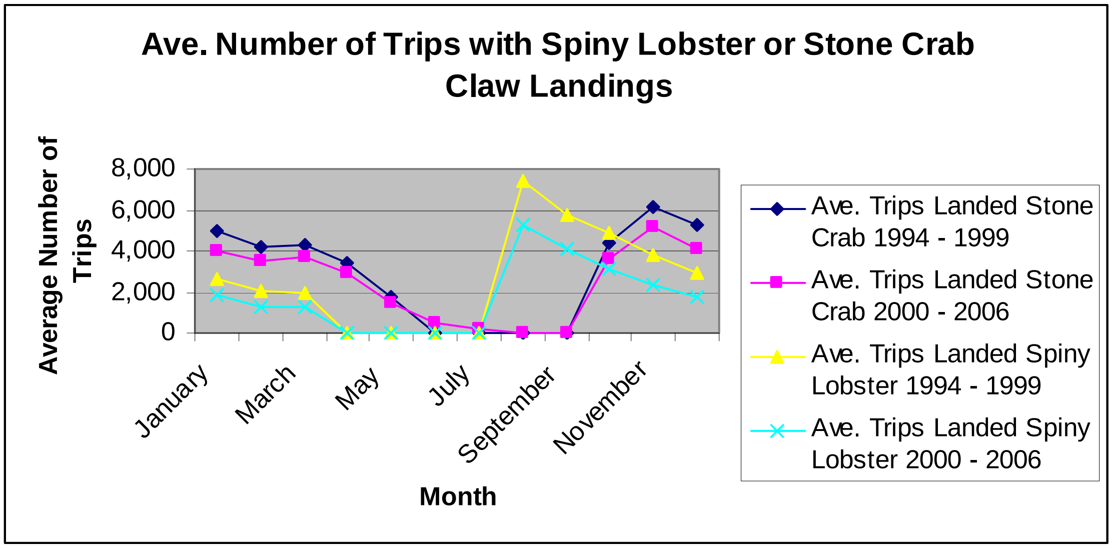

Figure 5.3.10. Average Number of Monthly Trips that Landed Either Spiny Lobster or Stone Crab Claws, 1994 – 1999 and 2000 – 2006. *Source*: Florida Fish and Wildlife Conservation Commission, Marine Fisheries Information System.

[28] Stone crab was originally a bycatch caught in spiny lobster traps; however, in the 1970s, it became a fishery. Today, many spiny lobster fishermen are also stone crab fishermen as well.

During the 2-day sport season, no person can harvest spiny lobster by any means other than by diving or using a bully net or hoop net (68B-24.005 F.A.C.)).
Bully and hoop nets and diving (breath-hold, scuba, or hookah) are the only legal recreational fishing methods (Recreational fishermen primarily dive to harvest the species; however, they also use bully nets and hoop nets). A bully net is a circular frame attached at right angles to the end of a pole and that supports a conical bag of webbing. The webbing is usually held up by means of a cord, which is released when the net is dropped over a lobster. A hoop net is a frame, circular or otherwise, that supports a shallow bag of webbing and is suspended by a line and bridles. The net is baited and lowered to the ocean bottom, to be raised rapidly at a later time to prevent the escape of the lobster.

It is estimated that the numbers of lobsters landed by recreational fishers represent an average of 23 percent of the total annual recreational and commercial numbers landed from the 1978-79 through 2003-04 fishing seasons. See Table 5.3.11.

Table 5.3.11. Florida Landings of Caribbean Spiny lobster, 1978-79 through 2003-2004 Fishing Seasons. *Source*: Florida Fish & Wildlife Conservation Commission.

Fishing Season	Rec. Landings	Com. Landings	Bait Landings	Total Landings	% Rec	% Comm	% Bait
1978-79	1,032,818	4,712,160	1,489,053	7,234,031	14.28%	65.14%	20.58%
1979-80	1,332,146	6,384,958	1,766,902	9,484,006	14.05%	67.32%	18.63%
1980-81	1,653,054	5,074,434	1,450,653	8,178,141	20.21%	62.05%	17.74%
1981-82	1,438,200	4,673,563	1,389,579	7,501,342	19.17%	62.30%	18.52%
1982-83	1,487,598	5,192,189	1,440,506	8,120,293	18.32%	63.94%	17.74%
1983-84	1,114,641	3,516,013	1,205,460	5,836,114	19.10%	60.25%	20.66%
1984-85	1,218,015	5,077,610	1,458,513	7,754,138	15.71%	65.48%	18.81%
1985-86	1,176,734	4,586,067	932,611	6,695,412	17.58%	68.50%	13.93%
1986-87	1,098,768	3,955,795	1,321,591	6,376,154	17.23%	62.04%	20.73%
1987-88	1,305,427	4,657,778	521,939	6,485,144	20.13%	71.82%	8.05%
1988-89	1,743,948	6,381,104	499,015	8,624,067	20.22%	73.99%	5.79%
1989-90	1,718,020	6,650,042	587,191	8,955,253	19.18%	74.26%	6.56%
1990-91	1,496,810	5,154,258	1,061,504	7,712,572	19.41%	66.83%	13.76%
1991-92	1,990,623	5,784,865	662,668	8,438,156	23.59%	68.56%	7.85%
1992-93	1,242,648	4,567,343	565,406	6,375,397	19.49%	71.64%	8.87%
1993-94	1,787,054	4,662,274	422,617	6,871,945	26.01%	67.85%	6.15%
1994-95	1,751,298	6,229,495	492,439	8,473,232	20.67%	73.52%	5.81%
1995-96	1,673,330	5,666,412	513,035	7,852,777	21.31%	72.16%	6.53%
1996-97	1,778,889	6,646,664	583,692	9,009,245	19.75%	73.78%	6.48%
1997-98	2,186,058	6,796,320	621,140	9,603,518	22.76%	70.77%	6.47%
1998-99	1,185,036	4,522,375	275,976	5,983,387	19.81%	75.58%	4.61%
1999-00	2,292,304	6,581,944	498,148	9,372,396	24.46%	70.23%	5.32%
2000-01	1,848,447	4,469,964	423,038	6,741,449	27.42%	66.31%	6.28%
2001-02	1,091,022	2,307,262	323,096	3,721,380	29.32%	62.00%	8.68%
2002-03	1,223,197	3,818,081	347,857	5,389,135	22.70%	70.85%	6.45%
2003-04	1,142,960	3,419,929	329,668	4,892,557	23.36%	69.90%	6.74%

The Florida Department of Environmental Protection (FDEP) has conducted annual mail surveys of recreational lobster fishers for the two-day sport season and the first month of the regular season since 1991 in order to estimate recreational lobster harvest and fisher participation (FDEP, 1996). Since 1985, recreational fishers have taken an average of approximately 1.5 million spiny lobsters annually through Labor Day. Statewide recreational landings for the most recent available survey that was conducted in 2006 were estimated to be 947,353 pounds (FWRI 2007). That estimate was 36 percent lower than the average landings in the previous available five years, from 2000 through 2004, and was 37 percent lower than the available historic average landings from 1992 through 2006.

5.3.8 Florida Counties with Commercial Landings of Spiny Lobster

5.3.8.1 Introduction

Seven counties account for about 99.5 percent of Florida's annual commercial landings of Caribbean spiny lobster, with Monroe County dominating by taking about 90 percent of the landings year after year. See Table 5.3.12. Both Monroe and Dade (Miami-Dade) Counties combined account for about 96 percent of the state's annual commercial landings. According to the FWRI (2007), most of the lobsters landed outside Monroe and Dade Counties from 1992 though 2006 were caught in the Keys and sold to wholesale dealers operating in Palm Beach County.

Table 5.3.12. Top 7 Counties in Commercial Landings of Caribbean Spiny Lobster, 1994 – 2006. Source: FL Fish and Wildlife Conservation Commission, Marine Fisheries Information System.

County	Ave. Annual CSL Landings	Portion of Ave. Annual FL CSL Landings	Combined Portions of FL Landings
Monroe	5,070,122	89.658%	89.6584%
Dade	366,385	6.479%	96.1375%
Palm Beach	69,507	1.229%	97.3666%
Broward	46,460	0.822%	98.1882%
Collier	34,981	0.619%	98.8068%
Brevard	20,837	0.368%	99.1753%
Duval	17,067	0.302%	99.4771%

The number of lobster/crawfish licenses has been in decline in Florida since fiscal year 1998-1999.[29] See Figure 5.3.11.

[29] The fiscal year is from July 30 to June 1.

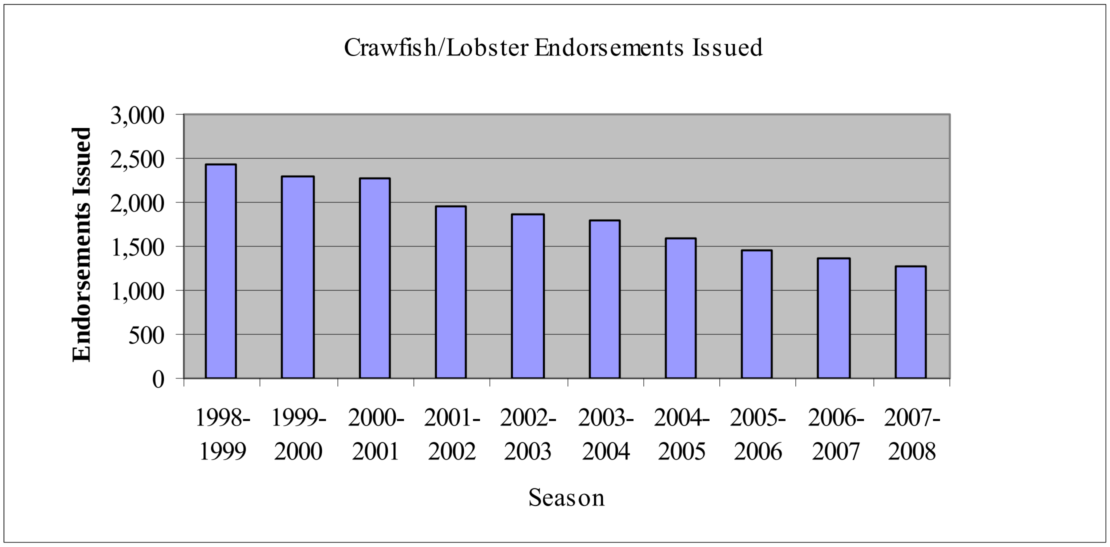

Figure 5.3.11. Florida Lobster/Crawfish License Endorsements Issued. Source: Florida Fish & Wildlife Commission.

5.3.8.2 Monroe County

Monroe County leads the state in landings of Caribbean spiny lobster year after year. From 1994 through 2006 Monroe County led the state in commercial landings of Caribbean spiny lobster, averaging about 90 percent of the state's commercial landings each year. See Table 5.3.13.

Table 5.3.13. Monroe County Commercial Landings of Caribbean Spiny Lobster. *Source*: FL Fish and Wildlife Conservation Commission, Marine Fisheries Information System.

Year	County CSL Landings (lbs)	FL CSL Landings (lbs)	Portion of FL Landings
1994	6,239,090	7,087,357	88.03%
1995	6,245,472	7,001,661	89.20%
1996	7,138,859	7,865,678	90.76%
1997	6,461,282	7,107,684	90.91%
1998	5,268,000	5,831,407	90.34%
1999	6,794,915	7,578,321	89.66%
2000	5,114,237	5,763,470	88.74%
2001	2,904,035	3,405,509	85.27%
2002	4,035,905	4,483,426	90.02%
2003	3,855,401	4,268,277	90.33%
2004	4,500,913	4,983,400	90.32%
2005	3,026,574	3,365,221	89.94%
2006	4,326,907	4,755,048	91.00%
Average	*5,070,122.31*	*5,653,573.77*	*89.58%*

Over 78 percent of the state's trap-tag certificates are held by individuals in Monroe County. See Table 5.3.14.

Table 5.3.14. Monroe County Trap Tag Certificates and Endorsement Figures, as of December 31, 2007. *Source*: FL Fish and Wildlife Commission.

2006			
	County	State	% State
Endorcement Holders	695	1,402	49.57%
Endorcement Accounts	403	615	65.53%
Endorcements Issued	826	1,638	50.43%
Revenue Collected	$94,300	$182,050	51.80%
Trap Tag Certificates	380,237	485,709	78.28%

2007			
	County	State	% State
Endorcement Holders	632	1,303	48.50%
Endorcement Accounts	365	582	62.71%
Endorcements Issued	751	1,512	49.67%
Revenue Collected	$85,575	$167,700	51.03%
Trap Tag Certificates	369,780	473,943	78.02%

2008			
	County	State	% State
Endorcement Holders	623	1,241	50.20%
Endorcement Accounts	353	550	64.18%
Endorcements Issued	739	1,443	51.21%
Revenue Collected	$84,200	$160,200	52.56%
Trap Tag Certificates	371,780	475,320	78.22%

The number of crawfish/lobster license holders has declined steadily since the 1998-99 season, and the 651 license holders for the 2006-07 season represents a 43 percent decline since the 1998-99 season. See Table 5.3.15.

Table 5.3.15. Monroe County Crawfish/Lobster License Holders. *Source*: FL Fish and Wildlife Commission.

Monroe County	
Season	License Holders
1998 - 1999	1,137
1999 - 2000	1,091
2000 - 2001	1,056
2001 - 2002	923
2002 - 2003	883
2003 - 2004	850
2004 - 2005	783
2005 - 2006	703
2006 - 2007	651
2007 - 2008	640

Wholesale seafood dealers in the county have not similarly declined. See Table 5.3.16.

Table 5.3.16 Monroe County Wholesale Seafood Dealers. *Source*: FL Fish and Wildlife Commission.

Season	Wholesale Dealers
1998 - 1999	104
1999 - 2000	110
2000 - 2001	107
2001 - 2002	107
2002 - 2003	110
2003 - 2004	117
2004 - 2005	116
2005 - 2006	116
2006 - 2007	105
2007 - 2008	106

The recreational spiny lobster fishery is very important to the County as well. In 2003, recreational landings of Caribbean spiny lobster were about 1.1 million pounds, and sales of recreational lobster fishing permits exceed 100,000 annually. Sharp *et al*. (2005) estimate approximately $24 million was spent on recreational lobster fishing in the Florida Keys from the opening of the recreational season through the first Monday in September in 2001. Recreational fishers who resided outside the Keys accounted for about $22 million (92 percent) of that $24 million spent on recreational lobster fishing in the Keys. In addition to the regular recreational season there is the Special Two-Day Sport Season, which occurs on the last consecutive Wednesday and Thursday in July. Those two days are the busiest boating days of the year in the County. From the 1993 through 2001 Special Two-Day Sport Seasons, the average annual number of spiny lobsters caught in Monroe County represented about 66 percent of the annual statewide total. The number of special recreational crawfish (spiny lobster) permits has increased since the 1998 – 1999 season.

Monroe County is the southernmost county in Florida and the United States. See Figure 5.3.11. It has a total area of 9,679 km^2 (3,737 square miles), with 2,582 km^2 being land and the remaining 7,097 km^2 (about 73 percent) being water (U.S. Census Bureau). See Figure 2-6. The County is made up of the Florida Keys and portions of Big Cypress National Preserve and Everglades National Park. The Florida Keys are a series of islands that extend over 220 miles in length and make up the third largest barrier reef ecosystem in the world and the only one of its kind in the country. The State of Florida has designated the Florida Keys as an Area of Critical State Concern to protect the area's ecologically richness, culturally significance, and environmentally sensitive nature (Florida Statute 1986; Florida Administrative Code §28-29, 1975). Over 60 percent of the Keys land mass is owned by the government and the vast majority of public land has been set aside for conservation. The County has only one highway, U.S. Highway 1, which is also called the Overseas Highway. Commercial activities and residential development are mostly concentrated along that route (National Research Council, 2002). Among the County's cities are Key West, Key Largo, Big Pine Key, Marathon and Plantation Key.

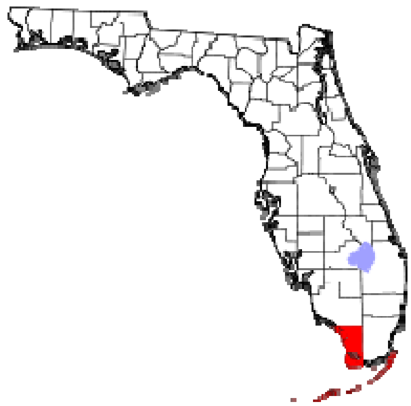

Figure 5.3.12. Monroe County. *Image Source*: Wikipedia.

More than 99.9 percent of the County's population lives on the Florida Keys. According to U.S. Census Bureau estimates, the population of the County fell 6.1 percent from April 1, 2000 to July 1, 2006, with approximately 74,737 people in 2006. During that period, there was a natural increase in population of 195 (4,642 births less 4,447 deaths) coupled with a net out-migration of 4,668 persons leaving the county (2,612 net international migration less 7,280 net internal out-migration). The number of housing units increased from 51,617 in 2000 to 52,911 in 2005, an increase of 2.5 percent. Median household income in 2004 was $42,195 and 9.2 percent of the persons in the county lived below poverty, in comparison to the statewide median household income of $40,900 and poverty rate of 11.9 percent.

Tourism is the largest sector in the county. There are more establishments in the Retail Trade (NAICS 44) and Accommodation & Food Services (NAICS 72) sectors than any other sectors, and these two sectors employ the most persons. In 2005, 35 percent of the county's employees were in Accommodation & Food Services and 21 percent in Retail Trade. See Table 5.3.17. Of the employer establishments in the Accommodation (NAICS 721) subsector, 164 (or 91) percent were in Traveler Accommodation (NAICS 7211) and 14 (or 8 percent) were in RV Parks & Recreational Camps (NAICS 7212). Similarly, of the nonemployer firms in the Accommodation subsector, 83 (or 87 percent) were in Traveler Accommodation and 4 (or 4 percent) were in RV Parks & Recreational Camps.

Table 5.3.16. 2005 Nonemployer and Employer Business Statistics, Monroe County. *Source*: U.S. Census, 2005 County Business Patterns and Nonemployer Statistics.

NAICS Code	Industry Code Description	Non-Employer Firms	Non-Employer Receipts ($1,000)	Employer Establish-ments	No. of Employees	Annual Payroll ($1,000)
11	Forestry, fishing, hunting & ag. support	992	34,476	16	20 - 99	*
21	Mining	5	160	1	0 - 19	*
22	Utilities	9	1,254	2	100 - 249	*
23	Construction	1,177	82,123	359	1,693	55,733

NAICS Code	Industry Code Description	Non-Employer Firms	Non-Employer Receipts ($1,000)	Employer Establish-ments	No. of Employees	Annual Payroll ($1,000)
31	Manufac-turing	107	5,337	80	338	9,652
42	Wholesale trade	136	15,495	112	480	18,964
44	Retail trade	601	44,847	723	6,422	145,298
48	Trans. & warehousing	393	19,220	141	942	25,076
51	Information	91	3,781	53	504	21,220
52	Finance & insurance	301	28,942	152	953	38,252
53	Real estate & rental & leasing	1,766	154,010	355	1,031	30,557
54	Professional, sci. & tech. services	1,219	68,691	334	1,320	51,592
55	Management of comps. & enterprises	0	0	6	91	5,136
56	Admin, support, waste mgt, remediation services	895	33,503	192	796	21,627
61	Ed. services	104	2,520	33	222	6,860
62	Health care & social assistance	421	21,970	214	2,373	97,625
71	Arts, entertain-ment & recreation	866	41,944	135	1,103	24,086
72	Accommoda-tion & food services	255	41,226	523	10,852	210,466
81	Other services (except public adm.)	1,362	43,583	308	1,331	29,204
99	Unclassified establish-ments	0	0	7	0 - 19	*
	TOTAL	10,700	643,082	3,746	30,631	
* : Stated as zero in 2005 County Business Patterns.						

The Monroe County Tourist Development Council estimates more than 3.49 million people visited the County in 2003 and 3.2 million visited the Florida Keys in 2006. Of visitors surveyed from March 2005 through February 2006, 80 percent were in the Florida Keys for recreation or vacation purposes. Of those surveyed, about 84 percent reported beach activities, 75 percent viewing wildlife, 57 percent diving and snorkeling, and 30 percent fishing as activities they participated in during their visit (Monroe County Tourist Development Council, Visitor Profile Survey). See Table 5.3.17.

Table 5.3.17. Recreational Activities of Florida Keys Visitors, March 2005 – February 2006. *Source*: Monroe County Tourist Development Council, Visitor Profile Survey.

Recreational Activity	Frequency	Percent of Responses	Percent of Cases
Diving	548	3.2	18
Snorkeling	1,171	6.8	38.6
Fishing	913	5.3	30.1
Viewing Wildlife	2,260	13.1	74.5
Boating	1,390	8.1	45.8
Beach Activities	2,547	14.8	83.9
Dine Out/Night Life	2,879	16.7	94.9
Museums/Historic Areas	1,659	9.6	54.7
Sightseeing & Attractions	2,727	15.8	89.9
Cultural Events	1,170	6.8	38.5
Total	17,264	100	

In 2002, there were 42 business establishments in the Charter-Fishing and Party-Fishing-Boats subsector (NAICS 4872102) with total annual revenue of about $5.5 million and 73 employees (U.S. Census, 2002 Transportation and Warehousing Subject Series). That same year there were 23 establishments in the Excursion-and Sightseeing-Boats subsector (NAICS 4872101) with total annual revenue of $17.3 million and 224 employees.

Leeworthy and Wiley (2002) estimate for the time period of June 2000 through May 2001, the general visitor population spent over 12.1 million person days in Monroe County.
Over 80 percent of those who visit the Keys arrive by automobile. From March 2005 to February 2006, 82 percent of those who visited the Keys arrived by automobile, 16 percent by air, and 2 percent by other means (Monroe County Tourist Development Council, Visitor Profile Survey). The Port of Key West is a small port; however, it serves cruise ships with itineraries in the Eastern and Western Caribbean and the Bahamas. The Key West Chamber of Commerce estimates 881,183 cruise passenger arrivals in the Port of Key West in 2006, up from 656,866 in 2000 (**www.keywestchamber.org/cominfo/trends.pdf**). In 2006, imports with a value of $36,283 and exports with a value of $11.7 million transited through the Port of Key West. There are two commercial airports in the Florida Keys: Key West International Airport and Florida Keys Marathon Airport. Key West International Airport had 276,154 arrivals in 2006, up from 275,386 in 2000 and remains the Keys primary airport for commercial activity. At present, only one commercial carrier, Delta Airlines, serves the Marathon Airport, and on July 13, 2007, the airline announced that it was suspending flights to the airport.

Fishing is another sector that is important to the Monroe County economy. In 2005, there were 971 nonemployer firms with annual receipts of $34.5 million in the fishing sector (NAICS 1141), which represent 9.1 percent of all nonemployer firms and 5.4 percent of annual receipts for all nonemployer firms in the County that year.

5.3.8.3 Dade (Miami-Dade) County

Dade County ranks second in the state in commercial landings of Caribbean spiny lobster, averaging over 6 percent of Florida's annual landings, and the two counties combined produce 96 percent of the state's commercial landings. See Table 5.3.18. Over 15 percent of FL trap-tag certificates are held by individuals in Dade County. See Table 5.3.19.

Table 5.3.18. Dade County Landings of Caribbean Spiny Lobster, 1994 – 2006. Source: FL Fish and Wildlife Conservation Commission, Marine Fisheries Information System.

Year	County CSL Landings (lbs)	FL CSL Landings (lbs)	County Portion of FL Landings
1994	611,769	7,087,357	8.63%
1995	511,983	7,001,661	7.31%
1996	456,166	7,865,678	5.80%
1997	429,838	7,107,684	6.05%
1998	377,816	5,831,407	6.48%
1999	512,157	7,578,321	6.76%
2000	328,144	5,763,470	5.69%
2001	215,947	3,405,509	6.34%
2002	242,047	4,483,426	5.40%
2003	273,557	4,268,277	6.41%
2004	329,370	4,983,400	6.61%
2005	197,510	3,365,221	5.87%
2006	276,701	4,755,048	5.82%
Average	*366,385.00*	*5,653,573.77*	*6.40%*

Table 5.3.19. Dade County Trap Tag Certificates and Endorcements, 2006 – 2008.

2006			
	County	State	% State
Endorcement Holders	217	1,402	15.48%
Endorcement Accounts	112	615	18.21%
Endorcements Issued	255	1,638	15.57%
Revenue Collected	$28,850	$182,050	15.85%
Trap Tag Certificates	71,087	485,709	14.64%

2007			
	County	State	% State
Endorcement Holders	219	1,303	16.81%
Endorcement Accounts	118	582	20.27%
Endorcements Issued	253	1,512	16.73%
Revenue Collected	$28,500	$167,700	16.99%
Trap Tag Certificates	74,166	473,943	15.65%

2008			
	County	State	% State
Endorcement Holders	207	1,241	16.68%

Endorcement Accounts	105	550	19.09%
Endorcements Issued	246	1,443	17.05%
Revenue Collected	$27,525	$160,200	17.18%
Trap Tag Certificates	78,472	475,320	16.51%

Dade County has a total area of 6,297 km^2 (2,431 square miles), with 5,040 km^2 being land and the remaining 1,257 km^2 (about 20 percent) being water (U.S. Census Bureau). Most of the area of water is Biscayne Bay, and another significant portion is adjacent waters of the Atlantic Ocean. Among its cities are Miami, Miami Beach, Coral Gables, and Key Biscayne. See Figure 5.3.11.

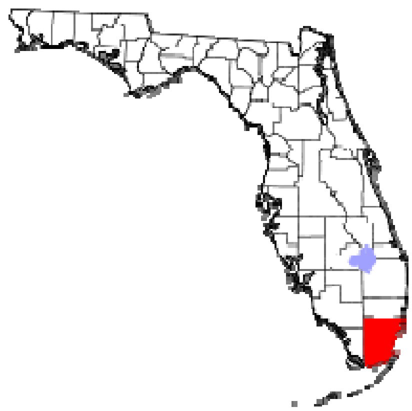

Figure 5.3.11. Dade County. *Image Source*: Wikipedia.

Dade County is the most populous county in Florida and the 8th most populous county in the nation. According to U.S. Census Bureau estimates, the population of the County grew 6.6 percent from April 1, 2000 to July 1, 2006, with approximately 2.4 million people in 2006. During that same period, the natural increase in population was 87,668 (204,079 births less 116,411 deaths) and net migration was 66,896 (257,492 net international migration less the 190,596 net internal out-migration). The number of housing units also increased from 852,414 in 2000 to 928,715 in 2005, an increase of about 9 percent. Median household income in 2004 was $34,682 and 17.1 percent of the persons in the county lived below poverty, in comparison to the statewide median household income of $40,900 and poverty rate of 11.9 percent.

Tourism is an important sector to the County economy and is the largest sector of Miami's economy. According to the Greater Miami Convention and Visitors Bureau, in 2007, 12 million overnight visitors spent $17.1 billion, an increase of $1.7 billion since 2005. Overnight visitors generated an economic impact of $13.9 billion. The Dante B. Fascell Port of Miami-Dade ranks as the world's busiest cruise/passenger port in the world. In 2006, over 3.7 million cruise passengers passed through and over 9 million tons of cargo transited through the port (Port of Miami). The combination of cruise and cargo activity supports about 98,000 jobs and generates an economic impact of $12 billion. Miami International Airport (MIA) handled 32.5 million passengers in 2006

(MIA website). Among U.S. airports, MIA ranks first in international freight, third in international passengers, and fourth in total freight.

In 2005, the County had 381 employer establishments in the industry subsector Traveler Accommodation (NAICS 7211) with 25,226 employees; 12 employer establishments in RV (Recreational Vehicle) Parks and Recreational Camps with 39 employees (U.S. Census Bureau, 2005 County Business Patterns). That same year there were 290 non-employer firms in Traveler Accommodation with annual sales of about $27.7 million and 14 non-employer firms in RV Parks & Recreational Parks with annual sales of $284,000 in the County (U.S. Census, 2005 Nonemployer Statistics). See Table 18. The largest sector by number of employees is Retail Trade (NAICS 44), which is followed by Health Care & Social Assistance (NAICS 62), Administrative and Support and Waste Management and Remediative Services (NAICS 56), Professional, Scientific & Technical Services (NAICS 54), and so on. See Table 5.3.20. Among nonemployers, the largest sector is Real Estate and Rental and Leasing (NAICS 53), which is followed by Professional, Scientific & Technical Services, Other Services (Except Public Administration), Construction, and so forth. See Table 5.3.21.

Table 5.3.20. 2005 Nonemployer and Employer Construction Statistics, Dade County. *Source*: U.S. Census Bureau, 2005 County Business Patterns and Nonemployer Statistics.

Industry Code	**Industry Code Description**	**Non-Employer Firms**	**Non-Employer Receipts ($1,000)**	**Employer Establish-ments**	**No. of Employees**
23	Construction	30,690	1,165,256	4,618	38,417
236	Construction of buildings	5,622	290,129	1,317	10,422
2361	Residential construction	4,601	240,578	1,054	6,278
2362	Nonresiden-tial construc.	1,021	49,551	263	4,124
237	Heavy and civil engineering construction	630	28,338	374	4,800
2371	Utility system construction	121	3,664	65	974
2372	Land subdivision	92	9,868	223	1,017
2373	Highway, street, and bridge construction	85	2,879	58	2,452
2379	Other heavy and civil engineering construction	332	11,927	28	357
23799	Other heavy and civil engineering construction	332	11,927	28	357

Industry Code	Industry Code Description	Non-Employer Firms	Non-Employer Receipts ($1,000)	Employer Establish-ments	No. of Employees
238	Specialty trade contractors	24,438	846,789	2,927	23,195

Table 5.3.21. 2005 Nonemployer and Employer Business Statistics, Miami-Dade County. *Source*: U.S. Census, 2005 County Business Patterns and Nonemployer Statistics.

NAICS Code	Industry Code Description	Non-Employer Firms	Non-Employer Receipts ($1,000)	Employer Establish-ments	No. of Employees	Annual Payroll ($1,000)
11	Forestry, fishing, hunting & ag. support	1,015	38,961	35	500 - 999	
21	Mining	38	2,187	29	1,073	62,003
22	Utilities	274	3,944	29	2,500 - 4,999	
23	Construction	30,690	1,165,256	4,618	38,417	1,482,470
31	Manufac-turing	3,669	212,073	2,378	46,621	1,561,117
42	Wholesale trade	7,658	814,973	8,514	67,342	2,884,026
44	Retail trade	16,420	765,506	10,335	118,182	2,870,980
48	Trans. & warehousing	23,596	1,000,767	2,725	51,193	1,936,735
51	Information	3,457	152,330	1,444	21,956	1,283,285
52	Finance & insurance	9,005	561,580	4,728	47,057	2,889,919
53	Real estate & rental & leasing	33,897	2,666,341	4,950	23,462	1,055,582
54	Professional, scientific & tech. serv.	31,153	1,381,648	11,047	60,355	3,488,485
55	Management of comps. & enterprises	0	0	291	17,005	1,311,656
56	Admin, support, waste mgt, remediation services	29,597	550,415	3,489	76,326	2,301,355
61	Ed. services	3,719	63,432	727	28,162	1,019,920
62	Health care & social assistance	26,415	905,533	7,715	114,198	4,439,517
71	Arts, entertain-ment & recreation	8,962	280,307	971	12,553	378,867
72	Accommoda-tion & food services	3,906	208,302	4,188	89,680	1,506,700

NAICS Code	Industry Code Description	Non-Employer Firms	Non-Employer Receipts ($1,000)	Employer Establish-ments	No. of Employees	Annual Payroll ($1,000)
81	Other services (except public adm.)	62,985	1,270,636	5,895	38,989	884,694
99	Unclassified establish-ments	0	0	158	100 - 249	
	TOTAL	296,456	12,044,191	74,266	858,080	
*:	Zero in 2005 County Business Patterns					

5.3.8.4. Palm Beach County

Palm Beach County ranks third in the state's commercial landings of Caribbean spiny lobster, averaging over 1 percent of FL's landings. See Table 5.3.22.

Table 5.3.22. Palm Beach County Commercial Landings of Caribbean Spiny Lobster, 1994 – 2006. *Source*: FL Fish and Wildlife Conservation Commission, Marine Fisheries Information System.

Year	County CSL Landings (lbs)	FL CSL Landings (lbs)	County Portion of FL Landings
1994	73,037	7,087,357	1.03%
1995	72,546	7,001,661	1.04%
1996	77,906	7,865,678	0.99%
1997	61,941	7,107,684	0.87%
1998	66,251	5,831,407	1.14%
1999	94,843	7,578,321	1.25%
2000	115,767	5,763,470	2.01%
2001	64,776	3,405,509	1.90%
2002	51,519	4,483,426	1.15%
2003	51,009	4,268,277	1.20%
2004	56,652	4,983,400	1.14%
2005	54,297	3,365,221	1.61%
2006	63,052	4,755,048	1.33%
Average	*69,507.38*	*5,653,573.77*	*1.28%*

Palm Beach County is the largest county in the state by size with a total area of 6,181 km^2 (2,386 squared miles), with 5,113 km^2 being land and the remaining 1,068 km^2 (about 17.3 percent) being water, much of which is in the Atlantic Ocean and Lake Okeechobee (U.S. Census Bureau). It has 47 miles of coastline. See Figure 5.3.12.

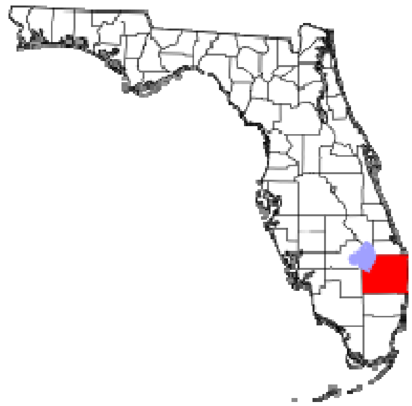

Figure 5.3.12. Palm Beach County, Florida. *Image Source*: Wikipedia.

The U.S. Census Bureau estimates the population of Palm Beach County grew over 12 percent from 2000 to 2005, with approximately 1.27 million people in 2005. The County's population growth has been dominated by in-migration from other parts of the country. From April 1, 2000 to July 1, 2006, it is estimated that there was a natural increase in the population of 6,431 (91,093 births less 88,806 deaths) and net migration of 139,754 (50,948 from net international migration plus 88,806 from net internal migration). Much of the population growth is attributable to the County being a popular destination for retirees. About 21 percent of the County's population was 65 years and over in 2005, as compared to that age group representing about 12 percent of the U.S. population and approximately 17 percent of Florida's population that year. Accompanying the increase in population has been an increase in employment. From 2000 to 2004, there was an increase of 77,553 full- and part-time jobs (U.S. Bureau of Economic Analysis). The increases in population and employment have generated increases in demand for homes, commercial and institutional buildings, and infrastructure. Median household income in the county in 2004 was $44,186 and 10.1 percent lived below poverty, as compared to the statewide median household income of $40,900 and poverty rate of 11.9 percent.

The three major multi-billion dollar industries in the county are tourism, construction, and agriculture, with tourism being number one (Palm Beach County government website, www.pbc.com/publicaffairs/facts1.htm). In 2004, over 7.2 million people visited the county, which supported $1.51 billion in wages and 7 percent of the jobs and generated an economic impact of $2.83 billion (Palm Beach County Tourist Development Council).[30]

In 2005, the top three industrial sectors by number of employees were Retail Trade (NAICS 44), Health Care & Social Assistance (NAICS 62), and Accommodation & Food Services (NAICS 72), the latter being a principal component of tourism. See Table 5.3.23. In 2005, the County had 154 employer establishments in the industry subsector Traveler Accommodation (NAICS 7211) with 5,000 to 9,999 employees; 14 employer

[30] A hotel visitor survey has found that the climate/weather, beaches/ocean, and beautiful area are what visitors like best about Palm Beach County (Palm Beach County Tourist Development Council).

establishments in RV (Recreational Vehicle) Parks and Recreational Camps with 63 employees (U.S. Census Bureau, 2005 County Business Patterns). See Table 21. That same year there were 229 non-employer firms in Traveler Accommodation with annual sales of about $27.3 million and 10 non-employer firms in RV Parks & Recreational Parks with annual sales of over $1 million in the County (U.S. Census, 2005 Nonemployer Statistics). Other important industrial sectors of the County economy include Professional, Scientific & Technical Services (NAICS 54), Retail Trade (NAICS 44), and Health Care and Social Assistance (NAICS 62).

Table 5.3.23. 2005 Nonemployer Firms and Employer Establishments, Palm Beach County. *Source*: U.S. Census Bureau, 2005 County Business Patterns and Nonemployer Statistics.

NAICS Code	Industry Code Description	Non-Employer Establish-ments	Non-Employer Receipts ($1,000)	Employer Establish-ments	No. of Employees	Annual Payroll ($1,000)
11	Forestry, fishing, hunting & agricultural support	636	27,851	78	1,398	20,666
21	Mining	18	1,971	24	234	12,828
22	Utilities	48	1,813	30	3,969	412,927
23	Construction	10,593	688,604	4,266	37,576	1,544,242
31	Manufacturing	1,221	74,104	975	15,769	753,088
42	Wholesale trade	2,793	251,624	2,436	19,902	1,052,622
44	Retail trade	7,849	453,732	5,458	73,486	1,831,500
48	Transportation & warehousing	4,172	215,349	773	8,935	326,350
51	Information	1,577	83,540	738	15,530	770,340
52	Finance & insurance	7,523	603,238	3,175	25,748	1,934,633
53	Real estate & rental & leasing	21,153	1,774,645	2,766	14,731	636,205
54	Professional, scientific & technical services	17,586	946,661	6,746	36,406	2,206,725
55	Management of companies & enterprises	0	0	217	16,799	1,268,578
56	Admin, support, waste mgt, remediation services	9,542	291,528	3,000	43,417	1,316,027
61	Educational services	2,106	43,080	469	9,864	301,140
62	Health care & social assistance	9,958	367,559	4,511	65,692	2,630,989
71	Arts, entertainment & recreation	4,906	189,810	796	16,627	453,617
72	Accommodation & food services	1,462	121,315	2,478	54,686	853,655
81	Other services (except public adm.)	16,293	554,540	3,625	23,587	564,578
99	Unclassified establishments	0	0	87	115	2,561
	TOTAL	119,436	6,690,964	42,648	484,471	18,893,271

5.3.8.5. Broward County

Broward County ranks fourth in annual landings of Caribbean spiny lobster. From 1994 through 2006 its landings represented 0.81 percent of the average annual landings during those years. County landings have dropped since reaching a peak of over 57,000 pounds in 2000. See Table 5.3.24.

Table 5.3.24. Broward County Landings of Caribbean Spiny Lobster, in Pounds, 1994 – 2006. Source: FFWCC.

Year	Spiny Lob	State Total Lbs	% of State Pounds
1994	67,891	7,087,357	0.96%
1995	71,723	7,001,661	1.02%
1996	94,219	7,865,678	1.20%
1997	56,600	7,107,684	0.80%
1998	43,121	5,831,407	0.74%
1999	50,921	7,578,321	0.67%
2000	53,619	5,763,470	0.93%
2001	57,617	3,405,509	1.69%
2002	25,394	4,483,426	0.57%
2003	16,711	4,268,277	0.39%
2004	28,664	4,983,400	0.58%
2005	21,067	3,365,221	0.63%
2006	16,435	4,755,048	0.35%
Average	46,460.15	*5,653,573.77*	*0.81%*

Broward County has a total area of 3,418 km^2 (1,320 square miles), with 3,122 km^2 being land and the remaining 296 km^2 (about 9 percent) being water (U.S. Census Bureau). Approximately 64 percent of the county's total area lies within the Everglades conservation area, and development is restricted to 410 square miles (Broward County Planning Services Division). Major Cities include Coral Springs, Fort Lauderdale, Hollywood and Pembroke Pines. See Figure 5.3.13.

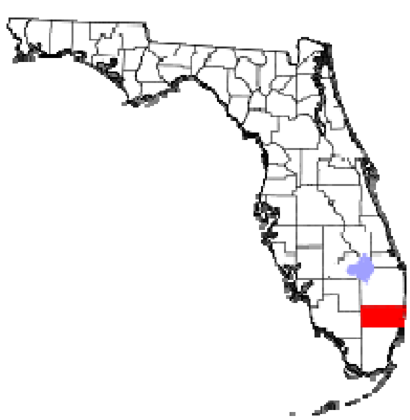

Figure 5.3.13. Broward County. *Image Source*: Wikipedia.

Broward County is the second most populated county in Florida and is the 15th most populous county in the nation. According to U.S. Census Bureau estimates, the population of Broward County grew 10.1 percent from April 1, 2000 to July 1, 2006, with approximately 1.79 million people in 2006. During that same period, the natural increase in population was 43,623 (142,787 births less 99,164 deaths) and net migration was 120,768 (100,986 net international migration plus 19,782 net internal migration), for a total increase of 164,391 people. The increase in population has resulted in increased demand for homes, retail and commercial buildings and infrastructure. Housing units increased from 741,043 in 2000 to 790,308 in 2005, an increase of less than 7 percent (U.S. Census). Median household income in the county in 2004 was $43,136 in 2004 and 11.6 percent of the persons in the county lived below poverty, as compared to the statewide median household income of $40,900 and the poverty rate of 11.9 percent. Service industries and retail trade dominate the county's economic environment. In 2005, there were more establishments in the Professional, Scientific & Technical Services sector (NAICS 54) than any other sector, and there were more paid employees in Retail Trade than any other sector. See Table 5.3.25.

Tourism's contribution is significant. In 2005, the county had a record of over 10 million visitors, a 6.3 percent increase from 2004 (Broward County Department of Urban Planning and Redevelopment, 2006). Tourism generates more than $8.4 billion and employs more than 112,000 people in the county. In 2005, Fort Lauderdale-Hollywood International Airport's over 22 million passengers broke the previous year's record of travelers passing through the facility.

In 2005, the County had 344 employer establishments in the industry subsector Traveler Accommodation (NAICS 7211) with 10,000 to 24,999 employees; 15 employer establishments in RV Parks and Recreational Camps (NAICS 7212) with 20 to 99 employees (U.S. Census Bureau, 2005 County Business Patterns). That same year there were 318 non-employer firms in Traveler Accommodation with annual sales of about $23.8 million and 17 non-employer firms in RV Parks & Recreational Parks with annual sales of $486,000 in the County (U.S. Census, 2005 Nonemployer Statistics).

Table 5.3.24. 2005 Nonemployer and Employer Business Statistics, Broward County. *Source*: U.S. Census, 2005 County Business Patterns and Nonemployer Statistics.

NAICS Code	Industry Code Description	Non-Employer Firms	Non-Employer Receipts ($1,000)	Employer Establish-ments	No. of Employees	Annual Payroll ($1,000)
11	Forestry, fishing, hunting & agricultural support	467	20,022	50	100 - 249	*
21	Mining	18	2,536	9	133	11,972
22	Utilities	87	4,369	26	500 - 999	*
23	Construction	15,482	824,796	4,729	45,489	1,915,366
31	Manufacturing	1,791	118,443	1,679	29,655	1,160,990

NAICS Code	Industry Code Description	Non-Employer Firms	Non-Employer Receipts ($1,000)	Employer Establish-ments	No. of Employees	Annual Payroll ($1,000)
42	Wholesale trade	4,383	439,736	4,710	41,514	1,976,541
44	Retail trade	11,293	579,188	7,374	102,197	2,625,584
48	Transportation & warehousing	7,821	382,114	1,346	21,480	811,196
51	Information	2,504	106,506	1,117	19,503	1,123,875
52	Finance & insurance	7,825	487,869	3,969	40,480	2,335,984
53	Real estate & rental & leasing	25,240	1,843,848	3,670	18,422	704,456
54	Professional, scientific & technical services	22,385	1,035,758	9,187	41,852	2,212,225
55	Management of comps. & enterprises	0	0	273	10,999	983,114
56	Admin, support, waste mgt, remediation services	14,601	386,155	3,869	65,367	1,833,766
61	Ed. services	2,782	55,593	603	15,046	450,758
62	Health care & social assistance	17,572	544,595	5,496	84,111	3,212,404
71	Arts, entertainment & recreation	6,714	222,151	960	9,728	316,824
72	Accommodation & food services	2,312	155,492	3,568	68,512	1,016,954
81	Other services (except public adm.)	27,791	808,376	4,847	30,422	753,542
99	Unclassified establish- ments	0	0	140	176	4,134
	TOTAL	171,068	8,017,547	57,622	646,067	23,509,177
*:	Zero in 2005 County Business Patterns					

Port Everglades infuses more than $2.4 billion annually to the county's economy (ibid). It handles about 4 million cruise passengers and over 26 million tons of cargo annually, and nearly 6,400 cargo and cruise ships call at the port each year (ibid). According to Broward County Department of Urban Planning and Redevelopment, Port Everglades has been ranked as one of the five fastest growing container ports among the nation's 20 largest seaports. It handles more than 22.1 percent of the entire state of Florida's waterborne imports and exports.

Fishing is another sector that is important to the Broward County economy, and coral reefs are important habitat for species targeted by commercial and recreational fishermen. In 2002, there were 26 business establishments in the charter-fishing-&-party-fishing-

boat subsector (NAICS 4872102) in the County (2002 Economic Census, Transportation and Warehousing Subject Series).

5.3.9 Puerto Rico

Puerto Rico is an archipelago comprised of the main island (Puerto Rico) and several smaller oceanic islands: Mona, Monito, Desecheo, Caja de Muertos, Vieques, and Culebra, and still smaller islands known as the "Cordillera de Fajardo." Its waters extend 9 nautical miles (10.36 statute miles) off its shore. See Figure 5.3.14. About one-third of the population lives around the capitol city of San Juan, and over 11 percent of the population in San Juan. Other major municipalities are Bayamón, Ponce, Carolina, Arecibo, Guaynabo, and Mayaguez.

Figure 5.3.14. Puerto Rico. *Image Source*: Central Intelligence Agency.

According to the U.S. Census Bureau, the population of Puerto Rico increased about 3 percent from April 1, 2000 to July 1, 2006, with approximately 3.93 million people in 2006. The increase in population has been accompanied by a larger percentage increase in housing units. Housing units increased from about 1.26 million in 2000 to approximately 1.44 million in 2005, an increase of about 14.2 percent. In 2005, median household income in Puerto Rico was $17,184, as compared to $46,242, which was the median household income for the U.S. as a whole.

Manufacturing dominates Puerto Rico's industrial sector. In fiscal year 2002, the Manufacturing sector accounted for approximately 42 percent of Puerto Rico's Gross Domestic Product. The value of sales, receipts or shipments from manufacturing was approximately $58.6 billion. See Table 5.3.25. The chemical industry is the largest component of the manufacturing sector, with about a 64 percent share (Government

Development Bank for Puerto Rico 2003), and that in turn is dominated by the pharmaceutical and medicine-manufacturing sector. Food, electronics, and apparel manufacturing are other major manufacturing industries in the Territory.
Retail Trade and Wholesale Trade follow Manufacturing as key sectors. In 2002, Retail and Wholesale Trade combined accounted for sales, receipts or shipments totaling $46.5 billion. The top three sectors by number of employees are Retail Trade, Health Care & Social Assistance, and Construction.

Table 5.3.25. 2002 Economic Census, Summary Statistics, Puerto Rico. *Source:* U.S. Census Bureau.

NAICS Code	Description	Employer Establish-ments	Sales, Receipts or Shipments ($1,000)	Annual Payroll ($1,000)	Paid Employees
21	Mining	44	107,000	18,834	949
22	Utilities	18	369,932	21,040	503
23	Construction	2,683	5,523,472*	1,009,747	67,288
31-33	Manufacturing	2,196	58,580,060	N	N
42	Wholesale trade	2,313	16,172,710	1,009,360	39,316
44-45	Retail trade	11,465	20,422,975	1,655,584	122,435
48-49	Transportation & warhousing	1,071	2,076,573	253,758	13,137
51	Information	462	3,686,792	633,161	19,696
52	Finance & insurance	1,809	10,233,015	1,152,628	36,059
53	Real estate & rental & leasing	1,783	1,698,631	148,334	8,183
54	Professional, scientific & technical services	3,965	2,836,774	701,485	26,197
55	Management of companies & enterprises	94	511,676	79,091	2,237
56	Administrative & support & waste management & remediation service	1,724	2,336,978	88,063	61,703
61	Educational services	306	242,810	74,829	4,647
62	Health care & social assistance	6,464	4,967,317	1,224,260	68,338
71	Arts, entertainment & recreation	369	278,975	45,393	3,115
72	Accommodation & food services	4,133	3,360,226	732,147	63,810
81	Other services (exceptu public administration)	3,324	1,470,563	281,805	18,417
N = Not available					
* value of construction					

San Juan Port is one of the world's busiest cruise ship ports and is a central hub for Caribbean cruises. Port of Ponce is the second largest port and Mayaqúez Port, the third. Smaller ports and harbors include Guánica, Guayanilla, Guayana, Fajardo, Culebra, and Vieques.

Puerto Rico's coastline attracts tourists, and tourism, including eco-tourism, is a very important industry; it represents about 6 percent of the Territory's Gross National Product (Message of the Executive Director of Puerto Rico Tourism Company, February 9-13, 2006). An estimated 5 million tourists visited Puerto Rico in 2004 (Central Intelligence Agency). It is anticipated that recent changes in passport law, which restrict the places where one may travel without a passport, may cause an increase in the number of U.S. citizens who visit the Territory because no U.S. passport is required to travel there.[31] The eastern coast of Puerto Rico, from Fajardo to Humacao and the offshore nature islands of Vieques and Culebra, have been popular destinations for tourists who snorkel and dive. Another popular snorkeling and diving location is off La Parguera on the southwestern coast, where one can find elkhorn and staghorn corals. Rincón, a municipality on the west coast, is a popular site for coastal tourism, where tourists engage in surfing, tanning, fishing, snorkeling, and SCUBA diving (Pendleton, 2002).

Fishing is another sector that is important to the Puerto Rican economy, and coral reefs are important habitat for species targeted by commercial, recreational and subsistence fishermen. During the period from 1995 through 2002, commercial fishermen caught an average of 1.6 million tons of fish annually, with 87 percent of the fishermen targeting reef fish and invertebrates, including conch and lobster (NOAA Coral Reef Ecosystem Research Plan). In 2005, domestic landings of shallow water reef fish totaled 771,656 pounds (350,022 kilograms) with a value of $1,766,337. These landings represent approximately 66 percent of total pounds of fish landed in Puerto Rico that year. In 2005, 173,445 pounds of spiny lobster were landed with a dockside value of $997,005 and 195,701 pounds of conch were landed with a dockside value of $498,094 (Fisheries of the United States 2005).

5.3.10 U.S. Virgin Islands

The U.S. Virgin Islands consists of the main islands of St. Croix, St. John, and St. Thomas, and 54 smaller islands and keys. Combined it has a land mass of about 134 square miles (346 square kilometers) and territorial waters that encompass approximately 972 square miles (1,564 square kilometers). The U.S. Virgin Islands' waters extend 3 nautical miles (3.45 statute miles) off its shore. See Figure 5.3.15.

[31] As stated in the final rule for Documents Required for Travelers Departing From or Arriving in the United States at Air-Ports-of-Entry from Within the Western Hemisphere (71 FR 68411, November 24, 2006), "Beginning January 23, 2007, all United States citizens and nonimmigrant aliens from Canada, Bermuda and Mexico departing from or entering the United States from within the Western Hemisphere at air-ports-of-entry will be required to present a valid passport."

Figure 5.3.15. U.S. Virgin Islands. *Image Source:* Central Intelligence Agency.

According to the U.S. Census Bureau, the population of the U.S. Virgin Islands increased from 101,809 in 1990 to 108,612 in 2000, about a seven percent increase. From 1990 to 2000, the population of St. Croix increased from 50,139 to 53,234, the population of St. John increased from 3,504 to 4,197 and the population of St. Thomas expanded from 48,166 to 51,181. The population increase was accompanied by an increase in the number of housing units, which rose from 39,290 in 1990 to 50,202 in 2000, an increase of over 27 percent in ten years. Median household income of the U.S. Virgin Islands as a whole was $24,704 in 2000, compared to the U.S. median of $41,994 at that time. *The World Factbook* estimates the July 2007 population to be 108,448 (www.cia.gov/library/publications/the-world-factbook/geos/rq.html).

Tourism is the largest contributor to the U.S. Virgin Islands' economy; it accounts for 80 percent of the Territory's Gross Domestic Product and employment (Central Intelligence Agency). In 1994, the total number of visitor arrivals was approximately 1.9 million and that number increased to over 2.6 million by 2004. It is anticipated that recent changes in U.S. passport laws, which restrict the places a U.S. citizen can travel to without a passport, may cause an increase in the number of U.S. citizens who visit the Territory because no U.S. passport is required to travel there. A survey conducted for the Virgin Islands Department of Planning and Natural Resources found that 100 percent of hotel industry participants answered that there would be a significant impact on tourist visits to the U.S. Virgin Islands if the coast/beaches were degraded or fisheries and/or coral reefs declined (U.S. Virgin Islands 2003).

Retail Trade is the largest sector by number of establishments, number of employees, annual payroll, and value of sales, receipts or shipments. See Table 5.3.26. Accommodation & Food Services is the second largest sector, followed by Construction. In 2002, the value of construction work was about $286 million, an increase of about 55 percent from 1997, and an increase of about 70 percent from 1992 (U.S. Census Bureau, Economic Census). Among this construction are new, remodeled, and expanded hotels and resorts. Important industries within manufacturing include petroleum refining, watch assembly, rum distilling, pharmaceuticals, textiles, and electronics.

Table 5.3.26. 2002 Economic Census Summary Statistics, U.S. Virgin Islands. *Source:* U.S. Census Bureau.

NAICS Code	Description	No. Estab.	Sales, Receipts or Shipments ($1,000)	Annual Payroll ($1,000)	Paid Employees
21	Mining	1	D	D	a
22	Utilities	4	D	D	a
23	Construction	190	285,582*	90,662	3,050
31-33	Manufacturing	63	172,830	27,151	1,058
42	Wholesale trade	74	262,932	27,664	1,028
44-45	Retail trade	680	1,217,466	128,444	6,653
48-49	Transportation & warhousing	106	181,965	34,194	1,134
51	Information	45	183,770	30,285	845
52	Finance & insurance	96	248,229	48,040	1,416
53	Real estate & rental & leasing	192	184,904	26,224	1,152
54	Professional, scientific & technical services	228	360,192	50,235	1,238
55	Management of companies & enterprises	23	30,745	2,183	76
56	Administrative & support & waste management & remediation service	155	135,267	35,834	2,050
61	Educational services	19	5,792	1,668	97
62	Health care & social assistance	203	93,289	24,428	1,232
71	Arts, entertainment & recreation	38	110,039	14,271	662
72	Accommodation & food services	313	331,008	92,357	5,639
81	Other services (exceptu public administration)	185	153,703	34,689	1,307
D = Data not disclosed a = 0 - 19 employees * Value of construction work					

5.3.11 Hurricanes

Hurricanes can have both positive and negative economic impacts on spiny lobster fishermen, especially those that use traps. The beneficial impact is that a hurricane can cause lobsters to move and go into traps and nets, which increases landings. However, the negative impacts include damages to and losses of traps, other gear, and vessels and associated losses of landings and revenues.[32]

On September 25, 1998, Hurricane Georges struck Florida with reported maximum sustained winds of approximately 95 miles per hour with gusts up to 115 miles per hour and an approximate storm surge of up to seven (7) feet. Several counties had widespread damage, including Monroe County (Wetherell). One of the worst hurricane seasons on record was the 2005 season. Of those that hit the coast of Florida, the four of Dennis (July), Katrina (August), Rita (September), and Wilma (October) had a significant adverse impact on spiny lobster trap fishers. According to a May 1, 2006, article at *keysnews.com*, Florida Keys lobster trap fishermen "reported losing up to 70 percent of their traps in the four hurricanes that skirted the Keys in 2005. Officials have estimated that the hurricanes cost lobster fishermen $35 million in lost traps and catch" (O'Hara, May 1, 2006). In April 2006, the Florida Hurricane Relief Fund, which was established in 2004, gave $0.5 million to the Florida Keys Commercial Fishermen's Association (Association) to help lobster and stone crab fishers in Monroe and Miami-Dade counties replace traps lost to the 2005 hurricane season. According to the Association's executive director, the money will be equally distributed among the fishermen who apply for aid (ibid).[33]

5.4 Administrative Environment

5.4.1 Federal Fishery Management

Federal fishery management is conducted under the authority of the Magnuson-Stevens Act (16 U.S.C. 1801 et seq.), originally enacted in 1976 as the Fishery Conservation and Management Act. The Magnuson-Stevens Act claims sovereign rights and exclusive fishery management authority over most fishery resources within the EEZ, an area extending 200 nautical miles from the seaward boundary of each of the coastal states, and authority over US anadromous species and continental shelf resources that occur beyond the EEZ.

Responsibility for federal fishery management decision-making is divided between the Secretary and eight regional fishery management councils that represent the expertise and interests of constituent states. Regional councils are responsible for preparing, monitoring, and revising management plans for fisheries needing management within their jurisdiction. The Secretary is responsible for promulgating regulations to implement proposed plans and amendments after ensuring management measures are consistent with the Magnuson-Stevens Act and with other applicable laws summarized in Section 10. In most cases, the Secretary has delegated this authority to NMFS.

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[32] Traps are not insurable.

[33] To prove eligibility, a commercial lobster and stone crab fishermen "must show tax receipts for the past several years and documents showing their landings" (O'Hara, May 1, 2006).

The Councils are responsible for fishery resources in federal waters of their respective regions. These waters extend to 200 nautical miles offshore from the nine-mile seaward boundary of the states of Florida Texas and the territory of Puerto Rico, and the three-mile seaward boundary of the Atlantic side of Florida and the states of Alabama, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, and the territory of the USVI.

The Councils consist of voting members: public members appointed by the Secretary; one each from the fishery agencies of the state or territory, and one from NMFS. The public is also involved in the fishery management process through participation on advisory panels and through council meetings that, with few exceptions for discussing personnel matters and litigation, are open to the public. The regulatory process is also in accordance with the Administrative Procedures Act, in the form of "notice and comment" rulemaking, which provides extensive opportunity for public scrutiny and comment, and requires consideration of and response to those comments.

Regulations contained within FMPs are enforced through actions of the NOAA's Office of Law Enforcement, the USCG, and various state authorities. To better coordinate enforcement activities, federal and state enforcement agencies have developed cooperative agreements to enforce the Magnuson-Stevens Act.

5.4.2 State Fishery Management

The purpose of state/territory representation at the council level is to ensure state/territory participation in federal fishery management decision-making and to promote the development of compatible regulations in state/territory and federal waters. The state and territorial governments have the authority to manage their respective state/territorial fisheries. Each of the states and territories exercises legislative and regulatory authority over their states'/territories' natural resources through discrete administrative units. Although each agency is the primary administrative body with respect to the states'/territories' natural resources, all states/territories cooperate with numerous state/territory and federal regulatory agencies when managing marine resources.

6.0 ENVIRONMENTAL CONSEQUENCES

6.1 Action 1: Minimum Size Limits for Spiny Lobster (*Panulirus argus)* Imported into the United States

6.1.1 Direct and Indirect Effects on the Physical, Biological, and Ecological Environment

Many regional populations of spiny lobsters are fully capitalized or overfished as indicated by declining catch-per-unit effort in local fisheries (Ehrhardt 1994; Fonteles-Filho 1994). The distribution and dispersal of *P. argus* is determined by the long planktonic larval phase, called the puerulus, during which time the infant lobsters are carried by the currents until they become large enough to settle to the bottom (Davis and Dodrill 1989). Individuals two to four years old exhibit nomadic behavior emigrating out of the shallows and moving to deeper, offshore environments. Given the wide distribution and nomadic behavior, it is hard to determine a definitive stock structure for this species. Additionally, there are a multitude of currents and other factors that influence the movement of water throughout the range of *P. argus* making it more difficult to predict, with any certainty, the distribution and settlement patterns of larvae.

The strong flow of the Caribbean Current as well as localized gyres in the south of Cuba, Central America, Puerto Rico, and around the Florida Keys increases the probability of the mixing of larval populations from different regions. Because of this mixing, regional cooperation is extremely important in managing the spiny lobster population. During a number of meetings (e.g., Merida, 2000 and OSPESCA, 2007), representatives from the various Caribbean, Central, and South American Nations have begun building a cooperative management strategy. This strategy includes the acknowledgement that spawning biomass and potential yield would benefit from an increase in the minimum size of lobster being caught. However, numerous issues still exist with implementation of this strategy in a number of participating countries.

As a means to facilitate this strategy, a number of countries and industry representatives have sought a law in the U.S. that would implement minimum conservation standards on lobster being imported into the U.S. As the top importer of spiny lobster products, the U.S. has considerable influence in the market of those products. If an import law were implemented to require spiny lobster products to meet minimum conservation standards, exporting countries and the fisheries within those countries would have incentive to meet those minimum conservation standards. These minimum conservation standards would achieve an increase in the spawning biomass and increase potential yield by limiting imports to a size at which approximately 50 % of the population has had a chance to spawn prior to harvest.

The measures presented for restricting imports are nearly identical to those put forth in the various meetings throughout the history of cooperative management meetings. As an example, the OSPESCA workshop accords of 2007 recommended a minimum harvest size for lobster tails of 140 mm (5.5 inches) and an average tail weight of 5 ounces, ranging from 4.5 to 5.5. The conservation standards presented in Action 1 **Alternative 3** are consistent with these recommendations. The difference in tail weight between the workshop accords and those in the document are a matter of an industry practice versus scientific conversions.

As discussed in Section 4.1, the 4.5 ounce tail weight recommendation was not based on scientific conversions from the recommended 140 mm tail length, but was instead based on industry practice of sorting and shipping. Tables 4.1.2 and 4.1.3 provide conversions from carapace length to tail length and tail weight based on Matthews et al. (2003). If we examine the 140 mm (5.5 inch) tail length recommendation, we see it is derived from one standard deviation of the mean for a 3.0 inch (76.2 cm) carapace length animal (table 4.1.3, in green). Therefore, if a tail length recommendation is based on one set of scientific standards, all conversions from the carapace length should be based on that same standard. Therefore, the appropriate tail weight to be used for a 3.0 inch carapace length animal would be a 4.15 ounce tail weight (Table 4.1.3, in yellow). This, like the tail length recommendation is based on one standard deviation from the mean for the measurements of a 3.0 inch carapace length animal. For the purpose of simplifying this requirement, the weight has been rounded to one decimal place to make the requirement a 4.2 ounce tail weight. For imports to the U.S. Caribbean, similar conversions from a 3.5 inch CL animal yield a minimum TW of 5.9 ounces and a TL of 6.2 inches (Table 4.1.3, in turquoise).

Preferred Alternative 2 would require imports to meet one of two sets of standards, dependent on port of entry for the product. For those products entering the U.S., the requirements would be the same as those for **Alternative 3** (4.2 oz TW, > 3" CL, 5.5" TL); for those products entering the U.S. Caribbean the minimum conservation standards would be slightly more restrictive. Currently, the U.S. Caribbean has a domestic law requiring spiny lobster to have a CL of at least 3.5 inches. Therefore, in an effort to be fair and equitable to U.S. Caribbean fishermen, the measures for importing spiny lobster to the U.S. Caribbean would require lobster to have at least a 5.9 oz TW, 3.5 inch CL, or 6.2 inch TL

The differences between the continental U.S. and U.S. Caribbean minimum size limits stems from the scientific uncertainty of the size at 50% maturity for spiny lobster and the fecundity of a typical female at a given size. As an illustration of fecundity at size, from the Florida Fish and Wildlife Conservation Commission's Ad Hoc Advisory Board synopsis:

"For spiny lobster, the typical number of eggs produced per clutch of a 3 inch carapace length female is 300 thousand eggs. A 3.5 inch carapace length female produces 500 thousand eggs; a 4 inch carapace length female produces 700 thousand eggs. A 3 inch carapace length lobster may produce two clutches, but by the time female lobsters attain a 4 inch carapace length, the typical number of clutches per breeding season is three, perhaps four."

By increasing the size limit from 3 to 3.5 inches, an increase of 250% to 350% in egg releases would be seen in a breeding season per lobster. Obviously this is an enormous increase in egg production and would have a significant impact on future lobster population size and structure.

To further understand the fecundity dynamics of female lobster and the uncertainty around size at maturity Bertelsen and Matthews (2001) examined two populations of spiny lobster in the Florida Keys. The authors compared the size structure, fecundity, and reproductive season of spiny lobsters in the Dry Tortugas National Park sanctuary with those of spiny lobsters in the south Florida fishery. The number of lobsters of both sexes larger than the legal size limit declined sharply in the fishery but not in the sanctuary. Clutch sizes were larger in the sanctuary (avg. 0.8 million) than in the fishery (avg. 0.3 million), and the reproductive season was shorter and more intense in the sanctuary than in the fishery. In addition, lobsters in the sanctuary begin egg production at a larger size and produce more eggs per gram of body mass than lobsters in the fishery.

Lobsters less than 70 mm CL were found to produce eggs in the fishery but very few lobsters less than 80 mm CL and none less than 70 mm CL produce eggs in the sanctuary.

Because of the obvious benefits of having a 3.5 inch CL minimum size, the Caribbean Council adopted this measure in their FMP and feel it would be more beneficial to the pan-Caribbean spiny lobster population to implement this size limit throughout the species range. Therefore, the Caribbean Council feels it is prudent and justifiable to require imports to meet the same minimum conservation standards as those applied to the local lobster population and which must be met by fishermen that harvest those lobsters.

Based on the discussion of the relationship between size and fecundity, **Preferred Alternative 2** would be more beneficial to the spiny lobster population than either **Alternative 1** or **Alternative 3**. **Preferred Alternative 2** would require at least some portion of lobster to meet the more conservative morphometric requirements (those imported to the U.S. Caribbean) and therefore benefit the population more. However, **Alternative 3** is more conservative than **Alternative 1** and would be more beneficial to the population than not having any import conservation standards in place. If **Alternative 1** were to be the preferred alternative, there would continue to be importation of lobsters below any size at maturity (i.e., juvenile lobsters), which would continue to contribute to the over-exploitation problems seen in much of the range of spiny lobsters. Therefore, **Preferred Alternative 2** would be the most beneficial to the pan-Caribbean spiny lobster population followed by **Alternative 3** and **Alternative 1** in decreasing order of benefits.

Aside from an increase in the spawning biomass and increase in potential yield, requiring lobsters to meet minimum conservation standards is expected to have effects on the communities these animals inhabit. The spiny lobster is an important predator and prey organism in the reef and seagrass community. After the larvae settle out of the planktonic phase, they enter the seagrass and macroalgae habitat where they feed on small gastropods, mollusks, amphipods, and ostracods. As adults, the lobsters feed on slow-moving or stationary invertebrates such as sea urchins, mussels, gastropods, clams, and snails (Lipcius and Cobb 1994). At both the juvenile and adult stage, spiny lobsters are an important food item for larger finfish and sharks.

By increasing the spawning biomass, it would be expected for more lobsters to settle out of the planktonic phase and into the juvenile habitat. More lobsters in the juvenile habitat would in turn have an effect on the food web dynamics of the seagrass macroalgae community and those inhabitants. Likewise, more lobsters would reach adult size and migrate out to the reef community where they would forage on slow moving or sessile invertebrates of that community. There would also be an expected increase of finfish and sharks preying on the increased biomass of lobsters. This series of events from increasing the spawning biomass would be expected to have overall benefits on the seagrass and reef communities inhabited by spiny lobster. Therefore, **Preferred Alternative 2** would indirectly have the most beneficial effect on the environment of the spiny lobster with **Alternative 3** providing somewhat reduced benefits and **Alternative 1** providing no additional benefits above what is witnessed in the seagrass and reef environments now.

The impacts of **Alternatives 1-3** will have no adverse affect on protected species occurring in U.S. waters, as this action is primarily administrative in nature. In the event these alternatives reduce spiny lobster fishing effort in exporting countries, the likelihood of adverse impacts from the fishery occurring to ESA-listed species located there may be reduced. However, any such benefit is anticipated to be very minor.

6.1.2 Direct and Indirect Effects on the Economic Environment

The greatest economic impact of the alternatives under consideration for Action 1, other than Alternative 1, should be on those who illegally import undersized Caribbean spiny lobster. Some currently legally imported spiny lobster are expected not to meet the proposed import-size standards and will be affected; however, the majority of legal spiny lobster imports are not expected to be affected by the proposed size standards. See Section 7.5.1. The greatest direct economic effect will be the significant reduction in illegal imports of undersized lobsters and the greatest indirect effects will be the associated reductions in illegal revenues, profits and revenues generated by those imports. The other direct economic effect will be fewer legal imports from countries whose size standards do not meet or exceed those proposed in each of the two alternatives, which will have associated reductions in legal revenues, profits and revenues generated by those imports. However, in the long run, the status of the domestic and foreign stocks should improve and with those improvements there should be associated economic benefits. See Section 7.5.1.4 for a comparison of the direct and indirect economic costs and benefits of the various alternatives for this particular action. The direct and indirect effects of this action are dependent upon the second action because without additional harvest restrictions, illegal importers may increase their use of methods to avoid detection of undersized lobsters, such as removing the meat from the shell and packaging it into chunks.

Action 1, other than Alternative 1, will also indirectly affect people who are presently damaged economically by the illegal importation of Caribbean spiny lobster, particularly Florida, Puerto Rico, and U.S. Virgin Islands spiny lobster fishermen who compete economically with those who add to the national supply of spiny lobster by importing and selling undersized lobsters. Domestic spiny lobster fishermen should benefit economically from an increase in market price that is associated with a reduction of market supply of spiny lobster that is caused by the improved detection and prevention of black market imports.

6.1.3 Direct and Indirect Effects on the Social Environment

Action 1, Alternatives 2 and 3 is expected to directly affect how people in the U.S. trade for non-domestically harvested Caribbean spiny lobster, especially those who presently knowingly or unknowingly import spiny lobsters that do not meet size standards of the country of origin. It should make those people who purposively import undersized spiny lobster less confident in black market activity, which should cause them to abandon or at least greatly reduce such illegal trade. At the same time, those who legally import spiny lobsters should become more confident that their import activities support sustainable spiny lobster fisheries, which may alter their domestic marketing of imported Caribbean spiny lobster by promoting it as a product of sustainable trade and fishing practices. However, the amount of confidence lost by black market traders or gained by legal importers would also depend upon the second action because Action 1 alone would not prevent illegal importers from removing the meat from the shell and packaging it into chunks to avoid detection of undersized lobsters. It should be noted, the proposed actions would also directly and indirectly affect those individuals, groups or communities that legally harvest and trade spiny lobster from countries that do not have size or other harvest restrictions that meet or exceed those proposed in the alternatives; however, most countries have size and harvest restrictions that satisfy the proposed import standards. In combination, both Action 1, Alternatives 2 and 3 and Action 2, Alternatives 2, 3, and 4 are expected to adversely affect cultural traditions and social networks of organized crime groups and communities that engage in the illegal importation of undersized spiny lobsters. Furthermore, the same combination of actions is expected to beneficially affect cultural traditions and social networks of groups and communities that engage in the legal importation of Caribbean spiny lobsters.

Action 1, other than Alternative 1, should indirectly affect people who buy, handle, transport, process, sell, and/or consume Caribbean spiny lobster after it has been imported by reducing the quantity of spiny lobster imported annually into the United States. The greatest indirect effect should be on those who knowingly or unknowingly buy, handle, transport, process, sell and/or consume imported undersized lobsters. In combination with Action 2, Alternatives 2, 3, and 4, Action 1, Alternatives 2 and 3 should adversely affect cultural traditions and social networks of organized crime groups and communities that purposively engage in the buying, handling, transports, processing, selling, and/or consumption of illegally imported spiny lobster by decreasing both the confidence and abilities of people within those groups and/or communities to engage in such activities. At the same time, Action 1, other than Alternative 1, in combination with Action 2, other than Alternative 1, should benefit cultural traditions and social networks of groups and communities that purposively support legal and sustainable trade practices by increasing the confidence and abilities of people within those groups and/or communities to buy, handle, transport, process, sell and/or consume imported spiny lobsters that are consistent with legal and sustainable trade and fishing practices.

Action 1, other than Alternative 1, should also indirectly affect domestic Caribbean spiny lobster fishermen by increasing their confidence in Federal efforts to protect and sustain their fishing livelihoods. In turn, the increased confidence should support existing cultural traditions and social networks of domestic spiny lobster fishermen and communities.

6.1.4 Direct and Indirect Effects on the Administrative Environment

Implementation and enforcement of size limits and other conservation standards is an administrative action designed to benefit the biological environment of the target species.

Therefore, the actions in this amendment will affect the administrative environment. Sections 5.3 and 5.4 discuss the affected administrative environments and the valued environmental components (VEC) of the administrative environment within the lobster fishery. This amendment will affect three VECs within the administrative environment: management, law enforcement, and industry.

Promulgating regulations is a management action that requires development, implementation, and monitoring of the regulations and their effects. This action is designed to improve the stock status of the Caribbean spiny lobster throughout its range, therefore it will be incumbent upon management to monitor the spiny lobster stock and ensure the regulations are having the desired effect on the stock. If the desired effects are not seen within the spiny lobster population, management will need to evaluate the regulations and adjust accordingly to achieve the purpose identified in the purpose and need section: improve stock status.

The other necessary component of regulations is the enforcement of those regulations. Without the efforts of law enforcement officials, no change in the lobster stock would be expected regardless of the regulations developed and implemented. Currently, the law enforcement environment is over-burdened in its attempts to stem the flow of undersized lobster entering the U.S. This burden is two-phased; one being the volume of lobster imports that enters the country (see Section 5.3) and the second is the lack of a strong regulation to enforce minimum conservation standards on imported lobsters. The volume of lobster imports is not likely to see a decrease as food resources throughout the world are constantly stretched to support a growing population. Therefore, a stronger regulatory framework to work under will provide the only relief to law enforcement officials.

Currently, any cases developed by law enforcement agents must be done under the Lacey Act. This law requires the cooperation of foreign nations, which has proven difficult in the past for a number of reasons, including resources, political will power, and foreign cooperation. With the implementation of either **Preferred Alternative 2** or **Alternative 3** law enforcement will have a more appropriate tool to stop or greatly reduce undersize imports from entering the country. Imports that do not meet the minimum conservation standards set forth in this amendment will be illegal and agents will be able to develop cases against those responsible for the imports without the need for foreign cooperation. Further, **Preferred Alternative 2** would be of greater value to law enforcement than **Alternative 3**.

Preferred Alternative 2 would require imports to meet the minimum conservation standards of the domestic law for the port of entry into which the imports are arriving. For example, imports into the USVI and Puerto Rico would need to have a TW measurement of 5.9 oz or greater. By requiring imports to meet the conservation standards of the port of entry, potential loopholes for harvesting domestic product and labeling it as imported product in an effort to circumvent domestic laws will be eliminated. This will eliminate the potential burden for law enforcement agents of disseminating local product from imported product as it all has to meet one set of standards. Therefore, **Preferred Alternative 2** would directly benefit law enforcement agents the most.

The third administrative environment effected by requiring imports to meet minimum conservation standards is that of the industry itself. Current industry practice sorts, packs, and sells lobster tails by weight category. These categories are generally whole ounce categories such as 4 ounce or 7 ounce tails, which includes a range of weights. For example a 7 ounce would have tails ranging in weight from 6.5 to 7.5 ounces. Under either **Preferred Alternative 2** or **Alternative 3** industry practice would have to change slightly to accommodate the minimum weight requirements into the appropriate whole weight category. **Preferred Alternative 2** would require industry to change the weight range for a 5 ounce tail to include tails weighing 4.2 ounces as opposed to the current 4.5 ounces for those imports into the U.S.; for those lobsters imported to the U.S. Caribbean, the 6 ounce category would need to be changed to include lobsters that weighed 5.9 ounces as opposed to the current 5.5 ounces. **Alternative 3** would require industry to change the weight range for a 5 ounce tail to include tails weighing 4.2 ounces as opposed to the current 4.5 ounces for all imports. And obviously, the 2, 3, and 4 ounce weight categories would need to be eliminated completely.

The implementation of minimum conservation standards is expected to indirectly benefit the administrative environment. Industry is expected to indirectly benefit through the increased production of the lobster stock, thus meeting an ever growing demand globally for protein sources. Law enforcement will be able to focus on a wider range of enforcement issue without having to devote such an inordinate amount of time to developing cases against importers of illegal size lobster as they now have to do through the Lacey Act.

6.2 Action 2: Other Import Restrictions

6.2.1 Direct and Indirect Effects on the Physical, Biological, and Ecological Environment

These other conservation standards applied to the spiny lobster products (i.e., prohibitions on the possession/importation of lobster tail meat, berried lobsters, lobsters that have been stripped or clipped) are expected to benefit the biological and ecological environment by providing additional protection to the spawning stock in the wider Caribbean. The degree to which these restrictions benefit the spiny lobster resource will depend largely on the effectiveness of enforcement at the country of exportation and the ability of LE officials to curtail the flow of such product. Establishing additional restrictions on the imports of spiny lobster such as prohibiting lobster meat and berried lobster, in combination with the size limits proposed in Action 1, would compliment efforts in improving the status of the spiny lobster stock. Prohibiting imports of berried lobster would allow for females to release those clutches and produce additional clutches, which will eventually recruit to the adult population and the fishery. While eliminating the allowance of lobster meat will protect smaller individuals that would otherwise be harvested and processed into lobster meat product.

As discussed in section 4.2, lobster importers/exporters developed methods for circumventing minimum size standards when there was “a lot of pressure on under 5 oz” by creating a “lobster meat” product. This “lobster meat” product would have the effect of undermining any conservation standard minimum size limits developed to increase the spawning stock biomass of the spiny lobster population. Therefore, **Preferred Alternative 2** and **Alternative 3** would eliminate this loophole that was developed when importers/exporters realized LE officials were cracking down on illegal size imports. By doing so, **Preferred Alternative 2** and **Alternative 3** are expected to have positive direct effects on the biological and ecological environment of spiny lobster.

Any measure designed to protect individuals in an active reproductive mode would obviously directly benefit the stock and help to achieve an increase in spawning stock biomass and long-term yield. The second part of **Preferred Alternative 2** and **Alternative 4** would achieve such a protection (prohibiting the importation of spiny lobster with eggs attached or importation of spiny lobster where the eggs, swimmerets, or pleopods have been removed or stripped). In order to achieve the maximum benefits of the minimum conservation standards in Action 1, females in the process of reproducing must be allowed to complete that biological process without disruption. Therefore, in order to afford females with the most protection, even those animals that have been physically mutilated (removal of eggs, swimmerets, etc) to “hide” the condition of the animal must be considered illegal.

Aside from an increase in the spawning biomass and increase in potential yield, requiring lobsters to meet minimum conservation standards is expected to have effects on the communities these animals inhabit. The spiny lobster is an important predator and prey organism in the reef and seagrass community. After the larvae settle out of the planktonic phase, they enter the seagrass and macroalgae habitat where they feed on small gastropods, mollusks, amphipods, and ostracods. As adults, the lobsters feed on slow-moving or stationary invertebrates such as sea urchins, mussels, gastropods, clams, and snails (Lipcius and Cobb 1994). At both the juvenile and adult stage, spiny lobsters are an important food item for larger finfish and sharks.

By increasing the spawning biomass, it would be expected for more lobsters to settle out of the planktonic phase and into the juvenile habitat. More lobsters in the juvenile habitat would in turn have an effect on the food web dynamics of the seagrass macroalgae community and those inhabitants. Likewise, more lobsters would reach adult size and migrate out to the reef community where they would forage on slow moving or sessile invertebrates of that community. There would also be an expected increase of finfish and sharks preying on the increased biomass of lobsters. This series of events from increasing the spawning biomass would be expected to have overall benefits on the seagrass and reef communities inhabited by spiny lobster. Therefore, **Preferred Alternative 2** would indirectly have the most beneficial effect on the environment of the spiny lobster with **Alternative 3** providing somewhat reduced benefits and **Alternative 1** providing no additional benefits above what is witnessed in the seagrass and reef environments now.

The impacts of **Alternatives 1-3** will have no adverse affect on protected species occurring in U.S. waters, as this action is primarily administrative in nature. In the event these alternatives reduce spiny lobster fishing effort in exporting countries, the likelihood of adverse impacts from the fishery occurring to ESA-listed species located there may be reduced. However, any such benefit is anticipated to be very minor.

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6.2.2 Direct and Indirect Effects on the Economic Environment

The greatest economic impact of the alternatives under consideration for Action 2 should be on those who illegally import Caribbean spiny lobster with eggs or with their eggs or pleopods removed. Some currently legally imported spiny lobster is expected not to meet the proposed harvest restrictions and will be affected; however, the majority of legal spiny lobster imports are not expected to be affected by these proposed alternatives. See Section 7.5.2. The greatest direct economic effect will be significantly less illegal imports and the greatest indirect effects will be associated reductions in illegal revenues, profits and revenues generated by those imports. The other direct economic effect will be fewer legal imports from countries whose size and other harvest standards do not meet or exceed those proposed in the two actions, which will have associated reductions in legal revenues, profits and revenues generated by those imports. However, in the long run, the status of the domestic and foreign stocks should improve and with that improvements there should be associated economic benefits. See Sections 7.5.1.4 and 7.5.2.5 for a comparison of the direct and indirect economic costs and benefits of the various alternatives for this action. The direct and indirect effects of the first action are dependent upon this action because without additional harvest restrictions, illegal importers may increase their use of methods to avoid detection of undersized lobsters, such as removing the meat from the shell and packaging it into chunks.

Action 2 should also indirectly affect people who are presently damaged economically by the illegal importation of Caribbean spiny lobster, particularly Florida, Puerto Rico, and U.S. Virgin Islands spiny lobster fishermen who compete economically with those who add to the national supply of spiny lobster by importing and selling lobsters with eggs or with their eggs or pleopods removed. Domestic spiny lobster fishermen should benefit economically from an increase in market price that is associated with a reduction of market supply of spiny lobster due to improved detection and prevention of black market imports.

6.2.3 Direct and Indirect Effects on the Social Environment

The United States is the largest importer of Caribbean spiny lobster, and the illegal international trade of the species is a serious problem. Action 2 is designed to reduce the problem by improving the detection and prevention of the illegal importation of female lobsters with eggs or those that have had their eggs removed and lobster meat taken from undersized lobsters.

Action 2, other than Alternative 1, is expected to directly affect how people in the U.S. trade for non-domestically harvested Caribbean spiny lobster, especially those who presently knowingly or unknowingly import female spiny lobsters with their eggs attached or removed and/or lobster meat taken from undersized lobsters. It should make those people who illegally import spiny lobster less confident in black market activity, which should cause them to abandon or at least greatly reduce such illegal trade. At the same time, those who legally import spiny lobsters should become more confident that their import activities support sustainable spiny lobster fisheries, which may alter their domestic marketing of imported Caribbean spiny lobster by promoting it as a product of sustainable trade and fishing practices. However, the amount of confidence lost by black market traders or gained by legal importers would also depend upon the first action because Action 2 alone would not discourage and reduce the importation of undersized lobsters. It should be noted, the proposed actions would also directly and indirectly affect those individuals, groups or communities that legally harvest and trade spiny lobster from countries that do not have these other harvest restrictions that meet those proposed in the alternatives; however, most countries have harvest restrictions that satisfy the proposed import standards. In combination, both Action 1 and Action 2 are expected to adversely affect cultural traditions and social networks of organized crime groups and communities that engage in the illegal importation of Caribbean spiny lobster. Furthermore, the same combination of actions is expected to beneficially affect cultural traditions and social networks of groups and communities that engage in the legal importation of Caribbean spiny lobsters.

Action 2 should indirectly affect people who buy, handle, transport, process, sell, and/or consume Caribbean spiny lobster after it has been imported by reducing the quantity of spiny lobster imported annually into the United States. The greatest indirect effect should be on those who knowingly or unknowingly buy, handle, transport, process, sell and/or consume illegally imported lobsters. In combination with Action 1, Action 2 should adversely affect cultural traditions and social networks of organized crime groups and communities that support, engage in, and benefit from the buying, handling, transports, processing, selling, and/or consumption of illegally imported spiny lobster. Also, in combination with the first action, this second action should increase the confidence of people, who receive Caribbean spiny lobster after importation, that the spiny lobsters that they are buying, handling, transporting, processing, selling and/or consuming are products of legal and sustainable trade and fishing practices.

Action 2 would also indirectly affect domestic Caribbean spiny lobster fishermen by increasing their confidence in Federal efforts to protect and sustain their fishing livelihoods. In turn, the increased confidence will support existing cultural traditions and social networks of domestic spiny lobster fishermen and communities.

6.2.4 Direct and Indirect Effects on the Administrative Environment

Implementation and enforcement of size limits and other conservation standards is an administrative action designed to benefit the biological environment of the target species. Therefore, the actions in this amendment will affect the administrative environment. Sections 5.3 and 5.4 discuss the affected administrative environments and the valued environmental components (VEC) of the administrative environment within the lobster fishery. This amendment will affect three VECs within the administrative environment: management, law enforcement, and industry.

Promulgating regulations is a management action that requires development, implementation, and monitoring of the regulations and their effects. This action is designed to improve the stock status of the Caribbean spiny lobster throughout its range, therefore it will be incumbent upon management to monitor the spiny lobster stock and ensure the regulations are having the desired effect on the stock. If the desired effects are not seen within the spiny lobster population, management will need to evaluate the regulations and adjust accordingly to achieve the purpose identified in the purpose and need section: improve stock status.

The other necessary component of regulations is the enforcement of those regulations. Without the efforts of law enforcement officials, no change in the lobster stock would be expected regardless of the regulations developed and implemented. Currently, the law enforcement environment is over-burdened in its attempts to stem the flow of undersized lobster entering the U.S. This burden is two-phased; one being the volume of lobster imports that enters the country (see Section 5.3) and the second is the lack of a strong regulation to enforce minimum conservation standards on imported lobsters. The volume of lobster imports is not likely to see a decrease as food resources throughout the world are constantly stretched to support a growing population. Therefore, a stronger regulatory framework to work under will provide the only relief to law enforcement officials.

Currently, any cases developed by law enforcement agents must be done under the Lacey Act. This law requires the cooperation of foreign nations, which has proven difficult in the past for a number of reasons, including resources, political will power, and cooperation. NOAA’s Office of Law Enforcement, Southeast Region, has made several significant Lacey Act cases involving undersized spiny lobster (w/ Honduras, Nicaragua, Bahamas, and an ongoing one with Brazil). These cases typically are criminal and are rather complex in nature due to the need for cooperation with foreign governments, poorly written foreign laws, and the millions of dollars of illegal proceeds. When investigating these significant lobster import cases, NOAA’s Special Agents and Department of Justice prosecutors have frequently encountered defense attorneys and defendants that have attempted to undermine the foreign lobster laws of the harvesting countries in order to invalidate the Lacey Act and the U.S. efforts to apprehend those responsible. A U.S. minimum restriction applicable to spiny lobster imports would greatly assist law enforcement and federal prosecutors to stem the illegal and profitable flow of undersized imports into the U.S. markets. With the implementation of **Preferred Alternative 2**, **Alternative 3**, or **Alternative 4** law enforcement will have a more appropriate tool to stop or greatly reduce illegal import products from entering the country. Imports that do not meet the minimum conservation standards set forth in this amendment will be illegal and agents will be able to develop cases against those responsible for the imports without the need for foreign cooperation. Further, **Preferred Alternative 2** would be of greater value to law enforcement than **Alternative 3** or **Alternative 4**.

Preferred Alternative 2 would require imports to meet the minimum conservation standards of the existing domestic laws. For example, the possession/harvest of berried females is illegal in both domestic FMP's. By requiring imports to meet the conservation standards of the domestic rules, potential loopholes for harvesting domestic product and labeling it as imported product in an effort to circumvent domestic laws will be eliminated. This will eliminate the potential burden for law enforcement agents of disseminating local product from imported product as it all has to meet one set of standards. Therefore, **Preferred Alternative 2** would directly benefit law enforcement agents the most.

The third administrative environment effected by requiring imports to meet minimum conservation standards is that of the industry itself. Current industry practice sorts, packs, and sells lobster tails by weight category. These categories are generally whole ounce categories such as 4 ounce or 7 ounce tails, which includes a range of weights. For example a 7 ounce would have tails ranging in weight from 6.5 to 7.5 ounces. Under either **Preferred Alternative 2, Alternative 3,** or **Alternative 4** no industry practice would have to change, other than the illegal activity seen in the documents identified in an earlier discussion and seen in Appendix A. Any mention of "lobster meat" would immediately be cause for concern by LE officials and thus, would not be expected to be seen in the industry practices.

The implementation of minimum conservation standards is expected to indirectly benefit the administrative environment. Industry is expected to indirectly benefit through the increased production of the lobster stock, thus meeting an ever growing demand globally for protein sources. Law enforcement will be able to focus on a wider range of enforcement issue without having to devote such an inordinate amount of time to developing cases against importers of illegal size lobster as they now have to do through the Lacey Act.

6.3 Comparison of Alternatives to Magnuson-Stevens Act National Standards

National Standard 1

This national standard states conservation and management measures shall prevent overfishing while achieving, on a continuing basis, the optimum yield from each fishery. The intent of this amendment is to provide foreign countries a market incentive to enhance the sustainability of the Pan-Caribbean spiny lobster population by restricting imports and the possession of imported products. This restriction is designed to realize the long-term benefits of a properly managed resource, which will increase yield (and thereby achieve optimum yield) by allowing those individuals that would otherwise perish in the status quo fishery to reach a sexually mature size and contribute to the reproductive capability of the stock.

National Standard 2

This national standard requires conservation and management measures be based on the best scientific information available. The rationale in developing the amendment is based on numerous peer-reviewed scientific studies from the U.S., the U.S. Caribbean and other similar tropical reef fisheries. These resources were analyzed and discussed in Sections 4 and 6, and provide the basis for the decision and selection of preferred alternatives.

National Standard 3

This national standard requires to the extent practicable, an individual stock of fish shall be managed as a unit throughout its range, and interrelated stocks of fish shall be managed as a unit or in close coordination. Spiny lobsters are found from North Carolina to Brazil throughout the Caribbean. This amendment will implement a minimum import size in an attempt to protect juvenile lobsters throughout the Caribbean.

National Standard 4

This national standard requires conservation and management measures not discriminate between residents of different states. This amendment will apply only to imports and in no way assigns domestic harvest privileges among U.S. fishermen.

National Standard 5

This national standard requires conservation and management measures shall, where, practicable, consider efficiency in the utilization of fishery resources; except that no such measure shall have economic allocation as its sole purpose. This amendment will only apply to imports and does not address the efficiency of the domestic fishery.

National Standard 6

This national standard requires conservation and management measures take into account and allow for variations among, and contingencies in, fisheries, fishery resources, and catches. This amendment will only apply to imports and does not address the management flexibility of the domestic fishery.

National Standard 7

This national standard requires conservation and management measures, where practicable, minimize costs and avoid unnecessary duplication. Currently there are no duplicative efforts for restricting imported spiny lobster products. Costs should be very minimal, as the requirements being implemented aim to remove undersized product from the marketplace, which can be quickly made up for by using only legal-sized lobsters.

National Standard 8

This national standard requires management and conservation measures take into account the importance of fishery resources to fishing communities by utilizing economic and social data in order to provide for the sustained participation of such communities and to the extent practicable, minimize adverse economic impacts on such communities. Social and economic analyses were performed for this document and are discussed in the appropriate sections. The intent of this amendment is to reduce importation of under-sized lobsters, thereby creating a sustainable fishery resource for these communities to continue utilizing; and any adverse domestic impacts are only expected for importers, not fishermen and communities.

National Standard 9

This national standard requires management and conservation measures minimize bycatch, to the extent practicable, and to the extent bycatch cannot be avoided, minimize mortality. The intent of this amendment is to eliminate undersize lobster from entering the marketplace. These undersize individuals would be considered bycatch in the continental fishery, thus an incentive for avoiding the capture of these individuals is an additional effect of the amendment.

National Standard 10

This national standard requires management and conservation measures promote, to the extent practicable, the safety of human life at sea. A minimum import size has no effect on safety at sea.

6.4 Mitigation Measures

Environmental impacts identified in sections 6.1, 6.2, and the following section, 6.5, did not identify any adverse environmental impacts. Therefore, there are no mitigation measures to be carried out.

6.5 Cumulative Effects Analysis

As directed by NEPA, federal agencies are mandated to assess not only the indirect and direct impacts, but the cumulative impacts as well. NEPA defines a cumulative impact as "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time" (40 C.F.R. 1508.7). Cumulative effects can either be additive or synergistic. A synergistic effect is when the combined effects are greater than the sum of the individual effects.

This section uses an approach for assessing cumulative effects that is based upon guidance offered by the CEQ publication "Considering Cumulative Effects" (1997). The report outlines 11 items for consideration in drafting a CEA for a proposed action.

1. Identify the significant cumulative effects issues associated with the proposed action and define the assessment goals.
2. Establish the geographic scope of the analysis.
3. Establish the timeframe for the analysis.
4. Identify the other actions affecting the resources, ecosystems, and human communities of concern.
5. Characterize the resources, ecosystems, and human communities identified in scoping in terms of their response to change and capacity to withstand stress.

6. Characterize the stresses affecting these resources, ecosystems, and human communities and their relation to regulatory thresholds.
7. Define a baseline condition for the resources, ecosystems, and human communities.
8. Identify the important cause-and-effect relationships between human activities and resources, ecosystems, and human communities.
9. Determine the magnitude and significance of cumulative effects.
10. Modify or add alternatives to avoid, minimize, or mitigate significant cumulative effects.
11. Monitor the cumulative effects of the selected alternative and adapt management.

The CEA for the biophysical environment will follow these 11 steps. Cumulative effects on the biophysical environment and the socio-economic environment will be analyzed separately.

1. Identify the significant cumulative effects issues associated with the proposed action and define the assessment goals.

In Section 5.0 (Description of the Affected Environment) the valued environmental components (VECs) that exist within the spiny lobster fishery environment are identified and the basis for their selection is established. This is associated with the completion of Step 1 in the CEQ's 11-step process. The VECs are as follows:

1. Managed Resource – Spiny Lobster (*P. argus*)
2. Non-target species
3. Habitat including EFH for *P. argus* and non-target species
4. Endangered and other protected resources
5. Human Communities

2. Establish the geographic scope of the analysis.

The analysis of impacts focuses on two different geographic areas. The first geographic area is related to the distribution and habitat of spiny lobster (Figure 5.2.1). Other affected VECs including non-target species, habitat, and endangered species are also within this geographic scope. The human community has a different geographic scope, which includes the range of the other VECs as well as the U.S. This community includes the fishing community which coincides with the managed species' geographic range, as well as the area where processing, importing, and shipping of frozen lobster tails takes place. Spiny lobster imports are known to arrive in the U.S. at ports from Los Angeles to Miami to New York. Additionally, with nationwide seafood restaurants that rely on these products, potentially all of the U.S. could be affected by any measures implementing minimum conservation standards for spiny lobster products.

3. Establish the timeframe for the analysis

The temporal scope of impacts of past and present actions for *managed resources*, *non-target species*, *habitat*, and *human communities* is primarily focused on actions that have occurred after FMP implementation (1982 for South Atlantic/Gulf; 1981 Caribbean). However, the primary temporal focus of this document coincides with the regionalization acknowledgement of the management of spiny lobster. Starting in 1999, Caribbean nations began to coordinate and cooperate on the management of spiny lobster while acknowledging that doing so was the only way to ensure successful management of the species. This amendment, in part, is a product of this region-wide effort to manage the spiny lobster stock throughout its range in the Caribbean and western Atlantic.

4. Identify other actions affecting the resources, ecosystems, and human communities of concern

As stated numerous times throughout the document, there is a Caribbean-wide initiative to manage the spiny lobster stock throughout its range through multi-national agreements, accords, and cooperation. Currently, a number of Caribbean nations are in the process or have already implemented minimum conservation standards in their fisheries regulations for spiny lobster. The actions in this amendment/EIS are consistent with the actions of these other nations; therefore, the other actions affecting the resources, ecosystems, and human communities identified in this amendment/EIS add no cumulative impact to what is being encountered already.

5. Characterize the resources, ecosystems, and human communities identified in scoping in terms of their response to change and capacity to withstand stresses.

All resources, ecosystems, and human communities identified in scoping and public input of this amendment/EIS are able to withstand the changes proposed in this document. The actions in this document are designed to increase the spawning stock biomass of the spiny lobster population and increase the long-term potential yield in the fishery. As discussed in sections 6.1 and 6.2, these changes are expected to benefit all affected environments.

6. Characterize the stresses affecting these resources, ecosystems, and human communities and their relation to regulatory thresholds

The stresses identified in this amendment/EIS are full or over-exploitation of the spiny lobster stock. In order to achieve the regulatory threshold of achieving OY, as defined in the MSA, the spawning stock biomass of the species must be increased. This action is designed to achieve that increase in spawning stock biomass and therefore increase long-term potential yield which will allow the fishery to achieve OY.

7. Define a baseline condition for the resources, ecosystems, and human communities

Because of its economic significance to both commercial and artisanal fisheries, it is difficult to determine a baseline or "naturally occurring condition" because the species has always been exploited. However, a modified but ecologically sustainable condition would be one in which the population increases the spawning stock biomass to a point where the population reaches a condition near to one in which only natural mortality is seen. Though achieving a condition approaching only natural mortality is nearly impossible to do with a species fished and exploited as heavily as spiny lobster, an attempt to increase the spawning stock biomass will ensure the species continues to be ecologically sustainable. This in turn will allow communities dependent on the spiny lobster fishery to maintain that dependence.

8. Identify the important cause-and-effect relationship between human activities and resources, ecosystems, and human communities

The full- or over-exploitation of the spiny lobster stock is a direct effect of human efforts. Spiny lobster is important economically to both commercial and artisanal fisheries, which has led to this exploitation. The effect of the human action being undertaken in this amendment/EIS will be the recovery of the spawning stock and an increase in long-term yield in the fishery.

9. Determine the magnitude and significance of cumulative effects

Cumulative effects of this action have no more magnitude or significance beyond that of the actions in this amendment/EIS themselves. Those effects are intended to increase the spawning stock biomass and thereby increase the long-term potential yield in the fishery. Both of these effects are expected to be beneficial for the affected environments.

10. Modify and add alternatives to avoid, minimize, or mitigate significant cumulative effects

No significant cumulative effects were identified, so no changes are necessary to the alternatives. However, if significant effects are identified, after this document is completed, an additional amendment will be undertaken to develop framework procedures for management of spiny lobster including procedures for addressing imports. This framework will allow managers to quickly adapt management to achieve the goals in the purpose and need if they are not achieved through this amendment or as new information becomes available.

11. Monitor the cumulative effects of the selected alternative(s) and adapt management

The effects of the selected alternatives will be monitored by two separate methods. The first is the monitoring conducted by law enforcement officials in their inspection and review of imports. If the selected alternatives are successful in achieving the secondary goal of reducing undersized lobster into the U.S., law enforcement officials should no longer see lobster tails that weigh below the 5 oz weight category.

The other way the effectiveness of this action will be monitored is through the productivity of the fishery. If this action is successful in achieving the stated purpose of increasing spawning stock biomass, increases in catch and catch per unit effort should be noticeable throughout the Caribbean. After this document is completed, an additional amendment will be undertaken to develop framework procedures for management of spiny lobster including procedures for addressing imports. This framework will allow managers to quickly adapt management to achieve the goals in the purpose and need if they are not achieved through this amendment or as new information becomes available.

6.6 Unavoidable Adverse Effects

Environmental impacts identified in sections 6.1, 6.2, and 6.5 did not identify any adverse effects.

6.7 Relationship Between Short-Term Uses and Long-Term Productivity

The intent of implementing minimum conservation standards is to increase long-term potential yield and increase the spawning stock biomass. The loss of short-term uses is negligible in comparison to the long-term benefits expected from the implementation of actions in this amendment/EIS. In fact, the short-term uses lost through the actions in this amendment/EIS will only be on the scale of a few days to a few weeks (Matthews, pers. Comm.). However, long-term productivity is expected to increase dramatically (see discussion in section 6.1.1 on reproduction at size).

6.8 Irreversible and Irretrievable Commitments of Resources

There are no irreversible or irretrievable commitments of agency resources proposed herein. The actions to impose minimum conservation standards are readily changeable by the Councils in the future. There may be some loss of immediate income (irretrievable in the context of an individual not being able to benefit from compounded value over time) to some sectors from the implementation of minimum conservation standards.

6.9 Any Other Disclosures

There are no additional disclosures regarding the proposed actions.

6.10 Evaluation of Significance Factors

The Council on Environmental Quality regulations implementing the National Environmental Policy Act and NOAA's Administrative Order (NAO) 216-6 require that decision-makers take into account both context and intensity when evaluating the significance of impacts resulting from a major federal action (40 CFR §1508.27; NAO 216-6, Section 6.01(b)). Evaluating significance with respect to context requires consideration of the local, regional, national, and/or global impacts of the action. Intensity refers to the severity of the impact, and is to be evaluated using specific criteria outlined at 40 CFR § 1508.27(b) and at NAO 216-6, Section 6.01(b). The key findings of the implementation of minimum conservation standards related to the significance of the impacts associated with the enhancement of the pan-Caribbean spiny lobster population follow. The findings are organized under the intensity criteria and include a consideration of the context in which the impacts occur.

1. Impacts may be both beneficial and adverse. A significant effect may exist even if the Federal agency believes that on balance the effect will be beneficial (40 CFR § 1508.27(b)(1); NAO 216-6, Section 6.01(b)(1)).

Implementing these minimum conservation standards will create an incentive for foreign nations harvesting spiny lobster to adhere to meet these standards in order to continue importing lobsters into their largest market, the U.S. In meeting these minimum conservation standards, nations throughout the Caribbean will be fostering the recovery and growth of the spiny lobster population (see Section 6.1.1 for a discussion of fecundity at size). This in turn will lead to a long-term increase in potential yield and the continued existence and possible expansion of the spiny lobster fishery throughout the Caribbean. Therefore, the impacts are beneficial to both the biological environment of spiny lobster and from producers (fishermen) to consumers in the human environment.

2. The degree to which the proposed action affects public health or safety (40 CFR § 1508.27(b)(2); NAO 216-6, Section 6.01(b)(2)).

The proposed actions are not likely to affect public health and safety. The implementation of minimum conservation standards will not affect harvest methods related to the safety of fishermen at sea, nor will it change the quality or safety of food.

3. Unique characteristics of the geographic area, such as proximity to historic or cultural resources, park lands, prime farmlands, wetlands, wild and scenic rivers, or ecologically critical areas (40 CFR § 1508.27(b)(3); NAO 216-6, Section 6.01(b)(3)).

This action effects the fisheries for spiny lobster throughout its range in the Caribbean and western Atlantic. Although there are a number of unique characteristics to the Caribbean basin, no effects on these areas is expected from the implementation of minimum conservation standards.

4. The degree to which the effects on the quality of the human environment are likely to be highly controversial (40 CFR § 1508.27(b)(4); NAO 216-6, Section 6.01(b)(4)).

The implementation of minimum conservation standards for spiny lobster products is not expected to be highly controversial. The potential impacts from the action are well known, and are not a source of uncertainty or related controversy.

5. The degree to which the possible effects on the human environment are highly uncertain or involve unique or unknown risks (40 CFR § 1508.2 7(b)(5); NAO 216-6, Section 6.01(b)(5)).

Minimum conservation standards such as size limits and animal condition restrictions have been used throughout the world in fisheries management. Therefore, their effect on the human environment is well known, and does involve any unique or unknown risks.

6. The degree to which the action may establish a precedent for future actions with significant effects or represents a decision in principle about a future consideration (40 CFR § 508.27(b)(6); NAO 216-6, Section 6.01(b)(6)).

The use of minimum conservation standards have been used for many years in a variety of fisheries throughout the world. Restrictions on imported products have also been in existence for many years. Therefore, this action does not present any new or unusual issues for future consideration.

7. Whether the action is related to other actions with individually insignificant but cumulatively significant impacts. Significance exists if it is reasonable to anticipate a cumulatively significant impact on the environment. Significance cannot be avoided by terming an action temporary or by breaking it down into small component parts (40 CFR § 1508.27(b)(7); NAO 216-6, Section 6.01(b)(7)).

This action is not expected to have a cumulative impact on the environment as discussed in section 6.5.

8. The degree to which the action may adversely affect districts, sites, highways, structures, or objects listed in or eligible for listing in the National Register of Historic Places or may cause loss or destruction of significant scientific, cultural, or historical resources (40 CFR § 1508.27(b)(8); NAO 216-6, Section 6.01(b)(8)).

The implementation of minimum conservation standards is not expected to have any effect on districts, sites, highways, structures, or objects in or eligible for listing in the National Register of Historic Places, or cause loss or destruction of significant scientific, cultural, or historical resources.

9. The degree to which the action may adversely affect an endangered or threatened species or its habitat that has been determined to be critical under the Endangered Species Act of 1973 (40 CFR § 1508.27(b)(9); NAO 216-6, Section 6.01(b)(9)).

The effects on endangered or threatened species or their habitat has been explored throughout the document (sections 5.2, 6.1.1, 6.2.1, 9.4, 9.13.5, and 9.14). No adverse effect was found for endangered or threatened species in the analysis performed for these sections.

10. Whether the action threatens a violation of Federal, State, or local law or requirements imposed for the protection of the environment (40 CFR § 1508.27(b)(10); NAO 216-6, Section 6.01(b)(10)).

All actions proposed under the Magnuson Stevens Fishery Conservation and Management Act must abide by federal, state, and local regulations imposed to protect the environment. This action does not threaten any violations of federal, state, or local law.

11. Whether the action may result in the introduction or spread of a non-indigenous species (NAO 216-6, Section 6.01(b)(11)).

The implementation of minimum conservation standards on an indigenous species will neither introduce nor spread non-indigenous species. Even if “market replacements” are brought in to supplement any reduction in spiny lobster imports, those replacements will be frozen, processed animals.

7.0 REGULATORY IMPACT REVIEW

7.1 Introduction

The NMFS requires a Regulatory Impact Review (RIR) for all regulatory actions that are of public interest. The RIR does three things: (1) it provides a comprehensive review of the level and incidence of impacts associated with a regulatory action; (2) it provides a review of the problems and policy objectives prompting the regulatory proposals and an evaluation of the major alternatives which could be used to solve the problem; and (3) it ensures that the regulatory agency systematically and comprehensively considers all available alternatives so that the public welfare can be enhanced in the most efficient and cost effective way.

The RIR also serves as the basis for determining whether any proposed regulations are a "significant regulatory action" under certain criteria provided in Executive Order 12866 (E.O. 12866) and whether the approved regulations will have a "significant economic impact on a substantial number of small business entities" in compliance with the Regulatory Flexibility Act of 1980 (RFA).

7.2 Problems and Objectives in the Fishery

The purpose and need, issues, problems, and objectives of the proposed Amendment are presented in Section 1.2 and are incorporated herein by reference. According to the Western Central Atlantic Fishery Commission, international trade of illegally harvested Caribbean spiny lobster is a serious problem, and especially problematic is the trade of lobsters whose sizes are below the legal minimum size standards of the country of origin. The U.S. is the largest importer of Caribbean spiny lobster, and existing regulations are insufficient to prevent the illegal importation of spiny lobster that is illegally harvested in its country of origin. U.S. law enforcement's ability to screen imports for compliance with the Lacey Act is compromised by vague foreign minimum harvest-size and other laws that are intended to protect Caribbean spiny lobster. By implementing uniform importation standards, law enforcement's ability to effectively prevent the importation of undersized and berried lobsters will be improved. This in turn may help protect the species both in the U.S. and in the Caribbean as a whole.

7.3 Methodology

This RIR assesses management measures from the standpoint of determining the resulting changes in costs and benefits to society. These proposed actions would impose import restrictions to eliminate illegal trade of Caribbean spiny lobster, and as such, its largest cost would be the losses of revenues and profits incurred by individuals who illegally import Caribbean spiny lobsters by bringing into the U.S. lobsters that violate the harvest and trade laws of the countries of origin. Similarly, the largest secondary cost would be the losses of revenues and profits by individuals who buy illegal lobsters from black-market importers and losses of incomes by employees of such importers.

These proposed actions may also reduce some legal imports of Caribbean spiny lobster. Hence, these actions may reduce the revenues and profits earned by some who legally import Caribbean spiny lobster and reduce the incomes of those employed by those legal importers. However, the bulk of the costs should be the losses of illegal revenues, profits and incomes that derive from black-market transactions.

To the extent practicable, the net effects of the proposed measures should be stated in terms of producer and consumer surplus, changes in profits, and employment in the direct and support industries. However, most of the costs are expected to be incurred by black-market importers and there is insufficient information to quantify possible changes to legal imports and associated economic variables. Therefore, the impacts of the proposed action are described in terms of qualitative changes in costs and benefits that derive from possible decreases in legal, not illegal, imports.

7.4 Description of the Fisheries

The Caribbean spiny lobster fishery is described in Section 5.3, and is incorporated herein by reference.

7.5 Impacts of the Management Alternatives

7.5.1 Action 1: Minimum Conservation Sizes of Spiny Lobster (Panulirus argus) Import Products into the United States

Three alternatives are considered for this action: a status-quo alternative and two alternatives that impose import-size standards.

7.5.1.1 Alternative 1

This is the status quo alternative, and, as such, would not impose minimum import-size standards for Caribbean spiny lobster. Current regulations are insufficient to prevent the illegal importation of Caribbean spiny lobster that is illegally harvested in its country of origin because U.S. law enforcement's ability to screen imports for compliance with the Lacey Act is compromised by those who intentionally falsify the country of origin and vague harvest standards of the country of origin.. Without improved methods of detection, illegal importation of undersized lobsters will continue and remain a serious threat to the long-run biological and economic success of this species.

The U.S. is the largest importer of Caribbean spiny lobster and illegal international trade of Caribbean spiny lobster has been and remains to be a serious problem. From 2002 through 2007, total U.S. imports of frozen rock lobster and other sea crawfish (HS 0306110000: *Palinurus* spp., *Panulirus* spp. and *Jasus* spp.) averaged 12,374.2 metric tons with a value of about $355.5 million, annually. The top 5 countries of origin of those imports by volume (metric tons) are Brazil, The Bahamas, Australia, Honduras and Nicaragua, who collectively represent about 68 percent of the total volume of those imports. Those same countries account for about 78 percent of the total dollar value of those imports. Of the top 10 countries of origin by volume of frozen rock lobster and other sea crawfish imports, 6 of those countries (Brazil, The Bahamas, Honduras, Nicaragua, Colombia and Belize) export Caribbean spiny lobster to the United States. See Table 7.5.1.1.

The Western Central Atlantic Fishery Commission (WECAFC) has reported that harvesting and trading of Caribbean spiny lobster below the minimum legal size is a serious problem, especially in Brazil. According to a 2002 report for the Second Workshop on the Management of Caribbean Spiny Lobster Fisheries in the WECAFC Area, during the 2001 lobster season in Brazil, 8.2 tons of lobsters from a 10-ton sample were under the minimum legal size. If that sample is indicative of lobsters imported into the U.S. from Brazil, then 82 percent ($62.1 million) of the $75.7 million of rock lobster imported annually from Brazil is illegal. See Table 7.5.1.1.

The top 5 countries of origin of non-frozen rock lobster and other sea crawfish (HS 0306210000) by volume are Mexico, Australia, China, Taiwan and United Kingdom. See Table 7.5.1.2 next page. Mexico is the only one among the top 10 countries of origin that harvests Caribbean spiny lobster. Among all countries of origin of non-frozen rock lobster the following harvest Caribbean spiny lobster: Mexico, Nicaragua, Turks and Caicos Islands, Honduras, Costa Rica, Venezuela, Guatemala, and Jamaica.

Table 7.5.1.1. Countries of Origin of U.S. Imports of Frozen Rock Lobster and Other Sea Crawfish (HS 030611000).[1] *Source*: USDA, Foreign Agricultural Service.

	Values in 1000 Dollars						
Country of Origin	2002	2003	2004	2005	2006	2007	*6-Year Ave*
Brazil	74,334	70,207	79,681	74,879	76,959	78,371	*75,739*
Australia[2]	44,830	62,444	65,060	70,341	66,205	78,928	*64,635*
Bahamas, The	51,016	61,427	53,333	44,363	45,383	45,288	*50,135*
Honduras	40,600	36,388	42,731	44,059	41,025	47,942	*42,124*
Nicaragua	41,227	36,692	40,144	32,901	42,375	41,266	*39,101*
South Africa, Repub.	11,573	13,053	16,209	18,209	18,525	19,930	*16,250*
United Arab Emirates	8,647	11,707	11,638	10,673	9,816	9,762	*10,374*
Colombia	10,410	8,631	8,643	7,219	9,368	7,929	*8,700*
Belize	8,002	7,727	7,648	6,998	6,595	7,959	*7,488*
Mexico	12,282	8,985	4,524	4,470	3,814	2,161	*6,039*
Oman	8,603	9,609	4,336	2,947	480	0	*4,329*
China, Peoples Rep.	357	3,217	4,683	3,099	4,763	6,326	*3,741*
Jamaica	4,489	5,298	3,786	3,741	1,629	2,033	*3,496*
New Zealand[1]	3,022	3,336	2,908	3,490	3,946	2,350	*3,175*
Panama	3,249	2,376	2,156	3,203	2,101	2,603	*2,615*
Thailand	2,582	3,024	2,016	1,503	2,716	3,074	*2,486*
St. Helena (Br W. Af)	2,818	4,660	2,859	1,372	972	1,974	*2,443*
Dominican Republic	377	175	535	2,642	4,205	2,882	*1,803*
Taiwan	1,499	2,086	3,510	1,311	1,331	888	*1,771*

	Values in 1000 Dollars						
Country of Origin	2002	2003	2004	2005	2006	2007	*6-Year Ave*
Turks & Caicos Isl.	599	477	1,740	2,433	2,579	2,346	*1,696*
Chile	872	408	437	1,776	737	1,642	*979*
Papua New Guinea	1,017	1,276	1,053	1,055	493	241	*856*
Ecuador	1,412	489	730	397	185	408	*604*
Haiti	2,054	900	319	0	0	0	*546*
Spain	16	151	958	705	449	683	*494*
Turkey	0	0	0	2,885	0	0	*481*
Costa Rica	654	346	375	324	276	460	*406*
India	941	609	12	15	0	218	*299*
Namibia	440	303	147	347	234	217	*281*
El Salvador	678	130	637	113	11	0	*262*
Sri Lanka	323	154	697	257	55	25	*252*
Indonesia	39	61	72	30	0	1,140	*224*
Vietnam	0	6	128	0	561	603	*216*
Leeward-Windward Is.[2]	55	77	486	489	11	5	*187*
Tanzania, United Rep.	0	0	240	660	179	0	*180*
Iceland	20	151	585	295	23	0	*179*
Guatemala	297	313	177	240	21	0	*175*
French Ind. Ocean TE[2]	0	0	0	915	0	0	*153*
Peru	12	19	4	0	0	610	*108*
Canada	0	252	77	204	0	0	*89*
Mozambique	0	18	323	11	73	0	*71*
Mauritius	355	0	0	0	0	0	*59*
Venezuela	0	119	88	0	0	95	*50*
France[2]	139	150	0	4	0	0	*49*
Netherlands	14	32	60	66	83	0	*43*
Sweden	0	0	105	43	0	0	*25*
Russian Federation	109	0	0	0	0	0	*18*
Japan	0	0	0	27	16	39	*14*
Guyana	0	0	37	0	0	0	*6*
British Pacific Is.[2]	0	0	36	0	0	0	*6*
United Kingdom	10	20	0	0	3	0	*6*
Malaysia	0	15	0	0	0	12	*5*
Phillipines	0	0	26	0	0	0	*4*
Korea, Republic of	0	0	25	0	0	0	*4*
Other Pacific Island[2]	0	0	0	0	22	0	*4*
Belgium-Luxembourg[2]	19	0	0	0	0	0	*3*
Trinidad & Tobago	0	0	13	0	0	0	*2*
French West Indies[2]	13	0	0	0	0	0	*2*
Kenya	3	0	0	0	0	0	*1*
Lithuania[2]	0	3	0	0	0	0	*1*
TOTAL	**340,084**	**357,602**	**367,985**	**350,713**	**348,220**	**370,408**	**355,835**

1. Includes all *Palinurus* spp., *Panulirus* spp. and *Jasus* spp.
2. Includes component countries identified by U.S. Customs.

Table 7.5.1.2. Countries of Origin of U.S. Imports of Not Frozen Rock Lobster and Other Sea Crawfish (HS 030621000), 2002 - 2007.[1] *Source*: USDA, Foreign Agricultural Service.

Country of Origin	Ave. MT	Ave $1000s	Trading Partner	Ave. MT	Ave $1000s
MEXICO	122	2086	MALAYSIA	0.6	6
AUSTRALIA[2]	10.0	370	LEEWARD-WINDWARD ISL[2]	0.5	4
CHINA, PEOPLES REPUB	5.5	27	FRANCE[2]	0.3	33
TAIWAN	4.6	51	GUATEMALA	0.3	9
UNITED KINGDOM	3.3	40	UKRAINE	0.3	2
NICARAGUA	3.1	70	ARMENIA, REPUBLIC OF	0.2	1
CANADA	2.8	35	JAMAICA	0.2	7
TURKS AND CAICOS ISL	2	52	BELGIUM-LUXEMBOURG[2]	0.1	0
NEW ZEALAND[2]	1.8	44	CHILE	0.1	3
GERMANY	1.5	12	SOUTH AFRICA, REPUBL	0.1	1
ECUADOR	1.2	10	SPAIN	0.1	1
HONDURAS	1	10	COTE D'IVOIRE	0.1	1
NIGERIA	0.93	70	NORWAY	0.05	0
COSTA RICA	0.8	14	DENMARK	0	1
VENEZUELA	0.8	4	*TOTAL*		2,895

1. Includes all *Palinurus* spp., *Panulirus* spp. and *Jasus* spp.
2. Countries that include component countries.

The lucrative legal and illegal markets for this species make overfishing a reality in Brazil, Colombia, Dominican Republic, Honduras, Jamaica, and Nicaragua. See Table 7.5.1.3.

Overexploiting Caribbean spiny lobster stocks in foreign fisheries could jeopardize the abundance and structure of U.S. stocks because the larval recruitment of U.S. stocks is dependent on the reproductive potential of stocks managed by other countries. The potential long-term adverse impact of the status-quo alternative is smaller domestic stocks of Caribbean spiny lobster and smaller commercial and recreational harvests because larval recruitment of U.S. stocks are dependent upon the reproductive potential of stocks managed by other countries. Florida commercial and recreational lobster fishers, as well as lobster dealers and others who derive economic benefits from Caribbean spiny lobster fishing in Florida, would experience the greatest long-term cost.

Table 7.5.1.3. Estimated status of national populations of Caribbean spiny lobster of WECAFC countries. *Source*: WECAFC 2007.

Status of Stock	Countries and Territories
Under-exploited	Venezuela (some areas)
Fully-exploited or stable	Antigua & Barbuda, Belize, Costa Rica, Cuba, Mexico, Puerto Rico & U.S. Virgin Islands, Turks & Caicos, USA (Florida), Venezuela (some areas)
Over-exploited	Nicaragua, Jamaica, Dominican Republic, Brazil, Colombia, Honduras
Unknown	Bahamas, Guadeloupe, Haiti, Martinique, other Less Antilles countries

In 2006, Florida landings of Caribbean spiny lobster valued about $27 million, and from 1997 through 2006 averaged about $23.5 million annually. See Table 7.5.1.4. Florida commercial fishermen catch Caribbean spiny lobster to be landed and used as bait.

Fishermen use the live undersized lobsters, known as "shorts", to attract Caribbean spiny lobster into traps. See Table 7.5.1.5.

Table 7.5.1.4. Florida Landings of Caribbean Spiny Lobster, 1997 – 2006.

Year	$ Landings
1997	29,098,538
1998	21,941,515
1999	32,549,303
2000	28,191,680
2001	17,023,338
2002	20,832,868
2003	18,871,358
2004	22,803,269
2005	16,691,634
2006	27,329,248
Ave	23,533,275

Table 7.5.1.5. Pounds of Caribbean Spiny Lobster Landed in Florida, from 1978-79 through 2003-04 Fishing Seasons. *Source*: FL Fish & Wildlife Conservation Commission.

Fishing Season	Recreational Landings	Commercial Landings	Bait Landings	Total Landings	% Recreational	% Commercial
1978-79	1,032,818	4,712,160	1,489,053	7,234,031	14.28%	65.14%
1979-80	1,332,146	6,384,958	1,766,902	9,484,006	14.05%	67.32%
1980-81	1,653,054	5,074,434	1,450,653	8,178,141	20.21%	62.05%
1981-82	1,438,200	4,673,563	1,389,579	7,501,342	19.17%	62.30%
1982-83	1,487,598	5,192,189	1,440,506	8,120,293	18.32%	63.94%
1983-84	1,114,641	3,516,013	1,205,460	5,836,114	19.10%	60.25%
1984-85	1,218,015	5,077,610	1,458,513	7,754,138	15.71%	65.48%
1985-86	1,176,734	4,586,067	932,611	6,695,412	17.58%	68.50%
1986-87	1,098,768	3,955,795	1,321,591	6,376,154	17.23%	62.04%
1987-88	1,305,427	4,657,778	521,939	6,485,144	20.13%	71.82%
1988-89	1,743,948	6,381,104	499,015	8,624,067	20.22%	73.99%
1989-90	1,718,020	6,650,042	587,191	8,955,253	19.18%	74.26%
1990-91	1,496,810	5,154,258	1,061,504	7,712,572	19.41%	66.83%
1991-92	1,990,623	5,784,865	662,668	8,438,156	23.59%	68.56%
1992-93	1,242,648	4,567,343	565,406	6,375,397	19.49%	71.64%
1993-94	1,787,054	4,662,274	422,617	6,871,945	26.01%	67.85%
1994-95	1,751,298	6,229,495	492,439	8,473,232	20.67%	73.52%
1995-96	1,673,330	5,666,412	513,035	7,852,777	21.31%	72.16%
1996-97	1,778,889	6,646,664	583,692	9,009,245	19.75%	73.78%
1997-98	2,186,058	6,796,320	621,140	9,603,518	22.76%	70.77%
1998-99	1,185,036	4,522,375	275,976	5,983,387	19.81%	75.58%
1999-00	2,292,304	6,581,944	498,148	9,372,396	24.46%	70.23%
2000-01	1,848,447	4,469,964	423,038	6,741,449	27.42%	66.31%

2001-02	1,091,022	2,307,262	323,096	3,721,380	29.32%	62.00%
2002-03	1,223,197	3,818,081	347,857	5,389,135	22.70%	70.85%
2003-04	1,142,960	3,419,929	329,668	4,892,557	23.36%	69.90%

In 2003, recreational landings of Caribbean spiny lobster were about 1.1 million pounds, and sales of recreational lobster fishing permits exceed 100,000 annually. Sharp et al. (2005) estimate approximately $24 million was spent on recreational lobster fishing in the Florida Keys from the opening of the recreational season through the first Monday in September in 2001. Fishers who resided outside the Keys accounted for about $22 million (92 percent) of the total monies spent on recreational lobster fishing in the Keys. In addition to the regular recreational season there is the Special Two-Day Sport Season, which occurs on the last consecutive Wednesday and Thursday in July. Those two days are the busiest boating days of the year in the County. From the 1993 through 2001 Special Two-Day Sport Seasons, the average annual number of spiny lobsters caught in Monroe County represents about 66 percent of the annual statewide total.

7.5.1.2 Alternative 2 of Action 1

Part A: No person in the U.S. would be allowed to import a spiny lobster (*Panulirus argus*), as follows:

Any spiny lobster of less than 5 ounces tail weight (5 ounces is defined as a tail that weighs 4.2 – 5.4 ounces). If the imported product does not meet this minimum weight requirement, the person importing the lobster can demonstrate compliance by showing that the product imported satisfies the tail length requirement, or that it was harvested from an animal that satisfied the minimum carapace length requirement of:

a. Greater than 3.0 inches (7.62 cm) carapace length if the animal is whole.
b. Greater than or equal to 5.5 inches (13.97 cm) tail length if only the tail is present.

Part B: No one in Puerto Rico or the U.S. Virgin Islands would be allowed to import a Caribbean spiny lobster (*Panulirus* argus) Any spiny lobster of less than 6.0 ounces tail weight (6 ounces is defined as a tail that weighs 5.9 – 6.4 ounces). If the imported product does not meet this minimum weight requirement, the person importing the lobster can demonstrate compliance by showing that the product imported satisfies the tail length requirement, or that it was harvested from an animal that satisfied the minimum carapace length requirement of:

a. Greater than or equal to 3.5 inches (8.89 cm) carapace length if the animal is whole.
b. Greater than or equal to 6.2 inches (15.75 cm) tail length if only the tail is present.

Under this alternative, tail weight would not be the only measurement used by law enforcement inspectors to determine if an individual tail or whole lobster is legal or not. Individual tails or lobsters that are inspected and do not meet the tail weight requirement, but have the appropriate carapace length or tail length measurement would be considered legal. In other words, any whole lobster or separated tail that meets or exceeds the carapace-length standard or the tail-weight standard would be a legally imported Caribbean spiny lobster, whether it satisfies the tail-weight standard or not. Consequently, to be judged as illegal, a whole lobster would not meet or exceed the tail-weight standard, tail-length standard or carapace-length standard, and a tail would not meet or exceed the tail-weight standard or tail-length standard.

7.5.1.2.1 Part A of Alternative 2 of Action 1

Many countries that harvest Caribbean spiny lobster have minimum harvest-size standards. See Table 7.5.1.6.

The following countries and territories have reported harvesting Caribbean spiny lobster during the period from 1962 through 2003, according to the FAO: Anguilla, Antigua and Barbuda, The Bahamas, Belize, Bermuda, Brazil, British Virgin Islands, Colombia, Costa Rica, Cuba, Dominican Republic, Grenada, Haiti, Honduras, Martinique, Mexico, Grenada, St. Kitts and Nevis, St. Lucia, Saint Vincent and Grenadines, Turks and Caicos, Nicaragua, Puerto Rico, Saint Kitts and Nevis, Trinidad and Tobago, Turks and Caicos Island, U.S., U.S. Virgin Islands, and Venezuela (Bolivarian Republic of). From 2002 through 2007 the following 17 countries that harvest Caribbean spiny lobster were the countries of origin of rock lobster imported into the U.S.: Bahamas, Belize, Brazil, Colombia, Costa Rica, Dominican Republic, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Trinidad and Tobago, Turks and Caicos Islands, and Venezuela. See Tables 7.5.1.1 and 7.5.1.2. This analysis initially presumes any imported spiny lobster that could be affected by this alternative would originate from one of the above 17 countries.

However, if any past shipments of spiny lobster remained within U.S. Customs jurisdiction until shipped out of a Florida port and did not come into possession in Florida, they were not required to be in compliance with Florida size standards. Therefore, the NMFS encourages importers of spiny lobster and others to provide comment on the assumption that past Caribbean spiny lobster imports that entered the country at a Florida port came to be possessed in Florida.

Table 7.5.1.6. Foreign Minimum Harvest-Size Standards for Caribbean Spiny Lobster. *Source*: FAO.

Country[1]	**Carapace Length (CL)**	**Tail Length (TL)**	**Tail Weight (TW)**	**Satisfies CL for Part A**	**Satisfies TL for Part A**	**Satisfies TW for Part A**	**Satisfies CL for Part B**	**Satisfies TL for Part B**	**Satisfies TW for Part B**
Anguilla	9.5 cm			Yes			Yes		
Antigua & Barbuda	9.5 cm			Yes			Yes		
Bahamas	***8.3 cm***	***14 cm***	***4.5 oz.***	***Yes***	***Yes***	***Yes***	***No***	***No***	***No***
Barbados									
Belize	***7.62 cm***	***11.3 cm***	***4 oz.***	***No***	***No***	***No***	***No***	***No***	***No***
Bermuda	9.2 cm		12 oz.	Yes		Yes	Yes		Yes
Brazil	***7.5 cm***	***13.0 cm***		***No***	***No***	***No***	***No***	***No***	***No***

Country[1]	Carapace Length (CL)	Tail Length (TL)	Tail Weight (TW)	Satisfies CL for Part A	Satisfies TL for Part A	Satisfies TW for Part A	Satisfies CL for Part B	Satisfies TL for Part B	Satisfies TW for Part B
British Virgin Islands	8.9 cm.			Yes			Yes		
Colombia-San Andres	***8.0 cm***	***14.0 cm***		***Yes***	***Yes***		***No***	***No***	
Colombia-Guajira	***6.9 cm***	***21.0 cm***		***No***	***Yes***		***No***	***Yes***	
Costa Rica									
Cayman Islands		15.2 cm			Yes			No	
Dominica									
Dominican Republic	***8.1 cm***	***12.0 cm***		***Yes***	***No***		***No***	***No***	
Grenada	9.5 cm.		7.1 oz.	Yes		Yes	Yes		Yes
Guadaloupe									
Guatemala									
Guyana									
Haiti[2]									
Honduras	***8.0 cm***	***14.5 cm***	***5 oz.***	***Yes***	***Yes***	***Yes***	***No***	***No***	***No***
Jamaica	***7.62 cm***			***No***			***No***		
Martinique	6.0 cm			No			No		
Mexico	***7.5 cm***	***13.5 cm***		***No***	***No***		***No***	***No***	
Monserrat									
Nicaragua	***7.5 cm***	***13.5 cm***	***5 oz.***	***No***	***No***	***Yes***	***No***	***No***	***No***
Panama									
St. Kitts & Nevis	9.5 cm			Yes			Yes		
St. Lucia	9.5 cm		12 oz.	Yes		Yes	Yes		Yes
Saint Vincent & the Grenadines	9.5 cm			Yes			Yes		
Turks and Caicos	***8.3 cm***		***7 oz.***	***Yes***		***Yes***	***No***		***Yes***
Trinidad & Tobago									
Venezuela	***12.0 cm***			***Yes***			***Yes***		

1. Countries listed in bold and italicized are countries of origin of U.S. imports of rock lobster from 2002 through 2007.
2. Has a whole weight standard of 5 ounces.

The following countries of origin have a carapace size standard that exceeds 3 inches (7.62 cm): Bahamas (8.2 cm), Colombia-San Andres (8.01 cm), Dominican Republic (8.05 cm), Honduras (8.01 cm), Turks and Caicos Islands (8.3 cm), and Venezuela (12.0 cm) have a carapace size standard that exceeds 3 inches. It is expected that spiny lobsters with a carapace size greater than 3 inches correspond to tail lengths and weights that comply with Part A, and, consequently, Part A is not expected to affect legal imports from the Bahamas, Dominican Republic, Honduras, Turks and Caicos Islands and Venezuela, or those lobsters legally harvested in Colombia's San Andres region.

Of the countries of origin with a tail-length size standard, the following three have a standard that equals or exceeds the 5.5-inch (14.0 cm) standard of Part A: Bahamas (14.0 cm), Colombia-San Andres (14.0 cm), Colombia-Guajira (21.0 cm), and Honduras (14.5 cm). It is expected that legal imports from countries with a tail-length size standard equal or greater than 5.5 inches comply with the tail weight and carapace length standards imposed by Part A. Therefore, legal imports of spiny lobster from the Bahamas, Colombia and Honduras are not expected to be affected by Part A of this alternative.

Five of the countries of origin have a tail-weight size standard and of those five, the following three have a standard that meets or exceeds 4.2 ounces (119.1 grams): Honduras (5 oz.), Nicaragua (5 oz.), and Turks and Caicos Islands (7 oz.). See Table 7.5.1.6. Legal imports from these 3 countries should not be affected by Part A of this alternative.

It follows from the previous three paragraphs that legal imports from the following 7 countries of origin should not be affected by Part A because of their size standards: Bahamas, Colombia, Dominican Republic, Honduras, Turks and Caicos Islands, Nicaragua, and Venezuela. It also follows that some legal imports from Belize, Brazil, Costa Rica, Guatemala, Guyana, Haiti, Jamaica, Mexico, Panama, and Trinidad and Tobago could be affected by Part A of this alternative. In the past 6 years, Guyana and Trinidad and Tobago have been the country of origin only once and there have been no imports of rock lobster from these countries since 2004. See Table 7.5.1.1.

As stated previously, the harvest and international trade of Caribbean spiny lobsters less than the legal minimum size is a serious problem. As the U.S. is the largest importer of spiny lobster, this alternative would significantly reduce black-market trade of this species.

Brazil (7.5 cm) and Mexico (7.46 cm) have a carapace size standard that is less than 3 inches (7.62 cm). Panama is reported to have a size limit; however, a preliminary review of Panama fishing laws did not find such a standard. Costa Rica, Guatemala, Guyana, Haiti, and Trinidad and Tobago have no carapace-size standard. In September 2006, the Working Group on Caribbean spiny lobster of the Western Central Atlantic Fishery Commission (WECAFC) met in Merida, Mexico, to attend the Regional Workshop on the Assessment and Management of Caribbean Spiny Lobster. The primary objective of the workshop was to review and update the status of Caribbean spiny lobster at national and international levels to seek international agreement on strategies to address management problems. Among the workshop's participants were representatives from Costa Rica, Haiti, and the Caribbean Regional Fishery Mechanism (CRFM) who agreed to a minimum carapace-length standard of 7.4 cm (2.91 inches). Guyana and Trinidad and Tobago are members of the Caribbean Regional Fishery Mechanism, and it is expected that those two countries will establish a carapace-size standard equal to or greater than 7.4 cm.

Belize (11.3 cm), Brazil (13.0 cm) and Mexico (13.5 cm) have tail-length standards less than required by Part A (14.0 cm), and the following countries of origin have no tail-length standard: Costa Rica, Guatemala, Guyana, Haiti, Jamaica, and Trinidad and Tobago. Belize has a tail-weight standard (4.0 oz.) less than the 4.2 oz. minimum established by Part A and Brazil, Costa Rica, Guatemala, Guyana, Haiti, Jamaica, Mexico, and Trinidad and Tobago have no tail-weight standards.

Florida law (*Florida Administrative Code* 68B-24.003(1)) states no person shall harvest or possess any spiny lobster with a carapace measurement of 3 inches or less or, if the tail is separated from the body, a tail measurement less than 5.5 inches. This analysis presumes that any spiny lobster that enters the country at a Florida port comes to be possessed in Florida. Consequently, that assumption means any spiny lobster that enters the country at a Florida port must already comply with the 3-inch carapace length and 5.5-inch tail length standards that would be imposed by Part A. It is anticipated that any lobster that meets the 3-inch carapace and 5.5-tail length standards would satisfy the tail weight standard, and comply with Part A as a whole. Therefore, this analysis presumes any spiny lobster that has entered and continues to enter the country at a Florida port becomes a possession in Florida and is not affected by Part A.

All rock lobster imports from Haiti and Guatemala historically have entered at a Florida port, and thus, this analysis presumes no legal imports of spiny lobster from Haiti or Guatemala would be affected by this alternative. Imports of rock lobster from Belize, Brazil, Costa Rica, Jamaica, Mexico and Panama enter the U.S. at both Florida and non-Florida ports. About 98 percent of the pounds and total dollar value of rock lobster annually imported from Jamaica enter at a Florida port. See Table 7.5.1.7. These rock lobster imports include all *Palinurus* species, *Panulirus* species and *Jasus* species.

Table 7.5.1.7. Percent of Imports of Frozen and Non-frozen Rock Lobster (HS 030611000 and 0306210000) from Belize, Brazil, Costa Rica, Jamaica, Mexico and Panama, 2006 – 2007, into Florida and Other State Ports.[1, 2]

	% FL Ports		% Non-FL Ports		Annual Ave 1000s $	
Country	Pounds	Dollars	Pounds	Dollars	Total All Ports	Non-FL Ports
Belize	31%	29%	69%	71%	7,488	5,316
Brazil[3]	4%	6%	96%	94%	75,739	71,952
Costa Rica	67%	75%	33%	25%	420	105
Jamaica	98%	98%	2%	2%	3,503	70
Mexico	46%	37%	54%	63%	8,125	5,119
Panama	1%	1%	99%	99%	2,615	2,589
Total					97,890	85,150

1. These imports include *Palinurus* species, *Panulirus* species and *Jasus* species.
2. These imports include both legal and undetected illegal imports.
3. If a 2001 sample of Brazilian lobster operations is representative of imports of rock lobster from that country, then 82 percent of the imports from Brazil are illegal.

The above countries harvest multiple species of rock lobster. For example, Mexico harvests and trades four species and Brazil and Jamaica two species each. Hence, imports of Caribbean spiny lobster from the above countries represent part, not the entirety, of the rock lobster imported from these countries.

It is illegal to harvest spiny lobsters with a carapace length less than 7.62 cm (76.2 mm) in Jamaica and Belize. As stated in section 4.1, it is estimated that 84 percent of those spiny lobsters with a 3-inch (7.62-cm) tail length would meet the tail length or tail weight requirement of Part A. Consequently, if all of the historical legal spiny lobster imports from these countries were no larger than their countries' minimum legal size, 84 percent of the spiny lobsters legally imported from Jamaica and Belize would not be affected by Part A. It is more likely, however, that many of the spiny lobsters legally imported from these countries exceed the minimum legal size. Therefore, it is more likely that less than 16 percent of the spiny lobsters legally imported from Jamaica and Belize would be affected by Part A. Those spiny lobsters currently imported legally but under the size required by Part A would have to remain in the water and grow at least another tenth of a millimeter before being harvested in either of the above two countries. It is similarly expected that spiny lobsters which are presently and legally exported whole or in part to the U.S. from Belize, Brazil, Costa Rica, Jamaica, Mexico and Panama and do not satisfy Part A requirements would have to remain in the water for no more than one additional molt.

Physical growth of lobsters is achieved through molting. An adult lobster molts an average of two and a half times each year. The entire molting event takes approximately ten minutes. The new exoskeleton will take about 12 days from the start of the molt to harden such that it cannot be dented; however the shell is not completely formed until the 28th day (Williams, 1984). In most countries harvesting molting or soft shelled lobsters is prohibited. This analysis presumes the average spiny lobster completes a molting cycle (from molt to hardened shell) every 4.8 months (12 months/2.5 molts) and at least once every lobster season.
This analysis assumes any spiny lobster that is currently legally imported into the U.S., but does not meet Part A size standards, would have to remain in the water an additional 4.8 months. Therefore, this alternative may be better understood as eliminating the illegal importation of spiny lobster and delaying, not prohibiting, some of the legal importation of a spiny lobster. The delay has advantages to both lobster fishermen and U.S. importers because larger lobsters have greater market value, and in the long run, the economic benefits of a sustainable resource should exceed the economic costs.

The bulk of the economic costs of this alternative would be the losses of revenues and profits associated with the illegal importation of Caribbean spiny lobster and the losses of income derived from that illegal activity. Decreases in revenues and profits earned from presently legal importation of spiny lobster would also occur; however, it is anticipated that most legal imports would not be affected by this alternative. The economic benefits of this alternative would be larger minimum-sized imported lobsters with greater market value and domestic and foreign revenues, profits and incomes that derive from a biologically and economically improved resource.

7.5.1.2.2 Part B of Alternative 2 of Action 1

Title 12, Chapter 9A, Section 319(b) of the *Virgin Island Code* (V.I.C.) states, "No person, firm or corporation shall take or have in his possession at any time, regardless of where taken, any spiny lobster (crawfish or crayfish) of the species *Panulirus argus* unless such spiny lobster … shall have a carapace length of more than three and one-half (3 ½) inches". This existing law is more stringent than with the minimum carapace length restriction imposed by Part B. Thus, the proposed carapace restriction of Part B has no effect on imports into the U.S. Virgin Islands. A spiny lobster with a carapace length greater than 3.5 inches is expected to have a tail length and tail weight that meets the tail length and weight restrictions that would be imposed by Part B. Consequently, this analysis expects this alternative would have no effect on imports of spiny lobster into the U.S. Virgin Islands. U.S. Customs data shows there were no imports of rock lobster (frozen or not) into the U.S. Virgin Islands from 2001 through 2007, which further supports the conclusion that this alternative would not affect imports into the U.S. Virgin Islands.

Puerto Rico regulation currently prohibits the possession of spiny lobster (*P. argus*) with a carapace less than 3.5 inches. This existing law is consistent with the minimum carapace length restriction imposed by Part B. Therefore, the proposed carapace restriction of Part B should have no effect on spiny lobster imports into Puerto Rico.

Part B is expected to have no economic impact on imports into Puerto Rico or the U.S. Virgin Islands.

7.5.1.2.3 Total Economic Impact of Alternative 2 of Action 1

The bulk of the economic costs of this alternative would be the losses of revenues and profits associated with the illegal importation of Caribbean spiny lobster and the losses of income derived from that illegal activity. Decreases in revenues and profits earned from presently legal importation of spiny lobster would also occur; however, it is anticipated that most legal imports would not be affected by this alternative. The economic benefits of this alternative would be larger minimum-sized imported lobsters with greater market value and enhanced long-run domestic and foreign revenues, profits and incomes that derive from a biologically and economically improved resource.

7.5.1.3 Alternative 3 of Action 1

No person shall import into the U.S. a Caribbean spiny lobster that is smaller than the existing Continental U.S. minimum size limit. Specifically, no one in the U.S. would be allowed to import a Caribbean spiny lobster (*Panulirus* argus):

1. 3.0 inches (7.62 cm) or less carapace length if the animal is whole.
2. Less than 5.5 inches (13.97 cm) tail length if only the tail is present.
3. Less than 5 ounces (5 ounces is defined as a tail that weighs 4.5 to 5.4 ounces).

This alternative extends the import restrictions established by Part A of Alternative 2 from the Continental U.S. to include the Continental U.S, Puerto Rico and U.S. Virgin Islands. The economic impact of this alternative in the Continental U.S. is equivalent to the economic impact of Part A of Alternative 2. See section 7.5.1.2.1.

Both Puerto Rico and the U.S. Virgin Islands have laws that prohibit the possession of spiny lobster with a carapace less than 3.5 inches long. This alternative would allow the importation of Caribbean spiny lobsters with a carapace less than 3.5 inches, which would be in contradiction with Puerto Rico and U.S. Virgin Islands law. This alternative would encourage illegal fishing operations in these territories. Domestic fishing operations in either of these two territories could illegally take undersized lobsters in territorial waters and claim them to be imports that meet the smaller size standard.

7.5.1.4 Comparison of Alternatives of Action 1

A comparison of the economic costs and benefits of the three alternatives is presented in Table 7.5.1.8.

Table 7.5.1.8. Summary of Economic Costs and Benefits of Action 1 Alternatives.

Action 1: Establish Import-Size Standards				
Alternative		**Description**	**Economic Cost**	**Economic Benefit**
1		Don't impose import-size standards	Continues illegal importation of undersized lobster Supports illegal fishing and overfishing Leads to long-run biological and economic damages	Maintains status quo revenues, profits and incomes from imports of Caribbean spiny lobster
2	Part A: U.S.	No imports with carapace length 3.0 inches or less No imports with tail length 5.5 inches less No imports with tail weight less than 5 ounces	Reduces some revenues, profits and incomes from legal trade	Reduces illegal importation of undersized lobster and associated illegal revenues, profits and incomes Discourages illegal fishing and overfishing Increases revenues, profits and incomes in long-run from legal use of resource
	Part B: Puerto Rico and U.S. Virgin Islands	No imports with carapace less than 3.5 inches No imports with tail length 6.2 inches less No imports with tail weight less than 5.9 ounces	None	None
3	U.S.	No imports with carapace length 3.0 inches or less No imports with tail length 5.5 inches less No imports with tail weight less than 5 ounces	Reduces some revenues, profits and incomes from legal trade	Reduces illegal importation of undersized lobster and associated illegal revenues, profits and incomes Discourages illegal fishing and overfishing Increased revenues, profits and incomes in long-run from legal use of resource
	Puerto Rico & U.S. Virgin Islands	No imports with carapace length 3.0 inches or less No imports with tail length 5.5 inches less	Encourages illegal operations in these territories Encourages overfishing in these territories	Increases revenues, profits and incomes from legal trade

		No imports with tail weight less than 5 ounces	Increases revenues, profits and incomes from illegal use of territorial resource Leads to long-run biological and economic damages to territorial resource	

7.5.2 Action 2: Establish other restrictions on importation of Caribbean spiny lobster

Four alternatives are considered for this action: a no action alternative and three alternatives. The second alternative is a combination of restrictions that are separated in the third and fourth alternatives.

7.5.2.1 Alternative 1 of Action 2

This is the no action alternative, and, as such, would not prohibit the importation of Caribbean spiny lobster meat that is removed from the exoskeleton nor importation of berried lobsters or those whose eggs, swimmerets or pleopods have been removed or stripped.

One method that illegal importers of spiny lobster use to reduce detection is by removing the meat from the exoskeleton of the lobsters and processing it into chunks. This alternative would maintain that loophole, and if Alternative 2 or 3 of Action 1 were implemented, it is likely that there would be increased imports of processed spiny lobster meat in order to avoid detection of undersized lobsters. Thus, this alternative in conjunction with Alternative 2 or 3 of Action 1 would likely increase the adverse biological and economic impacts caused by the importation of illegal spiny lobster.

In Florida, the harvest or possession of eggbearing spiny lobster is prohibited and any egg-bearing lobster found in traps must be immediately returned to the water free, alive and unharmed (68B-24.007 *F.A.C.*). The practice of stripping or otherwise molesting eggbearing spiny lobster in order to remove the eggs is prohibited and the possession of spiny lobster or spiny lobster tails from which the eggs, swimmerets or pleopods have been removed or stripped is prohibited (68B-24.007 *F.A.C.*). The U.S. Virgin Islands prohibits the take, possession or sale of egg-bearing spiny lobsters (Title 12 Chapter 9A §319(b) *V.I.C.*). Any egg-bearing lobsters captured in traps or pots must be returned into the water in a live and unharmed condition; and the practice of stripping, shaving, scraping, clipping or otherwise molesting egg-bearing lobsters in order to remove the eggs is prohibited (Title 12 Chapter 9A §319(d,e) V.I.C.). In Puerto Rico, there is a similar prohibition on the possession of egg-bearing spiny lobsters and molestation of egg-bearing lobsters.

According to the Western Central Atlantic Fishery Commission, most countries have laws forbidding the harvest of egg-bearing females, and the greatest offenses of those laws tend to be in foreign artisanal fisheries. See Table 7.5.2.1. One method that illegal harvesters of berried females use to remove the eggs is by removing the pleopods (also known as swimmerettes). Under the tail of a Caribbean spiny lobster are four pairs of small leaf-like structures which are the pleopods. Each pleopod on a female has two lobes: one lobe is paddle-like and the other resembles small pincers. The fertilized eggs attach to long hairs called "setae" on the pincer-like lobes of her pleopods. Prohibiting the removal of the pleopods would be easy to enforce because it is easy to detect if they have been removed or not. The status quo alternative would not reduce the illegal importation of female lobsters that have had their eggs removed and the associated adverse biological and economic impacts to the stock from such a practice.

Table 7.5.2.1. Other Foreign Harvest Restrictions for Caribbean Spiny Lobster. *Source*: FAO website.

Country[1]	**Prohibits Exportation Lobster Meat?**	**Prohibits Harvest of Berried Lobsters?**	**Prohibits Removal of Eggs?**	**Prohibits Removal of Pleopods?**
Anguilla		Yes	Yes	
Antigua & Barbuda		Yes	Yes	Yes
Bahamas		**Yes**	**Yes**	**Yes**
Barbados		Yes	Yes	
Belize		**Yes**	**Yes**	**Yes**
Bermuda		Yes	Yes	Yes
Brazil		**Yes**	**Yes**	
British Virgin Islands		Yes	Yes	Yes
Colombia		**Yes**	**Yes**	
Costa Rica		**Yes**	**Yes**	
Cayman				
Dominica		Yes		
Dominican Republic		**Yes**	**Yes**	
Grenada		Yes	Yes	Yes
Guadaloupe				
Guatemala				
Guyana				
Haiti		**Yes**	**Yes**	
Honduras		**Yes**	**Yes**	
Jamaica		**Yes**	**Yes**	
Martinique				
Mexico		**Yes**	**Yes**	
Monserrat				
Nicaragua		**Yes**	**Yes**	
Panama		**Yes**		
St. Kitts & Nevis		Yes		
St. Lucia		Yes	Yes	
Saint Vincent & the Grenadines		Yes	Yes	
Turks and Caicos		**Yes**	**Yes**	

Trinidad & Tobago				
Venezuela		**Yes**	**Yes**	

1. Countries listed in bold and italicized are countries of origin of U.S. imports of rock lobster from 2002 through 2007.

7.5.2.2 Alternative 2 of Action 2

This alternative would prohibit the importation of: 1) spiny lobster (tail) meat without the exoskeleton attached and 2) spiny lobster with eggs attached or where the eggs or pleopods (swimmerets) have been removed or stripped.

7.5.2.2.1 Prohibiting Importation of Meat Removed from the Shell

Most imports of spiny lobster are parts or wholes of the lobster with the meat attached to the exoskeleton; however, some imports are lobster meat that has been removed from the shell. One method that illegal importers have used and continue to use to avoid detection is to remove the meat from the exoskeletons of undersized and berried lobsters and then package the meat in chunks. This alternative would eliminate such illegal imports. It would also prohibit any currently legal imports of Caribbean spiny lobster meat that has been removed from the shell. Preliminary information suggests the ban on imports of lobster meat that has been extracted from the shell would have the greatest impact on illegal, not legal, trade.

The bulk of the economic costs of this ban would be the losses of illegal revenues and profits associated with the illegal importation of Caribbean spiny lobster meat and the losses of income derived from that illegal activity. Decreases in revenues and profits earned from presently legal importation of spiny lobster meat would also occur; however, the losses of legal revenues, profits and incomes are expected to be substantially lower by comparison. The economic benefits of this prohibition would be improved domestic and foreign revenues, profits and incomes that derive from a biologically and economically improved resource.

7.5.2.2.2 Prohibiting Importation of Berried Lobsters or Removal of Eggs or Pleopods

From 2002 through 2007, rock lobster imports have originated from the following 17 countries that harvest Caribbean spiny lobster: The Bahamas, Belize, Brazil, Colombia, Costa Rica, Dominican Republic, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Turks and Caicos Islands, Trinidad and Tobago, and Venezuela. See Tables 7.5.1.1 and 7.5.1.2. Of these 17 countries, Guatemala, Guyana, and Trinidad and Tobago do not have laws that prohibit the harvest of spiny lobsters with eggs or removal of eggs. See Table 7.5.2.1. Combined rock lobster imports from these three countries represent $183,000 (about 0.05 percent) of $356 million of frozen imports and $9,000 (about 0.3 percent) 0f the $2.9 million of non-frozen imports.

Panama has a law that prohibits the harvest of berried lobsters, but may not prohibit the removal of eggs. Imports of rock lobster from Panama represent about 0.7 percent of frozen rock lobster imports and none of the non-frozen imports.

Any imports of berried Caribbean spiny lobster or those with their eggs removed from the following countries are presently illegal under the Lacey Act: The Bahamas, Belize, Brazil, Colombia, Costa Rica, Dominican Republic, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Turks and Caicos Islands, and Venezuela. Consequently, a prohibition against the importation of berried lobsters or removal of eggs would not affect any legal imports from those 13 countries.

As stated previously in section 7.5.2.1, the possession of egg-bearing spiny lobster is prohibited in Florida, Puerto Rico and the U.S. Virgin Islands. Therefore, any imports of berried spiny lobster into Florida, Puerto Rico or the U.S. Virgin Islands, regardless of country of origin, are presently illegal. In 2006 and 2007, all imports of rock lobster from Guatemala entered the U.S. in Florida and this analysis presumes those imports came into possession in Florida. Hence, it is expected that all imports from Guatemala presently must comply with Florida law and any imports of berried lobsters from that country are illegal. Guyana and Trinidad and Tobago, the only other countries that do not prohibit the harvest of berried lobsters, have not exported rock lobster to the U.S. since 2005.

Florida, Puerto Rico, and the U.S. Virgin Islands prohibit the removal of eggs from female lobsters. In Florida, it is illegal to remove pleopods (or swimmerets). The U.S. Virgin Islands prohibits the practice of stripping, shaving, scraping, clipping or otherwise molesting egg-bearing lobsters in order to remove the eggs is prohibited and Puerto Rico prohibits the molestation of egg-bearing lobsters, which includes removal of the pleopods.

The typical method that illegal importers use to remove eggs from berried lobsters is to remove the pleopods (or swimmerets). Of the 17 countries that export Caribbean spiny lobster to the U.S., only the Bahamas and Belize have laws that prohibit such removal. Hence, the illegal importation of female lobsters that have had their eggs removed by clipping away their pleopods is a problem and would likely increase if Alternative 2 or 3 of Action 1 is implemented because illegal importers would likely substitute larger female lobsters that have had their eggs removed for undersized lobsters.

The bulk of the economic costs of prohibiting the importation of berried Caribbean spiny lobsters or those with their eggs or pleopods removed would be the losses of revenues and profits associated with the illegal importation of female spiny lobsters that have had their eggs stripped off by removing the pleopods and the losses of incomes that derive from such illegal activity. The economic benefits of this prohibition would be improved domestic and foreign revenues, profits and incomes that derive from a biologically and economically improved resource.

7.5.2.2.3 Total Economic Impact of Alternative 2 of Action 2

The bulk of the economic costs of prohibiting the importation of Caribbean spiny lobster meat that is removed from the exoskeleton would be the losses of revenues and profits associated with the illegal importation of both undersized spiny lobsters and those lobsters that have had their eggs removed and the losses of incomes that derive from such illegal activity. Decreases in revenues, profits and incomes earned from presently legal importation of spiny lobster meat separated from the shell would also occur; however, they are anticipated to be substantially lower by comparison to the losses of illegal revenues, profits and incomes generated from illegal operations that remove the meat from the shell.

Similarly, the prohibition against the importation of berried Caribbean spiny lobsters or those with their eggs or pleopods removed is expected to have the greatest impact on illegal operations that would lose revenues and profits generated from the illegal importation of female spiny lobsters that have had their eggs stripped off by removing the pleopods and the losses of incomes that derive from such illegal activity.

The economic combined benefits of this alternative would be improved domestic and foreign revenues, profits and incomes that derive from a biologically and economically improved resource.

7.5.2.3 Alternative 3 of Action 2

This alternative would prohibit the importation of spiny lobster meat without the exoskeleton attached and is identical to part 1 of Alternative 2, which bans the importation of spiny lobster meat without the exoskeleton attached. Consequently, its economic impact is identical to the economic impact described in section 7.5.2.2.1.

7.5.2.4 Alternative 4 of Action 2

This alternative would prohibit the importation of spiny lobster with eggs attached or where the eggs or pleopods (swimmerets) or have been removed or stripped. This alternative is identical to part 2 of Alternative 2. Thus, its economic impact is identical to the economic impact described in section 7.5.2.2.2.

7.5.2.5 Comparison of Economic Costs and Benefits of Alternatives

A summary of the economic costs and benefits of the four alternatives of Action 2 is presented in Table 7.5.2.2.

Table 7.5.2.2 Comparison of Economic Costs and Benefits of Action 2 Alternatives

Action 2: Establish Other Import Restrictions			
Alternative	**Description**	**Economic Cost**	**Economic Benefit**
1	Don't impose other import restrictions	Continues illegal importation of lobsters Supports illegal fishing and overfishing Leads to long-run biological and economic damages	Maintains status quo revenues, profits and incomes from trade
2	No imports of lobster meat detached from shell	Reduces some revenues, profits and incomes from legal trade	Reduces illegal importation of undersized and berried lobsters and those with eggs removed and associated illegal revenues, profits and incomes Discourages illegal fishing and overfishing Increases revenues, profits and incomes in long-run from legal use of resource
	No imports berried lobster or with eggs or pleopods removed	Reduces some revenues, profits and incomes from legal trade	Reduces illegal importation of berried lobsters and those with their eggs removed Discourages illegal fishing and overfishing Increases revenues, profits and incomes in long-run from legal use of resource
3	No imports of lobster meat detached from shell	Reduces some revenues, profits and incomes from legal trade	Reduces illegal importation of undersized and berried lobsters and those with eggs removed and associated illegal revenues, profits and incomes Discourages illegal fishing and overfishing Increases revenues, profits and incomes in long-run from legal use of resource
4	No imports berried lobster or with eggs or pleopods removed	Reduces some revenues, profits and incomes from legal trade	Reduces illegal importation of berried lobsters and those with their eggs removed Discourages illegal fishing and overfishing Increases revenues, profits and incomes in long-run from legal use of resource

7.6 Public and Private Costs of Regulations

The preparation, implementation, enforcement, and monitoring of this or any Federal action involves the expenditure of public and private resources which can be expressed as costs associated with the regulations. Costs associated with this amendment include:

Council costs of document preparation, meetings,
public hearings, and information dissemination $100,000

NOAA Fisheries administrative costs of document
preparation, meetings and review $100,000

Annual law enforcement costs ....$ Less than current costs

7.7 Determination of Significant Regulatory Action

Pursuant to E.O. 12866, a regulation is considered a "significant regulatory action" if it is expected to result in: (1) an annual effect of $100 million or more or adversely affect in a material way the economy, a sector of the economy, productivity, competition, jobs, the environment, public health or safety, or State, local, or tribal governments or communities; (2) create a serious inconsistency or otherwise interfere with an action taken or planned by another agency; (3) materially alter the budgetary impact of entitlements, grants, user fees, or loan programs or the rights or obligations of recipients thereof; or (4) novel legal or policy issues, arising out of legal mandates, the President's priorities or the principles set forth in this executive order. Based on the information above, this regulatory action was determined not to be economically significant because it would not have an annual effect of $100 million or more or adversely affect in a material way the economy or a sector of the economy, productivity, competition, or jobs. However, the action has been determined to be significant for purposes of E.O. 12866 because it may raise novel legal or policy issues in regards to international trade agreements.

8.0 REGULATORY FLEXIBILITY ANALYSIS

8.1 Introduction

The purpose of the Regulatory Flexibility Act (RFA) is to establish a principle of regulatory issuance that agencies shall endeavor, consistent with the objectives of the rule and applicable statutes, to fit regulatory and informational requirements to the scale of businesses, organizations, and governmental jurisdictions subject to regulation. To achieve this principle, agencies are required to solicit and consider flexible regulatory proposals and to explain the rationale for their actions to assure that such proposals are given serious consideration. The RFA does not contain any decision criteria; instead, the purpose of the RFA is to inform the agency, as well as the public, of the expected economic impacts of the alternatives contained in the FMP or amendment (including framework management measures and other regulatory actions) and to ensure that the agency considers alternatives that minimize the expected impacts while meeting the goals and objectives of the FMP and applicable statutes.

With certain exceptions, the RFA requires agencies to conduct a regulatory flexibility analysis for each proposed rule. The regulatory flexibility analysis is designed to assess the impacts various regulatory alternatives would have on small entities, including small businesses, and to determine ways to minimize those impacts. In addition to analyses conducted for the RIR, the initial regulatory flexibility analysis provides: (1) a description of the reasons why action by the agency is being considered; (2) a succinct statement of the objectives of, and legal basis for the proposed rule; (3) an identification, to the extent practicable, of all relevant Federal rules which may duplicate, overlap, or conflict with the proposed rule; (4) a description and, where feasible, an estimate of the number of small entities to which the proposed rule will apply; (5) a description of the projected reporting, record-keeping, and other compliance requirements of the final rule, including an estimate of the classes of small entities which will be subject to the requirements of the report or record; and (6) a description of significant alternatives to the proposed rule which accomplish the stated objectives of applicable statues and which minimize any significant economic impact of the proposed rule on small entities.

8.2 Statement of need for, objectives of, and legal basis for the proposed rule

The purpose and need, issues, problems, and objectives of the proposed Amendment are presented in Section 1.2 and are incorporated herein by reference. According to the Western Central Atlantic Fishery Commission, international trade of legally undersized Caribbean spiny lobster (*Panulirus argus*) is a serious problem. The U.S. is the largest importer of Caribbean spiny lobster and existing laws are insufficient to prevent the importation of lobsters illegally caught and traded. U.S. law enforcement's ability to screen imports for compliance with the Lacey Act is compromised by vague foreign minimum harvest-size and other laws that are intended to protect Caribbean spiny lobster. By implementing uniform importation standards, law enforcement's ability to effectively prevent the importation of undersized, berried lobsters and those with their eggs removed will be improved. This in turn may help protect the species both in the U.S. and in the Caribbean as a whole. These proposed actions are being considered by the National Marine Fisheries Service under the authority of the Magnuson-Stevens Fishery Conservation and Management Act.

8.3 Identification of Federal rules which may duplicate, overlap or conflict with the proposed rule

The Lacey Act, as amended in 1981 (16 USC §§ 3372 et seq.) prohibits the trade of fish, wildlife, or plants taken in violation of any foreign, state, tribal or other U.S. law. For example, it is a violation of the Lacey Act to import Caribbean spiny lobster (CSL) that is in violation of the country of origin's minimum harvest-size standard or other harvesting laws. Many of the countries that harvest CSL have minimum harvest-size standards and other harvest restrictions, some of which are equivalent to or greater than the proposed import standard and restrictions. See Table 7.5.1.6. No federal regulations or other federal laws have been identified that may duplicate, overlap or conflict with the proposed rule. However, Alternative 3 of Action 2 would produce import standards that are inconsistent with legal harvest standards established in Puerto Rico and the U.S. Virgin Islands.

8.4 Description of the projected reporting, record-keeping and other compliance requirements of the proposed rule, including an estimate of the classes of small entities which will be subject to the requirement and the type of professional skills necessary for the preparation of the report or records

The two proposed actions would not impose reporting or record-keeping requirements on any U.S. entity. Alternatives 2 and 3 of Action 1 would establish import-size standards. See Sections 7.5.1.2 and 7.5.1.3 for descriptions. Alternatives 2 through 4 of Action 2 would establish other import restrictions. See Sections 7.5.2.2 through 7.5.2.4 for descriptions.

8.5 Description and estimate of the number of small entities to which the proposed rule will apply

The two proposed actions would affect small businesses that import CSL into the United States from countries: 1) with legal minimum size standards that are less than those proposed in Alternatives 2 or 3 of Action 1 or without such standards and 2) without prohibitions against harvesting female lobsters with eggs, detaching eggs and/or removing pleopods (or swimmerets). It is anticipated that no small governmental jurisdictions or small not-for-profit organizations would be affected by this proposed action.

The following countries and territories have reported harvesting CSL during the period from 1962 through 2003, according to the FAO: Anguilla, Antigua and Barbuda, The Bahamas, Belize, Bermuda, Brazil, British Virgin Islands, Colombia, Costa Rica, Cuba, Dominican Republic, Grenada, Haiti, Honduras, Martinique, Mexico, Grenada, St. Kitts and Nevis, St. Lucia, Saint Vincent and Grenadines, Turks and Caicos, Nicaragua, Puerto Rico, Saint Kitts and Nevis, Trinidad and Tobago, Turks and Caicos Island, U.S., U.S. Virgin Islands, and Venezuela (Bolivarian Republic of). From 2002 through 2007 the following 17 countries that harvest Caribbean spiny lobster were countries of origin of rock lobster imported into the U.S.: Bahamas, Belize, Brazil, Colombia, Costa Rica, Dominican Republic, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Trinidad and Tobago, Turks and Caicos Islands, and Venezuela. See Tables 7.5.1.1 and 7.5.1.2. Caribbean spiny lobster is just one species among those identified as "rock lobster." Rock lobster includes all *Panulirus*, *Palinurus* and *Jasus* species.

Businesses that import CSL into the U.S. are expected to be within the following industries: Fish and Seafood Merchant Wholesalers (NAICS 424460), Fish and Seafood Markets (NAICS 445220), Fish and Frozen Seafood Processing (NAICS 311712), Packaged Frozen Food Merchant Wholesalers (NAICS 424420), and Supermarkets and Other Grocery (Except Convenience) Stores (NAICS 445110). The small business size standards for these industries are presented in Table 8.1 and corresponding 2002 Economic Census figures for the U.S. are presented in Tables 8.2 and 8.3.

Table 8.1. Industries of Small Businesses that Could Be Affected by Proposed Actions

Industry Description	NAICS Code	SBA Size Standard
Fish and Seafood Merchant Wholesalers	424460	100 employees
Fish and Seafood Markets	445220	$6.5 million
Packaged Frozen Food Merchant Wholesalers	424420	100 employees
Fish and Frozen Seafood Processing	311712	500 employees
Supermarkets and Other Grocery (Except Convenience) Stores	445110	$25 million

Table 8.2. Employer Establishments in Industries Likely to Import Caribbean Spiny Lobster for U.S. *Source*: 2002 Economic Census.

NAICS	Paid Employees	Annual Payroll $1000s	Estab.	Sales $1000s
424460	22,476	703,564	2,515	11933,530
445220	9,902	170,428	2,042	1,501,257
424420	94,880	3,607,395	3,629	66,097,512
311712	36,268	923,963	6,06	7,564,091
445110	2,437,750	42,790,166	66,150	395,233,897

In 2005 in Puerto Rico, there was one establishment in NAICS 31171, 13 in NAICS 424420, 6 establishments in NAICS 424460, 975 in NAICS 445110, and 7 in NAICS 445220 (U.S. Census Bureau, County Business Patterns for Puerto Rico). In the U.S. Virgin Islands in 2002, there were 16 employer establishments in NAICS 4244 with annual sales of about $77 million, 43 in NAICS 44511 with combined annual sales of about $204 million, 14 in NAICS 4452 with combined annual sales, and 6 in NAICS 311 of about $0.6 million. See Table 8.3.

Table 8.3 2002 Economic Census of Puerto Rico and U.S. Virgin Islands. *Source*: U.S. Census Bureau, 2002 Economic Census of Island Areas.

NAICS	**Puerto Rico**			**U.S. Virgin Islands**		
	Estab.	Employees	Annual Sales ($1000s)	Estab.	Employees	Annual Sales ($1000s)
311				6	89	6,030
3117	2	A	A			
4244	299	8,112	2.838,221	16	279	77,310
44511	1,053	22,710	3,318,949	43	1,389	204,332
4452	240	1,124	136,026	14	20 - 99	A
44522	7	10	861			

A: Census Bureau did not disclose.

8.5.1 Small Businesses that Could Be Affected by Alternatives 2 and 3

8.5.1.1 Small Businesses that Could Be Affected by Part A of Alt. 2

No legal imports from the following 7 countries of origin should be affected by Part A of Alternative 2 of Action 1 because of their size standards: Bahamas, Colombia, Dominican Republic, Honduras, Turks and Caicos Islands, Nicaragua, and Venezuela. See Section 7.5.1.2.1.

This action should affect more illegal importers of CSL than legal importers; however, some legal imports from Belize, Brazil, Costa Rica, Guatemala, Guyana, Haiti, Jamaica, Mexico, Panama, and Trinidad and Tobago could be affected by Part A of Alternative 2 of Action 1. In the past 6 years, Guyana and Trinidad and Tobago have been the country of origin only once and there have been no imports of rock lobster from these countries since 2004.

Florida law prohibits the possession of CSL that does not meet the size standards equivalent to Part A of this alternative. It is presumed for this initial analysis that imports of CSL that have entered and continue to enter the country at a Florida port come into possession in Florida and, therefore, already comply with Florida size requirements and the requirements that would be established by Part A. However, if any historical imports of spiny lobster remained within U.S. Customs jurisdiction until shipped out of a Florida port and did not come into possession in Florida, those imported spiny lobsters were not required to be in compliance with Florida size standards. Consequently, some of those past imports of CSL may not have satisfied the requirements being proposed in Part A. Therefore, the NMFS encourages any small businesses that imported and/or presently import spiny lobster through a Florida port to comment on the assumption that Caribbean spiny lobster imports that entered and continue to enter the country at a Florida port come to be possessed in Florida. All rock lobster imports from Haiti and Guatemala historically have entered at a Florida port, and therefore, this analysis presumes no legal imports of spiny lobster from Haiti or Guatemala would be affected by this alternative. Imports of rock lobster from Belize, Brazil, Costa Rica, Jamaica, Mexico and Panama enter the U.S. at both Florida and non-Florida ports. About 98 percent of the pounds and total dollar value of rock lobster annually imported from Jamaica enter at a Florida port. See Table 7.5.1.7. These rock lobster imports include all *Palinurus* species, *Panulirus* species and *Jasus* species.

Most rock lobster imports originate from Brazil. A preliminary review of 2006 through 2007 imports of frozen rock lobster from Brazil showed 17 different businesses that imported rock lobster from that country into the United States. Of those businesses, 3 were identified as being owned by a corporation or headquartered in a foreign country and at least 7 are not small businesses. Thus, it is initially concluded that at most 7 small businesses that import rock lobster from Brazil could be affected by the proposed action. At least 89 percent of the imports of rock lobster, however, are brought into the U.S. by foreign corporations and large businesses.

Small businesses indirectly affected would be those in Florida who benefit directly and indirectly from commercial and recreational harvest of Caribbean spiny lobster and are dependent upon the sustainability of the resource. See Section 5.3.7.

U.S. Customs data shows there were no imports of rock lobster (frozen or not) into the U.S. Virgin Islands from 2001 through 2007 and it is anticipated that few to zero imports and importers of rock lobster into the U.S. Virgin Islands would be affected by the alternative actions under consideration.

8.5.1.2 Small Businesses that Could Be Affected by Part B of Alt. 2

No legal imports of Caribbean spiny lobster into Puerto Rico or the U.S. Virgin Islands are expected to be affected by this Part B. See Section 7.5.1.2.2. Hence, no small businesses are expected to be affected by Part B of this alternative.

8.5.2 Small Businesses that Could Be Affected by Alternative 3

This alternative would: (1) directly and indirectly affect the same small businesses and have the same economic impact as Part A of Alternative 2 as described in Section 8.5.1.1 and (2) directly affect small businesses that import Caribbean spiny lobster into Puerto Rico and the U.S. Virgin Islands and indirectly small businesses that harvest and benefit from the harvest of Caribbean spiny lobster in Puerto Rico and the U.S. Virgin Islands. The impact on small businesses that import CSL into the two territories could be beneficial by increasing the allowed imports into the territories; however, the import standards would contradict existing laws in Puerto Rico and the U.S. Virgin Islands and could encourage overfishing of spiny lobster in territorial waters and illegal harvest in those waters, which would have an indirect and adverse impact small lobster fishing businesses. See Section 7.5.1.3.

8.5.3 Small Businesses that Could Be Affected by Alternatives 2 - 4

8.5.3.1 Small Businesses that Could Be Affected by Alternative 2

One method that illegal importers have used and continue to use to avoid detection is to remove the meat from the exoskeletons of undersized and berried spiny lobsters and then package the meat in chunks. This alternative would eliminate such illegal imports. It would also prohibit any currently legal imports of Caribbean spiny lobster meat that has been removed from the shell. Preliminary information suggests the ban on imports of lobster meat that has been extracted from the shell would have the greatest impact on illegal, not legal, trade. Most imported spiny lobster meat has the exoskeleton attached and would not be affected by this alternative; however, small businesses that import meat of the Caribbean spiny lobster that is separated from the shell would be directly affected by this alternative. See Section 7.5.2.2. Small businesses that exploit the resource or those that do business with those that do would benefit in the long-run by the improved status of the species.

From 2002 through 2007, rock lobster imports have originated from the following 17 countries that harvest Caribbean spiny lobster: The Bahamas, Belize, Brazil, Colombia, Costa Rica, Dominican Republic, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Turks and Caicos Islands, Trinidad and Tobago, and Venezuela. See Tables 7.5.1.1 and 7.5.1.2. Of these 17 countries, Guatemala, Guyana, and Trinidad and Tobago do not have laws that prohibit the harvest of spiny lobsters with eggs or removal of eggs. See Table 7.5.2.1. Combined rock lobster imports from these three countries represent $183,000 (about 0.05 percent) of $356 million of frozen imports and $9,000 (about 0.3 percent) of the $2.9 million of non-frozen imports. Panama has a law that prohibits the harvest of berried lobsters, but may not prohibit the removal of eggs. Imports of rock lobster from Panama represent about 0.7 percent of frozen rock lobster imports and none of the non-frozen imports. Therefore, this alternative may directly affect small businesses that import spiny lobster from Guatemala, Guyana, Panama, and Trinidad and Tobago by causing them to import fewer lobsters. However, the long-run improvement of the status of the species would generate beneficial economic impacts to those small businesses that directly and indirectly benefit from exploitation of the resource.

8.5.3.2 Small Businesses that Could Be Affected by Alternative 3

This alternative prohibits the importation of spiny lobster meat that is not attached to the exoskeleton. As stated previously, most spiny lobster imports have been meat within the shell; however, small businesses that import meat of the Caribbean spiny lobster that is separated from the shell would be affected by this alternative. See Section 7.2.2.2.2 and first paragraph of 8.5.3.1.

8.5.3.3 Small Businesses that Could Be Affected by Alternative 4

This alternative prohibits the importation of female lobsters with eggs attached and lobsters with either eggs or pleopods (or swimmerets) removed. See second paragraph of Section 8.5.3.1.

8.6 Substantial number of small entities criterion

The two actions being considered are not expected to affect a substantial number of small businesses each year. These actions are designed to significantly reduce illegal trade of Caribbean spiny lobster and the bulk of the adverse economic impacts are expected to affect illegal, not legal, importers of the lobster.

8.7 Significant economic impact criterion

The outcome of "significant economic impact" can be ascertained by examining two issues: disproportionality and profitability.

Disproportionality: Do the regulations place a substantial number of small entities at a significant competitive disadvantage to large entities?

Profitability: Do the regulations significantly reduce profit for a substantial number of small entities?

The two proposed actions are not expected to generate a significant adverse economic impact on small businesses that legally import Caribbean spiny lobster. It is expected that a substantial majority of currently legal imported lobster would not be affected. The purposes of the actions are to: 1) improve the detection of illegally traded Caribbean spiny lobsters and prosecution of those engaged in the illegal trade and 2) reduce the costs of such detection and legal action.

The National Marine Fisheries Service encourages small businesses to comment on any of the potential economic impacts of the two actions and their alternatives under consideration in this section and other sections of this document.

8.8 Description of significant alternatives

The two proposed actions are not expected to have a significant adverse economic impact on a substantial number of small entities that import Caribbean spiny lobster, either separately or in combination. Consequently, no significant alternatives, as defined by the RFA, have been considered; however, discussion of the expected impacts of the alternatives considered for each of the two actions as required by E.O. 12866 is contained in Section 7.

9.0 OTHER APPLICABLE LAWS

The MSFCMA (16 U.S.C. 1801 et seq.) provides the authority for U.S. fishery management. But fishery management decision-making is also affected by a number of other federal statutes designed to protect the biological and human components of U.S. fisheries, as well as the ecosystems within which those fisheries are conducted. Major laws affecting federal fishery management decision making are summarized below.

9.1 Administrative Procedures Act

All federal rulemaking is governed under the provisions of the Administrative Procedure Act (APA) (5 U.S.C. Subchapter II), which establishes a "notice and comment" procedure to enable public participation in the rulemaking process. Under the APA, NOAA Fisheries is required to publish notification of proposed rules in the *Federal Register* and to solicit, consider and respond to public comment on those rules before they are finalized. The APA also establishes a 30-day wait period from the time a final rule is published until it takes effect.

9.2 Coastal Zone Management Act

The Coastal Zone Management Act (CZMA) of 1972 (16 U.S.C. 1451 et seq.) encourages state and federal cooperation in the development of plans that manage the use of natural coastal habitats, as well as the fish and wildlife those habitats support. When proposing an action determined to directly affect coastal resources managed under an approved coastal zone management program, NOAA Fisheries is required to provide the relevant state agency with a determination that the proposed action is consistent with the enforceable policies of the approved program to the maximum extent practicable at least 90 days before taking final action.

9.3 Information Quality Act

The Data Quality Act (DQA) (Public Law 106-443), which took effect October 1, 2002, requires the government for the first time to set standards for the quality of scientific information and statistics used and disseminated by federal agencies. Information includes any communication or representation of knowledge such as facts or data, in any medium or form, including textual, numerical, cartographic, narrative, or audiovisual forms (includes web dissemination, but not hyperlinks to information that others disseminate; does not include clearly stated opinions).

Specifically, the Act directs the Office of Management and Budget (OMB) to issue government wide guidelines that "provide policy and procedural guidance to federal agencies for ensuring and maximizing the quality, objectivity, utility, and integrity of information disseminated by federal agencies." Such guidelines have been issued, directing all federal agencies to create and issue agency-specific standards to 1) ensure Information Quality and develop a pre-dissemination review process; 2) establish administrative mechanisms allowing affected persons to seek and obtain correction of information; and 3) report periodically to OMB on the number and nature of complaints received.

Scientific information and data are key components of FMPs and amendments and the use of best available information is the second national standard under the MSFCMA. To be consistent with the Act, FMPs and amendments must be based on the best information available, properly reference all supporting materials and data, and should be reviewed by technically competent individuals. With respect to original data generated for FMPs and amendments, it is important to ensure that the data are collected according to documented procedures or in a manner that reflects standard practices accepted by the relevant scientific and technical communities. Data should also undergo quality control prior to being used by the agency.

9.4 Endangered Species Act

The Endangered Species Act (ESA) of 1973 (16 U.S.C. Section 1531 et seq.) requires that federal agencies use their authorities to conserve endangered and threatened species, and that they ensure actions they authorize, fund, or carry out are not likely to harm the continued existence of those species or the habitat designated to be critical to their survival and recovery. The ESA requires NOAA Fisheries, when proposing a fishery action that "may affect" critical habitat or endangered or threatened species, to consult with the appropriate administrative agency (itself for most marine species, the U.S. Fish and Wildlife Service for all remaining species) to determine the potential impacts of the proposed action. Consultations are concluded informally when proposed actions "may affect but are not likely to adversely affect" endangered or threatened species or designated critical habitat. Formal consultations, resulting in a biological opinion, are required when proposed actions may affect and are "likely to adversely affect" endangered or threatened species or designated critical habitat. If jeopardy or adverse modification is found, the consulting agency is required to suggest reasonable and prudent alternatives.

On April 28, 1989, NOAA Fisheries Southeast Region (SERO) completed a formal consultation, including a Biological Opinion (Opinion), on the effects of commercial fishing activities in the Southeast Region on threatened and endangered species. The Opinion concluded that the Gulf of Mexico and South Atlantic spiny lobster fishery was likely to adversely affect, but not jeopardize the continued existence of ESA-listed sea turtles. Subsequent, informal consultations on the continued authorization of the fishery determined it was not likely to adversely affect ESA-listed species. The impacts of the Caribbean spiny lobster fishery on ESA-listed species were last evaluated in a formal consultation, concluded on May 19, 2005. The opinion concluded that Caribbean spiny lobster fishing was likely to adversely affect, but not jeopardize the continued existence of ESA-listed sea turtles.

As provided in 50 CFR 402.16, reinitiation of formal consultation is required when discretionary involvement or control over the action has been retained (or is authorized by law) and: (1) the amount or extent of the incidental take is exceeded; (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not previously considered; (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not previously considered; or (4) if a new species is listed or critical habitat designated that may be affected by the identified action.

Since the completion of the most recent formal consultations on these fisheries, two species of *Acropora* coral have been listed under the ESA, and may be affected by spiny lobster fishing. Additionally, new information is available revealing effects of the action that may affect listed species or critical habitat in a manner or to an extent not previously considered. Accordingly, NOAA Fisheries Office of Sustainable Fisheries has requested initiation of a Section 7 consultation with the SERO's Protected Resources Division for this amendment. NOAA Fisheries anticipates completion of the consultations on the Gulf of Mexico/South Atlantic and Caribbean spiny lobster fisheries prior to Secretarial review and approval of the fishery plan amendments for the spiny lobster fisheries.

9.5 Rivers and Harbors Act of 1899

The Rivers and Harbors Act was created in 1899 to prevent navigable waters of the United States from being obstructed. Section 10 of the Act requires that anyone wishing to dredge, fill, or build a structure in any navigable water and associated wetlands obtain a permit from the ACOE. An activity affecting wetlands may require a Section 404 and Section 10 permit, thus both sections are often included together in a permit notice. When these activities are permitted, and there is direct loss of submerged habitat, such as seagrasses, then mitigation is often required to compensate for this loss.

9.6 Clean Water Act

In 1972, Congress passed the Clean Water Act (CWA) - also known as the Water Pollution Prevention and Control Act - to protect the quality of the nation's waterways including oceans, lakes, rivers and streams, aquifers, coastal areas, and aquatic resources. The law sets out broad rules for protecting the waters of the United States; Sections 404 and 401 apply directly to waters and aquatic resources protection.

Section 404 of the Clean Water Act (often referred to as "Section 404" or simply "404") forbids the unpermitted "discharge of dredge or fill material" into waters of the United States. Section 404 does not regulate every activity in aquatic resources or coastal areas, but requires anyone seeking to fill any area to first obtain a permit from the Army Corps of Engineers (ACOE). Constructing bridges, causeways, piers, port expansion, or any other construction or development activity along a waterway or in aquatic resources generally requires a 404 permit. When a fill project is permitted, there may be mitigation required to replace lost aquatic resources.

Section 401 of the Clean Water Act requires that an applicant for a Section 404 permit obtain a certificate from their state's environmental regulatory agency (if the state has delegated such authority to the agency) that the activity will not negatively impact water quality. This permit process is supposed to prevent the discharge of pollutants (pesticides, heavy metals, hydrocarbons) or sediments into waters, which may be above acceptable levels, because decreased water quality may endanger the health of the people, fish, and wildlife. However, acceptable pollutant levels have not been established for many aquatic resources, which make it difficult for state agencies to fully assess a project's impact on water quality.

9.7 National Marine Sanctuaries Act

Under the National Marine Sanctuaries Act (NMSA) (also known as Title III of the Marine Protection, Research and Sanctuaries Act of 1972), as amended, the Secretary of Commerce is authorized to designate National Marine Sanctuaries to protect distinctive natural and cultural resources whose protection and beneficial use requires comprehensive planning and management. The National Marine Sanctuaries are administered by NOAA's National Ocean Service. The Act provides authority for comprehensive and coordinated conservation and management of these marine areas. The National Marine Sanctuary System currently comprises 13 sanctuaries around the country, including sites in American Samoa and Hawaii. These sites include significant coral reef and kelp forest habitats, and breeding and feeding grounds of whales, sea lions, sharks, and sea turtles. A complete listing of the current sanctuaries and information about their location, size, characteristics, and affected fisheries can be found at http://www.sanctuaries.nos.noaa.gov/oms/oms.html.

9.8 Fish and Wildlife Coordination Act

The Fish and Wildlife Coordination Act protects the quality of the aquatic environment needed for fish and wildlife resources. The Act requires consultation with the Fish and Wildlife Service and the fish and wildlife agencies of States where the "waters of any stream or other body of water are proposed or authorized, permitted or licensed to be impounded, diverted . . . or otherwise controlled or modified" by any agency (except TVA) under a Federal permit or license. NOAA Fisheries was brought into the process later, as these responsibilities were carried over, during the reorganization process that created NOAA. Consultation is to be undertaken for the purpose of "preventing loss of and damage to wildlife resources", and to ensure that the environmental value of a body of water or wetland is taken into account in the decision-making process during permit application reviews. Consultation is most often (but not exclusively) initiated when water resource agencies send the FWS or NOAA Fisheries a public notice of a Section 404 permit. FWS or NOAA Fisheries may file comments on the permit stating concerns about the negative impact the activity will have on the environment, and suggest measures to reduce the impact.

9.9 Executive Orders

9.9.1 E.O. 12114: Environmental Assessment of Actions Abroad

The purpose of this Executive Order is to enable responsible officials of Federal agencies having ultimate responsibility for authorizing and approving actions encompassed by this Order to be informed of pertinent environmental considerations and to take such considerations into account, with other pertinent considerations of national policy, in making decisions regarding such actions. While based on independent authority, this Order furthers the purpose of the National Environmental Policy Act and the Marine Protection Research and Sanctuaries Act and the Deepwater Port Act consistent with the foreign policy and national security policy of the United States, and represents the United States government's exclusive and complete determination of the procedural and other actions to be taken by Federal agencies to further the purpose of the National Environmental Policy Act, with respect to the environment outside the United States, its territories and possessions.

Agencies in their procedures shall establish procedures by which their officers having ultimate responsibility for authority and approving actions in one of the following categories encompassed by this Order, take into consideration in making decisions concerning such actions, a document described in Section 2-4(a):
(a) major Federal actions significantly affecting the environment of the global commons outside the jurisdiction of any nation (e.g., the oceans or Antarctica);
(b) major Federal actions significantly affecting the environment of a foreign nation not participating with the United States and not otherwise involved in the action;

(c) major Federal actions significantly affecting the environment of a foreign nation which provide to that nation:

> (1) a product, or physical project producing a principal product or an emission or effluent, which is prohibited or strictly regulated by Federal law in the United States because its toxic effects on the environment create a serious public health risk; or
>
> (2) a physical project which in the United States is prohibited or strictly regulated by Federal law to protect the environment against radioactive substances.

(d) major Federal actions outside the United States, its territories and possessions which significantly affect natural or ecological resources of global importance designated for protection under this subsection by the President, or, in the case of such a resource protected by international agreement binding on the United States, by the Secretary of State. Recommendations to the President under this subsection shall be accompanied by the views of the Council on Environmental Quality and the Secretary of State.

The purpose of this amendment/EIS is to increase the spawning biomass of the spiny lobster population in the waters of the Caribbean and tropical western Atlantic (the oceans). It has been determined in section 6 there will be significant biological affects in a positive form; and as indicated numerous times throughout the document, the restrictions considered in this document were developed in accordance with a number of international agreements and accords passed by foreign nations.

9.9.2 E.O. 12866: Regulatory Planning and Review

Executive Order 12866: Regulatory Planning and Review, signed in 1993, requires federal agencies to assess the costs and benefits of their proposed regulations, including distributional impacts, and to select alternatives that maximize net benefits to society. To comply with E.O. 12866, NOAA Fisheries prepares a Regulatory Impact Review (RIR) for all fishery regulatory actions that either implement a new fishery management plan or significantly amend an existing plan. RIRs provide a comprehensive analysis of the costs and benefits to society associated with proposed regulatory actions, the problems and policy objectives prompting the regulatory proposals, and the major alternatives that could be used to solve the problems. The reviews also serve as the basis for the agency's determinations as to whether proposed regulations are a "significant regulatory action" under the criteria provided in E.O. 12866 and whether proposed regulations will have a significant economic impact on a substantial number of small entities in compliance with the RFA. A regulation is significant if it is likely to result in an annual effect on the economy of at least $100,000,000 or has other major economic effects.

9.9.3 E.O. 12630: Takings

The Executive Order on Government Actions and Interference with Constitutionally Protected Property Rights, which became effective March 18, 1988, requires that each federal agency prepare a Takings Implication Assessment for any of its administrative, regulatory, and legislative policies and actions that affect, or may affect, the use of any real or personal property. Clearance of a regulatory action must include a takings statement and, if appropriate, a Takings Implication Assessment. Management measures limiting fishing seasons, areas, quotas, fish size limits, and bag limits do not appear to have any taking implications. There is a takings implication if a fishing gear is prohibited, because fishermen who desire to leave a fishery might be unable to sell their investment, or if a fisherman is prohibited by federal action from exercising property rights granted by a state.

9.9.4 E.O. 13089: Coral Reef Protection

The Executive Order on Coral Reef Protection (June 11, 1998) requires federal agencies whose actions may affect U.S. coral reef ecosystems to identify those actions, utilize their programs and authorities to protect and enhance the conditions of such ecosystems; and, to the extent permitted by law, ensure that actions they authorize, fund or carry out not degrade the condition of that ecosystem. By definition, a U.S. coral reef ecosystem means those species, habitats, and other national resources associated with coral reefs in all maritime areas and zones subject to the jurisdiction or control of the United States (e.g., federal, state, territorial, or commonwealth waters).

9.9.5 E.O. 13112: Invasive Species

The Executive Order requires agencies to use authorities to prevent introduction of invasive species, respond to and control invasions in a cost effective and environmentally sound manner, and to provide for restoration of native species and habitat conditions in ecosystems that have been invaded. Further, agencies shall not authorize, fund, or carry out actions that are likely to cause or promote the introduction or spread of invasive species in the U.S. or elsewhere unless a determination is made that the benefits of such actions clearly outweigh the potential harm; and that all feasible and prudent measures to minimize the risk of harm will be taken in conjunction with the actions. The actions undertaken in this amendment will not introduce, authorize, fund, or carry out actions that are likely to cause or promote the introduction or spread of invasive species in the U.S. or elsewhere.

9.9.6 E.O. 13132: Federalism

The Executive Order on federalism requires agencies in formulating and implementing policies that have federalism implications, to be guided by the fundamental federalism principles. The Order serves to guarantee the division of governmental responsibilities between the national government and the states that was intended by the framers of the Constitution. Federalism is rooted in the belief that issues that are not national in scope or significance are most appropriately addressed by the level of government closest to the people. This Order is relevant to FMPs and amendment given the overlapping authorities of NOAA Fisheries, the states, and local authorities in managing coastal resources, including fisheries, an the need for a clear definition of responsibilities. It is important to recognize those components of the ecosystem over which fishery managers have no direct control and to develop strategies to address them in conjunction with appropriate state, tribes and local entities (international too). The proposed management measures in this Amendment to the Spiny Lobster FMPs of the Caribbean and the South Atlantic/Gulf of Mexico have been developed with the local, federal and international officials.

9.9.7 E.O. 13141: Environmental Review of Trade Agreements

This Executive Order requires the U.S. Trade Representative, through the interagency Trade Policy Staff to conduct environmental reviews of three of the most common agreements: comprehensive multilateral trade rounds, bilateral or multilateral free-trade agreements, and major new trade liberalization agreements in natural resource sectors. Although the procedures for environmental impact assessment in Executive Order 13141 are not subject to NEPA, they follow similar guidelines. Understanding the importance of this E.O. in relation to this Amendment/EIS, NOAA Fisheries Service has made a concerted effort to involve the USTR and other agencies involved with trade negotiations to inform them of the intention of the actions being undertaken by the Councils and NOAA Fisheries Service.

9.9.8 E.O. 13158: Marine Protected Areas

Executive Order 13158 (May 26, 2000) requires federal agencies to consider whether their proposed action(s) will affect any area of the marine environment that has been reserved by federal, state, territorial, tribal, or local laws or regulations to provide lasting protection for part or all of the natural or cultural resource within the protected area.

9.9.9 E.O. 12898: Environmental Justice

This Executive Order mandates that each Federal agency shall make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations in the United States and its territories and possessions. Federal agency responsibilities under this Executive Order include conducting their programs, policies, and activities that substantially affect human health or the environment, in a manner that ensures that such programs, policies, and activities do not have the effect of excluding persons from participation in, denying persons the benefit of, or subjecting persons to discrimination under, such, programs policies, and activities, because of their race, color, or national origin. Furthermore, each federal agency responsibility set forth under this Executive Order shall apply equally to Native American programs.

Specifically, federal agencies shall, to the maximum extent practicable; conduct human health and environmental research and analysis; collect human health and environmental data; collect, maintain and analyze information on the consumption patterns of those who principally rely on fish and/or wildlife for subsistence; allow for public participation and access to information relating to the incorporation of environmental justice principals in Federal agency programs or policies; and share information and eliminate unnecessary duplication of efforts through the use of existing data systems and cooperative agreements among Federal agencies and with State, local, and tribal governments. The proposed actions would be applied to all participants in the fishery, regardless of their race, color, national origin, or income level, and as a result are not considered discriminatory. Additionally, none of the proposed actions are expected to affect any existing subsistence consumption patterns. Therefore, no environmental justice issues are anticipated and no modifications to any proposed actions have been made to address environmental justice issues.

9.10 Marine Mammal Protection Act

The MMPA established a moratorium, with certain exceptions, on the taking of marine mammals in U.S. waters and by U.S. citizens on the high seas. It also prohibits the importing of marine mammals and marine mammal products into the United States. Under the MMPA, the Secretary of Commerce (authority delegated to NOAA Fisheries) is responsible for the conservation and management of cetaceans and pinnipeds (other than walruses). The Secretary of the Interior is responsible for walruses, sea otters, polar bears, manatees, and dugongs.

In 1994, Congress amended the MMPA, to govern the taking of marine mammals incidental to commercial fishing operations. This amendment required the preparation of stock assessments for all marine mammal stocks in waters under U.S. jurisdiction; development and implementation of take-reduction plans for stocks that may be reduced or are being maintained below their optimum sustainable population levels due to interactions with commercial fisheries; and studies of pinniped-fishery interactions. The MMPA requires a commercial fishery to be placed in one of three categories, based on the relative frequency of incidental serious injuries and mortalities of marine mammals. Category I designates fisheries with frequent serious injuries and mortalities incidental to commercial fishing; Category II designates fisheries with occasional serious injuries and mortalities; Category III designates fisheries with a remote likelihood or no known serious injuries or mortalities. To legally fish in a Category I and/or II fishery, a fisherman must obtain a marine mammal authorization certificate by registering with the Marine Mammal Authorization Program (50 CFR 229.4) and accommodate an observer if requested (50 CFR 229.7(c)) and they must comply with any applicable take reduction plans.

The Caribbean spiny lobster trap/pot and Florida spiny lobster trap/pot fisheries are listed as part of a Category III fishery (72 FR 66048; November 27, 2007) because there has only been one documented interaction between these gears and marine mammals.

9.11 Paperwork Reduction Act

The Paperwork Reduction Act (PRA) of 1995 (44 U.S.C. 3501 et seq.) regulates the collection of public information by federal agencies to ensure that the public is not overburdened with information requests, that the federal government's information collection procedures are efficient, and that federal agencies adhere to appropriate rules governing the confidentiality of such information. The PRA requires NOAA Fisheries to obtain approval from the Office of Management and Budget before requesting most types of fishery information from the public. This action contains no PRA requirements.

9.12 Small Business Act

The Small Business Act of 1953, as amended, Section 8(a), 15 U.S.C. 634(b)(6), 636(j), 637(a) and (d); Public Laws 95-507 and 99-661, Section 1207; and Public Laws 100-656 and 101-37 are administered by the SBA. The objectives of the act are to foster business ownership by individuals who are both socially and economically disadvantaged; and to promote the competitive viability of such firms by providing business development assistance including, but not limited to, management and technical assistance, access to capital and other forms of financial assistance, business training and counseling, and access to sole source and limited competition federal contract opportunities, to help the firms to achieve competitive viability. Because most businesses associated with fishing are considered small businesses, NMFS, in implementing regulations, must make an assessment of how those regulations will affect small businesses. Implications to small businesses are discussed in the RIR herein (Section 7).

9.13 Magnuson-Stevens Act Essential Fish Habitat Provisions

The Magnuson-Stevens Act includes EFH requirements, and as such, each existing, and any new, FMPs must describe and identify EFH for the fishery, minimize to the extent practicable adverse effects on that EFH caused by fishing, and identify other actions to encourage the conservation and enhancement of that EFH. The Council and NMFS have determined there are no adverse effects to EFH in this amendment as discussed in the Environmental Consequences section (Section 6).

9.14 Migratory Bird Treaty Act

Under the Migratory Bird Treaty Act (MBTA), it is unlawful to pursue, hunt, take, capture, kill, possess, trade, or transport any migratory bird, or any part, nest, or egg of a migratory bird, included in treaties between the United States and Great Britain, Mexico, Japan, or the former Union of Soviet Socialists Republics, except as permitted by regulations issued by the Department of the Interior (16 U.S.C. 703-712). Violations of the MBTA carry criminal penalties; any equipment and means of transportation used in activities in violation of the MBTA may be seized by the United States government and, upon conviction, must be forfeited to it. To date, the MBTA has been applied to the territory of the United States and coastal waters extending three miles from shore. Furthermore, Executive Order 13186 (see Section 9.5.9) was issued in 2001, which directs federal agencies, including NOAA Fisheries, to take certain actions to further implement the MBTA.

9.15 National Environmental Policy Act

The National Environmental Policy Act (NEPA) of 1969 (42 U.S.C. 4321 et seq.) requires federal agencies to consider the environmental and social consequences of proposed major actions, as well as alternatives to those actions, and to provide this information for public consideration and comment before selecting a final course of action. Because NOAA Fisheries Service is proposing a major fishery action that may significantly affect the quality of the human environment, NOAA Fisheries Service has prepared this EIS to comply with NEPA and its implementing regulations.

9.16 Regulatory Flexibility Act

The purpose of the Regulatory Flexibility Act (RFA 1980, 5 U.S.C. 601 et seq.) is to ensure that federal agencies consider the economic impact of their regulatory proposals on small entities, analyze effective alternatives that minimize the economic impacts on small entities, and make their analyses available for public comment. The RFA does not seek preferential treatment for small entities, require agencies to adopt regulations that impose the least burden on small entities, or mandate exemptions for small entities.

Rather, it requires agencies to examine public policy issues using an analytical process that identifies, among other things, barriers to small business competitiveness and seeks a level playing field for small entities, not an unfair advantage.

After an agency determines that the RFA applies, it must decide whether to conduct a full regulatory flexibility analysis (IRFA or Final Regulatory Flexibility Analysis) or to certify that the proposed rule will not "have a significant economic impact on a substantial number of small entities. In order to make this determination, the agency conducts a threshold analysis, which has the following 5 parts: 1) Description of small entities regulated by proposed action, which includes the SBA size standard(s), or those approved by the Office of Advocacy, for purposes of the analysis and size variations among these small entities; 2) Descriptions and estimates of the economic impacts of compliance requirements on the small entities, which include reporting and recordkeeping burdens and variations of impacts among size groupings of small entities; 3) Criteria used to determine if the economic impact is significant or not; 4) Criteria used to determine if the number of small entities that experience a significant economic impact is substantial or not; and 5) Descriptions of assumptions and uncertainties, including data used in the analysis. If the threshold analysis indicates that there will not be a significant economic impact on a substantial number of small entities, the agency can so certify.

9.17 Small Business Act

Enacted in 1953, the Small Business Act requires that agencies assist and protect small-business interests to the extent possible to preserve free competitive enterprise.

9.18 Public Law 99-659: Vessel Safety

Public Law 99-659 amended the Magnuson-Stevens Act to require that a FMP or FMP amendment must consider, and may provide for, temporary adjustments (after consultation with the U.S. Coast Guard and persons utilizing the fishery) regarding access to a fishery for vessels that would be otherwise prevented from participating in the fishery because of safety concerns related to weather or to other ocean conditions.

10.0 SOCIAL IMPACT ASSESSMENT REQUIREMENTS AND DATA ISSUES

INTRODUCTION

Mandates to conduct Social Impact Assessments come from both the National Environmental Policy Act (NEPA) and the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act). NEPA requires federal agencies to consider the interactions of natural and human environments by using a "...systematic, interdisciplinary approach which will ensure the integrated use of the natural and social sciences...in planning and decision-making" [NEPA section 102 (2) (a)]. Under the Council on Environmental Quality's (CEQ, 1986) Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act, a clarification of the terms "human environment" expanded the interpretation to include the relationship of people with their natural and physical environment (40 CFR 1508.14). Moreover, agencies need to address the aesthetic, historic, cultural, economic, social, or health effects which may be direct, indirect or cumulative

(Interorganizational Committee on Guidelines and Principles for Social Impact Assessment, 1994).

Recent amendments to the Magnuson-Stevens Act require FMPs address the impacts of any management measures on the participants in the affected fishery and those participants in other fisheries that may be affected directly or indirectly through the inclusion of a fishery impact statement [Magnuson-Stevens Act section 303 (a) (9)]. Most recently, with the addition of National Standard 8, FMPs must now consider the impacts upon fishing communities to the extent practicable to assure their sustained participation and minimize adverse economic impacts upon those communities [Magnuson-Stevens Act section 301 (a) (8)]. Consideration of social impacts is a growing concern as fisheries experience increased participation and/or declines in stocks. With an increasing need for management action, the consequences of such changes need to be examined to minimize the negative impacts experienced by the populations concerned to the extent practicable.

DATA LIMITATIONS AND METHODS

Social impacts are generally the consequences to human populations that follow from some type of public or private action. Those consequences may include alterations to "...the ways in which people live, work or play, relate to one another, organize to meet their needs and generally cope as members of a society..." (Interorganizational Committee on Guidelines and Principles for Social Impact Assessment, 1994:1). In addition, included under this interpretation are cultural impacts that may involve changes in values and beliefs, which affect the way people identify themselves within their occupation, communities and society in general. Social impacts analyses help determine the consequences of policy action in advance by comparing the status quo with the projected impacts. Therefore, it is important that as much information as possible concerning a fishery and its participants be gathered for an assessment.

It is important to identify any foreseeable adverse effects on the human environment. With quantitative data often lacking, qualitative data can be used to provide a rough estimate of some of the impacts based on the best available science. In addition, when there is a body of empirical findings available from the social science literature, it needs to be summarized and referenced in the analyses.

SUMMARY OF SOCIAL IMPACT ASSESSMENT

Descriptions of the affected communities and expected effects of the alternatives considered in this amendment are provided in sections 5 and 6, respectively.

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Phil Steele, NMFS/SERO	ARA, Fishery Biologist	NEPA Review, DEIS

13.0 LIST OF AGENCIES, ORGANIZATIONS, AND PERSONS TO WHOM COPIES OF THE STATEMENT ARE SENT

Department of Commerce Office of General Counsel
Environmental Defense
Florida Fish and Wildlife Conservation Commission
Florida Keys Commercial Fishermen’s Association
National Fisheries Institute
National Marine Fisheries Service Office of General Counsel
National Marine Fisheries Service Office of General Counsel for International Law
National Marine Fisheries Service Office of General Counsel Southeast Region
National Marine Fisheries Service Southeast Regional Office
National Marine Fisheries Service Southeast Fisheries Science Center
National Marine Fisheries Service Silver Spring Office
National Marine Fisheries Service Office of Law Enforcement
Puerto Rico Department of Natural and Environmental Resources
State Department

United States Coast Guard
United States Fish and Wildlife Services
United States Trade Representative
USVI Department of Planning and Natural Resources

14.0 INDEX

APPENDICES

APPENDIX A – Office of Law Enforcement Case Documents
APPENDIX B – Scoping Comments
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APPENDIX D – Response to DEIS Comments

APPENDIX A – OFFICE OF LAW ENFORCEMENT CASE DOCUMENTS

MACRO SEAFOODS INC.
SEAFOOD EXPERIENCE SINCE 1971.

)O N.W. 77TH AVE,
SUITE 26
HIALEAH GARDENS FL 33016

TEL: (305) 827-5001
FAX:(305)827-5003
E-MAIL: SHAINDELE@AOL.COM

AUGUST 15, 2000

The seller admits to shipping 3 oz tails, then follows that statement up with the crackdown on under 5 oz tails (which are all illegal tails), but offers a solution to continue the trade in illegal size tails

ACE,

SHIPMENT LEAVING WEDNESDAY FROM NICA WITH APPROX 2800 LBS OF 3 OZ

THEY HAVE CLOSED DOWN THE BUYING OFFICES AT THE WHARF AS THERE IS ALOT OF PRESSURE (FOR NOW) ON UNDER 5 OZ, SO I EXPECT THIS BUSINESS WILL HAVE TO COME RECTLY FROM KEYS AND NOT THRU NORMAL SELLERS, THIS SIZE WILL BECOME ARCER.

INSURANCE: RECEIVED CALL THAT PROBABLITY OF PUTTING THE PACKAGE YOU REQUESTED IS LOOKING GOOD AND I MAY HAVE CALL THIS AFTERNOON.

P.

MACRO SEAFOODS INC.

SEAFOOD EXPERIENCE SINCE 1971.

O N.W. 77TH AVE,
SUITE 26
HIALEAH GARDENS FL 33016

TEL: (305) 827-5001
FAX:(305)827-5003
E-MAIL: SHAINDELE@AOL.COM

AUGUST 16/00

ACE,

APPROX 800-900 LBS OF LOBSTER MEAT FROM NICA DUE TO ARRIVE ON SAME BOAT AS 3 OZ

PRICE $8.75/LB

CAN YOU SELL THIS ? YES

LET ME KNOW

PETER

The buyer is notified their illegal 3 oz lobster tails are on the way with an inquiry as to whether they could sell lobster "meat." This is important because it is the beginning of the "meat" sale and seems to coincide exactly with the information concerning the crackdown on tails under 5 oz., again another way to continue with illegal business as usual

MACRO SEAFOODS INC.

SEAFOOD EXPERIENCE SINCE 1971

9500 N.W. 77TH AVE,SUITE 26
HIALEAH GARDENS, FL 33016

TEL: 305-827-5001
FAX ; 305=827-5003

SOLD TO ; **NEPTUNE FISHERIES INC.**
5714 CURLEW DRIVE
NORFOLK VA 23502

AUGUST 18, 2000

INVOICE # 2103

CASES	SIZE	NET WT.	LOBSTER TAILS	PRICE PER LB/UB DISCOUNTED	AMOUNT
65 CS	3 OZ	2600 LBS	FROZEN IQF MARAZUL BRAND	$10.90	$28,340.00
16 CS		640 LBS	LOBSTER MEAT NICA BRAND	$8.75	$ 5,600.00

Lobster meat shows up on the invoice along with the 3 oz tails. This invoice shows the sale of 3,240 lbs of illegal, undersized lobster

PRODUCT OF NICARAGUA

AMOUNT $ 33,940.00

NO OF CASES: 81

SENT "IN BOND" VIA BESTWAY TRANSPORT FROM MIAMI

APPENDIX B – SUMMARY OF SCOPING COMMENTS

SPINY LOBSTER SCOPING – ISLAMORADA, FL
JANUARY 24, 2008
DRAFT SUMMARY NOTES:

Mr. Eugenio Pineiro, Chairman of the Caribbean Council, read the chairman's statement on behalf of the Caribbean, Gulf, and South Atlantic Fishery Management Councils. Other members of the scoping meeting board were as follows: Tony Iarocci, chair of the South Atlantic Council's spiny lobster committee; Miguel Rolon, Executive Director of the Caribbean Council; Gregg Waugh, Deputy Executive Director of the South Atlantic council; Joe Kimmel, NMFS SERO; and Diana Martino, Caribbean council staff.

There were 9 members of the public present.

Gregg Waugh presented an overview of the scoping document and issues under consideration.

Karl Lessard – reviewed the Gulf Council's Spiny Lobster AP position: the AP supported Approach 1.

Gary Graves – Keys Fisheries, Marathon, Florida. Industry in his area support Approach 1; they also support prohibiting scrubbing tails, possession of berried lobsters, etc. They are concerned about using tail weight; fishermen can measure length on a boat but not weight. Fishermen may bring lobsters in that can't be exported because they don't meet the minimum size limit. They support 5.5" tail length for imports from the whole Caribbean. He distributed a sheet with information on production from his plant for tails that measure 5.5" and their weight; tails from shedding/molting lobsters may not weigh as much.

Bruce Irwin – member of South Atlantic Council Spiny Lobster AP. He thanked the CFMC for taking the initiative to address this issue to protect the stock of lobster. He supports Approach 1 with one point of concern about the weight as mentioned by Gary Graves.

Scot Zimmerman – FL Keys Commercial Fishermen's Association. We will be submitting written comments. Generally support the Councils' efforts to address imports. Support Approach 1. Concerned about a decline in landings in Florida and feel it is due to harvest of small lobsters in the Caribbean area. Mentioned a concern about the collection of wild juveniles for grow-out and potential impacts on the lobster stock.

Tom Hill – Key Largo Fisheries and a member of SFA. Support Approach 1. He is concerned about using weight because it changes with the size of tail due to molting, etc.

Tom Mathews – mentioned the concern of Paul Raymond (NMFS Law Enforcement) to consider the tail weight to aid enforcement. Writing the regulations as an import rule would address the concerns of industry because the tail weight requirement would only

apply to imports. A number of Caribbean countries have a voluntary (memorandum of agreement) 4.5 – 5.4 ounce tail size rule (ESPESKA) and this is what the countries want to see as an import regulation. Weight is important for tracking imports; this is very important for law enforcement and for making legal cases.
The scoping meeting ended at 7 p.m.

APPROACH 1 FROM THE SCOPING DOCUMENT

Approach 1 would be to prohibit imports smaller than the existing U.S. minimum size limits. For example, no one in the Continental U.S. would be allowed to import a Caribbean spiny lobster (Panulirus argus):

1. Less than 3.0 inches (7.62 cm) carapace length if the animal is whole.
2. Less than 5.5 inches (13.97 cm) tail length if only the tail is present.
3. Less than 5 ounces if want a tail weight (e.g., 4.2 – 5.4 ounces).

For Puerto Rico and the U.S. Virgin Islands, no one would be allowed to import a Caribbean spiny lobster (Panulirus argus):

1. Less than 3.5 inches (8.89 cm) carapace length if the animal is whole.
2. Less than 6.2 inches (15.75 cm) tail length if only the tail is present.
3. Less than 5.9 ounces if want a tail weight (need to specify what 5.9 or 6 ounces means in the industry).

CARIBBEAN FISHERY MANAGEMENT COUNCIL
268 Muñoz Rivera Ave.
Suite 1108
San Juan PR 00918-1920
Scoping Meetings
Summary
October 10, 2007

The Caribbean Fishery Management Council is requesting public comment on the following issues:
Queen Conch: Management alternatives for the queen conch fishery in the exclusive economic zone (EEZ) off St. Croix, USVI. The EEZ off Lang Bank (East of St. Croix) is seasonally open for harvesting of queen conch and regulations are in place that limit the size, establish a seasonal closure (July-September) and limits the harvest of commercial and recreational fishers. The Government of the Territory of the US Virgin Islands has extended the seasonal closure of queen conch from July 1 to December 31, in the territorial waters in St. Croix and has requested that the Council establish compatible regulations in the EEZ. The USVI have also established a quota for the fishery of 50,000 pounds per year. The alternatives considered by the Council include (1) No Action; (2) establishing compatible regulations (extended seasonal closure and 50,000 pounds per year) and (3) a complete closure of the queen conch fishery in the US Caribbean EEZ.

Escape Vents in traps: In order to reduce bycatch and fishing mortality in the stocks that are overfished, undergoing overfishing and approaching an overfishing condition, the

Council is considering the use of escape vents in fish traps and lobster pots. A number of options are being considered: ranging from one escape vent with shapes and sizes that could be rectangular (1” x 3” to 2” x 4”), circular (2.5” to 5”) or diamond shape (4.0” x 2” to 5.0” x 2.5”); 2 escape vents of each of the shapes and sizes mentioned above; 2 escape vents of different shapes and sizes (combination of one rectangular and one circular, etc.); and no action for fish traps. The same alternatives are considered for the lobster pots but the sizes of the rectangular shapes range from 2” x 20” to 21/4” x 20”.

Spiny Lobster: In this case, the management alternatives to implement a minimum size limit on imported spiny lobster may include, but are not limited to: a “no action”; alternatives to restrict the minimum import size based on carapace length; alternatives to restrict the minimum import based on tail length; and alternatives to restrict the importation of meat, which is not whole lobster or tailed lobster.

Scoping Meetings for Queen Conch, Lobster and Reef fish (traps and pots)
Summary of Comments
October 16,2007
Holiday Inn Windward Passage Hotel
St. Thomas, U.S.V.I.

1. Roberto Tapia - Enforcement DPNR
Additional enforcement staff members should be onboard by the end of next year for the U.S.V.I. Provided **no comments on the lobster**, queen conch, and reef fish issues.

2. David Berry - Commercial Fisherman
Queen Conch: Do not impose a closure (cost jobs).
Need re-stocking, hatchery production.
Spiny lobster: Juvenile lobsters being fished is the right thing to do.
Escape vents: No action.
Other comments: Support for the fishermen instead of fighting fishermen.

3. Julian Magras - Chairman, St. Thomas Fishermen's Association
Queen conch: No action.
Spiny lobster: Supports a carapace length of 3.5" for imports.
Escape vents: Regulations do not effect Puerto Rico (with a trap fishery in decline), nor the St. Croix fisherman (only 1 fishing trap) but directed to St. Thomas fishermen. The federal jurisdiction is 67% of the USVI area and this is discrimination, and 85% of trap fishers in St. Thomas. (See statement attached). No action.

4. David Olsen - Director, U.S.V.I. Division of Fish and Wildlife
Agrees with the comments made by Julian Magras

5. Louis Blanchard - Commercial Fisherman
Queen conch: No action.
Spiny lobster: No action.
Escape vents: Need to wait for results on the escape vents study currently

underway in St. Thomas. No action.
6. Michael Beny - Commercial Fisherman
Queen conch: No opinion.
Spiny lobster: Only allow lobsters as big as, or bigger than local size allowed (1 3.5" carapace length).
Escape vents: No action.

7. Jimmy Magner - Commercial Fisherman
Queen conch: Queen conch is not overfished in St. Croix (cited SEDAR 2007). Keep St. Croix open. (No action). If proven to be decreasing, then put a catch limit. Insufficient data. Studies are needed to gather more data.
Spiny lobster: Imports into the US should not be allowed if lobster size is less than 3.5" carapace length.
Escape vents: No action until survey is finished.

8. Harry Clinton - Recreational Fisherman
Agrees with the comments previously made. Local groups are already taking steps to protect the fisheries in the U.S.V.I., there is no need for the federal government to impose more regulations.
Queen conch: No comment.
Spiny lobster: Agrees with a carapace length of 3.5" for imports.
Escape vents: No comment.

9. Warren Querrard and Danny Beny - Commercial Fishermen
Queen conch: No action.
Spiny lobster: Agrees with a carapace length of 3.5" for imports.
Escape vents: No action.

10. Ricky LaPlace - Commercial Fisherman
Queen conch: No action.
Spiny lobster: Agrees with a carapace length of 3.5" for imports
Escape vents: No action.

11. Braison Bryant and father Terry Bryant - Commercial Fishermen
Queen conch: No comment.
Spiny lobster: Agrees with a carapace length of 3.5" for imports.
Escape vents: No action.

12. Ernest Quentel- Commercial Fisherman
Queen conch: Seasonal closure.
Spiny lobster: Agrees with a carapace length of 3.5" for imports.
Escape vents: No action. The escape panel suggested would make the fishermen lose 95% of their catch.

October 17,2007
Buccaneer Hotel, St. Croix, U.S.V.I.

1. Leopold Giddens - Commercial Fisherman, Fredericksted
There are 250 licensed commercial fishers in St. Croix and at least 75% of them should be present. DPNR needs to present the data.
Queen conch: No comment.
Spiny lobster: No comment.
Escape vents: No comment.

2. Edward Schuster - Chairman, Fisheries Advisory Committee (FAC) and President of St. Croix Fishermen Association
Queen conch: The FAC recommends a 5-month closure. DPNR established a 6-month closure. The FAC recommended changing the bag limit of 150 conchs per fisher to 200 conchs per boat to prevent overfishing. There is a need to self-regulate. A study needs to be conducted during the seasonal closure to assess the population for a more accurate account of the population. The FAC recommended to use 3 clean, 2 unclean conchs to the pound, instead of bringing the shell to shore. There are problems with dumping sites. It represents a risk to travel with the shells onboard. There should be no imports of queen conch during the closed season.
Spiny lobster: A study on larvae recruitment should be conducted in St. Croix. No comment on imports size.
Escape vents: Lobster traps not used in St. Croix but multi-purpose traps for fish and lobster. The Council should consider conducting a trap vents study in St. Croix, since the St. Croix fishers use hexagonal mesh instead of the square mesh used in St. Thomas.

3. Baltazar Felix IU - Commercial Fisherman
Queen conch: No Action. If not able to maintain fishery, then extend the closure.
Spiny lobster: No comment.
Escape vents: No comment.

4. Roltalia Nisbett – St Croix Resident
Queen conch: Allowance of 200 queen conchs per boat rather than 150 per fisher. No additional months of closure.
Spiny lobster: No comment.
Escape vents: No comment.

5. Frank Johnston – Conch Diver
Queen conch: Maintain the regulations as they are (three-month closure).
Hire more people during the months of closure to enforce the law.
Spiny lobster: Lobster imports should be compatible with local laws (3.5" carapace length).
Escape vents: Not needed, since the current mesh size and the escape panel already established are working good. No action.

6. Joseph Gilbert – Commercial Fisherman
Queen conch: Christmas is a very important time for conch fishers. No closure during the month of December. There was a recent incident on loitering by shells [NOTE: the regulations, both state and federal, require that conch be brought to shore intact, in the shell. These shells are dumped at various sites including areas of tourism. A judge ordered the shells to be dumped at sea.]
Spiny lobster: No comment.
Escape vents: No comment.

7. Gerson Martinez - Commercial Fisherman
Queen conch: Closed season should be from June to October 31**.** Conch is not depleted in St. Croix. Closure should be postponed until further studies are conducted.
Spiny lobster: Lobster imports should be compatible with local laws (3.5" carapace length).
Escape vents: No action. The mesh size used in St. Croix is working. Escape vents would represent a considerable economic loss.

9. Robert Thomas - St. Croix Resident
Comments on the logic of reporting 10 pounds of conch, which would be considered too little, and 100 pounds, which would be considered too much; either way the fishermen looses and there will be more regulations. Things are bad in the Island. There is no enforcement.
Queen conch: Leave the month of December open. There is a problem with the shells, they destroy the bottom of the vessels.
Spiny lobster: No comment.
Escape vents: No comment.

October 23,2007
Pierre Hotel
San Juan, Puerto Rico

1. Hector Mpez - Port Agent, Department of Natural and Environmental Resources (DNER)
Requested information from Dr. Olsen regarding the conch that remains in the freezer during the closure - how can they track what was caught before the season? How to prove it is not imported?
Queen conch: No comment.
Spiny lobster: No comment
Escape vents: No comment.

2. Aida Rosario - DNER Secretary's Designee
Queen conch: This is a matter for the U.S.V.I.
Spiny lobster: Agrees with a carapace length of 3.5" for imports, but Puerto Rico would have to revise the interstate law for imports to see how it would be applied.
Escape vents: Mesh size works; studies done at the Fisheries Research Laboratory show that the mesh size (1.5" hex and 2" square) were the most productive and still allow for

the escape of juveniles. Larger mesh sizes were not economically a good return. Need to study measures that are not protecting the resource and the impact on fishers.

October 24,2007
Ponce Hilton Hotel
Ponce, Puerto Rico

1. Maria Roman Reyes- Juana Diaz resident
Queen conch: No comment.
Spiny lobster: No comment.
Escape vents: There is no enforcement and the fishers are not marking their traps because they get stolen. They do not want to use GPS, etc., but keep the way of living. The regulations are so complicated that high school drop-outs are not entering the fishery.

2. Luis S. Rodriguez - Commercial Fisherman, Guayama Villa Pesquera Punta Pozuelo
Queen conch: No comment
Spiny lobster: No comment
Escape vents: The mesh size works. The material that is available now will not allow for cutting the mesh, it will make the trap too weak.

3. Miguel Ortiz - President, Villa Pesquera Pozuelo
Recreational fishers are fishing more and selling the catch. There is no enforcement and no license requirements for recreational fishers in place yet. Dorado and other species harvested during tournaments are sold. This happens everywhere around the Island.
Queen conch: No comment
Spiny lobster: Agrees with a carapace length of 3.5" for imports.
Escape vents: No action. It would hurt the fishermen. They would lose a lot of fishes that they are allowed to catch. Too much paper work, regulations in state waters and federal regulations do not help. The red hind seasonal closure is not working, too much fish wasted - area closures would work better, but the seasonal closure for the snapper works well. The imports are also competition because is fish for less money. No support has been given to the regulations that are in place.

4. Julio Reyes - Commercial Fisherman, Pescaderia Pastille, Juana Diaz
Queen conch: No comment
Spiny lobster: Agrees with a carapace length of 3.5" for imports
Escape vents: No action

October 25,2007
Mayaguez Holiday Inn
Mayaguez, Puerto Rico

1. Victor Padilla - Commercial Fisherman
Queen conch: No comment
Spiny lobster: Agrees with a carapace length of 3.5" for imports

Escape vents: No Action. The material available for traps today is very bad. The costs have increased. People are retiring from fishing because there are too many regulations and it is expensive to fish. The trap mesh oriented vertically, instead of horizontally allow small fish to escape (> 1.5 inch height). This might be a better solution rather than having an escape vent in the trap. Need to study the fishing with mallorquines (3 panels) being used for fishing lobsters. It does not allow the lobster to [walk] march, migrate. These nets trap everything, lobsters by the hundreds and small. The lobsters fished this way loose their legs, antennae, etc., and many other species are affected too. In contrast, the fishers know where to set the traps.

2. Andres Maldonado - Commercial Fisherman, Cab0 Rojo
Queen conch: The peak spawning season for queen conch is September (2nd week) and October. Open July and close October. Enforcement is not being done as it should, since the market is already flooded the first week of the open season. Fishing is being done during the closed season. The new regulations for St. Croix are not going to work since there is no enforcement, and the increased closure would force illegal actions. A three-month closure is not easy.
Spiny lobster: If lobster is one stock, maintain same opportunity for lobster spawning with the 3.5" carapace length size for imports.
Escape vents: No comment

3. Pedro Silva - Commercial Fisherman, Mayaguez
Queen conch: No comment
Spiny lobster: Agrees with a carapace length of 3.5" for imports
Escape vents: No action. Mallorquines and chinchorros are more damaging to fish. There is an enforcement problem. There are no regulations for recreational fishers, or no enforcement of regulations for the recreational fishers. Recreational fishers sell their catch against the law. Interventions at sea are only with commercial fishers and not with recreational. Enforcement agents need training.

November 13,2007
Curriculum Center
St. Croix, U.S.V.I.
(Second Scoping Meeting requested by the Fishermen)

1. Tom Daley - Commercial Fisherman
Mr. Daley brought a replica of the suggested escape vent and various species of fish to demonstrate how legally caught fish fall through the escape vent of more than 1" by 4".
Queen conch: Supports the six month closure for conch, as well as establishing a quota.
Spiny lobster: No comment.
Escape vent: The 1" by 4" allows the juveniles to escape. Any other size would be useless. St. Croix should be dealt with separately from St. Thomas and Puerto Rico in terms of the management measures that are put in place. The economy is in bad shape in St. Croix, and many people look at fishing as an alternative to make a living.

2. Edward Schuster - Commercial Fisherman
Queen conch: The closure should be £tom June to November, it should not run until December. Peak period for spawning runs until November. Supports the quota and the six-month closure. Studies should be conducted before having any more closures. Fishermen are more than willing to cooperate in the studies.
Spiny lobster: No comment.
Escape vents: No comment.

3. Gerson Martinez - Commercial Fisherman
Queen conch: Supports a six-month closure from June through November. December is not a peak spawning month.
Spiny lobster: No comment.
Escape vents: 2" by 4" and 2" by 6" allows all species of fishes that are caught legally to escape. No action.

4. Carlos Farchetti - Chief of Enforcement, U.S.V.I.
Queen conch: Supports the six-month closure From June through November. There are a lot of juvenile conch areas. More data should be gathered and presented to conclude if the conch is really in danger. Suggests having these juvenile areas videotaped, without identifying the location.
Spiny lobster: No comment.
Escape vents: No comment.

5. Winston Ledee - Commercial Fisherman, St. Thomas
Queen conch: Supports a six-month closure from June to November
Spiny lobster: No comment.
Escape vents: No action until studies are finished. There is no need for escape vents in lobster traps.

APPENDIX C – PUBLIC HEARING COMMENTS

CARIBBEAN FISHERY MANAGEMENT COUNCIL
268 MUNOZ RIVERA AVENUE, SUITE 1108
SAN JUAN, PUERTO RICO 00918

SPINY LOBSTER IMPORTS PUBLIC HEARINGS

SUMMARY OF COMMENTS

The Caribbean Fishery Management Council held public hearings on the Draft Environmental Impact Statement (DEIS) to establish a size limit for spiny lobster imports into the United States (see attached notice).

Following are the comments received at the public hearings:

Mayaguez, Puerto Rico
July 17, 2008

1. Fred Lentz – Fisherman/ Rincón, Puerto Rico

   In agreement with establishing a minimum size for imports of spiny lobsters into the U.S. Caribbean. He believes this would benefit the local fishers because the importers and restaurants will have to buy spiny lobster of the same size that the locals are required to fish and sell them for, resulting in a better economic return for the local fishermen.

2. Providencio Linares- Caribbean Maritime Educational Center

   In agreement with establishing a minimum size for imports of spiny lobsters into the U.S. Caribbean

San Juan, Puerto Rico
July 18, 2008

No deponents. No comments were received.

St. Thomas, U.S. Virgin Islands
July 21, 2008

1. David Olsen – Representing the St. Thomas Fishermen's Association (STFA)

   The STFA supports the establishment of a minimum size for imports of spiny lobster into the U.S. Caribbean. Dr. Olsen read for the record a letter offering the position and comments of the STFA (see letter attached.)

St. Croix, U.S. Virgin Islands
July 22, 2008

1. Michael Danse and Therese Chretien – Interested persons/St. Croix, USVI

   In agreement with establishing a minimum size for imports of spiny lobsters into the U.S. Caribbean.

MAGNUSON – STEVENS ACT/NEPA PUBLIC HEARINGS THE CARIBBEAN, GULF OF MEXICO, AND SOUTH ATLANTIC COUNCILS' AMENDMENT TO ADDRESS THE IMPORTATION OF SPINY LOBSTER PRODUCTS THAT DO NOT MEET U.S. CONSERVATION STANDARDS

SUMMARY OF PUBLIC COMMENTS

JULY 2008

Three public hearings were held, and all hearings began at 5:30 pm. The following Council members were present: Eugenio Piñeiro-Soler (Chair, CFMC), George Geiger (Chair, SAFMC), and Robert Gill (GMFMC). The following Council staff was present: Gregg Waugh (SAFMC), Assane Diagne (GMFMC), and Phyllis Miranda (GMFMC).

Gregg Waugh reviewed the issues in the import amendment; copies of the import amendment and public hearing summary were provided to all members of the public.

A summary of the comments received is shown below:

I. Public Hearing #1. July 21, 2008; Radisson Hotel; 3820 N. Roosevelt Blvd.; Key West, Florida. There were three members of the public present for the spiny lobster public hearing.

Mr. Peter Backel, Owner of Stock Island Lobster Company and member of the Florida Spiny Lobster Advisor Board. Our company has been in business since 1953 and these changes are long overdue. We support the preferred alternatives of the South Atlantic Council and believe that one import size limit (3" carapace length and 5.5" tail length) is the way to go.

Mr. Scott Zimmerman, Executive Director of the Florida Keys Commercial Fishermen's Association. Our organization supports the amendment; it has great potential to reduce mortality of shorts and this would support further recruitment to Florida from the Pan-Caribbean lobster stock. Protecting Pan-Caribbean lobsters through this import amendment is important for our stock here in Florida.

Ms. Libby Featherston, Ocean Conservancy, read portions of a draft letter that will be submitted during the written comment period. She supports a prohibition of imports that do not meet our standards in terms of size, berried, and lobster meat. She supports Alternative 2 for Action 1 and Alternative 2 for Action 2 (SAFMC preferred alternatives).

II. Public Hearing #2. July 22, 2008; Banana Bay; 4590 Overseas Highway; Marathon, Florida. There were two members of the public present (Karl Lassard and Scott Zimmerman) for the spiny lobster public hearing and one provided comments.

Mr. Scott Zimmerman, Executive Director of the Florida Keys Commercial Fishermen's Association. We support the minimum size import limitation. We would request the Councils examine one part of Alternative 2a that specifies greater than 3" carapace length – this does not reflect the 3" size limit which is Florida law. He spoke with Jason at the NMFS SERO today. We will be providing written comments. We are currently importing millions of pounds of small lobster tails and this has a negative impact on our resource in Florida given the stock linkages.

III. Public Hearing #3. July 23, 2008; Doubletree Hotel; 2649 S. Bayshore Dr.; Miami, Florida. There were no members of the public present for the spiny lobster public hearing.

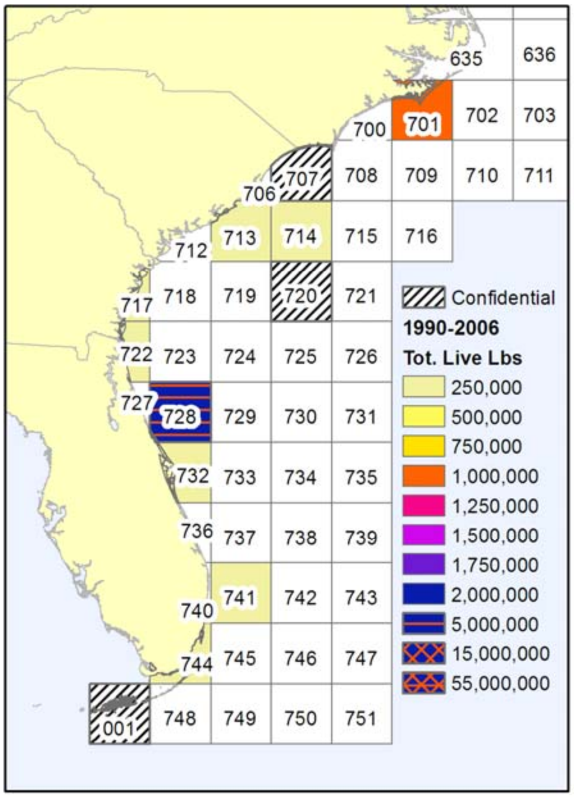
APPENDIX D – RESPONSE TO COMMENTS RECEIVED ON THE DRAFT ENVIRONMENTAL IMPACT STATEMENT (DEIS)

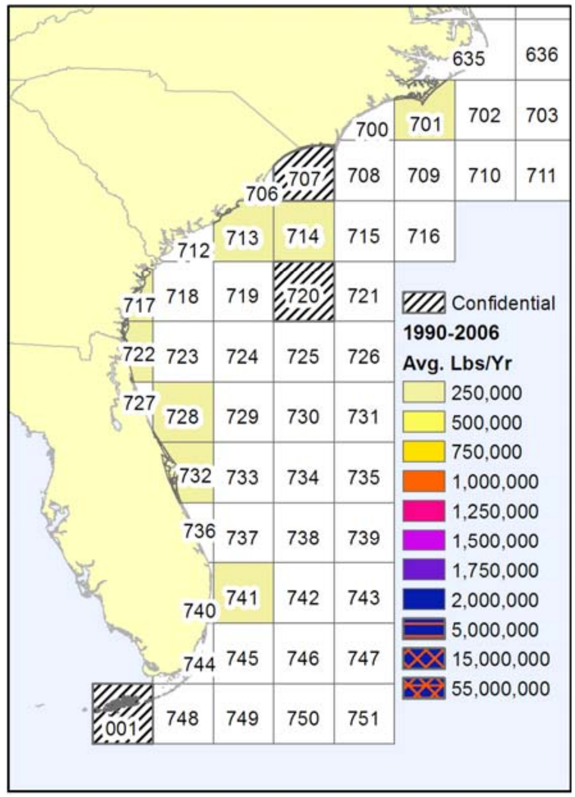
NOAA Fisheries Service received eight comments on the DEIS. Five were in full support of the measures described in the DEIS; Response: NOAA Fisheries Service agrees.

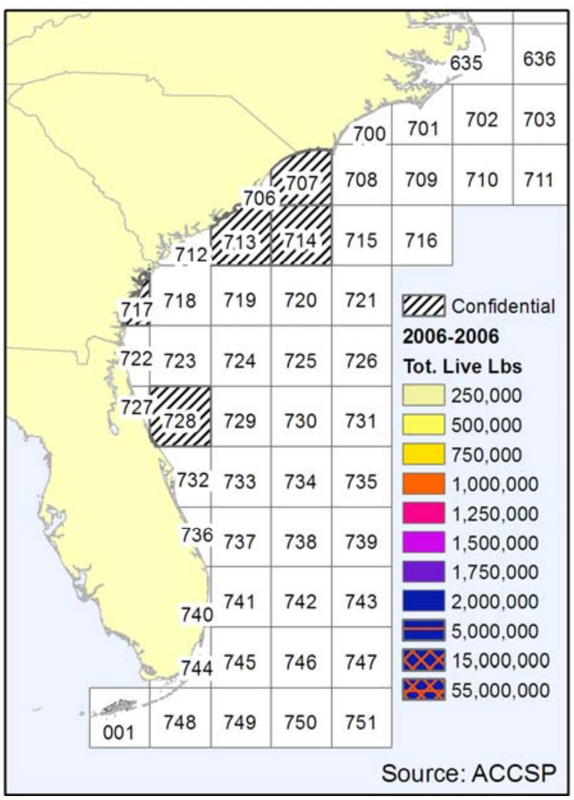
One comment was in support, but wanted to see the larger size limits applied to all imports; Response: While applying the larger size limit to all imports may be more beneficial in the long-term, a number of international and trade issues are of concern with trying to implement the larger size restrictions. Therefore, NOAA Fisheries Service used international collaboration as well as best available scientific information to develop the two sets of size limit standards to meet international needs as well as current domestic regulations.

Another comment was concerned with the impacts of the no action alternatives as preferred alternatives had not been selected. The Councils have selected their preferred alternatives (these have been identified in the document), which were identified as having a Lack of Objection. There was also a concern about the discussion and comparison of a fished versus a non-fished population of spiny lobster. The commenter wished to see a comparison between two fished populations in different parts of the Caribbean. While this would be an ideal discussion to include in the document, NOAA Fisheries Service is unaware of any studies having been conducted in this manner and merely wanted to demonstrate the potential for differences in spiny lobster populations in regards to size at 50% maturity. Another concern dealt with the use of one standard deviation instead of only one morphometric measurement. The commenter agreed this was more user-friendly, but felt clarification was needed to verify that the lesser lengths and weights are still large enough to accomplish the goals of this action. NOAA Fisheries Service believes the commenter mistook the weight range explanation and the one standard deviation discussion. The one standard deviation discussion deals with the appropriate tail length and tail weight to be used when derived from a carapace length measurement. For example, current regulations in the Gulf of Mexico and South Atlantic require a carapace length greater than 3 inches. The regulations also allow (with the appropriate permit) a tail length of 5.5 inches. The 5.5 inch tail length requirement was derived from a 3-inch carapace length animal's average tail length minus one standard deviation, thus the appropriate tail weight requirement should be derived in the same manner (i.e., the average tail weight of a 3-inch carapace length animal minus one standard deviation). The range of tail weights given for a 5-ounce animal use this approach (hence the 4.2 ounce lower end allowed), but recognize industry packing practices and define the range of weights for a 5-ounce animal (4.2 – 5.4 ounces).

The final comment received stated the agency had no comment on the DEIS.







ACCSP Catch: WRECKFISH
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	Conf.	Conf.	0.00
701	926.54	54.50	0.00
707	Conf.	Conf.	Conf.
713	100.41	5.91	Conf.
714	122.07	7.18	Conf.
717	96.52	5.68	Conf.
720	Conf.	Conf.	0.00
722	241.88	14.23	0.00
728	2,295.81	135.05	Conf.
732	33.00	1.94	0.00
741	0.22	0.01	0.00
744	0.03	0.00	0.00

Figure 5.4.1-1. Spatial Presentation of Wreckfish Commercial Catch (Source: ACCSP).

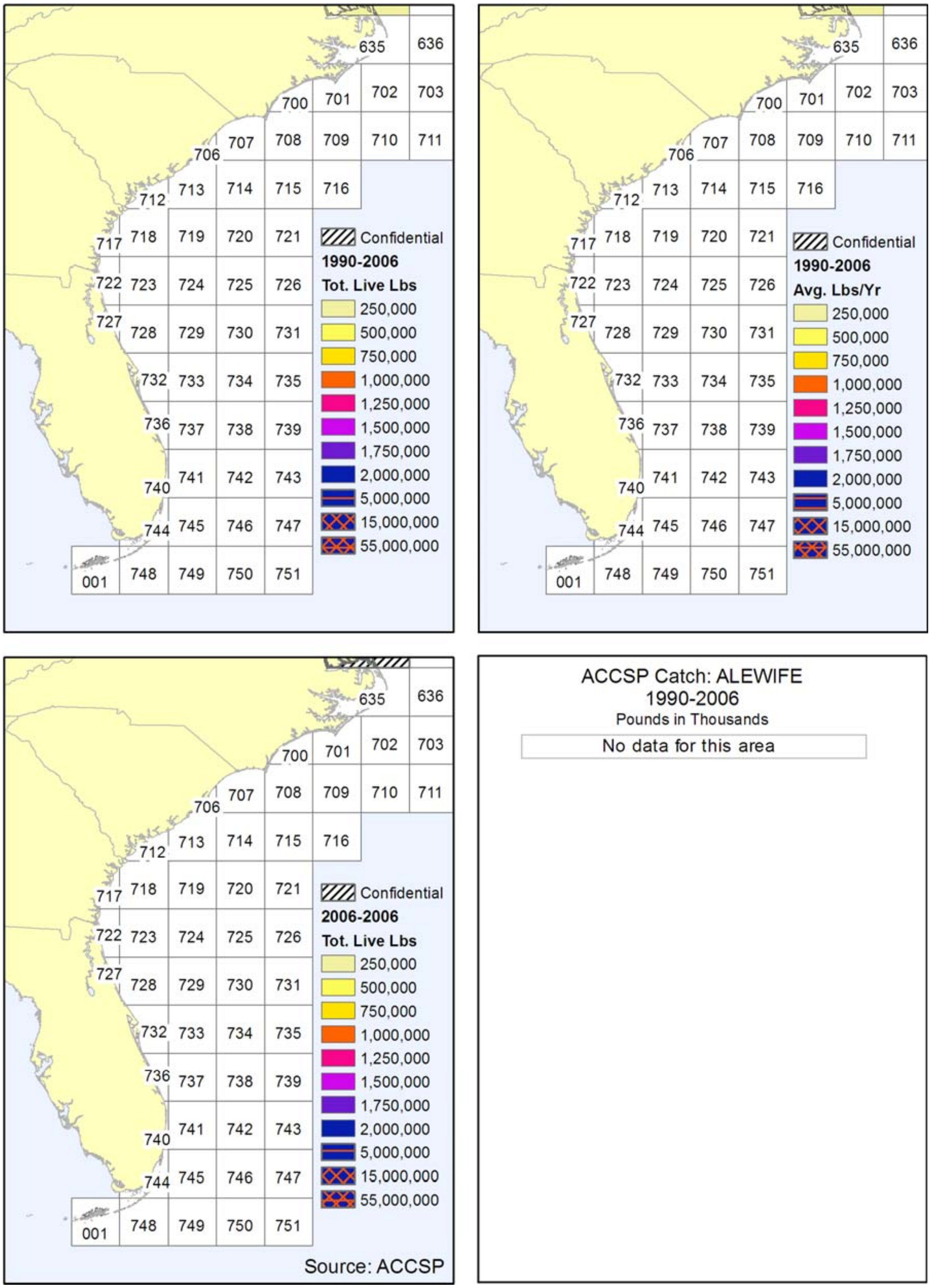
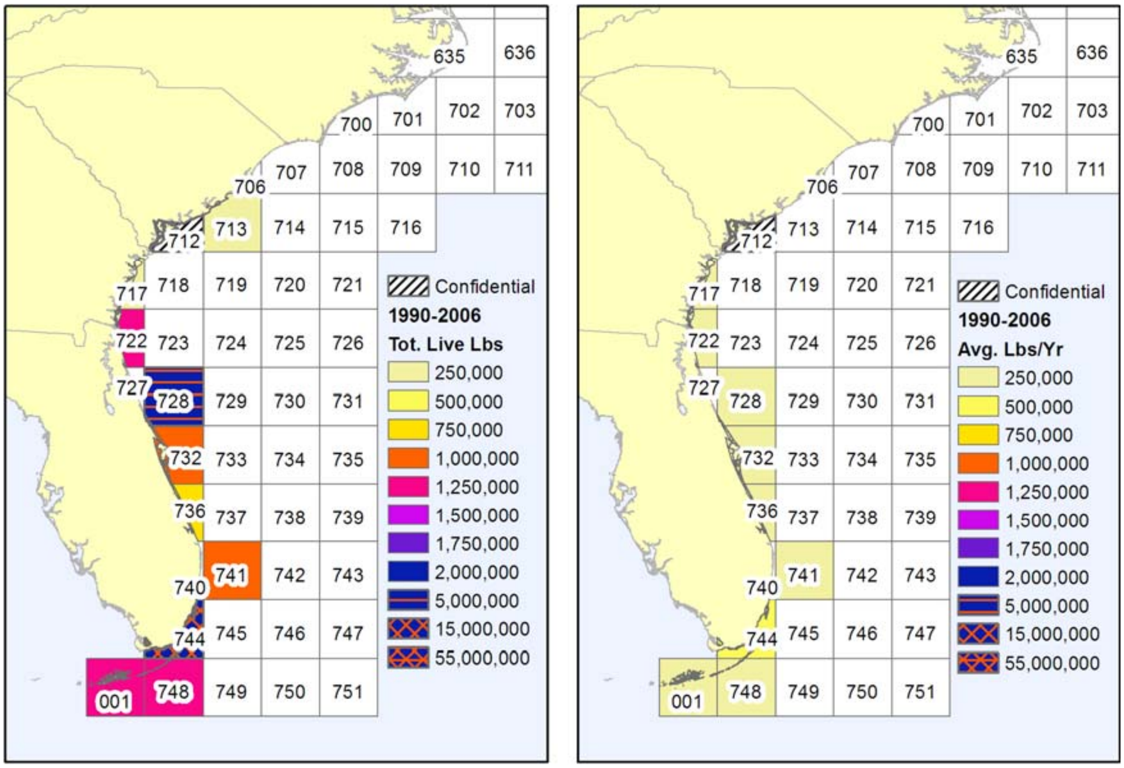
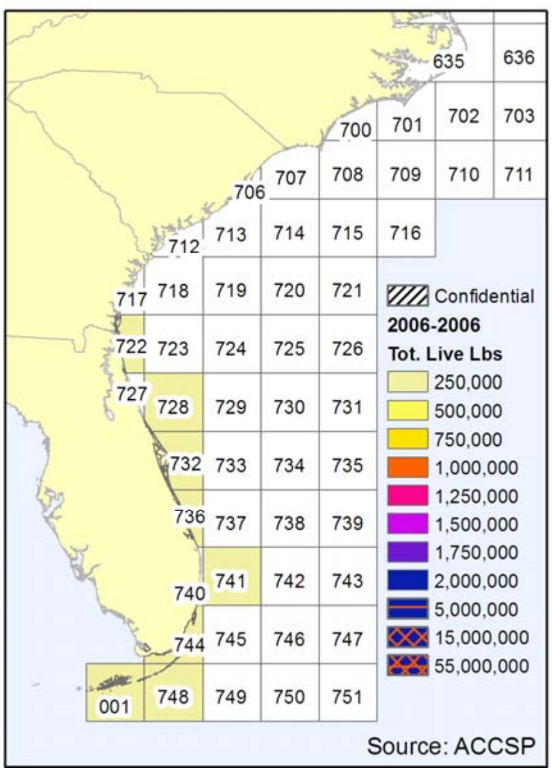


Figure 5.4.1-2. Spatial Presentation of Alewife Commercial Catch (Source: ACCSP).

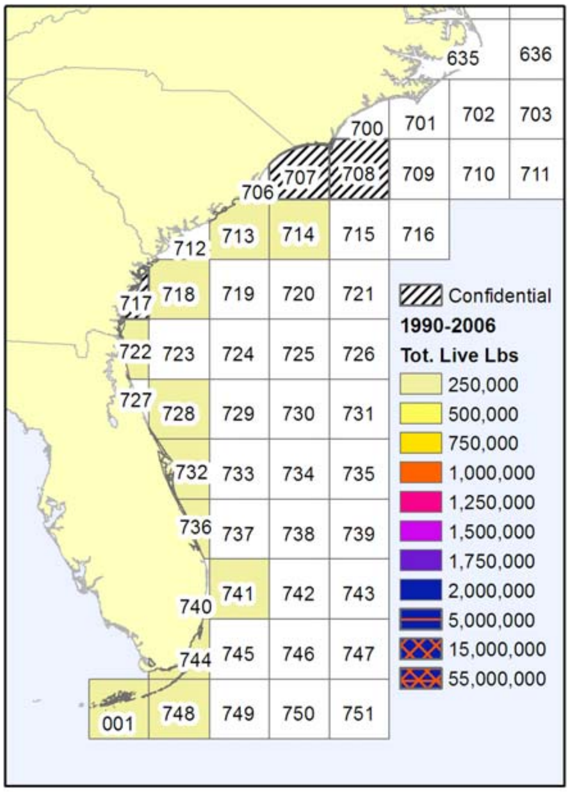


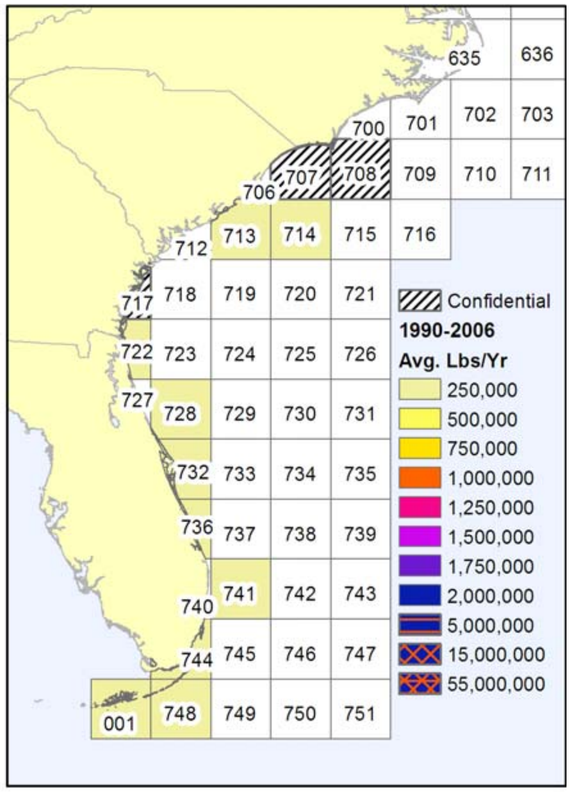


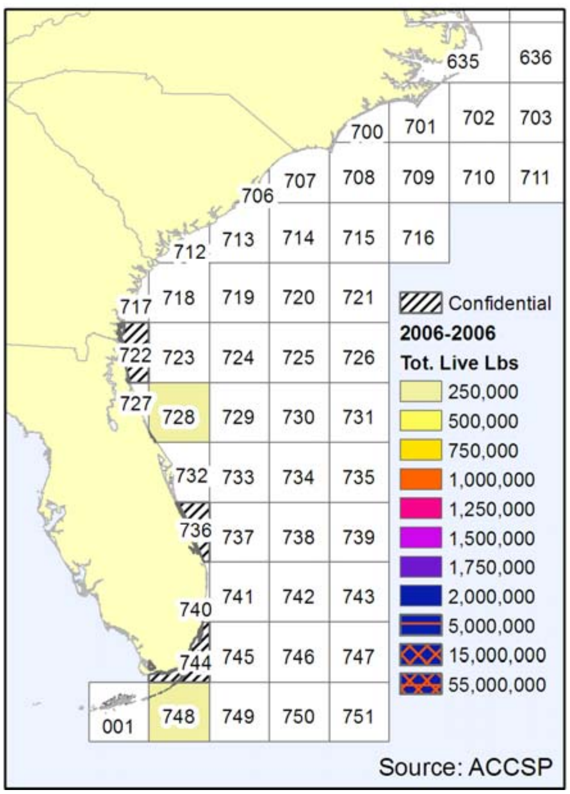
ACCSP Catch: AMBERJACK, GREATER
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	1,160.02	68.24	42.29
712	Conf.	Conf.	0.00
713	0.03	0.00	0.00
717	3.83	0.23	0.00
722	1,211.61	71.27	9.92
728	2,563.07	150.77	21.07
732	878.11	51.65	7.50
736	664.71	39.10	22.39
741	811.16	47.72	21.31
744	5,380.43	316.50	131.98
748	1,203.27	70.78	129.53

Figure 5.4.1-3. Spatial Presentation of Greater Amberjack Commercial Catch (Source: ACCSP).



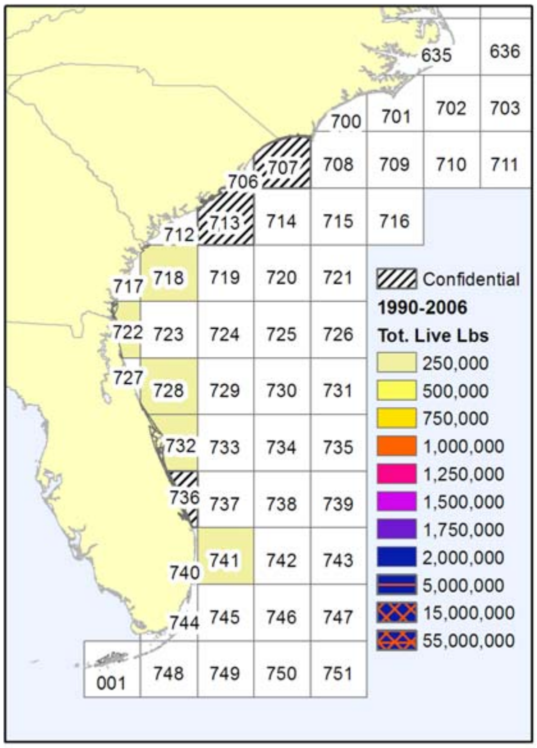


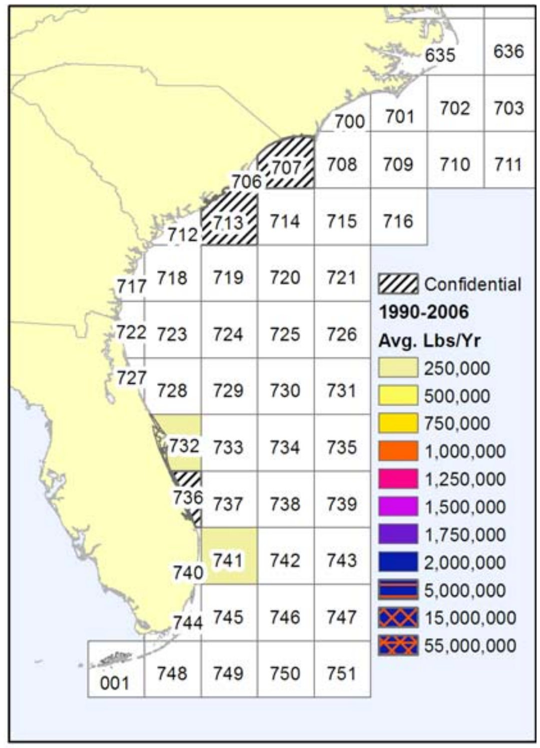


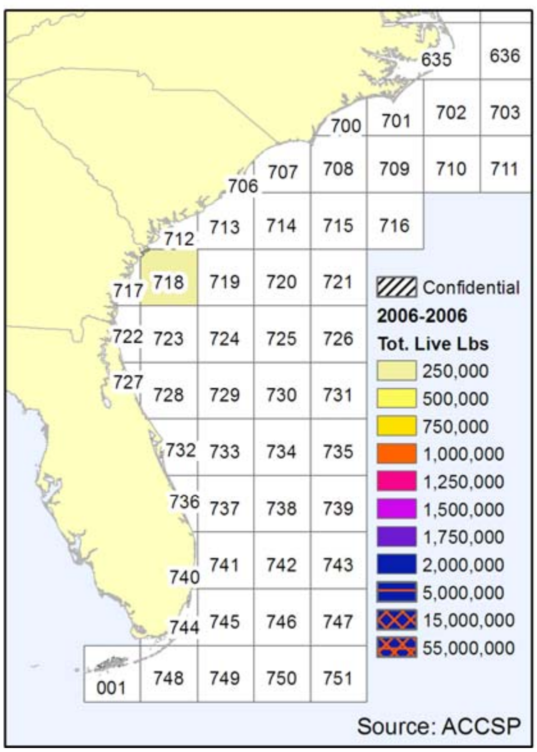
ACCSP Catch: AMBERJACK, LESSER
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	12.77	0.75	0.00
707	Conf.	Conf.	0.00
708	Conf.	Conf.	0.00
713	0.46	0.03	0.00
714	0.68	0.04	0.00
717	Conf.	Conf.	0.00
718	0.01	0.00	0.00
722	14.23	0.84	Conf.
728	9.71	0.57	0.92
732	2.21	0.13	0.00
736	4.68	0.28	Conf.
741	7.36	0.43	0.00
744	11.73	0.69	Conf.
748	7.26	0.43	0.06

Figure 5.4.1-4. Spatial Presentation of Lesser Amberjack Commercial Catch (Source: ACCSP).



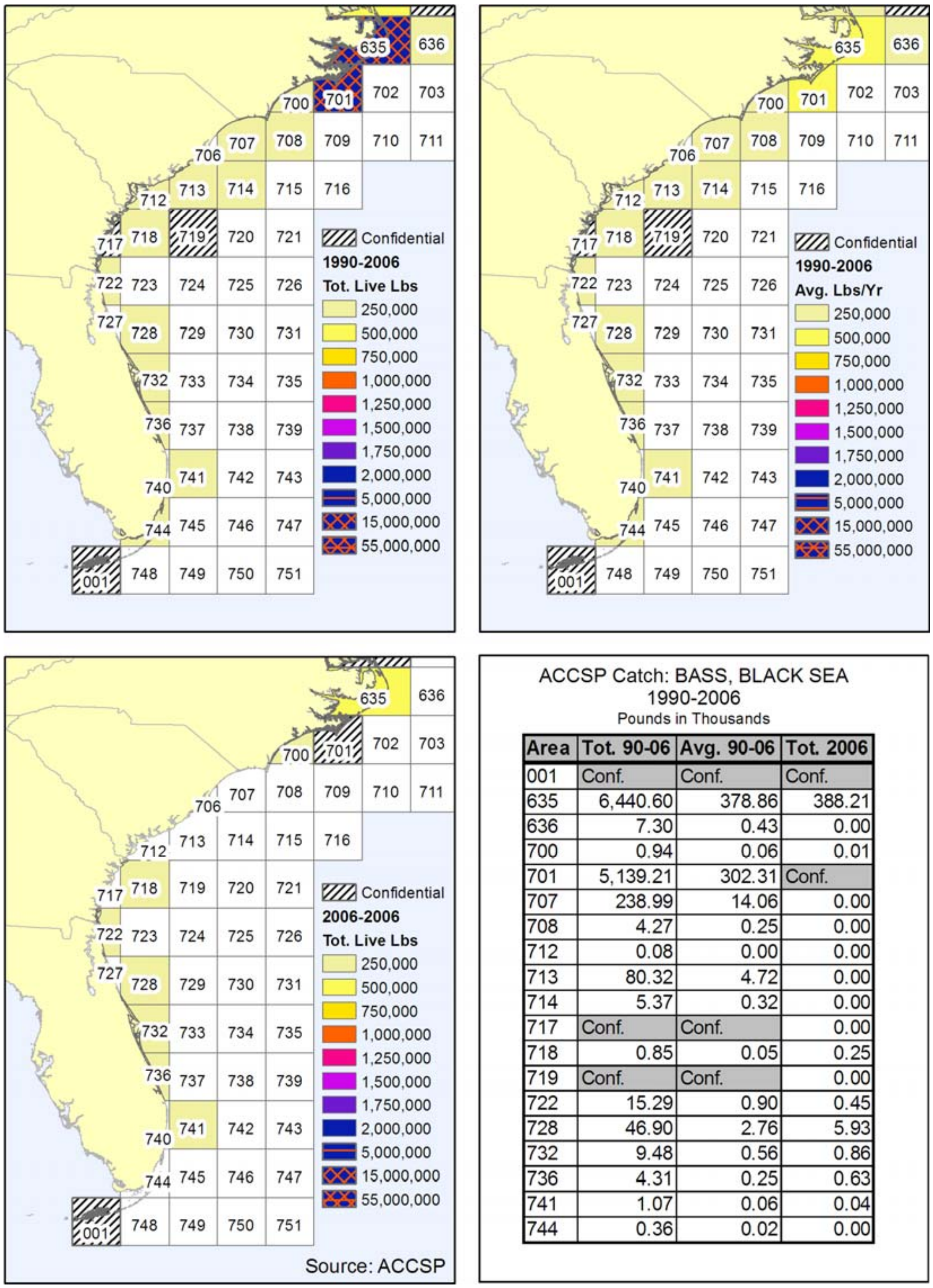




ACCSP Catch: BASS, BANK SEA
1990-2006
Pounds in Thousands

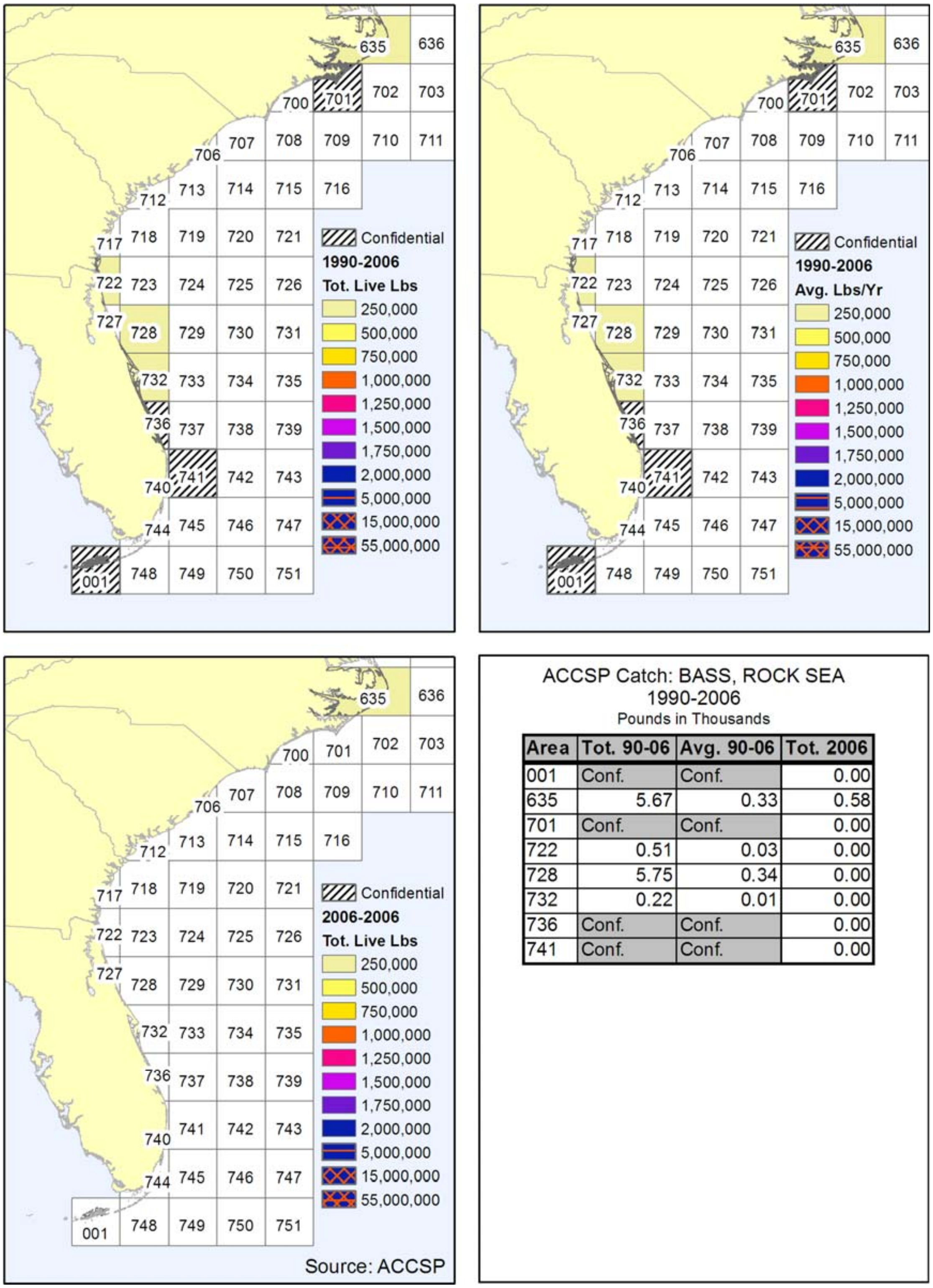
Area	Tot. 90-06	Avg. 90-06	Tot. 2006
707	Conf.	Conf.	0.00
713	Conf.	Conf.	0.00
718	0.05	0.00	0.03
722	0.03	0.00	0.00
728	0.01	0.00	0.00
732	0.07	0.00	0.00
736	Conf.	Conf.	0.00
741	0.09	0.01	0.00

Figure 5.4.1-5. Spatial Presentation of Bank Sea Bass Commercial Catch (Source: ACCSP).



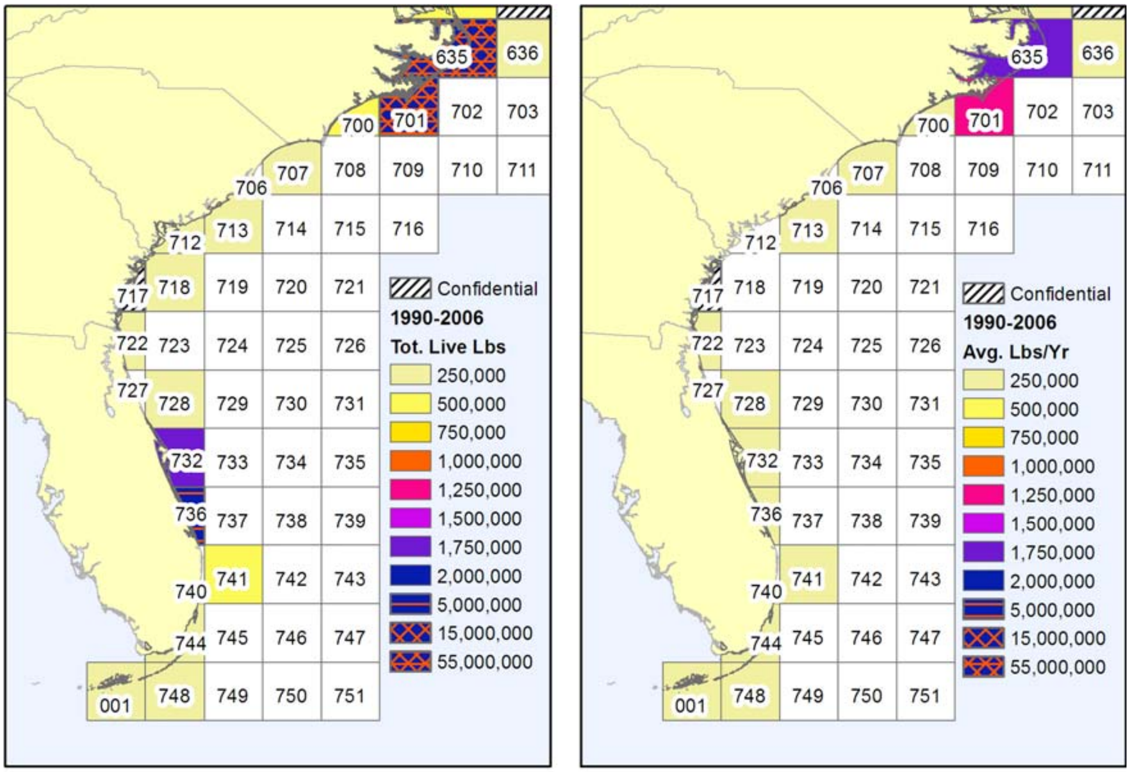
Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	Conf.	Conf.	Conf.
635	6,440.60	378.86	388.21
636	7.30	0.43	0.00
700	0.94	0.06	0.01
701	5,139.21	302.31	Conf.
707	238.99	14.06	0.00
708	4.27	0.25	0.00
712	0.08	0.00	0.00
713	80.32	4.72	0.00
714	5.37	0.32	0.00
717	Conf.	Conf.	0.00
718	0.85	0.05	0.25
719	Conf.	Conf.	0.00
722	15.29	0.90	0.45
728	46.90	2.76	5.93
732	9.48	0.56	0.86
736	4.31	0.25	0.63
741	1.07	0.06	0.04
744	0.36	0.02	0.00

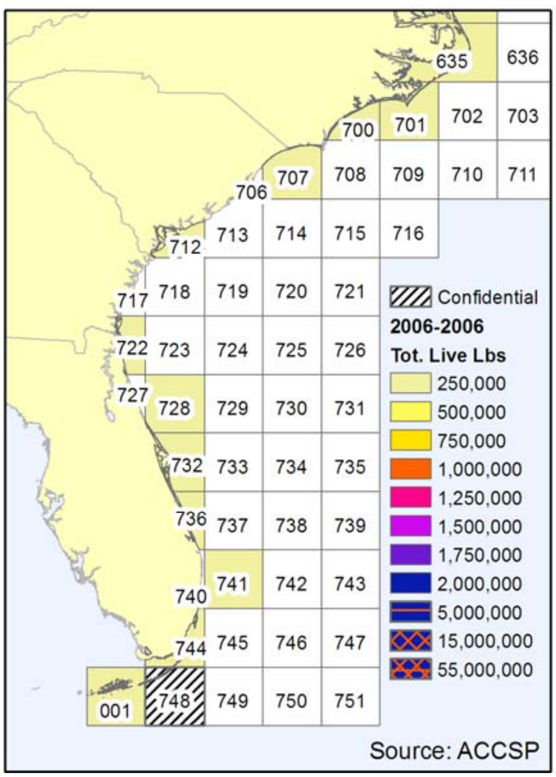
Figure 5.4.1-6. Spatial Presentation of Black Sea Bass Commercial Catch (Source: ACCSP).



Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	Conf.	Conf.	0.00
635	5.67	0.33	0.58
701	Conf.	Conf.	0.00
722	0.51	0.03	0.00
728	5.75	0.34	0.00
732	0.22	0.01	0.00
736	Conf.	Conf.	0.00
741	Conf.	Conf.	0.00

Figure 5.4.1-7. Spatial Presentation of Rock Sea Bass Commercial Catch (Source: ACCSP).



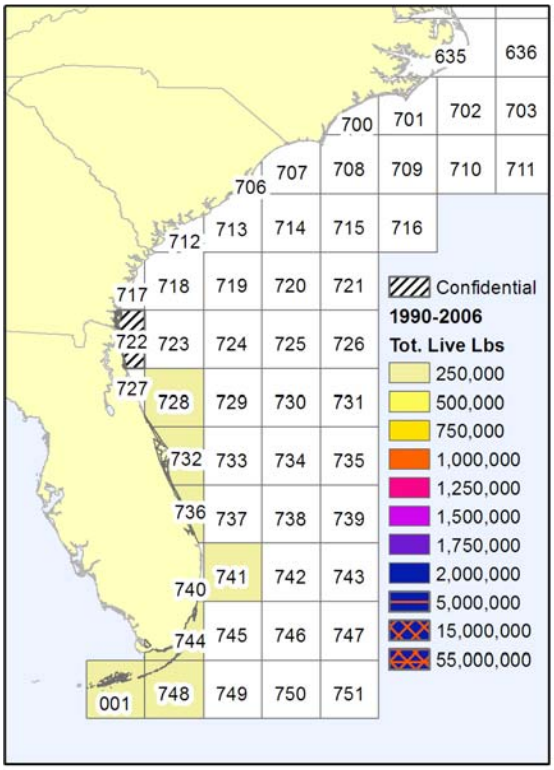


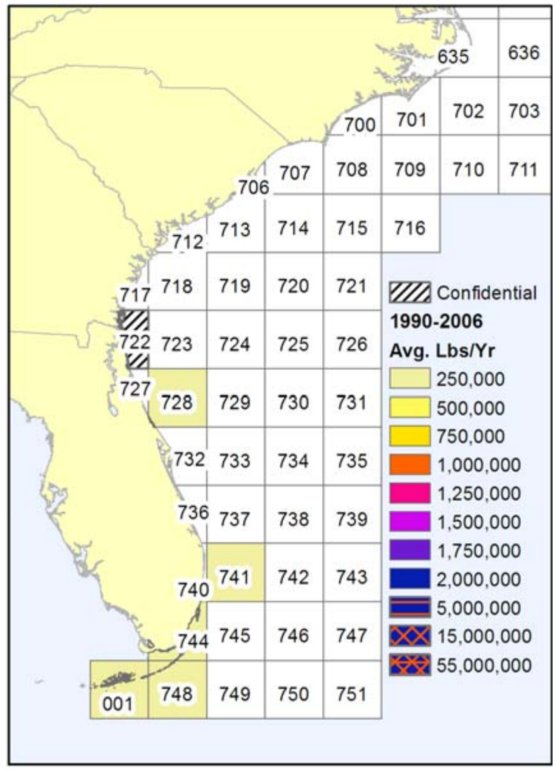
ACCSP Catch: BLUEFISH
1990-2006
Pounds in Thousands

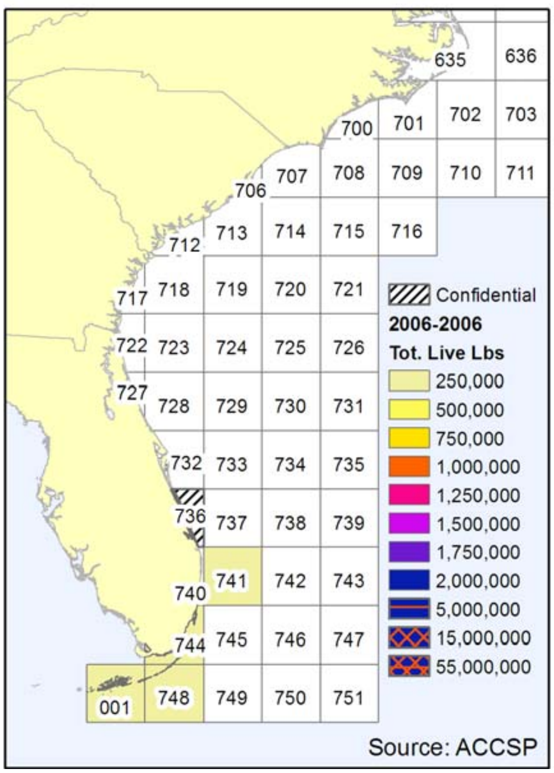
Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	92.11	5.42	12.72
635	28,658.04	1,685.77	146.80
636	1.45	0.09	0.00
700	358.74	21.10	3.54
701	18,966.46	1,115.67	29.56
707	2.19	0.13	0.34
712	0.01	0.00	0.01
713	0.07	0.00	0.00
717	Conf.	Conf.	0.00
718	0.01	0.00	0.00
722	52.42	3.08	0.16
728	93.01	5.47	0.45
732	1,580.69	92.98	38.59
736	3,374.83	198.52	43.92
741	252.17	14.83	12.18
744	123.70	7.28	0.27
748	35.62	2.10	Conf.

Figure 5.4.1-8. Spatial Presentation of Bluefish Commercial Catch (Source: ACCSP).

Appendix B. Spatial Presentations of commercial catch ACCSP



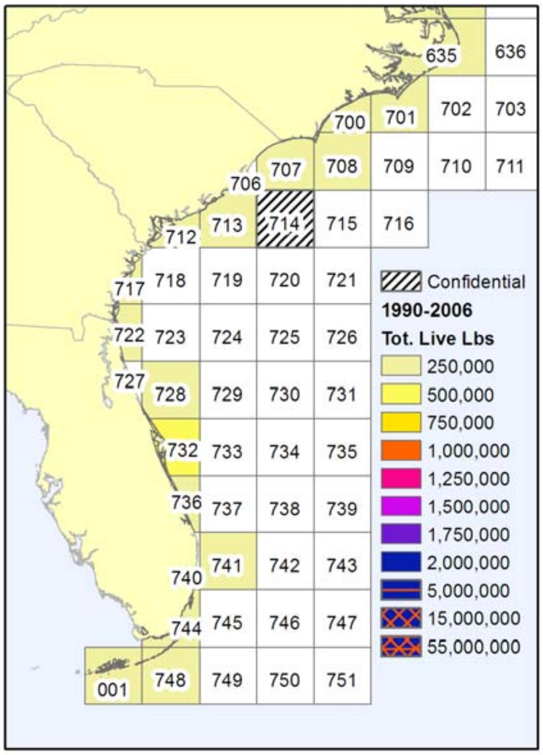


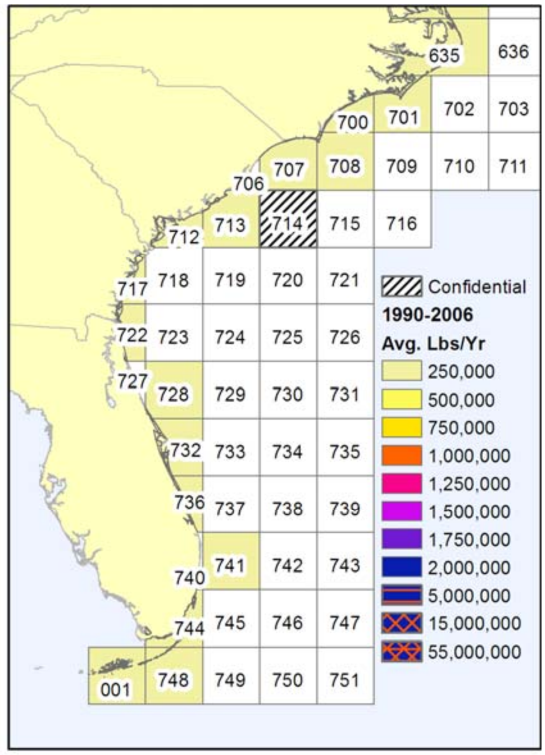


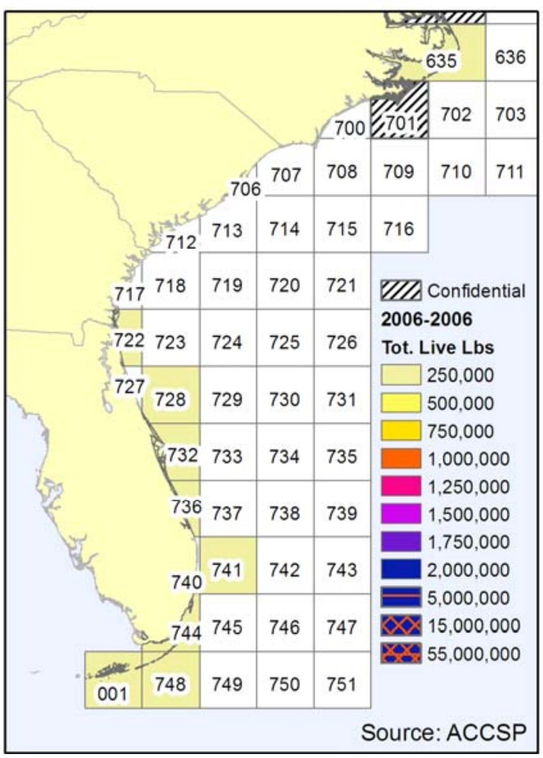
ACCSP Catch: CERO
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	80.01	4.71	1.96
722	Conf.	Conf.	0.00
728	0.09	0.01	0.00
732	0.02	0.00	0.00
736	0.06	0.00	Conf.
741	3.65	0.21	0.24
744	35.60	2.09	1.47
748	28.03	1.65	0.76

Figure 5.4.1-9. Spatial Presentation of Cero Mackerel Commercial Catch (Source: ACCSP).



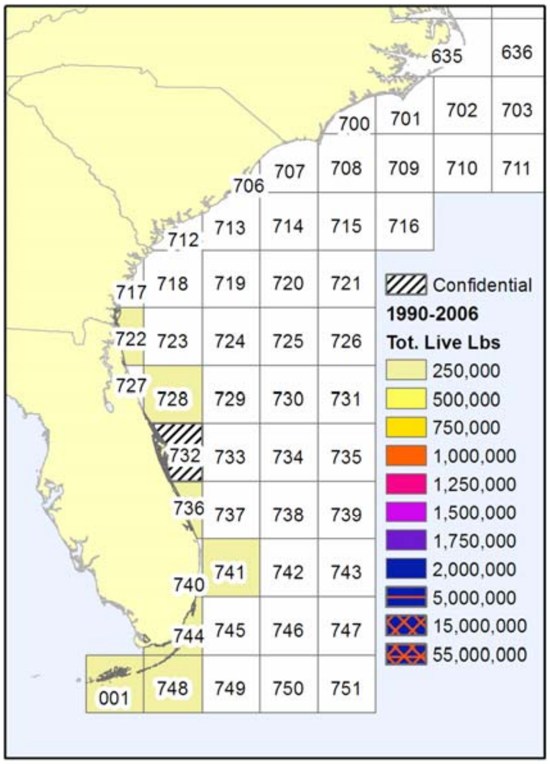


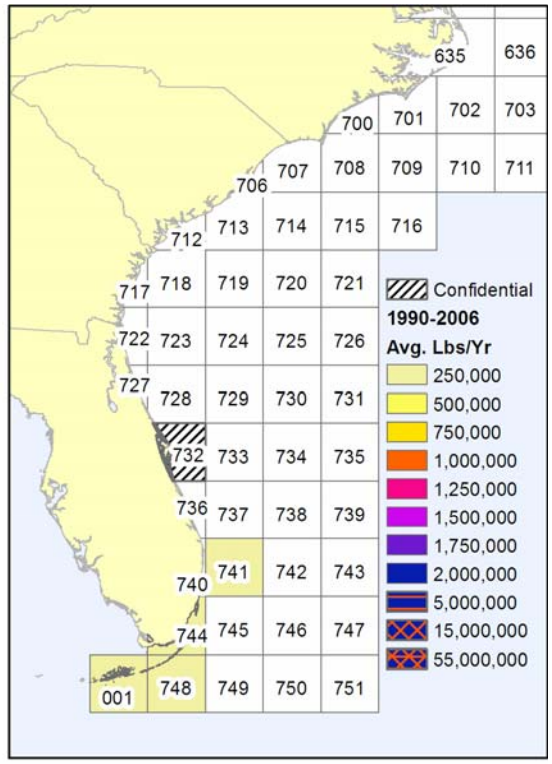


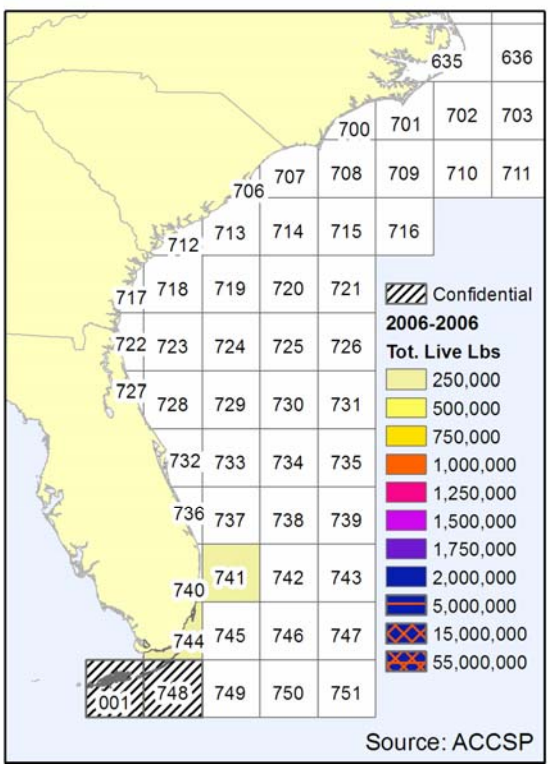
ACCSP Catch: COBIA
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	240.70	14.16	7.47
635	220.67	12.98	5.41
700	1.40	0.08	0.00
701	162.49	9.56	Conf.
707	2.69	0.16	0.00
708	0.64	0.04	0.00
712	2.31	0.14	0.00
713	3.19	0.19	0.00
714	Conf.	Conf.	0.00
717	1.19	0.07	0.00
722	230.52	13.56	4.53
728	182.95	10.76	6.54
732	332.23	19.54	17.05
736	200.07	11.77	16.56
741	98.01	5.77	10.54
744	57.53	3.38	1.59
748	113.60	6.68	3.02

Figure 5.4.1-10. Spatial Presentation of Cobia Commercial Catch (Source: ACCSP).





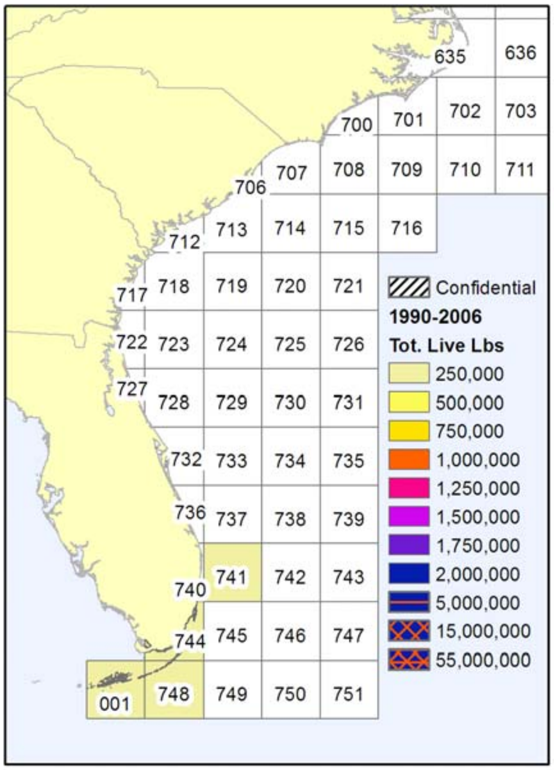


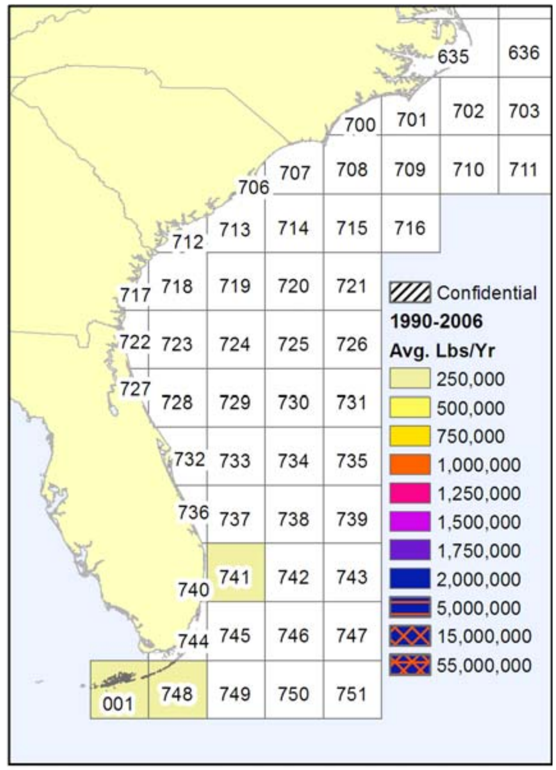
ACCSP Catch: CONEY
1990-2006
Pounds in Thousands

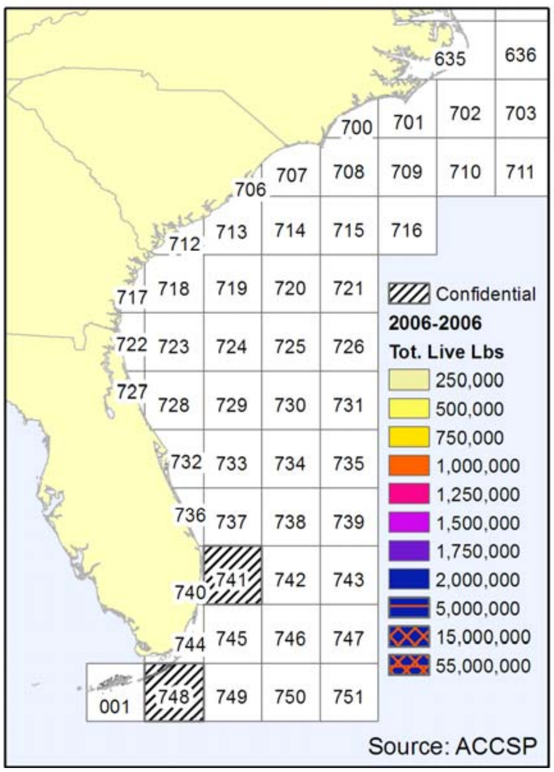
Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	0.44	0.03	Conf.
722	0.02	0.00	0.00
728	0.05	0.00	0.00
732	Conf.	Conf.	0.00
736	0.01	0.00	0.00
741	0.89	0.05	0.03
744	1.16	0.07	0.01
748	1.75	0.10	Conf.

Figure 5.4.1-11. Spatial Presentation of Coney Commercial Catch (Source: ACCSP).

Appendix B. Spatial Presentations of commercial catch ACCSP





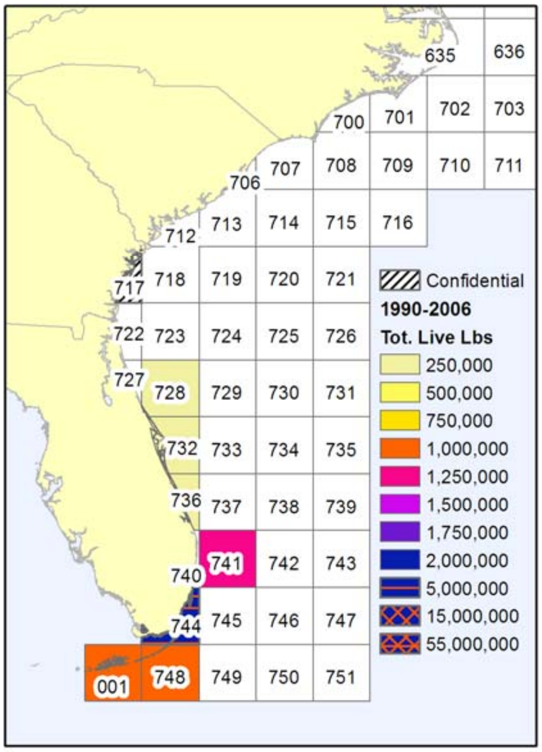


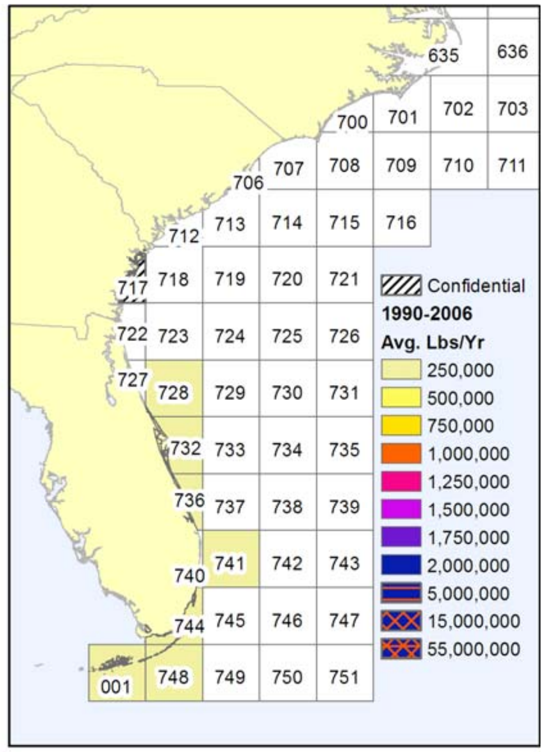
ACCSP Catch: COTTONWICK
1990-2006
Pounds in Thousands

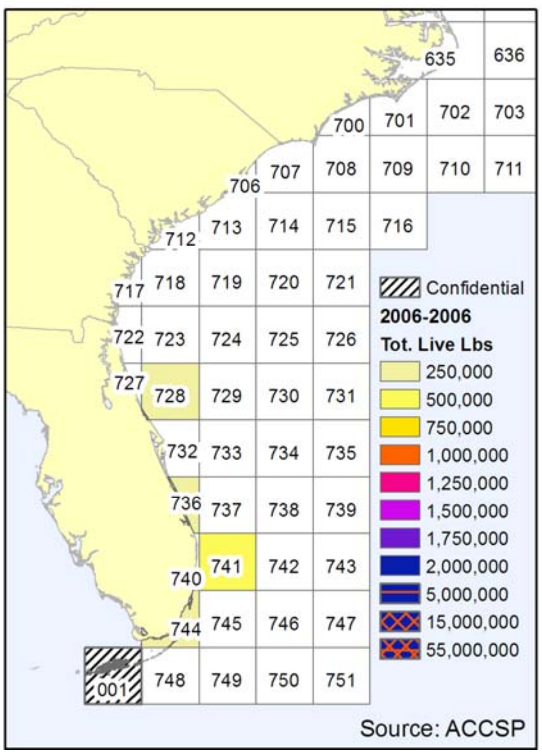
Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	0.20	0.01	0.00
741	0.22	0.01	Conf.
744	0.05	0.00	0.00
748	3.55	0.21	Conf.

Figure 5.4.1-12. Spatial Presentation of Cottonwick Commercial Catch (Source: ACCSP).

Appendix B. Spatial Presentations of commercial catch ACCSP



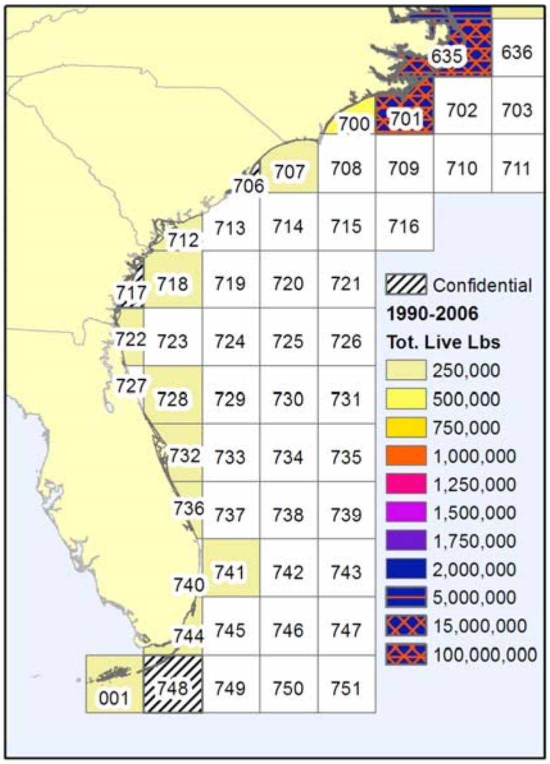


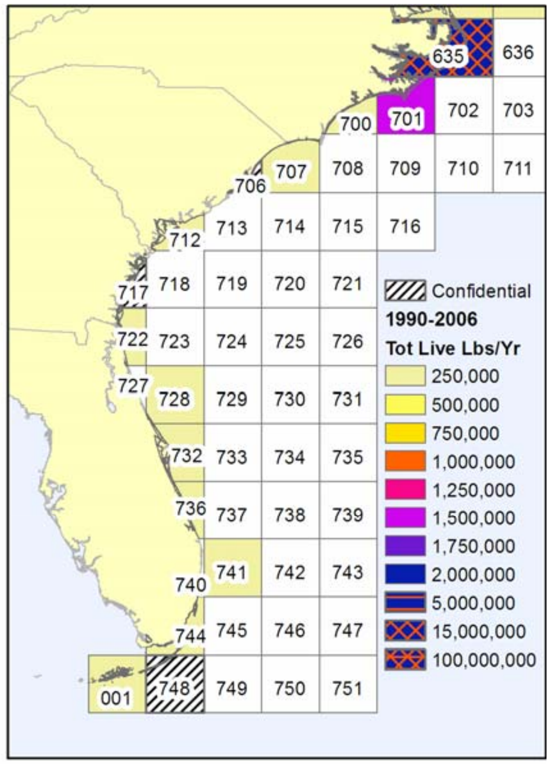


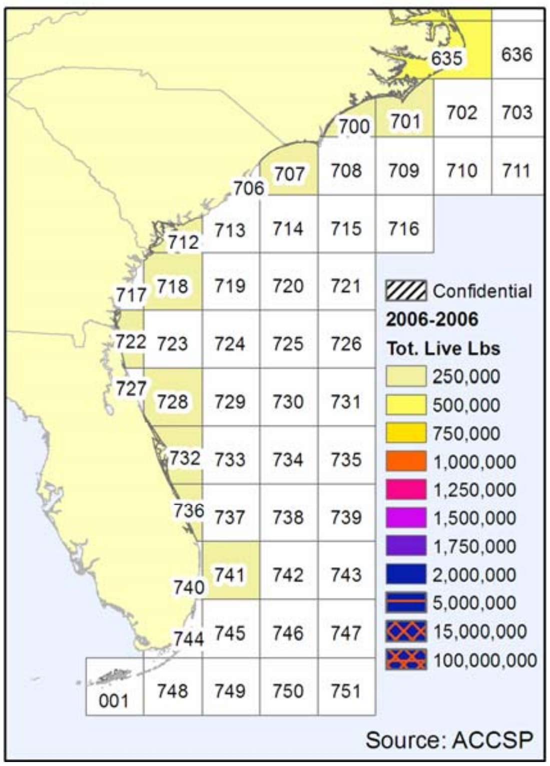
ACCSP Catch: CRAB, GOLDEN DEEPSEA
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	957.21	56.31	Conf.
717	Conf.	Conf.	0.00
728	36.81	2.17	5.15
732	74.75	4.40	0.00
736	21.08	1.24	21.08
741	1,178.92	69.35	259.31
744	3,164.60	186.15	212.75
748	945.07	55.59	0.00

Figure 5.4.1-13. Spatial Presentation of Golden Crab Commercial Catch (Source: ACCSP).



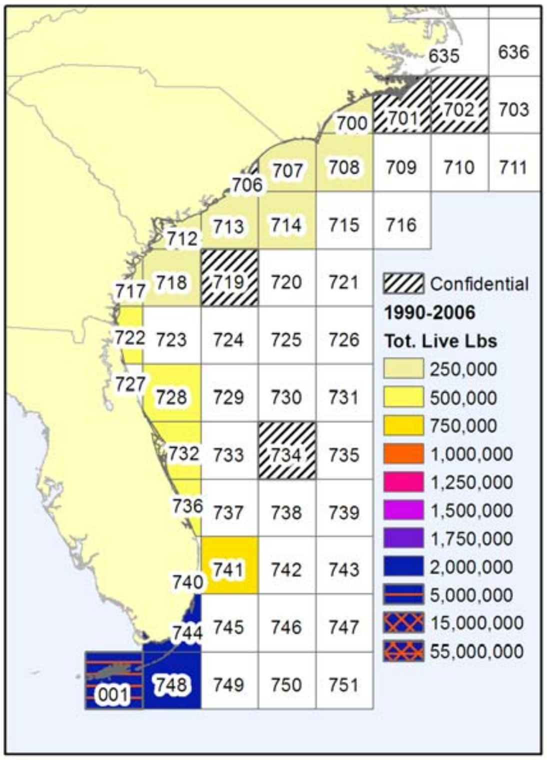


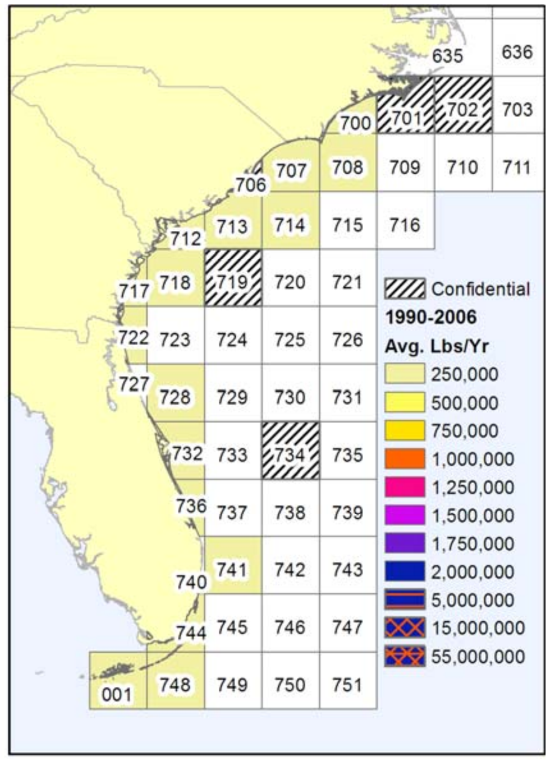


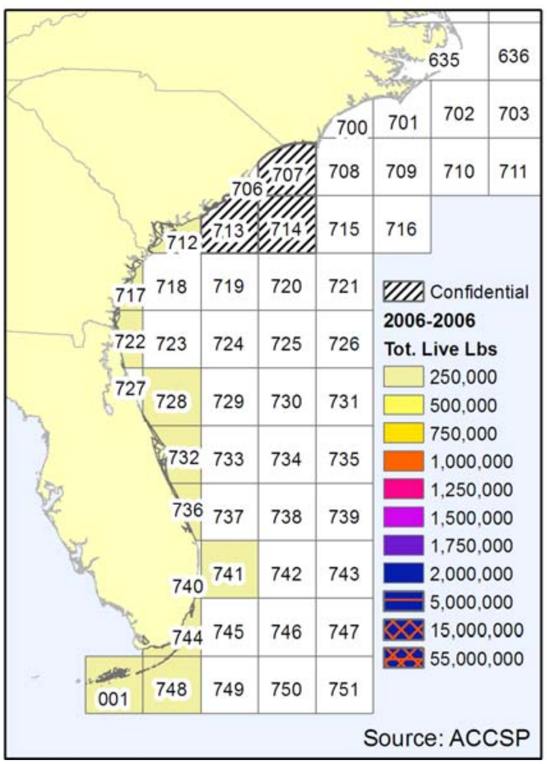
ACCSP Catch: CROAKER, ATLANTIC
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	5.26	0.31	0.00
635	99,584.17	5,857.89	382.44
700	321.63	18.92	1.74
701	24,715.00	1,453.82	3.84
706	Conf.	Conf.	0.00
707	2.82	0.17	0.15
712	0.10	0.01	0.00
717	Conf.	Conf.	0.00
718	0.01	0.00	0.01
722	147.75	8.69	1.17
728	7.93	0.47	0.00
732	44.88	2.64	8.94
736	167.25	9.84	13.77
741	40.11	2.36	1.91
744	1.29	0.08	0.00
748	Conf.	Conf.	0.00

Figure 5.4.1-14. Spatial Presentation of Atlantic Croaker Commercial Catch (Source: ACCSP).







ACCSP Catch: DOLPHIN
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	2,094.24	123.19	31.23
700	1.64	0.10	0.00
701	Conf.	Conf.	0.00
702	Conf.	Conf.	0.00
706	Conf.	Conf.	0.00
707	13.99	0.82	Conf.
708	23.16	1.36	0.00
712	68.86	4.05	19.80
713	57.51	3.38	Conf.
714	135.75	7.99	Conf.
717	97.44	5.73	37.09
718	0.47	0.03	0.00
719	Conf.	Conf.	0.00
722	405.69	23.86	19.90
728	456.96	26.88	14.02
732	450.34	26.49	22.10
734	Conf.	Conf.	0.00
736	490.79	28.87	13.25
741	718.54	42.27	16.28
744	1,762.87	103.70	43.80
748	1,984.22	116.72	77.72

Figure 5.4.1-15. Spatial Presentation of Dolphin Commercial Catch (Source: ACCSP).

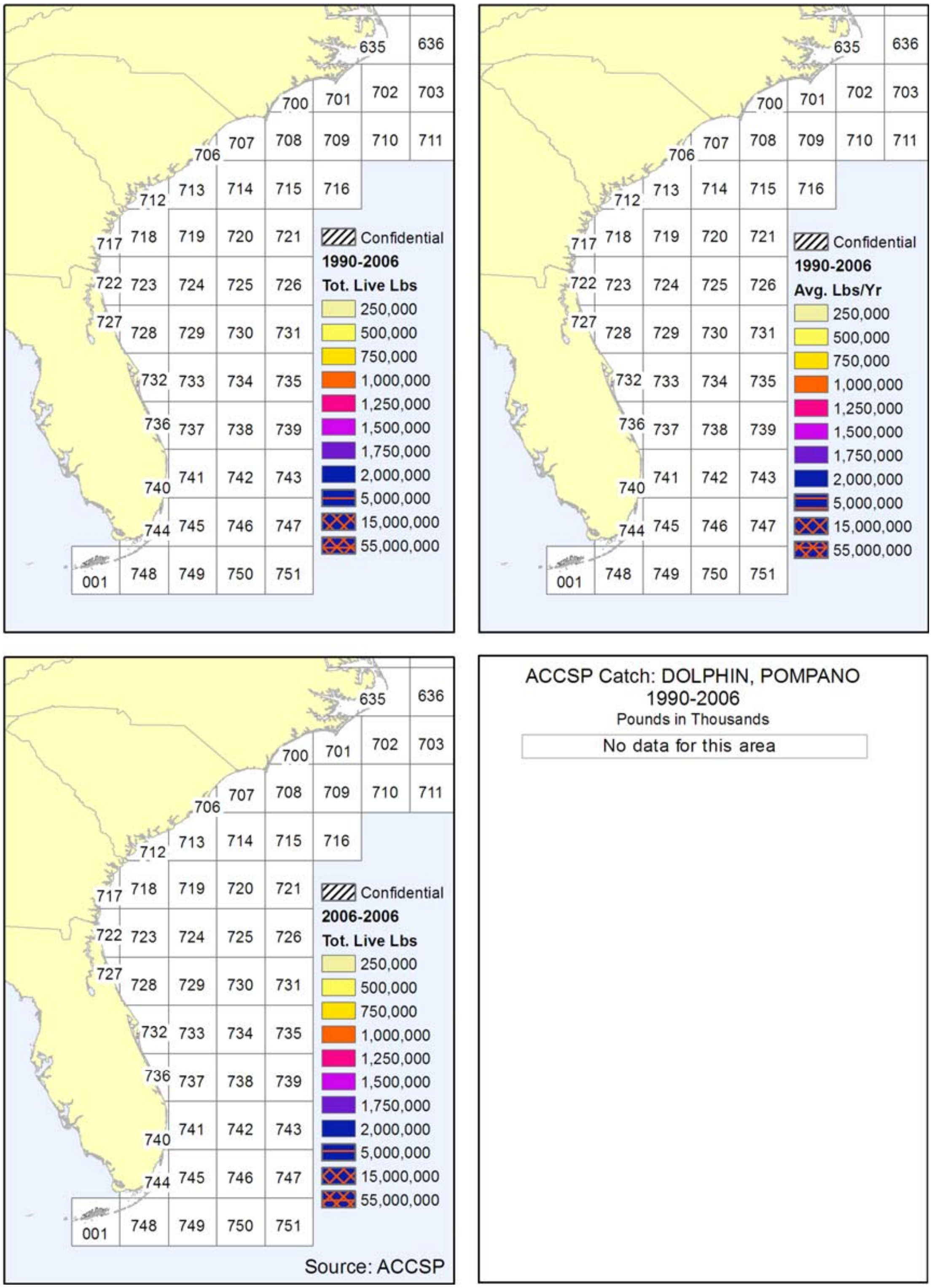
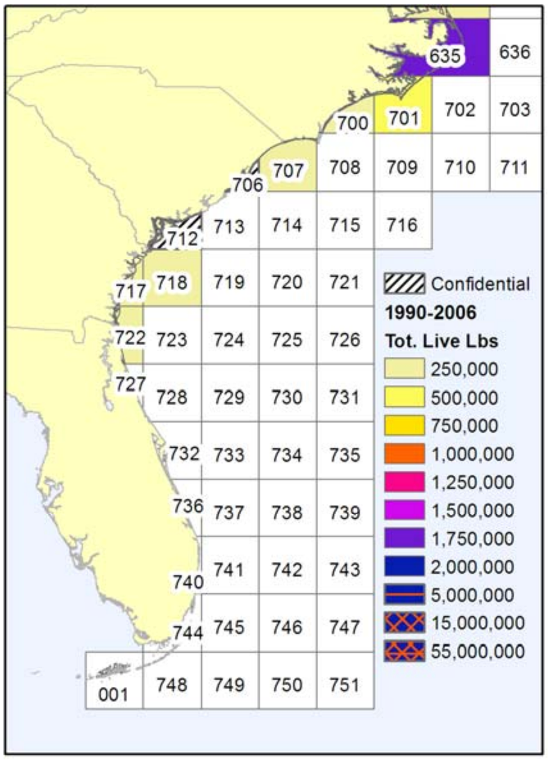
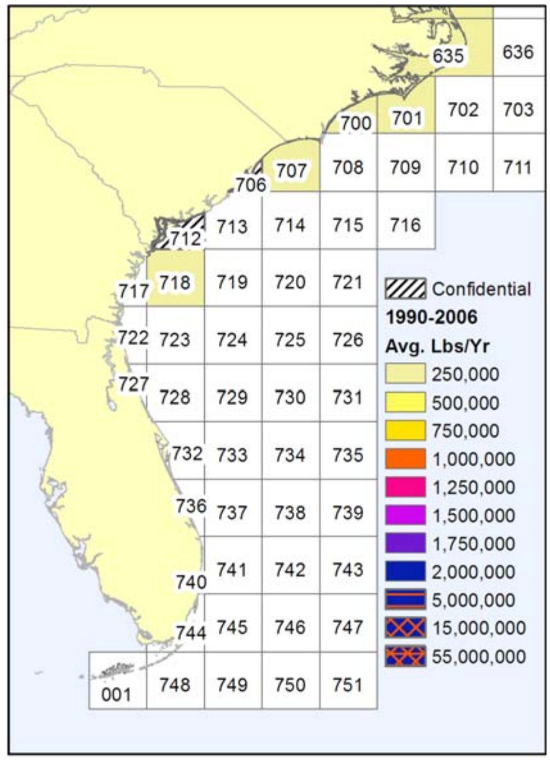
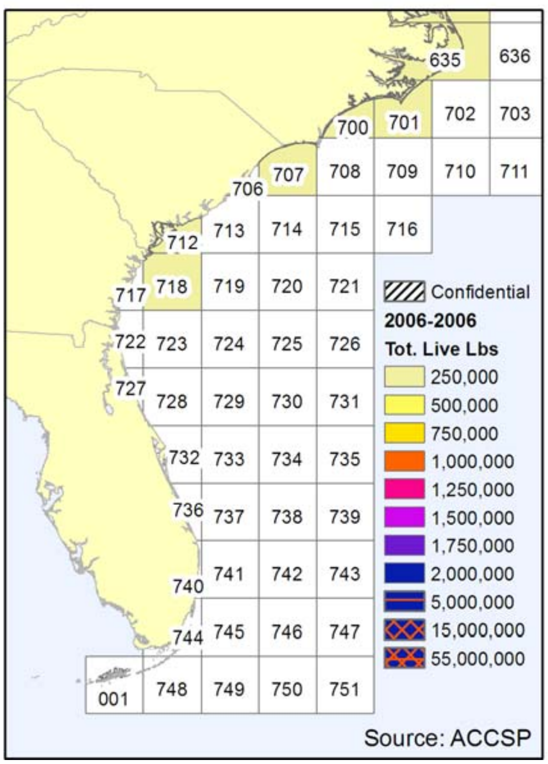


Figure 5.4.1-16. Spatial Presentation of Pompano Dolphin Commercial Catch (Source: ACCSP).



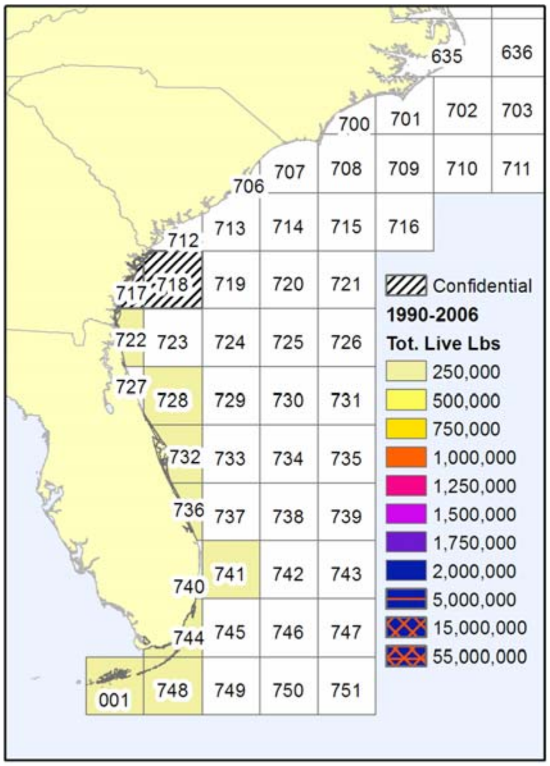


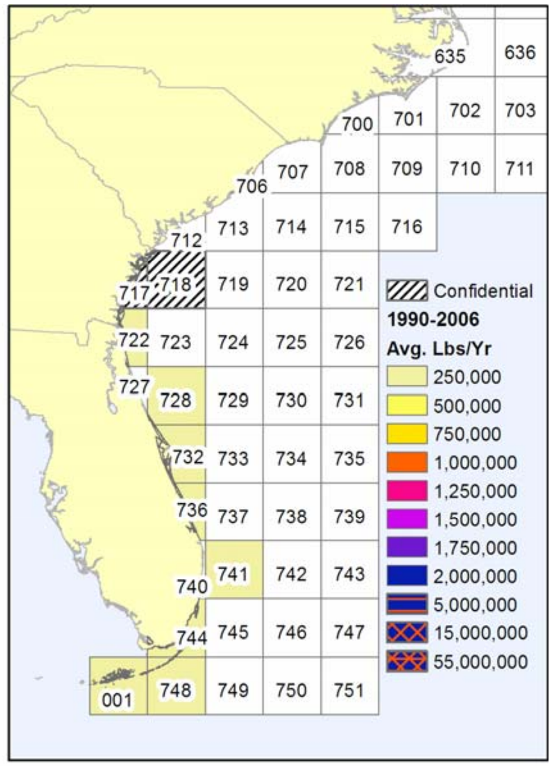


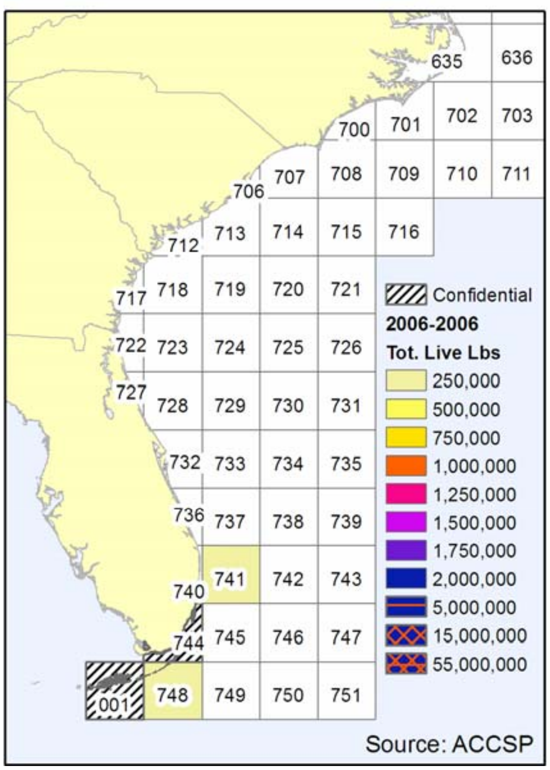
ACCSP Catch: DRUM, RED
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
635	1,732.09	101.89	44.01
700	248.51	14.62	21.32
701	441.30	25.96	15.48
706	Conf.	Conf.	0.00
707	6.30	0.37	1.14
712	Conf.	Conf.	0.10
717	0.03	0.00	0.00
718	0.42	0.02	0.34
722	0.02	0.00	0.00

Figure 5.4.1-17. Spatial Presentation of Red Drum Commercial Catch (Source: ACCSP).



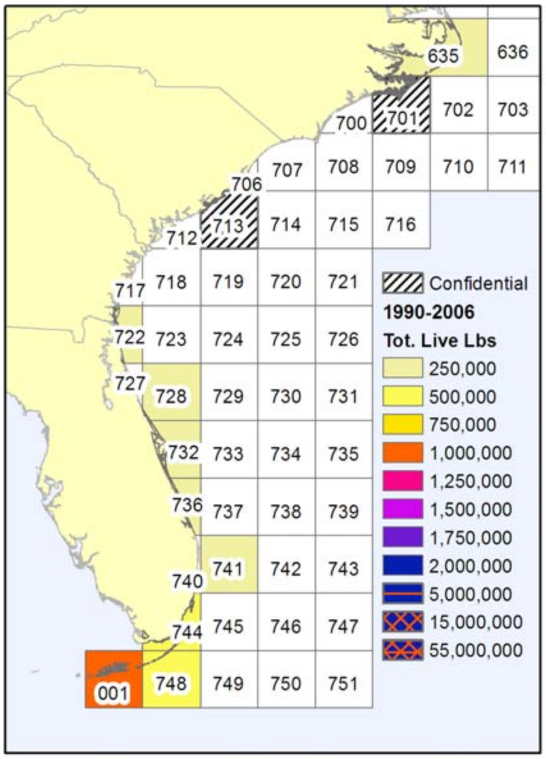


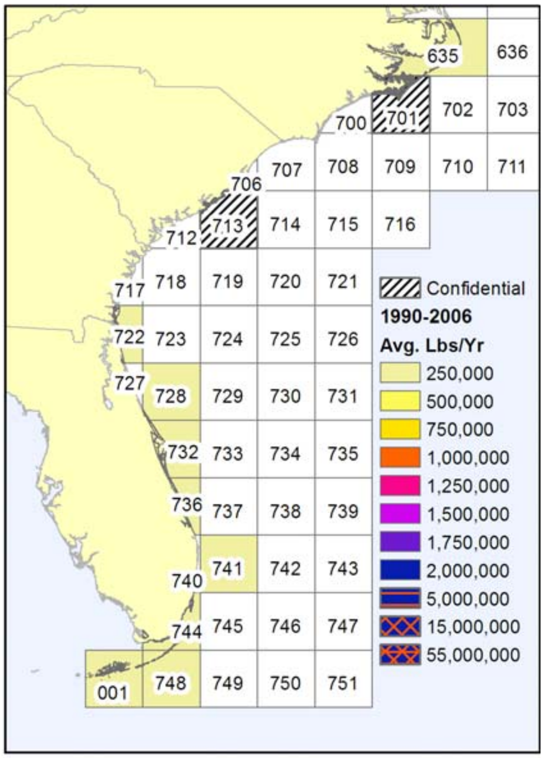


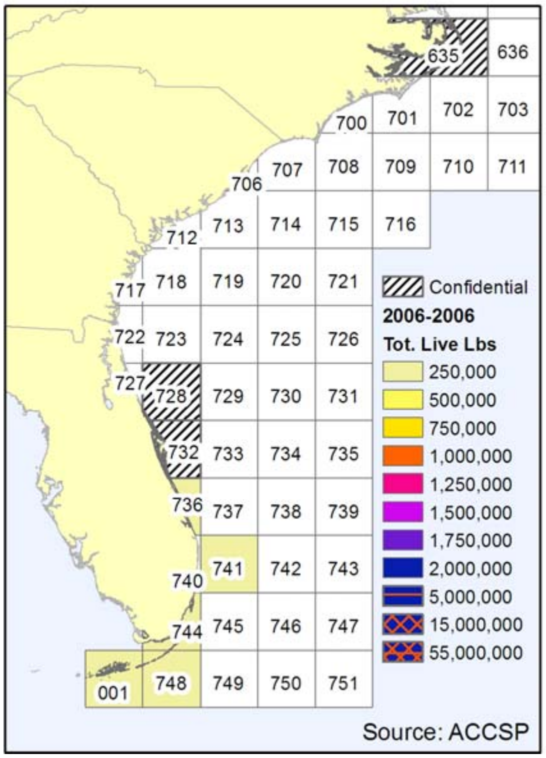
ACCSP Catch: GRAYSBY
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	1.54	0.09	Conf.
701	0.00	0.00	0.00
717	Conf.	Conf.	0.00
718	Conf.	Conf.	0.00
722	19.27	1.13	0.00
728	3.34	0.20	0.00
732	19.99	1.18	0.00
736	7.74	0.46	0.00
741	7.20	0.42	0.50
744	0.17	0.01	Conf.
748	1.56	0.09	0.06

Figure 5.4.1-18. Spatial Presentation of Graysby Commercial Catch (Source: ACCSP).



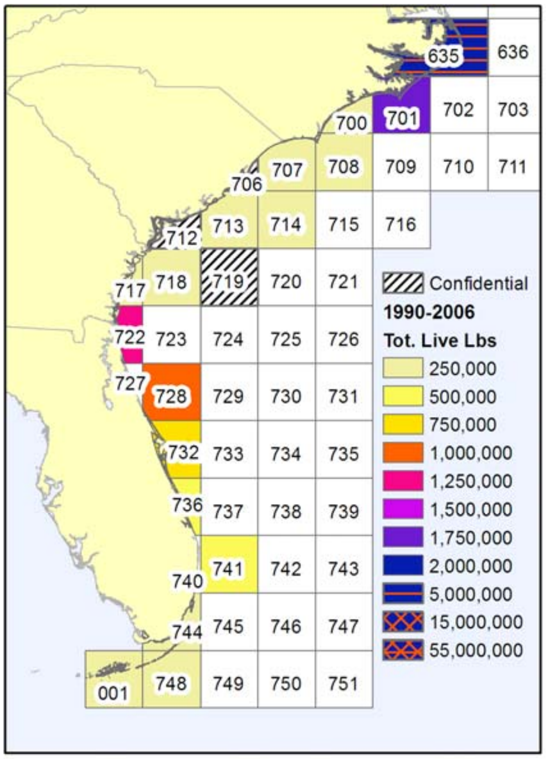


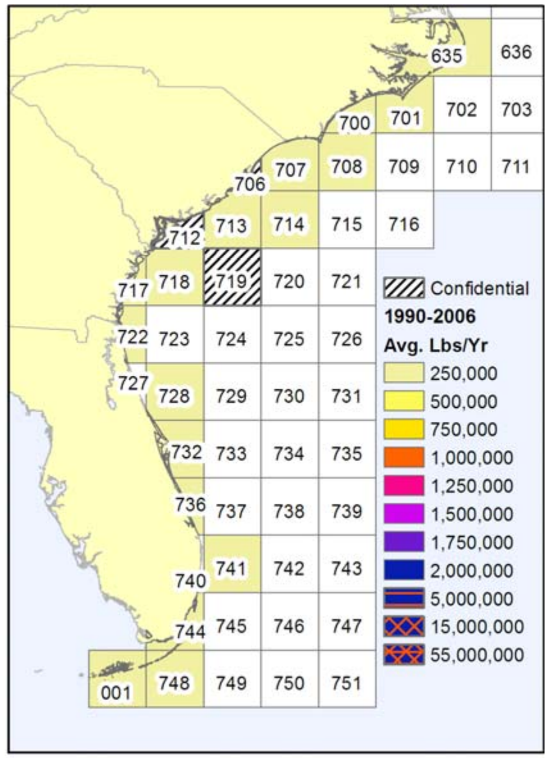


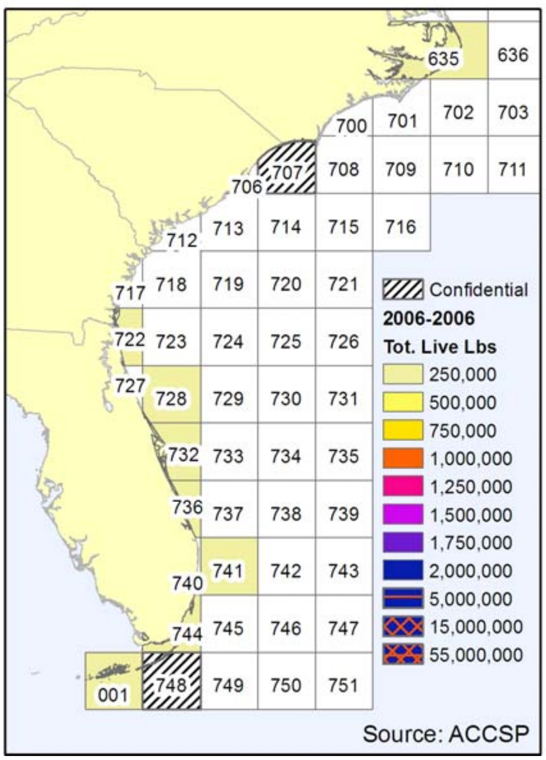
ACCSP Catch: GROUPER, BLACK
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	772.70	45.45	31.58
635	0.98	0.06	Conf.
701	Conf.	Conf.	0.00
713	Conf.	Conf.	0.00
722	6.74	0.40	0.00
728	15.95	0.94	Conf.
732	96.03	5.65	Conf.
736	54.26	3.19	4.42
741	133.53	7.85	1.87
744	306.99	18.06	12.09
748	376.13	22.13	21.57

Figure 5.4.1-19. Spatial Presentation of Black Grouper Commercial Catch (Source: ACCSP).





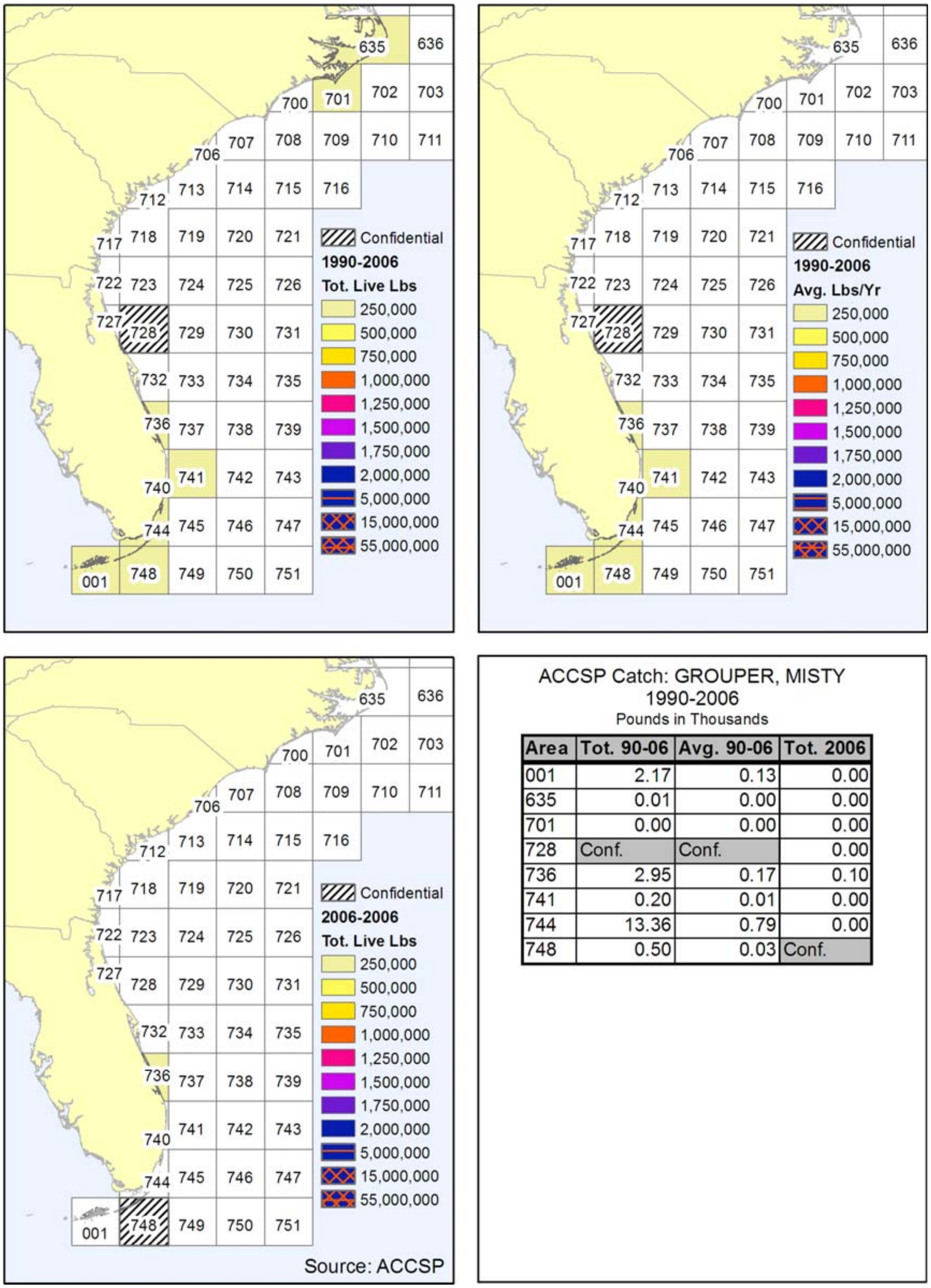


ACCSP Catch: GROUPER, GAG
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	44.58	2.62	3.19
635	2,246.83	132.17	195.33
700	34.93	2.05	0.00
701	1,696.83	99.81	0.00
706	Conf.	Conf.	0.00
707	208.77	12.28	Conf.
708	50.04	2.94	0.00
712	Conf.	Conf.	0.00
713	159.33	9.37	0.00
714	19.25	1.13	0.00
717	3.56	0.21	0.00
718	6.20	0.36	0.00
719	Conf.	Conf.	0.00
722	1,065.84	62.70	20.33
728	884.13	52.01	25.96
732	529.57	31.15	31.34
736	378.70	22.28	18.91
741	261.69	15.39	4.52
744	28.68	1.69	0.66
748	5.46	0.32	Conf.

Figure 5.4.1-20. Spatial Presentation of Gag Grouper Commercial Catch (Source: ACCSP).

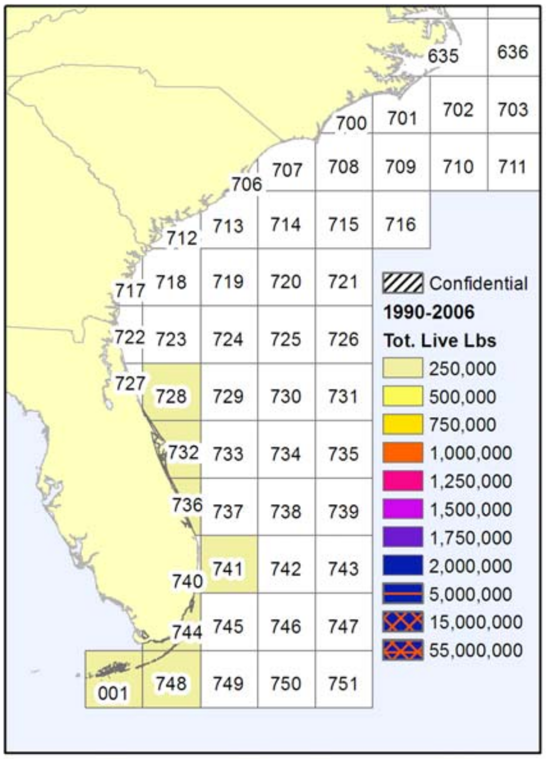
Appendix B. Spatial Presentations of commercial catch ACCSP

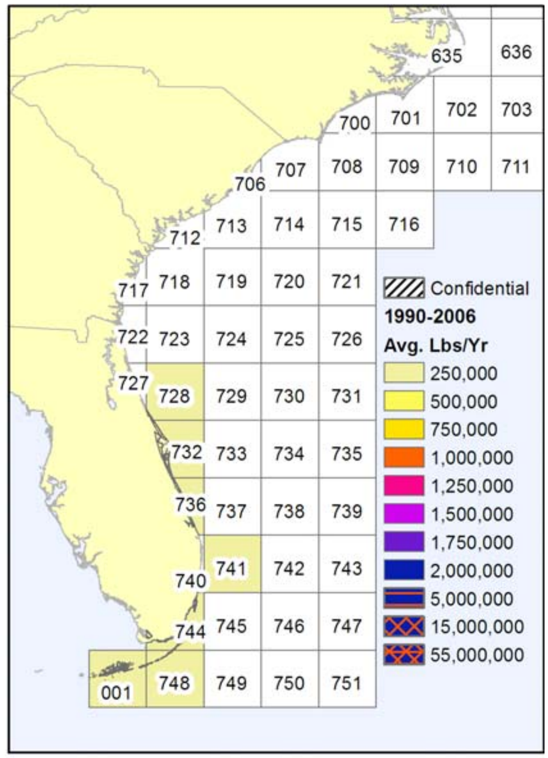


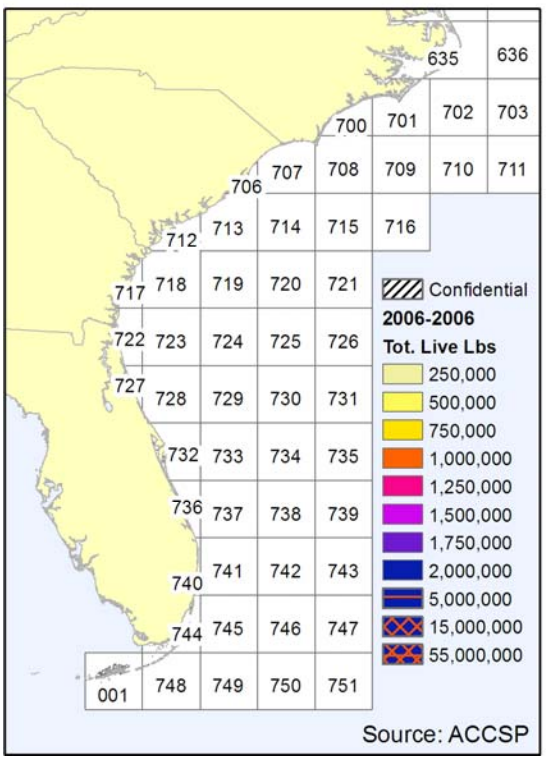
ACCSP Catch: GROUPER, MISTY
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	2.17	0.13	0.00
635	0.01	0.00	0.00
701	0.00	0.00	0.00
728	Conf.	Conf.	0.00
736	2.95	0.17	0.10
741	0.20	0.01	0.00
744	13.36	0.79	0.00
748	0.50	0.03	Conf.

Figure 5.4.1-21. Spatial Presentation of Misty Grouper Commercial Catch (Source: ACCSP).



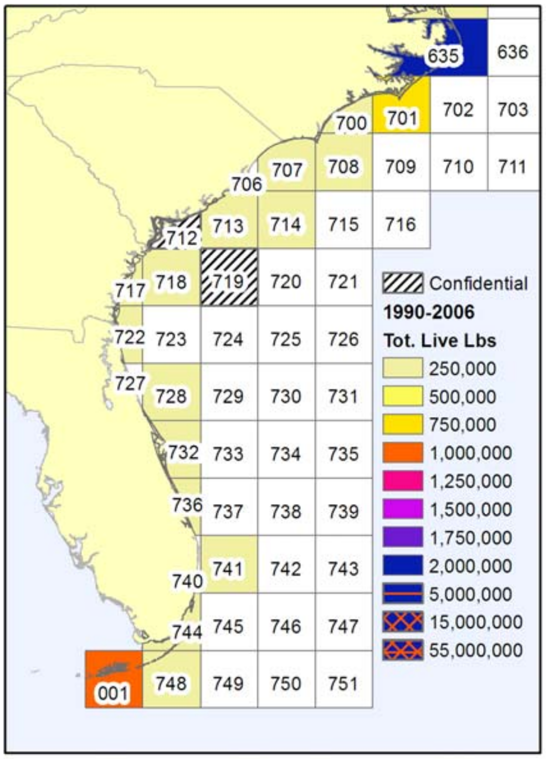


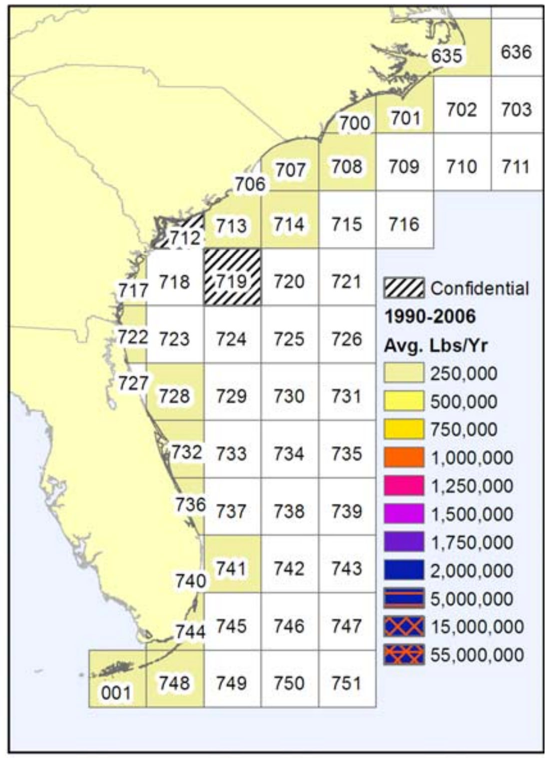


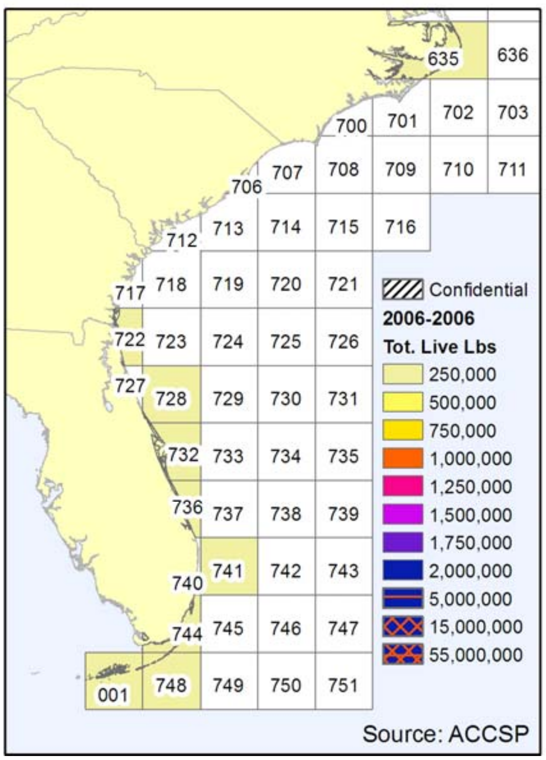
ACCSP Catch: GROUPER, NASSAU
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	0.07	0.00	0.00
728	1.91	0.11	0.00
732	0.59	0.03	0.00
736	0.09	0.01	0.00
741	1.10	0.06	0.00
744	0.41	0.02	0.00
748	0.18	0.01	0.00

Figure 5.4.1-22. Spatial Presentation of Nassau Grouper Commercial Catch (Source: ACCSP).





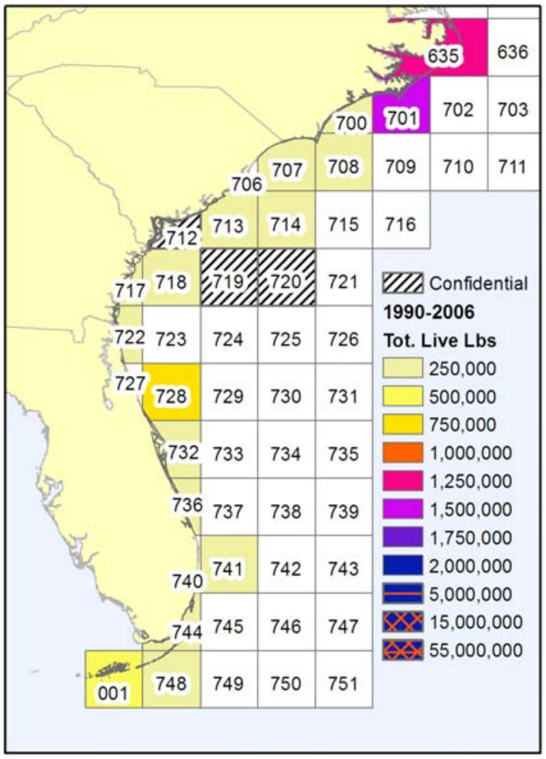


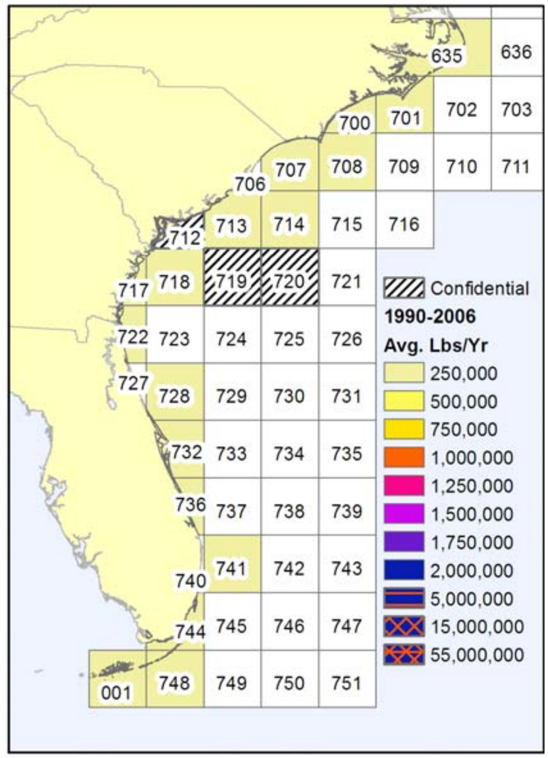
ACCSP Catch: GROUPER, RED
1990-2006
Pounds in Thousands

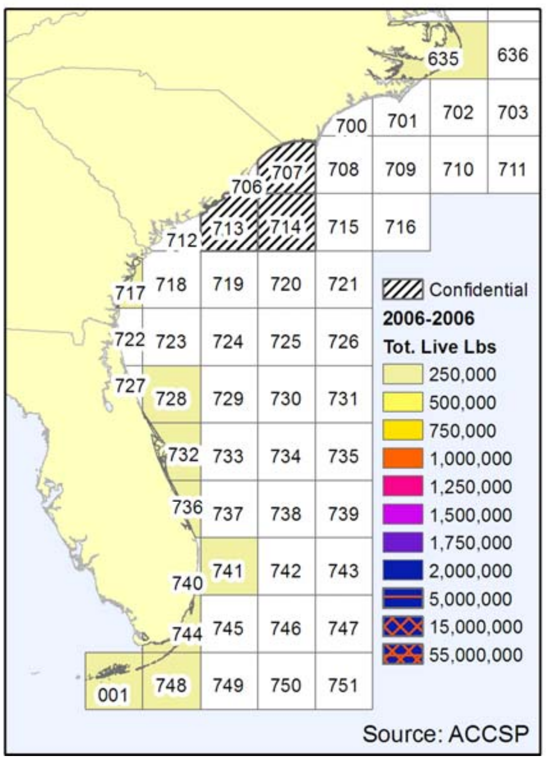
Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	781.23	45.95	18.43
635	1,886.43	110.97	189.20
700	20.68	1.22	0.00
701	576.26	33.90	0.00
707	27.66	1.63	0.00
708	16.51	0.97	0.00
712	Conf.	Conf.	0.00
713	11.86	0.70	0.00
714	0.51	0.03	0.00
717	0.11	0.01	0.00
718	0.03	0.00	0.00
719	Conf.	Conf.	0.00
722	51.01	3.00	1.69
728	108.76	6.40	5.44
732	45.57	2.68	2.08
736	37.56	2.21	1.02
741	42.01	2.47	0.72
744	113.65	6.69	3.97
748	147.27	8.66	1.56

Figure 5.4.1-23. Spatial Presentation of Red Grouper Commercial Catch (Source: ACCSP).

Appendix B. Spatial Presentations of commercial catch ACCSP





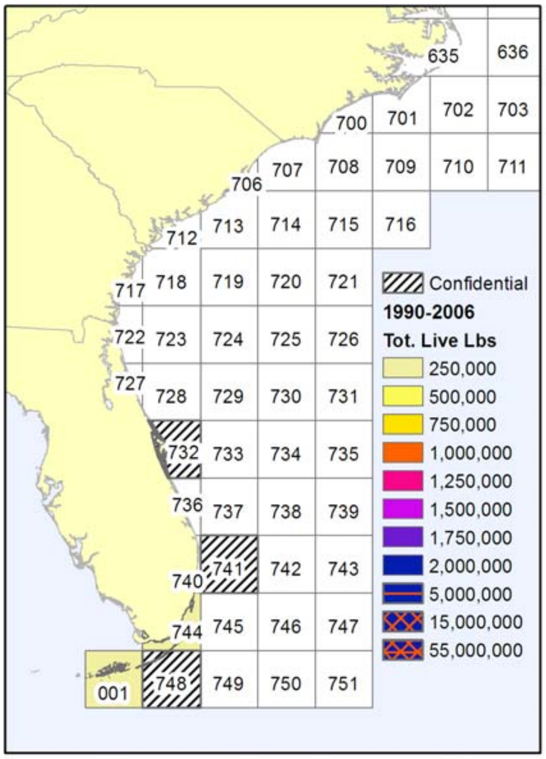


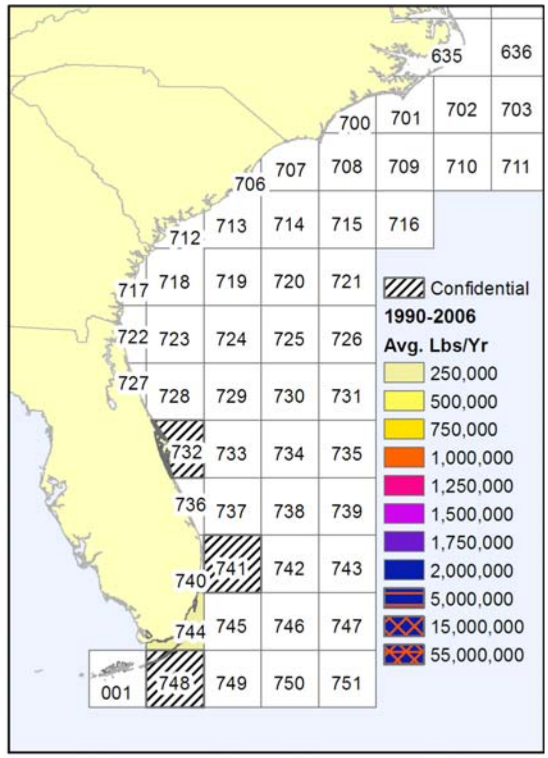
ACCSP Catch: GROUPER, SNOWY
1990-2006
Pounds in Thousands

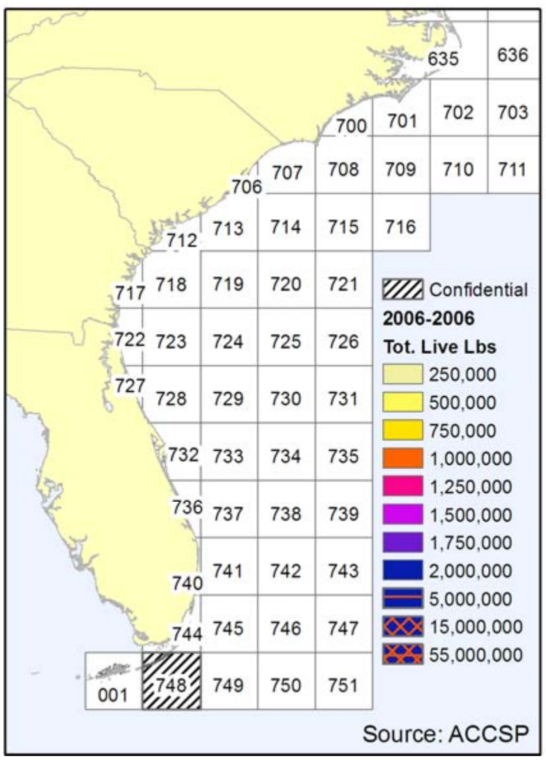
Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	329.64	19.39	9.08
635	1,118.18	65.78	15.87
700	0.19	0.01	0.00
701	1,275.36	75.02	0.00
707	37.92	2.23	Conf.
708	16.44	0.97	0.00
712	Conf.	Conf.	0.00
713	36.20	2.13	Conf.
714	43.13	2.54	Conf.
717	15.88	0.93	3.57
718	0.17	0.01	0.00
719	Conf.	Conf.	0.00
720	Conf.	Conf.	0.00
722	118.74	6.98	0.00
728	608.61	35.80	5.46
732	156.69	9.22	0.80
736	118.14	6.95	4.23
741	137.73	8.10	2.46
744	142.51	8.38	4.55
748	163.86	9.64	12.71

Figure 5.4.1-24. Spatial Presentation of Snowy Grouper Commercial Catch (Source: ACCSP).

Appendix B. Spatial Presentations of commercial catch ACCSP



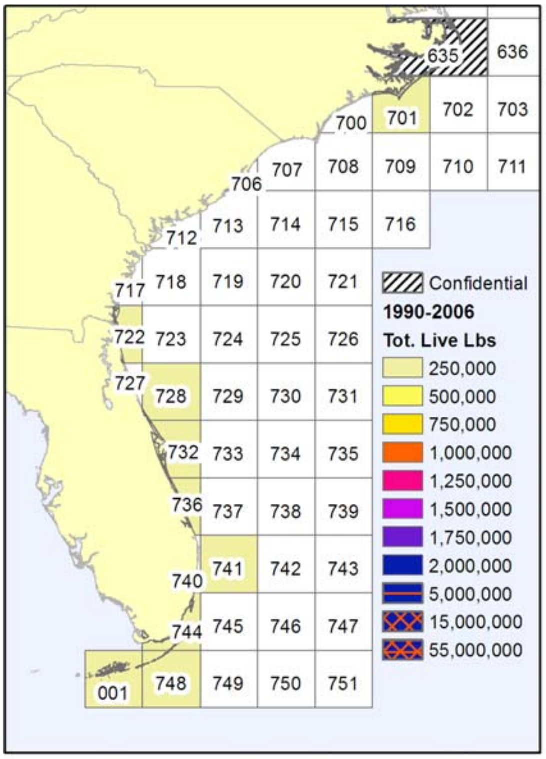


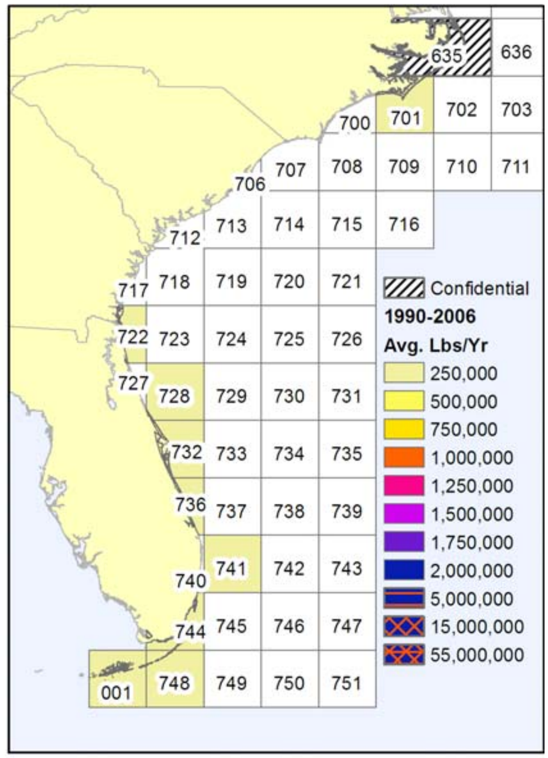


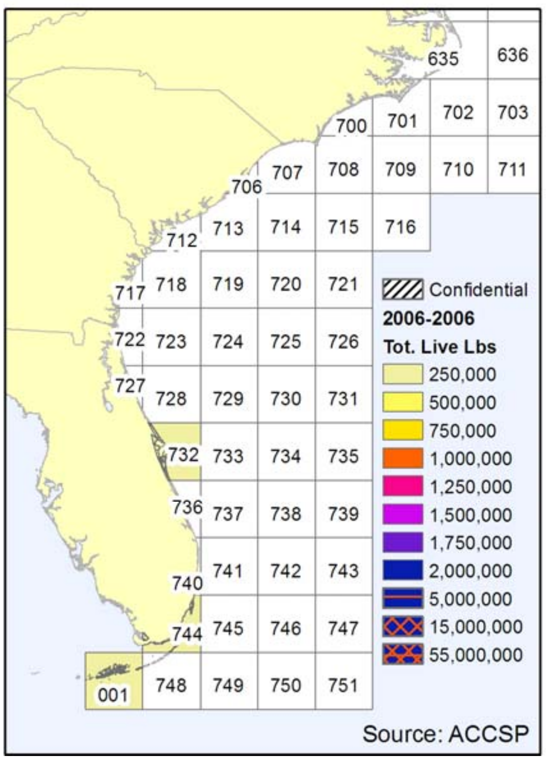
ACCSP Catch: GROUPER, TIGER
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	0.06	0.00	0.00
732	Conf.	Conf.	0.00
741	Conf.	Conf.	0.00
744	0.18	0.01	0.00
748	Conf.	Conf.	Conf.

Figure 5.4.1-25. Spatial Presentation of Tiger Grouper Commercial Catch (Source: ACCSP).



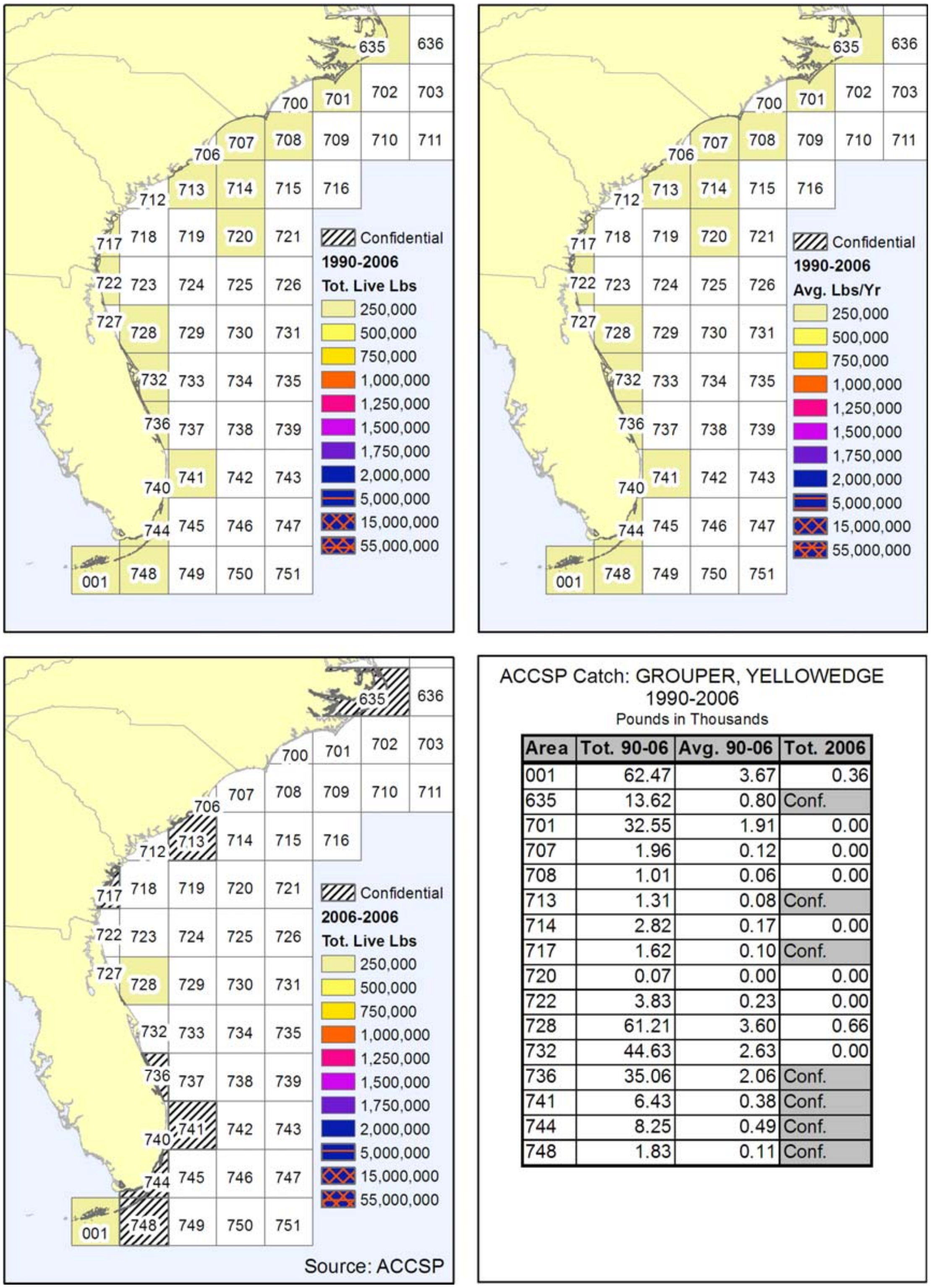




ACCSP Catch: GROUPER, WARSAW
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	9.47	0.56	0.18
635	Conf.	Conf.	0.00
701	2.66	0.16	0.00
722	1.54	0.09	0.00
728	13.70	0.81	0.00
732	18.99	1.12	0.10
736	1.83	0.11	0.00
741	4.34	0.26	0.00
744	4.50	0.26	0.08
748	0.87	0.05	0.00

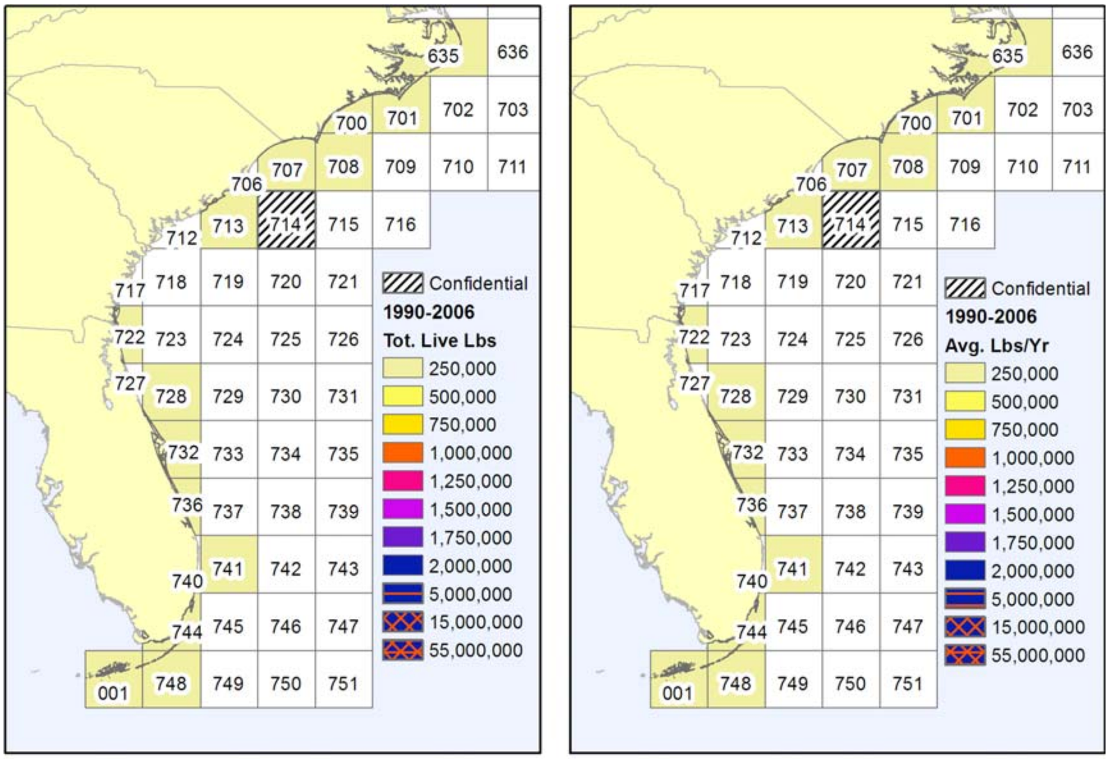
Figure 5.4.1-26. Spatial Presentation of Warsaw Grouper Commercial Catch (Source: ACCSP).

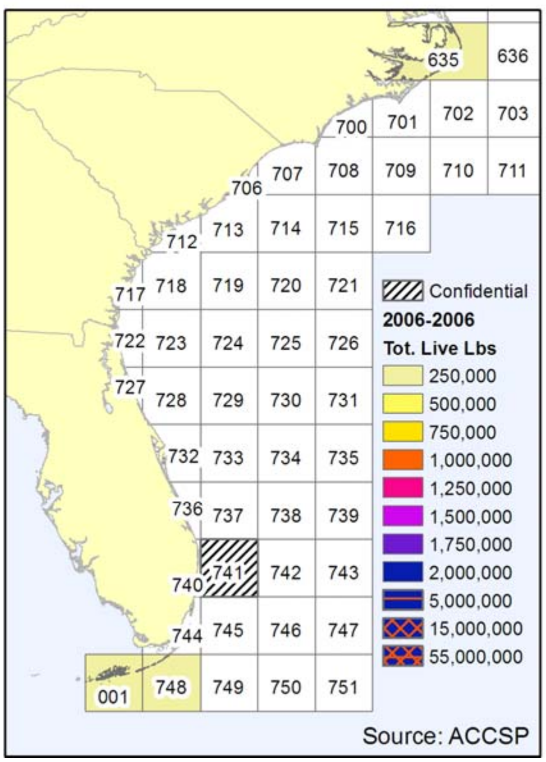


ACCSP Catch: GROUPER, YELLOWEDGE
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	62.47	3.67	0.36
635	13.62	0.80	Conf.
701	32.55	1.91	0.00
707	1.96	0.12	0.00
708	1.01	0.06	0.00
713	1.31	0.08	Conf.
714	2.82	0.17	0.00
717	1.62	0.10	Conf.
720	0.07	0.00	0.00
722	3.83	0.23	0.00
728	61.21	3.60	0.66
732	44.63	2.63	0.00
736	35.06	2.06	Conf.
741	6.43	0.38	Conf.
744	8.25	0.49	Conf.
748	1.83	0.11	Conf.

Figure 5.4.1-27. Spatial Presentation of Yellowedge Grouper Commercial Catch (Source: ACCSP).

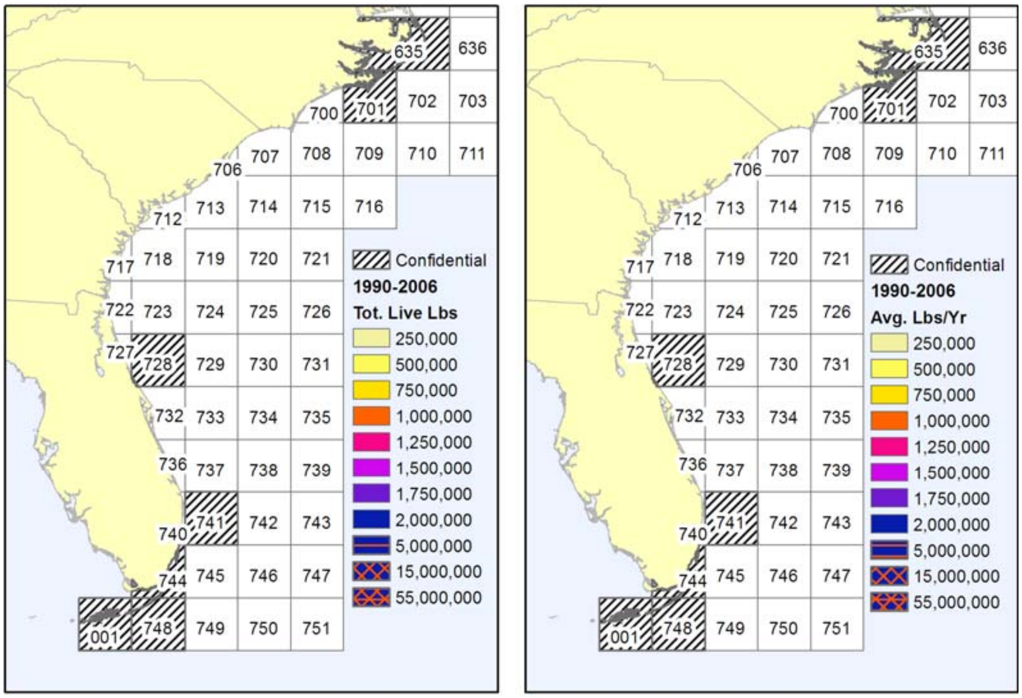


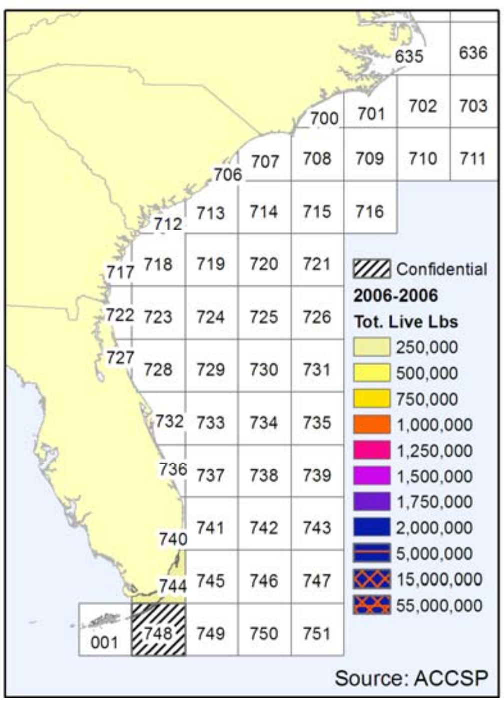


ACCSP Catch: GROUPER, YELLOWFIN
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	2.57	0.15	0.04
635	8.86	0.52	0.81
700	4.14	0.24	0.00
701	15.17	0.89	0.00
707	0.63	0.04	0.00
708	3.14	0.18	0.00
713	0.30	0.02	0.00
714	Conf.	Conf.	0.00
722	0.22	0.01	0.00
728	0.57	0.03	0.00
732	0.51	0.03	0.00
736	0.93	0.05	0.00
741	1.23	0.07	Conf.
744	2.08	0.12	0.00
748	0.52	0.03	0.22

Figure 5.4.1-28. Spatial Presentation of Yellowfin Grouper Commercial Catch (Source: ACCSP).



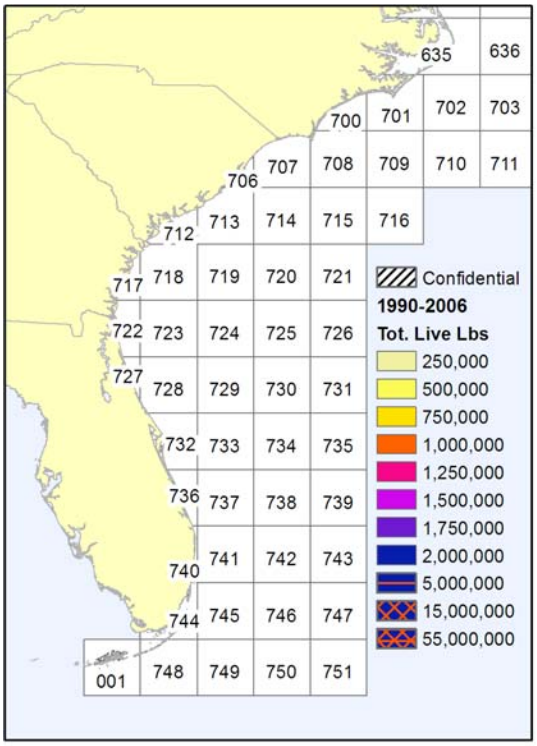


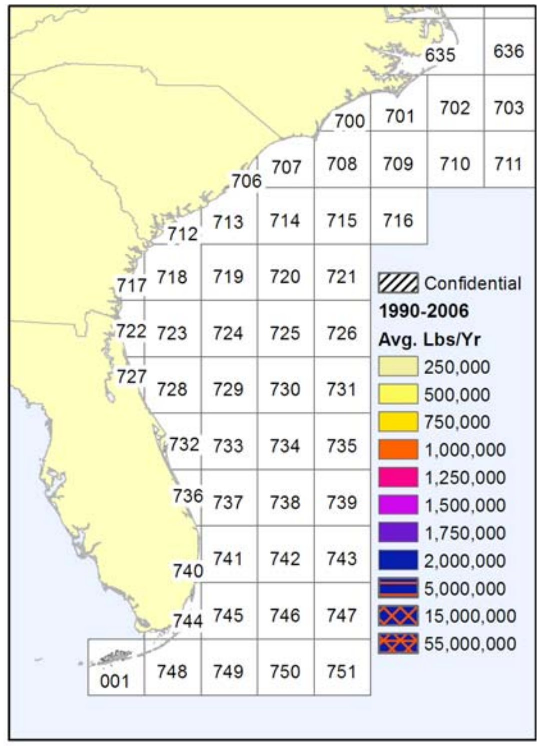
ACCSP Catch: GROUPER, YELLOWMOUTH
1990-2006
Pounds in Thousands

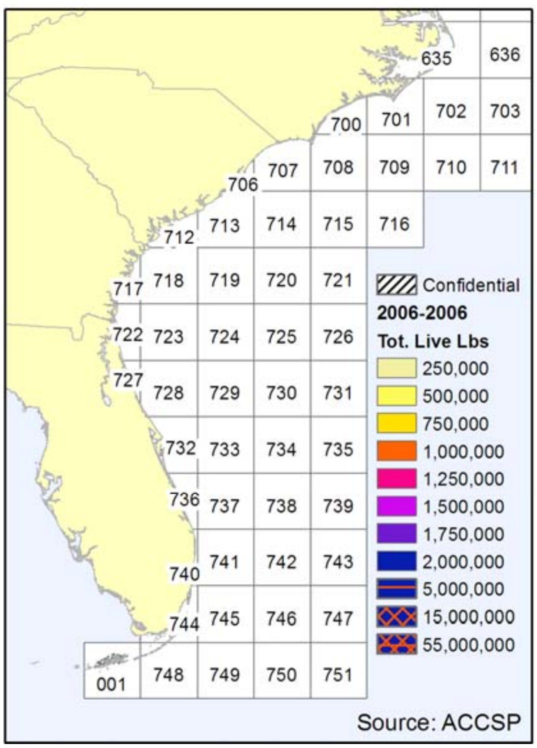
Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	Conf.	Conf.	0.00
635	Conf.	Conf.	0.00
701	Conf.	Conf.	0.00
728	Conf.	Conf.	0.00
741	Conf.	Conf.	0.00
744	Conf.	Conf.	0.02
748	Conf.	Conf.	Conf.

Figure 5.4.1-29. Spatial Presentation of Yellowmouth Grouper Commercial Catch (Source: ACCSP).

Appendix B. Spatial Presentations of commercial catch ACCSP



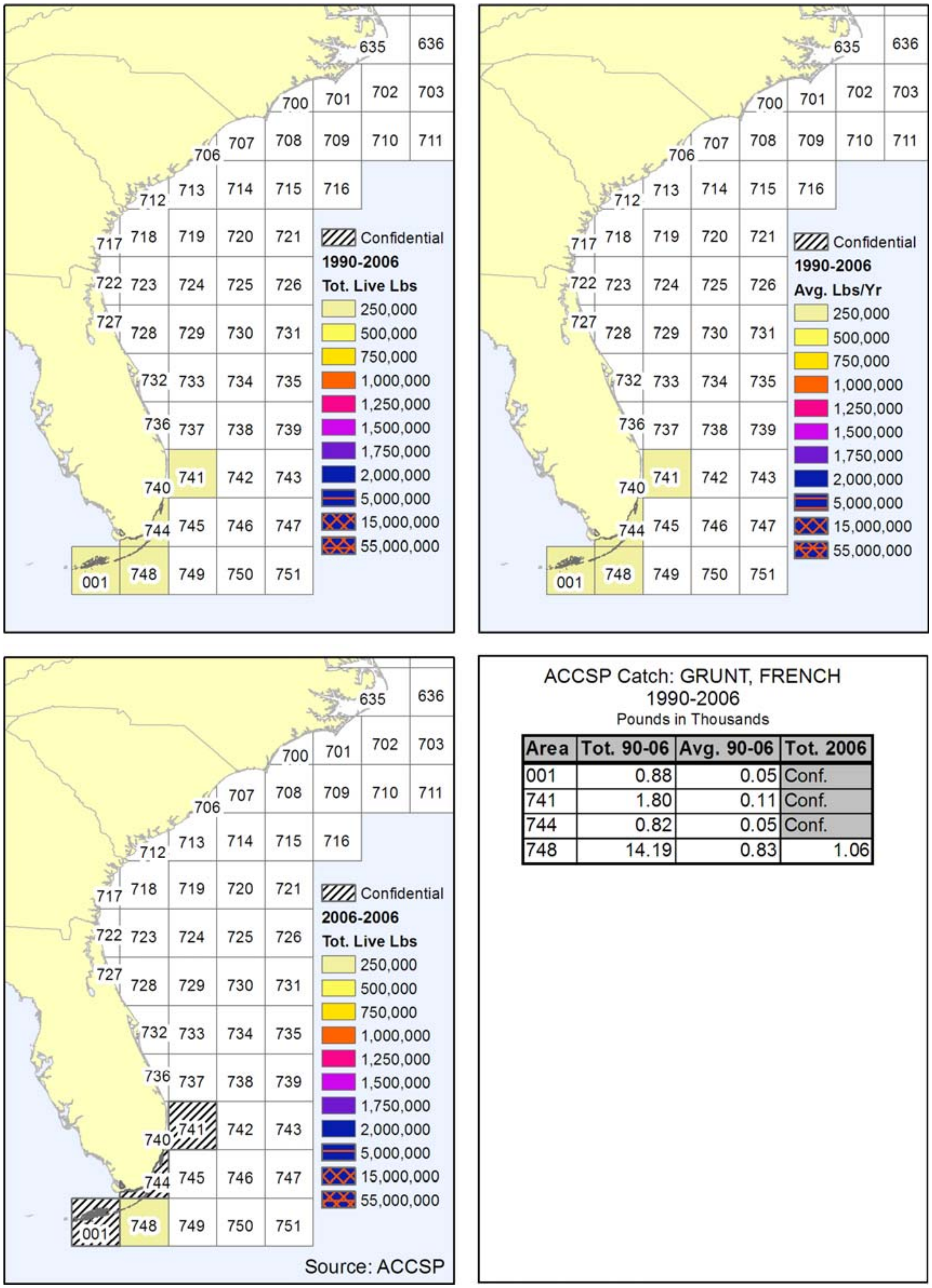




ACCSP Catch: GRUNT, BLUESTRIPED
1990-2006
Pounds in Thousands

No data for this area

Figure 5.4.1-30. Spatial Presentation of Bluestriped Grunt Commercial Catch (Source: ACCSP).



ACCSP Catch: GRUNT, FRENCH
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	0.88	0.05	Conf.
741	1.80	0.11	Conf.
744	0.82	0.05	Conf.
748	14.19	0.83	1.06

Figure 5.4.1-31. Spatial Presentation of French Grunt Commercial Catch (Source: ACCSP).

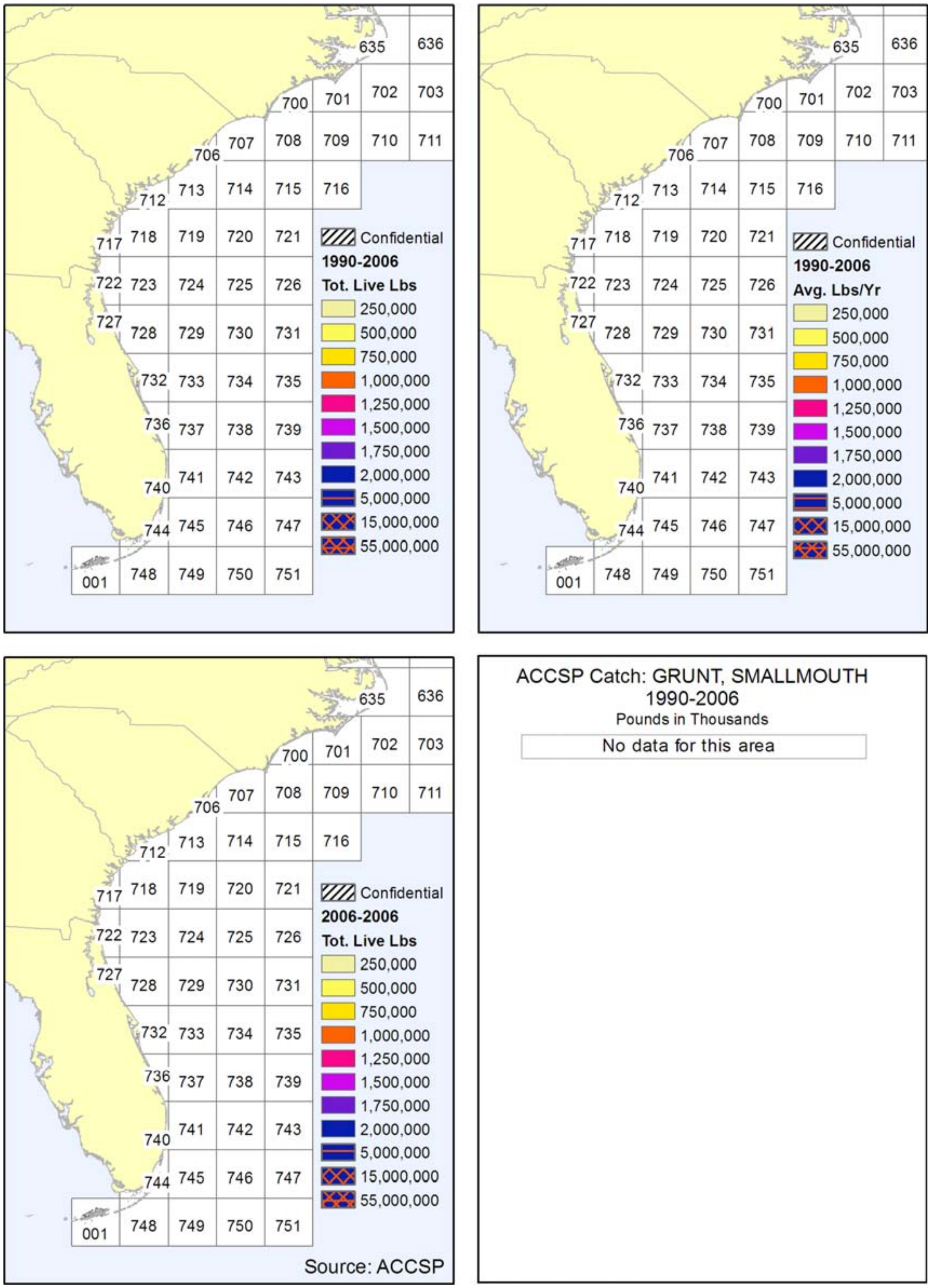


Figure 5.4.1-32. Spatial Presentation of Smallmouth Grunt Commercial Catch (Source: ACCSP).

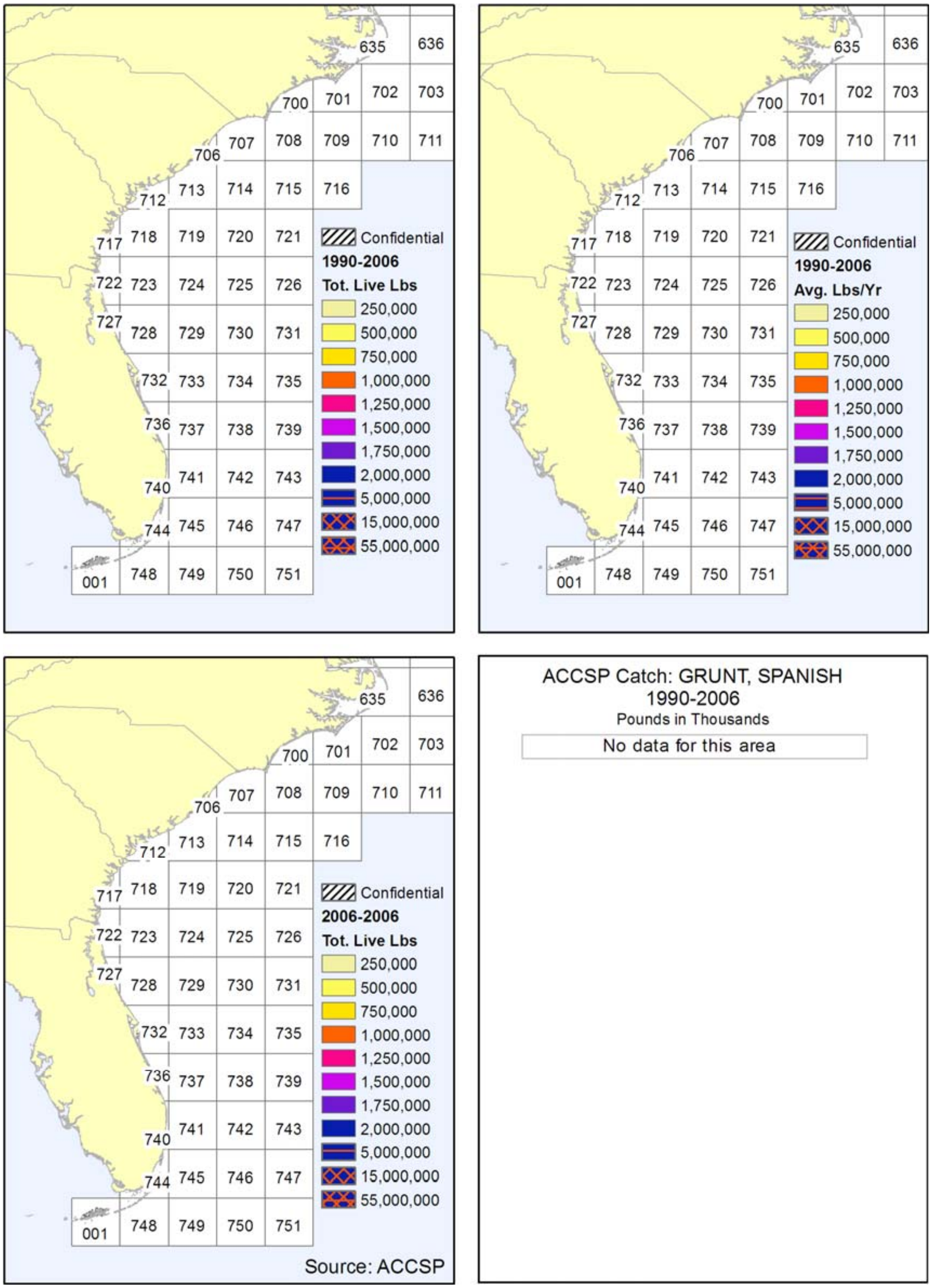
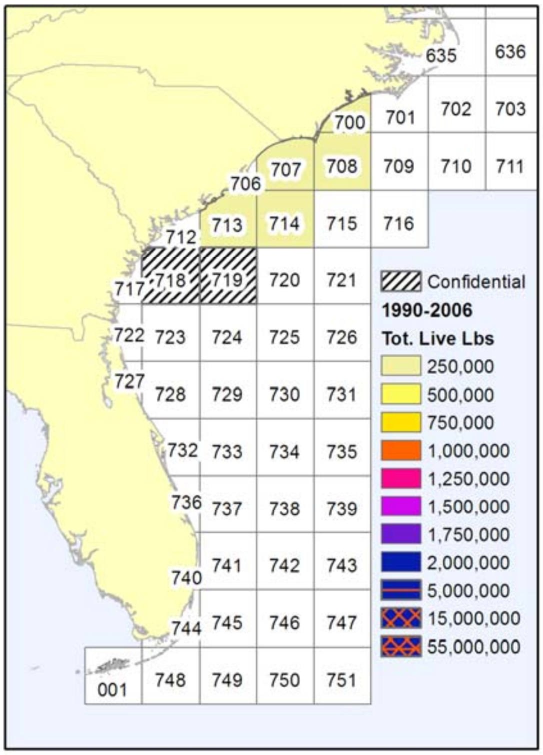
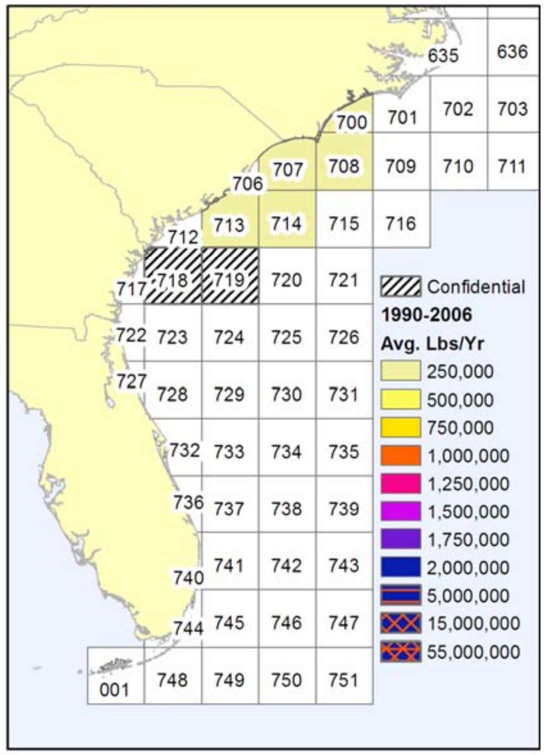
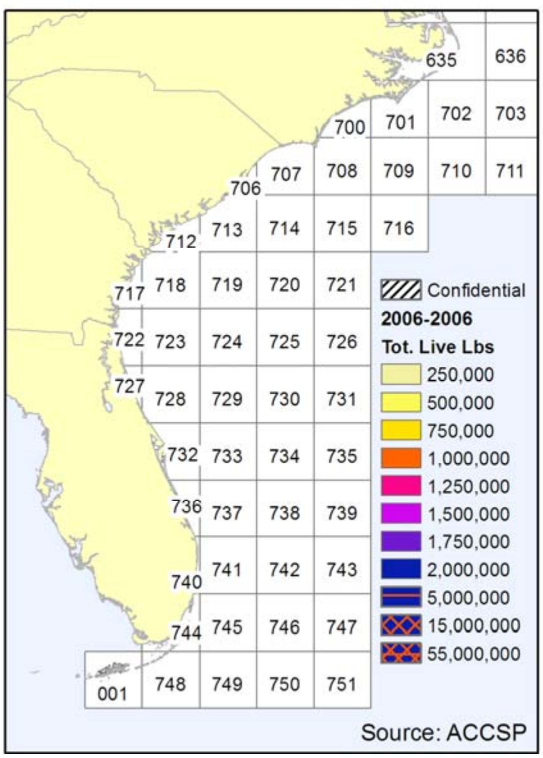


Figure 5.4.1-33. Spatial Presentation of Spanish Grunt Commercial Catch (Source: ACCSP).







ACCSP Catch: GRUNT, WHITE
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
700	3.47	0.20	0.00
707	21.49	1.26	0.00
708	1.67	0.10	0.00
713	8.18	0.48	0.00
714	0.61	0.04	0.00
718	Conf.	Conf.	0.00
719	Conf.	Conf.	0.00

Figure 5.4.1-34. Spatial Presentation of White Grunt Commercial Catch (Source: ACCSP).

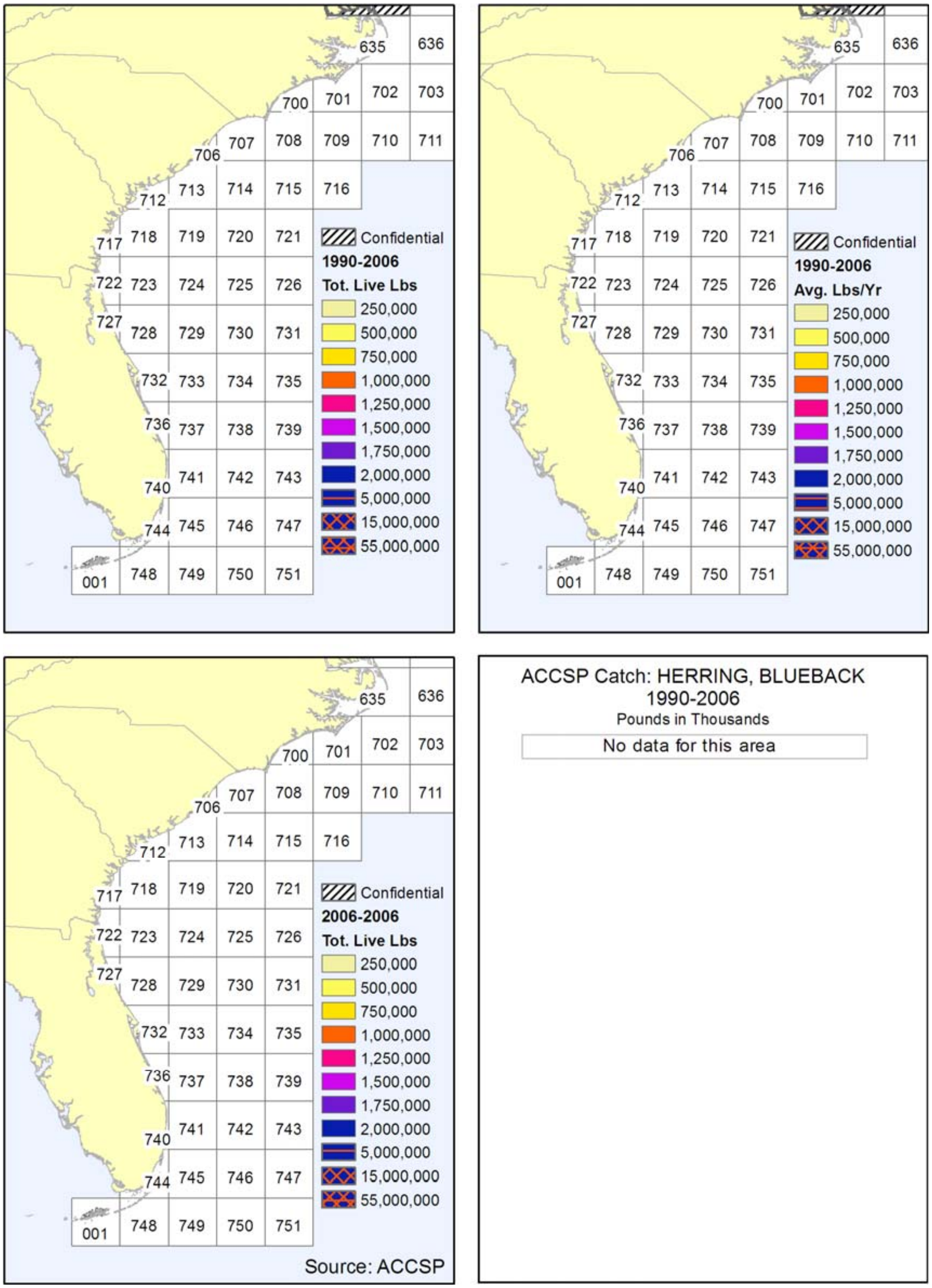
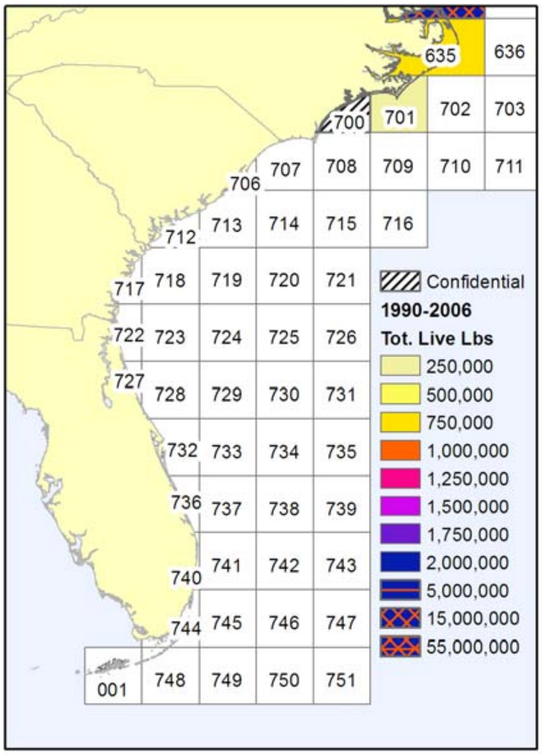
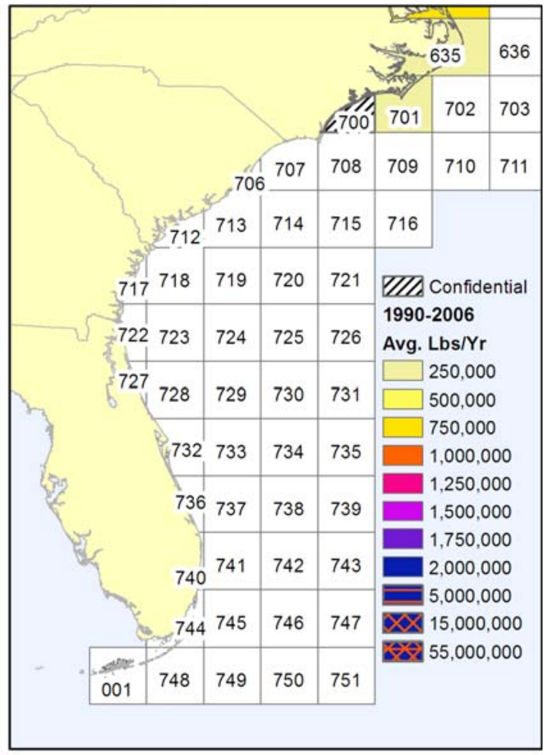
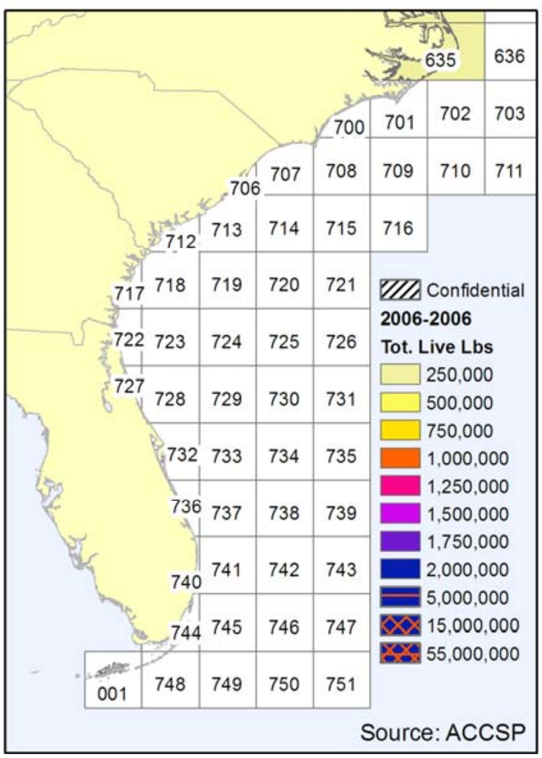


Figure 5.4.1-35. Spatial Presentation of Blueback Herring Commercial Catch (Source: ACCSP).



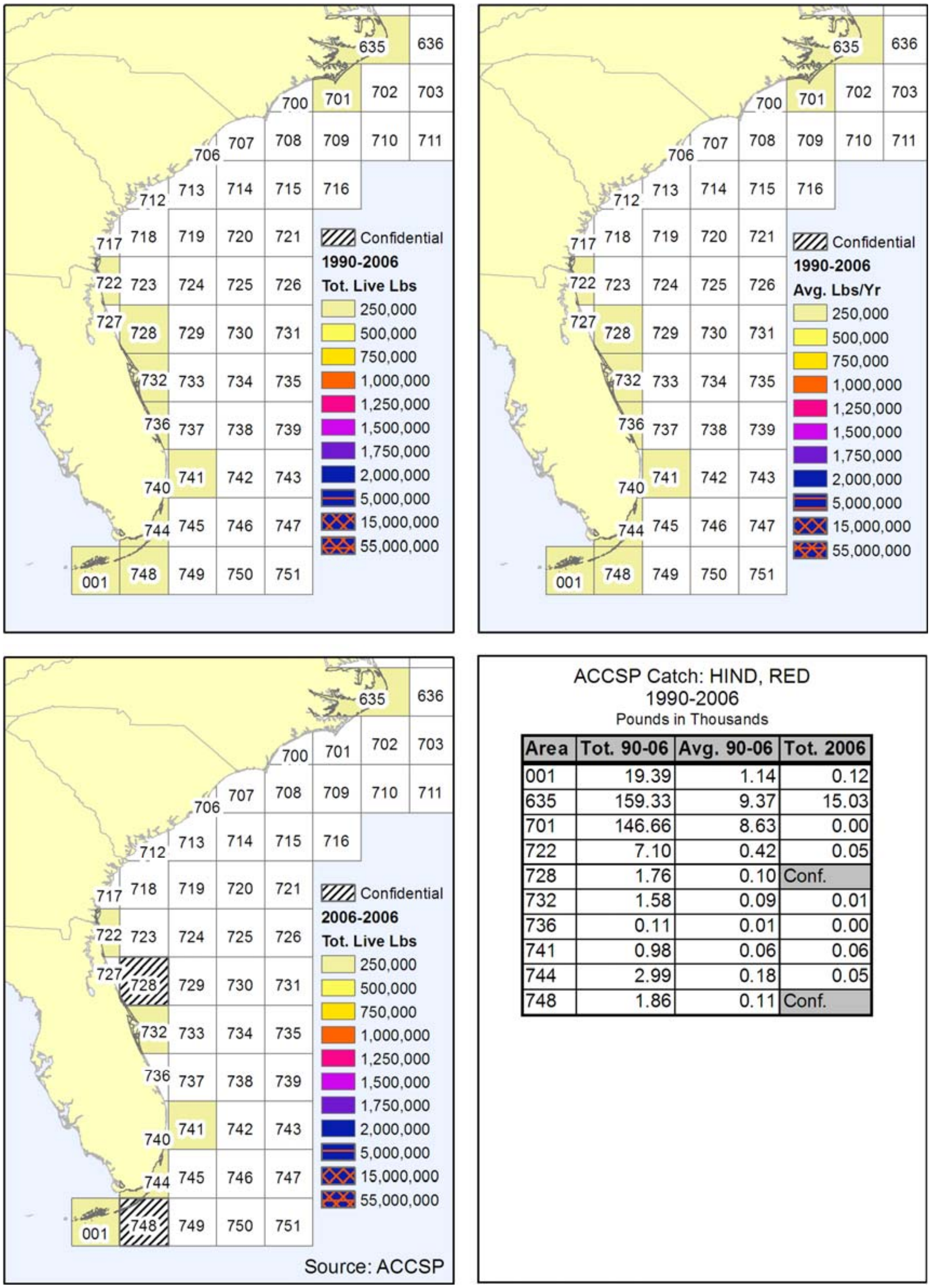




ACCSP Catch: HERRINGS, RIVER
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
635	690.05	40.59	13.46
700	Conf.	Conf.	0.00
701	180.32	10.61	0.00

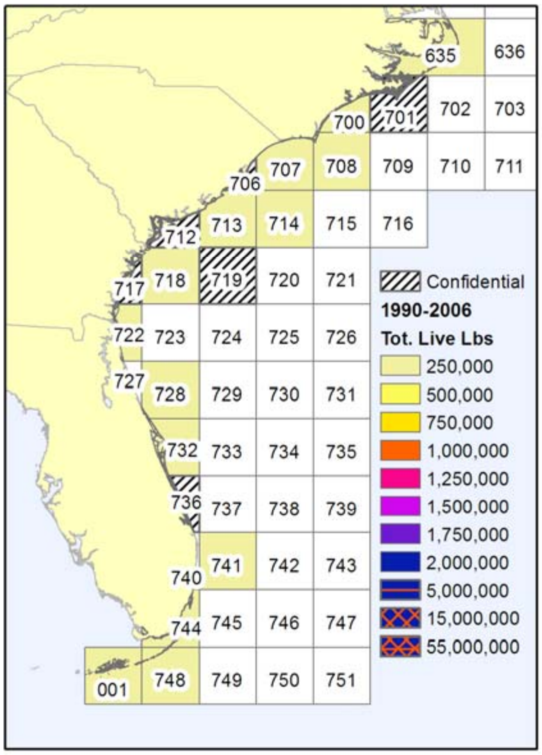
Figure 5.4.1-36. Spatial Presentation of River Herring Commercial Catch (Source: ACCSP).

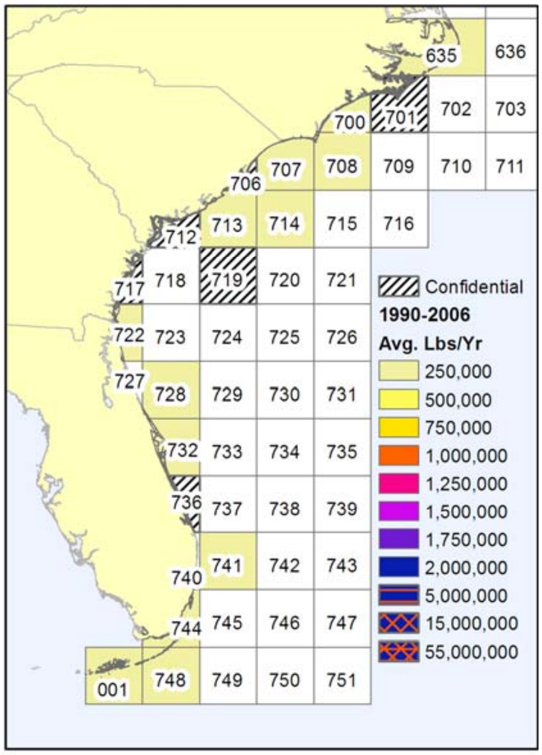


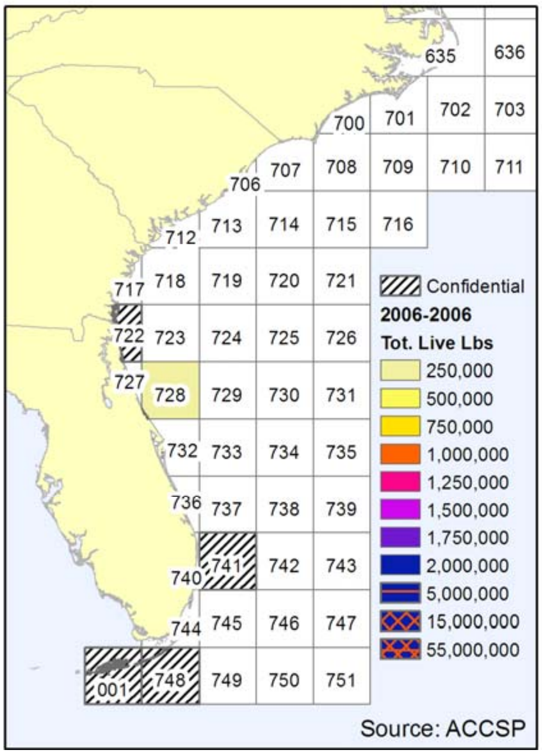
ACCSP Catch: HIND, RED
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	19.39	1.14	0.12
635	159.33	9.37	15.03
701	146.66	8.63	0.00
722	7.10	0.42	0.05
728	1.76	0.10	Conf.
732	1.58	0.09	0.01
736	0.11	0.01	0.00
741	0.98	0.06	0.06
744	2.99	0.18	0.05
748	1.86	0.11	Conf.

Figure 5.4.1-37. Spatial Presentation of Red Hind Commercial Catch (Source: ACCSP).



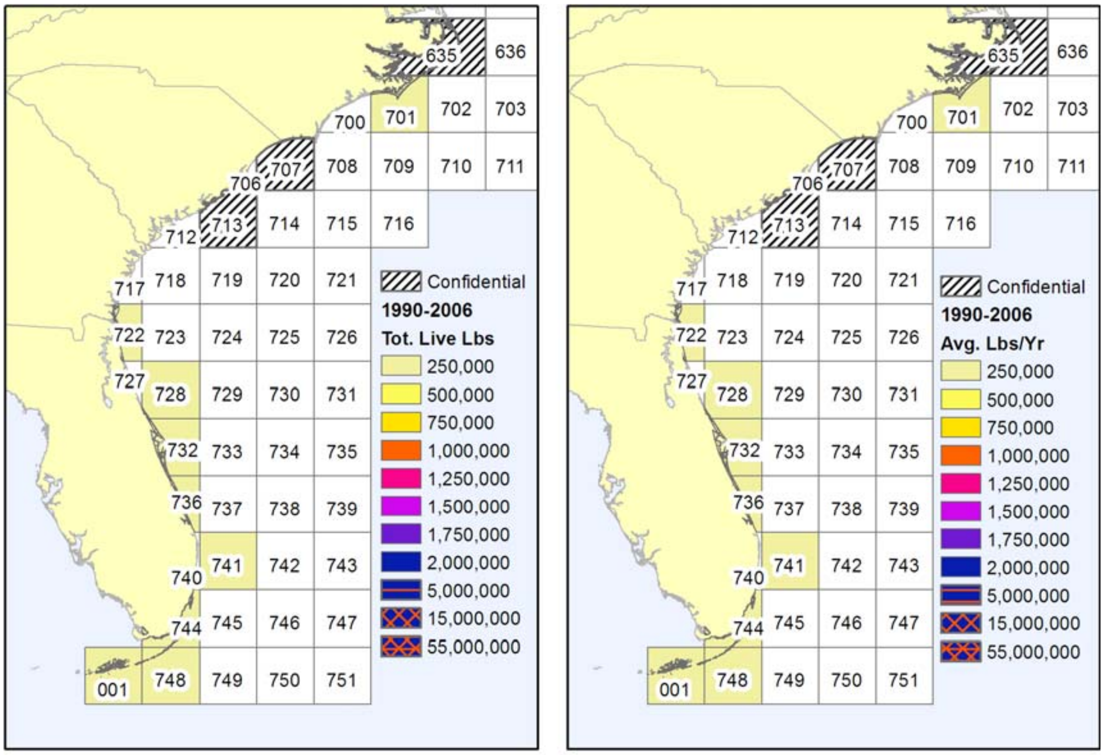


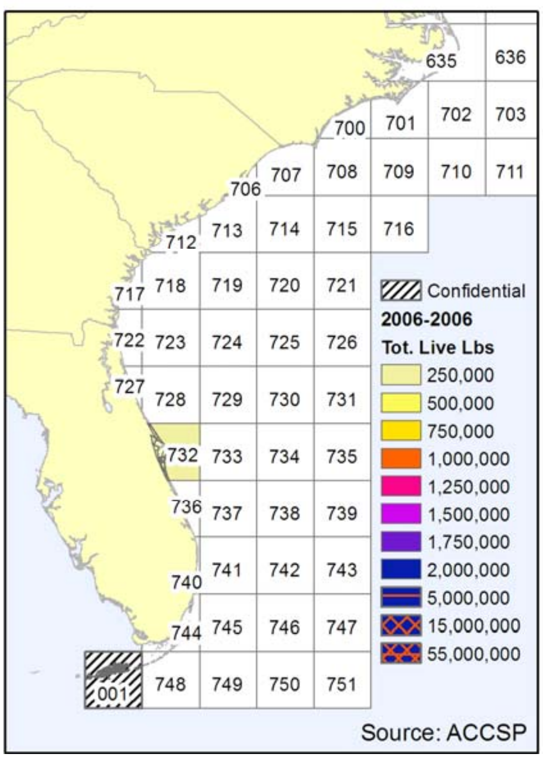


ACCSP Catch: HIND, ROCK
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	0.30	0.02	Conf.
635	0.09	0.01	0.00
700	5.19	0.31	0.00
701	Conf.	Conf.	0.00
706	Conf.	Conf.	0.00
707	17.42	1.02	0.00
708	7.07	0.42	0.00
712	Conf.	Conf.	0.00
713	7.23	0.43	0.00
714	0.52	0.03	0.00
717	Conf.	Conf.	0.00
718	0.03	0.00	0.00
719	Conf.	Conf.	0.00
722	4.15	0.24	Conf.
728	0.92	0.05	0.05
732	0.11	0.01	0.00
736	Conf.	Conf.	0.00
741	1.00	0.06	Conf.
744	0.59	0.03	0.00
748	0.27	0.02	Conf.

Figure 5.4.1-38. Spatial Presentation of Rock Hind Commercial Catch (Source: ACCSP).

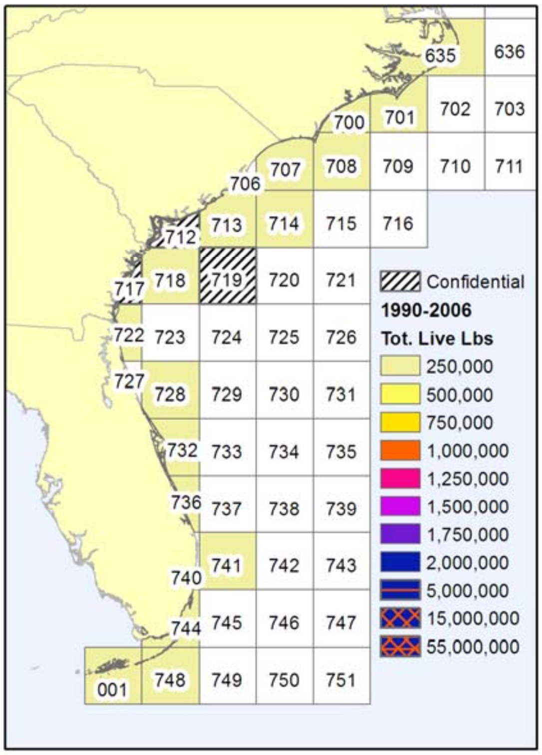


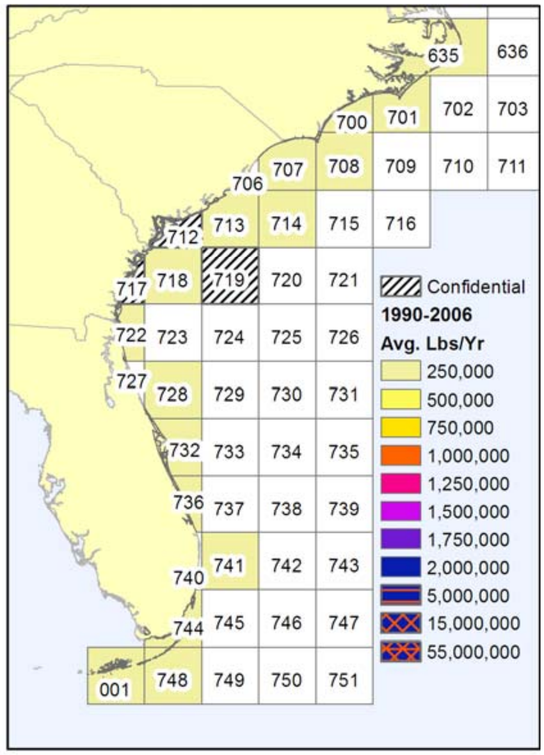


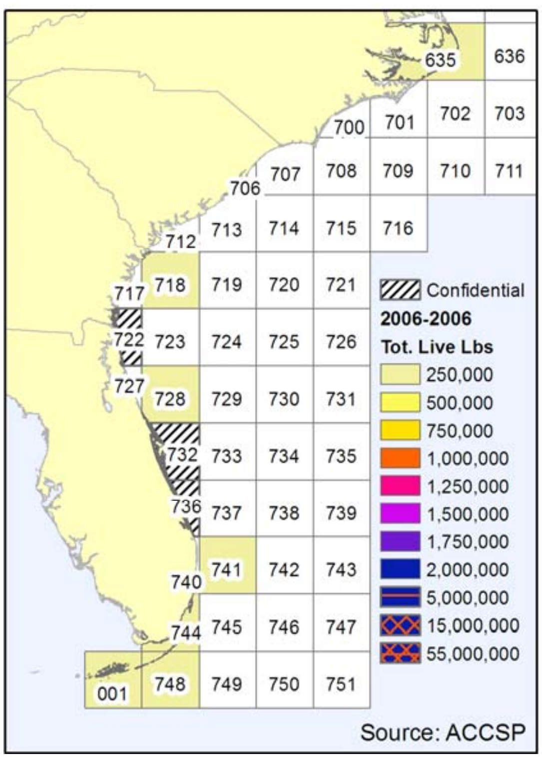
ACCSP Catch: HIND, SPECKLED
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	17.39	1.02	Conf.
635	Conf.	Conf.	0.00
701	16.73	0.98	0.00
707	Conf.	Conf.	0.00
713	Conf.	Conf.	0.00
722	1.35	0.08	0.00
728	0.44	0.03	0.00
732	0.82	0.05	0.02
736	0.15	0.01	0.00
741	0.41	0.02	0.00
744	0.90	0.05	0.00
748	0.25	0.01	0.00

Figure 5.4.1-39. Spatial Presentation of Speckled Hind Commercial Catch (Source: ACCSP).



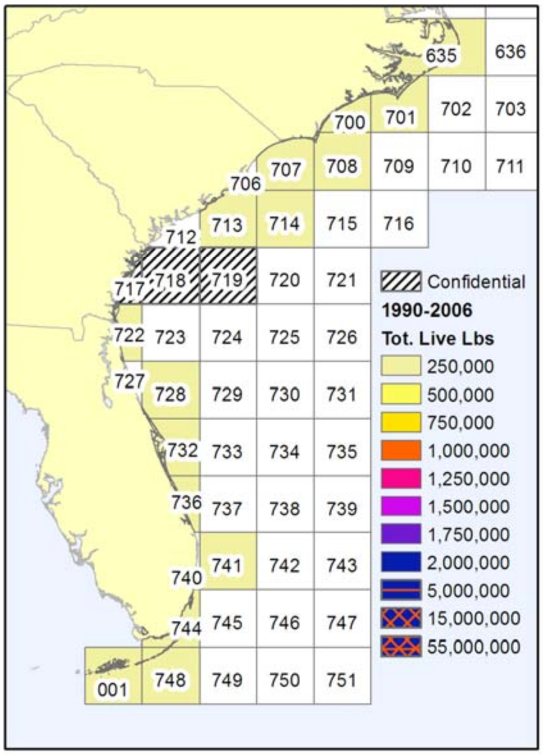


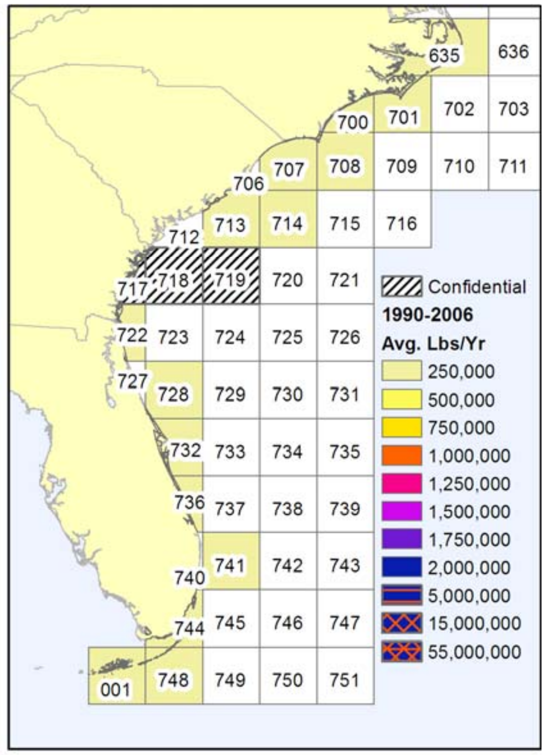


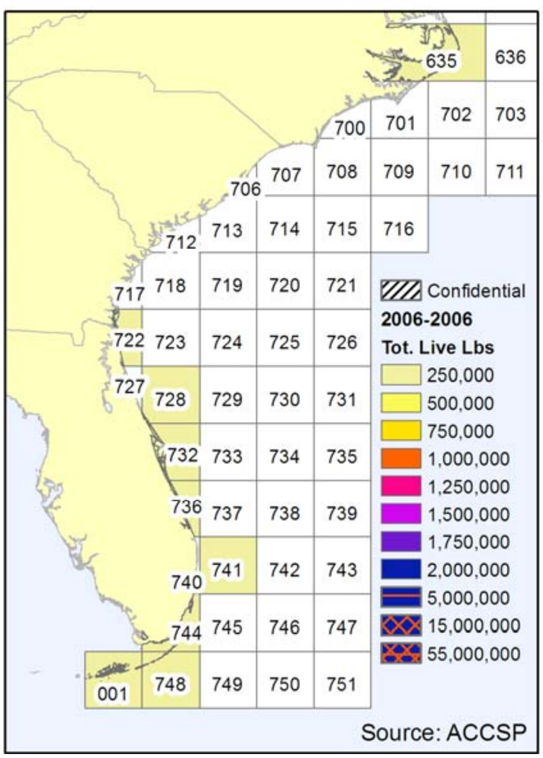
ACCSP Catch: HOGFISH
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	160.65	9.45	3.43
635	106.49	6.26	7.14
700	3.08	0.18	0.00
701	148.31	8.72	0.00
707	7.51	0.44	0.00
708	3.92	0.23	0.00
712	Conf.	Conf.	0.00
713	6.43	0.38	0.00
714	0.19	0.01	0.00
717	Conf.	Conf.	0.00
718	0.08	0.00	0.01
719	Conf.	Conf.	0.00
722	13.36	0.79	Conf.
728	5.37	0.32	0.20
732	2.55	0.15	Conf.
736	6.33	0.37	Conf.
741	43.20	2.54	2.17
744	63.38	3.73	3.59
748	43.17	2.54	1.48

Figure 5.4.1-40. Spatial Presentation of Hogfish Commercial Catch (Source: ACCSP).



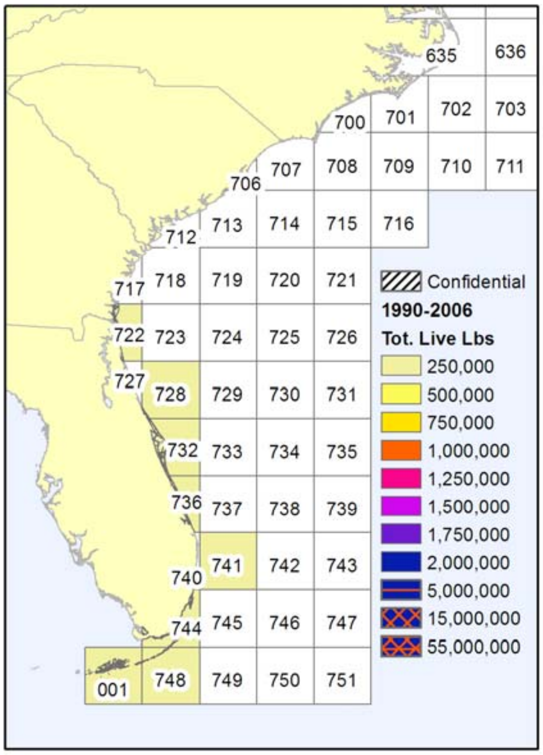


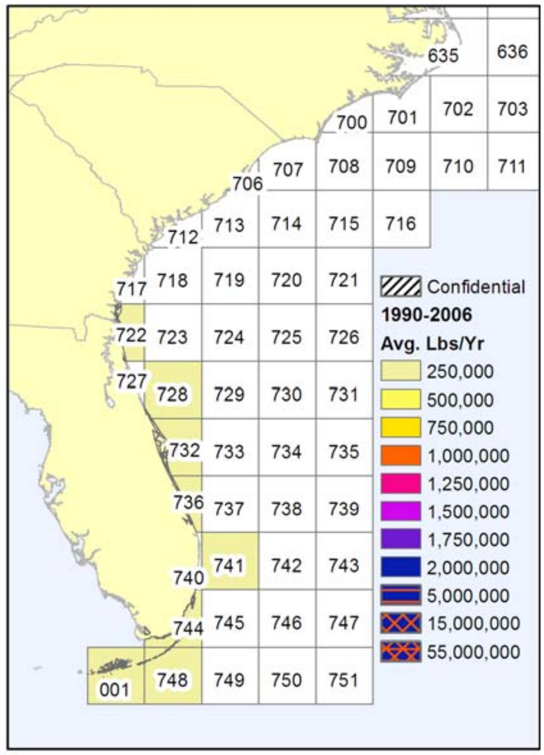


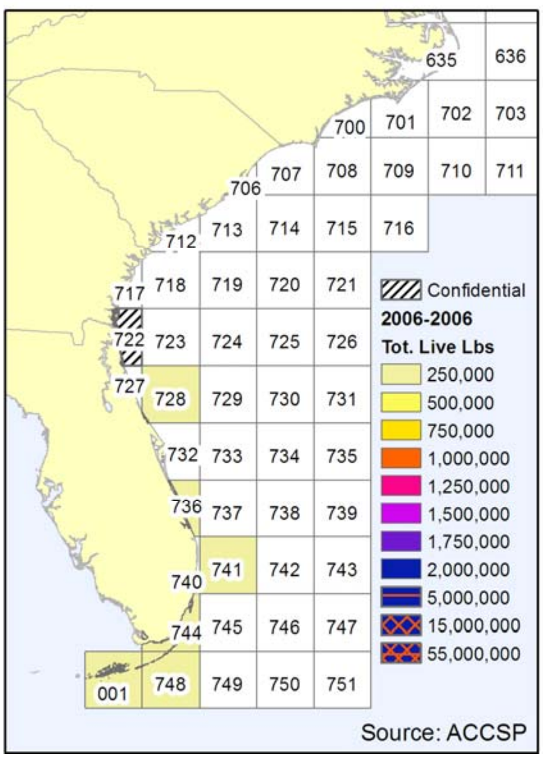
ACCSP Catch: JACK, ALMACO
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	12.21	0.72	1.93
635	107.58	6.33	11.51
700	16.69	0.98	0.00
701	0.95	0.06	0.00
707	34.90	2.05	0.00
708	6.52	0.38	0.00
713	10.72	0.63	0.00
714	1.07	0.06	0.00
717	Conf.	Conf.	0.00
718	Conf.	Conf.	0.00
719	Conf.	Conf.	0.00
722	117.82	6.93	5.14
728	224.69	13.22	13.18
732	0.92	0.05	0.05
736	3.46	0.20	0.11
741	11.37	0.67	0.70
744	187.59	11.03	1.23
748	18.85	1.11	6.39

Figure 5.4.1-41. Spatial Presentation of Almaco Jack Commercial Catch (Source: ACCSP).



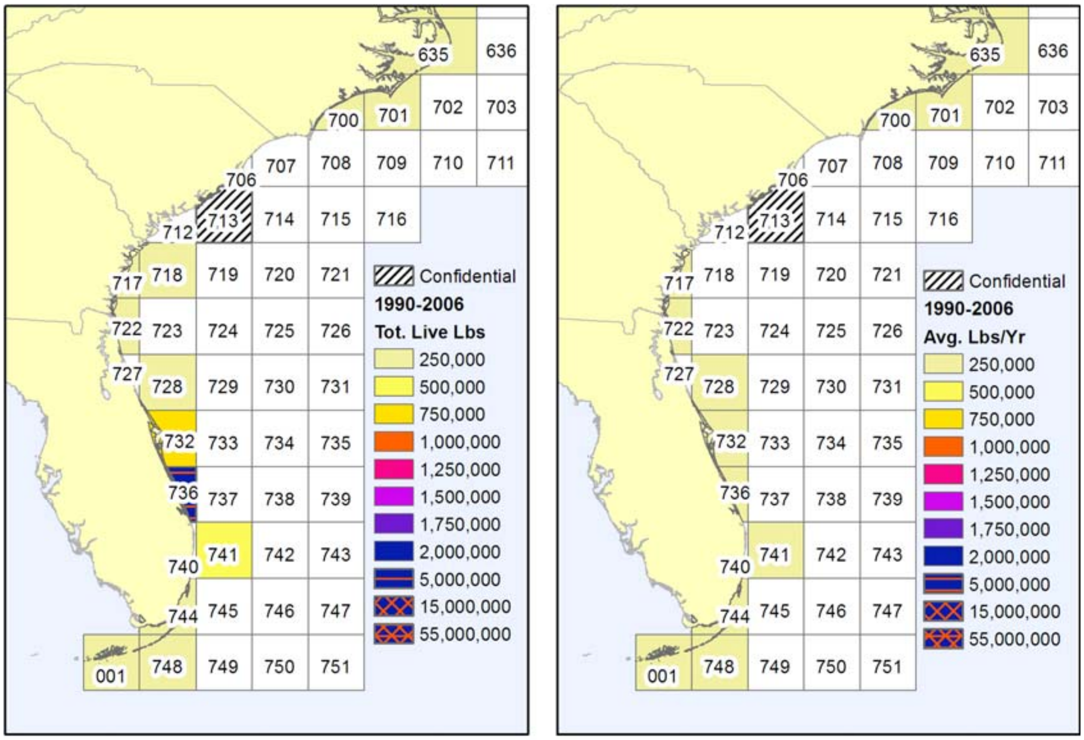


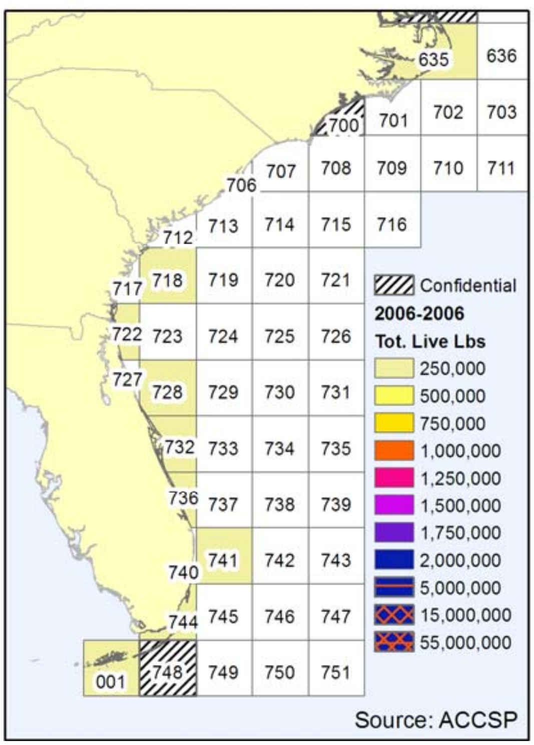


ACCSP Catch: JACK, BAR
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	15.39	0.91	2.76
722	7.17	0.42	Conf.
728	8.20	0.48	0.29
732	0.12	0.01	0.00
736	0.20	0.01	0.02
741	1.75	0.10	0.19
744	10.70	0.63	0.28
748	1.63	0.10	0.09

Figure 5.4.1-42. Spatial Presentation of Bar Jack Commercial Catch (Source: ACCSP).

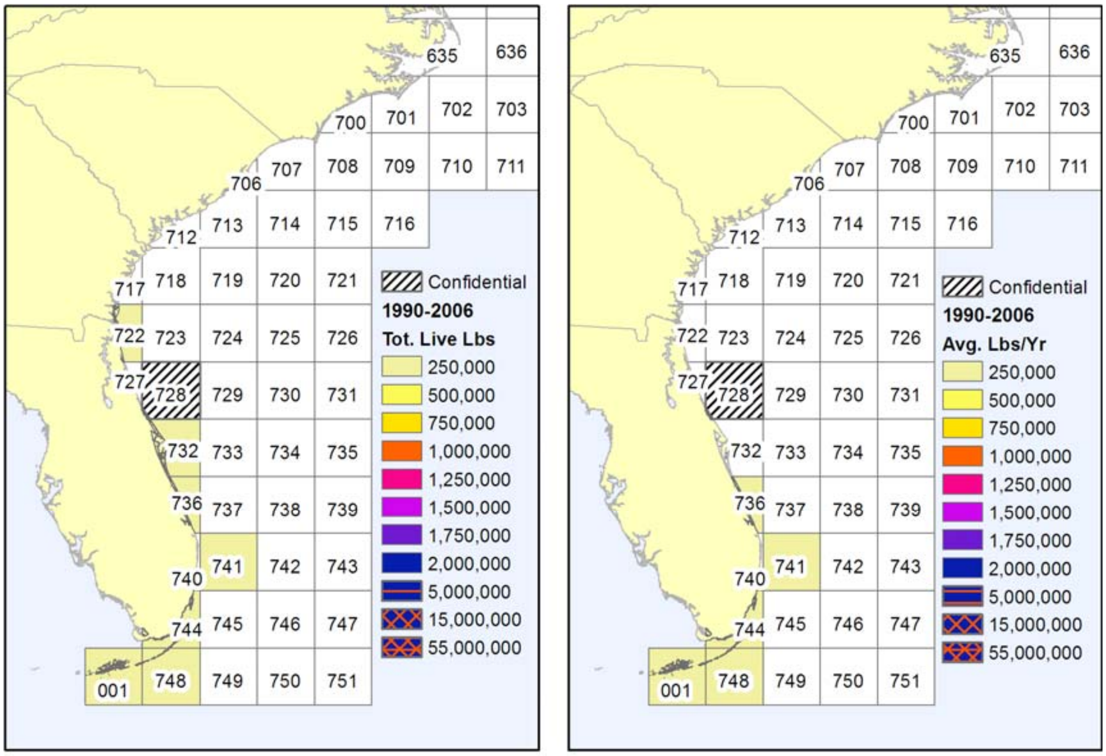


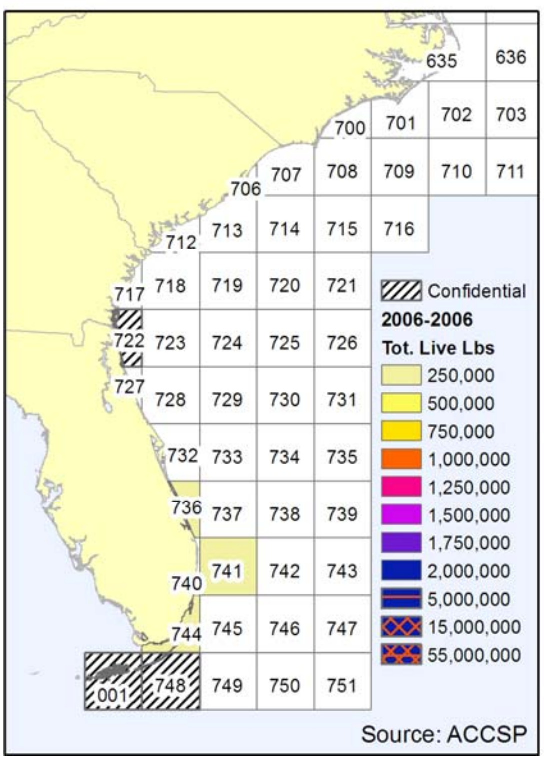


ACCSP Catch: JACK, CREVALLE
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	58.93	3.47	0.20
635	58.76	3.46	0.76
700	0.13	0.01	Conf.
701	37.71	2.22	0.00
713	Conf.	Conf.	0.00
717	1.18	0.07	0.00
718	0.01	0.00	0.01
722	60.03	3.53	0.64
728	246.81	14.52	9.33
732	702.81	41.34	9.13
736	2,094.75	123.22	117.02
741	397.60	23.39	35.95
744	142.30	8.37	5.89
748	26.25	1.54	Conf.

Figure 5.4.1-43. Spatial Presentation of Jack Crevalle Commercial Catch (Source: ACCSP).

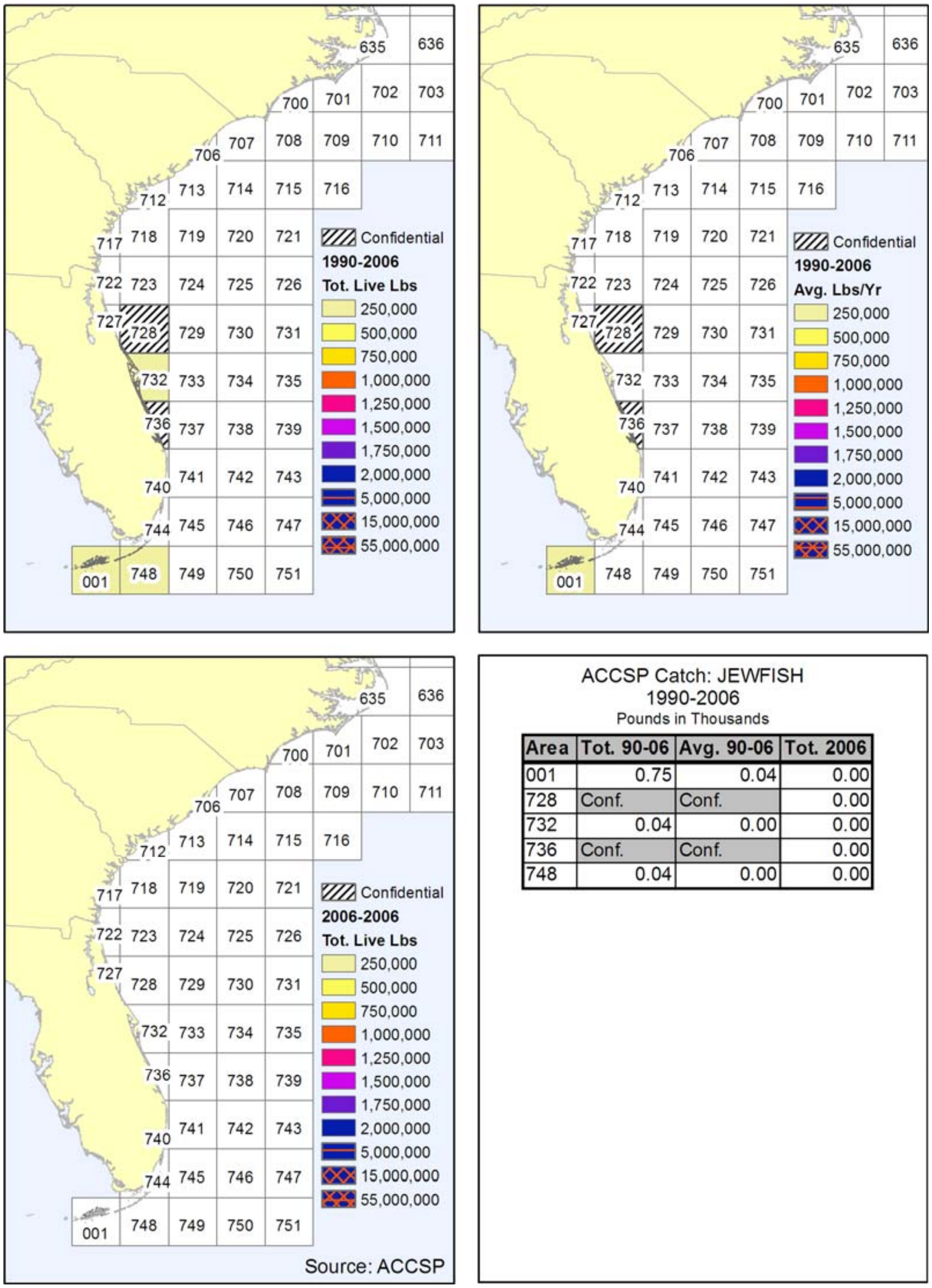




ACCSP Catch: JACK, YELLOW
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	9.31	0.55	Conf.
722	0.03	0.00	Conf.
728	Conf.	Conf.	0.00
732	0.02	0.00	0.00
736	0.37	0.02	0.02
741	2.17	0.13	0.29
744	22.19	1.31	0.70
748	4.98	0.29	Conf.

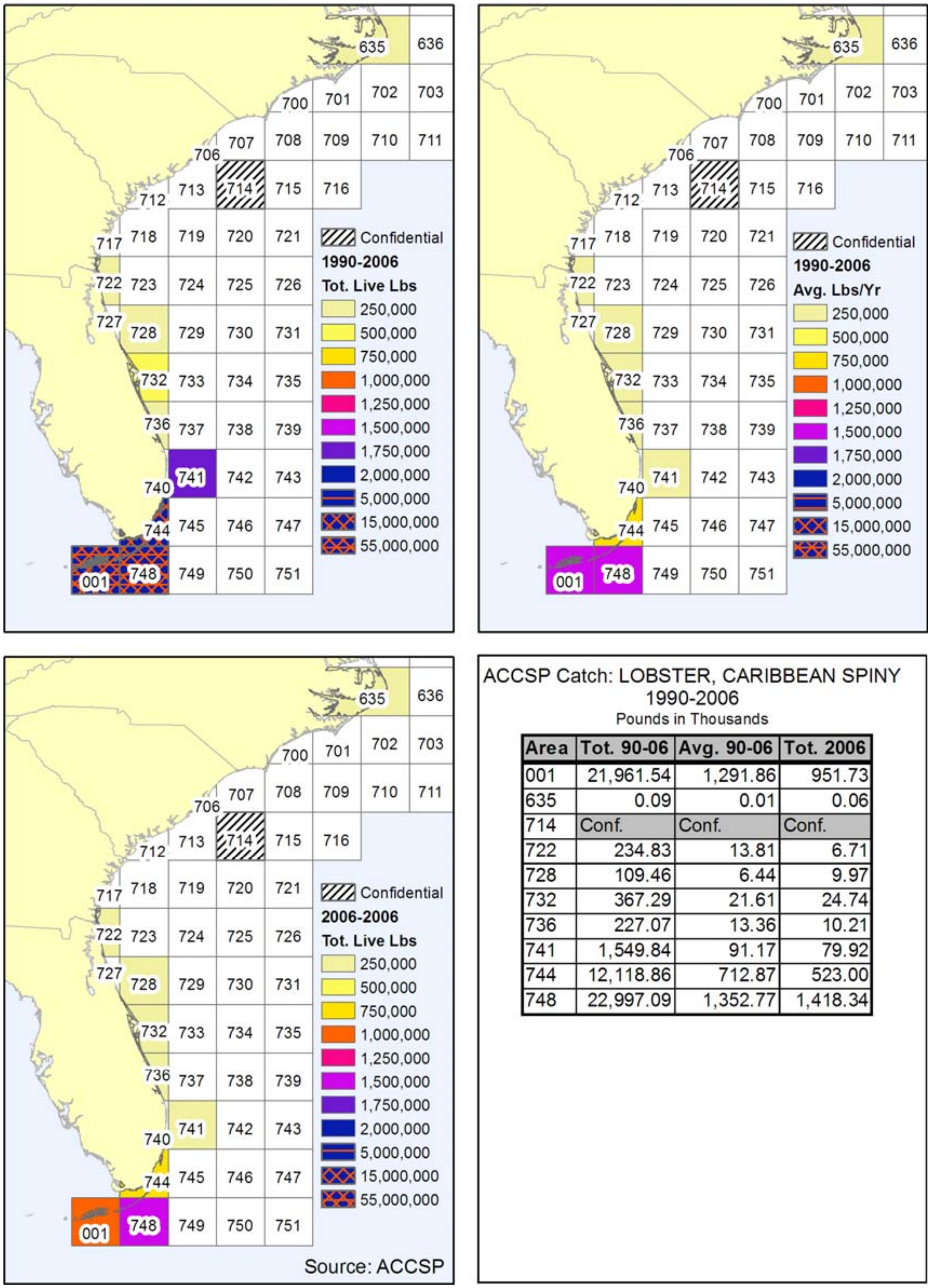
Figure 5.4.1-44. Spatial Presentation of Yellow Jack Commercial Catch (Source: ACCSP).



ACCSP Catch: JEWFISH
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	0.75	0.04	0.00
728	Conf.	Conf.	0.00
732	0.04	0.00	0.00
736	Conf.	Conf.	0.00
748	0.04	0.00	0.00

Figure 5.4.1-45. Spatial Presentation of Goliath Grouper (Jewfish) Commercial Catch (Source: ACCSP).

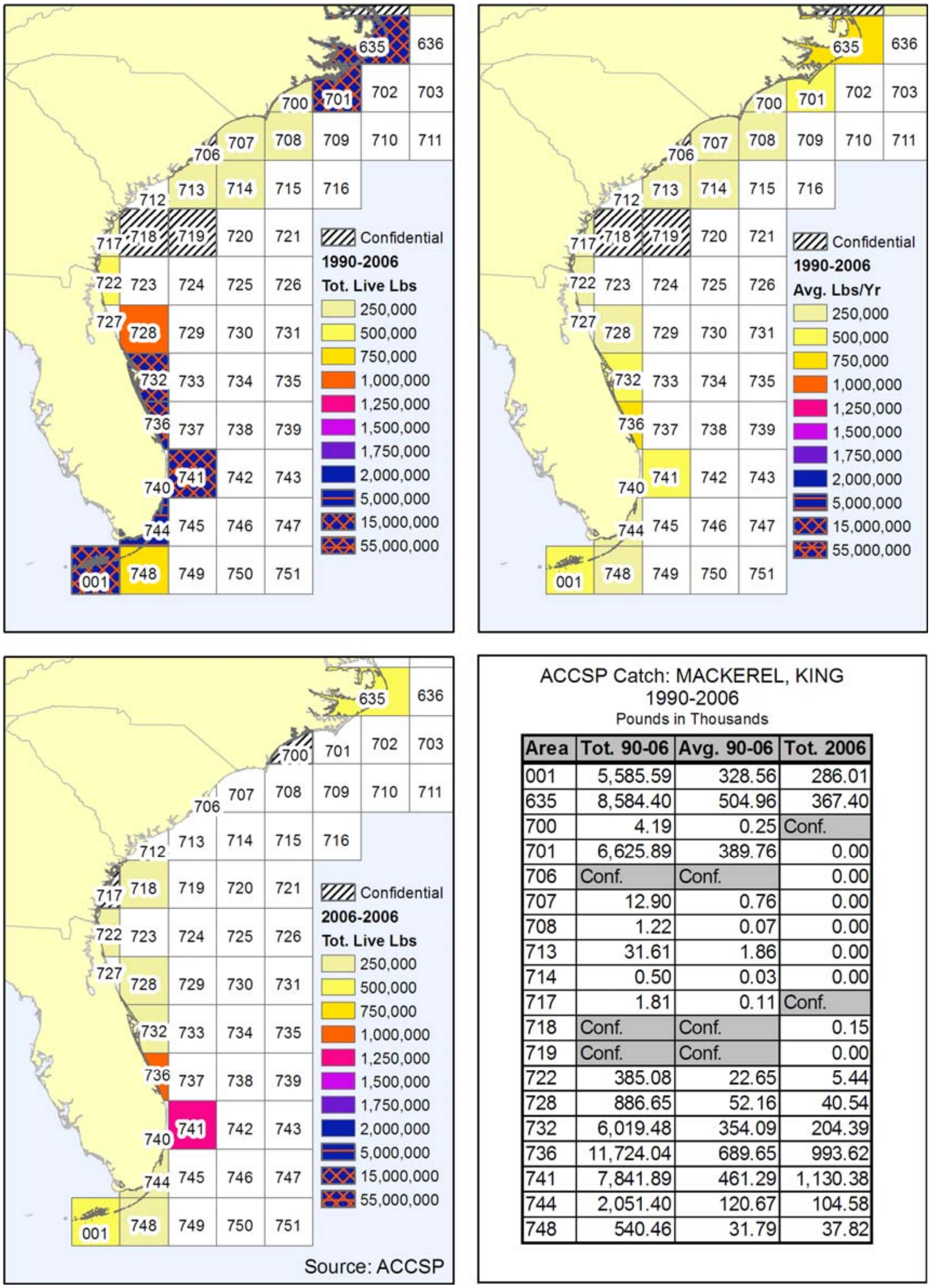


ACCSP Catch: LOBSTER, CARIBBEAN SPINY
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	21,961.54	1,291.86	951.73
635	0.09	0.01	0.06
714	Conf.	Conf.	Conf.
722	234.83	13.81	6.71
728	109.46	6.44	9.97
732	367.29	21.61	24.74
736	227.07	13.36	10.21
741	1,549.84	91.17	79.92
744	12,118.86	712.87	523.00
748	22,997.09	1,352.77	1,418.34

Figure 5.4.1-46. Spatial Presentation of Spiny Lobster Commercial Catch (Source: ACCSP).

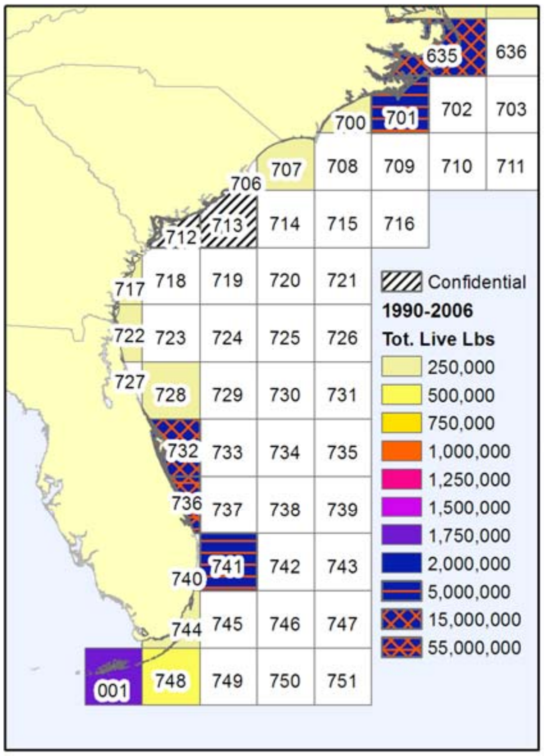
Appendix B. Spatial Presentations of commercial catch ACCSP

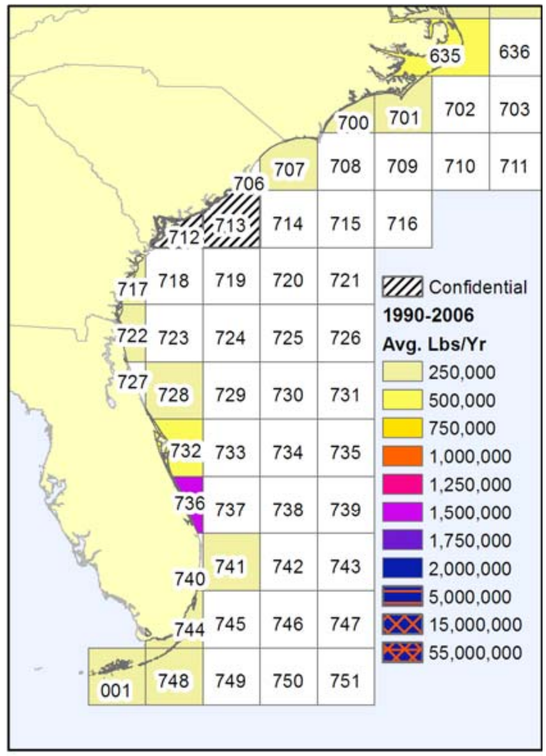


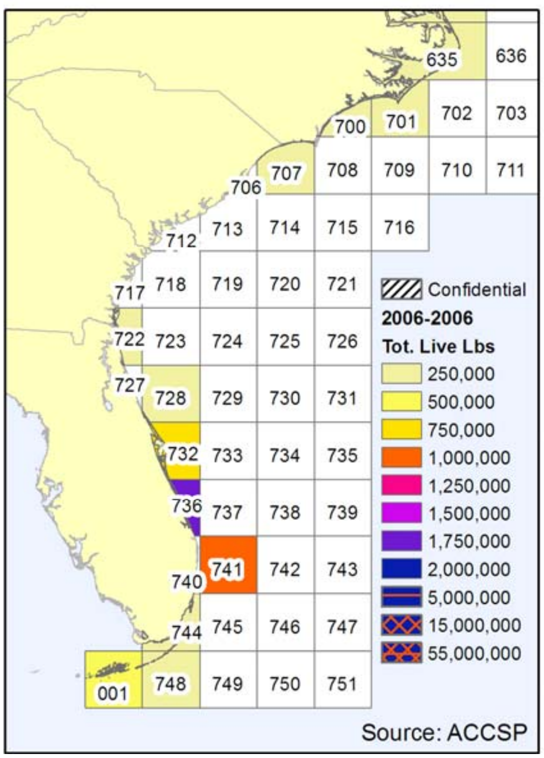
ACCSP Catch: MACKEREL, KING
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	5,585.59	328.56	286.01
635	8,584.40	504.96	367.40
700	4.19	0.25	Conf.
701	6,625.89	389.76	0.00
706	Conf.	Conf.	0.00
707	12.90	0.76	0.00
708	1.22	0.07	0.00
713	31.61	1.86	0.00
714	0.50	0.03	0.00
717	1.81	0.11	Conf.
718	Conf.	Conf.	0.15
719	Conf.	Conf.	0.00
722	385.08	22.65	5.44
728	886.65	52.16	40.54
732	6,019.48	354.09	204.39
736	11,724.04	689.65	993.62
741	7,841.89	461.29	1,130.38
744	2,051.40	120.67	104.58
748	540.46	31.79	37.82

Figure 5.4.1-47. Spatial Presentation of King Mackerel Commercial Catch (Source: ACCSP).





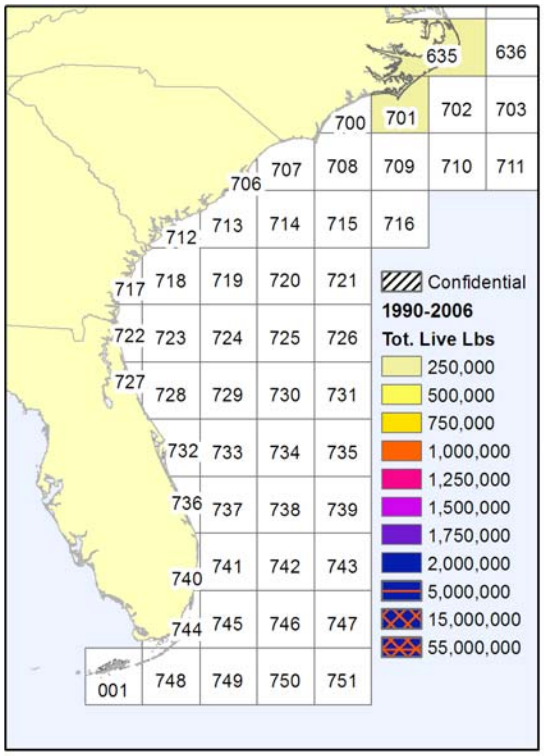


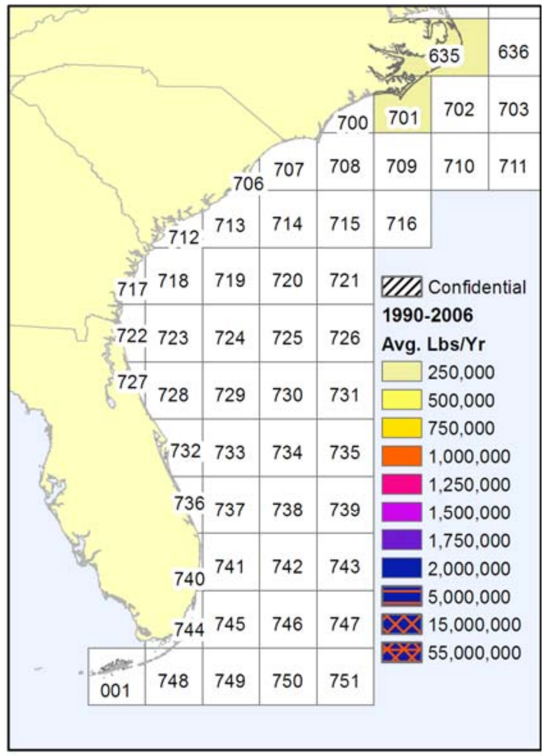
ACCSP Catch: MACKEREL, SPANISH
1990-2006
Pounds in Thousands

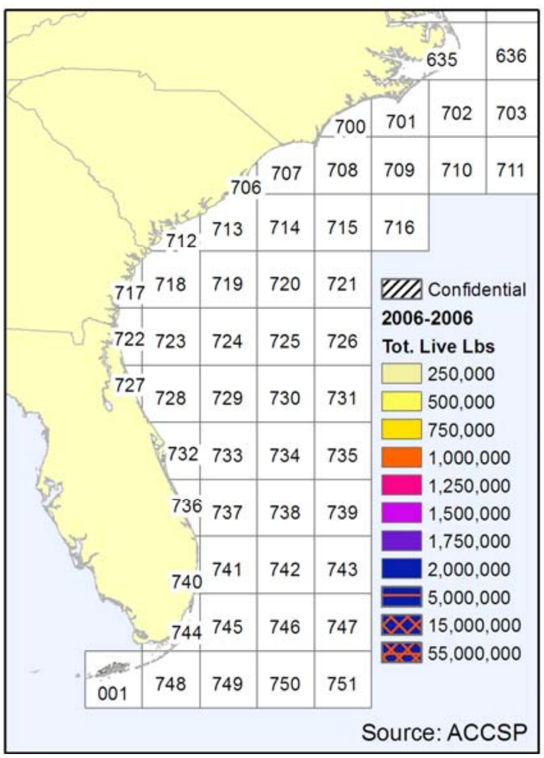
Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	1,560.72	91.81	261.29
635	5,539.03	325.83	50.71
700	174.25	10.25	0.51
701	2,922.69	171.92	1.28
707	0.46	0.03	0.03
712	Conf.	Conf.	0.00
713	Conf.	Conf.	0.00
717	0.12	0.01	0.00
718	0.00	0.00	0.00
722	57.08	3.36	0.11
728	34.19	2.01	5.72
732	8,475.71	498.57	531.67
736	25,079.06	1,475.24	1,647.73
741	3,373.76	198.46	839.83
744	201.60	11.86	12.44
748	466.84	27.46	4.19

Figure 5.4.1-48. Spatial Presentation of Spanish Mackerel Commercial Catch (Source: ACCSP).

Appendix B. Spatial Presentations of commercial catch ACCSP







ACCSP Catch: MARGATE
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
635	0.98	0.06	0.00
701	61.71	3.63	0.00

Figure 5.4.1-49. Spatial Presentation of Margate Commercial Catch (Source: ACCSP).

Appendix B. Spatial Presentations of commercial catch ACCSP

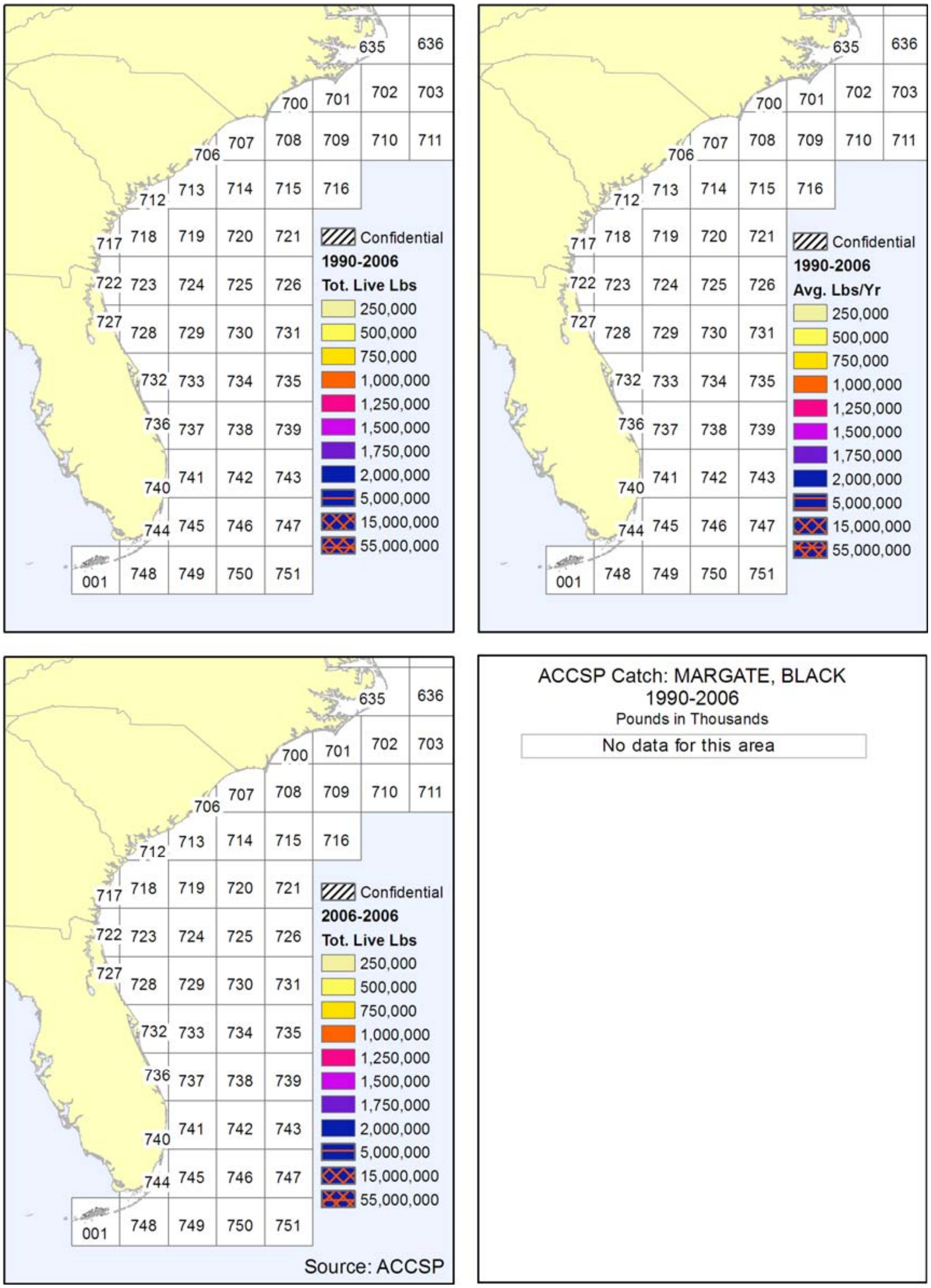


Figure 5.4.1-50. Spatial Presentation of Black Margate Commercial Catch (Source: ACCSP).

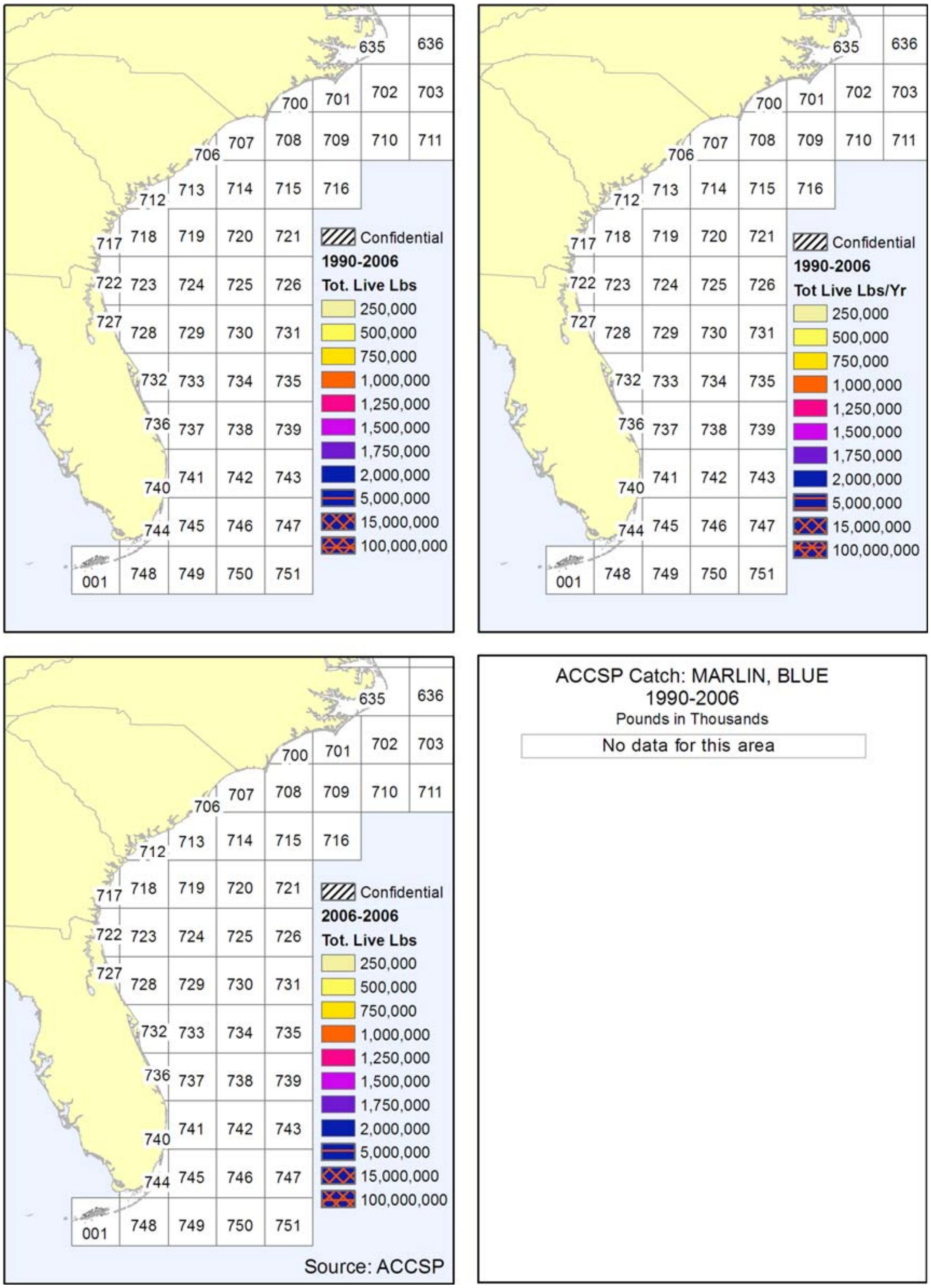


Figure 5.4.1-51. Spatial Presentation of Blue Marlin Commercial Catch (Source: ACCSP).

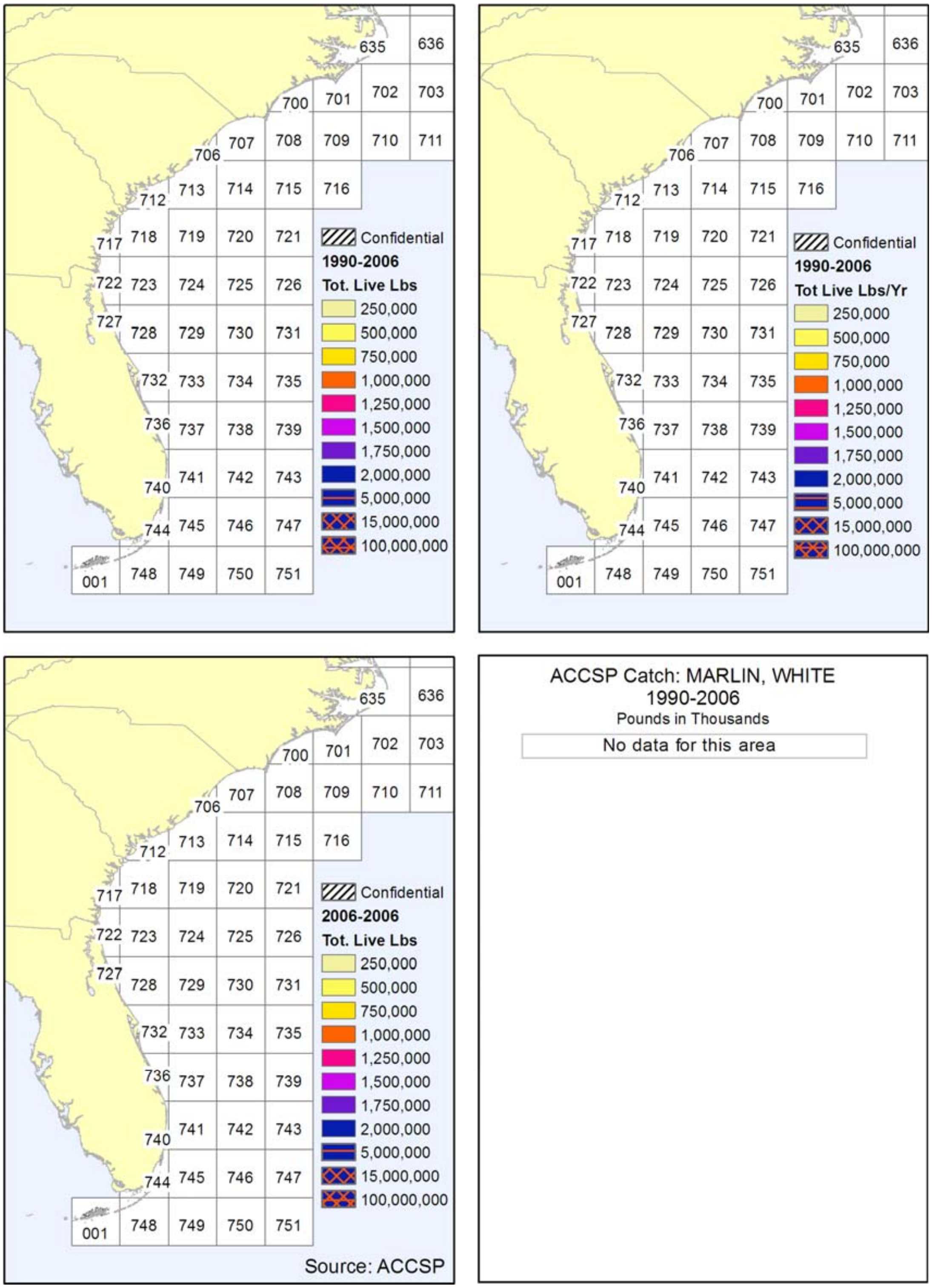
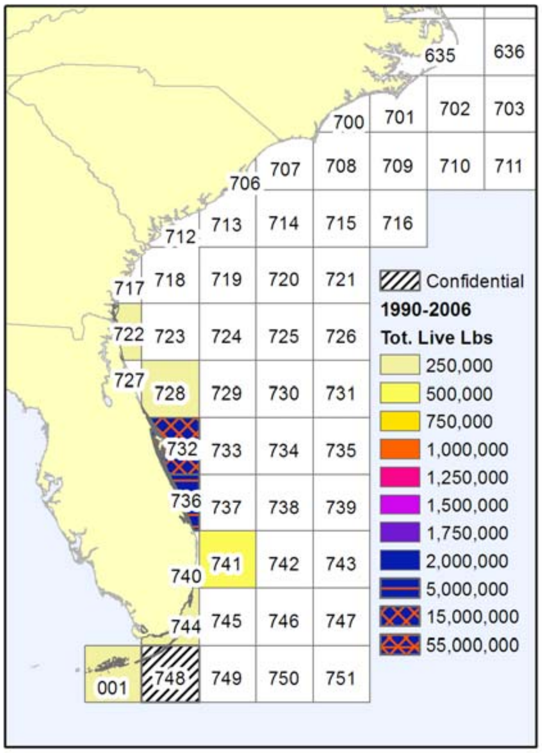
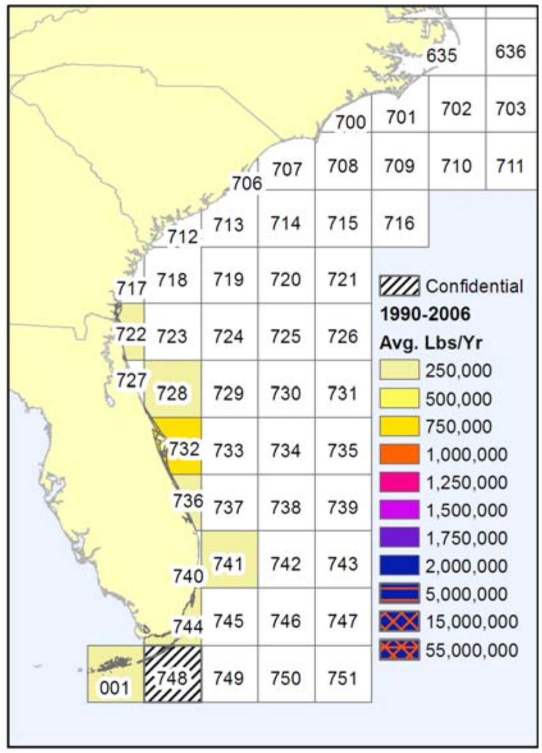
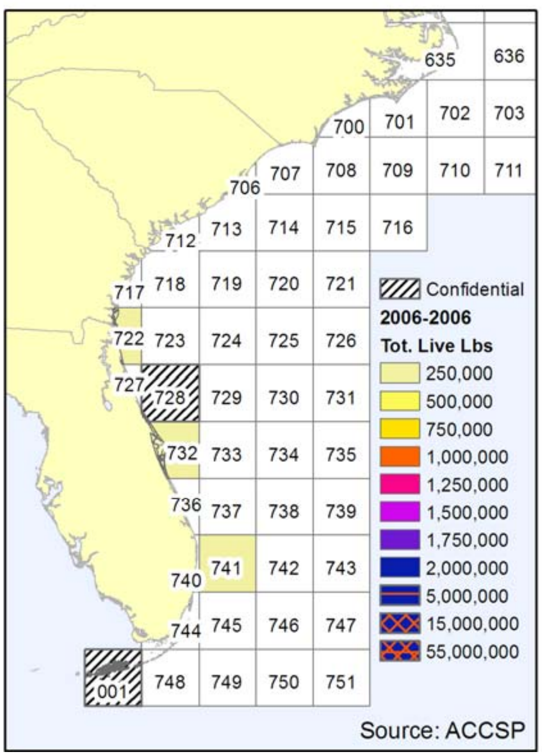


Figure 5.4.1-52. Spatial Presentation of White Marlin Commercial Catch (Source: ACCSP).



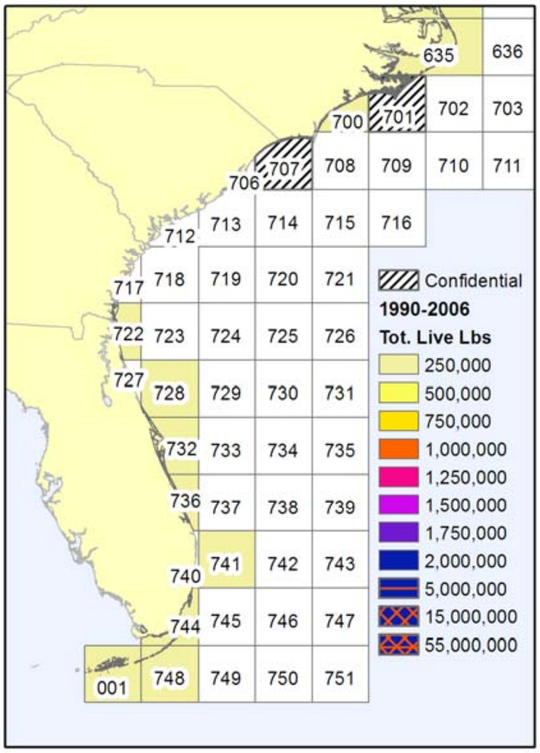


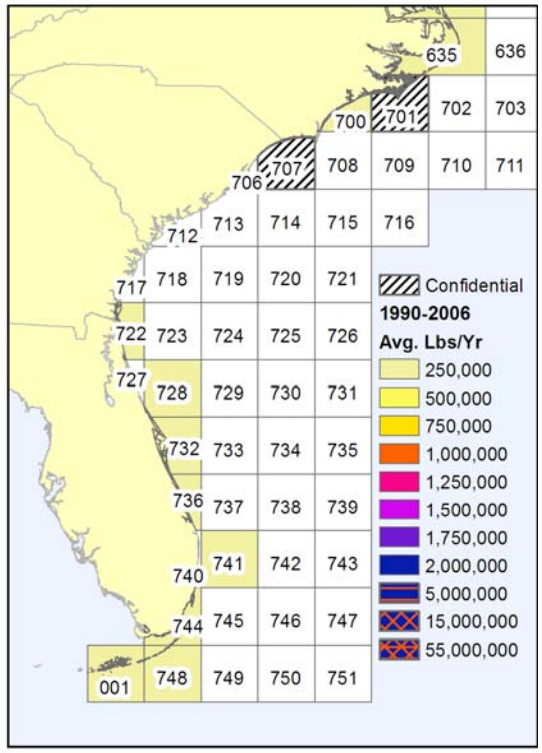


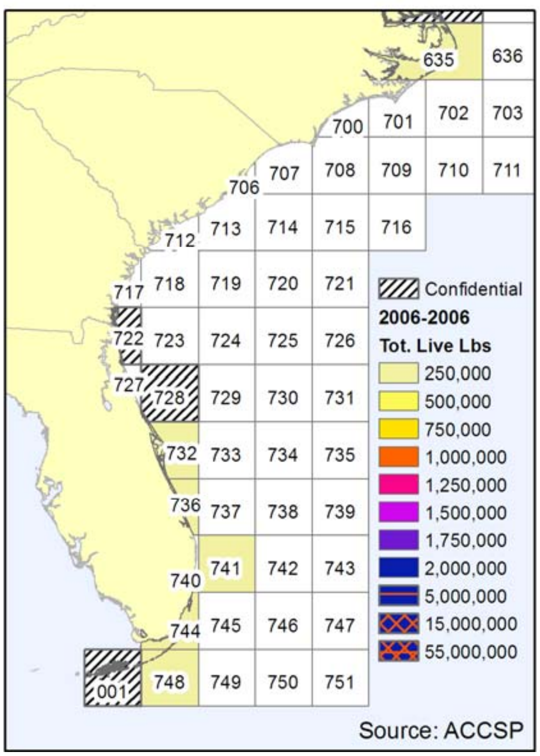
ACCSP Catch: MENHADEN, ATLANTIC
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	0.23	0.01	Conf.
722	195.37	11.49	22.69
728	168.43	9.91	Conf.
732	8,727.39	513.38	80.27
736	3,510.46	206.50	0.00
741	351.31	20.67	3.73
744	13.39	0.79	0.00
748	Conf.	Conf.	0.00

Figure 5.4.1-53. Spatial Presentation of Atlantic Menhaden Commercial Catch (Source: ACCSP).



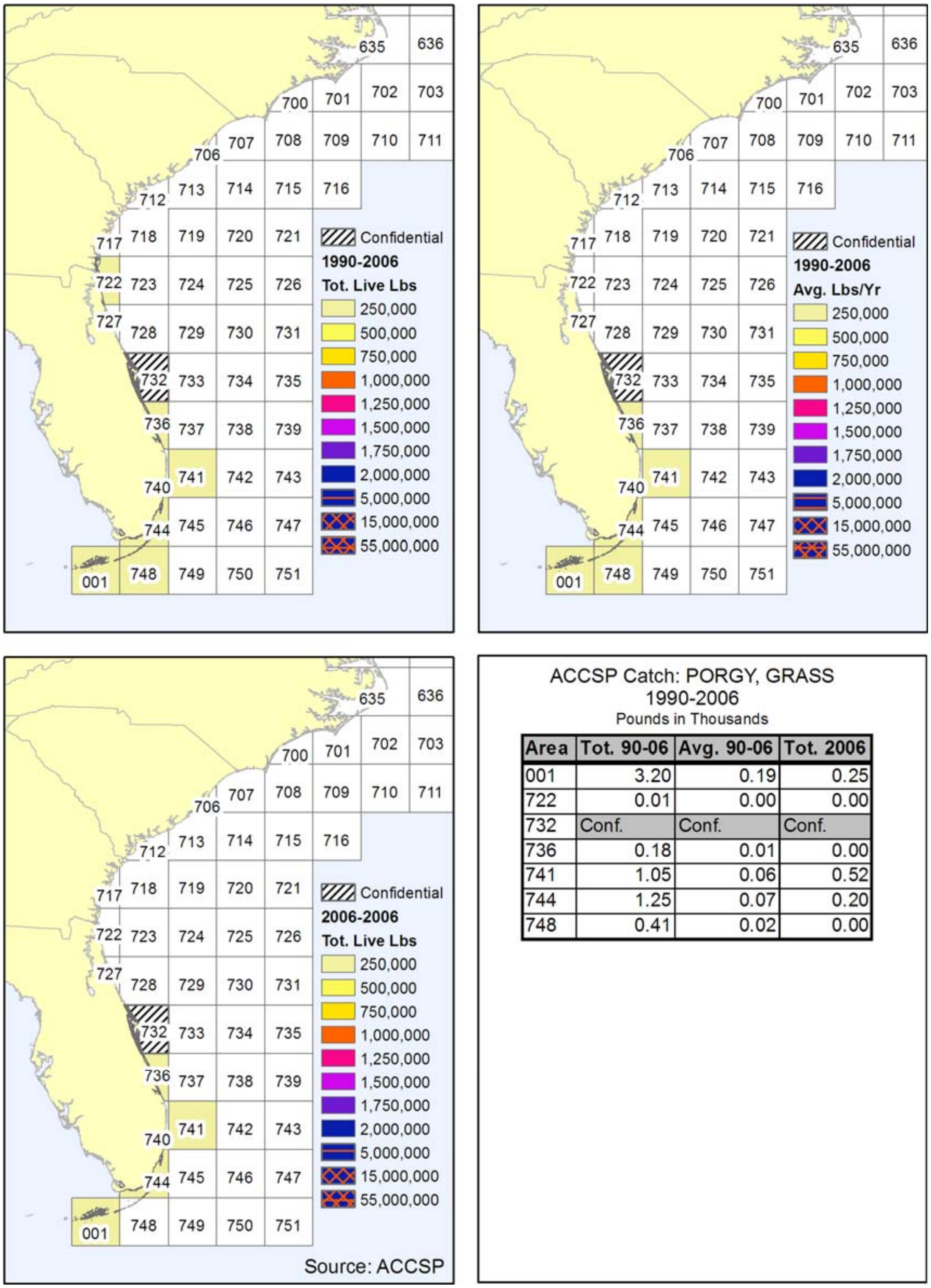




ACCSP Catch: PINFISH
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	3.37	0.20	Conf.
635	244.62	14.39	14.54
700	0.53	0.03	0.00
701	Conf.	Conf.	0.00
707	Conf.	Conf.	0.00
722	0.30	0.02	Conf.
728	0.83	0.05	Conf.
732	104.02	6.12	5.46
736	63.97	3.76	4.07
741	2.12	0.12	0.18
744	3.95	0.23	0.89
748	1.44	0.08	1.14

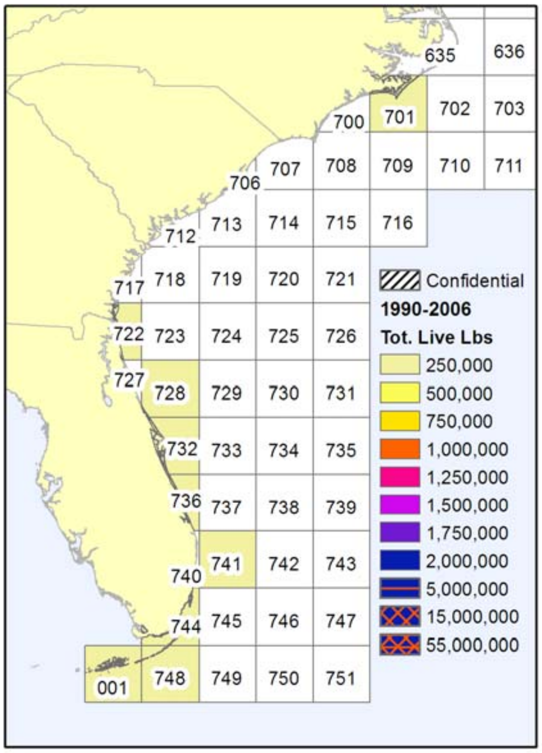
Figure 5.4.1-54. Spatial Presentation of Pinfish Commercial Catch (Source: ACCSP).

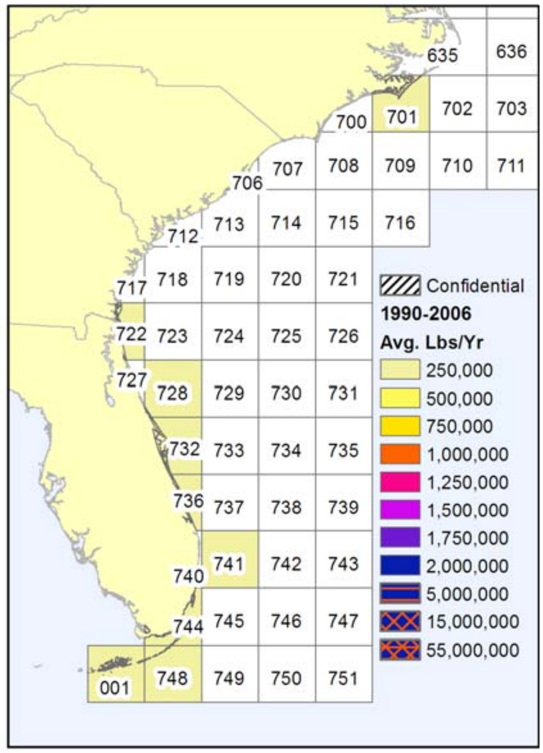


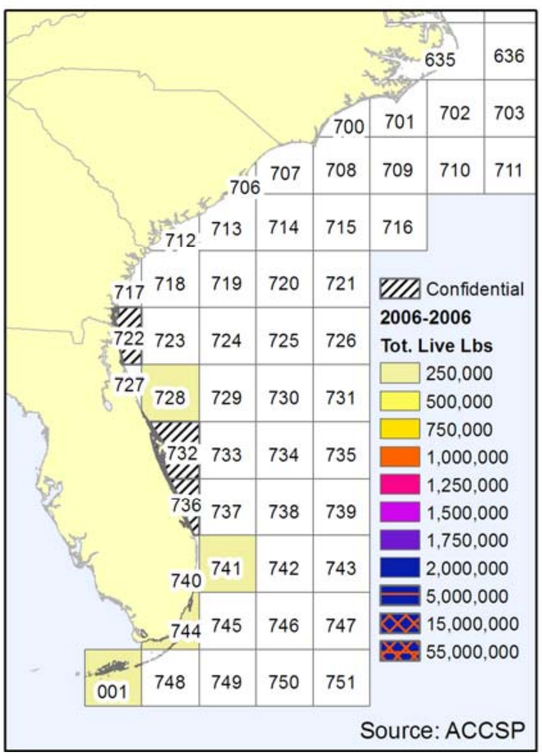
ACCSP Catch: PORGY, GRASS
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	3.20	0.19	0.25
722	0.01	0.00	0.00
732	Conf.	Conf.	Conf.
736	0.18	0.01	0.00
741	1.05	0.06	0.52
744	1.25	0.07	0.20
748	0.41	0.02	0.00

Figure 5.4.1-55. Spatial Presentation of Grass Porgy Commercial Catch (Source: ACCSP).



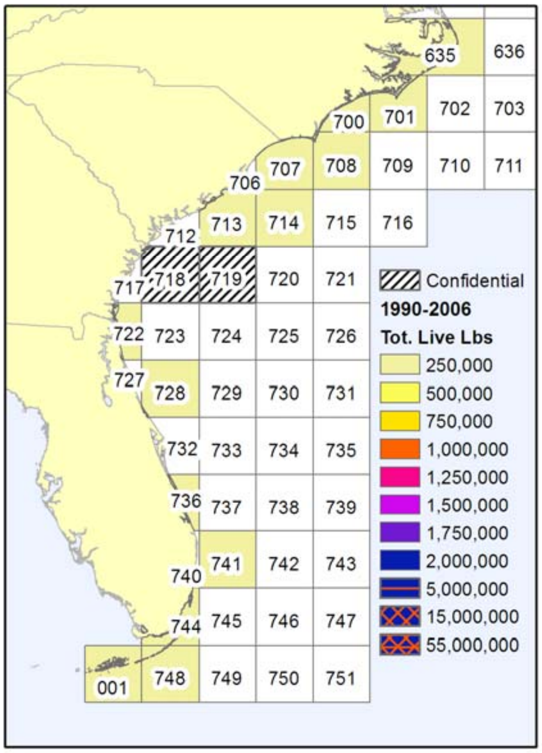


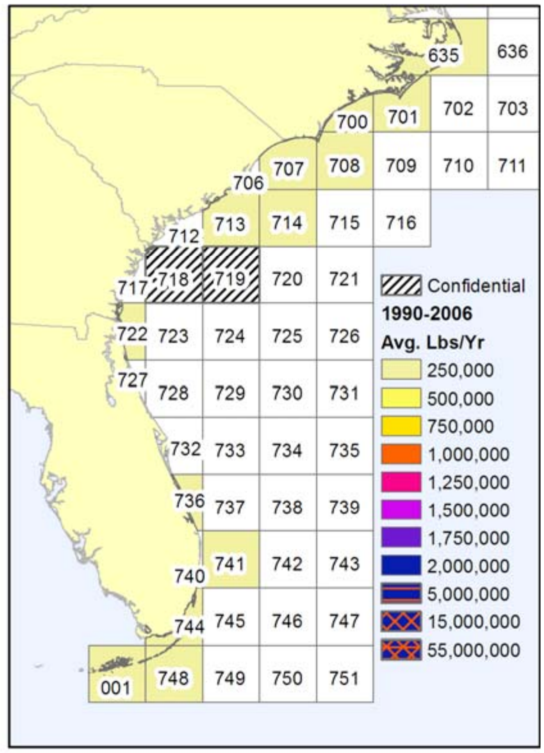


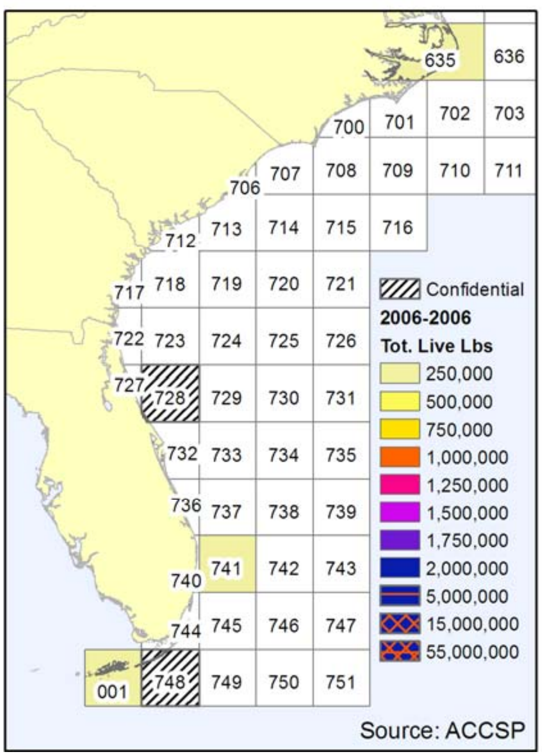
ACCSP Catch: PORGY, JOLTHEAD
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	6.83	0.40	1.06
701	2.49	0.15	0.00
722	1.36	0.08	Conf.
728	0.23	0.01	0.06
732	0.09	0.01	Conf.
736	0.52	0.03	Conf.
741	2.08	0.12	0.53
744	3.46	0.20	0.28
748	6.71	0.39	0.00

Figure 5.4.1-56. Spatial Presentation of Jolthead Porgy Commercial Catch (Source: ACCSP).



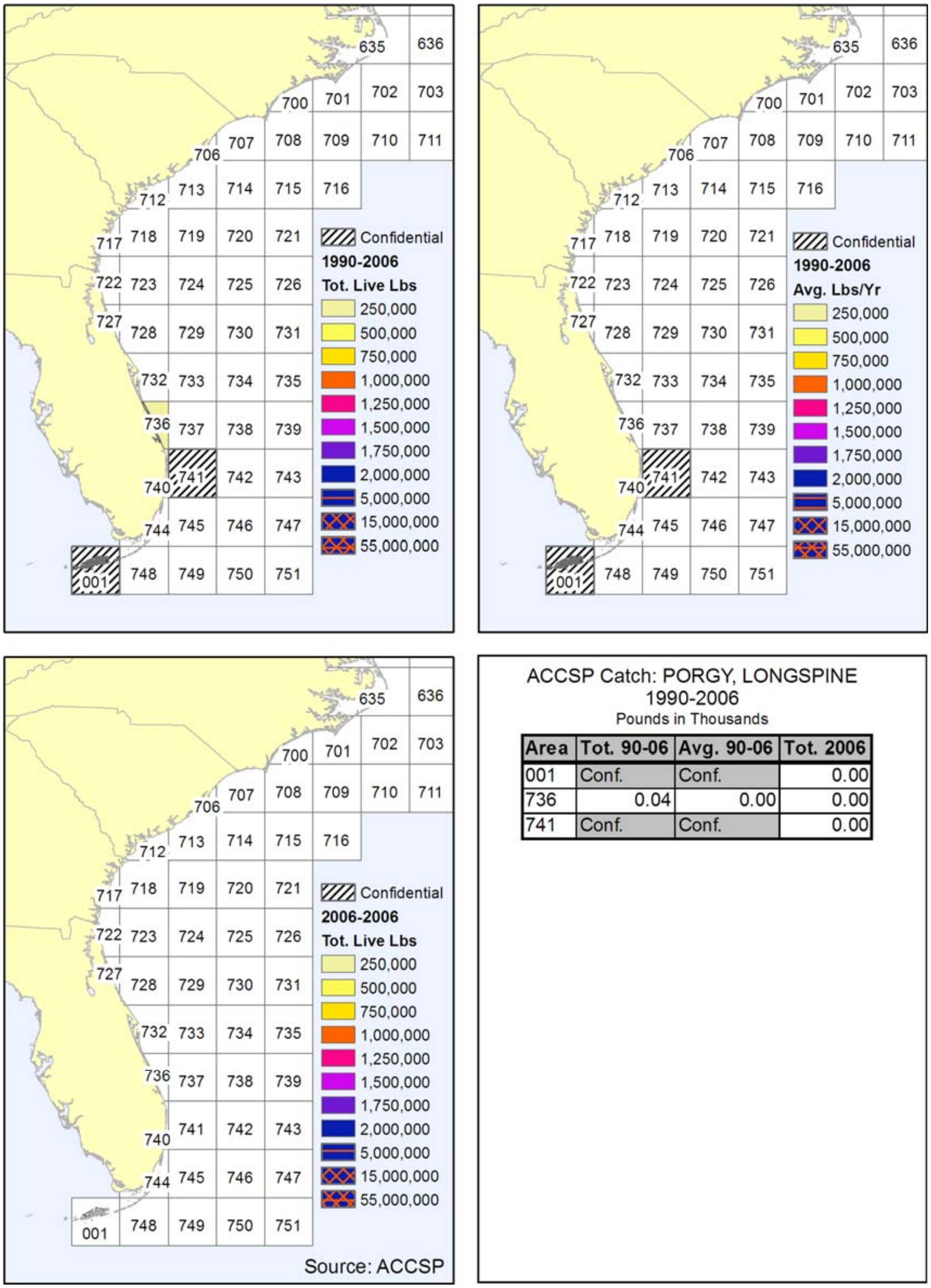




ACCSP Catch: PORGY, KNOBBED
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	0.98	0.06	0.30
635	171.95	10.11	11.69
700	1.72	0.10	0.00
701	224.61	13.21	0.00
707	5.60	0.33	0.00
708	0.48	0.03	0.00
713	3.21	0.19	0.00
714	0.27	0.02	0.00
718	Conf.	Conf.	0.00
719	Conf.	Conf.	0.00
722	0.07	0.00	0.00
728	0.02	0.00	Conf.
736	0.17	0.01	0.00
741	0.76	0.04	0.12
744	0.17	0.01	0.00
748	0.81	0.05	Conf.

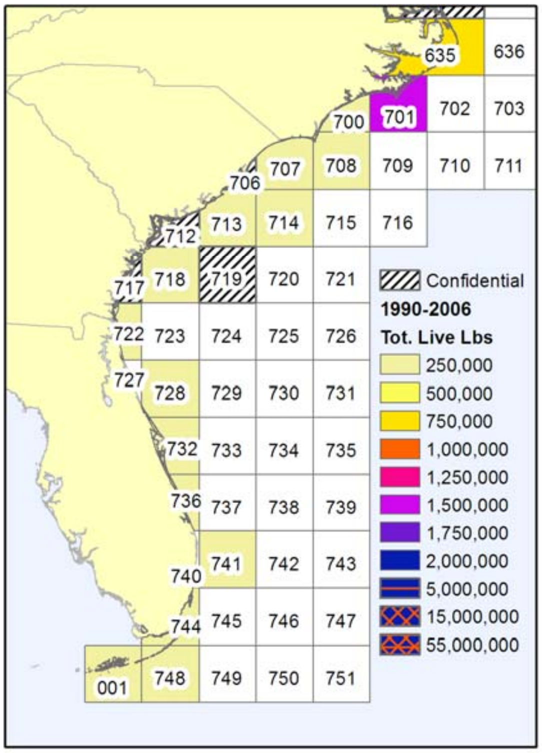
Figure 5.4.1-57. Spatial Presentation of Knobbed Porgy Commercial Catch (Source: ACCSP).

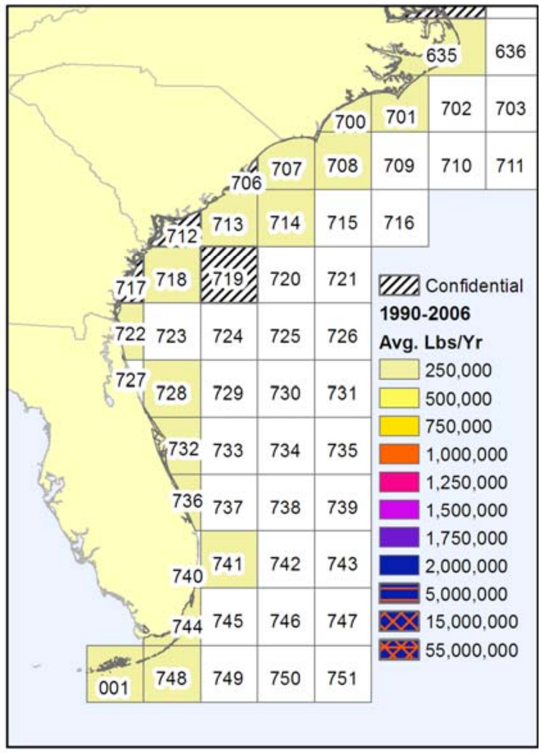


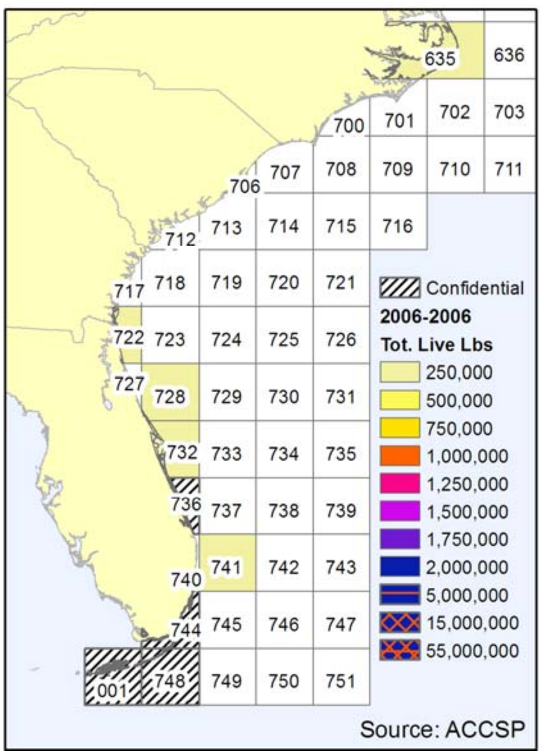
ACCSP Catch: PORGY, LONGSPINE
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	Conf.	Conf.	0.00
736	0.04	0.00	0.00
741	Conf.	Conf.	0.00

Figure 5.4.1-58. Spatial Presentation of Longspine Porgy Commercial Catch (Source: ACCSP).



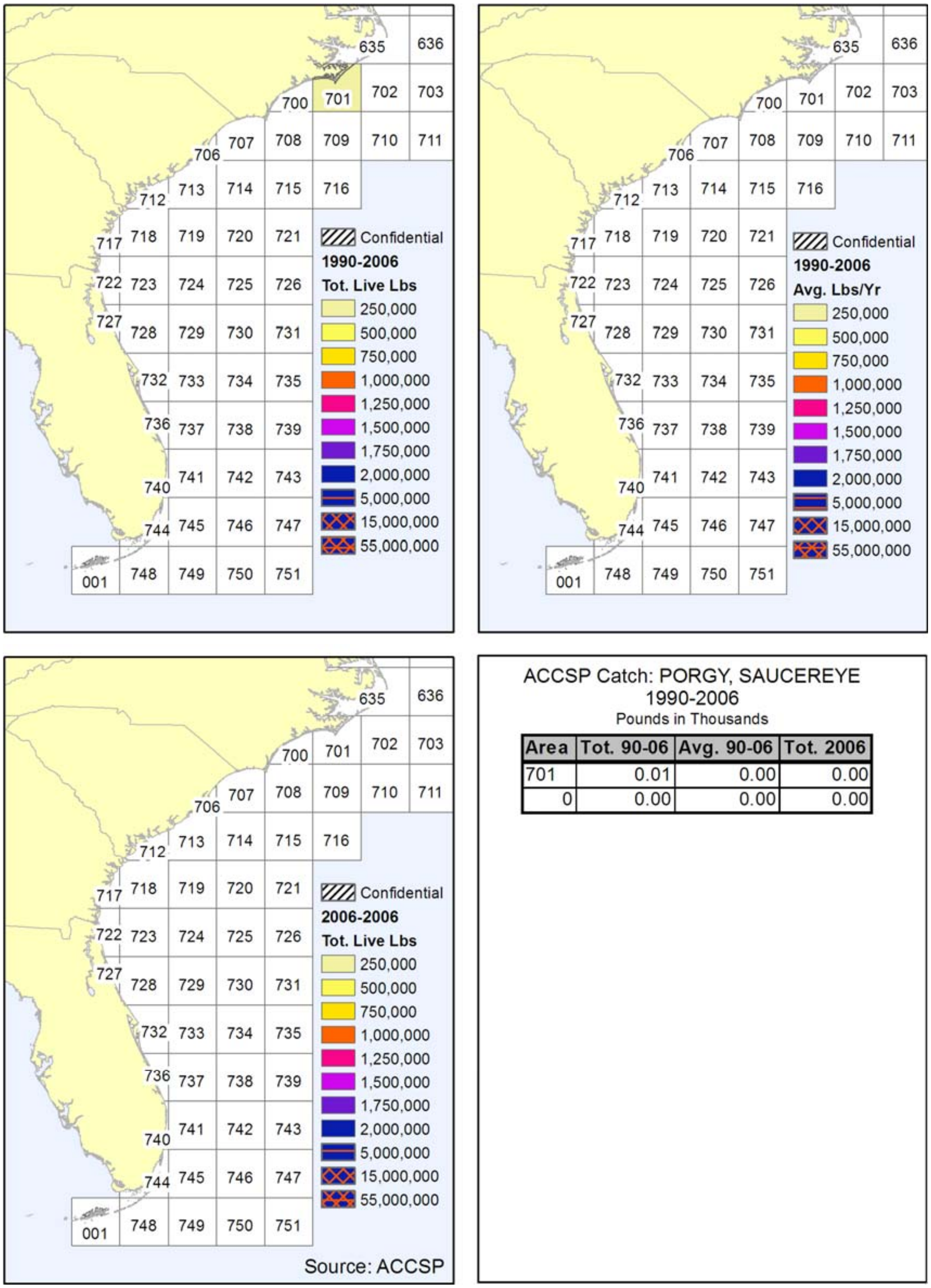




ACCSP Catch: PORGY, RED
1990-2006
Pounds in Thousands

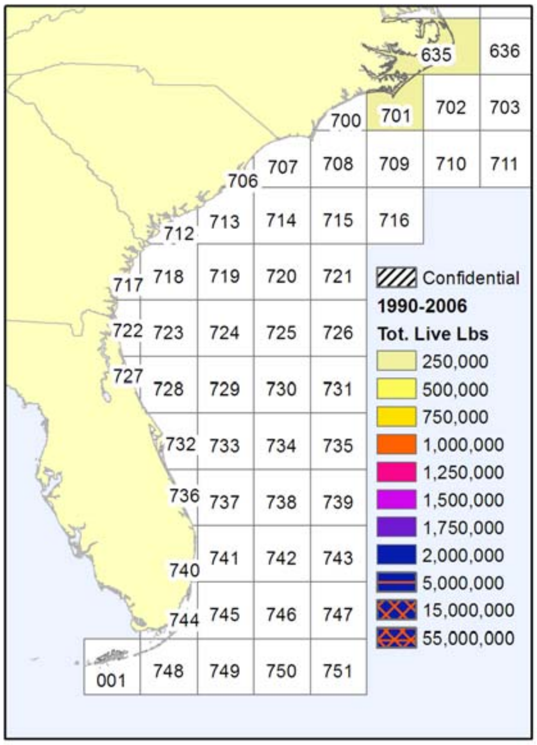
Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	0.10	0.01	Conf.
635	661.34	38.90	34.18
700	0.95	0.06	0.00
701	1,476.01	86.82	0.00
706	Conf.	Conf.	0.00
707	14.26	0.84	0.00
708	1.19	0.07	0.00
712	Conf.	Conf.	0.00
713	9.22	0.54	0.00
714	0.73	0.04	0.00
717	Conf.	Conf.	0.00
718	0.32	0.02	0.00
719	Conf.	Conf.	0.00
722	149.45	8.79	5.48
728	36.18	2.13	2.43
732	18.49	1.09	0.08
736	1.45	0.09	Conf.
741	2.85	0.17	0.44
744	1.05	0.06	Conf.
748	0.65	0.04	Conf.

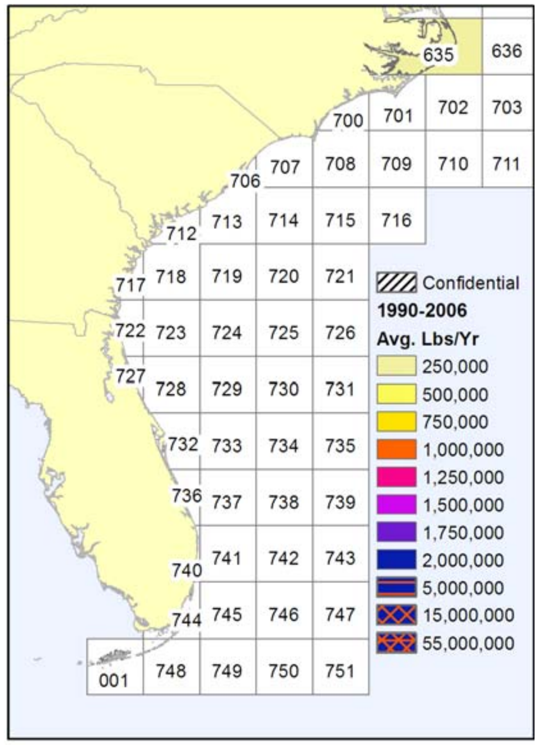
Figure 5.4.1-59. Spatial Presentation of Red Porgy Commercial Catch (Source: ACCSP).

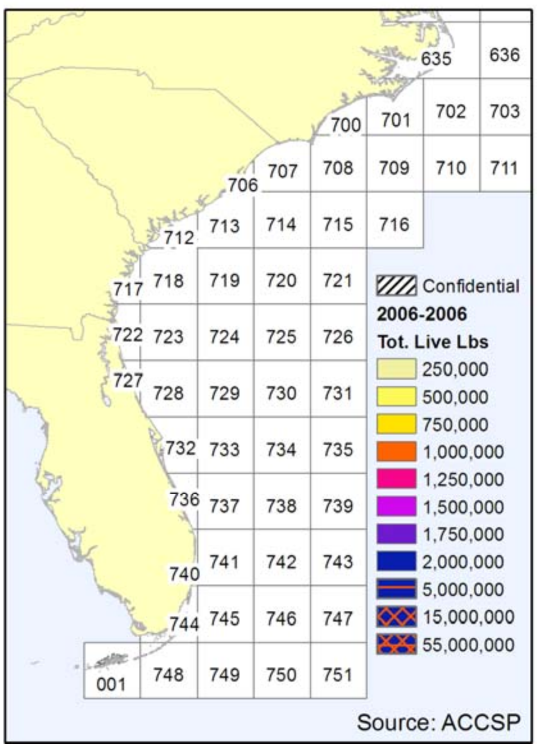


Area	Tot. 90-06	Avg. 90-06	Tot. 2006
701	0.01	0.00	0.00
0	0.00	0.00	0.00

Figure 5.4.1-60. Spatial Presentation of Saucereye Porgy Commercial Catch (Source: ACCSP).



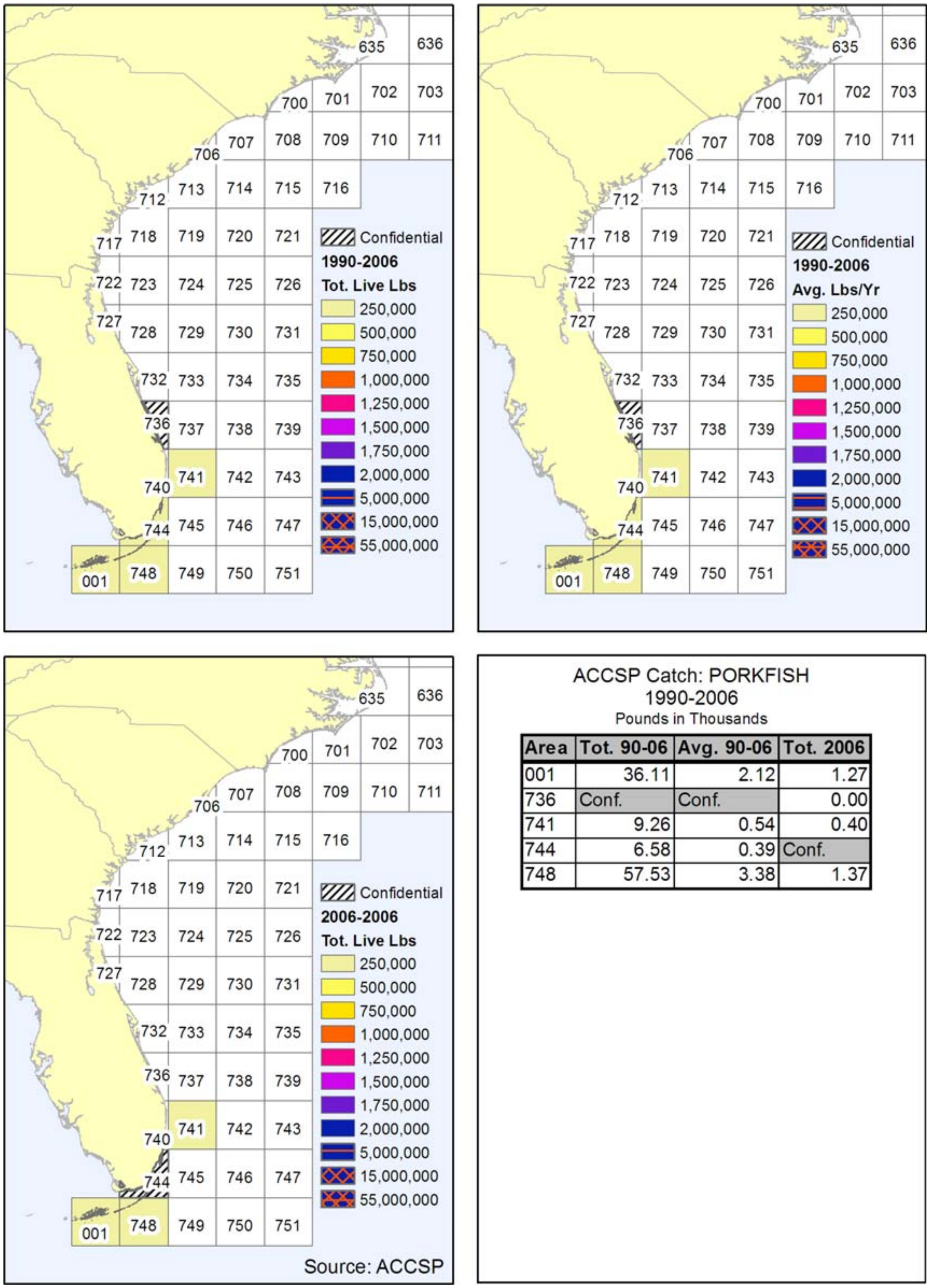




ACCSP Catch: PORGY, WHITEBONE
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
635	0.40	0.02	0.00
701	0.04	0.00	0.00

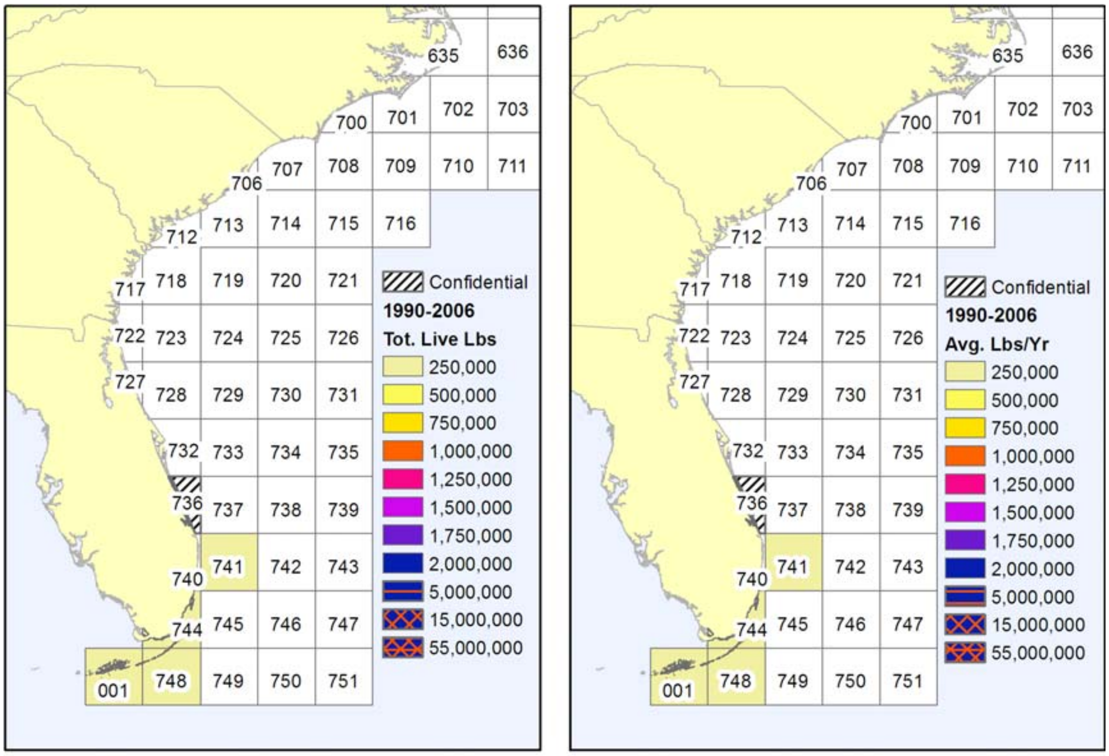
Figure 5.4.1-61. Spatial Presentation of Whitebone Porgy Commercial Catch (Source: ACCSP).

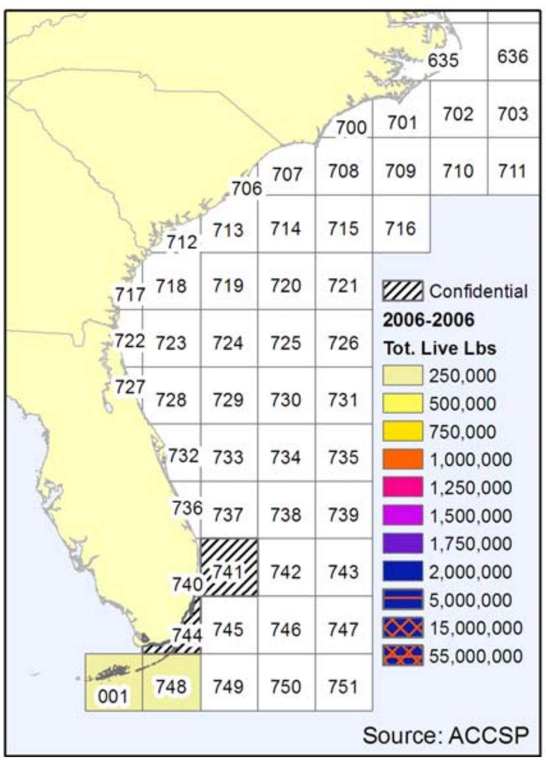


ACCSP Catch: PORKFISH
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	36.11	2.12	1.27
736	Conf.	Conf.	0.00
741	9.26	0.54	0.40
744	6.58	0.39	Conf.
748	57.53	3.38	1.37

Figure 5.4.1-62. Spatial Presentation of Porkfish Commercial Catch (Source: ACCSP).

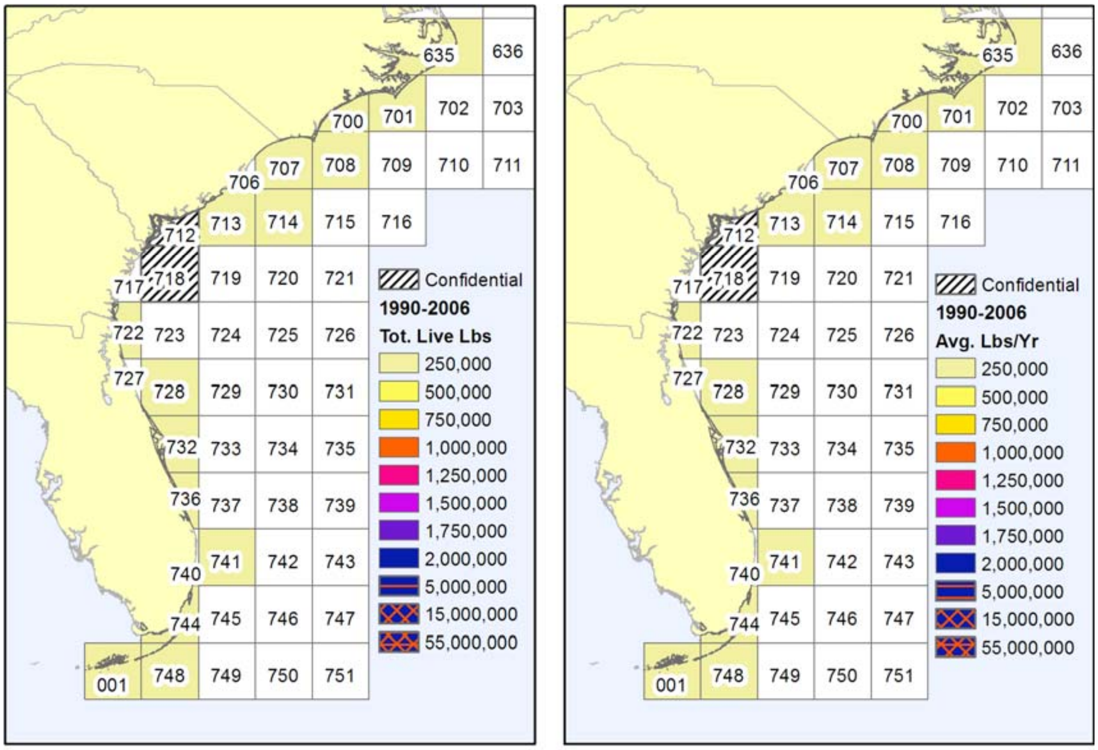


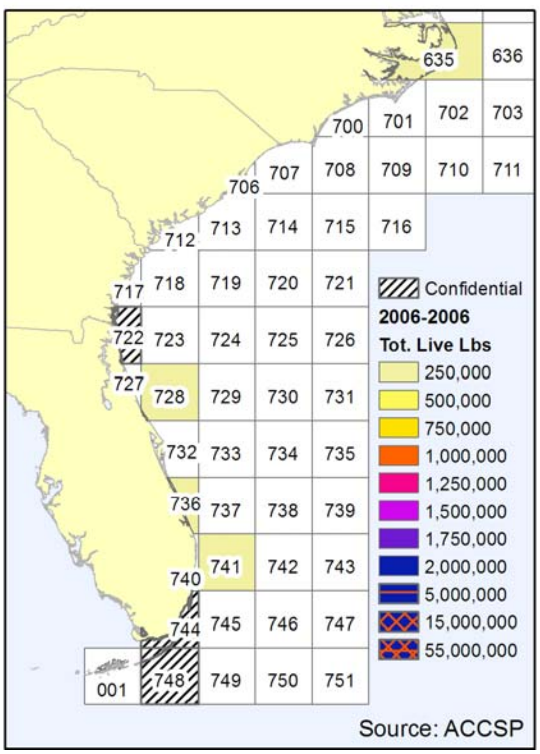


ACCSP Catch: PUDDINGWIFE
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	0.63	0.04	0.01
736	Conf.	Conf.	0.00
741	0.46	0.03	Conf.
744	0.46	0.03	Conf.
748	1.57	0.09	0.06

Figure 5.4.1-63. Spatial Presentation of Puddingwife Commercial Catch (Source: ACCSP).

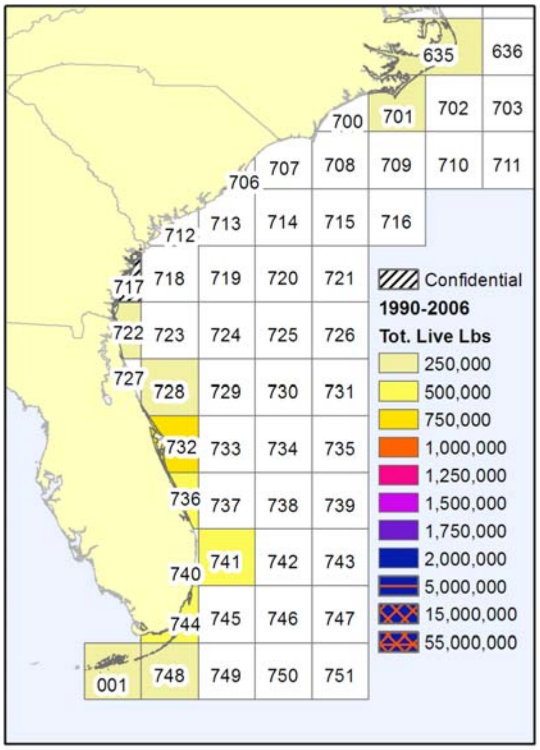


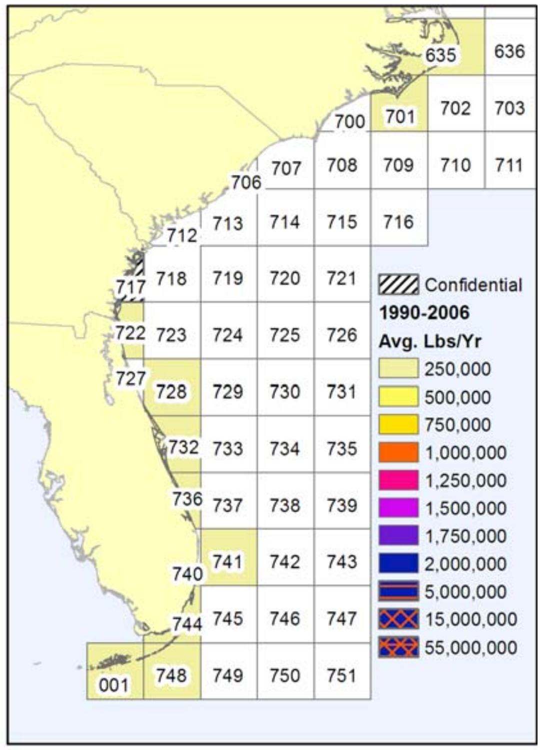


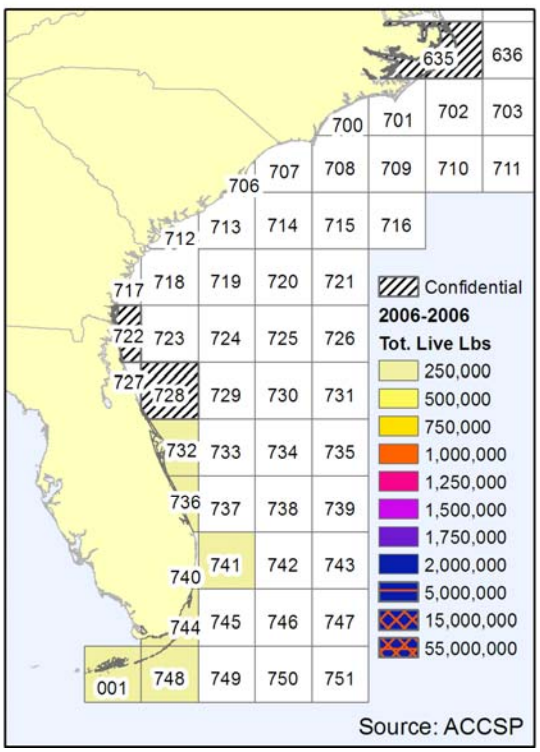
ACCSP Catch: RUDDERFISH, BANDED
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	2.72	0.16	0.00
635	24.49	1.44	3.99
700	1.02	0.06	0.00
701	3.46	0.20	0.00
707	10.64	0.63	0.00
708	2.24	0.13	0.00
712	Conf.	Conf.	0.00
713	13.27	0.78	0.00
714	0.86	0.05	0.00
718	Conf.	Conf.	0.00
722	20.25	1.19	Conf.
728	14.50	0.85	0.63
732	7.30	0.43	0.00
736	41.64	2.45	0.26
741	82.83	4.87	1.98
744	57.51	3.38	Conf.
748	11.54	0.68	Conf.

Figure 5.4.1-64. Spatial Presentation of Banded Rudderfish Commercial Catch (Source: ACCSP).







ACCSP Catch: RUNNER, BLUE
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	177.80	10.46	7.41
635	17.37	1.02	Conf.
701	14.72	0.87	0.00
717	Conf.	Conf.	0.00
722	4.49	0.26	Conf.
728	1.97	0.12	Conf.
732	511.58	30.09	36.86
736	407.81	23.99	37.00
741	274.97	16.17	36.70
744	320.73	18.87	11.86
748	75.52	4.44	9.74

Figure 5.4.1-65. Spatial Presentation of Blue Runner Commercial Catch (Source: ACCSP).

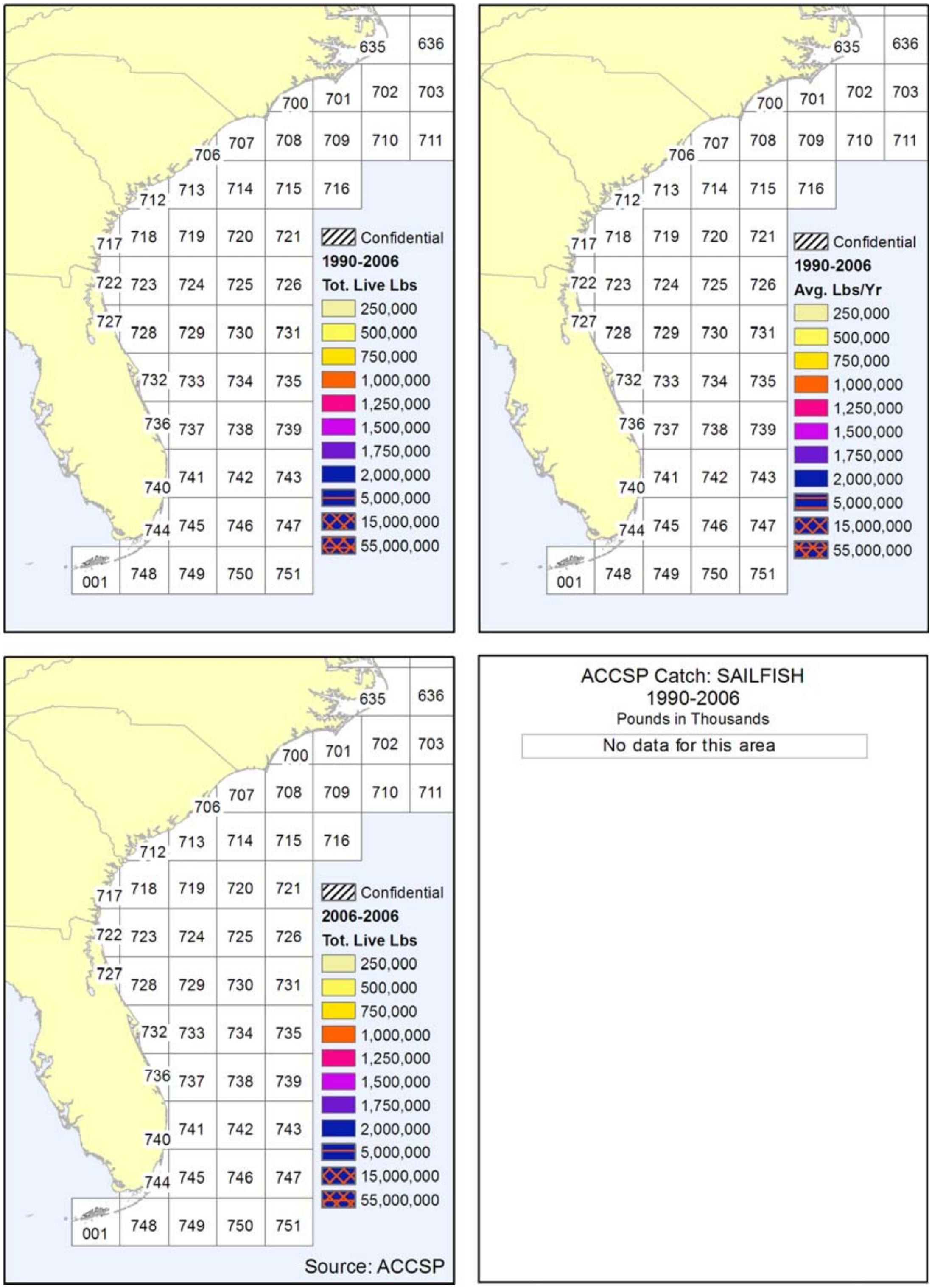
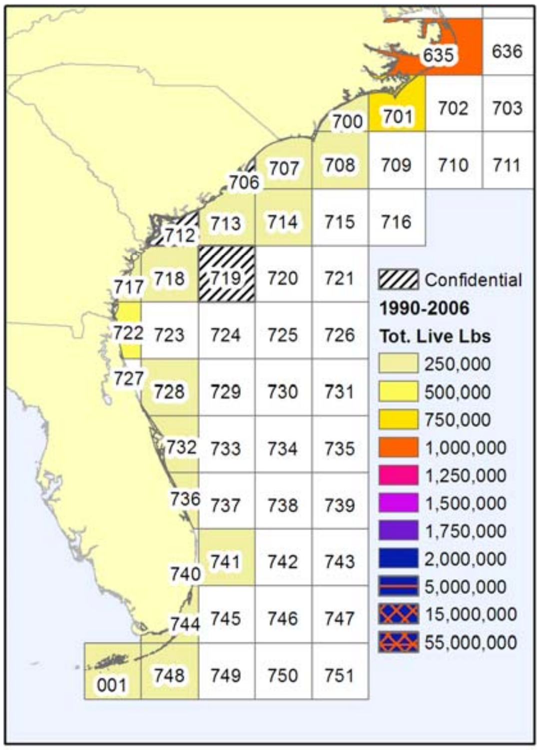
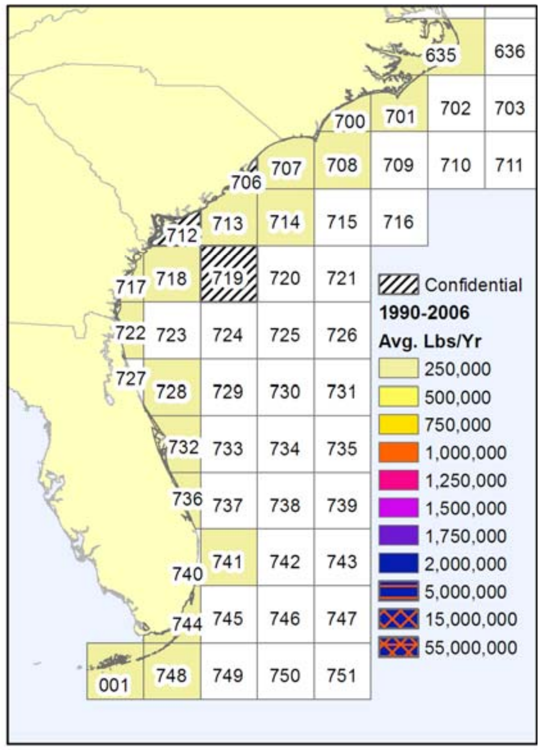
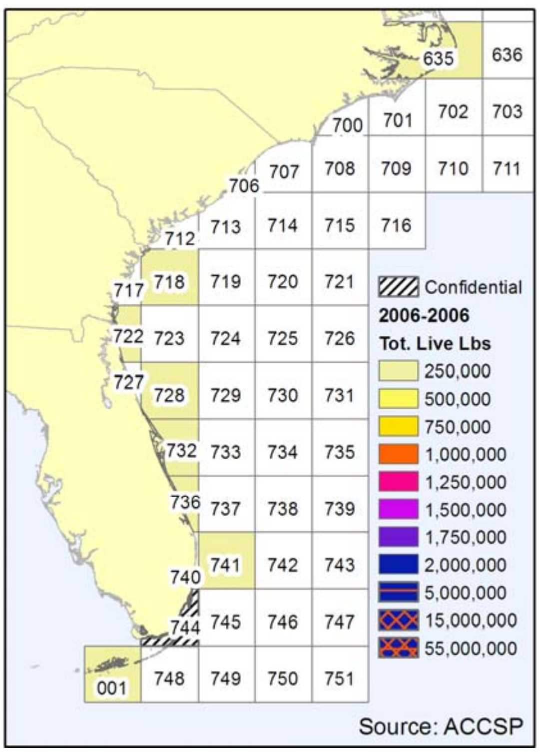


Figure 5.4.1-66. Spatial Presentation of Sailfish Commercial Catch (Source: ACCSP).



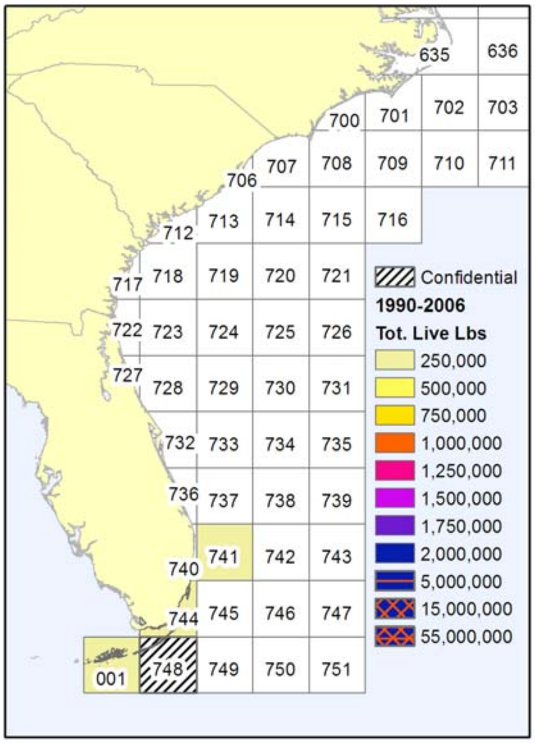


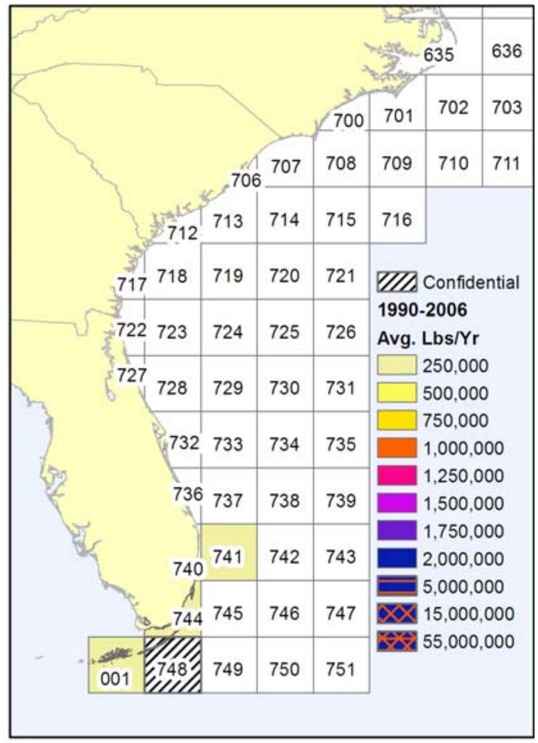


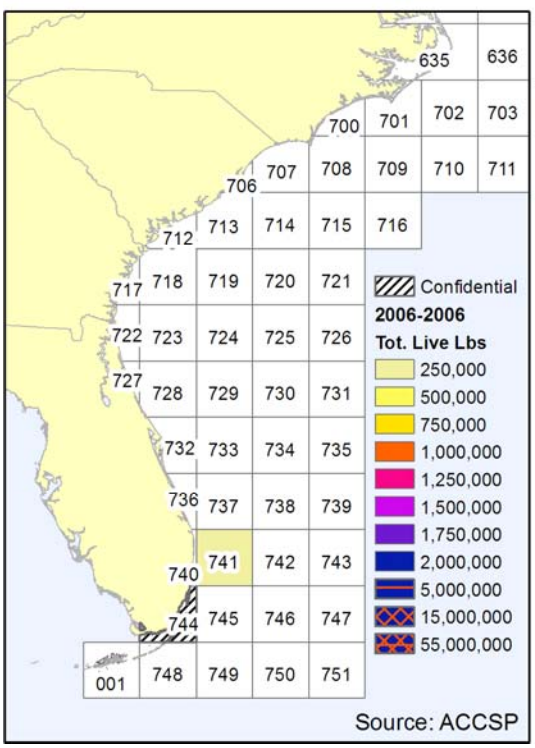
ACCSP Catch: SCAMP
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	26.47	1.56	0.61
635	900.00	52.94	92.22
700	14.09	0.83	0.00
701	706.00	41.53	0.00
706	Conf.	Conf.	0.00
707	163.69	9.63	0.00
708	21.83	1.28	0.00
712	Conf.	Conf.	0.00
713	94.22	5.54	0.00
714	10.72	0.63	0.00
717	0.94	0.06	0.00
718	2.45	0.14	0.04
719	Conf.	Conf.	0.00
722	310.31	18.25	5.49
728	143.19	8.42	5.37
732	32.95	1.94	1.09
736	15.60	0.92	0.36
741	5.78	0.34	0.13
744	3.27	0.19	Conf.
748	1.09	0.06	0.00

Figure 5.4.1-67. Spatial Presentation of Scamp Commercial Catch (Source: ACCSP).



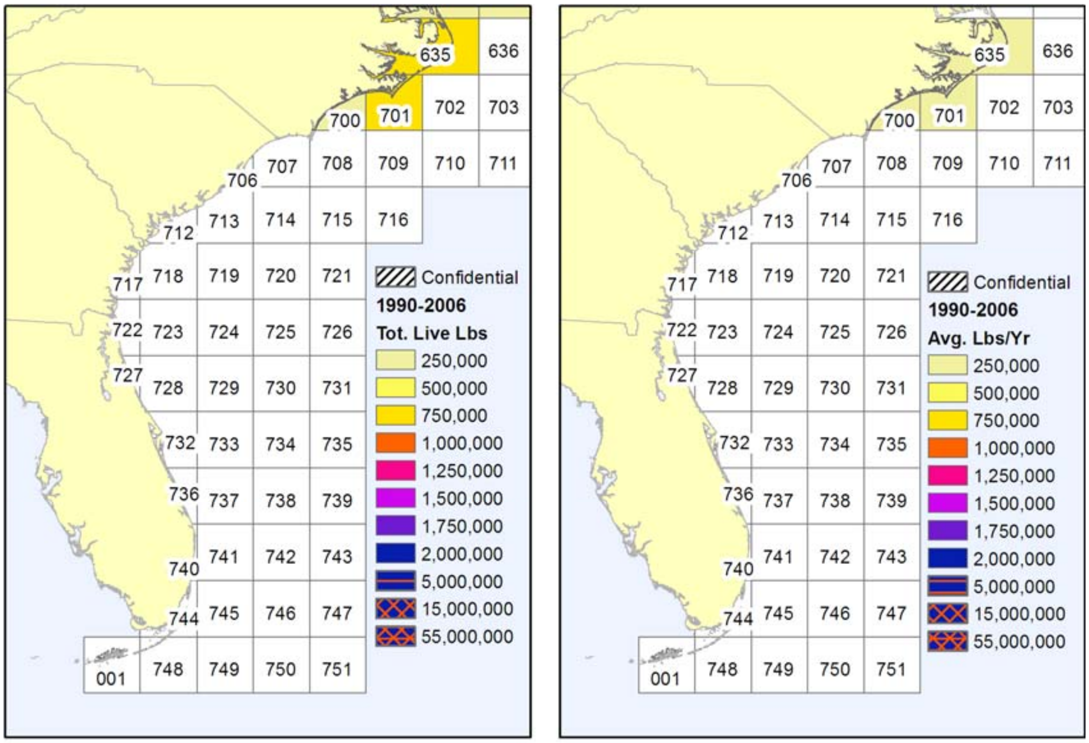


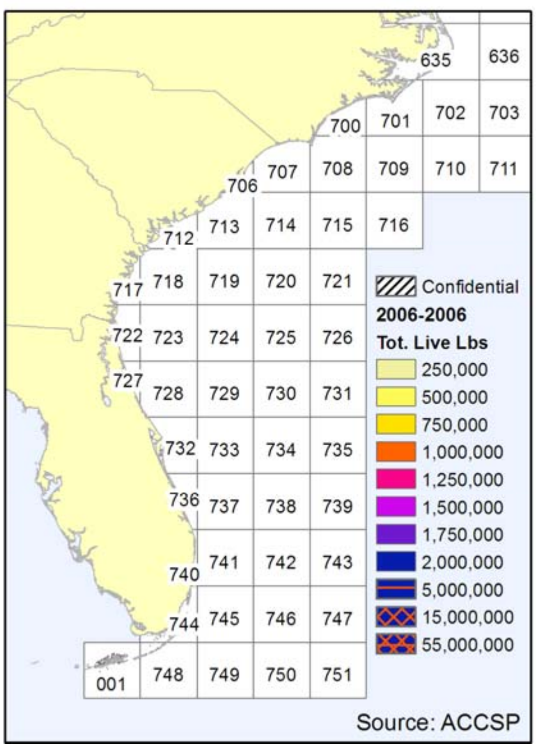


ACCSP Catch: SCHOOLMASTER
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	0.21	0.01	0.00
741	0.16	0.01	0.01
744	0.15	0.01	Conf.
748	Conf.	Conf.	0.00

Figure 5.4.1-68. Spatial Presentation of Schoolmaster Commercial Catch (Source: ACCSP).

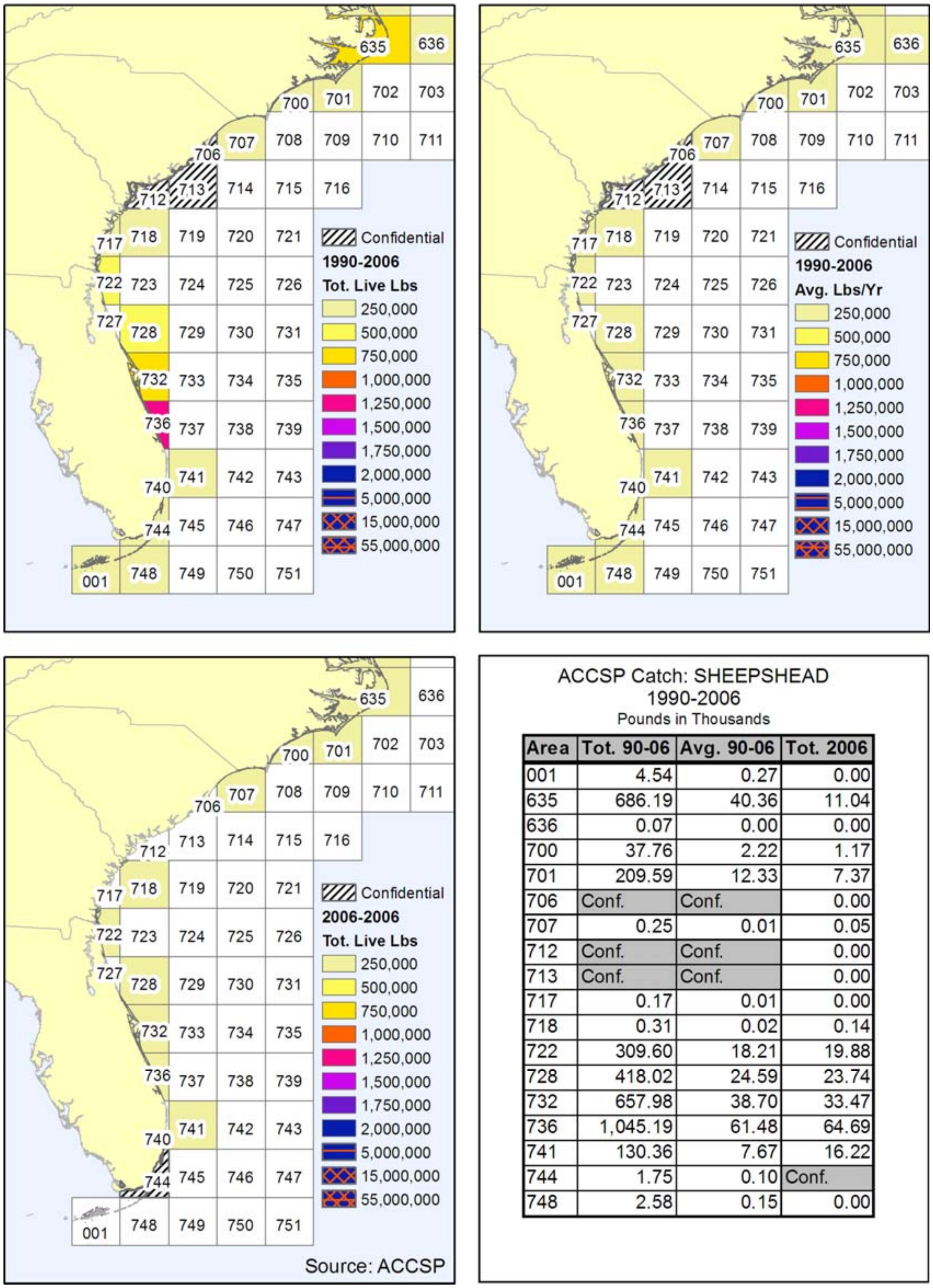




ACCSP Catch: SCUP
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
635	731.64	43.04	0.00
700	0.15	0.01	0.00
701	590.35	34.73	0.00

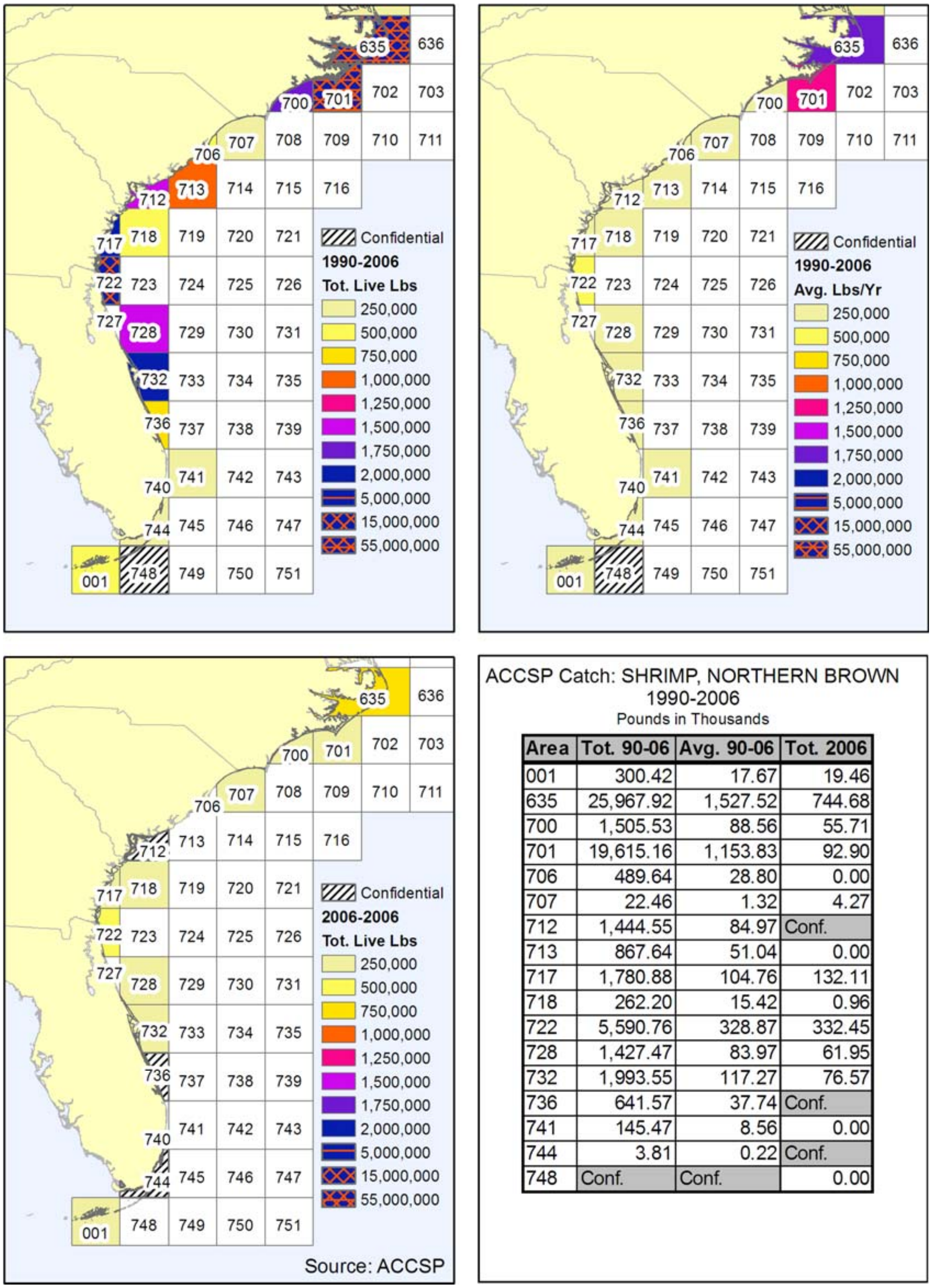
Figure 5.4.1-69. Spatial Presentation of Scup Commercial Catch (Source: ACCSP).



ACCSP Catch: SHEEPSHEAD
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	4.54	0.27	0.00
635	686.19	40.36	11.04
636	0.07	0.00	0.00
700	37.76	2.22	1.17
701	209.59	12.33	7.37
706	Conf.	Conf.	0.00
707	0.25	0.01	0.05
712	Conf.	Conf.	0.00
713	Conf.	Conf.	0.00
717	0.17	0.01	0.00
718	0.31	0.02	0.14
722	309.60	18.21	19.88
728	418.02	24.59	23.74
732	657.98	38.70	33.47
736	1,045.19	61.48	64.69
741	130.36	7.67	16.22
744	1.75	0.10	Conf.
748	2.58	0.15	0.00

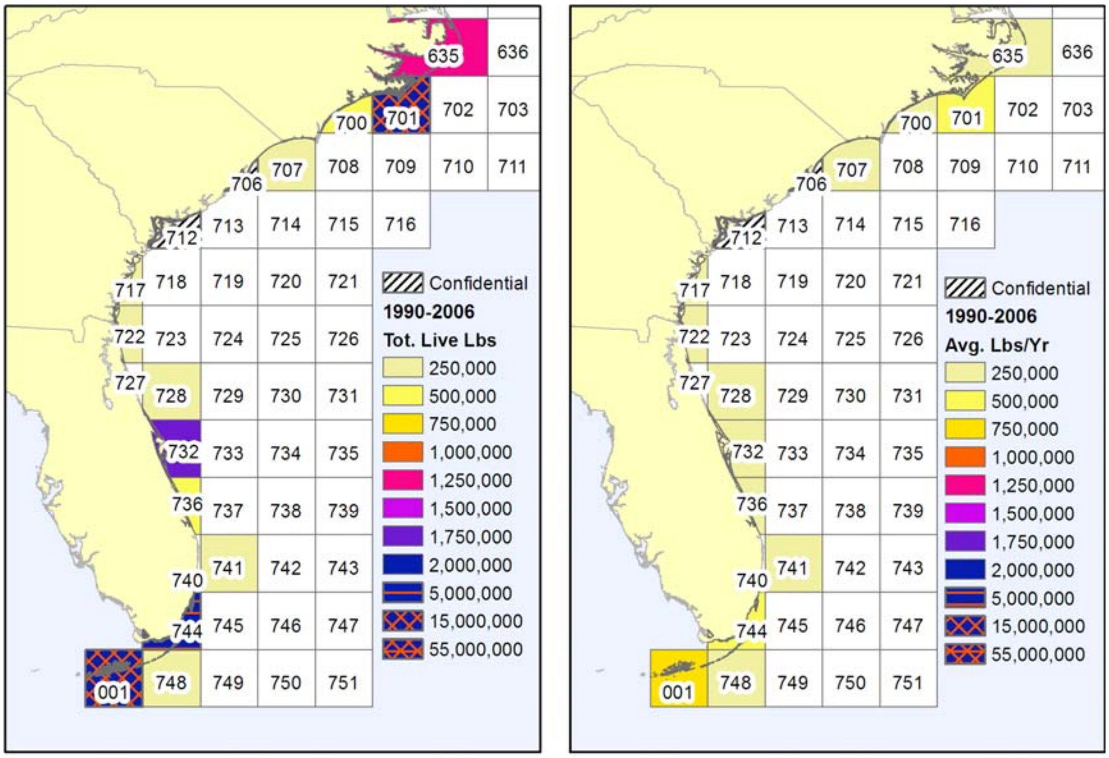
Figure 5.4.1-70. Spatial Presentation of Sheepshead Commercial Catch (Source: ACCSP).

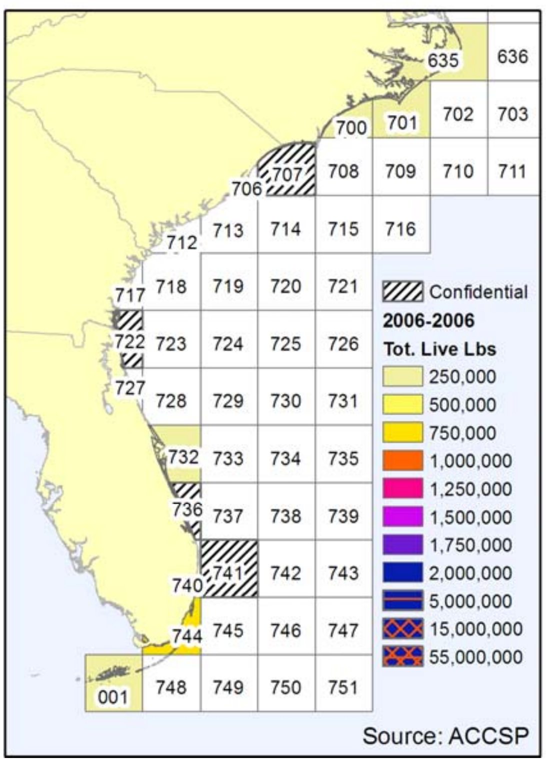


ACCSP Catch: SHRIMP, NORTHERN BROWN
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	300.42	17.67	19.46
635	25,967.92	1,527.52	744.68
700	1,505.53	88.56	55.71
701	19,615.16	1,153.83	92.90
706	489.64	28.80	0.00
707	22.46	1.32	4.27
712	1,444.55	84.97	Conf.
713	867.64	51.04	0.00
717	1,780.88	104.76	132.11
718	262.20	15.42	0.96
722	5,590.76	328.87	332.45
728	1,427.47	83.97	61.95
732	1,993.55	117.27	76.57
736	641.57	37.74	Conf.
741	145.47	8.56	0.00
744	3.81	0.22	Conf.
748	Conf.	Conf.	0.00

Figure 5.4.1-71. Spatial Presentation of Brown Shrimp Commercial Catch (Source: ACCSP).

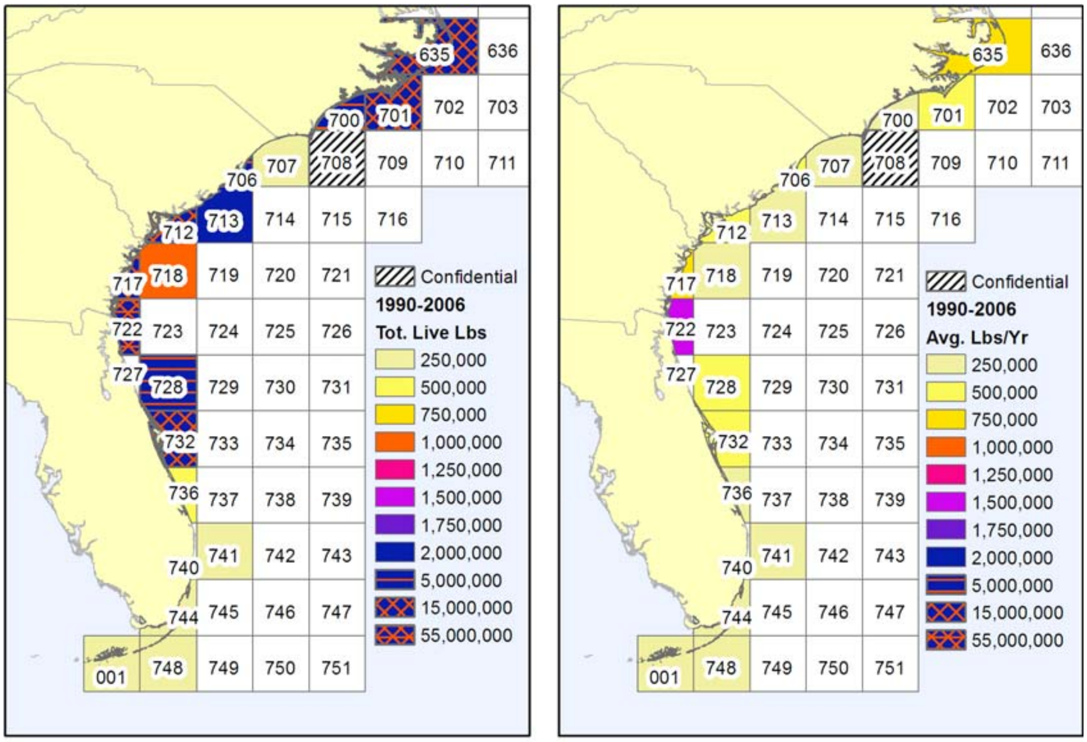


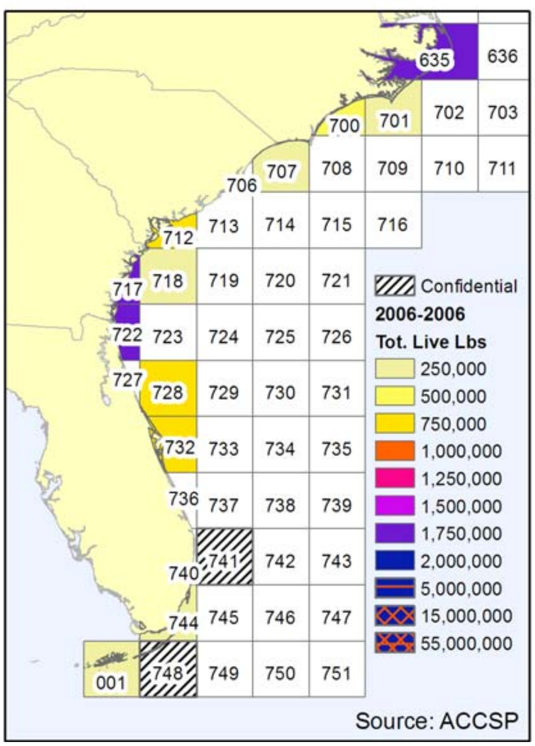


ACCSP Catch: SHRIMP, NORTHERN PINK
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	10,458.49	615.21	190.24
635	1,178.27	69.31	20.41
700	271.79	15.99	2.14
701	7,595.11	446.77	26.25
706	Conf.	Conf.	0.00
707	0.41	0.02	Conf.
712	Conf.	Conf.	0.00
717	32.55	1.91	0.00
722	112.94	6.64	Conf.
728	55.80	3.28	0.00
732	1,621.69	95.39	35.07
736	359.92	21.17	Conf.
741	193.80	11.40	Conf.
744	4,796.86	282.17	539.41
748	147.66	8.69	0.00

Figure 5.4.1-72. Spatial Presentation of Pink Shrimp Commercial Catch (Source: ACCSP).

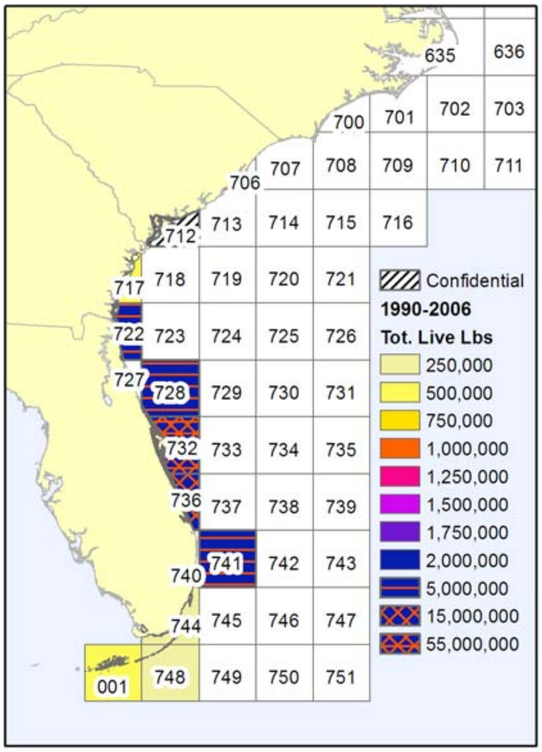


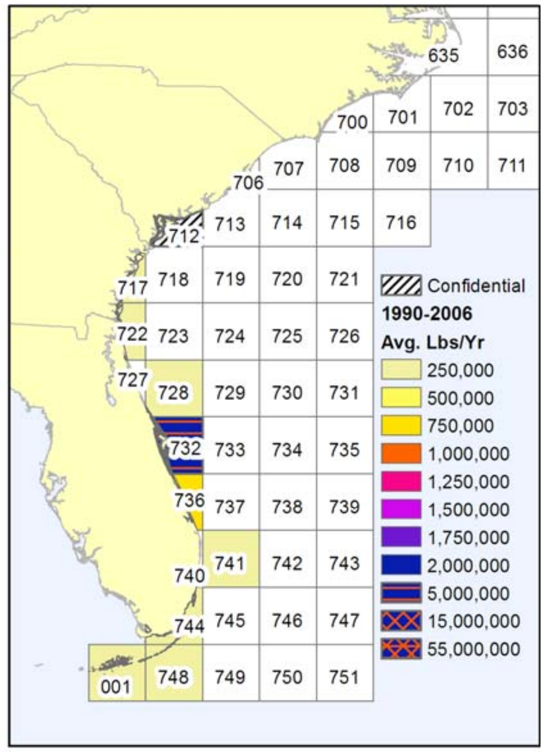


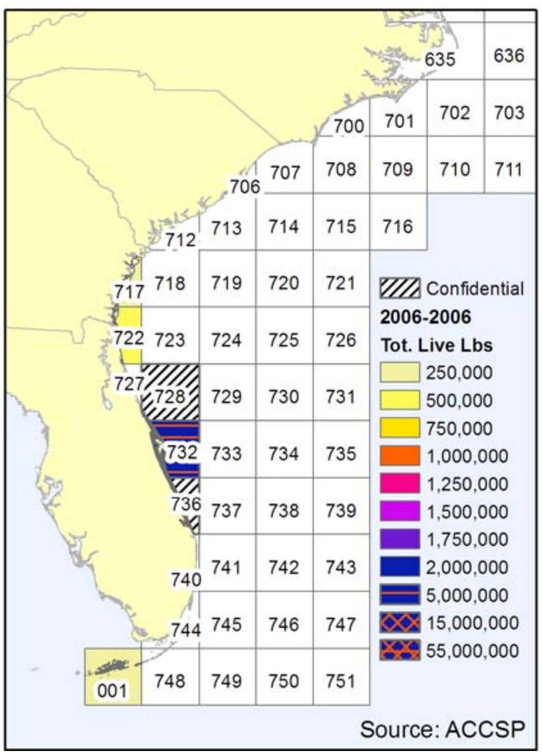
ACCSP Catch: SHRIMP, NORTHERN WHITE
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	48.79	2.87	6.18
635	11,285.54	663.86	1,633.48
700	3,278.56	192.86	305.69
701	6,355.52	373.85	204.20
706	4,348.57	255.80	0.00
707	127.56	7.50	3.23
708	Conf.	Conf.	0.00
712	6,109.20	359.36	540.67
713	1,983.46	116.67	0.00
717	9,725.56	572.09	1,585.06
718	917.15	53.95	140.50
722	22,794.18	1,340.83	1,740.44
728	4,602.29	270.72	589.27
732	6,313.56	371.39	528.66
736	260.86	15.34	0.00
741	32.13	1.89	Conf.
744	173.35	10.20	116.43
748	6.97	0.41	Conf.

Figure 5.4.1-73. Spatial Presentation of White Shrimp Commercial Catch (Source: ACCSP).



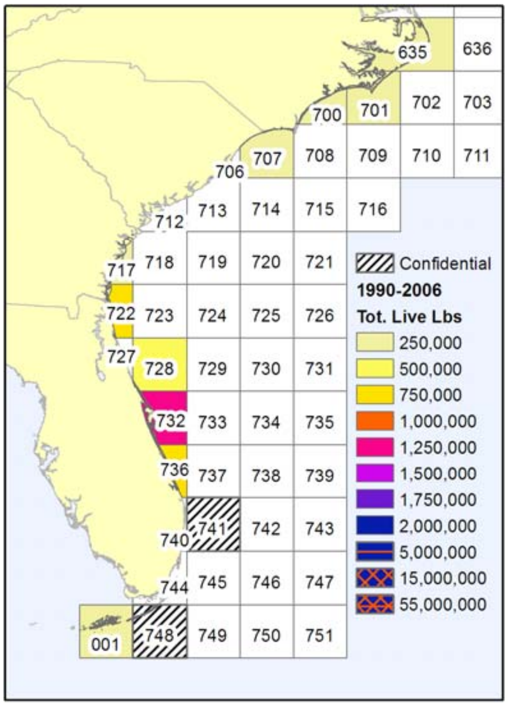


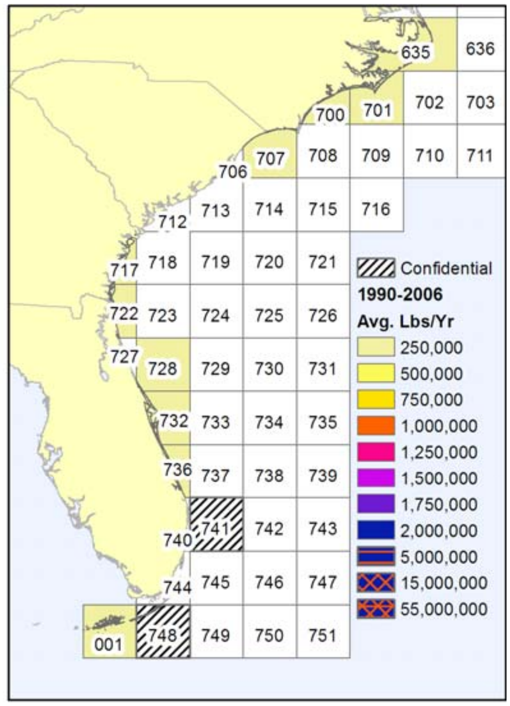


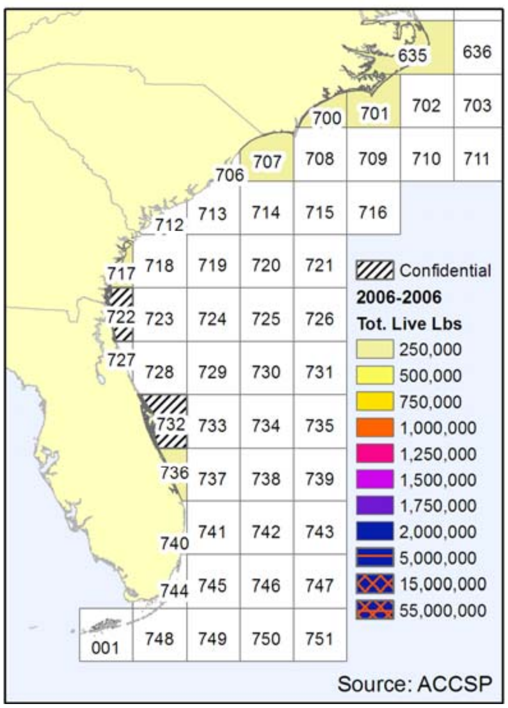
ACCSP Catch: SHRIMP, ROCK
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	360.59	21.21	13.12
712	Conf.	Conf.	0.00
717	266.45	15.67	155.34
722	2,427.36	142.79	445.66
728	2,143.15	126.07	Conf.
732	50,286.93	2,958.05	2,307.82
736	11,121.82	654.22	Conf.
741	2,776.69	163.33	0.00
744	10.81	0.64	0.00
748	76.03	4.47	0.00

Figure 5.4.1-74. Spatial Presentation of Rock Shrimp Commercial Catch (Source: ACCSP).



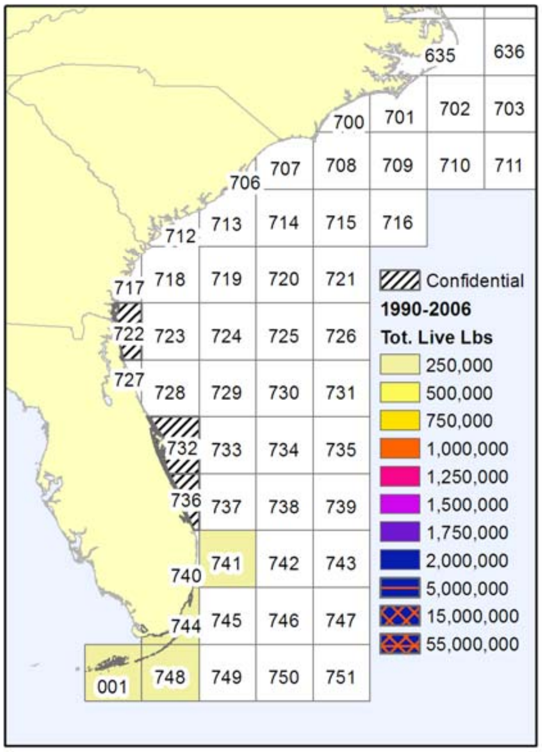


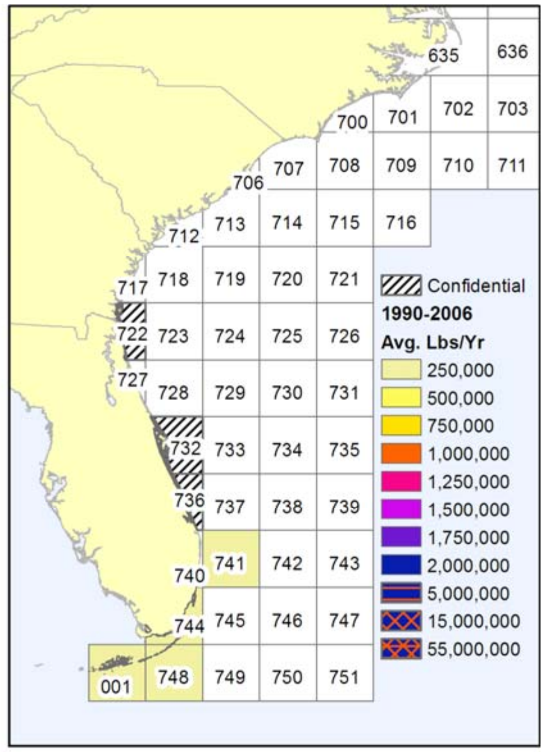


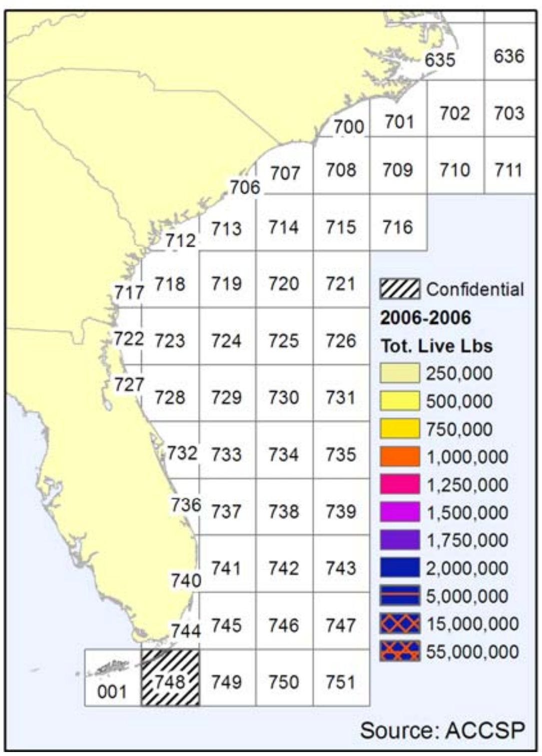
ACCSP Catch: SHRIMP, ROYAL RED
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	211.48	12.44	0.00
635	66.30	3.90	65.48
700	2.68	0.16	2.68
701	17.19	1.01	17.19
707	0.57	0.03	0.57
717	8.75	0.51	1.32
722	611.27	35.96	Conf.
728	301.52	17.74	0.00
732	1,188.18	69.89	Conf.
736	504.13	29.65	62.96
741	Conf.	Conf.	0.00
748	Conf.	Conf.	0.00

Figure 5.4.1-75. Spatial Presentation of Royal Red Shrimp Commercial Catch (Source: ACCSP).



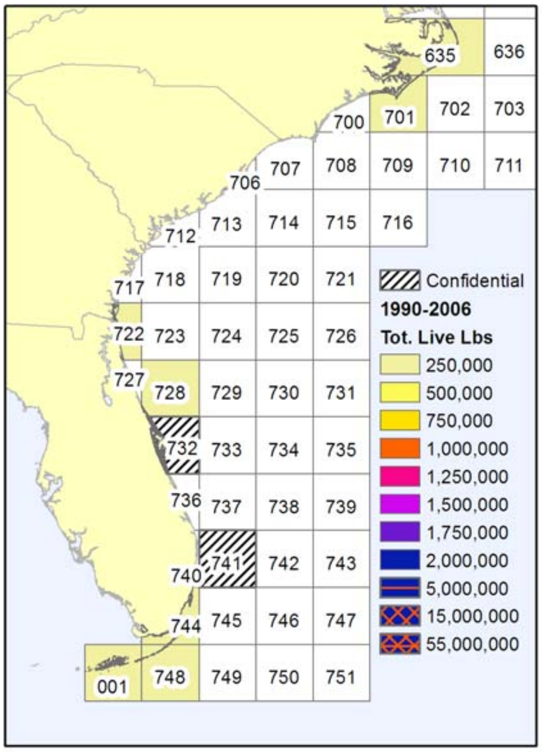


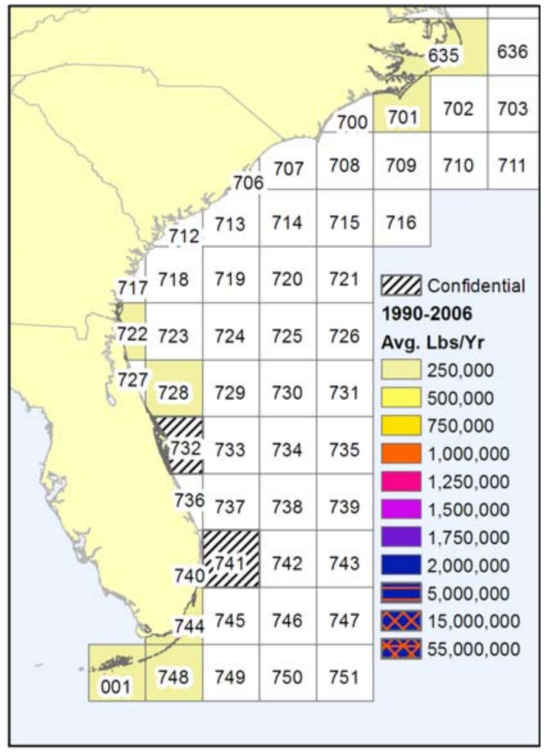


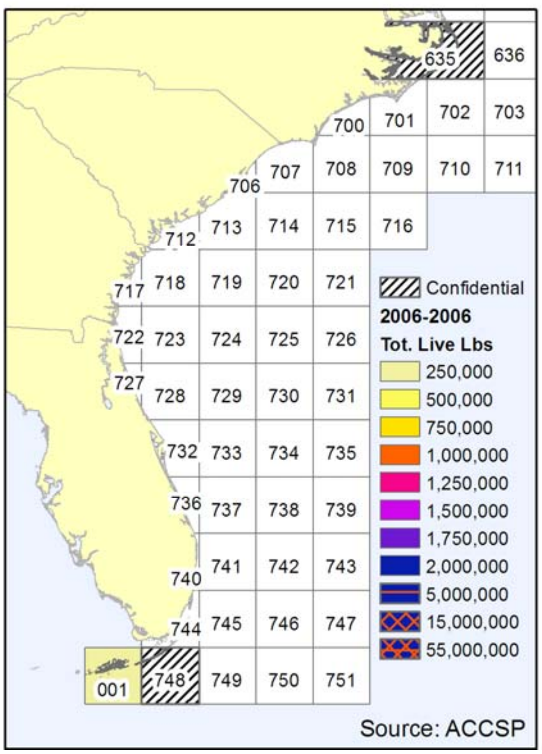
ACCSP Catch: SNAPPER, BLACK
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	0.19	0.01	0.00
722	Conf.	Conf.	0.00
732	Conf.	Conf.	0.00
736	Conf.	Conf.	0.00
741	0.13	0.01	0.00
744	5.75	0.34	0.00
748	0.87	0.05	Conf.

Figure 5.4.1-76. Spatial Presentation of Black Snapper Commercial Catch (Source: ACCSP).



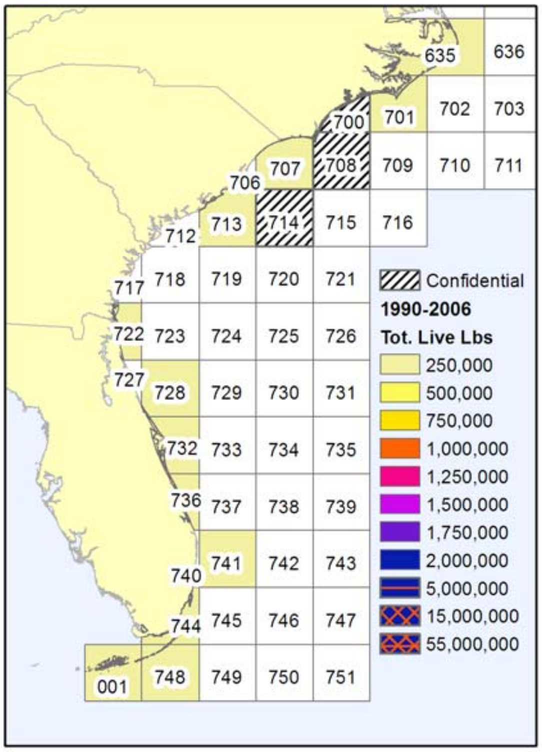


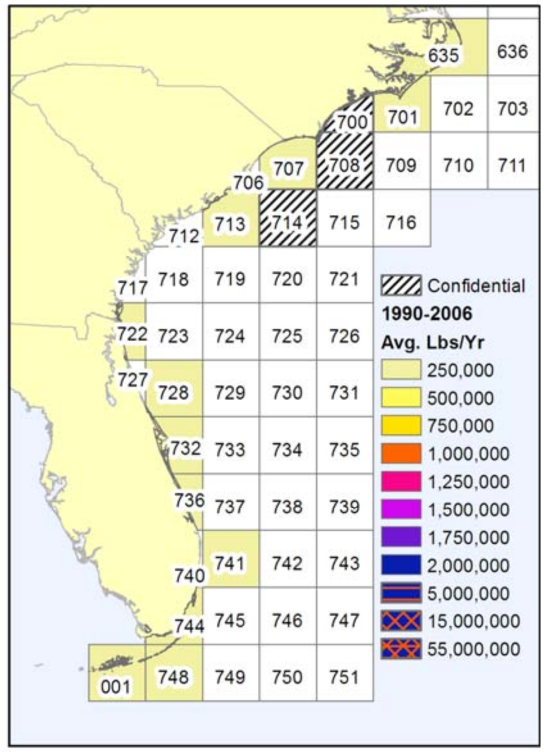


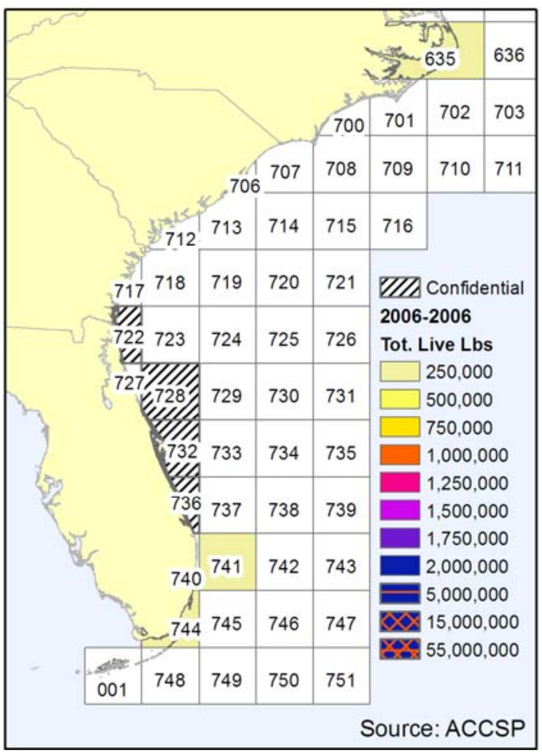
ACCSP Catch: SNAPPER, BLACKFIN
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	2.43	0.14	0.08
635	0.53	0.03	Conf.
701	0.07	0.00	0.00
722	0.30	0.02	0.00
728	0.20	0.01	0.00
732	Conf.	Conf.	0.00
741	Conf.	Conf.	0.00
744	0.76	0.04	0.00
748	0.17	0.01	Conf.

Figure 5.4.1-77. Spatial Presentation of Blackfin Snapper Commercial Catch (Source: ACCSP).



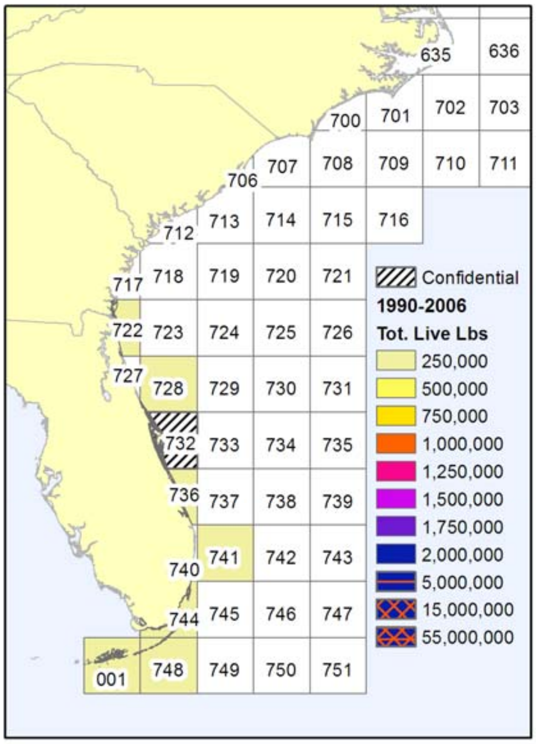


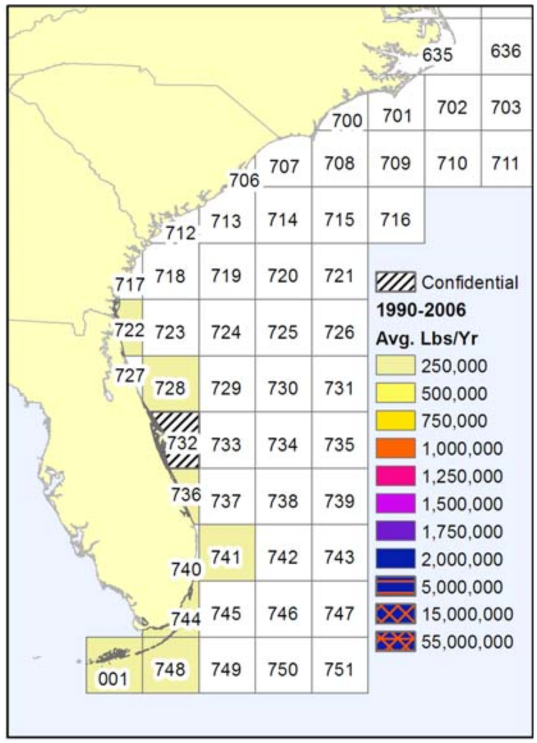


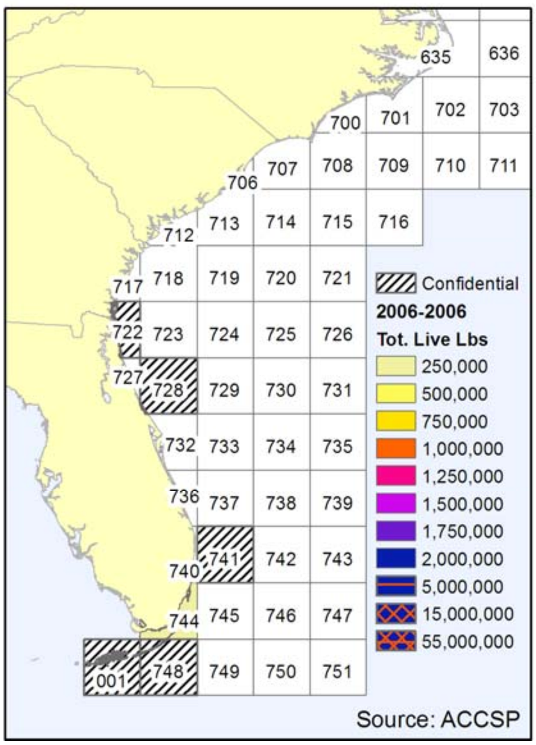
ACCSP Catch: SNAPPER, CUBERA
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	1.65	0.10	0.00
635	1.20	0.07	0.24
700	Conf.	Conf.	0.00
701	1.89	0.11	0.00
707	0.28	0.02	0.00
708	Conf.	Conf.	0.00
713	0.27	0.02	0.00
714	Conf.	Conf.	0.00
722	11.14	0.66	Conf.
728	2.34	0.14	Conf.
732	11.36	0.67	Conf.
736	1.60	0.09	Conf.
741	4.24	0.25	0.15
744	9.86	0.58	0.27
748	1.58	0.09	0.00

Figure 5.4.1-78. Spatial Presentation of Cubera Snapper Commercial Catch (Source: ACCSP).



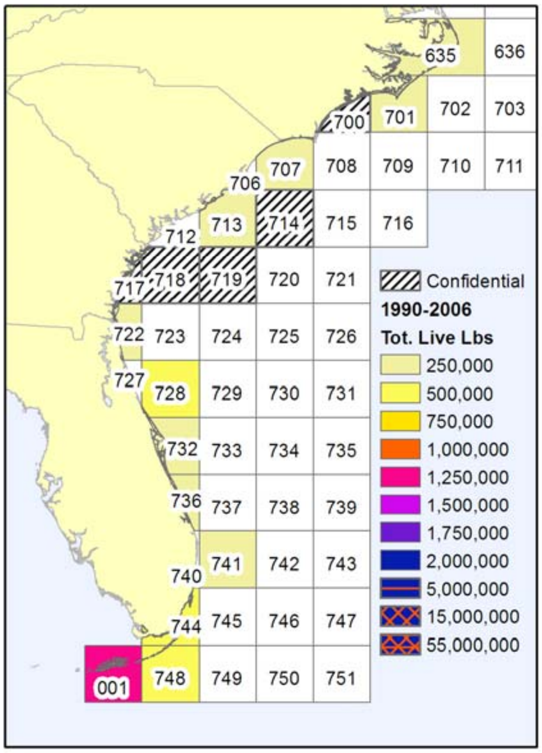


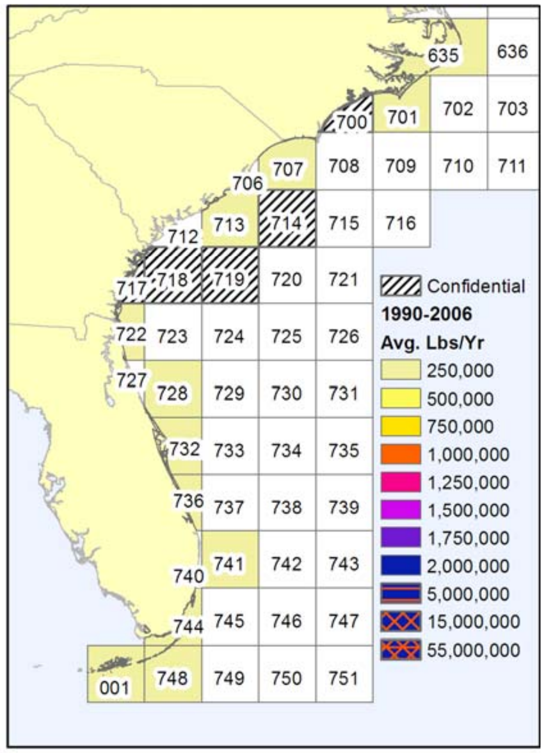


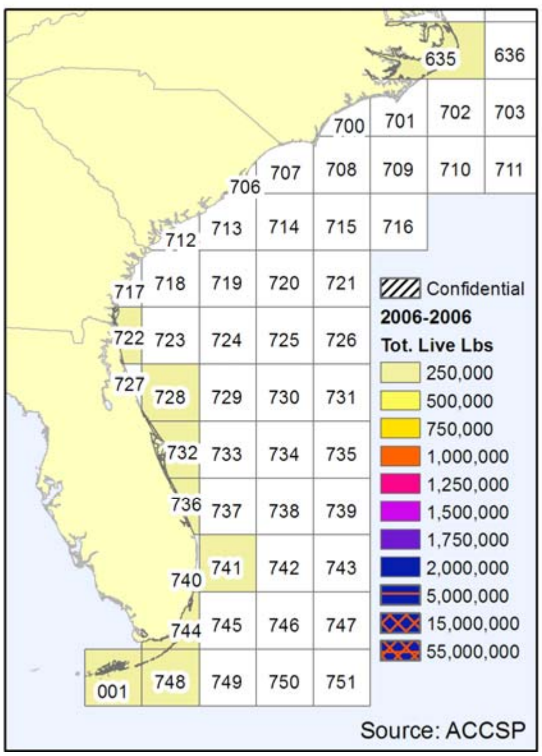
ACCSP Catch: SNAPPER, DOG
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	2.26	0.13	Conf.
722	0.78	0.05	Conf.
728	0.12	0.01	Conf.
732	Conf.	Conf.	0.00
736	0.19	0.01	0.00
741	1.77	0.10	Conf.
744	1.96	0.12	0.07
748	0.31	0.02	Conf.

Figure 5.4.1-79. Spatial Presentation of Dog Snapper Commercial Catch (Source: ACCSP).



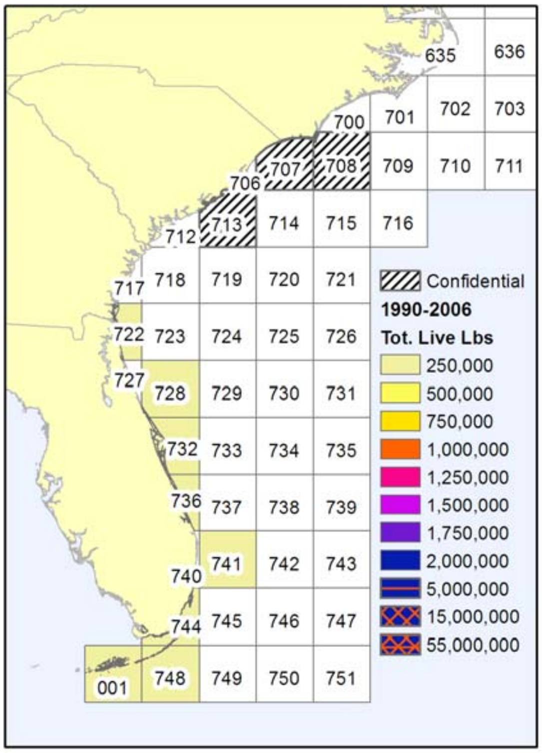


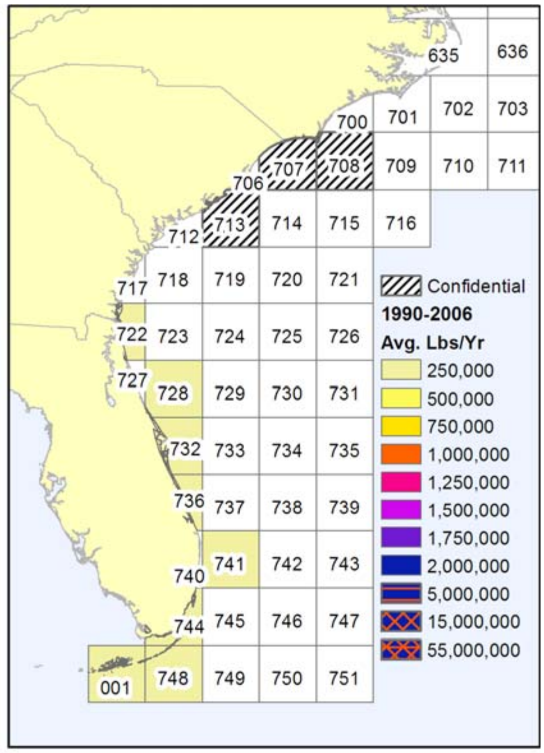


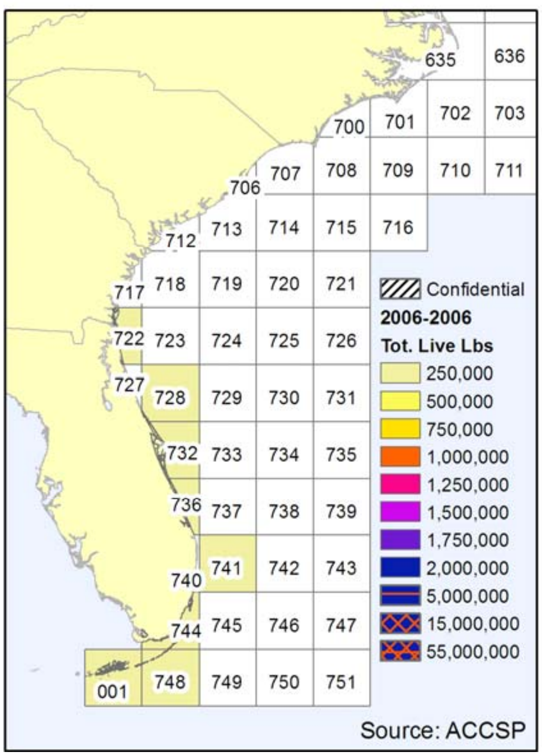
ACCSP Catch: SNAPPER, GRAY
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	1,131.74	66.57	47.01
635	0.91	0.05	0.26
700	Conf.	Conf.	0.00
701	1.54	0.09	0.00
707	0.43	0.03	0.00
713	0.52	0.03	0.00
714	Conf.	Conf.	0.00
717	Conf.	Conf.	0.00
718	Conf.	Conf.	0.00
719	Conf.	Conf.	0.00
722	106.23	6.25	1.20
728	266.39	15.67	5.01
732	141.05	8.30	2.22
736	92.03	5.41	1.66
741	88.08	5.18	3.88
744	314.45	18.50	11.03
748	492.69	28.98	11.18

Figure 5.4.1-80. Spatial Presentation of Gray Snapper Commercial Catch (Source: ACCSP).



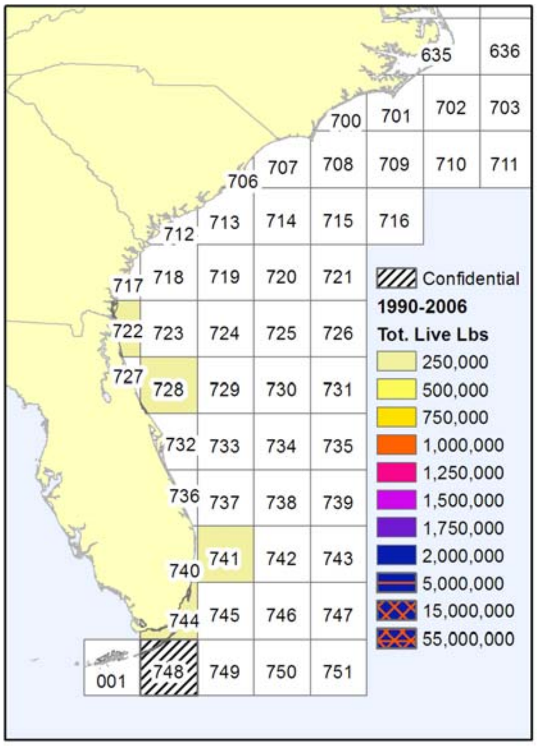


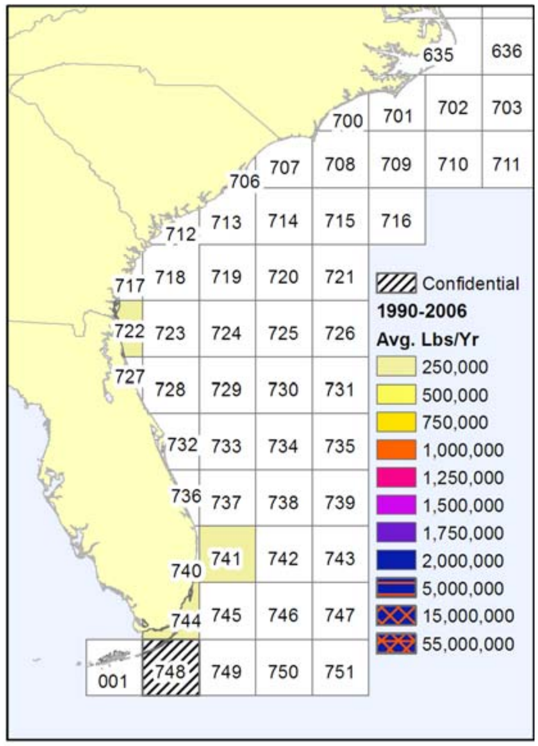


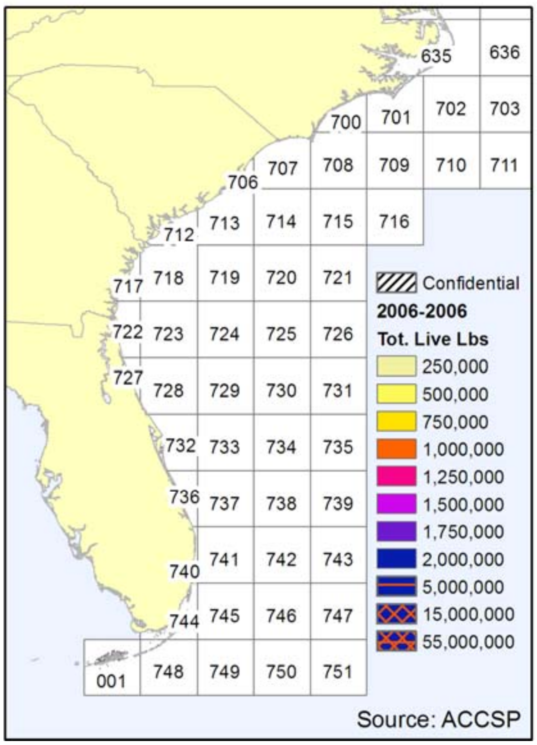
ACCSP Catch: SNAPPER, LANE
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	142.87	8.40	2.11
707	Conf.	Conf.	0.00
708	Conf.	Conf.	0.00
713	Conf.	Conf.	0.00
722	0.93	0.05	0.01
728	4.78	0.28	0.04
732	5.50	0.32	0.04
736	9.68	0.57	0.13
741	27.64	1.63	2.26
744	25.36	1.49	0.04
748	23.56	1.39	0.32

Figure 5.4.1-81. Spatial Presentation of Lane Snapper Commercial Catch (Source: ACCSP).



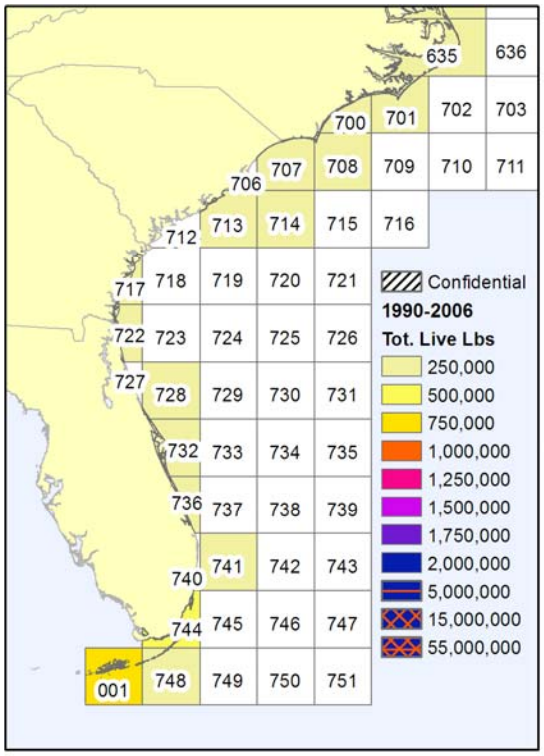


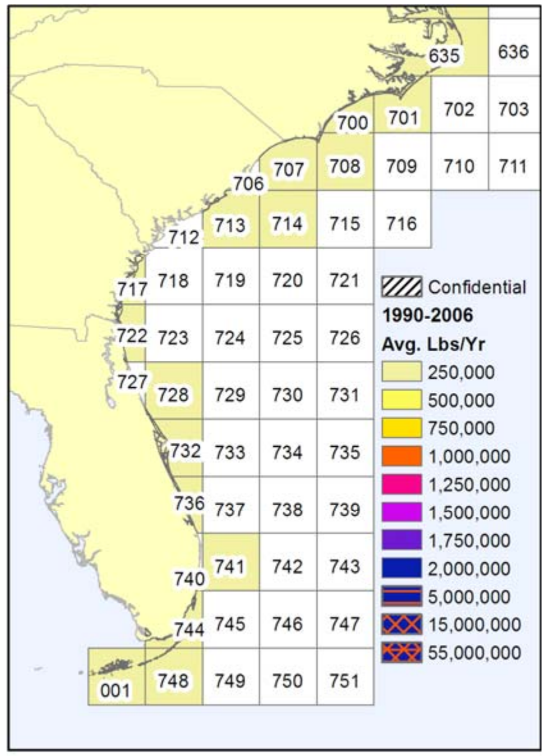


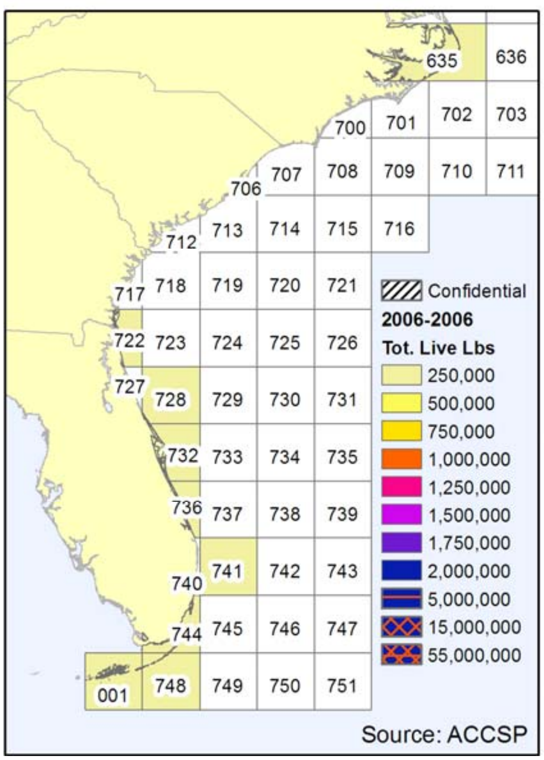
ACCSP Catch: SNAPPER, MAHOGANY
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
722	0.22	0.01	0.00
728	0.03	0.00	0.00
741	0.24	0.01	0.00
744	0.09	0.01	0.00
748	Conf.	Conf.	0.00

Figure 5.4.1-82. Spatial Presentation of Mahogany Snapper Commercial Catch (Source: ACCSP).



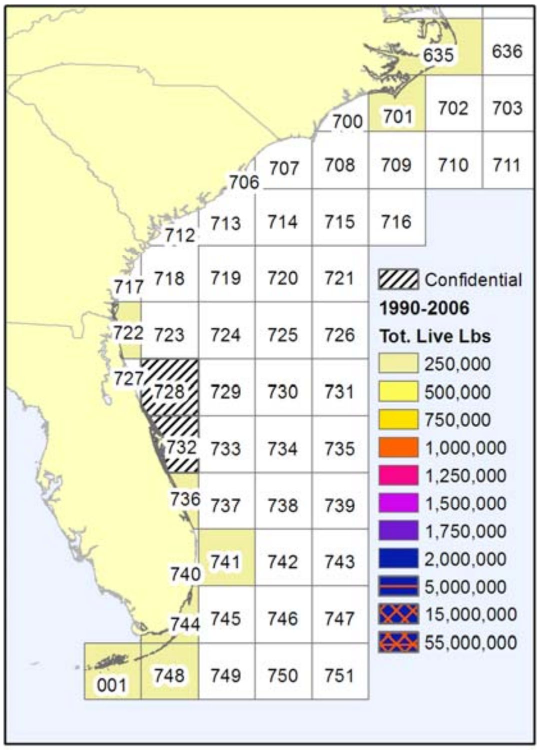


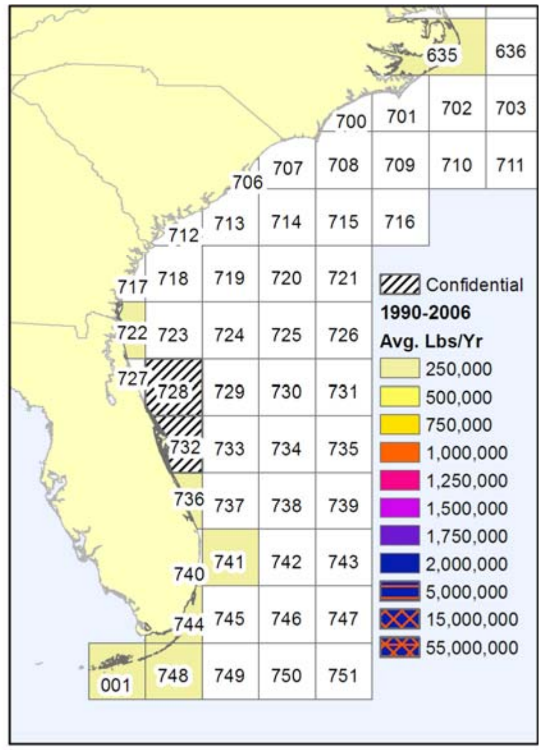


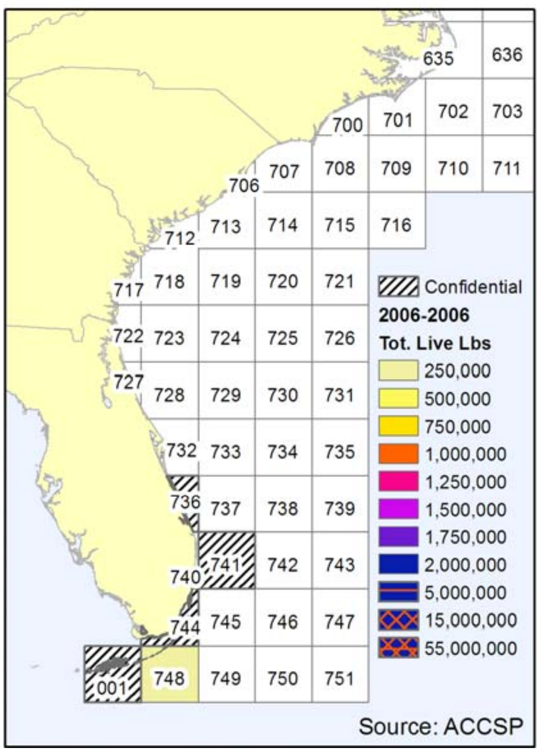
ACCSP Catch: SNAPPER, MUTTON
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	630.16	37.07	20.78
635	12.43	0.73	1.09
700	0.66	0.04	0.00
701	12.65	0.74	0.00
707	3.17	0.19	0.00
708	1.64	0.10	0.00
713	2.04	0.12	0.00
714	0.15	0.01	0.00
717	0.89	0.05	0.00
722	67.34	3.96	1.50
728	39.24	2.31	1.51
732	10.35	0.61	0.16
736	32.86	1.93	0.52
741	241.33	14.20	6.02
744	377.37	22.20	13.35
748	206.58	12.15	8.37

Figure 5.4.1-83. Spatial Presentation of Mutton Snapper Commercial Catch (Source: ACCSP).



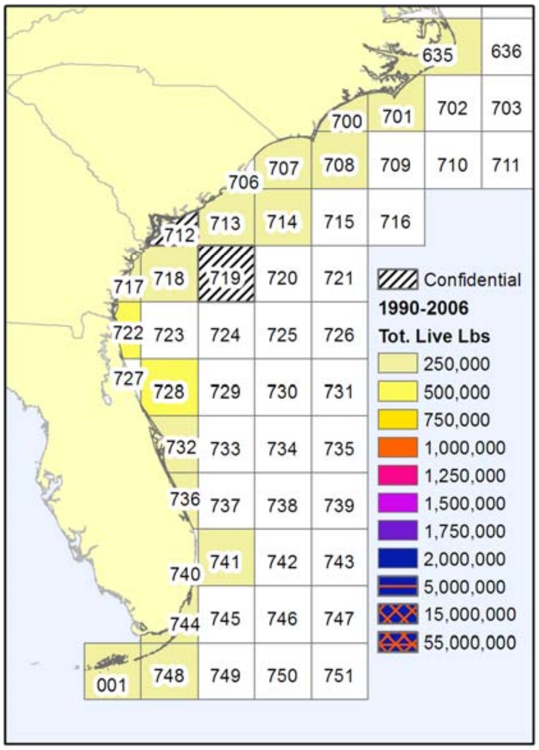


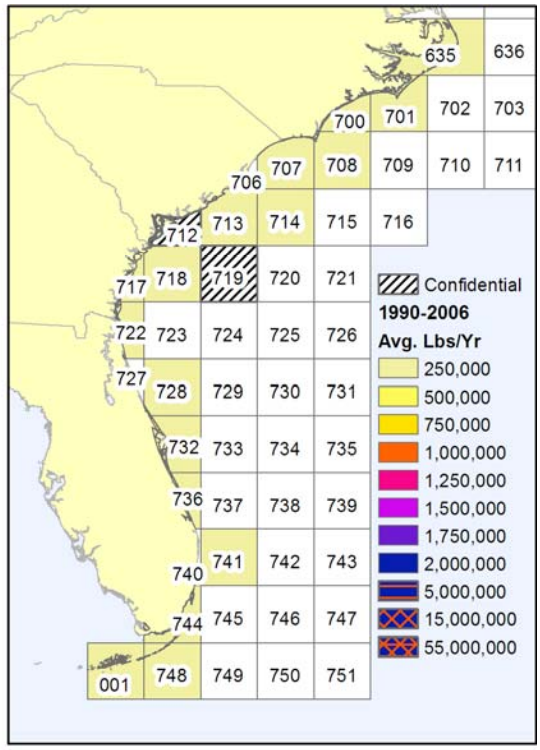


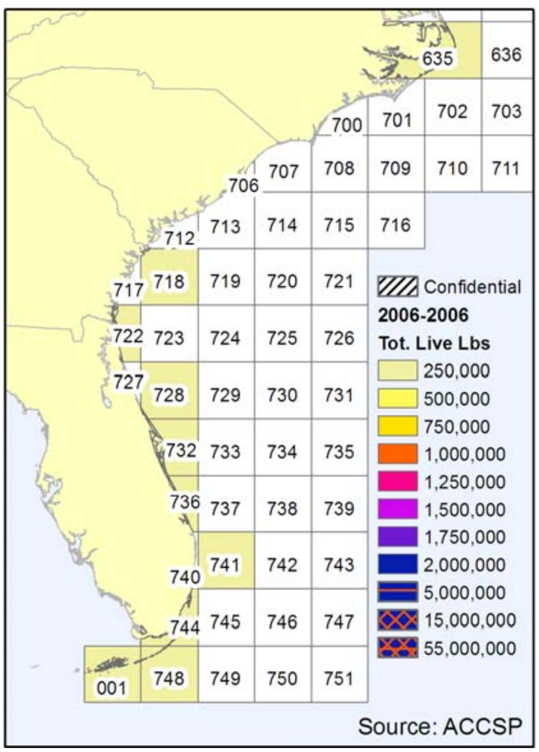
ACCSP Catch: SNAPPER, QUEEN
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	24.86	1.46	Conf.
635	0.07	0.00	0.00
701	0.04	0.00	0.00
722	0.10	0.01	0.00
728	Conf.	Conf.	0.00
732	Conf.	Conf.	0.00
736	4.41	0.26	Conf.
741	1.62	0.10	Conf.
744	41.71	2.45	Conf.
748	12.13	0.71	1.83

Figure 5.4.1-84. Spatial Presentation of Queen Snapper Commercial Catch (Source: ACCSP).



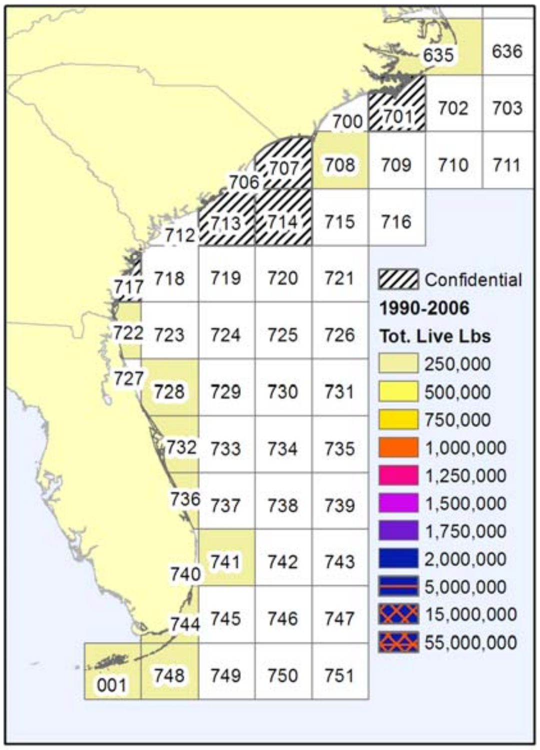


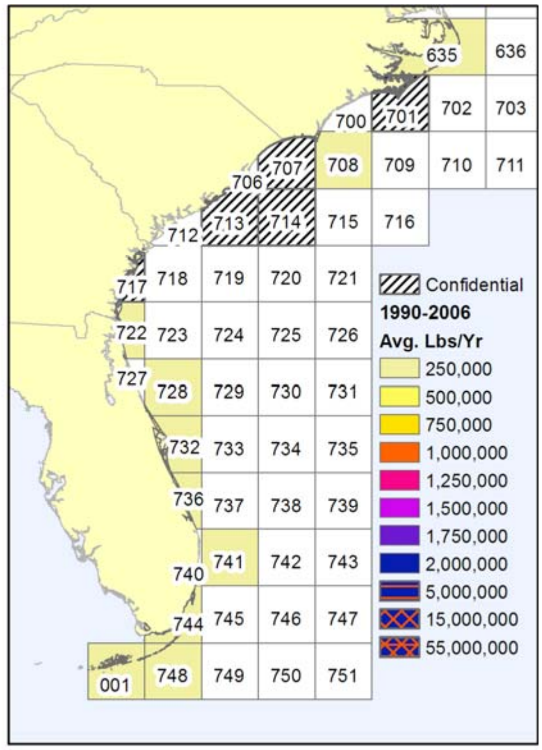


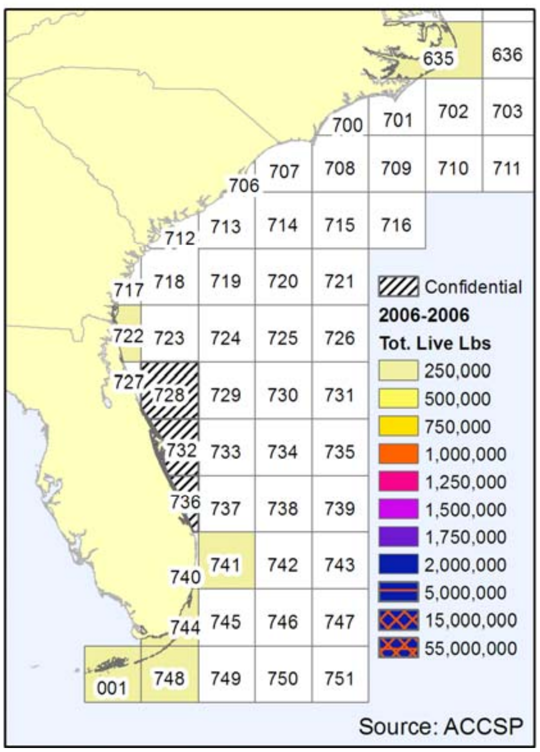
ACCSP Catch: SNAPPER, RED
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	45.31	2.67	1.28
635	108.03	6.35	4.65
700	0.80	0.05	0.00
701	169.09	9.95	0.00
707	32.08	1.89	0.00
708	1.40	0.08	0.00
712	Conf.	Conf.	0.00
713	37.73	2.22	0.00
714	6.09	0.36	0.00
717	1.15	0.07	0.00
718	2.08	0.12	0.08
719	Conf.	Conf.	0.00
722	379.75	22.34	8.05
728	469.84	27.64	23.71
732	177.30	10.43	9.63
736	29.93	1.76	1.78
741	7.90	0.46	0.18
744	26.69	1.57	0.26
748	2.79	0.16	0.33

Figure 5.4.1-85. Spatial Presentation of Red Snapper Commercial Catch (Source: ACCSP).



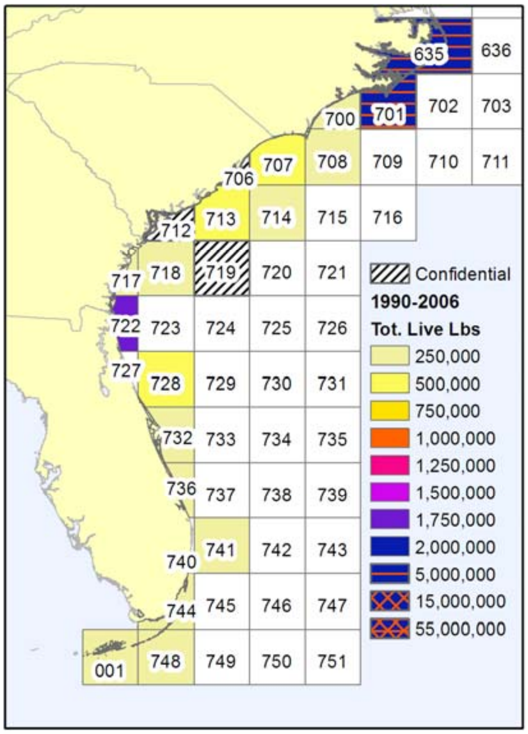


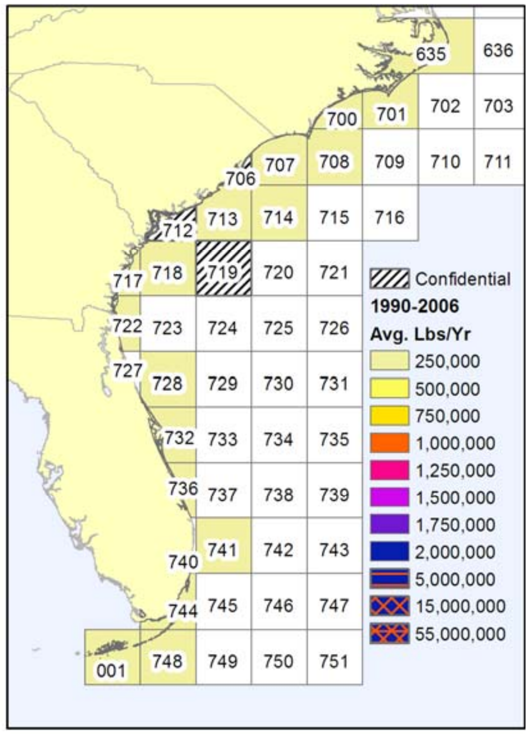


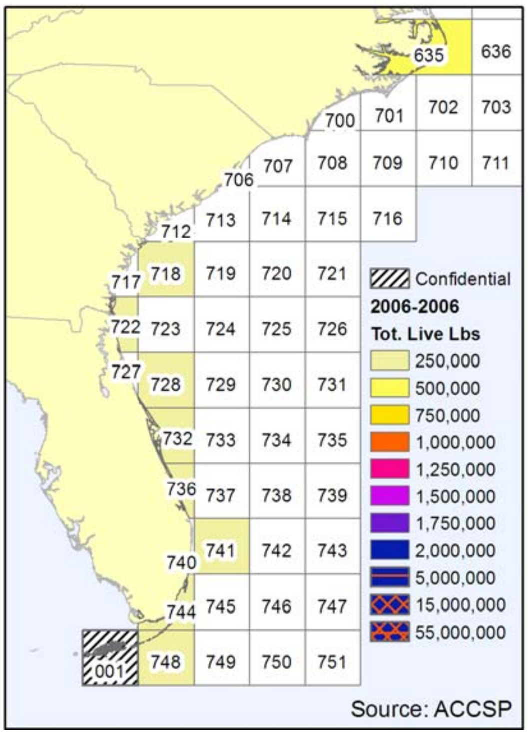
ACCSP Catch: SNAPPER, SILK
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	148.69	8.75	0.16
635	12.16	0.72	0.55
701	Conf.	Conf.	0.00
707	Conf.	Conf.	0.00
708	0.25	0.01	0.00
713	Conf.	Conf.	0.00
714	Conf.	Conf.	0.00
717	Conf.	Conf.	0.00
722	6.70	0.39	0.03
728	1.23	0.07	Conf.
732	1.04	0.06	Conf.
736	2.99	0.18	Conf.
741	10.44	0.61	0.09
744	80.90	4.76	1.77
748	19.68	1.16	2.24

Figure 5.4.1-86. Spatial Presentation of Silk Snapper Commercial Catch (Source: ACCSP).





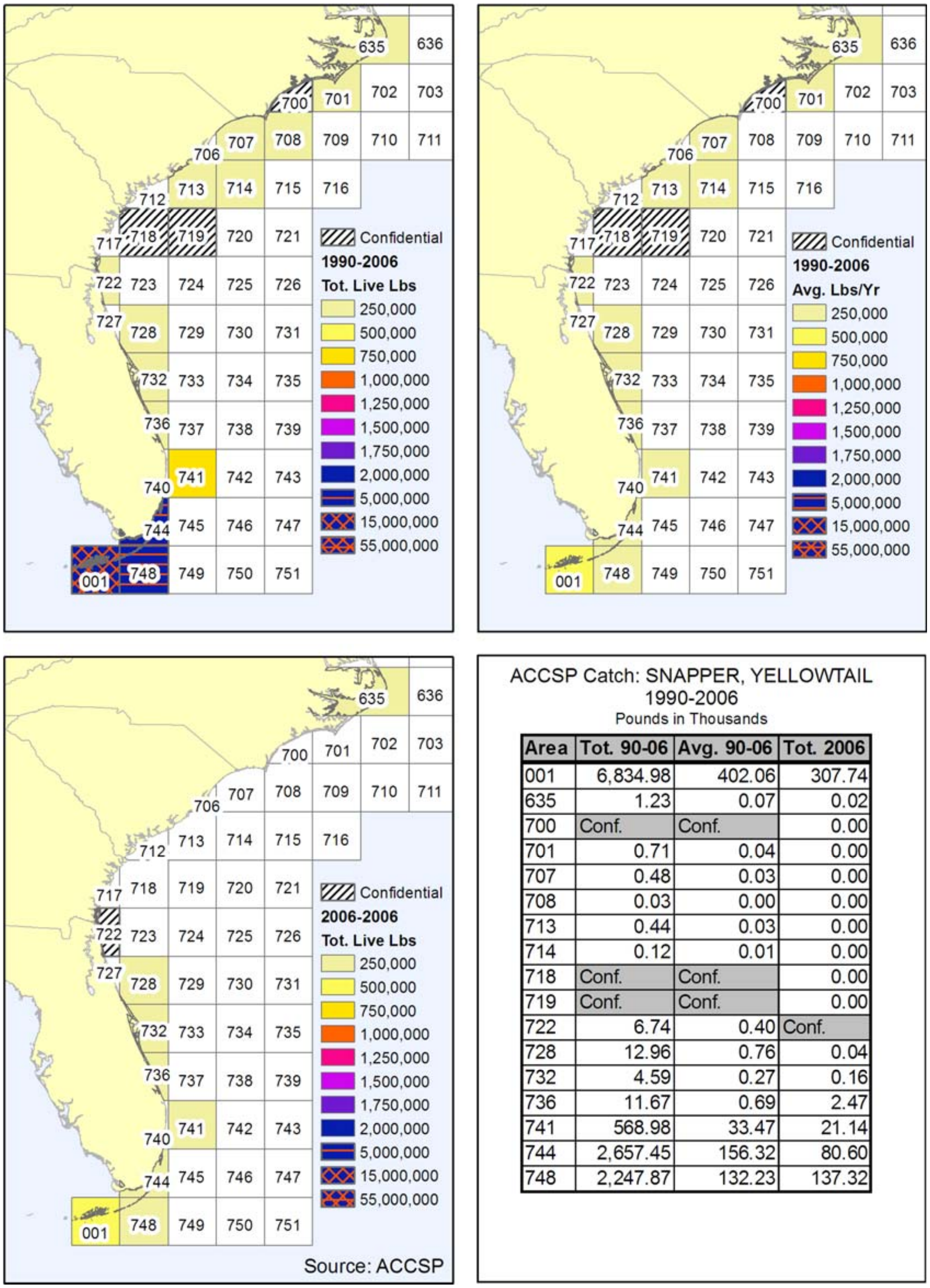


ACCSP Catch: SNAPPER, VERMILION
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	32.61	1.92	Conf.
635	3,851.42	226.55	277.21
700	16.10	0.95	0.00
701	2,794.39	164.38	0.00
706	Conf.	Conf.	0.00
707	460.71	27.10	0.00
708	32.03	1.88	0.00
712	Conf.	Conf.	0.00
713	287.54	16.91	0.00
714	22.75	1.34	0.00
717	0.35	0.02	0.00
718	13.46	0.79	0.21
719	Conf.	Conf.	0.00
722	1,544.39	90.85	56.42
728	371.74	21.87	37.77
732	6.97	0.41	0.22
736	41.57	2.45	0.43
741	56.81	3.34	3.68
744	47.68	2.80	0.40
748	5.60	0.33	1.12

Figure 5.4.1-87. Spatial Presentation of Vermilion Snapper Commercial Catch (Source: ACCSP).

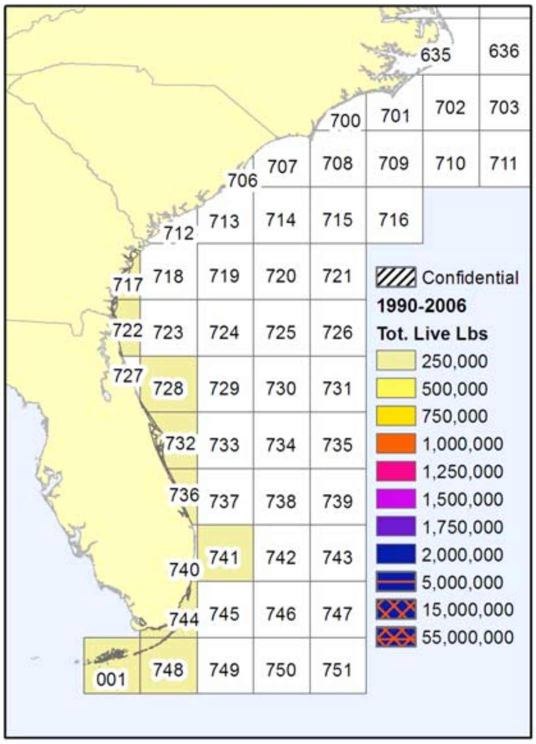
Appendix B. Spatial Presentations of commercial catch ACCSP

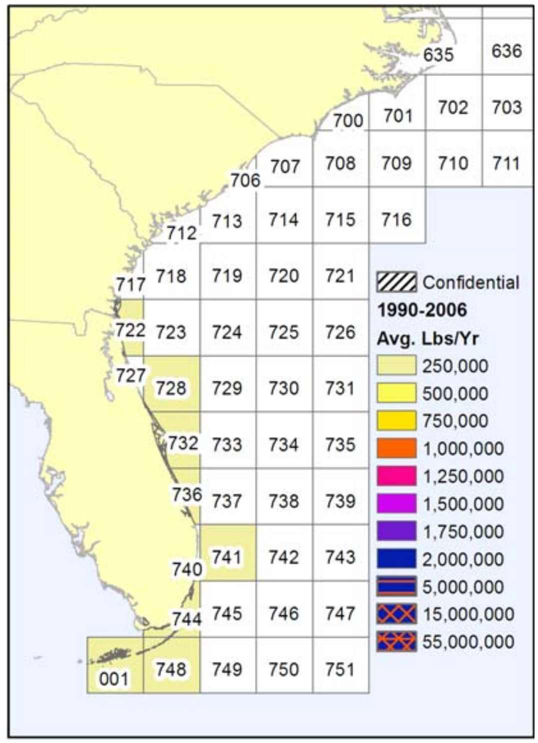


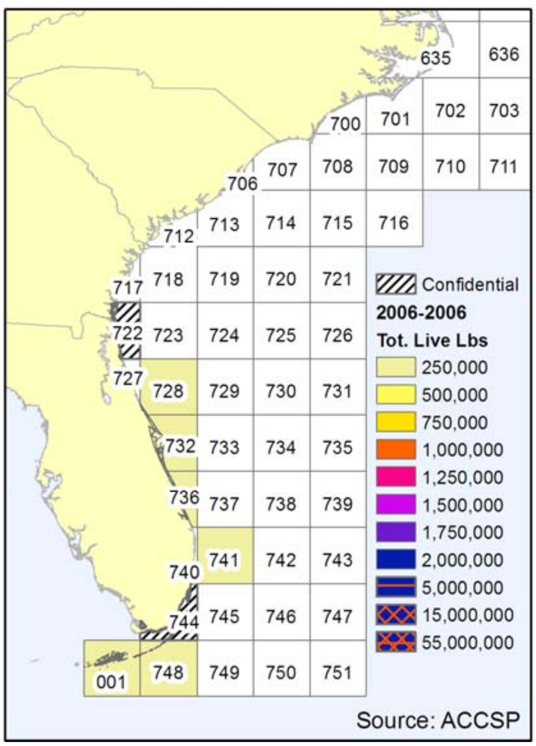
Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	6,834.98	402.06	307.74
635	1.23	0.07	0.02
700	Conf.	Conf.	0.00
701	0.71	0.04	0.00
707	0.48	0.03	0.00
708	0.03	0.00	0.00
713	0.44	0.03	0.00
714	0.12	0.01	0.00
718	Conf.	Conf.	0.00
719	Conf.	Conf.	0.00
722	6.74	0.40	Conf.
728	12.96	0.76	0.04
732	4.59	0.27	0.16
736	11.67	0.69	2.47
741	568.98	33.47	21.14
744	2,657.45	156.32	80.60
748	2,247.87	132.23	137.32

Figure 5.4.1-88. Spatial Presentation of Yellowtail Snapper Commercial Catch (Source: ACCSP).

Appendix B. Spatial Presentations of commercial catch ACCSP



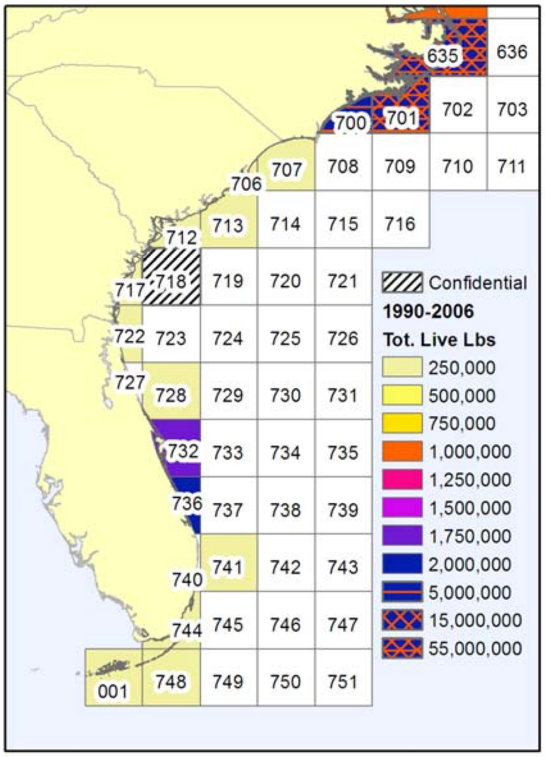


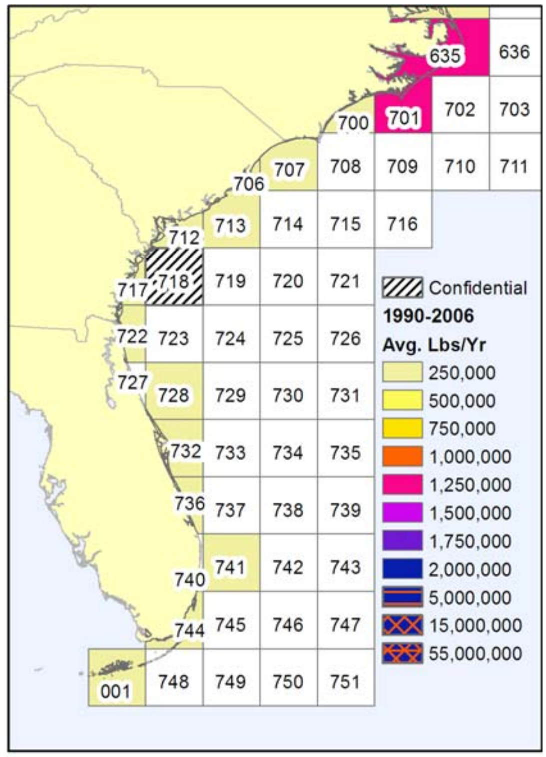


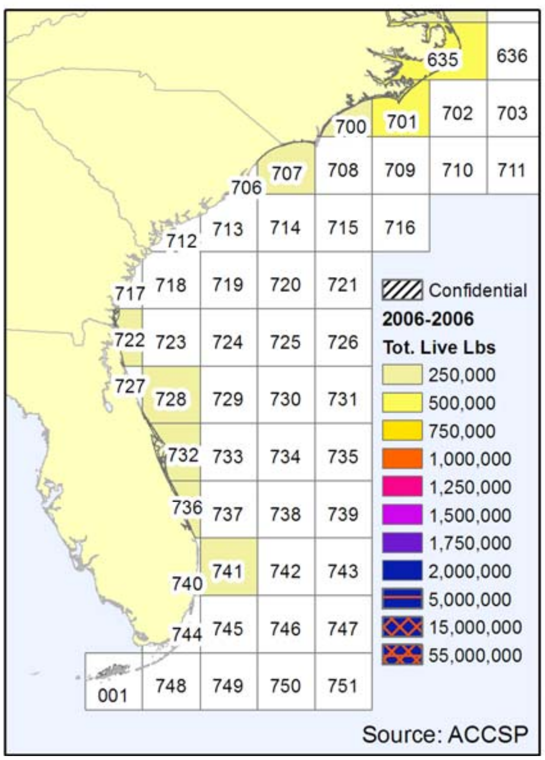
ACCSP Catch: SPADEFISH, ATLANTIC
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	1.06	0.06	0.26
717	0.06	0.00	0.00
722	9.09	0.53	Conf.
728	4.12	0.24	0.28
732	16.88	0.99	0.60
736	71.48	4.20	10.21
741	15.19	0.89	3.30
744	0.54	0.03	Conf.
748	5.01	0.29	0.73

Figure 5.4.1-89. Spatial Presentation of Atlantic Spadefish Commercial Catch (Source: ACCSP).





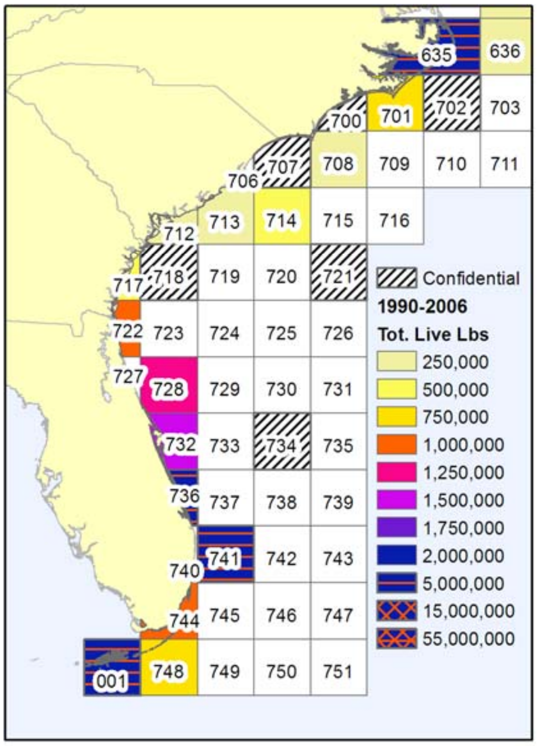


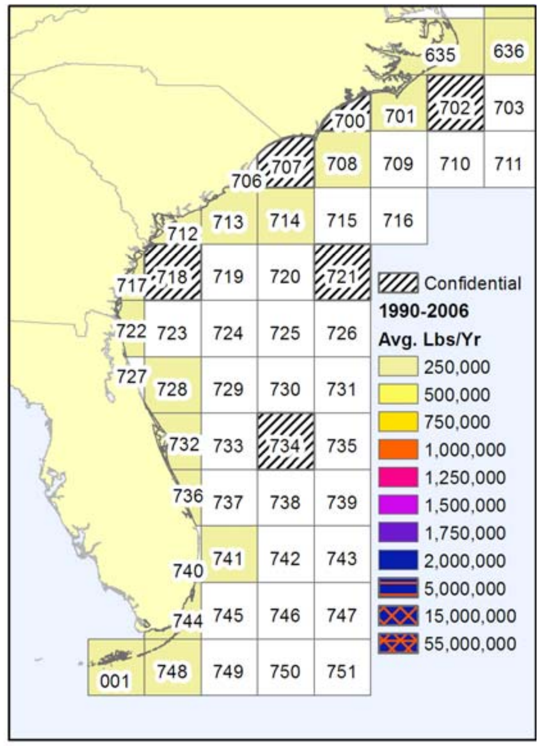
ACCSP Catch: SPOT
1990-2006
Pounds in Thousands

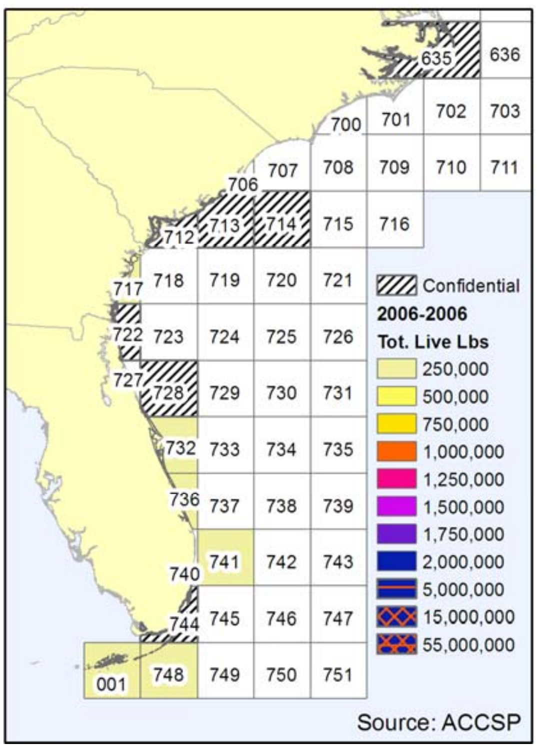
Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	0.93	0.05	0.00
635	17,279.50	1,016.44	363.89
700	4,241.71	249.51	104.28
701	19,306.95	1,135.70	400.81
706	4.19	0.25	0.00
707	149.58	8.80	9.06
712	0.94	0.06	0.00
713	7.70	0.45	0.00
717	0.13	0.01	0.00
718	Conf.	Conf.	0.00
722	116.56	6.86	0.65
728	39.08	2.30	0.46
732	1,673.55	98.44	7.71
736	1,953.49	114.91	13.04
741	7.31	0.43	0.23
744	3.73	0.22	0.00
748	0.03	0.00	0.00

Figure 5.4.1-90. Spatial Presentation of Spot Commercial Catch (Source: ACCSP).

Appendix B. Spatial Presentations of commercial catch ACCSP



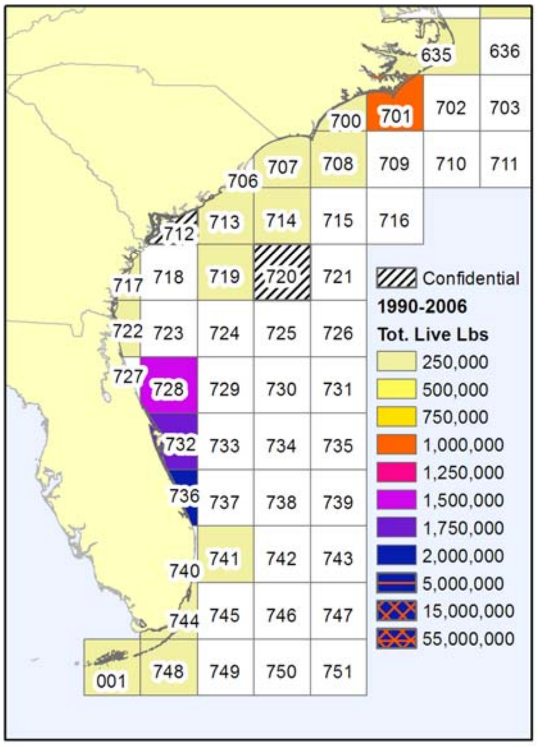


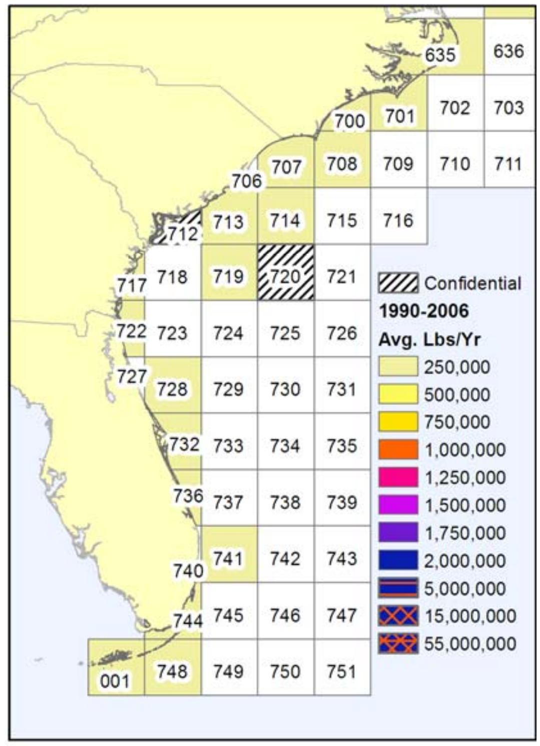


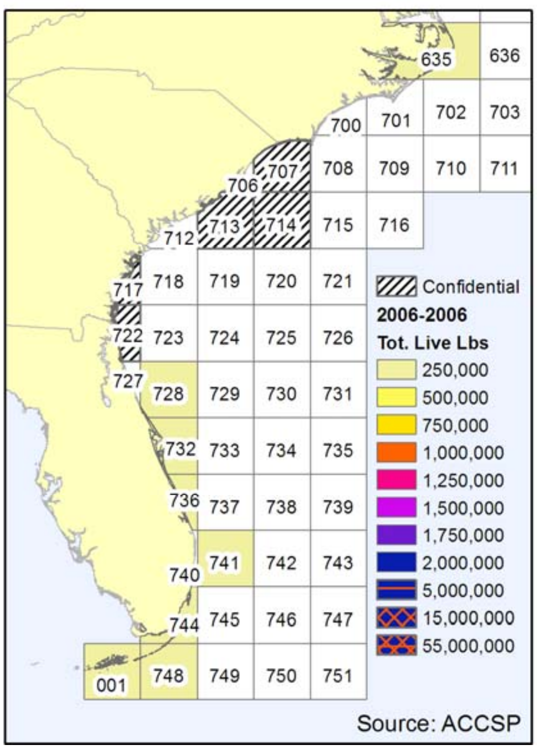
ACCSP Catch: SWORDFISH
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	3,446.54	202.74	3.98
635	3,516.31	206.84	Conf.
636	0.90	0.05	0.00
700	Conf.	Conf.	0.00
701	581.74	34.22	0.00
702	Conf.	Conf.	0.00
707	Conf.	Conf.	0.00
708	10.63	0.63	0.00
712	112.02	6.59	Conf.
713	206.01	12.12	Conf.
714	312.07	18.36	Conf.
717	397.52	23.38	98.42
718	Conf.	Conf.	0.00
721	Conf.	Conf.	0.00
722	844.50	49.68	Conf.
728	1,155.03	67.94	Conf.
732	1,318.33	77.55	125.64
734	Conf.	Conf.	0.00
736	2,590.45	152.38	17.07
741	4,136.09	243.30	69.57
744	919.59	54.09	Conf.
748	659.36	38.79	0.24

Figure 5.4.1-91. Spatial Presentation of Swordfish Commercial Catch (Source: ACCSP).



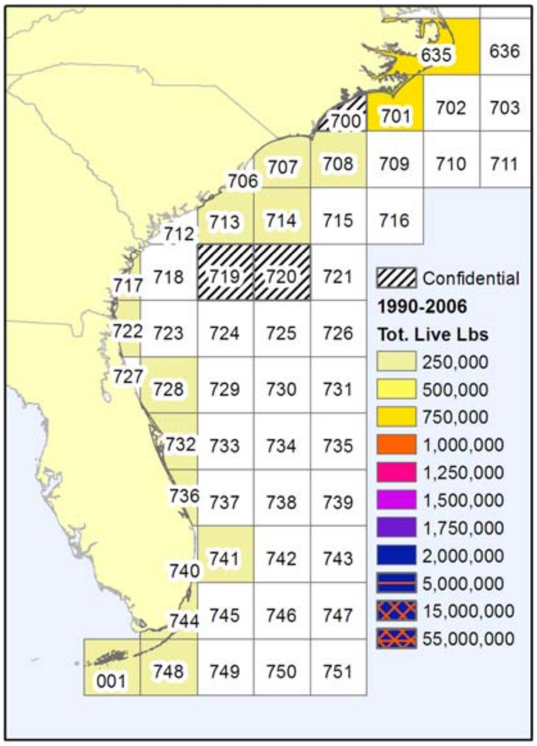


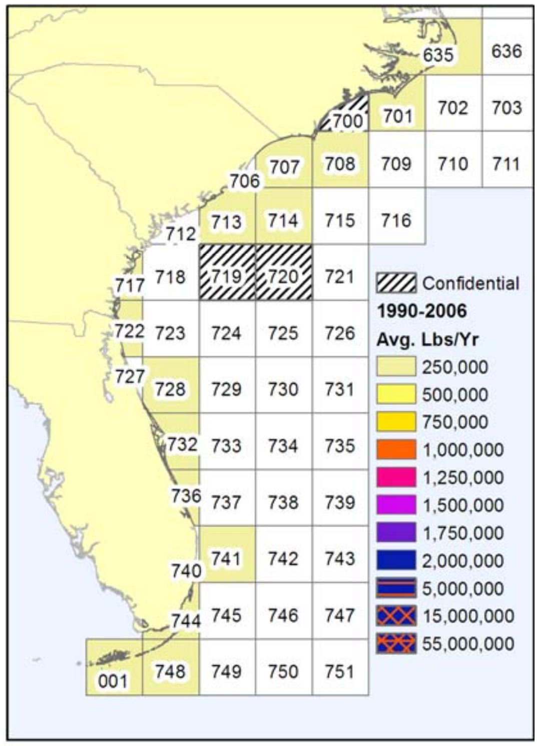


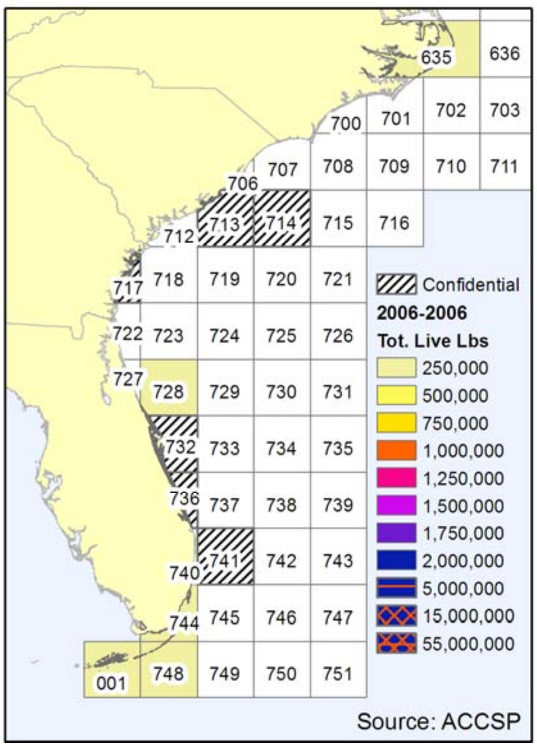
ACCSP Catch: TILEFISH
1990-2006
Pounds in Thousands

Area	Tot. 90-0(	Avg. 90-0(	Tot. 200(
001	85.05	5.00	3.15
635	187.64	11.04	0.28
700	0.65	0.04	0.00
701	847.64	49.86	0.00
707	29.99	1.76	Conf.
708	40.31	2.37	0.00
712	Conf.	Conf.	0.00
713	46.34	2.73	Conf.
714	54.53	3.21	Conf.
717	25.70	1.51	Conf.
719	1.01	0.06	0.00
720	Conf.	Conf.	0.00
722	13.67	0.80	Conf.
728	1,392.26	81.90	89.80
732	1,666.81	98.05	86.16
736	1,929.91	113.52	115.63
741	176.09	10.36	12.68
744	42.89	2.52	0.74
748	10.96	0.64	0.51

Figure 5.4.1-92. Spatial Presentation of Tilefish Commercial Catch (Source: ACCSP).



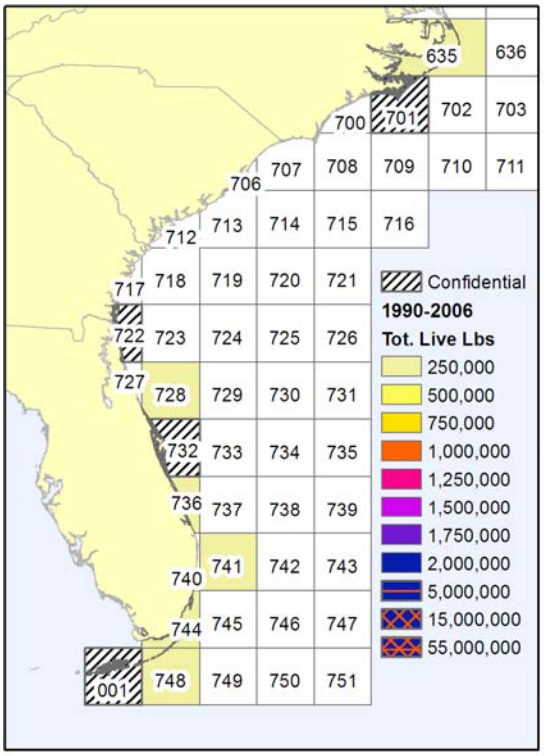


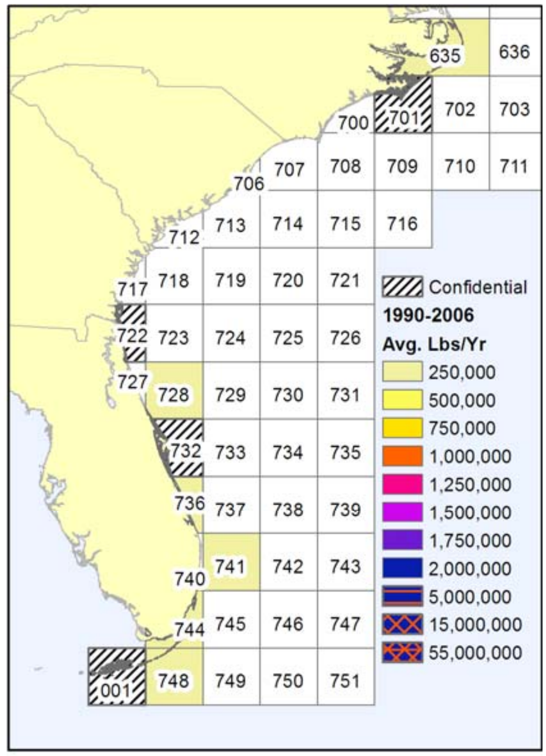


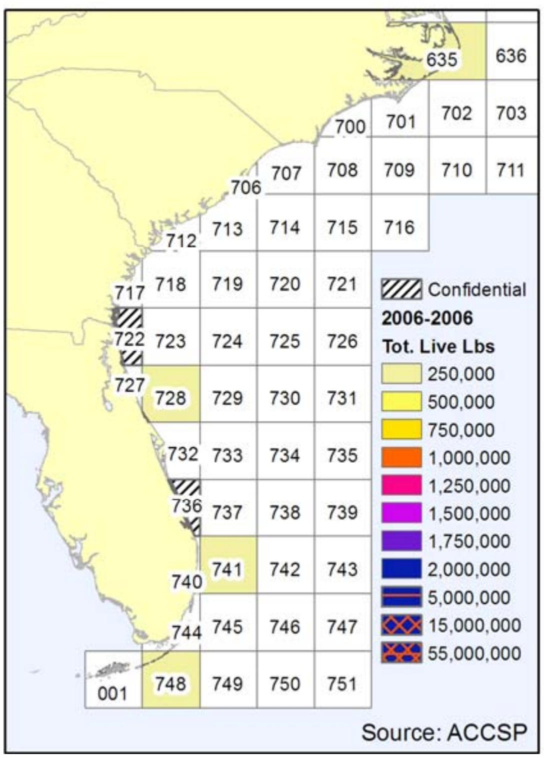
ACCSP Catch: TILEFISH, BLUELINE
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	134.94	7.94	1.94
635	695.74	40.93	1.69
700	Conf.	Conf.	0.00
701	591.58	34.80	0.00
707	11.57	0.68	0.00
708	10.29	0.61	0.00
713	7.93	0.47	Conf.
714	13.23	0.78	Conf.
717	0.81	0.05	Conf.
719	Conf.	Conf.	0.00
720	Conf.	Conf.	0.00
722	4.39	0.26	0.00
728	40.23	2.37	2.13
732	75.53	4.44	Conf.
736	45.64	2.68	Conf.
741	32.81	1.93	Conf.
744	56.15	3.30	0.78
748	66.43	3.91	3.86

Figure 5.4.1-93. Spatial Presentation of Blueline Tilefish Commercial Catch (Source: ACCSP).



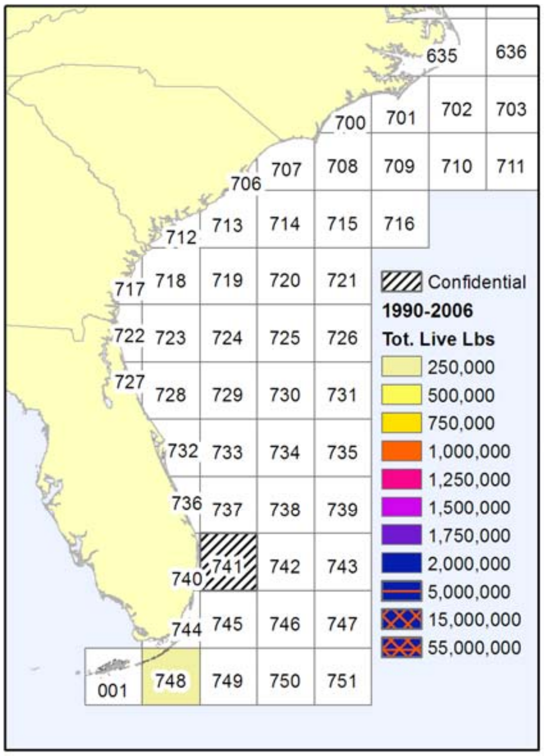


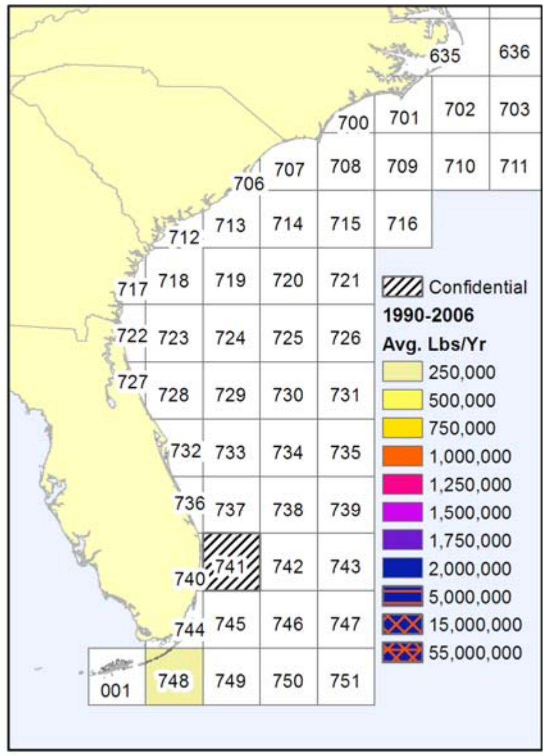


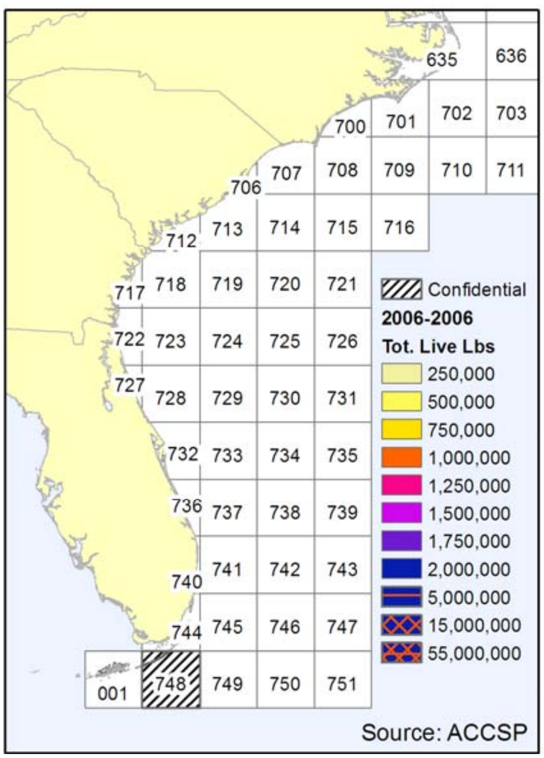
ACCSP Catch: TILEFISH, SAND
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	Conf.	Conf.	0.00
635	10.30	0.61	0.60
701	Conf.	Conf.	0.00
722	Conf.	Conf.	Conf.
728	0.24	0.01	0.01
732	Conf.	Conf.	0.00
736	0.14	0.01	Conf.
741	5.19	0.31	1.46
744	0.37	0.02	0.00
748	0.46	0.03	0.03

Figure 5.4.1-94. Spatial Presentation of Sand Tilefish Commercial Catch (Source: ACCSP).







ACCSP Catch: TOMTATE
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
741	Conf.	Conf.	0.00
748	0.37	0.02	Conf.

Figure 5.4.1-95. Spatial Presentation of Tomtate Commercial Catch (Source: ACCSP).

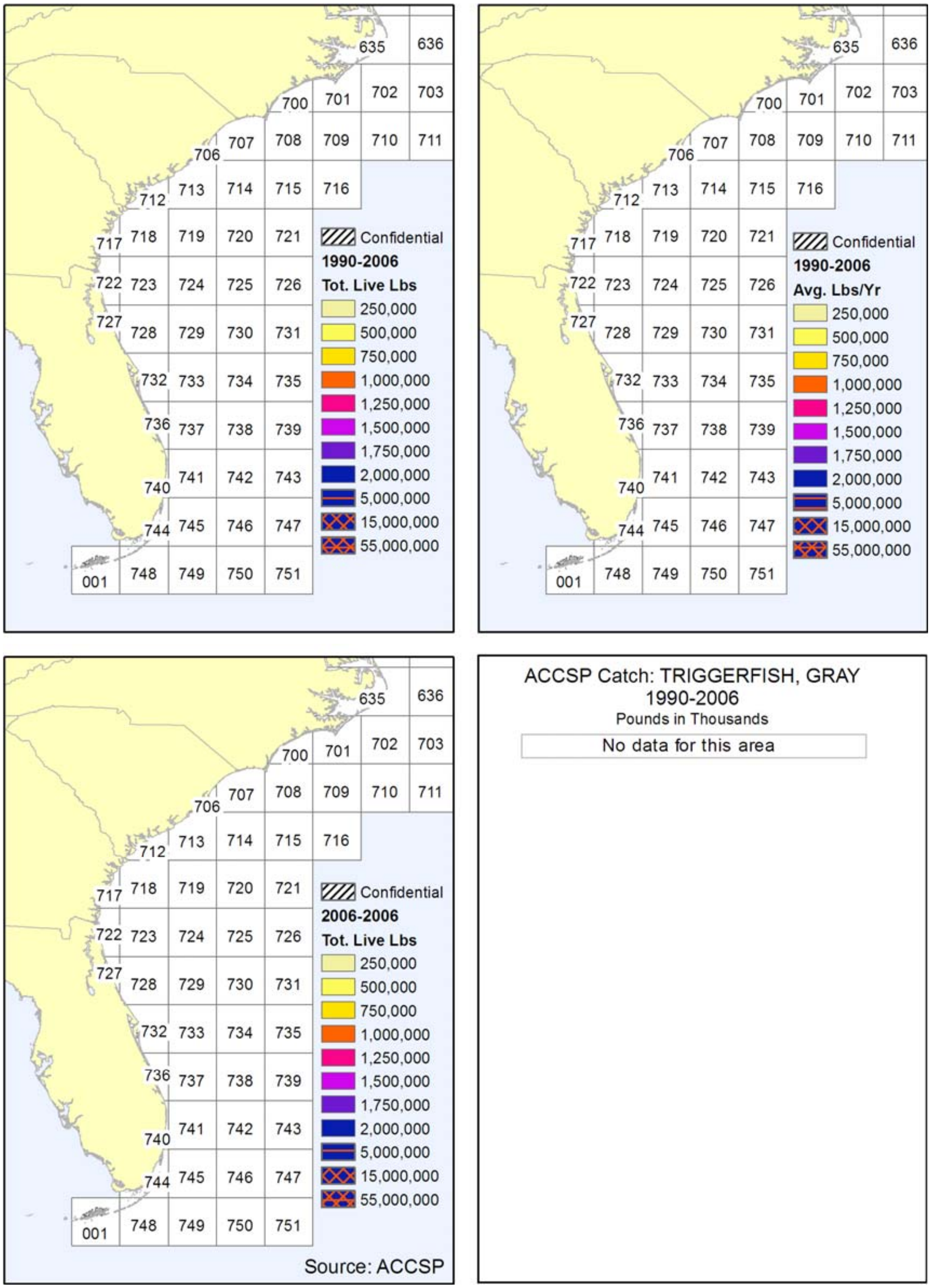


Figure 5.4.1-96. Spatial Presentation of Gray Triggerfish Commercial Catch (Source: ACCSP).

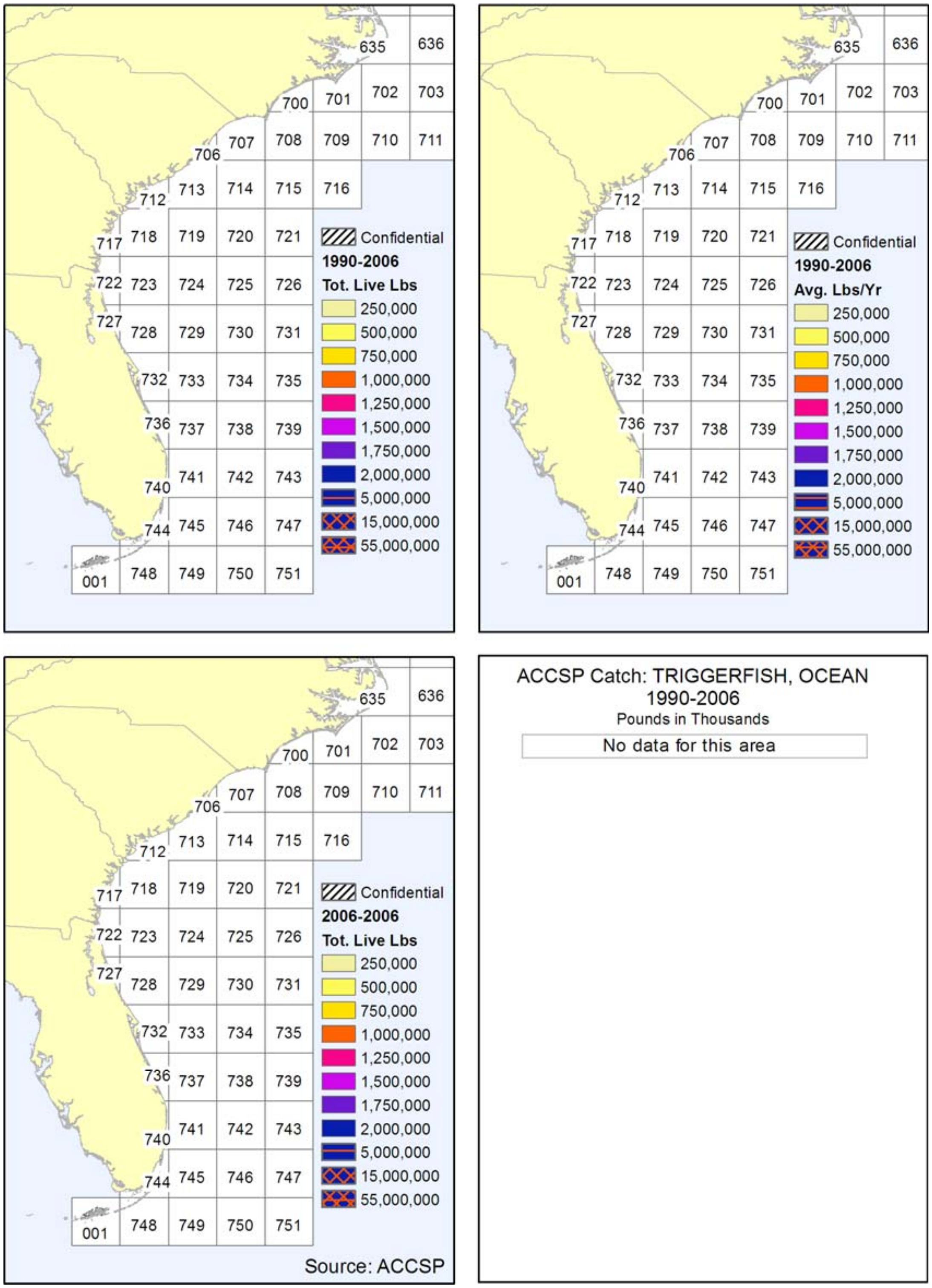
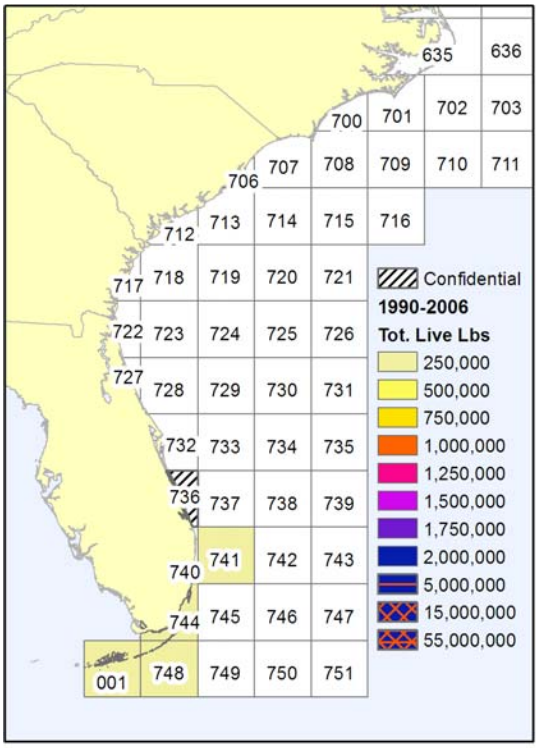
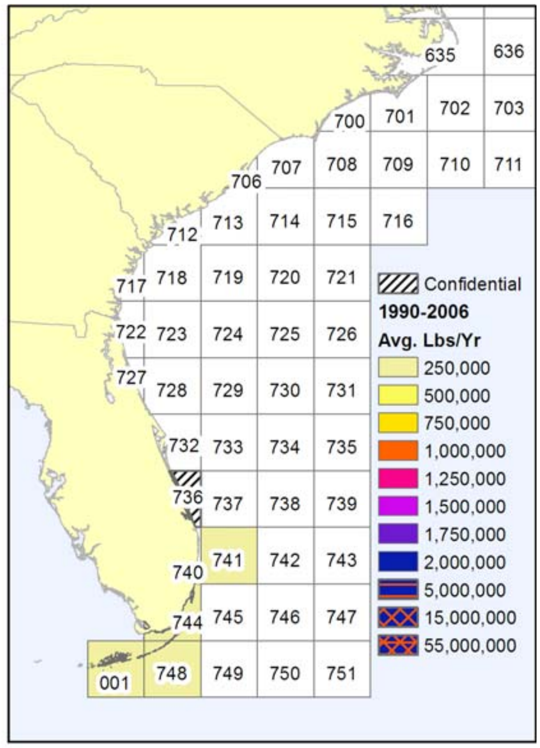
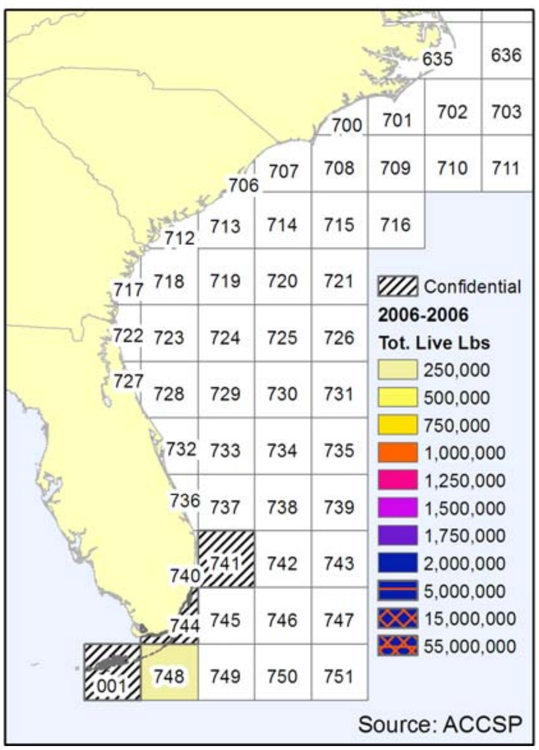


Figure 5.4.1-97. Spatial Presentation of Ocean Triggerfish Commercial Catch (Source: ACCSP).



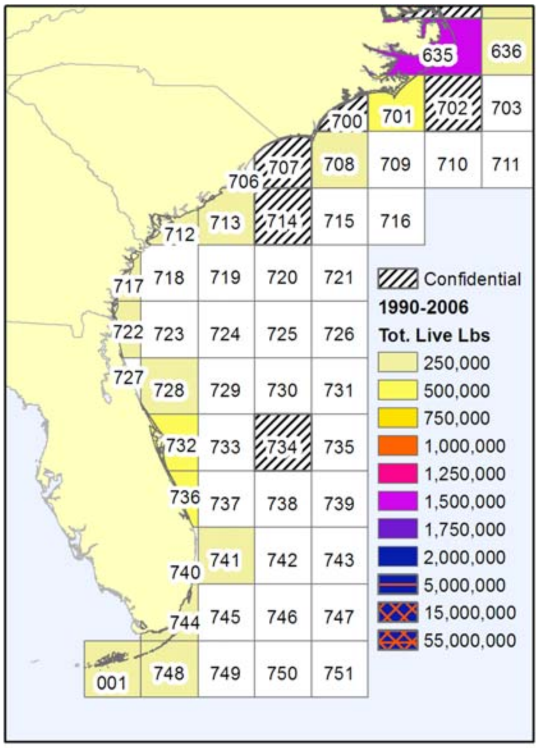


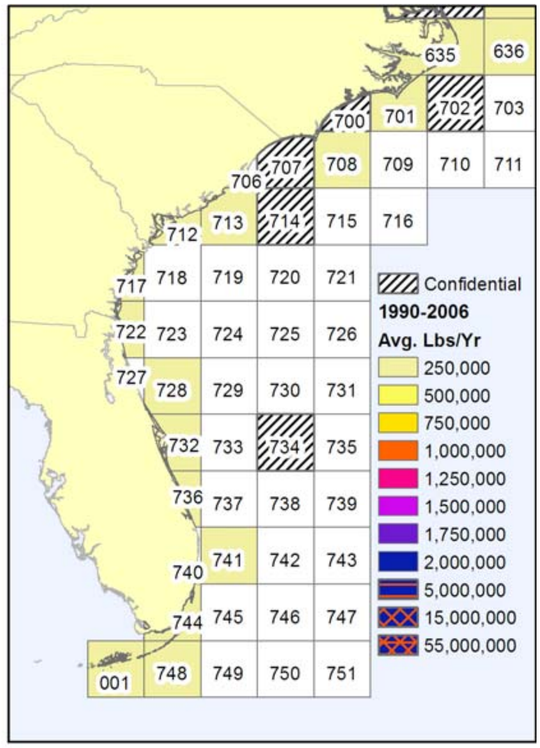


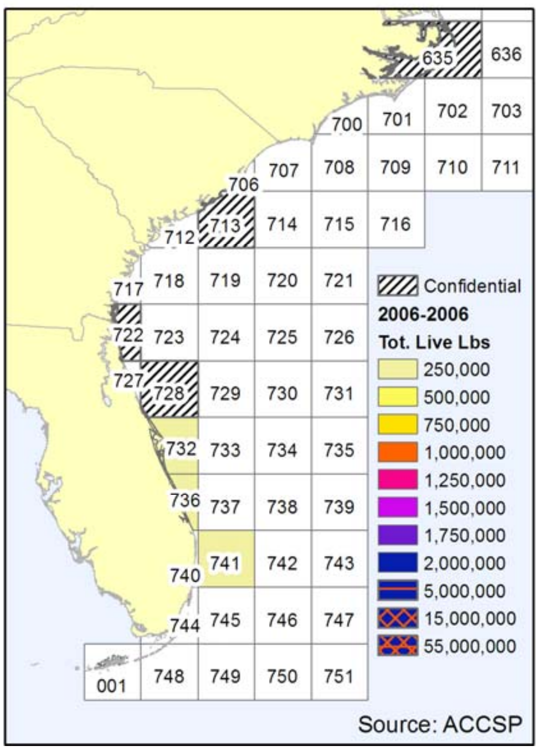
ACCSP Catch: TRIGGERFISH, QUEEN
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	0.10	0.01	Conf.
736	Conf.	Conf.	0.00
741	0.51	0.03	Conf.
744	0.42	0.02	Conf.
748	1.05	0.06	0.01

Figure 5.4.1-98. Spatial Presentation of Queen Triggerfish Commercial Catch (Source: ACCSP).



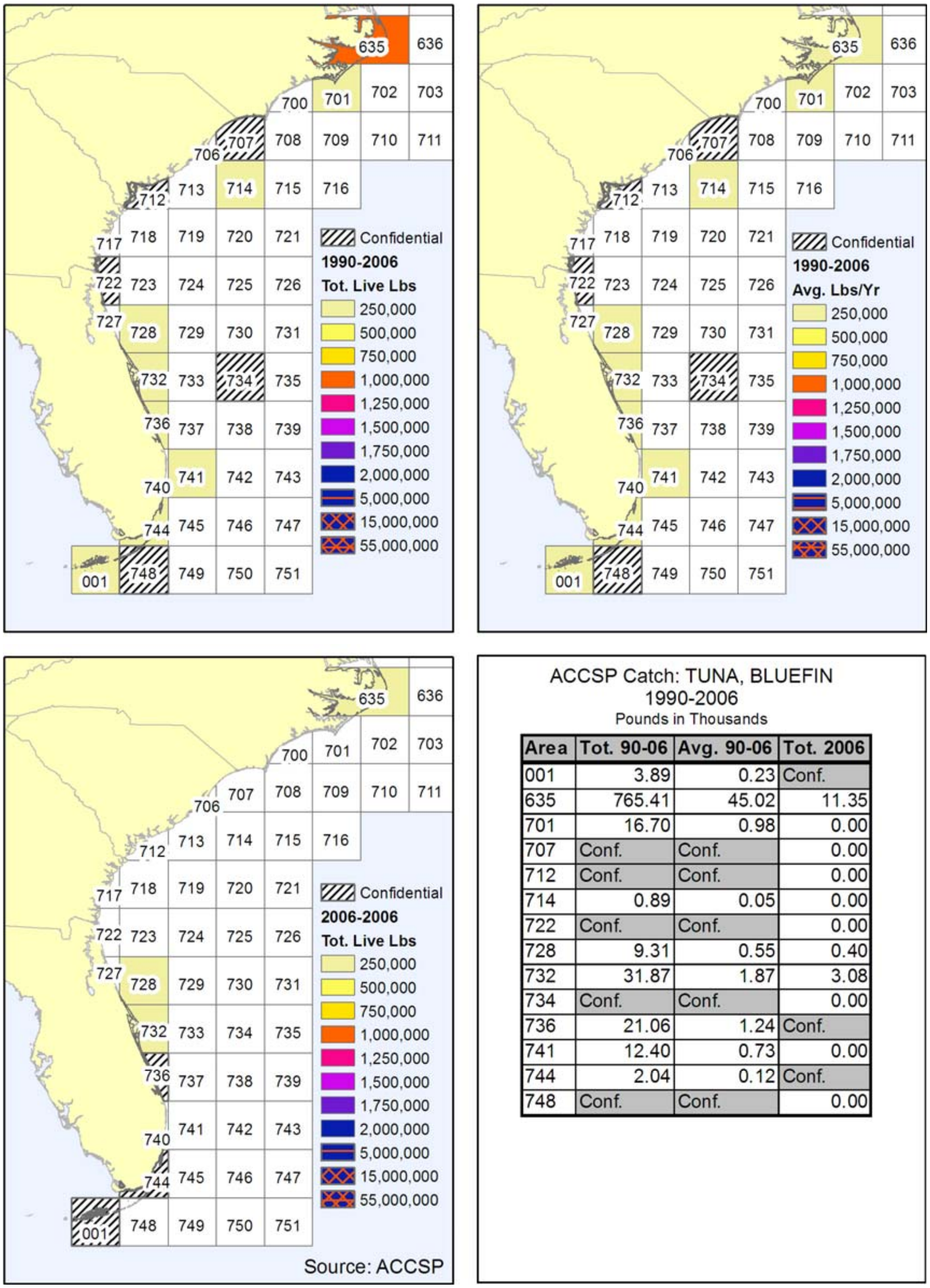




ACCSP Catch: TUNA, BIGEYE
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	125.47	7.38	0.00
635	1,396.44	82.14	Conf.
636	0.19	0.01	0.00
700	Conf.	Conf.	0.00
701	407.16	23.95	0.00
702	Conf.	Conf.	0.00
707	Conf.	Conf.	0.00
708	0.87	0.05	0.00
712	0.45	0.03	0.00
713	0.44	0.03	Conf.
714	Conf.	Conf.	0.00
717	6.13	0.36	0.00
722	54.95	3.23	Conf.
728	174.77	10.28	Conf.
732	376.43	22.14	65.58
734	Conf.	Conf.	0.00
736	268.45	15.79	2.26
741	101.93	6.00	3.89
744	15.31	0.90	0.00
748	15.61	0.92	0.00

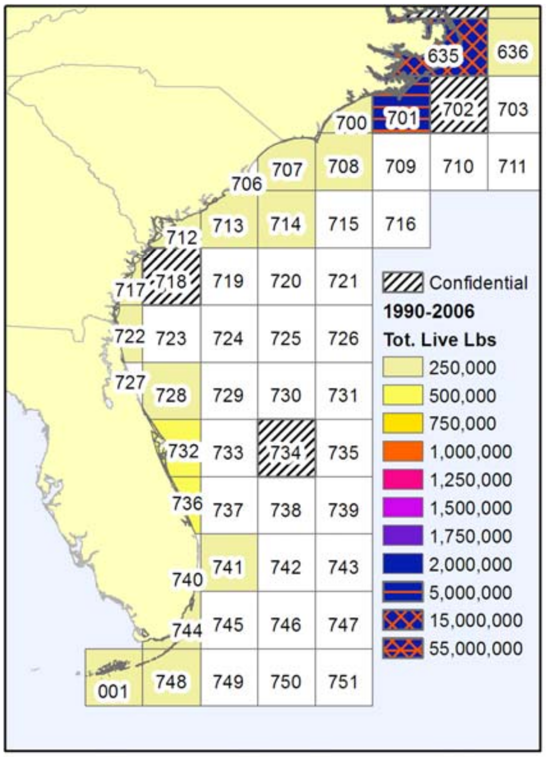
Figure 5.4.1-99. Spatial Presentation of Bigeye Tuna Commercial Catch (Source: ACCSP).

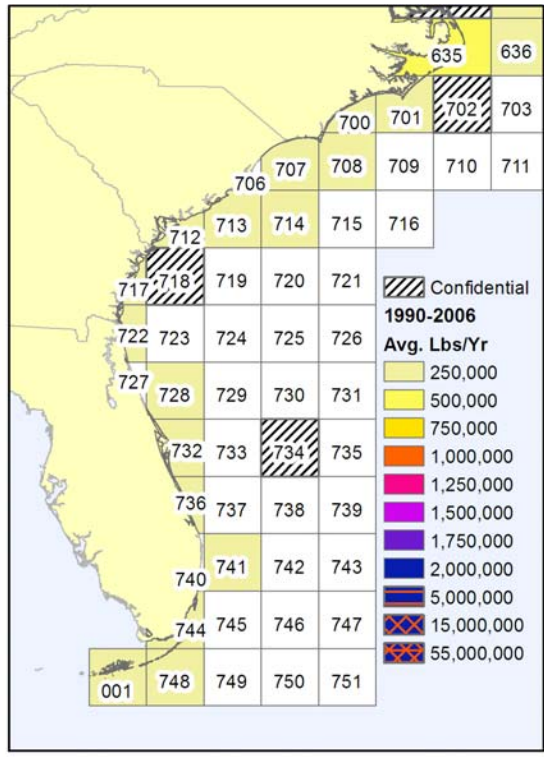


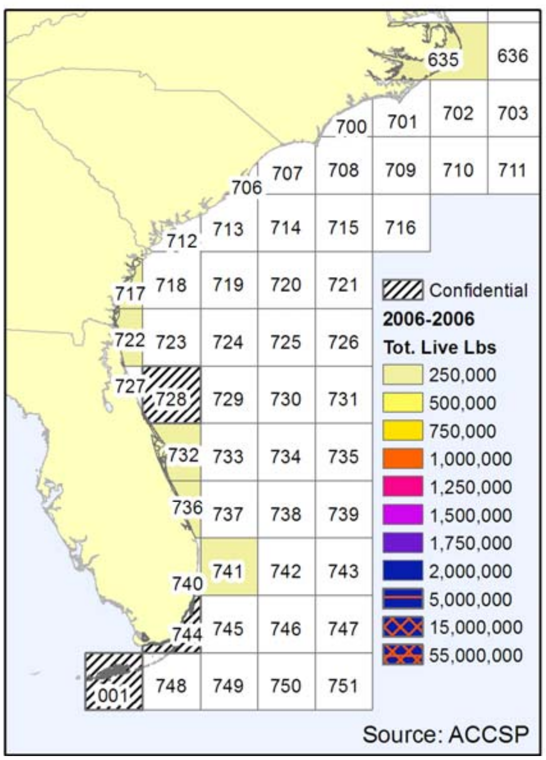
ACCSP Catch: TUNA, BLUEFIN
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	3.89	0.23	Conf.
635	765.41	45.02	11.35
701	16.70	0.98	0.00
707	Conf.	Conf.	0.00
712	Conf.	Conf.	0.00
714	0.89	0.05	0.00
722	Conf.	Conf.	0.00
728	9.31	0.55	0.40
732	31.87	1.87	3.08
734	Conf.	Conf.	0.00
736	21.06	1.24	Conf.
741	12.40	0.73	0.00
744	2.04	0.12	Conf.
748	Conf.	Conf.	0.00

Figure 5.4.1-100. Spatial Presentation of Bluefin Tuna Commercial Catch (Source: ACCSP).



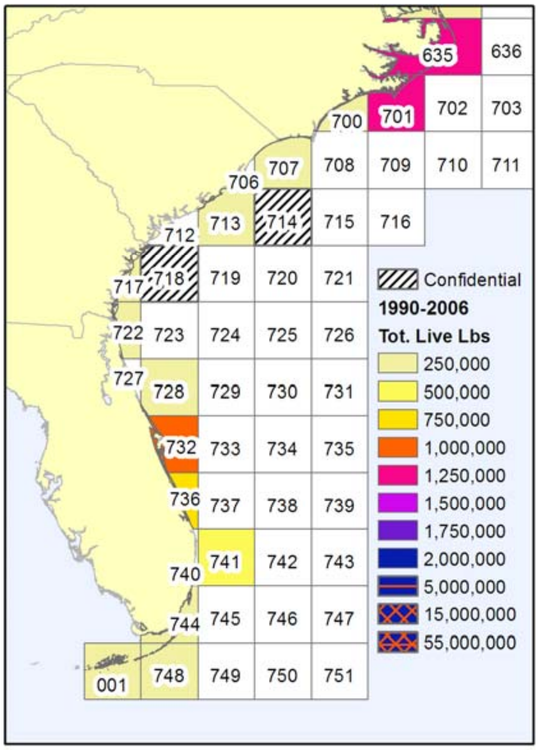


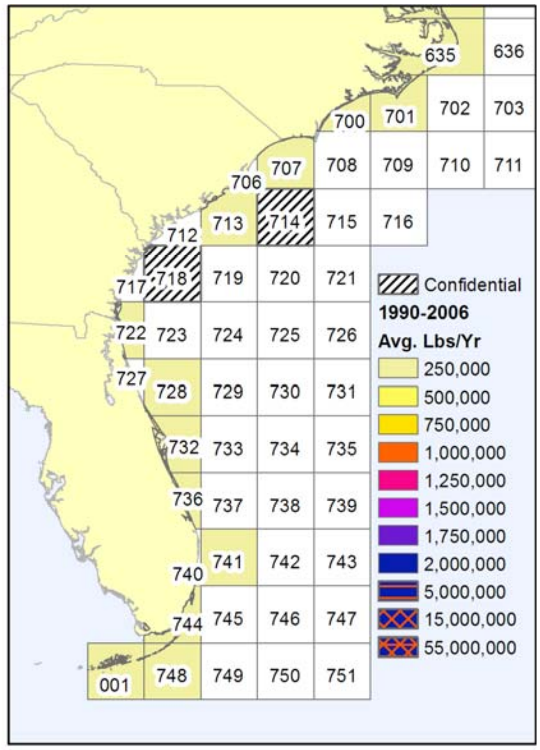


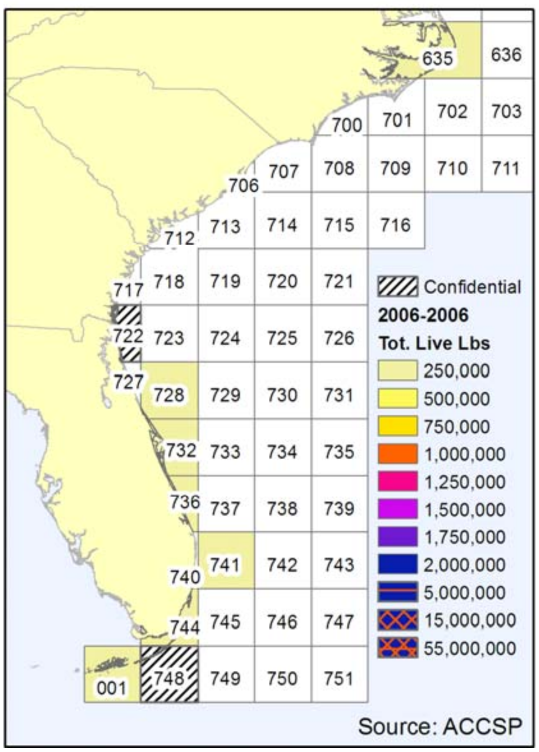
ACCSP Catch: TUNA, YELLOWFIN
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	147.06	8.65	Conf.
635	7,798.52	458.74	73.36
636	9.50	0.56	0.00
700	2.71	0.16	0.00
701	3,488.37	205.20	0.00
702	Conf.	Conf.	0.00
707	10.31	0.61	0.00
708	0.27	0.02	0.00
712	5.81	0.34	0.00
713	4.17	0.25	0.00
714	5.16	0.30	0.00
717	23.71	1.39	0.46
718	Conf.	Conf.	0.00
722	118.92	7.00	0.28
728	206.03	12.12	Conf.
732	331.50	19.50	53.61
734	Conf.	Conf.	0.00
736	253.63	14.92	8.72
741	139.23	8.19	2.38
744	37.66	2.22	Conf.
748	25.88	1.52	0.00

Figure 5.4.1-101. Spatial Presentation of Yellowfin Tuna Commercial Catch (Source: ACCSP).





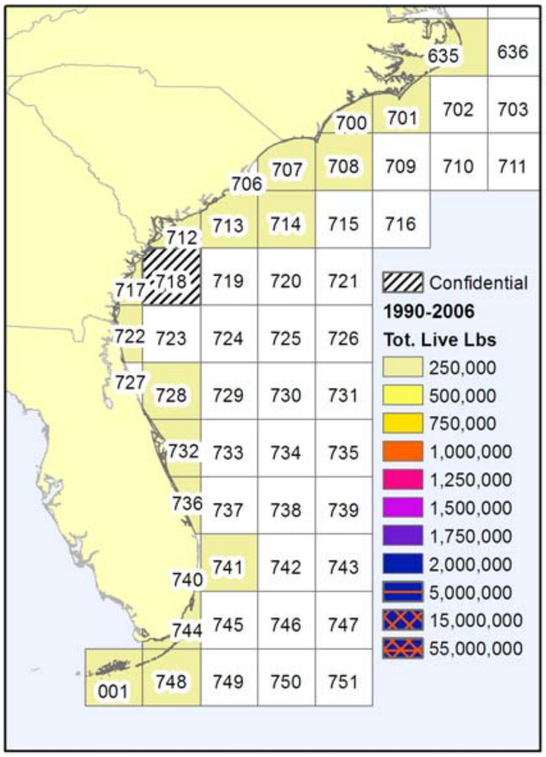


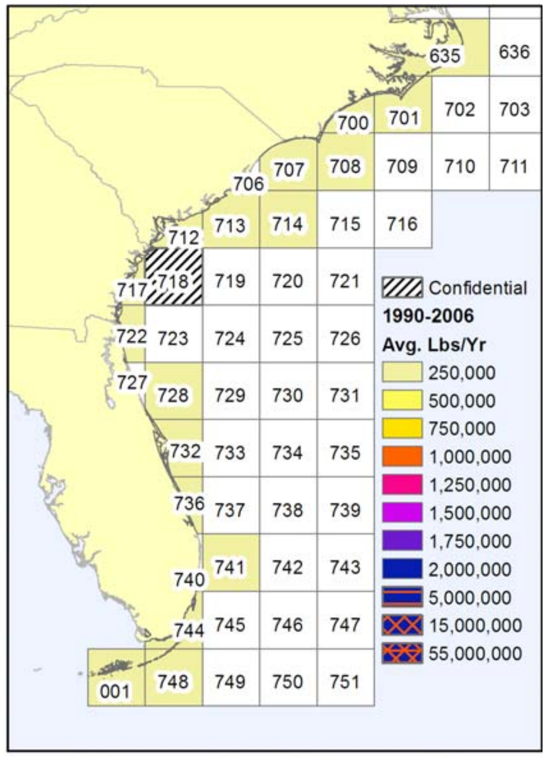
ACCSP Catch: TUNNY, LITTLE
1990-2006
Pounds in Thousands

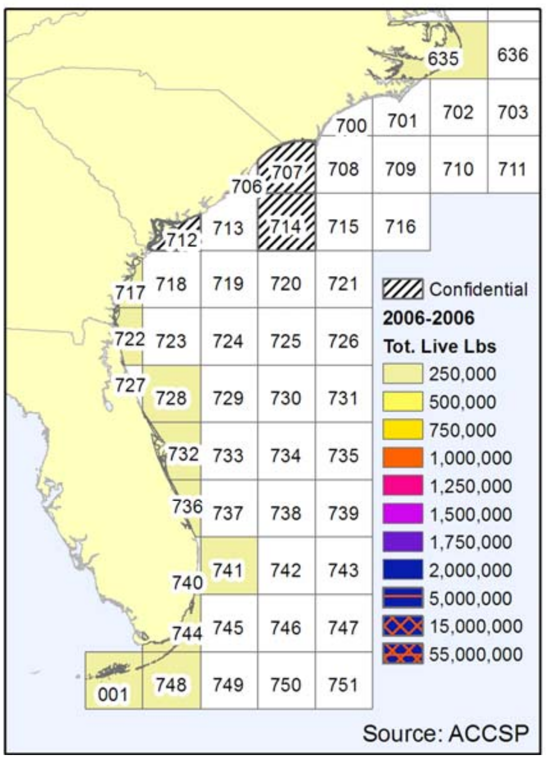
Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	59.78	3.52	0.46
635	1,184.35	69.67	18.56
700	0.46	0.03	0.00
701	1,023.37	60.20	0.00
707	0.33	0.02	0.00
713	0.62	0.04	0.00
714	Conf.	Conf.	0.00
717	0.01	0.00	0.00
718	Conf.	Conf.	0.00
722	18.78	1.10	Conf.
728	38.68	2.28	0.34
732	783.82	46.11	19.48
736	578.94	34.06	67.70
741	302.91	17.82	86.68
744	189.23	11.13	3.04
748	3.39	0.20	Conf.

Figure 5.4.1-102. Spatial Presentation of Little Tunny Commercial Catch (Source: ACCSP).

Appendix B. Spatial Presentations of commercial catch ACCSP



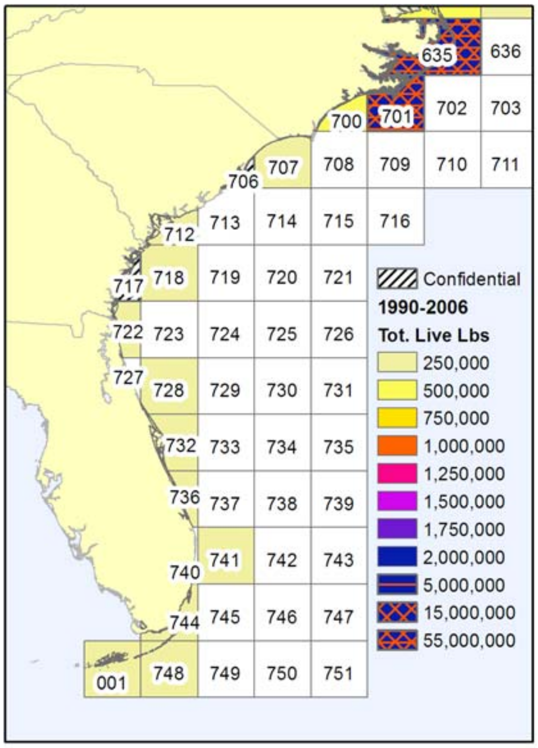


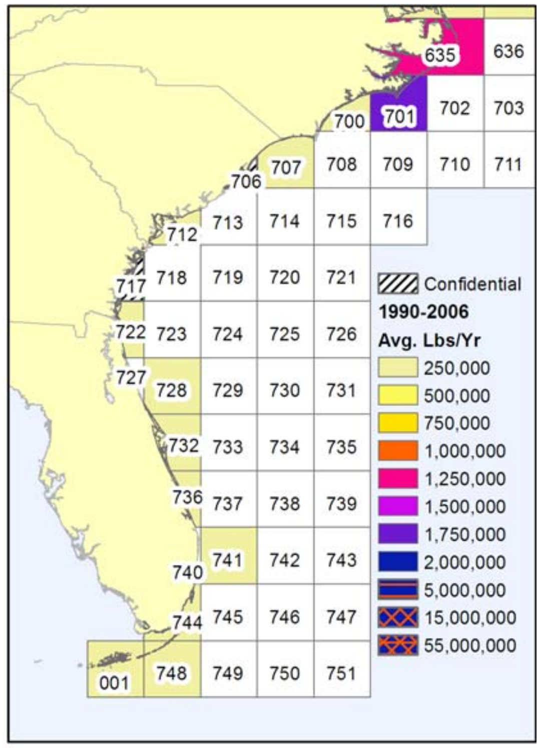


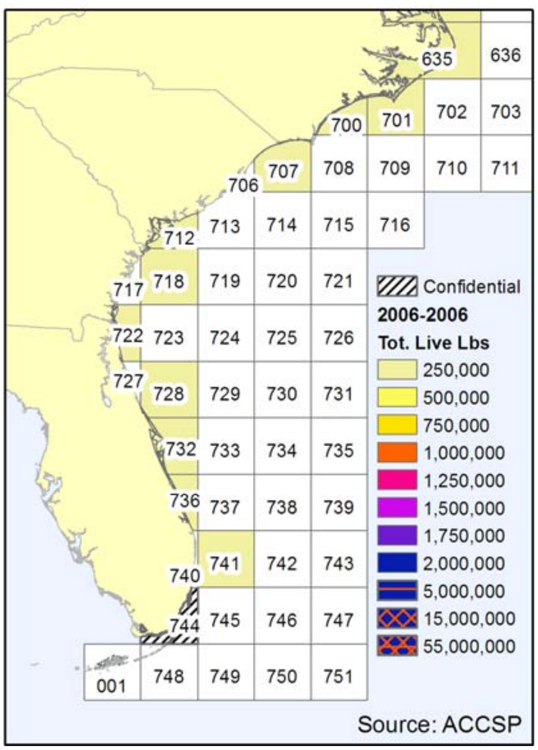
ACCSP Catch: WAHOO
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	120.72	7.10	4.74
635	191.75	11.28	7.51
700	0.76	0.04	0.00
701	152.07	8.95	0.00
707	2.20	0.13	Conf.
708	0.37	0.02	0.00
712	1.09	0.06	Conf.
713	4.54	0.27	0.00
714	2.60	0.15	Conf.
717	2.04	0.12	0.96
718	Conf.	Conf.	0.00
722	31.30	1.84	0.55
728	78.21	4.60	1.37
732	37.38	2.20	1.13
736	50.57	2.97	1.14
741	73.22	4.31	2.12
744	67.65	3.98	1.92
748	48.95	2.88	1.76

Figure 5.4.1-103. Spatial Presentation of Wahoo Commercial Catch (Source: ACCSP).







ACCSP Catch: WEAKFISH
1990-2006
Pounds in Thousands

Area	Tot. 90-06	Avg. 90-06	Tot. 2006
001	0.75	0.04	0.00
635	20,325.41	1,195.61	90.50
700	277.68	16.33	2.29
701	28,087.10	1,652.18	61.19
706	Conf.	Conf.	0.00
707	0.44	0.03	0.05
712	0.10	0.01	0.09
717	Conf.	Conf.	0.00
718	0.05	0.00	0.05
722	166.04	9.77	1.33
728	8.17	0.48	0.01
732	67.64	3.98	2.16
736	55.56	3.27	1.49
741	1.01	0.06	0.04
744	0.70	0.04	Conf.
748	0.09	0.01	0.00

Figure 5.4.1-104. Spatial Presentation of Weakfish Commercial Catch (Source: ACCSP).

FISHERY ECOSYSTEM PLAN OF THE SOUTH ATLANTIC REGION

VOLUME IV: THREATS TO THE SOUTH ATLANTIC ECOSYSTEM AND RECOMMENDATIONS

April 2009

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ABBREVIATIONS AND ACRONYMS

ABC	Acceptable Biological Catch
ACCSP	Atlantic Coastal Cooperative Statistics Program
ACE	Ashepoo-Combahee-Edisto Basin National Estuarine Research Reserve
APA	Administrative Procedures Act
AUV	Autonomous Underwater Vehicle
B	A measure of stock biomass either in weight or other appropriate unit
B_{MSY}	The stock biomass expected to exist under equilibrium conditions when fishing at F_{MSY}
B_{OY}	The stock biomass expected to exist under equilibrium conditions when fishing at F_{OY}
B_{CURR}	The current stock biomass
CEA	Cumulative Effects Analysis
CEQ	Council on Environmental Quality
CFMC	Caribbean Fishery Management Council
CPUE	Catch per unit effort
CRP	Cooperative Research Program
CZMA	Coastal Zone Management Act
DEIS	Draft Environmental Impact Statement
EA	Environmental Assessment
EBM	Ecosystem-Based Management
EEZ	Exclusive Economic Zone
EFH	Essential Fish Habitat
EFH-HAPC	Essential Fish Habitat - Habitat Area of Particular Concern
EIS	Environmental Impact Statement
EPAP	Ecosystem Principles Advisory Panel
ESA	Endangered Species Act of 1973
F	A measure of the instantaneous rate of fishing mortality
$F_{30\%SPR}$	Fishing mortality that will produce a static SPR = 30%.
$F_{45\%SPR}$	Fishing mortality that will produce a static SPR = 45%.
F_{CURR}	The current instantaneous rate of fishing mortality
FMP	Fishery Management Plan
F_{MSY}	The rate of fishing mortality expected to achieve MSY under equilibrium conditions and a corresponding biomass of B_{MSY}
F_{OY}	The rate of fishing mortality expected to achieve OY under equilibrium conditions and a corresponding biomass of B_{OY}
FEIS	Final Environmental Impact Statement
FMU	Fishery Management Unit
FONSI	Finding Of No Significant Impact
GOOS	Global Ocean Observing System
GFMC	Gulf of Mexico Fishery Management Council
IFQ	Individual fishing quota
IMS	Internet Mapping Server
IOOS	Integrated Ocean Observing System
M	Natural mortality rate

MARMAP	Marine Resources Monitoring Assessment and Prediction Program
MARFIN	Marine Fisheries Initiative
MBTA	Migratory Bird Treaty Act
MFMT	Maximum Fishing Mortality Threshold
MMPA	Marine Mammal Protection Act of 1973
MRFSS	Marine Recreational Fisheries Statistics Survey
MSA	Magnuson-Stevens Act
MSST	Minimum Stock Size Threshold
MSY	Maximum Sustainable Yield
NEPA	National Environmental Policy Act of 1969
NMFS	National Marine Fisheries Service
NMSA	National Marine Sanctuary Act
NOAA	National Oceanic and Atmospheric Administration
NRC	National Research Council
OY	Optimum Yield
POC	Pew Oceans Commission
R	Recruitment
RFA	Regulatory Flexibility Act
RIR	Regulatory Impact Review
SAFE	Stock Assessment and Fishery Evaluation Report
SAFMC	South Atlantic Fishery Management Council
SEDAR	Southeast Data, Assessment, and Review
SEFSC	Southeast Fisheries Science Center
SERO	Southeast Regional Office
SDDP	Supplementary Discard Data Program
SFA	Sustainable Fisheries Act
SIA	Social Impact Assessment
SSC	Scientific and Statistical Committee
TAC	Total allowable catch
T_{MIN}	The length of time in which a stock could rebuild to B_{MSY} in the absence of fishing mortality
USCG	U.S. Coast Guard
USCOP	U.S. Commission on Ocean Policy
VMS	Vessel Monitoring System

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6.0 Threats to the South Atlantic Ecosystem

6.1 Adverse impacts of non-fishing activities

The waters and substrate that comprise essential fish habitat (EFH) as defined by the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act), and under jurisdiction of the South Atlantic Fishery Management Council (SAFMC), are diverse, widely distributed, and closely affiliated with other aquatic and terrestrial environments. These characteristics make them readily susceptible to a large number of human activities.

The Essential Fish Habitat (EFH) Interim Final Rule (Federal Register 62 FR 244) defines EFH as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." The following definitions apply for interpreting the definition of the EFH rule:

- Waters include aquatic areas and their physical, chemical, and biological properties that are used by fish and invertebrates, and where appropriate may include areas historically used by fish and invertebrates;
- Substrate includes sediment, hard bottom, structures underlying the waters, and biological communities;
- Necessary means the habitat required to support a sustainable fishery and a healthy ecosystem; and
- Spawning, breeding, feeding, or growth to maturity covers species' full life cycle.

Fish habitat is the geographic area where the species occurs at any time during its life. This area can be described by ecological characteristics, location, and time. EFH includes waters and substrate that focus distribution; (e.g., coral reefs, marshes, or submerged aquatic vegetation), and other characteristics that are less distinct such as turbidity zones, water quality, and salinity gradients. Habitat use may change or shift over time due to climatic change, human activities and impacts, and/or other factors such as change with life history stage, species abundance, competition with other species, and environmental variability in time and space. The type of habitat available, its attributes, and its functions are important to species productivity, diversity, health, and survival.

Convention for Threats Identification

The ecological requirements for managed species and biotic communities, including identification of EFH, are addressed in this document. Threats to those habitats are described in terms of those that generally occur landward of the shoreline (Threats to Estuarine Processes) and those that occur oceanward of the shoreline (Threats to Offshore Processes). Threats to Estuarine Processes include but are not limited to agriculture; aquaculture; silviculture; urban/suburban development; commercial and industrial activities; navigation; recreational boating; mining; hydrologic modifications; transportation projects; and natural events and global change. Threats to Offshore

Processes include navigation; dumping; offshore sand and mineral mining; oil and gas exploration, development, and transportation; commercial and industrial activities; and natural events and global change. A more comprehensive list of individual activities that may be considered as threats is provided in Section 6.3.17.

Every reasonable effort was made to identify the principal non-fishing and fishing-related threats to EFH and to provide examples and information concerning the relationship between threat-related activities and EFH. Other information sources and examples undoubtedly exist and related studies are underway or are in various stages of publication. Accordingly, the following discussion is a starting point for the identification of threats to EFH. While it meets the strict time limitations imposed by the Magnuson-Stevens Act, regular updating is required to ensure comprehensive and current coverage of the topic addressed.

6.1.1 Freshwater/estuarine/inshore processes

Many species of the South Atlantic region are dependent during at least some life history stages on near-shore waters vulnerable to impacts from land-based sources. Especially vulnerable are species or species groups that require estuaries or freshwater tributaries as primary larval or post-larval habitat. In the southeast, these species include anadromous fish such as striped bass, blueback herring, alewife, American shad, hickory shad, and sturgeons; and brackish species including Atlantic menhaden, summer and southern flounder, red drum, spot, croaker, weakfish, penaeid shrimp, blue crab, and others (Epperly and Ross 1986).

Nearshore EFHs at risk from land-based impacts include submerged shellfish beds; subtidal and intertidal mudflats and shell hash; SAV beds, including eelgrass (*Zostera marina*), Cuban shoal grass (*Halodule wrightii*), and widgeon grass (*Ruppia maritima*); tidal freshwater forested wetlands dominated by tupelo-cypress communities (*Taxodium distichum*, *Nyssa aquatica*), and emergent tidal marshes including both saltmarshes dominated by smooth cordgrass (*Spartina alterniflora*) and brackish marshes dominated by black needlerush (*Juncus roemerianus*). These habitats may be affected both by direct destruction and by degradation of water quality or other factors such as hydrologic modification. Elimination or degradation of wetlands not immediately adjacent to EFH also may diminish the quality and productiveness of downstream estuaries.

The precise relationship between fishery production and habitats is undetermined. Accordingly, the exact degree to which habitat alteration has affected fishery production is also unknown, but is thought to be substantial. Turner and Boesch (1987) assembled and examined evidence of the relationship between the extent of wetland habitats and the yield of fishery species that depend on coastal bays and estuaries. The evidence examined show that fishery stock losses follow wetland losses and fishery stock gains follow wetland gains. While most of the studies were related to shrimp production, other fisheries are likely follow this trend.

In the southeastern U.S., the dominant sources of land-based impacts include major land-disturbing activities such as agriculture, silviculture, and residential and commercial development. The following discussions characterize major threats in the coastal zone of the southeast, summarize ways that EFH is impacted, and characterize the current extent of such impacts. Impacts can occur at three scales: immediate watersheds of EFH; broader watersheds of important estuarine nurseries; and distant or indirect impacts mediated through more widespread movement of water and its chemical and physical make-up.

6.1.1.1 Agriculture

Agriculture in the southeast has undergone dramatic changes over time. Most operations were at one time individual and small-scale enterprises, but in recent years have transformed into highly integrated, large-scale industries. Besides the extensive conversion of wetlands to crop and animal production, the most dramatic change in southern agriculture is the large scale expansion in animal production that has occurred during the last decade. The most dramatic increases have occurred in corporate hog operations in North Carolina. According to North Carolina Agricultural Statistics, the 1996/1997 hog numbers (8,969,200) for the 44 coastal counties are more than quadruple the 1986 numbers (2,117,800) for the same area. At the same time, the number of hog farms has declined precipitously, by a factor of three.

Other southeastern states have not yet experienced the same increase in swine herds. South Carolina's coastal counties, in fact, experienced a net reduction in swine herds from 374,000 head in 1986 to 194,900 head in 1996 (South Carolina Agricultural Statistics). Georgia had a similar decrease in the coastal plain counties, decreasing from 400,911 head in 1987 to 317,795 head in 1992 (Georgia Agricultural Statistics). Florida numbers experienced a decline in Atlantic watersheds from about 23,541 head in 1987 to 12,482 head in 1992 (Florida Agricultural Statistics). Part of the reason for the differences in hog production among the states is the development of industrial hog-growing technologies in North Carolina, plus differences in state regulatory programs. South Carolina, for instance, recently adopted very stringent and restrictive new laws governing hog-growing operations.

Poultry production, a second major agricultural animal product, has also increased substantially in the southeast. Again, North Carolina leads the nation in several poultry categories. In 1996, 313,735,000 birds were produced in coastal North Carolina; up from 45,588,966 birds in 1986. South Carolina coastal counties also showed a significant increase in production over this decade: 57,834,000 birds were produced in 1986 and 140,038,000 in 1996. The increases in the Georgia and Florida Atlantic coastal counties were much more moderate from 1987 to 1992, with production rates of 12,907,265 to 15,438,031 birds, and 2,780,706 to 2,886,335 birds, respectively (all data from state agricultural statistics).

Patterns in cropland use also have been in flux. In the North Carolina coastal plain, harvested cropland has remained almost static during the past decade, at about three million acres. However, fertilizer use has increased from 848,927 tons in 1986 to 2,006,251 tons in 1996 (not including swine and other animal waste land application). During the same period, South Carolina has experienced a net decrease in harvested acreage in the coastal plain, from 1,759,162 acres to 1,589,420 acres, but a net increase in fertilizer usage of about 38% to 331,597 tons. Harvested cropland along the Georgia coast is up slightly, to about 900,000 acres in 1992. Comparable data on fertilizer usage are not yet available. Harvested cropland in the Florida Atlantic coastal plain is down from about 1.1 million acres in 1992 to 675,081 acres in 1996. (All data from state agricultural statistics).

The overall pattern in crop production is one of great intensification of use on a fairly stable land base. Large increases in fertilizer usage and manure-based nitrogen fluxes (from surface and groundwater and from airborne sources) have occurred during the last decade in at least some southeastern states, including watersheds that were already artificially enriched.

Nutrient pollution can result in cascading ecological and economic impacts, including fish kills due to oxygen depletion, seagrass die-offs, excessive and sometimes toxic algal blooms, changes in marine biodiversity, increases in human illnesses, and loss of tourism (NRC 2000). For example, in southeast Florida nutrient inputs to Lake Okeechobee from central Florida agriculture activities (primarily sugar) are then discharged to important estuaries including the St. Lucie estuary. Timed releases associated with flood control activities result in large quantities of nutrient-laden water inputs to the St. Lucie estuary. Between 2004 and 2005, it is estimated that approximately 320 billion gallons of this water was diverted to the St. Lucie estuary. Many researchers have suspected that algal blooms and resulting fish kills in 2005-2006 were a result of this activity.

<u>Potential Threats to EFH from Agriculture</u>

Potential threats include: conversion of wetlands to agricultural lands, or for farm related purposes such as roads and irrigation ponds; direct and non-point source discharge of fill, nutrients, chemicals, and surface and ground waters into streams, rivers, and estuaries; hydrologic modification of ditches, dikes, farm ponds and other similar structures and water control devices; damage to wetlands and submerged bottoms by livestock grazing and/or movement; and cumulative and synergistic effects caused by association of these and other related activities.

Certain agricultural activities present a threat to EFH in the southeast. The major components of this threat include wetland conversion, nutrient over enrichment with subsequent deoxygenation of surface waters, shading by excessive algae and plant growth, and stimulation of toxic dinoflagellates; sedimentation; and delivery of toxicants into sensitive waters. Agriculture (including silviculture) accounted for 87% of all wetland losses observed nationally between the mid 1950's and mid 1970's (Tiner 1984). This loss has been estimated at more than 458,000 acres per year between the mid 1950's and mid 1970's in the coterminous U.S. (Tiner 1984). The most extensive losses observed in the southeast were in Florida and North Carolina where agricultural drainage continues to destroy large tracts of wetlands (Tiner 1984). Current agriculture conversion statistics for the southeast show that:

- During the mid-1970s to the mid-1980s "Florida showed a net wetland loss of 260,000 acres, mainly from the destruction of palustrine wetlands. Two-thirds of the loss of palustrine wetlands was attributable to agricultural development..." (Hefner et al. 1994).
- "Between the mid-1970s and mid 1980s, more than 100,000 acres of freshwater forested wetlands in Georgia were destroyed, mostly because of conversion to land uses such as agriculture" (Dahl et al. 1991).
- Between 1982 and 1989, South Carolina lost 155,500 acres, of this amount agriculture was responsible for 28% (Dahl 1997).
- In North Carolina about one-third of the wetland alteration in the coastal plain has occurred since the 1950s. Of this amount, agriculture was responsible for about 42% (Cashin et al. 1992).

Excessively enriched waters often do not support desirable species or populations of fish and invertebrates. They also may not support food chain and other ecological assemblages needed to sustain desirable species and populations. When overly abundant, nutrients such as nitrogen (ammonia) and phosphorus may degrade or eliminate EFH and its flora and fauna through several processes. Most problematic of these is the process whereby dissolved oxygen in the water is reduced by decaying plant life that prospered under nutrient rich conditions. In severe oxygen depletion situations fish and invertebrates may suffocate from oxygen deprivation.

Nutrient enrichment may also lead to direct toxicity when toxic organism populations "bloom" or become excessively large -- situations that are becoming more prevalent and which are discussed in detail in subsequent sections. Although affected by acidity, water temperature, and other factors, total ammonia concentrations in excess of about 2 mg/L normally exceed the chronic exposure level for fish (Mueller and Helsel 1996). In alkaline water at high temperature, the criteria may be exceeded by total ammonia concentrations of less than 0.1 mg/L. The natural conversion of ammonia to nitrate in streams removes oxygen from water and, therefore, may also harm fish (Mueller and Helsel 1996). While less problematic in estuarine and marine environments, phosphorus is a major factor in nutrient enrichment and eutrophication of freshwater systems. There are no minimum discharge standards for phosphorus; however, the U.S. EPA recommends that phosphates should not exceed 0.05 mg/L when discharged into streams entering lakes and reservoirs (Muller and Helsel 1996). Since freshwater systems may be used directly by anadromous fish, and they may also discharge into coastal waters, the quality of these waters has considerable bearing on many commercially and recreationally important aquatic resources and their habitats, including EFH. The nutrient inputs from central Florida agriculture (i.e., sugar) to Lake Okeechobee, the St. Lucie estuary, and Indian River Lagoon are suspected to have caused algal blooms, seagrass die-offs, and notable bivalve and fish kills in 2005-2006. In addition, the nutrient inputs are also suspected to have adversely impacted reefs located just outside the St. Lucie Inlet (e.g., Peck's reef).

In extreme situations living resources may be temporally or permanently displaced due to shifts in the aquatic food web, or by the physical presence of certain plant life. Excessive plant growth may also impede requisite functions (e.g., photosynthesis) of desirable plant life, hence EFH, as in the case of SAV where leaves may become covered with dense growths of algae, diatoms, and other biota such as bacteria and fungi.

Agriculture is believed to be the single largest contributor of nutrients into southeastern watersheds. The largest human additions of nitrogen result from an increased use of inorganic fertilizers (NRC 2000). In the Tar-Pamlico Estuary Basin in North Carolina, agriculture is responsible for approximately 45% of total nitrogen loading to the estuary, and 55% of phosphorus loading (NCDEHNR 1997a). An additional 33% of nitrogen and 17% of phosphorus comes from atmospheric sources that include, but is not limited to agriculture (NCDEHNR 1994, 1997a). In the adjacent Neuse River Basin, 54% of nitrogen is estimated to arise from agricultural sources (NCDEHNR 1993, 1997b). These two tributaries discharge into Pamlico Sound, the nation's second largest estuary, and the largest in the southeast.

Animal production is a threat to southeastern estuarine nutrient balances. The current usual management practice for manure from swine and other confined domestic mammals is storage and treatment in anaerobic lagoons followed by land application. This process relies on volatilization of nitrogen to account for roughly 80% of the total produced nitrogen, with concomitant downwind delivery in a zone of influence of roughly 100 kilometers (Rudek 1997). Airborne deposition of nitrogen into coastal waters in the region has been verified from field data to be a major source of enrichment in a number of southeastern estuaries. The most complete work at this time is focused on the Neuse River Estuary in North Carolina, where primary production was boosted two to three times by atmospheric deposition at ambient levels (Paerl et al. 1995a, 1995b). Actual plant uptake by crops on land-application fields accounts for no more than 10% of nitrogen use. Surplus nitrogen is delivered to shallow groundwater systems which, in turn, feed warm-season surface flows into adjacent streams and rivers. Thus, the vast majority of this material is redeposited on land and in surface waters.

Studies by Barker (1997) and Barker and Zublena (1995) also show that many North Carolina coastal counties are receiving swine-based nitrogen and/or phosphorus at levels in excess of total crop-plant growth needs. This analysis actually underestimates the problem, because it considers only direct land-applied nutrients and ignores swine-based atmospheric deposition in these counties. A report compiled for Senator Tom Harkin (D-IA) analyzed manure production patterns nationally by county and found zones of very high production in coastal North Carolina and in individual counties in the other three southeastern states. That document also reports excessive production above crop growth needs in many areas (Minority Staff 1997).

A recent estimate of agricultural emissions of ammonia from the North Carolina coastal plain is about 200.3 million lbs of nitrogen from animal waste, and 15 million lbs of nitrogen from fertilizers. Hogs alone contribute about 135 million lbs of nitrogen emissions in coastal North Carolina; larger than the entire National Atmospheric Deposition Program estimate of airborne deposition from all sources in the North Carolina coastal plain (Rudek 1997).

In response to nutrient enrichment problems and public concern, the North Carolina General Assembly has moved to impose a two-year moratorium on the development of new or enhanced hog farms, pending the replacement of current anaerobic lagoon technology with a more acceptable alternative.

High nutrient loadings also have been documented in other southeastern river basins and estuaries. Among seven river basins in Florida and Georgia examined recently by the U.S. Geological Survey, two in Georgia (the Altamaha and the Satilla) were found to be very high in nitrogen inputs at 5,470 $(kg/yr)/km^2$ and 5,430 $(kg/yr)/km^2$, respectively. Animal waste was the dominant source of nitrogen loading in both basins. Fertilizer was the biggest source in the St. Johns River Basin in Florida, and the Ogeechee Basin in Georgia. The most dominant sources of nutrient loading are non-point-source in origin, and predominantly agricultural (USGS 1997).

The National Water Quality Assessment Program is also examining the Santee Basin and nearby coastal drainages in South Carolina. Data from 1994 covering 24,868 square miles in South and North Carolina are being considered for this analysis. Although definitive information is not yet available, nutrient pollution of lakes and the rivers themselves has been identified as a major water quality issue for the program (USGS 1994). The first reports from this program are now available and include an annotated bibliography of water quality databases and recent publications on the water quality of the region (Abrahamsen et al. 1997).

Impacts of sediment from non-point-sources including agriculture and silviculture remain at the top of the water pollution list nationally (USEPA 1990) and in the southeastern states (NCDEHNR 1996b). While sediment-based impacts are typically considered to be most acute in freshwater systems, sediment pollution can also threaten EFH. Because sedimentation is a natural process in most aquatic systems it is generally not problematic except where deposition rates vastly exceed ambient conditions. In these situations, benthic animals and plants and demersal fishes that are unable to adjust or relocate may be buried or undergo disruption in growth and reproduction. Lethal and non-lethal effects of turbidity include ingestion of non-food particles by shellfish and polychaete worms, clogging of pores and gills, erosion of gills and other apparatuses such as fins, tentacles, and cilia that may be used for locomotion and feeding, burial of eggs and juveniles, and burial of substrates that may be needed for cover, attachment, and reproduction. In areas that support SAV, primary production levels may be reduced where light penetration is limited by increased turbidity.

While generally less important as a potential threat to EFH in the South Atlantic region, sediment deprivation may be locally troublesome since subsidence and erosion of wetlands and other habitats may result. Impounded coastal wetlands used for rice culture and other agricultural crop production in North Carolina, South Carolina, and Georgia are notable since large areas have been permanently altered even though tidal flow has been restored in many cases. In the Altamaha River Estuary in Georgia vast areas of freshwater and brackish tidal forested wetlands have been converted to emergent wetlands following construction of dikes and ditches that interrupted both deposition of alluvial materials and other processes.

Sediment pollution from agriculture is widespread in the coastal zone of the southeastern states. For example, North Carolina's "303d list," the listing of degraded water bodies required to be compiled by the Clean Water Act, contains an array of coastal streams degraded at least in part by agricultural sediment pollution. These include tributaries of the northeast Cape Fear River and Black River; Potecasi Creek (Chowan River); Trent River (Neuse Basin); Little River (Pasquotank Basin); Tranter's, Grindle, Conetoe and Town creeks (Tar-Pamlico Basin); and Newport River (NCDEHNR 1996a).

Pathogens from agricultural sources also threaten EFH, especially shellfish waters. The biggest single threat is probably poorly managed animal waste. A secondary source is land-disturbing activity related to putting new land into agricultural production. This may result in additional delivery of fecal coliform bacteria in quantities of potential concern.

The most dramatic cases of contamination of EFH from agricultural sources include spills of animal waste into coastal watersheds. North Carolina has suffered a number of recent spills, including many in the summer of 1995. A large swine lagoon rupture in 1995 spilled about 25 million gallons of waste into the New River Estuary causing severe anoxia, stimulating toxic algal blooms, and elevating fecal bacteria concentrations in both the receiving waters and sediments. Effects of this event persisted for over 61 days (Burkholder et al. 1997). Similar, but smaller, events were documented into tributaries of the Cape Fear River Estuary, North Carolina, from both swine and poultry sources. Impacts included large nutrient delivery, algal blooms, and contamination with huge loads of fecal bacteria; including pathogenic *Clostridium perfringens* (Mallin et al. 1997). This study documented 30 animal waste spills in North Carolina in 1995 and 1996. Bacteria from other agricultural sources also may contribute to contamination of shellfish waters. As wetland landscapes are developed for agriculture, offsite water delivery is enhanced (Skaggs et al. 1980). Many scientists believe that this hydrologic effect may contribute to elevated fecal coliform counts in receiving waters. This is suggested by preliminary studies in Otter Creek, Broad Creek, and the South River, North Carolina (J. Sauber, personal communication).

The variation in the scope and composition of agricultural non-point-source discharges and in the receiving waters creates an almost endless range of possible effects on aquatic resources, including EFH. Exposure of estuarine finfish and shellfish to toxic levels of insecticides, herbicides, and fungicides may occur, resulting in significant declines in populations (Scott 1997). Sublethal effects also are evident. For example, many compounds released by agricultural operations may adversely affect hormones such as estrogen and androgen that are linked to immune suppression (Scott 1997). These compounds usually do not kill the animal immediately, but reduce its life span and often its ability to reproduce.

Agricultural compounds that have been identified as having properties damaging to aquatic organisms include the commonly used herbicides aldicarb and atrazine and others such as, endosulfan, chlorpyrifos, and trace metals such as copper and mercury.
The enormous variation in the scope and composition of agricultural nonpoint source discharges and in the environmental nature of the receiving waters creates an almost endless range of possible effects on aquatic resources, including EFH. As noted in Scott (1997):

"Agricultural nonpoint source (NPS) runoff may result in significant discharges of pesticides, suspended sediments and fertilizers into estuarine habitats adjacent to agricultural areas or downstream from agricultural watersheds. Exposure of estuarine finfish and shellfish to toxic levels of insecticides, herbicides, and fungicides may occur, resulting in significant declines in field populations. Development of new management techniques such as Integrated Pest Management (IPMs), Best Management Practices (BMPs), and Retention Ponds (RP) are risk management tools which have been used to reduce contaminant risk from agricultural NPS runoff."

In association with Scott's (1997) observations, the National Ocean Service (NOS), Charleston Laboratory examined effects of NPS agricultural runoff on living marine resources in an attempt to define impacts on fishery resources and to develop risk reduction strategies to minimize/mitigate impacts. Investigations involving coastal estuarine ecosystems in South Carolina examined several sites used for vegetable farming (e.g., tomatoes, cucumbers, snap beans), where varied levels of risk reduction strategies were employed. The studies used grass shrimp (*Palaemonetes pugio*) and the mummichog (*Fundulus heteroclitus*) as well as other macropelagic populations. These two species represent more than 85% of the total macrofaunal (greater than 15mm) densities in small tidal creek nursery grounds in South Carolina and they are important due to their role in estuarine food webs. The studies demonstrated that pesticide exposure caused fish and invertebrate abundance reductions and mortality. Comparison of field results with laboratory toxicity tests clearly established that implementation of an integrated risk reduction strategy can significantly reduce NPS agricultural pesticide runoff. At intensively managed (IPM, BMPs, and RP) agricultural sites where strict NPS control techniques were administered, instream pesticide (azinphosmethyl, endosulfan, and fenvalerate) levels were reduced by 89-90% (Preceding from Scott 1997).

According to Scott (1997) the commonly used herbicides aldicarb and atrazine are potential endocrine disrupting chemicals (e.g., compounds that adversely affect hormones such as estrogen and androgen) and are linked to immune suppression. A 1992, Texas investigation found atrazine at concentrations greater than 60 ug/L in 98% of surface water samples that were taken on an annual basis. Laboratory toxicity tests of atrazine effects on estuarine phytoplankton revealed that chronic, low level atrazine exposure over multiple generations lead to enhanced sensitivity of phytoplankton and combined alachlor and atrazine exposure caused greater than simple additive toxicity in phytoplankton (Scott 1997).

The chronic effects of agriculture derived non-point source discharge have been extensively studied in Florida where impacts are occurring on a large scale basis. Essentially all of Florida Bay has undergone significant and undesirable biological, chemical, and physical change due to large scale agricultural practices, including hydrologic modification, in the Everglades. While these changes are occurring primarily in waters that lie outside of SAFMC jurisdiction, they are notable because of their size, magnitude, and complexity. Two basic lessons from the Everglades/Florida Bay situation also have application in watersheds found along the South Atlantic. They are: (1) the chronic environmental and ecological effects of regional agricultural practices may be extremely large and devastating and (2) the financial costs associated with analyzing and remedying these effects are likely to be enormous and possibly ineffective.

The factors associated with EFH degradation by agricultural related hypoxia are only poorly understood, but are of concern. Thus far, the extensive hypoxic zones and conditions observed in the Gulf of Mexico have not occurred in the South Atlantic region. Exceptions include relatively small, yet harmful, localized events in portions of North Carolina and South Carolina. In this region, North Carolina's estuarine waters are particularly vulnerable due to their shallow depths, poor flushing characteristics, and the abundance of hog farms found in the coastal zone. Although the most conspicuous effect of hypoxia is the mortality of larger fish and possibly invertebrates, even greater harm may be occurring with sensitive larval and juvenile forms since they are most vulnerable to oxygen depletion and other forms of environmental perturbation.

6.1.1.2 Aquaculture

Potential Threats to EFH from Aquaculture

Potential threats include: dredging and filling of wetlands and other coastal habitats and other modification of wetlands, submerged bottoms, and waters through introduction of pens, nets, and other containment and production devices; introduction of waste products and toxic chemicals; and introduction of exotic organisms; in addition to competition with wild stock for food sources.

Nationwide aquaculture is a vibrant industry with the annual value of product sold exceeding $866 million in 2005, although revenues have declined somewhat over the past 10 years (U.S. Department of Agriculture 2006). Within the Atlantic southeastern U.S., the annual value of product sold amounted to over $94 million in 2005, with Florida ($57.4 million) and North Carolina ($24.7 million) leading Georgia ($4.5 million) and South Carolina ($4.7 million). All aquaculture facilities in these states are located either on uplands or in coastal waters and no offshore aquaculture farms presently exist in the Atlantic southeastern U.S. The primary aquaculture operations in the Atlantic southeastern U.S. are shellfish farms (including hatcheries for production of seed stock), production of marine species in closed-recirculation systems, and production for enhancement of native fishery stocks.

The growing demand for seafood reflects both the growth of the U.S. population and the increased awareness of health benefits that result from a diet that includes seafood (Nesheim and Yaktine 2007). Currently, more than 80% of the U.S. seafood supply is imported, with over 40% of that amount coming from foreign aquaculture operations. Considering the substantial economic incentive to increase aquaculture production in the U.S. and the gradual elimination of technological barriers, expansion of the domestic aquaculture industry is expected over the next decade. Offshore areas may receive particular attention for development (Stickney et al. 2006).

Aquaculture and Fishery Habitats

Aquaculture has long been a source of human food. Within the last century, the technology of aquaculture has changed dramatically allowing application of semi-intensive and intensive farming systems. While this concentrates aquaculture activities to relatively small spatial areas and sets the stage for potential environmental conflicts, these concerns can be mitigated through appropriate management measures (Marine Aquaculture Task Force 2007). Balancing the demand for seafood and economic growth with the need to maintain coastal and marine ecosystems is a challenge that aquaculture accepts.

Nash et al. (2005) used the framework of an ecological risk assessment to examine common perceptions about the impacts of aquaculture on coastal and offshore habitats. The framework for this assessment was developed by the United Nations World Health Organization, has undergone extensive peer review, and is widely applied nationally and internationally. Ten types of potential impacts from aquaculture are noted: (1) increased organic loading from fecal material, uneaten food, and the decomposition of dead fish; (2) increased inorganic loading from fecal material and uneaten food; (3) residual heavy metals from uneaten food (primarily zinc) and from antifouling treatments (primarily copper); (4) transmission of disease to wild populations; (5) transmission of residual therapeutants to wild populations; (6) biological interactions from non-native species or genetically modified organisms with native populations from escapees, eggs, and gametes; (7) physical interactions with native populations through entanglement with nets, moorings, and other structures; (8) physical impacts on habitat from dredging, filling, nets, moorings, or other structures needed to establish a facility; (9) reductions in native populations from use of wild-caught juveniles for grow out; and (10) harvesting of industrial fisheries for use as fish feed. The assessment concludes that the level of risk from these sources is none to low when proper management measures are in place, including siting facilities to avoid areas with low water circulation or high boat traffic, judiciously managing stocking densities and managing waste, carefully selecting grow-out stock, and adhering to best management practices to control fouling, escapes, predation, diseases, and so forth. Use of geographic information systems (GIS) has led to spatial models that aid the examination of alternative sites for aquaculture operations (for an example from the southeastern U.S., see Arnold et al. 2000).

NOAA is building a broad based aquaculture program to enable expansion of all suitable forms of marine aquaculture within the context of complementing seafood production from wild catch, safeguarding environmental resources, and balancing multiple uses. An important objective of this program is to establish a comprehensive regulatory program for marine aquaculture operations. This program will complement existing regulatory programs that already apply to aquaculture operations, such as regulation the U.S. Army Corps of Engineers and U.S. Coast Guard of the placement of structures within navigable waters, regulation of water quality by the U.S. Environmental Protection Agency and individual states, regulation of therapeutants by the Food and Drug Administration, and oversight of interactions with fisheries and endangered species by NOAA's National Marine Fisheries Service.

6.1.1.3 Silviculture

Forested wetlands are the most abundant wetland type along the eastern seaboard. They include such diverse types as black spruce bogs, cedar swamps, red maple swamps, and bottomland hardwood forests (Tiner 1984). Scrub/shrub and forested wetlands account for over 59.4 million acres within coastal counties from North Carolina to Florida (Field et al. 1991). These wetlands also have been the most affected by forestry practices and, to a lesser degree, development. At a national level, from the mid 1950's to the mid 1970's, about 440,000 acres/year of palustrine wetlands (including forested wetlands) were lost (Tiner 1984). About 87% of this loss is accounted for by agricultural development; including silviculture (Tiner 1984). Trends in the southeast follow the national trend with North Carolina and Florida registering the most extensive wetland losses (Tiner 1984).

<u>Potential Threats to EFH from Silviculture</u>
Potential threats include: conversion of wetlands to silviculture production sites or for tree removal and other silviculture related purposes such as roads and irrigation ponds; direct and/or non-point-source discharge of fill, nutrients, chemicals, and surface and ground waters into streams, rivers and estuaries; hydrological modification to include ditches, dikes, irrigation ponds and other similar structures and water control devices; damage to wetlands and submerged bottoms by timber harvest activities; connected actions such as the construction of roads, and cumulative and synergistic effects caused by association of these and other silviculture and non-silviculture related activities.

The southeastern United States produces more industrial timber than any other region of the world. This timber production is from a forest base that includes almost one-half of the world's industrial forest plantations (Lee et al. 2005). Silviculture presents a significant threat to EFH largely due to the concentration of this activity in landscape positions near certain EFH, especially anadromous fish spawning and nursery areas and brackish primary and secondary nursery areas. Although silviculture typically is a less intensive land use activity than agriculture or urban development (Hughes 1996), the periodic intense disturbances associated with harvest, the installation and maintenance of dense drainage systems in wetlands and former wetlands, changes in vegetation, and the use of nutrient supplements and toxicants can significantly and adversely affect surface waters, EFH, and their associated biota.

The most important fundamental change with installation of intensive silviculture pertains to the water management system. Dense drainage systems allow the removal of significant amounts of water from hydric soil sites, intercept rain, and dewater stored groundwater. The effect on the wetlands can be serious if water tables are lowered such that hydric soils lose their water content. Organic constituents of hydric soils can then be oxidized, causing soil subsidence and liberation of previously bonded metals and nutrients. Clearing vegetation from wetland soils may also divert surface water into runoff pathways to the extent that both annual average runoff and event-related peak flows are exacerbated (Daniel 1981; McCarthy and Skaggs 1992). This runoff is a threat because it can change salinity regimes in receiving brackish water systems and it carries excess nutrients and other potential pollutants into sensitive waters and EFH (Pate and Jones 1980).

Conversion of mixed forested wetland and depressional cypress dome areas to silviculture is known to significantly reduce the water table. Studies have shown that slash pine (*Pinus elliottii*) through evapotransport can reduce the water table in an area by up to 36-inches depending on tree maturation. This reduction in subsurface water is higher than wetland canopy species that might have been originally found in a converted wetland area and contribute to soil subsidence and oxidation (value loss). Further this change in land-use (conversion of a wetland to silviculture) and the accompanying hydrological alterations change how these areas are regulated. In Florida, some silviculture areas are not regulated by state or federal agencies as wetlands even though many of the wetland characteristics are still evident (hydric soils, wetland vegetation, and hydroperiod). As a result conversion of these areas to commercial and residential development is expedited and compensatory mitigation for wetland function loss (albeit impaired or reduced) is not sought (Kruczynsky, personal communication).

The sensitivity of EFH to water balance perturbations is variable and poorly understood. Although some important species are highly sensitive to excessive salinity changes at young age classes (e.g., brown shrimp; Hunt et al. 1980), relatively little is known about the overall implications of flow modification from drained silvicultural areas. Limited studies on pumped drainage water in North Carolina showed minor impact to juvenile and adult spot and Atlantic croaker in response to pumping (Broad Creek Study Report). Effects on spring post-larval settlement periods for brown shrimp remain speculative since the effects of rainfall during pumping have not been determined.

In the Altamaha drainage in Georgia, water balance disturbance is thought to be a key factor in declining catch per unit effort of blue crab and shrimp (J. Holland, personal communication) and an in-depth hydrological investigation of that area has been proposed. Livingston et al. (1997) showed that reductions in freshwater inflow to the Apalachicola River Estuary in Florida led to initial turbidity reductions and increased primary productivity. Over time productivity reductions and major food web shifts were observed, probably in response to decreased nutrient delivery. As reported by Livingston et al. (1997) food web shifts remained minor so long as river flow did not greatly exceed natural limits. There is a concern that southeastern watersheds would respond in a similar manner.

Silviculture also has the potential to significantly affect nutrient delivery patterns into EFH, both through soil amendments with nitrogen and phosphorus and through changes in nutrient processing and delivery systems. Modification of these delivery patterns can be a threat to EFH. Typical forestry operations in the southeast add limited nitrogen and phosphorus during the growing cycle (Amatya et al. 1996). In addition, typical wetland soils are effective at removing incident nitrogen through nitrification and denitrification pathways. Wetlands are important sinks for atmospherically derived nitrogen. As such, riparian and isolated wetlands may buffer EFH from vehicle and animal waste-derived nitrogen enrichment. Drainage networks effectively short-circuit this buffering capacity by reducing retention periods and denitrification opportunities (Whigham et al. 1988; EDF and WWF 1992).

The huge areas involved and their proximity to sensitive estuaries makes forestry a major player in nutrient enrichment. For instance, in North Carolina's Neuse River Estuary, forests account for 17% of total nitrogen delivery (NCDEHNR 1993). The adjacent Pamlico Basin reflects a forestry contribution for nitrogen of about 10% (NCDEHNR 1994).

Sediment yields from silviculture in the coastal zone are not considered a substantial threat to EFH. Sedimentation is typically lower than Piedmont or mountain sites as a result of lower terrestrial slopes and enhanced opportunity for deposition in the slower moving receiving waters, including canal systems.

Information is poor on forestry contributions to fecal coliform contamination in the southeast. Initial studies have found relationships between elevated runoff rates after clear cutting and fecal coliform delivery, but other factors were also at work (J. Sauber, personal communication).

Non-nutrient pollution from silviculture is also of concern, though poorly documented. A number of studies have shown release of mercury and other metals from peat soils subjected to intensive drainage (Evans et al. 1984; Gregory et al. 1984). Elevated mercury concentrations also have been found in organic sediments in riparian coastal watersheds (Otte et al. 1987). In North Carolina, fish from the Waccamaw Basin show elevated mercury levels (NCDEHNR 1996b) and metal levels in sediments are elevated throughout the Albemarle-Pamlico Region due to a variety of sources (Riggs et al. 1991). Although not directly related to silviculture, real estate ventures by timber companies have converted large areas of forest land to residential property. This has resulted in much faster rates of surface water runoff and discharge of waters that contain higher concentrations of pesticides and fertilizers. In coastal areas and in inland locations bordering rivers and streams, property values may be greatly increased and the conversion of forest land to residential and commercial property is proceeding at a rapid rate. Further, connected actions, such as the construction of access roads to silviculture sites increase the overall area of impact.

6.1.1.4 Urban/Suburban Development

The southeastern United States has undergone one of the highest rates of landscape changes in the country, in part due to changing demographics and land use practices over the last few decades (Milesi et al. 2003). In particular this trend has been observed in the coastal regions of the southeast. Nine of our nation's ten largest cities are located in coastal watersheds (Bureau of the Census 2002). With its extensive and accessible coastline and mild winter climate the southeast coastal zone is one of the nation's fastest growing regions. The regional growth rate here is more than four times the national average (Chambers 1992) and between 1980 and 2010 the South Atlantic coastal population is expected to increase by as much as 73% (Chambers 1992). While coastal watershed counties comprise less than 25% of the land area in the United States, they are home to more than 52% of the total U.S. population. A study of coastal population trends predicts average increases of 3,600 people a day moving to coastal counties, reaching a total population of 165 million by 2015. These figures do not include the 180 million people who visit the coast every year (U.S. Commission on Ocean Policy 2004).

As the population increases so does urbanization. People require homes and related infrastructure such as roads, schools, water and sewer facilities, power transmission lines, etc. These needs often are met at the expense of EFH since residential growth has led to large scale modification of wetlands and other irreplaceable environments. Research indicates that nearby water bodies can become seriously degraded when more than 10% of the watershed is covered by roads, parking lots, roof tops, and similar surfaces (NRDC 1999). Tiner (1984) estimates that about 8% of the national rate of wetland losses that occurred from the mid 1950's to the mid 1970's resulted from urban development. Other effects of urbanization include increased sedimentation rates during and after construction, loss of surrounding upland recharge areas and wetland biofiltration and habitat functions. These effects could be ameliorated to some extent by maintaining sufficient buffers and less exploitive developmental patterns. The effect could be dampened by constructing within existing land contours and removing only the canopy necessary for project success. Currently in areas under development all existing vegetation is cleared and burned, all contours are removed and wetland soils are removed and replaced or filled over. Buffer ordinances, if they exist, are typically between 30 and 50 feet adjacent to estuarine systems; this width is not strongly supported by scientific literature.

Chemicals produced and used by people also find their way into the waters as point-source and non-point source runoff. Examples include oil from roads and parking lots, and pesticides, herbicides, and fertilizers from golf courses and residential lawns. This has reduced water quality in waters and wetlands adjacent to urban developments. As a result, the quality of EFH is often much reduced and thousands of acres of shellfish waters are closed. The South Carolina Department of Natural Resources' (SCDNR) Tidal Creek Project (TCP) provides insight into the effects of urbanization and suburban development on South Carolina tidal creeks (Holland et al. 1996, 2004; Sanger et al. 1999a,b). This study has implications for other states as well. The study examines developmental effects on salinity, dissolved oxygen (DO), and pollution in tidal creeks having trophic, shelter, and nursery functions required by commercially, recreationally, and ecologically important fish and invertebrates. The study reveals the complexity of the environmental and ecological factors involved and shows correlations between development; changes in tidal creek chemical, physical, and biological characteristics; and alteration of species distribution, composition, and abundance. In general, the physical-chemical characteristics of headwater creeks were significantly altered when the amount of impervious surface exceeded 10-20% and living resources were altered when the amount of impervious surface exceeded 20-30% cover.

The TCP identified salinity as a major factor in controlling the distribution and abundance of living marine resources (Holland et al. 1996, 2004). In watersheds having the greatest areas of roofs, roads, and parking lots it was found that recruitment and colonization by benthic fauna in these areas was less predictable than in more stable environments. TCP confirms that suitable DO concentrations are essential for maintaining balanced indigenous populations of fish, shellfish, and other aquatic biota in tidal creeks and that pollution-related decreases in DO may pose the greatest threat to the environmental quality of estuaries (Holland et al. 1996, 2004). With respect to contaminants, an examination of both metal and organic contaminants taken in connection with the TCP study indicate that metal contaminants were 2-10 times lower in forested watersheds compared to industrial/urban watersheds (Sanger et al. 1999a). Organic contaminants, such as PAHs, PCBs, and DDT were also much lower in forested creeks compared to the industrial/urban creeks.

In another study at larger watershed scales (14-digit Hydrologic Unit Code), Van Dolah et al. (in press), noted significant correlations in the concentrations of inorganic and organic contaminants and fecal coliform bacteria concentrations with the amount of urban suburban development. The correlation between contaminant concentrations and urban/suburban land cover, was stronger in tidal creek habitats within these watersheds, compared to data obtained from larger open water habitats within these watersheds. Additionally the percentage of sites within the watersheds having elevated contaminants and fecal coliform bacteria was much greater in watersheds having greater than 50% urban/suburban development compared with those watersheds having less than 30% urban/suburban cover.

As the linkage between urban and suburban development and declining fish abundance and health or quality is reinforced, the implications of anticipated population growth in coastal areas become even greater. This situation is especially critical in the southeast where recreationally and commercially important species are almost totally dependent on estuaries for their survival and for about $5.5 billion in annual commercial fishery benefits (Chambers 1990).

Potential Threats to EFH from Urban/Suburban Development

Potential threats include conversion of wetlands to sites for residential and related purposes such as roads, bridges, parking lots, commercial facilities, reservoirs, hydropower generation facilities, and utility corridors; direct and/or nonpoint-source discharge of fill, nutrients, chemicals, cooling water, and surface waters into ground water, streams, rivers and estuaries; hydrological modification to include ditches, dikes, flood control and other similar structures; damage to wetlands and submerged bottoms; and cumulative and synergistic effects caused by association of these and other developmental and non-developmental related activities.

Wetlands and other important coastal habitats continue to be adversely and irreversibly altered for urban and suburban development. (Note: certain related activities such as navigation are discussed in later sections). Of major concern is the piecemeal elimination of wetlands by filling for houses, roads, septic tank systems, etc. Wetland filling can directly eliminate or diminish the functional value of EFH and associated areas and resources. While the total area of wetlands affected by development is unknown, the rate of conversion was once estimated at 8% of the national average loss of 458,000 acres or 36,640 acres per year (Tiner 1984). Requests to alter coastal areas remain high and between 1981 and 1996, for example, in the southeast the NOAA Fisheries Service reviewed more than 23,871 proposals requesting to alter wetlands for housing, shoreline structures, docks, roadways, and other related activities. A survey of 5,622 of these proposals involved 19,729 acres of wetlands (see Tables 26, 27, 28, & 29). Between 1996 and 2006, NOAA Fisheries Service reviewed an additional 1,962 applications to fill wetlands to construct housing and 1,886 applications for shoreline modifications. Note that the acreage cited would not include wetland impacts from nationwide permits, dock footprint, loss of bottom area under pilings, or a great percent of shoreline fortification that is designated as "*di minimus*" by the COE and typically can range one to three feet from an existing seawall or bulkhead.

Another major threat posed by urban and suburban development is that of non-point-source discharges of the chemicals used in day to day activities, in operating and maintaining homes, roads, vehicles, etc. In addition to chemical input, changes that affect the volume, rate, location, frequency, and duration of surface water runoff into coastal rivers and tidal waters are likely to be determinants in the distribution, species composition, abundance, and health of southeastern fishery resources and their habitat. Results of various studies in the South Atlantic Bight indicate that chemical contaminants from industrial, urban/suburban, and agricultural sources may cause impacts in estuarine ecosystems. Highest contaminant concentrations and greatest impacts were observed in the headwaters of small tidal creeks, which are nursery grounds for fish, crustaceans and molluscs. Protection and management of nonpoint-source runoff loading into these watersheds is essential in protecting habitat quality (Scott et al. 1997). In the long-term, impacts of chemical pollution (e.g., petroleum hydrocarbons, halogenated hydrocarbons, metals, etc.) are likely to adversely impact fish (Schaaf et al. 1987). Despite current pollution control measures and stricter environmental laws, toxic organic and inorganic chemicals continue to be introduced into marine and estuarine environments.

Results of the previously mentioned TCP investigation confirm that suitable DO concentrations are essential for maintaining balanced indigenous populations of fish, shellfish, and other aquatic biota in tidal creeks and that pollution related decreases in DO may pose the greatest threat to the environmental quality of estuaries. The study found that:

- DO in tidal creeks fluctuated with phases of the moon, time of day, and tidal stage.
- DO in tidal creeks in developed and undeveloped watersheds often did not meet the state water quality standard of 4mg/L.
- The most stressful DO levels occurred during early morning and at night-time low tides.
- The DO levels in tidal creeks in developed watersheds were less predictable and had greater unexplained variance than those of undeveloped watersheds.
- Point in time DO measurements in tidal creeks do not adequately represent exposure of living resources stressful low DO levels.
- Living resources in tidal creeks in developed watersheds were more frequently exposed to stressful low DO levels than those inhabiting tidal creeks with undeveloped watersheds.
- The factors that contribute to low DO in South Carolina tidal creeks need further study and a DO budget for tidal creeks and associated saltmarshes is needed so that the major factors controlling low DO conditions can be identified and addressed from a management perspective.

With respect to contaminants, bioassays of sediments taken in connection with the TCP study indicate that potentially toxic conditions for living marine resources may occur in the upper reaches of tidal creeks in developed watersheds. Polyaromatic hydrocarbons in sediments were highest where surface runoff from roads was discharged into tidal creeks and sediment bound pesticides were more prevalent in the marsh and near houses. (Preceding is a summary taken from Holland et al. 1996).

Finally with regard to urban/suburban development, and in particular regard to nonpoint-source discharges, the South Carolina Statewide Water Quality Assessment for FY 1992-1993 (SCDHEC 1994) provides an indication of the role of non-point source discharges in one southeastern state. According to the Assessment:

- Nonpoint-source (NPS) pollution is the most responsible factor for nonsupport of classified water uses in rivers, lakes, and estuaries in the state.
- Of the 26,313 river miles assessed via water quality monitoring stations, 10,534 miles, or 40%, were determined to be partially supporting or not supporting overall use. NPS sources of pollution were identified as the contributing factor 33% of the time. These NPS sources included agriculture, pasture land, silviculture, construction, urban runoff/storm sewers, resource extraction, and hydromodification.
- South Carolina has approximately 945 square miles of estuaries, including marshes. The assessment analyzed data collected from 342 square miles of

estuaries. About 30% of the estuarine areas do not fully support overall use. NPS pollution sources were identified as the contributing factor 38% of the time.

- Of the 135 shellfish areas assessed, 63% were impacted by NPS, including marinas, 22% were impacted by point sources, and 27% were unconditionally approved (the percentages totaled exceed 100% due to multiple source impacts).
- The South Carolina NPS Task Force listed the 32 highest priority water bodies/watersheds that are targeted for implementation action. Of these water bodies/watersheds, 15 are located in the coastal zone.
- Sixty-two watershed units are located in the coastal zone. Based on information from the Statewide Assessment and from more recent Watershed Water Quality Management Strategies, 44% of these units have been impaired by NPS pollution; 39% have been impaired by unknown sources of pollution; 24% have been impaired by point sources; 16% have been impaired by natural or other sources; and 30% have no known impairment [The percentages totaled exceed 100% due to multiple source impacts. Also, based on the Statewide Assessment, 38 of the 62 watershed units (or 61%) have not been fully assessed].

Point source discharges related to urbanization derive mainly from municipal sewage treatment facilities or storm water discharges that are controlled through Environmental Protection Agency (EPA)-mandated regulations under the Clean Water Act and by state water quality regulations. Threats related to these discharges are probably less important than the other factors previously discussed because efforts are underway to improve treatment. The primary concerns with municipal point-source discharges involve treatment levels needed to attain acceptable nutrient inputs and overloading of treatment systems due to rapid development of the coastal zone. It is also important to consider that the portion of water entering estuaries from sewage treatment plants is increasing. In locations where treatment is poor, or water conditions are unsuitable for adequate dilution of discharges, EFH may be adversely affected. Of primary concern is excessive nutrification of receiving waters, but other factors such as those associated with nonpoint -source discharges also apply.

The EPA withdrew the storm water Phase II direct final rule published on April 7, 1995 (60 FR 17950) and promulgated a new final rule in its place (60 FR 17958). This action by the EPA instituted changes to the National Pollutant Discharge Elimination System (NPDES) stormwater permit application regulations under the Clean Water Act for Phase II dischargers. Phase II dischargers generally include all point-source discharges of storm water from commercial, retail, light industrial and institutional facilities and from municipal separate storm sewer systems serving populations of less than 100,000. This rule establishes a sequential application process in two tiers for all Phase II stormwater discharges. The first tier provides the NPDES permitting authority flexibility to require permits for those Phase II dischargers that are determined to be contributing to a water quality impairment or are a significant contributor of pollutants to waters of the U.S. "Permitting authority" refers to the EPA or States and Indian Tribes with approved NPDES programs. The EPA expects this group to be small because most of these types of dischargers have already been included under Phase I of the storm water program.

The second tier includes all other Phase II dischargers. This larger group will be required to apply for permits by the end of six years, but only if the Phase II regulatory program in place at that time requires permits. The EPA has stated that it is open to, and committed to, exploring a number of non-permit control strategies for the Phase II program that will allow efficient and effective targeting of real environmental problems. As part of this commitment, the EPA has initiated a process to include stakeholders in the development of a supplemental Phase II rule under the Federal Advisory Committee Act. This rule was finalized March 1, 1999 and determines the nature and extent of requirements that apply to the various types of Phase II facilities prior to the end of the six-year application period defined by the rule.

However, in practice, the EPA's NPDES for Phase II dischargers program, can be slow to implement and has limited enforcement authority. Further, stormwater requirements in the State of Florida have resulted in the loss/conversion of wetlands as required treatment ponds are commonly placed in wetlands whose capacity to assimilate contaminates far exceeds any benefit provided by the area loss for stormwater abatement. Further conversion of wetlands to stormwater ponds permanently eliminates these areas ability to contribute dissolve and particulate detrital organic carbon and their ecological habitat functions. These conversions are not seen or recorded as wetland losses although the lost ecologically contribution of these areas has an enormous impact on fisheries.

6.1.1.5 Transportation

Transportation projects such as the construction and maintenance of bridges and roadways typically involve long-term planning and permit consultation with NOAA Fisheries Service. Such projects can occur over estuarine waters, within estuarine emergent wetlands, and/or other important wetlands that are hydrologically connected to tidal waters. From 1996 to 2005 NOAA Fisheries Service reviewed 2,352 actions related to transportation.

<u>Potential threats to EFH from transportation projects</u>

Potential threats include fragmentation of the ecosystem by isolation and bifurcation of EFH, storm water discharges and runoff, shading of submerged aquatic vegetation from bridges, and blasting associated with bridge or structure demolition.

Transportation project can lead to habitat fragmentation, which results in the isolation of EFH from certain life history stages of recreationally and commercially important fisheries. This isolation limits the food chain by not allowing certain assemblages of organisms to easily traverse from one ecotype to another. This is especially true for fisheries such as the snapper grouper complex that use mangroves swamps and seagrass beds for one or more life history stages. This fragmentation could also potentially limit movements of catadromous and anadromous fishes by isolating populations from a spawning or nursery ground. Fragmentation can also result in the isolation of large tracts of freshwater wetlands. Through this isolation, the trophic functions provided by these wetlands are limited and allochthonous input is cut off to downstream estuaries and EFH.

Flushing of upstream wetlands and EFH can be impacted by fragmentation. If mitigation measures (e.g., culverts and bridges) are not taken to maintain adequate flow on both sides of a roadway, waters can become stagnant and limit the benefits to commercial and recreational fisheries.

Storm water discharges are a concern where bridges or roadways cross or are adjacent to EFH. Runoff from roadways could impact EFH if water is not collected and treated prior to discharge. The treatment of the storm water, including surface water management systems, should be located outside of EFH.

Blasting and demolition pose threats to EFH and managed fisheries. Direct and indirect impacts to EFH should be avoided and best management practices utilized when demolition occurs. This can include detonating small charges (otherwise known as test blasts or fish scares) to direct fish away from the area where the demolition will take place. Bubble curtains are also used in some cases to minimize fish kills.

Direct and indirect affects to EFH can also result from construction. Submerged aquatic vegetation can be impacted directly or indirectly from the installation of pilings and shading associated with bridges. The areas adjacent to bridges can be impacted as well from the shadow cast from the structure. These impacts must be considered when evaluating the effects of a transportation project on EFH.

6.1.1.6 Industrial/Commercial Activities

The southeastern U.S. is a prime location for industrial siting. The climate is favorable, economic incentives exist, land is readily available and relatively inexpensive, an adequate labor base exists, and the infrastructure for shipping of supplies and products is well developed. Further, the region's many rivers and streams provide an abundance of water needed for textile mills, paper mills, and heavy manufacturing (e.g., steel fabricating) and other similar facilities.

In addition to a favorable setting for industrial development, commercial growth is ever expanding. Although less conspicuous in many areas, the tourism industry also is a vital part of the coastal economy and many of the South's most popular vacation spots are located on or near the coast. With expansion of this industry, new hotels, related businesses, marinas, roads, and other facilities are being built. The increase in visitors and resource users is expected to continually grow and may diminish only when, as a result of overuse and development, the environmental quality of the area is reduced. Population growth and tourism bring many benefits to coastal communities, including new jobs and businesses and enhanced educational opportunities. Burgeoning industries associated with tourism and recreation in coastal areas (such as hotels, resorts, restaurants, fishing and dive stores, vacation housing, marinas, and other retail businesses) have created one of the nation's largest and fastest-growing economic forces (U.S. Commission on Ocean Policy 2004). In just four southeast Florida coastal counties, recreational diving, fishing, and ocean-watching activities generate $4.4 billion in local sales and almost $2 billion in local income annually (Johns 2001) and more than 2.9 million people visit the Florida Keys each year (Leeworthy and Vanasse 1999).

<u>Potential Threats to EFH from Industrial/Commercial Activities</u>

Potential threats include conversion of wetlands to industrial and appurtenant sites such as roads, parking, and administrative and distribution centers; point and nonpoint-source discharge of fill, nutrients, chemicals, cooling water, air emissions, and surface and ground waters into streams, rivers, estuaries and ocean waters; hydrological modification to include ditches, dikes, water and waste lagoons; intake and discharge systems; hydropower facilities; and cumulative and synergistic effects caused by association of these and other industrial and non-industrial related activities. In addition to ongoing activities, previous industrial and commercial activities have, in many locations, led to deposition of harmful materials that are subject to resuspension and reincorporation into aquatic food chains.

Industrial and commercial development can affect EFH in a number of ways. Most apparent is the conversion of wetlands and upland buffers to sites for buildings, plants, parking, storage and shipping or materials and products, and treatment or storage of wastes or by-products. Because of an abundance of hard impervious surfaces associated with industrial and commercial operations they are often major contributors of non-point-source contaminants into aquatic environments, including those that support EFH. Many industries, (e.g., paper mills), consume and pollute large volumes of water needed to sustain a healthy coastal environment. Industries may also produce airborne emissions that contain contaminants. These contaminants have been shown to reappear in coastal waters and EFH. A readily observable example is acidification of waters from atmospheric deposition of industrial emissions and coal fired power plants. Commercial development along the South Atlantic coast also has been extensive and relatively few coastal areas are free of commercial development. Past development practices were especially detrimental and before adequate regulation it was not uncommon to excavate and fill marshes and shallow water environments for residential, commercial and industrial uses. Such practices have been largely eliminated because most of the coast is either developed or protected from such practices. However, uplands are a decreasing commodity in the coastal zone and the demand for filling wetlands and other aquatic sites is likely to persist. Consequently, proposals aimed at altering wetlands for commercial and other purposes will continue to require local, state, and federal involvement if significant adverse impacts to EFH are to be effectively controlled.

The total amount of EFH that has been eliminated or degraded by commercial and industrial development is unknown, but it is extensive. NOAA Fisheries Service data show that between 1981 and 1996, 1,466 proposals were received for industrial and commercial development in wetlands that are subject to the regulatory provisions of the Rivers and Harbor Act and Section 404 of the Clean Water Act. In association with this, 430 proposals sought approval to alter about 3,202 acres of EFH (see Tables 26, 27, 28, & 29). Between 1996 and 2006, NOAA Fisheries Service reviewed approximately 2,126 applications for industrial and commercial activities and associated wetland impacts in the South Atlantic area.

Point-source discharges from commercial activities may be similar to those associated with urban and suburban development. Accordingly, the information and discussions contained in Section 4.1.1.3 should apply. Pollution and water use may alter the flow, pH, hardness, dissolved oxygen, and chemical composition parameters that affect individuals, populations, and communities (Carins 1980). Within aquatic systems industrial point-source discharges also may alter species and population diversity, nutrient and energy transfer, productivity, biomass, density, stability, connectivity, and species richness and evenness both at the point of discharge and downstream locations (Carins 1980). Growth, visual acuity, swimming speed, equilibrium, feeding rate, response stimuli, predation rate, photosynthetic rate, spawning seasons, migration routes, and resistance to disease and parasites of finfish, shellfish, and related organisms may be altered by chemical and thermal changes. Some industries, such as paper mills, are major water users and associated effluent can dominate and control conditions in substantial portions of rivers and other water bodies where they are located. Usually parameters such as substrate, currents, dissolved oxygen, pH, nutrients, temperature, and suspended materials are key factors affecting the distribution and abundance of EFH. The direct and synergistic effects of other discharge components such as heavy metals and various chemical compounds are not well understood, but current research shows that these constituents may be of greater importance than previously thought. For example, more subtle factors such as endocrine disruption in aquatic organisms and reduced ability to reproduce or compete for food are being uncovered (Scott et al. 1997).

The cumulative effect of many types of discharges on various aquatic systems also is not well understood, but attempts to mediate their effects are reflected in various water quality standards and programs in each state and within the various water systems. Industrial wastewater effluent is regulated by the EPA through the NPDES permitting program. This program provides for issuance of waste discharge permits as a means of identifying, defining, and controlling virtually all point-source discharges. The complexity and the magnitude of effort required to administer the NPDES permit program limit overview of the program and federal agencies. Consequently, the NOAA Fisheries Service and the FWS generally do not provide comments on NPDES application notices. For these same reasons, it is not presently possible to estimate the singular, combined, and synergistic effects of industrial (and domestic) discharges on aquatic ecosystems.

Where chronic non-point-source discharges and accidental releases of harmful or toxic substances mix, especially harmful effects on aquatic life and habitat, including EFH, is likely. An added concern with industrial operations is the release of contaminants into the atmosphere. Such materials may be transported various distances and directly and indirectly deposited into aquatic ecosystems (Baker et al. 1993). In the southeast, surface water acidification and mercury accumulation in sediments are of particular concern since sources of these material lie in other regions and are not subject to local and regional (southeastern) controls. In view of this, the regulation of surface water contamination from atmospheric pollution should be addressed from a local, regional, and international perspective.

6.1.1.7 Navigation

Support for navigation in the southeast Atlantic region has resulted in widespread modification of subtidal and intertidal areas used by commercial and recreational vessels. Significant modification to offshore habitats has also occurred and this is discussed in the Marine/offshore Processes Section. Primary threats to EFH from navigation in estuarine waters include the construction, maintenance, and expansion of thousands of miles of waterways such as the Atlantic Intracoastal Waterway and the myriad of other channels that lead to marinas, ports, turning basins, and harbors. Construction and maintenance of existing ports and recreationally-based marinas and basins have altered substantial areas of EFH. Expansion of existing channels and waterways to accommodate larger vessels, primarily mega-yachts and Post-Panamax vessels, is becoming an increasing threat to inshore EFH, namely seagrasses. Dredged material disposal and disposal of contaminated sediments is also an issue. Filling of wetlands and conversion of EFH from shallow to deep water habitats are persistent threats associated with new facilities and the maintenance and expansion of existing facilities. Where coastal inlets are stabilized and maintained for navigation purposes effects on nearshore environments and fish and invertebrate populations may be substantial in addition to blockages of littoral sediment transport.

A second major concern related to navigation is the host of environmental problems associated with vessel operations. These range from contamination of water by oil, grease, anti-fouling paints, and discharges of sewage, garbage, and debris to the direct destruction of EFH by grounding, anchor damage, propwashing, scarring, etc. Most physical damage is accidental; however, activities such as propwashing could be avoidable for example, through better signage in waterways near shallow SAV habitats and a greater of level of enforcement. However, regarding the latter, it should be recognized that many State and local enforcement programs are severely understaffed and underfunded.

<u>Potential Threats to EFH from Navigation</u>

Navigation related threats to EFH located within estuarine waters can be separated into two categories: Navigation support activities and vessel operations. Navigation support activities include, but are not limited to, excavation and maintenance of channels (includes disposal of excavated materials); construction and operation of ports, mooring and cargo handling facilities; construction and operation of ship repair facilities; and construction of channel stabilization structures such as jetties and revetments. Potentially harmful vessel operations activities include, but are not limited to: discharge or spillage of fuel, oil, grease, paints, solvents, trash, and cargo; grounding/sinking/prop scaring in ecologically/environmentally sensitive locations; exacerbation of shoreline erosion due to wakes; salt water intrusion into brackish systems; and transfer and introduction of exotic and harmful organisms through ballast water discharge.

<u>Navigation Support Activities</u>

The most conspicuous navigation-related activity in many estuarine waters is the construction and maintenance of navigation channels and the related disposal of dredged materials. The amount of subtidal and intertidal area affected by new and maintenance dredging is unknown, but undoubtedly great. Orlando et al (1988) analyzed 18 major east coast estuaries from North Carolina to Florida east coast and found over 703 miles of navigation channels and 9,844 miles of shoreline modifications related to navigation works. Between 1981 and 1986 the NOAA Fisheries Service received over 4,877 proposals for new navigation projects in the South Atlantic region. A detailed analysis showed that 1,692 of these proposals involved plans to alter 24,825 acres of EFH through dredging and filling (Tables 26, 27, 28, & 29). From 1996-2006, NOAA Fisheries Service received 1,055 applications for maintenance dredging related activities and 720 application-related to construction of marinas and navigation channels in the South Atlantic area.

However, the potential threats to EFH from widening and deepening navigation channels warrant close examination. In many South Atlantic areas, marina owners and inland navigation districts have submitted applications to the Corps of Engineers for widening and deepening activities to accommodate mega-yachts and provide navigation access for mega-yacht vessels to private interior berthing, testing, and repair facilities located in the vicinity of inlets. Mega-yachts are typically classified as private luxury recreational motor or sailing vessels that are greater than 80 feet in length and there are approximately 735 that would access South Atlantic navigation channels (FWS 2005). In Palm Beach County, Florida alone proposed impacts associated with Atlantic Intracoastal Waterway and other channel expansion projects exceed 30 acres of seagrass habitat within Lake Worth Lagoon and typically involve dredging deeper than the Water Resources Development Act Congressionally authorized depths, for example from -10 NGVD to -16 NGVD. The seagrass habitats located around inlets are typically unique and ecologically significant due to the influence of clear oceanic waters that enter through the inlet and provide water clarity that cannot be found in locations further from the inlet. For example, the seagrass habitat located in close proximity to the Lake Worth Inlet (Florida) allows seagrass to grow at depths of over 10 feet as opposed to more remote seagrass habitat, which may only reach depths of 4 feet.

According to a FWS report, the overriding factor in the decline of estuarine and marine wetlands in the U.S. between 1998 and 2004 was the loss of emergent saltmarsh to open saltwater systems due to and manmade activities such as dredging, water control, and commercial and recreational boat traffic (Dahl 2006). While channel excavation itself is usually visible only from the surface while the dredge or other equipment are in the area, the need to dispose of excavated materials has left its mark in the form of confined and unconfined disposal sites, including those that have undergone human occupation and development. Chronic and individually small discharges and disturbances routinely affect water and substrate and may be significant from a cumulative or synergistic perspective. EFH impacts include, direct removal/burial of organisms as a result of dredging and placement of dredged material; turbidity/siltation effects, including increased light attenuation from turbidity; contaminant release and uptake of nutrients, metals, and organics; release of oxygen consuming substances; noise disturbance to aquatic and terrestrial organisms; and alteration of hydrodynamic regimes and physical habitat.

The maintenance and stabilization of coastal inlets also is a prominent navigation activity. Studies and reports by the COE, the NOAA Fisheries Service, and others link jetty construction to possible changes in plankton movement (USACE 1980; USDC 1991; Miller 1988; Miller et al. 1984). This is a major concern since significant modification of inlet hydrodynamics may diminish the ability of sub-adult fish and invertebrates to reach estuarine nursery grounds. Where significant reductions in recruitment (into estuarine waters) of desirable species is realized, production declines in ecologically, recreationally and commercially important species may result. The use of jetties to stabilize navigation channels at coastal inlets also has been linked to changes in coastal geomorphology that affects nearshore environments. For example, coastal geologists have expressed concern that construction of jetties at Oregon Inlet on the North Carolina Outer Banks could cause catastrophic beach erosion and accelerate barrier island migration (Pilkey and Dixon 1996). Such change could adversely affect the extensive and highly productive submerged vegetation beds which are located behind the coastal barriers.

The relocation of freshwater/saltwater transition zones due to channel deepening may be, in some cases, responsible for significant environmental and ecological change. As an example, salinity shifts after channel deepening and water diversion in the lower Savannah River caused vegetation shifts from freshwater to brackish species in surrounding wetlands. In the lower Savannah River, increased mortality of sub-adult striped bass also has been linked to salinity increases caused by navigation-related modifications such as channel deepening and flow diversion. Modifications that increase estuarine salinities may also create more hospitable conditions for shellfish predators such as boring sponge, oyster drill, and keyhole limpet.

In southeast Florida, increased channelization by dredging and the addition of rocky structures may have favored shifts from estuarine assemblages to reef assemblages because of comparatively higher abundances and diversities of incoming ichthyoplankton, higher inshore salinities, and replacement of vegetation with hard structure that favors reef species (Lindeman 1997). Similar situations are possible in other watersheds where dredging and dredged material disposal are prominent features; however, little documentation of these changes is available. Another example includes the St. Johns River in North Florida. The St. Johns River's watershed encompasses 50% or more of the east coast of Florida flowing north and in the 1800's flowed out onto an alluvial flood plan of shallow non-navigable sand bars. Construction of the Jacksonville Port has deepened and channelized the river mouth, now -52 NGVD. As a result, the amount of salt water intrusion has completely altered the estuarine system of the lower St. Johns River.

The expansion of ports and marinas has become an almost continuous process due to economic growth, competition between ports, and significant increases in vessel numbers and vessel size. Elimination or degradation of aquatic and upland habitats are commonplace since port and marina expansion almost always require the use of open water, submerged bottoms, and riparian zones. Ancillary related activities and development often utilize even larger areas, many of which provide water quality and other functions needed to sustain living marine resources. Vessel repair facilities use highly toxic cleaners, paints, and lubricants that can contaminate waters and sediments. Modern pollution containment and abatement systems and procedures can prevent or minimize toxic substance releases; however, constant and diligent pollution control efforts must be implemented. The operation of these facilities also poses an inherent threat to EFH by adversely affecting water quality in and around these facilities. The extent of the impact usually depends on factors such as flushing characteristics, facility size, location, depth, and configuration. When facilities such as marinas are constructed it is common to restrict shellfish harvest in a set or established zone that may be affected by sewage and other hazardous materials. It is now common practice to consider safe zones with respect to public health and aquatic resources when siting marina and port facilities.

Major ports in the South Atlantic region include Morehead City and Wilmington in North Carolina; Georgetown, Charleston, and Port Royal in South Carolina; Savannah and Brunswick in Georgia; and Fernandina Beach, Jacksonville, Port Canaveral, Port Everglades, Fort Pierce, Palm Beach, and Miami in Florida. Many eastern seaboard ports are subject to proposals to widen and deepen to accommodate Post-Panamax vessels or deep-draft vessels too large to fit through the Panama Canal. Impacts resulting from these projects can be substantial and can involve alternatives to dredge through coral reef, hardbottom habitat, and seagrasses.

In 2005, the Port of Miami, located in Biscayne Bay which is a State of Florida designated Outstanding Florida Water, completed a harbor deepening project that used confined blasting to fracture rock that was too hard to be removed via conventional dredge. In 2004, the Corps of Engineers finalized an Environmental Impact Statement to widen and deepen the entrance channel and other interior areas of the Port to -50 NGVD. The Recommended Plan would impact approximately 415 acres of habitat including over 6.3 acres of seagrass habitat, 28.7 acres of low-relief hardbottom/reef habitat, 20.7 acres of high relief hardbottom/reef habitat, 123.5 acres of rock/rubble habitat, and 236.4 acres of unvegetated bottom habitat (COE 2003).

The COE recently finalized a Reef Report for Port Everglades Outer Entrance Channel Expansion Project that concluded that over 150,000 corals and 21 acres of reef could be lost through proposed expansion activities (COE 2006). This project is in the feasibility phase and the COE proposes to release the draft Environmental Impact Statement in October 2007. In addition to the reef impacts, this project could impact up to 5 acres of seagrass (including one acre of the federally listed *Halophila johnsonii*), 11.55 acres of mangroves (8.48 acres of which are currently held in a conservation easement for impacts from previous Port activities), and 20.09 acres of previously dredged hardbottom, for which no compensatory mitigation is currently proposed (FWS 2005).

Cargo arriving and departing through these ports is diverse and ranges from highly toxic and hazardous chemicals and petroleum products to relatively benign materials such as wood chips. Major spills and other discharges of hazardous materials are uncommon, but are of constant concern since large and significant areas of estuarine habitat and fishery resources are at risk. Expansion of these facilities and certain operation and maintenance activities are likely to occur at the expense of EFH.

There have been recent positive trends in the development of beneficial uses for clean dredged materials. For example, the deepening of the Wilmington Harbor navigation channel in North Carolina generated rock that is being used for creation of an offshore reef. Similar activities are being investigated in connection with planned deepening of Charleston Harbor in South Carolina. These activities will require monitoring to evaluate their success, but if beneficial other uses of dredged material could be developed. On a cautionary note, conversion of one habitat type to another may not be desirable since associated ecological trade-offs could be harmful to desirable or managed species. The classic example of this is the Winyah Bay, South Carolina dredged material disposal site, where submerged and intertidal bottoms have been converted to emergent marsh without any assessment of the ecological role of the disposal site.

Dredging and disposal of excavated materials is a major component of all southeastern ports and many marinas. Dredged materials are often contaminated and extensive testing for heavy metals and other contaminants is required. At many locations finding suitable disposal sites for dredged materials is also difficult and costly. Whenever contaminated dredged materials are placed in offshore waters, or in locations where decant is discharged into surrounding waters there is high probability that these contaminants will reenter aquatic food webs. As existing upland disposal sites are filled this problem is likely to be exacerbated. Already, direct overboard dispersal of dredged material occurs at some location such as in reaches of the Atlantic Intracoastal Waterway in North Carolina. In other locations such as the Savannah River, Georgia, a technique referred to as “agitation dredging” is used. In this case, about 200,000 cubic yards of materials are resuspended from ship berths each year by bottom dragging or by hydraulic excavation with direct disposal into the adjacent navigation channel. In addition, hydraulic bottom scour systems are presently in place in Wilmington, North Carolina, and experimental use of these devices is planned at one facility in Savannah and at the U.S. Navy’s Kings Bay, Georgia, Submarine Base. The environmental impact associated with the use of this technique is unclear, but significant use of bottom scouring devices could be problematic since planktonic and weak swimming fish and invertebrates could be impinged or entrained in intakes and plumbing, and turbidity and sedimentation could be exacerbated. Of particular concern is those aquatic environments that contain anadromous fish since planktonic and weak swimming fish could be heavily impacted.

An additional, but more limited dredging practice is the prop dredging of bottoms, mostly by recreational vessels, to obtain navigable depths. This practice is generally performed without benefit of state or federal permits and is almost always destructive.

The SAFMC is opposed to open water disposal of dredged material into aquatic systems when adverse impacts to habitat used by fisheries under its jurisdiction are likely. The SAFMC urges state and federal agencies, when reviewing permits considering open water disposal, to identify the direct and indirect impacts such projects could have on fisheries habitat. It is also their view that the conversion of one naturally functioning aquatic system at the expense of creating another (marsh creation through open water disposal) must be justified using the best available information.

Construction of piers and docks also affects EFH, but the degree of the impact is often disputed. Impacts are dependent on the size, location, and number of similar structures in a given area. Pier and dock construction often involves jetting of pilings and this causes temporary and localized affects on EFH due to increased sedimentation and habitat displacement. Sedimentation may be a problem in systems such as SAV that are already stressed and are declining or have marginal value due to low water clarity. The pilings are treated and toxic chemicals are released into the waters and sediments, but this is not perceived to be a major problem since the pilings are eventually covered with encrusting and fouling organisms. Perhaps the greatest threats from piers and docks are those associated with marsh and SAV shading and the erosion, due to wave action, of substrates in the vicinity of support piles. Substantial harm to SAV and benthic communities may also result from secondary effects associated with boat use, including constant grounding due to wave and tidal action.

The overall biological effects of piers and docks has not been well quantified. However, between 1981 and 1996, the NOAA Fisheries Service reviewed requests for almost 6,000 piers and docks along the southeast coast between North Carolina and Florida. Between 1996 and 2006, NOAA Fisheries Service reviewed an additional 7,540 applications to construct docks and pilings. In areas having marginal depths and especially where SAV is present, habitat damage in the vicinity of piers and docks may be substantial and disproportionately large in cases where such structures are abundant (Ludwig et al. 1997). These structures represent a substantial feature in southeastern watersheds and they warrant continued monitoring and regulatory review. In response to this, NOAA Fisheries Service and U.S. Army Corps of Engineers Jacksonville District jointly developed *Dock Construction Guidelines in Florida for Docks or Other Minor Structures Constructed in or over Submerged Aquatic Vegetation, Marsh or Mangrove Habitat* in addition to the *Key for Construction Conditions for Docks or Other Minor Structures Constructed in or over Johnson's seagrass (Halophila johnsonii)* (see http://www.saj.usace.army.mil/permit/hot_topics/Dock_Guidelines/dockindex.htm). In general, these guidelines provide environmentally responsible access to Florida waters.

<u>Vessel Operations</u>
In connection with watercraft operation and support the USEPA (1993) has identified several principal concerns. These include pollutants discharged from boats; pollutants generated from boat maintenance activities; exacerbation of existing poor water quality conditions; pollutants transported in storm water runoff from parking lots, roofs, and other impervious surfaces; and the physical alteration or destruction of wetlands and of shellfish and other bottom communities during the construction of marinas, ramps, and related facilities.

Marinas and other sites where vessels are moored or operate often are plagued by accumulation of anti-fouling paints in bottom sediments, by fuel spillage, and overboard disposal of trash and wastewater. In areas where vessels are dispersed and dilution factors are adequate, the water quality impacts of vessel operations are likely to be offset to some degree. In a study of marinas in North Carolina it was found that marinas may contribute to increases in fecal coliforms, sediment oxygen demand, and chlorophyll a, and decreases in dissolved oxygen (NCDEHNR 1990). In addition, boating and other activities (e.g., fish waste disposal) may contribute to increased water temperature, bioaccumulation of pollutants by organisms, water contamination, sediment contamination, resuspension of sediments, loss of SAV and estuarine vegetation, changes in sediment composition loss of benthic organisms, changes in circulation patterns, shoaling, and shoreline erosion. Pollutants associated with marinas include nutrients, metals, petroleum hydrocarbons, pathogens, and polychlorinated biphenyls (USEPA 1993).

Marina personnel and boat owners use a variety of boat cleaners, such as teak cleaners, fiberglass polish, and detergents and cleaning boats over the water, or on adjacent upland, creates a high probability that some cleaners and other chemicals will enter the water (USEPA 1993). Copper-based antifouling paint is released into marina waters when boat bottoms are cleaned in the water (USEPA 1993). Tributyl-tin, which is a major environmental hazard, has been largely banned except for use on military vessels. Fuel and oil are often released into waters during fueling operations and through bilge pumping. Oil and grease are commonly found in bilge water, especially in vessels with inboard engines, and these products may be discharged during vessel pump out (USEPA 1993).

Sewage and other wastes discharged from recreational boats may be most problematic in marinas and anchorage sites where vessels are concentrated. Despite existing federal and state regulations involving discharges of sewage and other materials, detection and control of these activities are difficult and discharges still occur. According to the 1989 American Red Cross Boating Survey, there were about 19 million recreational boats in the U.S. (USEPA 1993). About 95% of these boats were less than 26 feet in length and a large number of these boats used a portable toilet, rather than a larger holding tank. Given the large percentage of smaller boats, facilities for the dumping of portable toilet waste should be provided at marinas that service significant numbers of boats under 26 feet in length (USEPA 1993).

Increased recreational boating activity may contribute significantly to pollution of southeastern coastal waters by petroleum products. All two-cycle outboard engines require that oil be mixed with gasoline, either directly in the tank or by injection. That portion of the oil that does not burn is then ejected, along with other exhaust products, into the water. In 1990, 52,030 boats were registered in coastal North Carolina (North Carolina Wildlife Resources Commission, personal communication). Based on this number, conservative estimates indicate that about 84,549 gallons per year of oil (in fuel) is discharged annually into North Carolina’s coastal waters (Hoss and Engel 1996). For comparison purposes, hydrocarbon discharges for coastal North Carolina in 1982, from boating and urban runoff are about 470 and 2,270 tons, respectively. Increased use of personal water craft such as jet skis has added to the volume of hydrocarbon being introduced into southeastern waters since the engine exhaust from these vessels is discharged directly into the propellant water jet. Similar problems are inferred for other states and areas having high concentrations of boats.

The chronic effects of vessel grounding, prop and jet ski scarring, and anchor damage are generally more problematic in conjunction with recreational vessels. While grounding of ships and barges is less frequent, individual incidents can have significant localized effects. Propeller damage to submerged bottoms occur in all areas where vessels ply shallow waters. In addition, direct damage to multiple life stages of associated organisms, including egg, larvae, juveniles, and through water column de-stratification (temperature and density), resuspending sediments, and increasing turbidity (Stolpe 1997; Goldsborough 1997) have been observed in connection with vessel operation. This damage is particularly troublesome in North Carolina and Florida, the two South Atlantic states with submerged rooted vegetation in their coastal waters. In North Carolina, no official quantitative estimate of SAV damage has been performed; however, preliminary observations indicate that damage to the state's 135,000 acres of SAV is localized around marinas or other boat access points (R.L. Ferguson, personal communication). Scarring estimates for Florida indicate that about 173,000 of the state's 2.7 million acres of SAV are scarred (Sargent et al. 1995). On the Atlantic coast of Florida there are about 69,360 acres of SAV and 3,770 acres (18%) have been scarred by prop and other water craft action.

The ever increasing number of registered power boats along the South Atlantic coastal zone, and those temporarily entering coastal areas through tourism ensure that this threat is likely increase over time. Power boat registrations on Florida's east coast, not including sailboats, totaled 108,048 vessels in 1992-93. Of these, 95% were pleasure craft (Sargent et al. 1995).

The rapid increase in popularity of jet skis or "personal water craft" is also problematic. While these vessels are not propeller driven, the water jet removes sediment from seagrass roots and rhizomes and can cause damage. Further, these craft can operate in shallower waters and can access seagrass areas with relative ease, in addition to direct impacts to grassbeds. These machines are exceedingly loud and can create large wakes. It is reasonable to hypothesize that the audio and physical environment of shallow nursery areas may be disrupted in manners which stress postlarval life stages. The degree of stress is currently uninvestigated.

Incidences of commercial groundings are few, but where they occur on hard bottom habitats damage may be extensive and long-term. For example, groundings in the Florida Keys National Marine Sanctuary have caused extensive damage to coral reefs and signs of recovery are slow to appear.

The cumulative effect of anchor scarring in seagrass beds is not as damaging as that caused by propeller and jet powered vessels. On coral reefs, however, damage caused by anchoring of recreational boats is significant (Davis 1977). Dragging or pulling anchors

through coral beds breaks and crushes the coral, destroying the coral formation. Most reef damage of this type occurs in the Florida Keys and in nearshore waters.
The effects of vessel induced wave damage have not been quantified, but may be extensive. The most damaging aspect relates to the erosion of intertidal and SAV wetlands located adjacent to marinas, navigation channels, and boating access points such as docks, piers, and boat ramps. Wake related erosion in places along the Atlantic Intracoastal Waterway and elsewhere is readily observable and has undoubtedly converted substantial areas of emergent wetlands to less important habitat such as submerged bottom. In heavily trafficked areas bottoms may become unstable and colonization by bottom dwelling organisms may not be possible. Indirect effects may include the resuspension of sediments and contaminants that can affect EFH. Where sediments flow back into existing channels, the need for maintenance dredging, with its attendant impacts, may increase.

The introduction of exotic species by vessel operations is linked largely to the world wide movement of commercial vessels. Exotic species may be brought into the U.S. by several methods, but capture and release in ballast waters is of most concern. With the introduction of the zebra mussel into the Great Lakes and its rapid dispersal into other waters, considerable attention is being directed at this problem. According to one estimate, two million gallons of foreign ballast water are released every hour into U.S. waters (Carlton 1985). This possibly represents the largest volume of foreign organisms released on a daily basis into North American ecosystems. The introduction of exotic organisms threatens native biodiversity and could lead to changes in relative abundances of species and individuals that are of ecological and economic importance. This has already been observed in other parts of the world. While EFH has not been directly affected, recent introduction of a brown mussel into the Gulf of Mexico is of concern and is being investigated. It is anticipated that technology such as use of filters or open ocean exchange of bilge waters can be used to reduce the spread of non-native species. Considering the extent of port development and shipping along the South Atlantic, addressing this issue is of paramount importance.

6.1.1.8 Inshore Mining

Inshore mining, as a category of EFH threats, is generally confined to a few specific locations where associated effects may be substantial. Between 1981 and 1996 the NOAA Fisheries Service received only 434 of these proposals for review. Of these, 307 were from Florida and involved phosphate mining. While these activities undoubtedly have a dramatic effect on local landscapes and wetlands, the majority are well inland of most EFH locations. Where these activities occur along the coast, phosphate rock, sand, gravel, stone, and marl are generally mined. Phosphate rock is sought mostly for fertilizer production and the other materials are used mostly for fill, roadbed construction, and concrete production. The products of mining operations may eventually be transported to other locations and construction and operation of shipping facilities and navigation channels could involve EFH.

<u>Threats to EFH from Inshore Mining Activities</u>

Potential threats include conversion of wetlands to mine pits and uplands, or to reclaimed aquatic sites and uplands that lack pre-mine habitat and fishery production values; direct and/or non-point-source discharge of fill, tailings, chemicals, cooling and processing water, and surface and ground waters into streams, rivers and estuaries; hydrological modifications including those associated with ditches, dikes, water and waste lagoons, intake and discharge systems; and cumulative and synergistic effects associated with other mining and non-mining activities. Related shipping, storage, and processing facilities also can threaten EFH.

Where mining activities occur in areas identified as EFH, the local effect is often dramatic and extremely damaging. In eastern North Carolina phosphate mining has essentially eliminated an entire estuarine creek ecosystem in Beaufort County. The only phosphate mine in North Carolina is found in Beaufort County and located adjacent to the estuarine waters of Pamlico and South Rivers which are tributaries of Pamlico Sound. A 2006 proposal for continuation of mining would result in the loss of about 3,000 acres of wetlands of a variety of types, including the loss of approximately 30 acres of fresh and brackish estuarine emergent wetlands and freshwater/brackish water submerged aquatic vegetation located in the upper reaches of 5 estuarine creeks whose headwaters would be within the proposed mine expansion's footprint. Wetlands losses of this magnitude are significant on an ecosystem scale and the extent to which mitigation would offset these losses is uncertain at best. Alternative mining plans are available to the applicant that would be less damaging to wetlands and EFH; however, the company was opposed to these alternatives based on economic issues including profit margin.

In Dade and Monroe Counties, Florida, limestone removal operations have converted large areas of wetlands to open pits. The majority of these operations occur in the "Lake Belt", which is an approximately 57,515-acre area that was established by the Florida Legislature in 1997 for the purpose of implementing the Miami-Dade County Lake Belt Plan. The area lies west of Miami and east of Everglades National Park. To date, mining in the Lake Belt area has thus far converted approximately 4,900 acres of freshwater wetlands into lakes. The Clean Water Act Section 404 permits authorized by the COE require the mining industry to fund acquisition, restoration, and long-term management of lands in the Pennsuco wetlands, which is the area sandwiched between the Lake Belt and the Florida Everglades.

While most state and federal regulations require restoration of mine sites, such action is costly and often fails to produce environments that are similar in ecological character and productivity to those that were destroyed. EFH designation could further fishery management opportunities in certain locations and in the case of certain mining activities. In locations where suitable mitigation cannot be provided, the creation of new mines and expansion of existing operations may be curtailed or prohibited. Other less intrusive mining operations, such as minor removal of sand and gravel, are likely to continue, but needed environmental protection measures (e.g., seasonal work restrictions) could be specified to minimize impacts to fishery resources and prevent significant harm to EFH. However, this is not always the case as illustrated by a proposed 750 acres mineral mining project in New Hanover County, North Carolina that would adversely impact about 300 acres of tidally influenced forested wetlands located adjacent to the northeast Cape Fear River. The wetlands to be impacted and the adjacent waters in the river are designated as fish management areas by the North Carolina Division of Marine Fisheries and are therefore EFH. While approval of wetland losses of this type is unlikely, the frequency of this type of mining activity is likely to increase given the increase in development in coastal states and the need for aggregate fill for highway and commercial construction.

The construction and operation of mining-related facilities such as storage, processing, and shipping facilities and other related infrastructure such as roads, also presents a threat to EFH. Discussions found in Sections 6.1.1.6 and 6.1.1.7 address these factors.

6.1.1.9 Hydrologic Modifications

Alteration of freshwater flows into coastal marine waters, typically via the construction of canals, has changed temperature, salinity, and nutrient regimes, reduced the extent of wetlands, and degraded estuarine and nearshore marine habitats (Reddering 1988; Whitfield and Bruton 1989). The following summary is largely taken from Serafy et al. (1997). Profound changes to the south Florida ecosystem have occurred with the construction of an extensive inland and coastal canal system by the COE which began as early as 1917 (Hoffmeister 1974; Teas et al. 1976). Today, the system constitutes a 1400-mile network of canals, levees, locks and other flood control structures which modulates fresh water flow from Lake Okeechobee, the Everglades, and coastal areas. These areas, which serve as nursery areas for a wide diversity of organisms, have experienced drastic changes in both the amount of freshwater they receive, and in the fashion in which it is delivered. For example, in southern Biscayne Bay, Florida, canal locks are all that separate this occasionally hypersaline lagoon from the entirely freshwater canal systems. When the locks open, the salinity of marine waters downstream often drops 20 ppt within 60 minutes before recovering as rapidly (Wang and Cofer-Shabica 1988). This may occur several times a day and over several months, particularly during the rainy season (i.e., May to October) when water temperatures are also at maximum levels.

<u>Potential Threats to EFH from Hydrologic Modifications</u>

Most hydrologic modifications are performed with other activities that are identified as having potential to adversely impact EFH. As such, the activities involved are similar or identical to those identified in other sections. Other threats are possible with mosquito control, aquaculture, wildlife management, and flood control projects and activities. Hydrologic modification can involve entire watersheds and drainage basins for large scale water diversion projects, where silviculture and/or agriculture activities are large in scale and/or intensity, and where runoff from urban and suburban development is substantial. Threats related to hydrologic modification can involve any activity that alters water quality or the rate, duration, frequency, or volume at which water enters or moves through an aquatic system. Consequently, activities associated with industrial, urban, and suburban development (including those occurring on uplands), ditching, *draining, diking, and impounding may all qualify as hydrologic modification related threats.*

Rapid salinity fluctuations can represent a significant stress for a marine organism, depending on its osmoregulatory ability and/or its behavioral response (Serafy et al. 1997). In fishes, abrupt salinity changes can cause mineral imbalances in the blood which tends to become diluted as salinity drops, and concentrated as it rises -- either of which can be lethal (Mazeaud et al. 1977). Rectification of proper osmotic balance in response to salinity stress requires energy expenditure, often at the cost of growth, reproduction and/or resistance to other stressors, including high temperature (Moore 1972; Schreck 1990). The combination of high temperatures and low salinity pulses on marine organisms has received only limited attention (Moore 1972; Albertson 1980). Only one study has examined the combined effects of high temperature and freshwater pulses on subtropical marine fishes of the Western Atlantic. Serafy et al. (1997) combined a field survey of nearshore fishes in Biscayne Bay, Florida, with a series of laboratory-based freshwater pulse experiments. A 13-month trawl project was supplemented with high temperature - low salinity challenge experiments on eight fishes: five species that dominated canal-influenced habitats (*Eucinostomus gula*, *Lagodon rhomboides*, *Haemulon sciurus*, *Opsanus beta*, and *Lucania parva*) and three species that were less common in these areas (*Cynoscion nebulosus*, *Haemulon favolineatum*, and *Cyprinodon variegatus*). Of the five fishes that dominated the nearshore habitats, three exhibited no mortality when subjected to freshwater pulses, while *L. rhomboides* and *L. parva* exhibited 12.5% and 50% mortality rates, respectively. Mortality was 100% for the three species that were less common in habitats influenced by canals. These laboratory and field results support the hypothesis that anthropogenic changes to fresh water delivery regimes can play a partial role in determining the species compositions of nearshore fish assemblages within Biscayne Bay, Florida.

Holland et al. (1996) found that salinity was a major factor in controlling the distribution and abundance of living marine resources in South Carolina estuaries. In watersheds having the greatest areas of roofs, roads, and parking lots it was found that surface water discharges tended to be “flashier” and that recruitment and colonization by benthic fauna in these areas was less predictable than in more stable environments.

Mosquito control activities and associated threats to EFH have become better understood in recent years. Between 1996 and 2006, NOAA Fisheries Service reviewed 203 applications for mosquito control and related activities in the South Atlantic area. Although efforts to alleviate the hydrologic modifications resulting from this activity are underway (27,000 acres of reconnected impoundments in the Indian River Lagoon) much of the area altered by ditching and draining of saltmarsh throughout the east coast has not been addressed. Although tidal water still flows into most of these saltmarsh areas it flows in prescribed dredged channels and does not interact with much of the marsh surface expect through extreme high tide events. Without sheet flow of water across the marsh surface much of the ecological benefit of saltmarsh is underutilized. Some of these areas are receiving hydrological restoration but efforts have been under funded and go largely unrecognized.

6.1.1.10 Dams, Impoundments, and Other Barriers to Fish Passage

Natural river systems throughout the world have been extensively modified for a variety of societal purposes including withdrawals for irrigation, public water supplies, navigation, flood control, and hydroelectric power. Over half of the world's large river systems (172 of 292) are affected by dams constructed in the past century (Nilsson et al. 2005). Approximately 800,000 dams have altered riverine habitats worldwide, with approximately 2 major dams constructed each day for the past 50 years (World Commission on Dams 2000). In the United States the total number of dams built during 1700- present is not known with certainty. The National Inventory of Dams (FEMA and U.S. Army Corps of Engineers 1994, 1996) listed approximately 76,000 dams including those deemed to be a threat to life and property downstream, those greater than 6 feet high with more than 50 acre-feet of storage, and those 25 feet or greater in height with more than 15 acre-feet of storage. The National Research Council estimated well over 2.5 million dams existed in the United States in 1992. All of the watersheds tributary to the South Atlantic Shelf Ecosystem are highly affected by large mainstem flood control and hydropower dams and many small dams constructed for various purposes. Bush, et al. (1998) in a review of existing dam location data identified 6,944 dams in South Atlantic watersheds (North Carolina to Florida).

Thousands of wetland acres have been impounded each year in the southeast for purposes such as waterfowl habitat creation, aquaculture, agriculture, flood control, and mosquito control. Historically, large areas of wetlands were impounded in South Carolina for rice production. Projects range in size from minor, such as repair of existing embankments, to large-scale projects where constructing dikes and water- control structures may affect relatively large wetland tracts.

Numerous dams and other structures have been built on major rivers for industrial water uses, hydropower facilities, reservoirs, and as part of flood control projects. Those facilities near the coast can have an adverse effect by blocking fish passage, and modifying hydrology and sediment and nutrient flows to coastal waters. Dams affect or disrupt many natural processes including upstream and downstream movements of fish and other aquatic species, export of organic carbon, natural hydrological variability and seasonal flow patterns, seasonal temperature, dissolved oxygen and nutrient export patterns, and riverine, estuarine, and coastal geological processes (Freeman et al. 2003; World Commission on Dams 2000).

<u>Potential Threats to EFH from Dams, Impoundments, and Other Barriers to Fish Passage</u>
Direct effects of impoundments and other barriers are removal of habitat, conversion of habitat away from historic usage, alteration of hydrology, and modification of water quality by modification of temperature, salinity, and nutrient and sediment fluxes. Flow regimes often are controlled and differ substantially from pre-impoundment flows. This can adversely affect anadromous fish migration and spawning as well as food production for prey species needed by larvae and juveniles. Riverine, estuarine, and coastal marine ecosystems have evolved in synchrony with natural seasonal river flow variability and

discharge patterns. Species life cycles, reproduction, and sustainable populations may be disrupted by man-made barriers and their many effects as described previously.

Large acreages of coastal wetlands have been impounded along the southeast Atlantic. Reasons vary, but include aquaculture, waterfowl production, mosquito control, and in the Old South prior to 1912, rice production. The overall amount of impounded coastal wetlands is not known, but probably exceeds 200,000 acres. Between 1981 and 1996, the NOAA Fisheries Service reviewed 721 proposals of varying sizes that blocked or impounded EFH (Tables 26-29). A review of 190 of these projects revealed that about 7,131 acres of EFH would be adversely altered through these projects. From 1996-2006, the NOAA Fisheries Service Habitat Conservation Division received 465 applications for barriers and impoundments.

A primary biological concern for barriers and impoundments is the impact on estuarine-dependent marine fisheries production. Most impoundments are managed for resources other than fish (e.g., waterfowl). The management regimes, based largely on seasonal consideration, may exclude or severely restrict access by fish and invertebrates. This decreases habitat area and proportionately, the production of fishery resources. Even if fisheries gain access, conditions within impoundments may not be hospitable and organisms may not be able to escape and enter harvestable and reproductively active populations found in surrounding waters. Other management regimes, such as marsh burning, may adversely affect fishery resources. Water quality and nutrient outflow also may be compromised.

However, it is important to note that existing impoundments can be managed to reduce their impacts on estuarine habitat, although some impacts may remain, (e.g., blockage of ingress-egress, reduction of carbon and nutrient export). New impoundments pose a potential risk to EFH and fish production and must be carefully evaluated. However, within the South Atlantic, some positive aspects are evident related to existing impoundments. Because wetlands have been extensively damaged, these areas (especially old rice fields) provide a wealth of available habitat. Further, production of fisheries organisms within these areas is often excellent. Crab production, for example, has been shown to be high in some areas and the production of many estuarine-dependent species has been observed.

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The effects of riverine dams and impoundments on riverine and coastal ecosystem processes, habitats, and health may be profound. Ecological functions of riverine ecosystems affected by dams may be grouped into five primary components: hydrology, biology, geomorphology, water quality, and connectivity (Instream Flow Council 2002). Each of the five components is strongly linked with physical habitat structure, important nutrient and carbon cycles, and health and productivity of estuarine and coastal marine ecosystems. Explained in simplest terms, the effects of dams are manifested through the broad impact categories of habitat fragmentation and flow regulation, in addition to alteration of morphological processes.

With respect to coastal ecosystems and managed fisheries, arguably the most critical effects of dams include blockage and consequent reduction in available reproductive habitat for sea-run diadromous fishes, and large-scale alteration of the distribution and periodicity of freshwater inflows.

Diadromous fishes including shad, herring and other alosines are important components of estuarine and marine food webs. Prior to construction of dams in Atlantic river basins large annual spawning runs of shad and herring and other diadromous species supported important coastal and river fisheries. Early accounts described annual spawning runs of shad and river herring in rivers including the Potomac, Susquehanna, Roanoke, and Savannah in the tens of millions (Baird 1887) with landings in individual river basins exceeding today's total Atlantic Coast managed fishery landings by a wide margin. Baird was among the first marine scientists to suggest the relationship between diadromous fish biomass and support for stocks of other commercially important marine species. Construction of dams in Atlantic Coast river basins began soon after European colonization in the early 1700s and continued in cycles through the early 1970s (Watson 1996). Nearly all large river basins in the South Atlantic were closed to significant diadromous fish spawning runs by mainstem dams by the 1960s and 1970s. Busch et al. (1997) estimated the reduction in Atlantic Coast riverine habitats for diadromous species due to construction of dams. In the North Atlantic region (Maine to Connecticut) stream access for diadromous species has been reduced by 91%, and the corresponding reduction for the South Atlantic Region (North Carolina to Florida) is 77%. As dam construction progressed, along with unregulated exploitation and increasing pollution, the Atlantic Coast shad fishery remained one of the most economically important fisheries into the 1940s prior to construction of the last major mainstem dams after the Second World War (Hightower 1997). Today the formerly large spawning runs of shad, river herring, striped bass and sturgeon are reduced to small remnant populations or have disappeared entirely in some rivers. Because of the drastic reductions in abundance of shad and other alosine species, their importance in food web support has also diminished and may represent a significant limiting factor in recovery of some federally managed species.

The timing, duration, and frequency of river flows are critically linked to the health and function of riverine, estuarine and coastal marine ecosystems and fisheries (Taylor et al., 1990). Estuarine and coastal marine wetlands and deepwater habitats are highly dependent upon inputs of freshwater and associated nutrients and sediments from rivers (Berkamp et al. 2000). Seasonal periods of increased river discharge and consequent inflow to estuaries and coastal waters may serve as biological triggers for fish and invertebrate migrations and reproductive cycles. More prominent examples include upstream spawning movements of shad, striped bass, and sturgeon to spawning habitats in river channels; and movements of spawning blueback herring and Atlantic menhaden into floodplain forested wetlands and deepwater sloughs (Rulifson 1982; Pardue 1983; Meador 1982). Natural seasonal patterns and variations in freshwater inflows to estuarine and coastal marine habitats provide suitable salinity and nutrient conditions for reproduction and growth of oysters, blue crabs, shrimp and many estuarine-dependent species. Regulation of river flows by dams, particularly for flood control and hydropower production, may significantly alter natural patterns of river discharge to which many species life cycles have adapted during their evolutionary history. River regulation may affect seasonal salinity patterns over large areas of estuarine and coastal marine habitats. Dams with large storage capacity can reduce downstream flows during critical late winter and spring diadromous fish migrations, resulting in reduced water level and duration and areal extent of inundation, severely limiting fish production. Dams and reservoirs trap river-borne sediments, resulting in reduction of nutrient-rich sediment deposition in downstream floodplain wetlands and alluvial deltas. Resulting disruption of alluvial delta and wetland formation processes may cause large scale floodplain and wetland subsidence, adversely affecting habitat stability and productivity for estuarine and coastal marine fisheries.

Thermal stratification of large reservoirs during summer months often results in biological oxygen depletion of the cooler water of the hypolimnion, with consequent discharge of cooler water with low dissolved oxygen downstream of the dam. Fish and other aquatic life may be eliminated or adversely affected in riverine or estuarine areas downstream as far as the deoxygenation persists. Large, shallow impoundments lacking thermal stratification may result in solar warming with consequent release of water with elevated temperatures to downstream riverine and estuarine habitats. During warmer summer months, the resulting elevated water temperatures may exceed the tolerance levels for fish species adapted to naturally occurring seasonal temperature regimes. Where dams and river regulation have been in place for many years, the continuing cumulative effects of habitat fragmentation, altered flows, water temperatures, and dissolved oxygen conditions may result in shifts in aquatic species community structure and composition. Populations of federally managed diadromous, estuarine and marine species may be limited by the continuing effects of dams and river regulation.

Dams and other barriers have been constructed on almost every major southeastern river. They serve multiple purposes including hydropower production, water supply, and flood attenuation. Dams located on the Roanoke and Neuse Rivers in North Carolina, the Cooper and Santee Rivers in South Carolina and on the Savannah River on the South Carolina-Georgia border are major impediments to anadromous fish migrations, as mentioned above. Most of these structures are old and were built either before their effects on fish and other wildlife were known, or at a time when environmental concerns were of lesser importance than economic and political factors. Considering the present level of knowledge of their effect on fish migration and production, water quality, and flow alteration, it is unlikely that major new structures will be built. The present challenge is to revisit older structures to determine their usefulness and where their negative impacts outweigh their benefits, they should be removed or modified. An example is removal of the Quaker Neck Dam on the Neuse River in North Carolina. Where removal is not feasible then consideration must be given to providing for, or improving fish passage and for modifying flow regimes to mimic pre-impoundment flows. These considerations will rely on new research and improvements in fish passage technologies.

6.1.1.11 Other sources of nonpoint-source pollution

Potential Threats to EFH from Other Sources of Nonpoint Source Pollution
Potential threats include reduced water quality, erosion, increased contaminants, increased sedimentation, and disease.

The more common sources of NPS pollution include runoff from agriculture, pasture lands, silviculture, mining, and developed areas as well as erosion created from modifying rivers, streams, and shorelines. These sources have separate sections in the Fishery Ecosystem Plan. Three additional sources of NPS runoff deserve brief mention and include construction sites, marinas, and septic systems

Runoff from construction sites can be considerable sources of NPS pollution (Carpenter et al. 1998). Construction sites occupy a relatively small percentage of land surface area, but rates of erosion from these sites can be high leading to a large amount of pollution coming from these small areas. Erosion rates from watersheds under development can approach 50 times the rate from agriculture lands and 500 times the rate from areas with undisturbed plant cover. Eroded material from construction sites contributes to siltation of water bodies as well as eutrophication. Best management practices for controlling runoff from construction sites are well known and should be followed to avoid impacting fishery resources.

Understanding NPS pollution associated with marinas can be difficult because marinas can be both a source of pollutants generated by activities occurring within the marina as well as the place where pollutants generated elsewhere collect (Flory 2005; USEPA 2001). Construction of the basins, docks, jetties, and bulkheads needed for marina operations typically reduce water circulation, and this reduced circulation promotes the settling of fine sediments that often have organic material, metals, or other pollutants attached to them. These materials concentrate in marina sediments and, at times, also can concentrate in marina waters. The pollutants that might be generated at a marina or accumulate within a marina basin include nutrients and pathogens (from pet waste and overboard sewage discharge), sediments (from parking lot runoff and shoreline erosion), fish waste (from dockside fish cleaning), petroleum hydrocarbons (from fuel and oil drippings and spills and from solvents), toxic metals (from antifouling agents and debris from boat maintenance), and liquid and solid wastes (from engine and hull maintenance and general marina activities).

Many contaminants generated from boat maintenance and general marina use (e.g., oil and grease drippings from cars) are insoluble in water. In the slow flowing, protected waters of the marina, the fine particles that these materials adhere to settle and accumulate in the sediments. While these sediments may then release their contaminants into the water in response to physical disturbance (such as dredging, propeller wash, or storms) or from changes in water chemistry (such as pH or dissolved oxygen concentration), effects upon benthic organisms and fishery resources are of greatest concern. Most benthic organisms either burrow into the sediment or feed by sorting through large volumes of sediment in search of prey items or detritus. Both behaviors bring benthic organisms into close contract with any contaminants that may be present and these contaminants can then accumulate in the bodies of the benthic animals. Fishery species that feed upon these benthic organisms are then exposed to concentrated doses of the contaminants, which may reduce the health or reproduction of the fishery individuals or make them unsuitable for consumption by humans.

Pollutants from marinas can cause pollution problems in the water column. These problems usually take the form of decreased levels of dissolved oxygen and increased levels of metals and petroleum hydrocarbons. Pollutants that cause these problems get into the water through storm water runoff, discharges from boats, and spills of fuel or bilge water. Low levels of dissolved oxygen can be a problem any place where organic material accumulates. The decay of organic material consumes oxygen from surrounding water. If the low circulation promotes accumulation of organic material while at the same time hindering exchange with oxygen-laden waters outside the marina, the result can be insufficient oxygen for fishery species.

In addition to pollutants that reduce the quality of sediment or the water, marinas often are associated with silt that can impair seagrass, oyster, or other habitats that support fishery resources. Increased boat traffic within and near a marina can erode shoals and the shoreline suspending large amounts of sediment into the water that fall upon fishery habitats. Waves generated by boat wakes can wash away seagrass that is loosely rooted in sediments and the benthic organism living at the sediment surface.

NPS pollution associated with marinas can be reduced by ensuring marinas are designed to flush regularly with adjacent waters; locating marinas close to tidal inlets and away from the headwaters of tidal creeks is part of these design decisions. Shorelines should be vegetated to reduce erosion. Stormwater runoff can be controlled by well designed and maintained stormwater management systems. Marina fueling and sewage collection stations should be maintained and designed to make cleanup of spills easier.

Septic systems include the underground system of pipes and tanks designed to use naturally occurring bacteria and microorganisms to treat bathroom, kitchen and laundry wastewater. In older homes, a septic system may be little more than a cesspool and a pipe that connects the cesspool to the house. In newer homes, a septic system usually includes a septic tank, distribution box, drain field, and pipes that connect these elements. Passing sewage and household wastewater through a septic system protects the environment from contamination. Microorganisms and insects living within the drain field help decontaminate waste materials by consuming leftover waste particles. Improperly maintained septic systems can allow nutrients and pathogens to enter ground waters and surface waters that flow into coastal ecosystems. The excess nutrients can lead to eutrophication and low levels of dissolved oxygen, both of which can impair habitats used by fishery species. The pathogens can spread disease that reduce the health of fishery species.

NPS pollution from septic systems can be reduced by ensuring the systems are inspected annually and pumped regularly. Pumping out every three to five years is recommended for a three-bedroom house with a 1,000-gallon tank; smaller tanks should be pumped more often. Storm drains should not be diverted into septic systems because the extra load on the systems will overwhelm its ability to process nutrients and eliminate pathogens. Any measure that decreases water use within a home can help a septic system protect coastal water quality by reducing the likelihood of overflow from the system.

6.1.1.12 Non-native or nuisance species

Update on Aquatic Invasive Species Management in the Southeast-March 2008
Marilyn Barrett-O'Leary Southeast Aquatic Resources Partnership (SARP)

Aquatic invasive species are a part of fisheries and wildlife management in all of the Southeast Aquatic Resources Partnership (SARP) states. Many of the states manage specific species cooperatively, but we do not have comprehensive regional management. For example, Texas and Louisiana partnered with some federal agencies to bring massive chemical control to reduce a giant salvinia infestation on Caddo Lake, a popular angling lake on the two states' shared border. Florida, a state with better funding resources than many of its neighbors, routinely shares research results and outreach products (on many invasive plants and animals) to promote regional control. All of the states are members of at least one regional Aquatic Invasive Species (ANS) panel, providing biannual meetings to share information and committees to work on problems regionally.

Every SARP state has developed an ANS management plan. Most have completed that process, which involves forming a task force, gathering information, identifying overlapping jurisdictions, setting priorities, and devising action plans. Most important, these activities lead to governor's buy in and signature, interagency agreements such as MOUs, and continuation of the task force in some form to facilitate management. As of this date, every SARP state has at least one agency person with ANS as part of his/her scope of work. Some have individuals with ANS as his/her exclusive scope of work. The states of Louisiana, Texas, Florida, Virginia and Missouri have officially accepted plans. Kentucky, South Carolina, Alabama, Tennessee and Mississippi are in the final, official stages of seeking national acceptance of their plans. They have effectively identified the problem and are already integrating solutions into their agency activities. Oklahoma, Georgia, North Carolina, and Arkansas are still developing their plans. Both

Georgia and North Carolina are developing plans that combine management of terrestrial and aquatic invasive species. All states are aware of the need to work in that direction. All of these states face similar issues. Below are a few of them:

1. Invasive species are not all bad or all good – they may cause problems in certain circumstances but actually benefit certain groups or situations. Management (treatment, regulation, education) requires ecological and economic evaluation on local, regional, and national levels and cooperation among state, local, and federal agencies.

2. Invasive species almost always alter the ecosystem; they seldom simply slip into an unfilled niche. They thrive in disturbed systems. Therefore, ecological management can contribute to invasive species prevention and control. Unfortunately, states are not funded or equipped to manage all state waters at that level, and every state has many water bodies that are managed privately or by federal agencies.

3. The general population has only fleeting knowledge of this problem, and often, unwittingly, contributes to it. Consistent, continuous education is needed over the long term. SARP agencies are trying to educate one of the most involved segments of the population – the recreational fisher – to clean off boats before leaving the dock, place unused live bait into the trash rather than dumping it into the water, and to refrain from moving live fishes in an attempt to 'stock' for certain fish. Similar, targeted education efforts need to be made towards many other population segments. Tax dollars need to be earmarked for this management.

6.1.2 Marine/offshore processes

6.1.2.1 Navigation

Offshore maintenance dredging for navigation is mainly limited to inlet bar channels and other port entrances; (e.g., Port Canaveral, Florida). The sediments are typically coarse and the bottom communities are low diversity reflecting the dynamic nature of these areas. Bottom organisms occupying this zone are generally sparse and adapted to the dynamic nature of the habitat they occupy. As such, dredging in these locations generally does not pose the same magnitude or type of impact incurred when working in nearshore environments. The same is true for vessel operations, although to some degree the problems discussed in Section 4.1.1.6 also apply. Vessel operation impacts are mainly linked to sinking, grounding, routine disposal trash and wastes, and the accidental release or spillage of cargo and fuel.

However, offshore new dredging, namely widening and deepening existing port entrance channels to accommodate super-carriers, i.e., Post-Panamax vessels an impact complex hard bottom communities along channel walls in addition to reef trends. For example, the Jacksonville District COE in conjunction with Port Everglades is presently completing a feasibility study in part to evaluate the widening and deepening of the Port Everglades Outer Entrance Channel. The project could impact offshore marine habitats, including hard bottom and coral reef communities located offshore Fort Lauderdale, Florida (Broward County). In total, 11.9 acres of hard bottom habitat on the outer reef (Reef 3) may be removed during construction (COE 2006).

Potential Threats to EFH from Navigation

Potential threats include excavation and burial of EFH in connection with creation, expansion and maintenance of navigation channels; elevation of turbidity and resuspension of toxic and harmful components of dredged materials (includes material that cause elevated sediment and dissolved oxygen demands); interruption of coastal sand movement and sub-adult fish migration through construction of channel stabilization structures such as jetties; potentially harmful vessel operations such as discharge or spillage of fuel, oil, grease, paints, solvents, trash, and cargo; grounding/sinking/prop scaring in ecologically/environmentally sensitive locations; exacerbation of shoreline erosion due to wakes; and transfer and introduction of exotic and harmful organisms through ballast water discharge.

With a few exceptions, offshore dredging is performed using hopper dredges. Hopper dredges generally dump accumulated material through a split hull; however, the use of these dredges in connection with pipelines and vessel pump out is becoming more commonplace, especially where sand is needed for beach fill. Closer inshore, sidecast dredges may be used where wave amplitude is slight and dredging volumes are relatively minor. In protected waters pipeline dredges are almost always used since they provide the most effective and efficient means for removing and redepositing bottom sediments. On rare occasion, as in the case of the Cape Canaveral Ship Channel, pipeline dredges may be used in open waters but their vulnerability to wave damage generally precludes this. Bucket dredges and scows are employed in some locations, but such use is usually limited to situations where other dredges cannot operate due to water depth and pumping distances (for pipeline dredges).

In connection with offshore waters, threats to EFH are most significant in terms of possible burial of benthic communities in the vicinity of dump sites and in connection with turbidity from dumped materials. Contamination of the water column and bottoms is also possible if the dredged material is contaminated. Sediments may also be re-dispersed after being dumped in offshore sites and burial of productive bottoms is possible. On occasion, designated dump sites are not adequately studied or they change and high quality benthic habitat may be damaged or destroyed.

Although most ports are located in estuarine waters, navigation related threats can also be severe in offshore waters. As the shipping industry moves towards super containerships, the many eastern seaboard ports are evaluating the need to widen and deepen offshore entrance channels. Currently, only a limited number of ports can accommodate Post-Panamax vessels. The Port of New York/New Jersey is the only port along the Atlantic seaboard that is undergoing expansion work to support super-carriers.

Additional threats to EFH from offshore navigation occur through the overboard disposal of trash, cargo, and wastewater from ocean going vessels, and disposal of dredged

material (see Section 7.4.2.1). Although comparisons are unavailable, it is likely that most vessel-related disposal occurs on the open ocean, rather than in estuarine and nearshore waters where such activities are likely to be observed.
Within Florida waters, particularly in the Florida Keys and Fort Lauderdale, vessel groundings represent a chronic threat to live coral habitat. Anchoring is also a problem, however, it has become less of a threat through wide spread use of single point mooring buoy systems. Vessel groundings can be broken into two broad categories: large vessel and ship groundings that often result in severe injury to live coral colonies and non-living reef framework; and small recreational boat groundings that result in numerous strikes to individual coral colonies in both inshore and offshore areas. Large vessel and ship groundings occur infrequently, but result in far more significant injury to coral reefs and other habitat types. Recreational boat groundings are much more frequent. Between 1993 and 1997, 2089 groundings were reported in the Florida Keys National Marine Sanctuary. Many more are likely unreported.

Table 6.1-1 Reported Vessel Groundings* in Florida Keys National Marine Sanctuary (FKNMS) 1993 to 1997.

Year	Total Reported Vessel Groundings
1993	280
1994	550
1995**	400
1996**	399
1997**	460
Total	2089

*Data from FKNMS & Florida Marine Patrol Computer Assisted Dispatch Report
** Grounding data for 1995 through 1997 are incomplete and require further data analysis.
Note: The above numbers do not represent coral reef groundings alone. Reported groundings occur in all types of habitats found in the FKNMS.

Accurate baseline data for live coral coverage exist mainly for reefs in the Florida Keys but not for the remaining habitat that contains stony corals that do not form reefs. In some cases though, sufficient data are available to allow calculation of the actual extent of a grounding incident. For example, on August 10, 1994, the R/V *Columbus Iselin*, a 154-foot research vessel, was conducting survey work for the University of Miami when it struck Looe Key, a spur and groove reef. Approximately 345 square meters of living coral and 338 square meters of non-living coral reef framework were destroyed.

Injuries to coral from groundings take several forms and include crushing, splitting and fragmentation, dislodging colonies, and depending on the severity of the incident, sedimentation and/or burial. In general, groundings occur on or near the reef crest where coral formations are closest to the water surface. Species commonly injured in the reef crest include elkhorn coral (*Acropora palmata*), staghorn coral (*A. cervicornis*), fire coral (*Millepora complanata*), starlet coral (*Siderastrea siderea*), mustard hill coral (*Porites astreoides*), and knobby zoanthidean (*Palythoa mammillosa*). Species that inhabit deeper areas such as brain coral (*Diploria strigosa*), star coral (*Montastrea annularis*), and large star coral (*Montastrea cavernosa*) are at risk from deep draft vessels. Small individual groundings may recover over time, but the loss of live coral coverage is likely to take decades. Catastrophic groundings involving large ships or freighters may never fully recover.

Since 1994, there have been at least 10 reported large-scale groundings near the existing anchorage off Port Everglades (in Florida) that have collectively damaged over 3 acres of coral reef habitat. The existing shallow water anchorage is located between two lines of reef. Dozens of undocumented anchor and anchor chain drag impacts have also occurred damaging an undetermined amount of reef. The U.S. Coast Guard has proposed anchorage rulemaking to revise the existing anchorage locations to strengthen existing anchoring requirements and guidelines in order to provide a higher degree of protection to the reef resources.

6.1.2.2 Dumping

Dredged material disposal in ocean waters generally involves disposal of sediments dredged from inshore areas such as port facilities. Where navigation approaches from offshore and inlets are involved these materials may also be placed in offshore sites. Most of the sediments taken from inshore areas are fine, contain some degree of contamination, and produce at least short-term impacts such as turbidity plumes when removed or deposited. The overall effects of dumping on or near EFH can range from immeasurable to significant and are not well studied. Therefore, dredging and disposal are typically evaluated on a case-by-case basis. The SAFMC policy on dumping provides additional detail on the subject. The principal authority for designating ocean disposal sites for placement of dredged material is the Regional Administrator of the EPA. The EPA develops and publishes Environmental Impact Statements (EIS) and the rule making paperwork for ocean dredged material disposal site (ODMDS) designations. Corps of Engineer Districts provides the EPA with the necessary information to prepare the EIS and to identify significant issues to be addressed in the site designation process. Information required from the Districts includes: zone or siting feasibility data, justification for the need for ocean disposal, and alternatives to ocean disposal. The purpose of the EPA site designation process is to establish sites that minimize impacts to the environment, economize disposal site management and monitoring activities, and support multiple users (C. McArthur personal communication).

Under provisions of the Marine Protection Research and Sanctuaries Act (MPRSA), ocean disposal of hazardous and toxic materials, other than dredged materials, is prohibited by U.S. flag vessels and by all vessels operating in the U.S. territorial sea and contiguous zone. The EPA may issue emergency permits for industrial waste dumping into ocean waters if an unacceptable human health risk exists and no other alternative is feasible. The MPRSA assigns responsibility the ocean disposal of dredged material to the EPA and the COE. This involves designating ocean sites for disposal of dredged material; issuing permits for the transportation and disposal of the dredged material; regulating times, rates, and methods of disposal and the quantity and type of dredged material that may be dumped; developing and implementing effective monitoring programs for the sites; and evaluating the effect of dredged material disposed at the sites (C. McArthur, personal communication).

To date, offshore ocean dumping sites have been approved for ports at Wilmington, North Carolina; Brunswick and Savannah, Georgia; Georgetown, Charleston and Port Royal, South Carolina; and Miami, Palm Beach, Port Everglades, Fort Pierce, Jacksonville, and Fernandina Beach, Florida (C. McArthur, personal communication). The COE has identified Jacksonville Harbor as possibly needing a new or expanded ODMDS.

Table 6.1-2 Region IV of the U.S. Environmental Protection Agency identifies the following concerns in connection with existing South Atlantic Ocean Dredged Material Disposal Sites (ODMDS):

Ocean Dredged Material Disposal Site	Site Specific Concerns
Charleston, SC ODMDS	Live bottom areas proximal to the site subject to possible impact.
Miami, FL ODMDS	Effect of disposal plumes on nearshore coral reefs are under investigation.
Port Everglades, FL ODMDS	Burial of deepwater hard bottoms and shelf edge zones that support managed species. Conversion of sediment type could affect tilefish burrows. Possible presence of deepwater corals (e.g. *Oculina varicosa*).
Palm Beach, FL ODMDS	Burial of deepwater hard bottoms and shelf edge zones that support managed species. Conversion of sediment type could affect tilefish burrows. Possible presence of deepwater corals (e.g. *Oculina varicosa*).
Fort Pierce, FL ODMDS	Offsite transport of disposed dredged material and subsequent burial of nearby hard bottom communities is of concern to local community.
Jacksonville, FL ODMDS	Lies within Northern Right Whale Critical Habitat and site may be undersized.
Fernandina, FL ODMDS	Lies within Northern Right Whale Critical Habitat.
Brunswick, GA ODMDS	Lies within Northern Right Whale Critical Habitat.
Wilmington, NC ODMDS	Wood debris in dredged material suspected of

	migrating off site into shrimping grounds.

Dumping of trash, wastewater, and unwanted cargo is more likely to occur on the open seas since it is less observable here than in inshore waters. Prior to passage of the Marine Plastic Pollution Research and Control Act (MPPRCA) of 1987 (PL 100-220), an estimated 14 billion lbs of garbage were being dumped into the ocean each year. More than 85% was believed to have come from the world's shipping fleet in the form of cargo-related wastes. See section 6.1.2.2.3 below.

Potential Threats to EFH from Dumping

Potential threats include burial of habitats and their flora and fauna, introduction of contaminants and toxic substances into waters and substrates, increased and harmful turbidity levels, and creation of hazards to fishing and navigation.

Threats associated with ocean dumping sites include covering of live bottom or hard bottom areas in or near a dump site; disposal of fish processing wastes; converting the sediment type in areas that support tilefish; impacts to nearshore coral reefs and live bottoms by disposal plumes; offsite transport of disposed dredged material and subsequent burial of nearby hard bottom communities; designated sites that are too small to handle the load; migration of debris (e.g., wood) to fishing grounds; derelict vessel disposal; and the location of dumping sites within critical habitat of endangered species such as the northern right whale.

Because monitoring of disposal activities is sometimes inadequate, there are reports of dredged material dumping outside of designated dump sites (short dumping). One recent example of a possible short dumping event involves the excavation associated with the Fort Pierce Harbor, Florida, expansion project. In this case, over 400,000 cubic yards of dredged material from this project was dumped at a mid-shelf site. Numerous complaints arose thereafter from fisherman and divers that the fill was short-dumped and large areas of reef habitat had been covered. These sites had previously served as productive snapper/grouper fishing locations. EPA Region IV undertook a number of studies into this issue. EPA monitoring reports are available at http://www.epa.gov/region4/water/oceans/sites.htm#ftpierce. Reed (1996) summarizes information available at the time regarding the mud deposits potentially derived from this event.

Another documented example of dumping occurring outside the designated ODMDS occurred during the Charleston Harbor Deepening Project. A total of 53 documented incidents of unauthorized disposal activity outside the ODMDS were reported subsequent to dredging for the Charleston Harbor Deepening Project. The unauthorized dumps were first detected during a routine assessment of the ODMDS and surrounding area using side scan sonar (Jutte et al. 2001). The documented dumps placed large quantities of mud and clay on sandy bottom habitat, with some located very near hard bottom reef habitat. Subsequent surveys over a four year period to determine whether movement of material from these sites or the ODMDS was having an adverse impact on nearby reef habitats did not identify clear loss of habitat with the exception of one site located closest to the ODMDS. The abundance finfish and large sessile invertebrates, such as sponges and corals also did not appear to be adversely affected during the survey period (Crowe et al. 2006).

In areas that have been suspect of short-dumping, such as the ODMDS located offshore the Port of Miami, the EPA Region IV and NOAA Fisheries Service habitat office have developed additional permit conditions that include:
1. The permittee shall use an electronic positioning system to navigate to and from the ODMDS;
2. The permittee shall certify the accuracy of the electronic positioning system proposed for use during disposal operations at the ODMDS;
3. The permittee shall not allow any water or dredged material placed in a hopper dredge or disposal barge or scow to flow over the sides or leak from such vessels during transportation to the ODMDS;
4. A disposal operations inspector and/or the captain of any tug boat, hopper dredge, or other vessel used to transport dredged material to ODMDS shall ensure compliance with disposal operation conditions defined in this permit;
5. If the disposal operations inspector or the captain detects a violation, he or she shall immediately report the violation to the relevant county Seaport Department, the Corps of Engineers District, and to NOAA Fisheries Service;
6. When dredged material is disposed, no portion of the hopper dredge or disposal barge or scow shall be farther than 500 feet of the center of the ODMDS;
7. The permittee shall use an automated disposal verification system that will continuously track (1 minute intervals) the horizontal location and draft condition of the disposal vessel (hopper dredge or disposal barge or scow) to and from the ODMDS;
8. The required digitally recorded data should include: date, time, vessel name, dump number, beginning and ending coordinates of the dredging area for each load, location at points of initiation and completion of disposal, description of material disposed (rock rubble, sand, clay or silt), volume of load, and disposal technique;
9. The permittee shall conduct a bathymetric survey of the ODMDS within 30 days following project completion;
10. The number and length of the survey transects shall be sufficient to encompass the ODMDS and a 0.25 nautical mile wide area around the site. The transects shall be spaced at 500_foot intervals or less;
11. Vertical accuracy of the survey shall be ±0.5 feet; and
12. At the dredge site, barges must be either lashed to dredges or cables must be floated to avoid impact to submerged resources.

Similarly, at the Charleston ODMDS site a number of constraints similar to those used in Miami were adopted, and it also included limiting the barge traffic to areas that were outside know hard bottom habitat.

Even with the use of approved practices and disposal sites, ocean disposal of dredged materials is expected to cause environmental harm since contaminants will continue to be released, productive bottoms will still be buried, and localized turbidity plumes and reduced oxygen zones will persist. Further, analyses are needed for use in dump site designation. For example, there have already been observed cases (e.g., at Charleston) where dump sites were designated and then, after dumping had been initiated, it was determined that valuable hard bottom habitats were located in or near the dump site. However, at the Charleston Harbor site, while it was determined that valuable hard bottom habitat is located adjacent to the dump site, monitoring has confirmed that construction of a berm along the edges of the disposal site is containing the majority of the dredged material, with the exception of occasional missed targeting and these are generally in the vicinity of the adjacent channel from which the vessel is traversing.

The effects of new disposal techniques such as creation of nearshore berms and “beneficial uses” of dredged material such as creation of shallow water habitats and emergent wetlands are, in many cases, unclear and may cause long-term geomorphological and ecological change that is harmful to certain species and environments. In the Charleston ODMDS, the deepening project included the construction of large berms along the border of the ODMDS that were composed primarily of cooper-marl material that would stay in place. The logic for constructing these berms was to inhibit significant movement of the disposed material within the ODMDS to sensitive bottom habitats located nearby. This effort appeared to be successful based on subsequent monitoring activities (Crowe et al. 2006). The SAFMC recognizes offshore berm construction as a disposal activity. As such, its policies regarding disposal of dredged materials apply. The SAFMC also recommends that research should be conducted to quantify larval fish and crustacean transport and use of inlets prior to any consideration of placement of underwater berms. Until the impacts of berm creation in inlet areas on larval fish and crustacean transport are determined, the SAFMC recommends that disposal activities should be confined to an approved ODMDS. The SAFMC further believes that new offshore and near shore underwater berm creation activities should be reviewed under the most rigorous criteria and on a case-by-case basis.

In the absence of MPRSA and MPPRCA repeal or weakening, major dumping threats to EFH within federal waters should be limited mostly to illegal dumping and accidental disposal of material in unapproved locations. However, many agencies lack sufficient staff and funds to carry out mandated responsibilities and the opportunity for illegal and accidental dumping may be substantial. The effect of insufficient monitoring and enforcement is evident by the tons of debris, sometimes including hazardous materials such as syringes and medical wastes that are deposited along the nation’s beaches every year.

As noted in Section 7.4.2.1 the SAFMC has developed Policies for disposal of dredged material in waters under its jurisdiction. With regard to use of ODMDSs, the policy provides that:

- The ODMDS should be designated or re-designated so as to avoid the loss of live or hardbottom habitat and minimize impacts to all living marine resources.

- Notwithstanding the fluid nature of the marine environment, all impacts from the disposal activities should be contained within the designated perimeter of the ODMDS.
- The final designation of the ODMDS should be contingent upon the development of suitable management plans and a demonstrated ability to implement and enforce that plan.
- The Council encourages EPA to press for the implementation of such management plans for all designated ODMDSs.
- All activities within the ODMDS are required to be consistent with the approved management plan for the site. The Council's Habitat and Environmental Protection Advisory Panel when requested by the Council will review such management plans and forward comment to the Council. The Council may review the plans and recommendations received from the advisory sub-panel and comment to the appropriate agency.
- ODMDS management plans should specify those entities/ agencies which may use the ODMDS, such as port authorities, the U.S. Navy, the Corps of Engineers, etc. Other potential users of the ODMDS should be acknowledged and the feasibility of their using the ODMDS site should be assessed in the management plan.
- Feasibility studies of dredge disposal options should acknowledge and incorporate the ODMDS in the larger analysis of dredge disposal sites within an entire basin or project. For example, Corps of Engineers' analyses of existing and potential dredge disposal sites for harbor maintenance projects should incorporate the ODMDS as part of the overall analysis of dredge disposal sites.

6.1.2.3 Marine Debris

One of the more conspicuous byproducts of commercial and recreational boating activities in coastal environments is the discharge of marine debris, trash, and organic wastes into coastal waters, beaches, intertidal flats, and vegetated wetlands. The debris ranges in size from microscopic plastic particles (Carpenter et al. 1972), to mile-long pieces of drift net, discarded plastic bottles, bags, aluminum cans, etc. In laboratory studies, Hoss and Settle (1990) demonstrated that larvae of estuarine-dependent fishes including Atlantic menhaden, spot, mullet, pinfish, and flounder consume polystyrene microspheres. Investigations have also found plastic debris in the guts of adult tuna, striped bass, and dolphin (Manooch 1973; Manooch and Mason 1983). Based on the review of scientific literature on the ingestion of plastics by marine fish, Hoss and Settle (1990) conclude that the problem is pervasive. Most media attention given to marine debris and sea life has focused on threatened and endangered marine mammals and turtles, and on birds. In these cases, the animals become entangled in netting or fishing line, or ingest plastic bags or other materials. Recently, a 35-foot- long sperm whale stranded and died in North Carolina due to ingestion of a plastic float, plastic jugs, a large piece of rubber, 50 feet of nylon rope, and a large plastic bag (D. Engel, personal communication).

The production of plastic resin in the U.S. increased from 6.3 billion lbs in 1960 to 47.9 billion lbs in 1985. The increased production, utilization, and subsequent disposal of petro-chemical compounds known as plastics has created a serious problem of persistent marine debris. Marine ecosystems have, over the years, become the final resting place for a variety of plastics originating from many ocean and land-based sources including the petroleum industry, plastic manufacturing and processing activities, sewage disposal, and littering by the general public and government entities (commercial fishing industry, merchant shipping vessels, the U.S. Navy, passenger ships, and recreational vessels) (Department of Commerce 1988c).

Effective January 1, 1989, the disposal of plastic into the ocean is regulated under the Plastic Pollution Research and Control Act of 1987, implementing MARPOL Annex V. Recognizing worldwide concern for preservation of our oceanic ecosystems, the Act prohibits all vessels, including commercial and recreational fishing vessels, from discharging plastics in U.S. waters and severely limits the discharge of other types of refuse at sea. This legislation also requires ports and terminals receiving these vessels to provide adequate facilities for in-port disposal of non-degradable refuse, as defined in the Act.

The utilization of plastics to replace many items previously made of natural materials in commercial fishing operations has increased dramatically. The unanticipated secondary impact of this widespread use of plastics is the creation of persistent marine debris. Commercial fishing vessels have historically contributed plastics to the marine environment through the common practice of dumping garbage at sea before returning to port and the discarding of spent gear such as lines, traps, nets, buoys, floats, and ropes. Two types of nets are routinely lost or discarded drift gill nets and trawl nets (Department of Commerce 1988c). These nets are durable and may entangle marine mammals and endangered species as they continue to fish or when lost or discarded.

An estimated 16 million recreational boaters utilize the coastal waters of the United States (Department of Commerce 1988c). Disposal of spent fishing gear (e.g. monofilament fishing line), plastic bags, tampon applicators, six pack yokes, styrofoam coolers, cups and beverage containers, etc. is a significant source of plastic entering the marine environment.

In the mid 1970s, the National Academy of Science (NAS) estimated that approximately 14 billion lbs of garbage was disposed of annually into the world's oceans. Approximately 85% of total trash is produced from merchant vessels, with 0.7% of that total, or eight million lbs annually being plastic. The use of plastics has risen dramatically since the NAS study. In 1987, 20% of all food packaging was plastic and by the year 2000 this figure was expected to rise to 40% (CEE 1987).

The main contribution of plastic to the marine environment from cruise ships is the disposal of domestic garbage at sea. Ships operating today carry between 200 and 1,000 passengers and dispose of approximately 62 million lbs of garbage annually, of which a portion is plastics (CEE 1987).

The U.S. Navy operates approximately 600 vessels worldwide, carrying about 285,000 personnel and discharging nearly four tons of plastic refuse into the ocean daily (Department of Commerce 1988a). The U.S. Coast Guard and NOAA operate 226 vessels which carry nearly 9,000 personnel annually and have internal operating orders prohibiting the disposal of plastic at sea. MARPOL Annex V does not apply to public vessels although the Plastic Pollution Research Control Act of 1987 requires all Federal agencies to come into compliance by 1994 (CEE 1987).

6.1.2.4 Offshore Sand and Mineral Mining and Beach Fill

To date, offshore mining for minerals has not been a significant issue in the South Atlantic region (oil and gas mining is discussed separately). However, several pending proposals are under regulatory consideration. Earlier consideration of mining for manganese nodules and removal of useable materials and metals from seawater have not materialized, probably due to market conditions. Recent discovery of large phosphate deposits in waters off North Carolina could eventually lead to requests to mine these deposits. As readily available upland sources of minerals and other materials are depleted, the extraction of marine deposits will become more feasible and likely to occur. The mining of sand for beach nourishment presents a large, complex, and politically charged threat to EFH in the southeast. Between 1981 and 1996, the NOAA Fisheries Service reviewed more than 200 dredge proposals to nourish beaches. Between 1996 and 2006, NOAA Fisheries Service reviewed an additional 312 dredge proposals to nourish beaches. Most of these projects are large in scope and affect miles of coastline and nearshore habitats. Where sand is removed from nearshore environments, channels, and inlets, additional EFH alteration is possible due to a number of factors such as down drift erosion and removal of materials that eventually nourish shallow waters located behind barrier islands. A survey of 120 of the more than 200 beach nourishment projects received by the NOAA Fisheries Service showed that about 5,735 acres of aquatic sites were subject to excavation and filling.

The Federal Outer Continental Shelf (OCS) contains large sand deposits that MMS anticipates could serve as long-term sources of borrow material for beach nourishment projects. In the last few years, the potential for exploitation of these resources has rapidly grown with identification of suitable sand resource areas in some OCS regions. At the same time, the demand for high quality sand suitable for beach nourishment, coastal protection, and other public and private projects is anticipated to increase during coming years (Hammer et al. 2004). However, the SAFMC is concerned that excavation of the offshore shoals could have significant adverse consequences to the shoreline and living marine resources.

<u>Potential Threats to EFH from Offshore Sand and Mineral Mining</u>

Potential threats include: removal of substrates that provide habitat for fish and invertebrates; creation (or conversion) of habitats to less productive or uninhabitable sites such as anoxic holes or silt bottom; burial of productive habitats in the vicinity of the mine site or in nearshore disposal sites (as in beach nourishment); release of harmful *or toxic materials either with actual mining, or in connection with machinery and materials used for mining; creation of harmful turbidity levels; and modification of hydrologic conditions that cause erosion of desirable habitats.*

Offshore mining of sand for beach nourishment has steadily increased along the South Atlantic coast. Presently, sand mining and beach nourishment activities are performed along the entire South Atlantic coast from North Carolina to Florida. Major projects include those at Wrightsville Beach, North Carolina; Myrtle Beach and Folly Beach in South Carolina; and many of Florida's beaches such as Palm Beach, Boca Raton, Fort Lauderdale and Miami Beach. Large-scale beach nourishment has also been performed at Tybee Island in Georgia; however, the material for that project was obtained from the Savannah Harbor deepening project. In addition to the larger projects that can involve millions of cubic yards of material, a substantial number of smaller projects involving beach scraping and removal of nearshore and inlet sand deposits are performed annually. While most of the larger projects are publicly funded and performed by the COE, many of these smaller projects are paid for with local revenues and/or private funds.

Although some of the environmental effects of sand mining and beach nourishment are documented there is much that is not known or studied (National Research Council 1995). NOAA Fisheries Service and the FWS began raising questions over related effects as long as twenty years ago. In North Carolina and South Carolina concern over nearshore populations of mole crab (*Emerita talpoida*) and donax (*Donax spp.*) was raised with several projects. Although frequently requested, no long term studies on impacts to these and other beach fauna were ever performed. The fate of these species, from a population perspective, is of concern since they are important food items for transitory and resident fishes (e.g., Florida pompano, kingfishes, and spot) that are of economic and recreational importance (Hackney et al. 1996). Limited studies performed by Reilly and Bellis (1978) showed significant reductions in occurrence and biomass of mole crabs and Donax at nourished beaches. Considering that many miles of southeastern beach front are now filled and/or subjected to scraping and sand relocation each year the cumulative effect of this activity could be substantial. Reviews of numerous beach nourishment projects suggest that the overall infaunal communities recover relatively rapidly (months to less than 1yr) although some species may remain adversely affected (NRC 1995). Much depends on the compatibility of the material placed on the beach relative to what was present prior to the project.

In Florida, beach nourishment projects require the dredging and filling of millions of cubic yards of fine sediments among shallow cross-shelf habitats, repetition or these activities at 3-10 year intervals, and tens of millions of dollars in annual expenditures (ACOE 1996). A U.S. Fish and Wildlife report (2004) prepared pursuant to Resolution 4 from the 8th Coral Reef Task Force meeting held on October 2-3, 2002, in San Juan, Puerto Rico, concluded that projects involving filling and dredging for beach nourishment and port development have caused the most impacts to coral reef habitats in southeast Florida since 1985. Among mid-shelf sand plains, often having nearby reef habitats, dredges create large craters and increased turbidity. At both dredge and fill sites, acres of shallow water hard bottom, worm reef, seagrass, or other habitats can be directly buried or subjected to elevated turbidity. Nearshore reefs buried or indirectly affected by dredging in south and central Florida can be utilized by over 325 invertebrate species (Nelson 1989), 190 fish species, and serve as nursery habitats for many managed species (Lindeman et al. 2000). The timing of burial and anthropogenic turbidity spikes may have important effects upon the recruitment of settlement-stage fishes and invertebrates. Early spring through early fall dredge related burial of hard bottom may eliminate habitat required by larvae of many marine organisms during peak recruitment periods (Hackney et al. 1996; Lindeman and Snyder 1999).

Based primarily on summary tabulations of data for southeast Florida within ACOE (1996), Lindeman (1997) estimates that:

- At least 47 large-scale offshore dredge and inshore fill projects have occurred since 1960.
- Approximately 97 additional large-scale dredge projects are conservatively planned to occur between 1997 and 2046.
- Over 48,000,000 cubic yards of offshore sediments have been dumped within an intertidal/subtidal corridor of approximately 500 feet x 110 miles in the last 36 years.
- Over 80,000,000 additional cubic yards of excavated offshore material may be dumped within the same corridor of subtropical southeast Florida in the next 50 years.

Long-term estimates of mean turbidity values under natural conditions are not available for most areas. Therefore, the percentages of affected animals and algae that can tolerate repetitious (e.g., 2 to 4 hours to 4 to 6 times a day for three months) sedimentation and elevated turbidity events (that may approximate continuous three-month storms), are unknown. With exception of hurricanes, highly turbid nearshore conditions in southeast Florida are typically the product of winter storms and heavy runoff during the rainy season. Near Miami, Florida turbidity in the nearshore hard bottom habitat is highly variable, and affected by winds, longshore currents, swell condition and upland runoff. Summer-fall months normally show lower turbidity levels of 1-4 NTUs (Nephelometric Turbidity Units) and winter-spring months show higher average levels (3-7 NTUs) (Miami-Dade DERM unpublished). Direct effects of dredging activities on corals have been discussed by Marszalek (1981), Goldberg (1988) and Blair et al. (1990). Although sublethal effects of elevated turbidity are poorly known in tropical marine environments, some information is available. Bak (1978) showed that a relatively short period of dredge-induced turbidity stress created an abrupt decrease in growth in two species of hard corals (*Agaricia* and *Madracis*). From both the magnitude and duration of suppressed calcification, he concluded that such metabolic shock may have long-term consequences on reproduction. Long-term resuspension of bottom sediments has been shown to adversely affect an important hard coral, *Montastrea annularis* (Dodge et al. 1974). Teleniski and Goldberg (1995a; 1995b) have recently demonstrated negative effects of sediment loads on hard corals at turbidity levels of approximately 18 NTUs. This is noteworthy, as the Florida state administrative threshold for temporary shut-downs of dredge operations is substantially higher (29 NTUs). Such work is needed for other taxa and would provide a scientific basis for maximum turbidity thresholds (Goldberg 1988; Teleniski and Goldberg 1995b). Herrnkind et al. (1988) demonstrated that increased siltation can cause direct loss of critical habitat for spiny lobster recruitment. Enhanced resuspension of sediments over time and chronic turbidity may lower key growth and reproduction rates of some algal and invertebrate populations which are a basis for primary and secondary production on an ecosystem scale (Lindeman 1997b). The potential for management decisions to multiply over time and impact unintentionally large spatial scales is of concern (Odum 1982; Rothschild et al. 1994) and is particularly relevant when affected species are also over harvested (Ault et al. in press).

Adopting 15 NTU above background as a threshold level for turbidity in Florida and other areas where waters are naturally not turbid is supported by sound science and appropriate for the following additional reasons:

1. Research associated with investigations by Telesnicki and Goldberg (1995) examined the effects of turbidity measured as an absolute value. In southeast Florida, turbidity standards are based on relative conditions (i.e., above background conditions);
2. We do not have adequate statistical competency to conclude that turbidity monitoring stations would be positioned in a manner that would capture the densest portion of the turbidity plume. Inherent risks associated with this warrant adoption of a more conservative threshold level; and
3. Although elevated turbidity levels may not directly or instantaneously kill corals, construction-induced turbidity may have long-term adverse impacts on corals (e.g., reduced reproductive health) that cannot be detected without carefully designed long-term monitoring.

In other areas of the southeast where waters are more naturally turbid and sensitive bottom fauna such as reef habitat are not present, a higher NTU criteria may be desired. For example, the South Carolina Department of Health and Environmental Control has adopted a threshold of 25 NTU for impaired versus non-impaired estuarine and marine waters. While monitoring of turbidity plumes associated with beach nourishment operations in South Carolina have been limited, Van Dolah et al. (1994) monitored sediment plumes associated with a beach nourishment operation on Folly Beach, South Carolina to determine the both the amount and extent of turbidity. During calm seas, values of about 100NTU were measured in the surf zone at the pipeline outfall. Turbidity levels dropped to less than 50 NTU in the upcurrent direction over a fairly short distance (less than 200 m), and more slowly in the downcurrent direction 500-1000 m. Under more turbulent conditions of strong winds and rough seas, turbidity levels increased to over 200 NTU directly in front of the pipeline and higher turbidities were documented over a larger extent of the beach. However, turbidities in South Carolina's surf zone are naturally turbid, and turbidity values of about 100NTU were occasionally recorded at a reference beach in the Folly Beach study.

In addition, resource management agencies are examining the value of integrating Acoustic Current Doppler Current Profile (ADCP) technology into water quality monitoring protocols. ADCP is an instrument with capability of collecting acoustic backscatter data through the full depth of the water column and has demonstrated utility in other projects, especially in areas that are characterized by shifting currents (e.g., a project in Long Island Sound in which ADCP was utilized in the turbidity monitoring program in order to accurately locate the plume so that targeted water column sampling could be accomplished). We note that the nature of a plume in open water can be highly variable both spatially and temporally and can be further complicated by winds and seas. Therefore, to overcome these challenges and position the monitoring in the right place at the right time, full depth profiling with ADCP may be essential to the integrity of the monitoring performed. Use of third party environmental inspectors for water quality monitoring has also been included in recent large scale offshore construction project Corps of Engineers permits.

The SAFMC is concerned that excavation of the offshore shoals could have significant adverse consequences to the shoreline and living marine resources. Between 1995 and 2006, the Minerals Management Service (MMS) provided approximately 14 million cubic yards of material from the Outer Continental Shelf (OCS) for 9 coastal projects in Florida (8) and South Carolina (1). Although many offshore shoals have not been thoroughly studied with respect to fish utilization, SAFMC believes the shoals serve as a benthic nursery area, refuge, and feeding ground for a variety of fishery resources. The SAFMC identifies sandy shoals as EFH for migratory pelagic fish, including king mackerel, Spanish mackerel, cobia, and dolphin. Clarke et al. (1988) and Michel et al. (2001) note the geomorphology of offshore shoals provide a unique assembly of micro-habitats that facilitate high biological productivity.

The MMS and Corps of Engineers are evaluating the St. Lucie Shoal (located offshore St. Lucie and Martin Counties, Florida) as a potential excavation site for beach renourishment in Dade and St. Lucie Counties. Anecdotal evidence suggests that the shoal is biologically unique and diverse, supporting fisheries that are economically and recreationally important, such as the migratory species listed above, sailfish, and prey species consumed by these fishery species.

In South Carolina, a survey of multiple sites dredged for beach nourishment purposes identified that most sites were slow to refill (average of 7 yrs among 5 sites) and generally refilled with non-beach compatible material (Van Dolah et al. 1998).

The SAFMC is concerned that mining shoals for sand may alter the local wave climate bringing about erosion that could affect EFH. Through an evaluation of the potential impacts from dredging linear shoals in the U.S. Gulf and Atlantic continental shelves, Hayes and Nairn (2004) concluded that the deflation of a shoal feature could change wave patterns between the shoal and the shoreline. In turn, such dredging could change longshore and cross-shore sand-transport patterns and erosion and accretion rates along the shore. Kelley et al. (2004) verified this conclusion in their examination of a borrow site offshore Martin County (depths were approximately 8 to 10 m), and recommend application of wave transformation numerical modeling tools that recognize the random nature of incident waves as they propagate onshore when examining incremental and cumulative changes from sand dredging on the continental shelf.

Furthermore, the SAFMC is concerned that excavation of nearshore borrow areas in addition to the placement of fill in nearshore areas could adversely affect hardbottom reefs in the area that are known to support corals and worm reefs colonized by *Phragmatopoma lapidosa*. Nearshore hardbottoms and worm reefs are also identified as EFH and HAPC by the SAFMC. These reefs reduce wave energy and stabilize shorelines (Kirtley 1967; Kirtley and Tanner 1968) and provide structural habitat for hundreds of fishery organisms (Gore et al. 1977; Nelson 1989; Lindeman and Snyder 1999). Avoidance and minimization of impacts to hardbottom resources is needed. Due to the importance of these concerns, SAFMC recommends that MMS and the COE continue to coordinate closely with the NOAA Fisheries Service Habitat Conservation Division to ensure the EFH assessments and NEPA documents contain sufficient detail to support federal decision making.

Other offshore mineral and mining does not presently occur along the South Atlantic coast. Extensive phosphate deposits have been located in Onslow Bay in North Carolina and large quantities of mineral nodules containing manganese and other metals are abundant along the continental shelf floor. It is reasonable to conclude that mining of these and other materials could become economically feasible. If initiated, mining of marine bottoms would cause substantial bottom disturbance that could impact productive hard bottom communities, shellfish beds, and wintering grounds for demersal fish. Since related port and processing facilities do not presently exist, new mooring and dockside facilities would be needed and related secondary impacts would be expected. These impacts are discussed in detail in Section 7.4.2.1 of this document.

6.1.2.5 Oil and Gas Exploration, Development, and Transportation

Extensive areas of the South Atlantic have been designated and blocked off for oil and gas development. Prior to 2003, this activity had been relatively dormant, unlike the pipelines and liquefied natural gas (LNG) facilities that proliferate in the Gulf of Mexico. Initial exploration in the vicinity of Cape Hatteras several years ago did not advance due to environmental and other concerns including consistency issues associated with North Carolina’s Coastal Zone Management Program. As of this writing, interest in the potential for renewed oil and gas exploration off North Carolina is again being considered. Environmental Impact Statements have been prepared for Mid-Atlantic Sale 121 and South Atlantic Sale for the exploration of oil and gas offshore of Cape Hatteras, North Carolina. Should gas or oil be found, the laying of pipe to North Carolina’s shoreline facilities would likely have to traverse barrier islands and associated wetlands. As oil and gas levels decline, exploration will undoubtedly resume and if economically viable reserves are located, this activity could expand and inshore and offshore EFH could be at risk.

There are currently three natural gas pipeline proposals in Florida that propose to construct pipelines from the Bahamas to southeast Florida. Between 1996 and 2006, NOAA Fisheries Service reviewed 548 applications and support documents associated with pipelines in the South Atlantic area. The NOAA Fisheries Service Southeast Region Habitat Conservation Division (HCD) office is engaged in three separate EFH consultations for natural gas pipeline projects proposed to be constructed from southeast Florida to the Bahamas. One of three projects (AES Ocean Express) has received Department of the Army (DA) authorization and a Federal Energy Regulatory Commission (FERC) license to proceed with construction. However, to our knowledge, all of these projects are still awaiting the necessary approvals from the Bahamian government.

One pipeline company (Calypso), recently filed an application with the U.S. Coast Guard to construct a deepwater port located approximately 5 to 10 off the eastern coast of Florida to the northeast of Port Everglades in a water depth of approximately 640 to 950 feet.

<u>Potential Threats to EFH from Oil and Gas Exploration, Development, and Transportation</u>

Potential threats include elimination or damage to bottom habitat due to drill holes and positioning of structures such as drilling platforms, pipelines, anchors, etc., water intake and impacts to ichthyoplankton, release of harmful and toxic substances form extracted muds, oil, and, gas and from materials used in oil and gas recovery; discharges of potentially large volumes of drilling fluids (muds) used during the well drilling process and produced (brine) water from the extraction phase; damage to organisms and habitats due to accidental spills; damage to fishing gear due to entanglement with structures and debris; and damage to fishery resources and habitats including deep water habitats, due to anchoring and effects of blasting (used in platform support removal); and indirect and secondary impacts to nearshore aquatic environments affected by product receiving, processing, and distribution facilities.

The various threats to EFH that would result from natural gas pipeline installation and construction depend on project location and construction methods proposed. Horizontal directional drilling was one of the primary nearshore construction methods evaluated, but eventually ruled out due to concerns that pertain to frac-outs, which are generally caused when the drill head moves through an area of unconsolidated sediments. Frac-outs are typically monitored through monitoring the hydrostatic pressure differential. Considering that frac-outs can occur anywhere along or near the pipeline route, pressure monitoring alone was not sufficient in areas that support reef. Frac-outs can occur as a slight release of mud or an uncontrolled flow of drilling muds.

According to Stauber et al. (2003), with sufficient geotechnical information it is possible to calculate a maximum allowable borehole pressure curve for a given HDD bore profile. Using this information, preliminary bore plans could be developed that provide reasonable assurance that the bore could be completed without incident. Therefore, SAFMC recommends that pipeline applications include an HDD Risk Analysis to ensure that the bore paths identified are the least likely to contribute to a frac-out.

Other threats to EFH could occur as a result of offshore dredging of exit pits and direct burial of resources through the pipeline placement, movement, and/or articulated concrete mats which are typically proposed for use in water depths of less than 200 feet for pipeline stabilization. In addition, drilling muds and the use of additives, such as Envis (a mixed metal hydroxide) or StaFlo (a polyanionic cellulose) are commonly used during drilling operations to control drilling mud flow and fluid loss. Another potential threat is hydrostatic testing which is typically proposed to verify that the pipeline was properly installed and structurally sound. Chemicals may be proposed for use in hydrostatic testing and can include corrosion inhibitors, biocides, oxygen scavengers, and leak detection dye that would be used for pipe treatment and as seawater additives.

Another nearshore construction approach involves tunneling, which is preferred over HDD but has not been tested yet in nearshore areas of southeast Florida. Tunneling poses less risk to the marine environment because it may be possible to conduct operations independent of weather and it reduces or eliminates the risk of frac-outs because the operation is conducted under much less pressure and at greater depths. However other issues are still being evaluated, such as the potential for localized slumping or heave, tunnel failure, a higher probability of a frac-out near the tunnel exit location, and hydrostatic testing, as mentioned above.

To date, only one deepwater LNG port has been proposed in the South Atlantic. However, the Federal Energy Regulatory Commission has received three applications (including Calypso) to construct pipelines from southeast Florida to the Bahamas. To date, none of the applications has received approval from the Bahamian government to construct regassification facilities. Therefore, SAFMC is concerned about the potential for multiple deepwater ports to be proposed offshore southeast and east-central Florida. The September 2006 Calypso application states that approximately 273 acres of deepwater habitats could be impacted as a result of anchoring activities. Benthic organisms may be adversely affected from direct crushing and disturbance of sediments in the immediate vicinity of the anchors. The Calypso LNG terminal is proposed to be located on or adjacent to the Miami Terrace, which is a proposed deepwater coral HAPC. Hardbottom and coral resources found along the Miami Terrace and Escarpment are identified as EFH and HAPC by the SAFMC. Reed et al. (2006) characterized the fauna on the Miami Terrace and Escarpment as consisting of gorgonacean octocorals, colonial scleractinian corals (including thickets of *Lophelia pertusa*, *Madrepora oculata*, and *Enallopsammia profunda*), stylasterine hydrocorals, and Antipatharia. Diverse populations of the sponges Hexactinellida and Demospongia also occur along the Miami Terrace and Escarpment. In addition, based on studies conducted for the Calypso Pipeline Final Environmental Impact Statement, side-scan sonar results from the area show highly reflective signatures, which suggests the substrate is hardbottom mixed with medium carbonate sands and silty sands.

Unlike the open loop LNG facilities proposed and in operation in the Gulf of Mexico, the Calypso LNG facility is proposed to be a closed loop system (it should be noted, however, that Calypso could have chosen to use open loop regasification technologies and, given cost considerations, so might any other LNG company that looks at the Atlantic coast off Florida). Open loop systems use seawater for the regasification of LNG and water intakes can exceed 100 million gallons of water per day. However water intake associated with closed loop systems is only for engine cooling and can range from approximately 30-60 million gallons per day depending on the number, type, and duration of vessels at Port. With the closed loop system proposed in the South Atlantic, the discharge water would be approximately 13 degrees Fahrenheit warmer than the intake water.

Applications for LNG facilities should adequately consider potential impacts to fishery resources and the project's proximity to the Gulf Stream. The conditions and flow of the Gulf Stream are variable on time scales ranging from two days to entire seasons. Important spawning locations can occur along the Gulf Stream front (e.g., *Coryphaena*, *Xiphius*) (SAFMC 1998). Movement of the Gulf Stream front also affects the distribution of adult fishes (Magnuson et al. 1981); hook-and-line fishermen and longliners target much of their fishing effort in these frontal zones.

Biological and economic analyses of impacts related to impingement and entrainment of the various life stage histories of fishery resources are needed to allow the SAFMC, public, and NOAA to assess the costs of lost fisheries production from the water intake/discharge component of the Calypso LNG deepwater port. Such examinations should include detailed comparisons of the environmental impacts and environmental costs of alternative closed-loop regasification technologies to understand more fully the potential impacts to fishery resources. Analyses should be based on an assumption of 100% zooplankton mortality that would result from water intake, unless the applicant can show applicable studies demonstrating otherwise. In addition, surveys of the ichthyoplankton communities within project areas are needed because in many areas, including water off Fort Lauderdale, there are no site-specific data regarding ichthyoplankton resources. Such surveys should be designed to provide a quantitative assessment of the impacts to fishery resources. In addition, the surveys should be designed to support the monitoring of impacts from port operations on fishery resources so that adjustments to those operations can be made in a timely manner. Although the continental shelf of the South Atlantic Bight has been the focus of moderate interest for exploration of oil and gas resources, there are presently no ongoing related activities in the region with exception of that mentioned above.

In addition to what is presented above and considering the current status of the industry, a brief overview of the facilities that might be emplaced on the Outer Continental Shelf (OCS) to facilitate oil and gas exploration, development, and production is also presented. This includes drilling vessels (jack-ups, semi-submersibles, and drill ships), production platforms, offshore moored terminals, and pipelines.

Oil and gas related activities are inherently intrusive and pose a considerable level of threat to marine and estuarine ecosystems, including EFH. As discussed below, exploration and recovery operations may cause substantial localized bottom disturbance. Where large scale development is undertaken the area of impact may be greatly expanded and become regional in scale. The toxic nature of hydrocarbon products and certain drilling materials (e.g., drilling muds), spill cleanup chemicals, and the large volume of unrefined and refined products that must be moved within the coastal zone places large areas and resource bases as risk.

Structure emplacement can be expected to disturb some bottom area and, if anchors are deployed, the area of disturbance could be expanded. Jack-up rigs and semi-submersibles are generally used in water depths not exceeding 400 meters and disturb about 1.5 ha (3.7 ac) of bottom each. Conventional fixed platforms are also employed where water depths are less than 400 meters and they disturb about 2 ha (4.9 ac). Where water depths exceed 400 meters, dynamically-positioned drill ships may be used and sea floor disturbance is usually limited to the well site. Tension leg platforms may also be employed at these depths and the potential bottom disturbance area associated with these structures is about 5 ha (10.25 ac).

Each exploration rig, platform, terminal, and pipeline emplacement on the OCS can be expected to disturb surrounding areas. Exploration rigs, platforms, and pipe laying barges use an array of eight 9,000 kg anchors to position a rig and barge, and to move the barge along the pipeline route. These anchors are continually moved as the pipe laying operation proceeds and the total area actually affected by the anchors will depend on water depth, wind, currents, anchor chain length, and the size of the anchors and chain (MMS 1996). With conventional, fixed multi-leg platforms, which are anchored to the sea floor by steel pilings, explosives are generally used to sever conductors and pilings. These support structures are substantial in size since they must withstand hurricane conditions and have an average lifespan of about 20 years. The Minerals Management Service requires severing support structures at five meters below the sea floor surface so as to preclude interference with commercial fishing operations.

Possible injury to biota from use of explosives extends horizontally to 900 meters from the detonation site, and vertically to the surface. Based on MMS data, it is assumed that approximately 80% of removals of conventional fixed platforms in the Gulf of Mexico, in water less than 400 meters in depth, will be performed with explosives (MMS 1996). Alternative methodologies such as mechanical cutting and inside burning are often ineffective and are hazardous to workers.

Associated bottom debris commonly associated with over water oil and gas operations includes cable, tools, pipe, drums, assorted trash, and structural parts of platforms. The amount of bottom debris deposited around a site may vary and may be measured in tons. Extensive analysis of remotely-sensed data within developed lease blocks indicates that the majority of ferromagnetic bottom debris falls within a 450 meter radius of the site. The Fisherman's Contingency Fund, which was established by the oil and gas industry, provides recourse to commercial fishing interests for recovery of equipment losses due to shrimp net entanglement (MMS 1996).

Blowouts occur when improperly balanced well pressures result in sudden, uncontrolled releases of petroleum hydrocarbons. Blowouts can occur during any phase of development: exploratory drilling, development drilling, production, or workover operations. About 23% of all blowouts will have associated oil spills, of which 8% will result in oil spills greater than 50 barrels, and 4% will result in spills greater than 1000 barrels. In subsurface blowouts, sediment will be resuspended and bottom disturbance will generally occur within a 300 meter radius. Whereas larger grain sediment will settle first, fined grained material may remain in suspension for periods of up to thirty days or longer. Fine grained material may be redistributed over a significantly large area depending on the volume of sediment disturbed, bottom morphology, and currents (MMS 1996).

The major operational wastes associated with offshore oil and gas exploration and development include drilling fluids and cuttings, and produced waters. Other important wastes include: from drilling--waste chemicals, fracturing and acidifying fluids, and well completion and workover fluids; from production--produced sand, deck drainage, and miscellaneous well fluids; and from other sources--sanitary and domestic wastes, gas and oil processing wastes, ballast water, storage displacement water, and miscellaneous minor discharges (MMS 1996). Major contaminants or chemical properties of materials used in oil and gas operations may include those that are highly saline; have a low ph.; contain suspended solids, heavy metals, crude oil compounds, organic acids, priority pollutants, and radionuclides; and those which generate high biological and chemical oxygen demands. Pierce et al. (1980) documented that wild fish have been injured by petroleum pollutants. Grizzle (1983) suggested that larger liver weights in fish collected in the vicinity of production platforms versus control reefs could have been caused by increased toxicant levels near the platforms. He also suspected that severe gill lamella epithelium hyperplasia and edema in red snapper, vermilion snapper, wenchman, sash flounder, and creole fish were caused by toxicants near the platforms. These types of lesions are consistent with toxicosis.

Accidental discharge of oil can occur during almost any stage of exploration, development, or production on the OCS or in near shore base areas. Oil spills may result from many possible causes including equipment malfunction, ship collisions, pipeline breaks, human error, or severe storms. Oil spills may also be attributed to support activities associated with product recovery and transportation. In addition to crude oil spills, chemical, diesel, and other oil-product spills can occur with OCS activities. Of the various potential OCS-related spill sources, the great majority are associated with product transportation activities (MMS 1996).

As of this writing, only test wells have been drilled in the South Atlantic Bight area and these have been confined to inshore areas. All of these wells were capped immediately after drilling. No production or transportation facilities such as offshore terminals and pipelines have been built, nor are any such facilities currently planned in South Atlantic

Bight waters. Despite this, millions of barrels of crude oil and refined product transit South Atlantic Bight waters by tank vessel every year and the potential exists for the discharge of thousands of barrels of oil due to vessel collision or sinking. Discharge of untreated ballast water from transiting vessels is also a chronic low level source of petroleum-based pollution.

6.1.2.6 Commercial and Industrial Activities

Direct physical encroachment into offshore environments by industrial activities is relatively limited along the South Atlantic seaboard. Notable exceptions include thermal intake and outfall structures associated with power plants in North Carolina and Florida, and sea walls that are used to protect commercial and industrial development. Several municipal sewage outfalls which discharge commercial and possibly light industrial wastes also exist. Although direct physical impacts may be minor on a regional scale, water quality effects are largely unknown. Indirect effects, such as those associated with point and nonpoint-source discharges are thought to be substantially greater since it has been shown that discharges, including trash and debris, from land based activities may reach coastal waters and food webs.

Commercial development for hotels, motels, and related infrastructure along the South Atlantic shoreline has been extensive. Because many of these developments are located on unstable and shifting coastlines, maintaining associated buildings, revetments, bridges, causeways, beaches etc. has, and will continue to have an adverse effect on nearshore and offshore processes and environments.

<u>Potential Threats to EFH from Commercial and Industrial Activities</u>
Potential threats include: direct and/or non-point-source discharge of chemicals, placement of intake structures, and protective sea walls (often used in connection with commercial establishments), and cumulative and synergistic effects caused by these and other industrial and non-industrial related activities.

Future exploration and recovery of marine resources and placement of offshore mooring and unloading facilities could substantially threaten offshore EFHs. Although none of these activities or facilities are presently being planned, it is likely that continued economic growth, depletion of limited natural resources, and use of limited coastal lands will eventually lead to greater exploitation of offshore resources.

Electric power generation is needed for commercial and industrial development, and for residential purposes (See Section 4.1.1.4). Between 1996 and 2006, NOAA Fisheries Service evaluated 85 proposals to construct new or expand existing electric generation facilities. When located in coastal waters, power generation facilities may adversely affect EFH and associated biota. Potential threats include direct displacement of wetlands, submerged bottoms, and vegetated upland buffer areas for generation facilities and ancillary uses such as fossil fuel storage, cooling towers, and water intake and outfall structures; construction of navigation channels and docks for unloading coal, oil, and other materials needed for operation of generators and equipment; discharge of toxic substances from air emissions; cooling waters (e.g., chlorine); and from point and nonpoint-source discharges emanating from impervious surfaces and coal and slag piles; discharge of thermal discharges that may be lethal to flora and fauna, or that serve as attractants that subject fish, invertebrates, and marine mammals to thermal stress when changes in plant operation or weather occur; and entrainment and impingement of living marine resources in which organisms succumb to or are damaged as a result of entrapment in intake structures or capture on screens.

An example of an electric power generation plant and threats to EFH is the Florida Power and Light's Turkey Point Power Plant, located along Biscayne Bay in Dade County Florida, which directly impacted over 24 acres of estuarine emergent wetlands, including mangrove wetlands, seagrass, and open water habitat in order to construct a natural gas-fired electric generating facility to provide electricity to meet the projected 2007 demand in southeast Florida. An additional 10.7 acres of wetlands were impacted through secondary effects. The wetlands at the subject site are high quality, uncommon, and provide direct benefits to the fishery resources of Biscayne Bay. The bay's extensive seagrass beds, mangrove wetlands, and hardbottom communities support a diverse array of fishes and invertebrates including over 512 species of fishes and over 800 species of invertebrates which have widely variable environmental requirements for growth and reproduction.

Although relatively minor in its present scale, the commercial harvest of *Sargassum* from coastal waters off North Carolina is of concern. *Sargassum* weed lines and associated frontal zones provide cover, trophic, and other attributes needed to sustain endemic fish and invertebrates of the pelagic *Sargassum* community and associated fauna. The weed lines may be especially important during early life stages of sea turtles and certain fish and they are important sites for the North Carolina and South Carolina offshore recreational fishery.

The occurrence of methyl mercury in the flesh of the large piscivorous fish such as king and Spanish mackerel and other large pelagic and demersal species such as amberjack, wahoo, snapper, and grouper has been documented and is of concern largely with respect to human consumption of these species (D. Engel, personal communication). The probable source of these contaminants is atmospheric input from worldwide inventories associated with emissions from incinerators, fossil fueled power plants, automobiles, and industry. As such, the regulation of surface water contamination from atmospheric pollution may require local, regional, and international efforts.

Effects related to commercial development are similar to those from urban and suburban development and the discussions in Section 4.1.1.4 apply. Further, effects of shoreline modifications such as beach nourishment are found in Section 4.1.2.3.

6.1.2.7 Artificial Reefs

Artificial reef construction in the South Atlantic has substantially increased over the last 10 years. Project scales range from single family homeowners applying to place reef balls under docks for lobster recruitment to 3,000 acre areas located in offshore areas. Project applications typically state that the purpose of the project is to "further develop three artificial reef sites to increase the marine flora and fauna within the area for local fishermen and SCUBA divers without detriment to the existing reef structures or fish populations." However, artificial reefs are also constructed to replace natural reef habitats. Construction at the larger scale sited typically involves the placement of a variety of materials including concrete, limestone boulders, submerged vessels, and other approved items.

Potential Threats to EFH from Artificial Reefs

Potential threats to EFH include permanent conversion of one habitat type to another, introduction of predators, possible increased fishing activity and relic gear on structures.

Although the SAFMC recognizes and appreciates applicant's efforts to provide additional marine habitat, information regarding the level of impact this project would have on EFH resources is needed in the application process. This information need includes a thorough assessment of environmental impacts and details concerning its design and specifications. The type of information that should be contained in an artificial reef application includes:

- It should be demonstrated that the project will provide enhanced marine fisheries habitat. This may be achieved through (but not limited to):
  - Identifying the specific fisheries and life history stages that will be enhanced by the proposed work.
  - Demonstrating a clear link between the structural design and the fisheries the artificial reef will support.

- The applicant should demonstrate full consistency with NOAA's *National Artificial Reef Plan* (1985) and the draft plan revision (2001)[1], including, but not limited to, the following provisions:
  - Demonstrated consistency with the applicable state's artificial reef plan (e.g., the State of Florida's Artificial Reef Plan). Through this, the applicant should:
  - Have a specific objective for fisheries management or other purpose stated in the goal of the statewide, or site-specific plan;
  - Have biological justification relating to present and future fishery management needs;
  - Have minimal negative effects on existing fisheries, and/or conflicts with other uses;
  - Have minimal negative effects on other natural resources and their future use;
  - Use materials that have long-term compatibility with the aquatic environment;

[1] National Artificial Reef Plan (revised 2001). National Marine Fisheries Service. Available on-line at: http://www.nmfs.noaa.gov/irf/Revised_PLAN_11_16.pdf

    - Conduct monitoring during and after construction to determine whether the reef meets permit terms and conditions and is functioning as anticipated.
- The applicant should ensure that the proposed artificial reef structure will not threaten the integrity of natural habitats in the area, including live/hardbottoms, corals, seagrasses, and macroalgae;
- The application should verify that any vessels deployed have been cleaned in accordance with Environmental Protection Agency Guidelines;
- The constructed reef should remain stable during a 100-year storm event;
- The applicant should identify the most extreme sea state and wave surge conditions under which work will be undertaken; and
- An entity should be identified to demonstrate the capability of assuming long-term financial liability for the deployment, biological and stability monitoring, and maintenance of the artificial reef.

Artificial reefs can serve as effective fishery management tools (when coupled with additional fishery management measures, for example the designation of no-take zones) to attract fish and, in some situations, mitigate for anthropogenic and natural damage to coral and hardbottom reefs. The SAFMC concurs with the leading artificial reef researchers in this region (see Bohnsack 1989) that artificial reefs are unlikely to benefit heavily exploited or overfished populations without other management actions. Conversely, if not properly sited they may have only minimal habitat value and could even degrade existing reef resources if placed on or in close proximity to such habitats. Artificial reefs are also constructed as mitigation reefs. A U.S. Fish and Wildlife report (2004) prepared pursuant to Resolution 4 from the 8th Coral Reef Task Force meeting held on October 2-3, 2002, in San Juan, Puerto Rico, concluded that projects involving filling and dredging for beach nourishment and port development have caused the most impacts to coral reef habitats in southeast Florida since 1985. The 26 Florida projects (16 completed; 10 pending) reviewed in this report impacted 217 acres of reef, and mitigated with 113 acres of artificial reef. However, a study is needed that would provide information as to impacts to hard bottom communities of shoreline projects, including whether proposed mitigations are adequate to offset the environmental impacts of the activities. General practice in Florida is to permit mitigation for shallow hard bottom communities in deeper waters is contributing to a substantial net loss of the shallow communities and related functions.

6.1.2.8 Alternative Energy Technologies

Sections below excerpted from MMS Alternative Energy Synthesis report: Michel, J., Dunagan, H., Boring, C., Healy, E., Evans, W., Dean, J.M., McGillis, A. and Hain, J. 2007. Worldwide Synthesis and Analysis of Existing Information Regarding Environmental Effects of Alternative Energy Uses on the Outer Continental Shelf. U.S. Department of the Interior, Minerals Management Service, Herndon, VA, MMS OCS Report 2007-038. 254 pp. <u>*See Report for references in following sections.*</u>

Offshore wind turbines

An offshore wind farm is a set of turbines that generate electricity from the mechanical force that the wind imparts upon an object and are specifically designed for their oceanic location. Each modern oceanic turbine is capable of producing up to 4.5 megawatts of power (some older turbines installed in the 1990s produced less than 1 megawatt, newer turbines under development may produce 5 to 10 megawatts), and the hub of the turbine is 180 feet or more above the sea surface. Present proposals include systems with blades that will reach more than 510 feet above the sea surface. The number of turbines in a farm varies and will be affected by economics, space, and demand for the electricity generated. The number of turbines in proposed farms ranges from three units in a proposed research setting to over 150. The turbines need to be separated from each other by a distance of 0.25 mile or more in order to reduce the effect one turbine has upon the wind field experienced by adjacent turbines. Wind farms include a distribution platform that serves as a hub for the cables that collect power from each turbine and the fewer, but larger, cables that carry the power to shore.

A recent study conducted by the Minerals Management Service (MMS 2007) cites the following as the current primary economic and technical feasibility determinants that affect the choice of sites for offshore wind parks:

- Availability of a substantial, relatively constant wind resource
- Shallow water (less than 30 meters deep)
- Proximity to an area of high electricity consumption
- Distance to shore

Water depth is a critical design element that currently limits installation in deeper waters because of technology and economic constraints. Existing wind parks in Europe are installed in very shallow water (up to 15 m deep). Most North American wind resources are in water greater than 30 m deep, requiring development of economically feasible new technologies for wind turbine structures that can withstand wave and wind action in deeper areas (MMS 2007).

In addition to the water depth limitations of technology as of 2007, significant economic concerns are associated with the distance from shore and the length of subsea electrical cable required to reach the onshore electrical grid. Although available wind turbine designs allow installation in waters less than 30 m deep, wind parks operating in Europe are in shallower coastal areas (water depths of approximately 15 m). In the United States, wind parks are likely to be developed along the Atlantic seaboard and the Gulf of Mexico (MMS 2007).

The Cape Wind project offshore of Massachusetts and the Long Island Offshore Wind Park (LIOWP) offshore New York are in the environmental impact statement (EIS) stage, and other projects are planned along the northern and central U.S. coast. In addition, two leases have been granted by the State of Texas to develop wind parks off the coastline of Padre Island and Galveston Island. Additional projects are in the early planning stages along the U.S. east coast and Gulf of Mexico (MMS 2007).

Potential threats to EFH from Offshore Wind Turbines

Operational characteristics of each turbine design and its size are influenced by the minimum sustained winds occurring in an area and needed to make the wind farm profitable. Studies from the northeastern U.S. conclude a minimum wind speed of 16 mph or more is needed, studies from the southeastern U.S. conclude wind speeds of 11 to 13 mph are sufficient (Stewart 2005). Analyses are not simple; wind persistence, direction and natural turbulence can limit a turbine's ability to produce electricity even though its blades are spinning. Analyses must also consider the efficiency of the turbines and the number of days in a year when the wind reaches or exceeds the minimum speed required to produce electricity. Other factors that influence the feasibility of establishing a wind farm include proximity to an established electrical grid and water depth, because market availability and water depth affect construction cost. Some authorities suggest 180 feet is a maximum depth; developers of the wind farm off Cape Cod, MA, actively sought waters less than 50 feet deep. Lloyd's Insurance has set 12 fathoms as their insurance risk limit. The occurrences of high winds are an issue since they can damage the turbine systems. Wind speeds that cause the blades to rotate above 14 revolutions per minute trigger most systems to shutdown.

In the United States, there are no offshore wind farms in operation, although six projects are currently being considered (Dennehey 2006; Ludwig 2006). Two are off the coast of Cape Cod, MA, two of the coast of Texas, one off the coast of Long Island, NY, and one is being considered off the Pacific Northwest Coast. Evaluations of the general environment off North Carolina and Georgia by universities conclude that wind farms warrant further investigation in these areas (Halks et al. 2005; Stewart 2005). Offshore wind farms have been established in Europe, especially in Denmark, and business forecasts indicate additional farms are likely due to tax and business incentives that focus on renewable energy (Danish Energy Authority 2005, see also http://home.planet.nl/~windsh/offshoreplans.html).

There are three general designs currently in use for anchoring turbines to the sea bottom, and the design chosen affects the extent of the environmental impacts (Danish Energy Authority 2005). A gravity foundation uses a large base (much broader than the pylon) with supplemental mass being placed on the base structure to anchor the pylon on the seafloor. A monopile base is a piling driven deep into the sea floor to create the stable anchor and is similar in diameter to the pylon itself; monopiles are currently used in water depths up to 60 feet. Multi-pole bases consist of piling systems similar to those used in small offshore oil and gas platforms; pilings are driven into the sea bottom over an area that is broader than the pylon that supports the turbine and the pylon is attached to a framework and platform that links the pilings. When commenting on a proposal by Cape Wind Associates for a wind farm on Nantucket Sound, MA, NOAA Fisheries Service indicated a preference for the 46-ft diameter, monopole design because it impacts less sea bottom and fishing gear is less likely to snag on this type of structure. Research being done in Europe is examining the feasibility of floating foundations and hybrids between monopile and gravity foundations that will allow farms to be located in deeper water without requiring a foundation that occupies a large amount of sea bottom. One of the wind farms proposed for New York plans to investigate the stability of a jack-up barge as its base, and the wind farms proposed for Texas are exploring use of oil and gas platforms that are no longer needed by the petroleum industry.

Long-term impacts to coastal ecosystems from wind farms are unclear because only a few offshore wind farms have existed for more than 10 years. However, all the wind farms recently constructed or authorized in Europe include substantial monitoring programs, so lack of data should not remain a problem for long. U.S. Army Corps of Engineers (2004) and the Danish Energy Authority (2005) provide initial lists and summaries of the impacts that can be expected from an offshore wind farm and the latter also provides Internet links to Web sites planned for distributing future study results.

Direct impacts to coastal ecosystems include usurpation of seafloor habitat(s) by the pilings, distribution platforms, and cables that connect the turbines to the onshore power grid. Especially when the monopile design is used, the cumulative area impacted is small; for example, Cape Winds Associates estimates the pylons from their farm of 130 turbines would occupy less than one acre of sea bottom. Construction equipment impacts during cable and system installations would add to this acreage. Direct effects to the sea bottom also may occur from alteration of current fields moving past the foundations, but these impacts to be manageable in most circumstances.

The most obvious affect of the pilings on marine biota will be from the structures serving as fish habitat. Many fish are attracted to any structure that provides relief from the otherwise featureless sea floor. Benthic organisms, which may adhere to a pylon or its base, depending on local conditions and construction materials, may add to the attractiveness of the structure to fish. Although unlikely to be an issue, there is some concern that electromagnetic fields (EMF) may disrupt the movements of sharks and other aquatic resources that navigate by sensing the earth's electromagnetic fields. Wind farms can transmit direct current, which has a greater capacity than alternating current to create localized EMF. Recent research indicates the severity of this impact may be small. Vibrations transmitted from the structures and systems to the water column and affecting the behavior of fish is a concern but not much is known about the severity of this impact. Monitoring in Europe has not found evidence of either EMF or vibration impacting aquatic resources (Ludwig 2006). Indirect impacts to marine biota may result from wind farms shifting navigation away from preferred routes into areas where marine mammals or fishery resources are more concentrated. The Federal Aviation Administration and military have recently identified that wind farms create a shadow effect on near ground, tracking radars.

Socioeconomic impacts have been controversial. Many members of the public object to the expected deteriorations in the vistas caused by the wind farms as well as wind farms occupying preferred fishing grounds. However, the Europeans have experienced a sharp increase in eco-tourism at their wind farm sites. The public also has been focused on impacts to seabirds, although impacts to birds seem uncommon based on preliminary evidence (Danish Energy Authority 2005).

Ocean current technology

(Excerpted from MMS 2007 report)
Ocean current technology is similar to wind technology, only underwater. Instead of wind, ocean current pushes turbine blades to transfer kinetic energy. Similar to wind turbines, the blades of the current turbines move at a very slow speed. For example, one type of design has vertical turbine rotors that rotate 10 to 30 revolutions per minute, which is approximately 10 times slower than ship propellers. Although the rotors move slowly, they produce a significant amount of energy because of the density of water moving them.

In the United States, no operating commercial systems using ocean current technology are connected to an electrical grid at this time (MMS 2006). However, the technology to harness ocean current energy as an alternative energy source is in the developmental stage. Demonstration and pilot studies of different prototypes are taking place throughout the world. Marine current velocities are lower than those of wind, but because water is 835 times denser than air, a 3-knot current has the kinetic energy of 161 km/h wind. The total potential energy contained in marine currents worldwide is estimated at approximately 5,000 GW (MMS 2006).

Available data indicate that current velocities between 2 and 5 meters per second (m/s) would be required to make ocean current energy technology economically viable at a particular site (MMS 2006).

In the United States, the most promising sources of ocean current energy include the Florida Current (part of the Gulf Stream) and the California Current (MMS 2006). These ocean current resources are located relatively close to shore and near centers of high electricity demand, making ocean current energy an attractive resource. In addition, ocean currents tend to be significantly more constant than wind resources, which can fluctuate greatly over relatively short periods of time.

A number of turbine designs exist, some of which have been through field testing while others are still in the development phase (MMS 2007). Florida Hydro is testing a disk-like design called the Open Center Turbine for use in the Florida Current (**Figure 6.1-1**).The moving parts of this technology are encased within the unit. Designed to produce 2.5 MW, the turbine was tested off Palm Beach, FL.

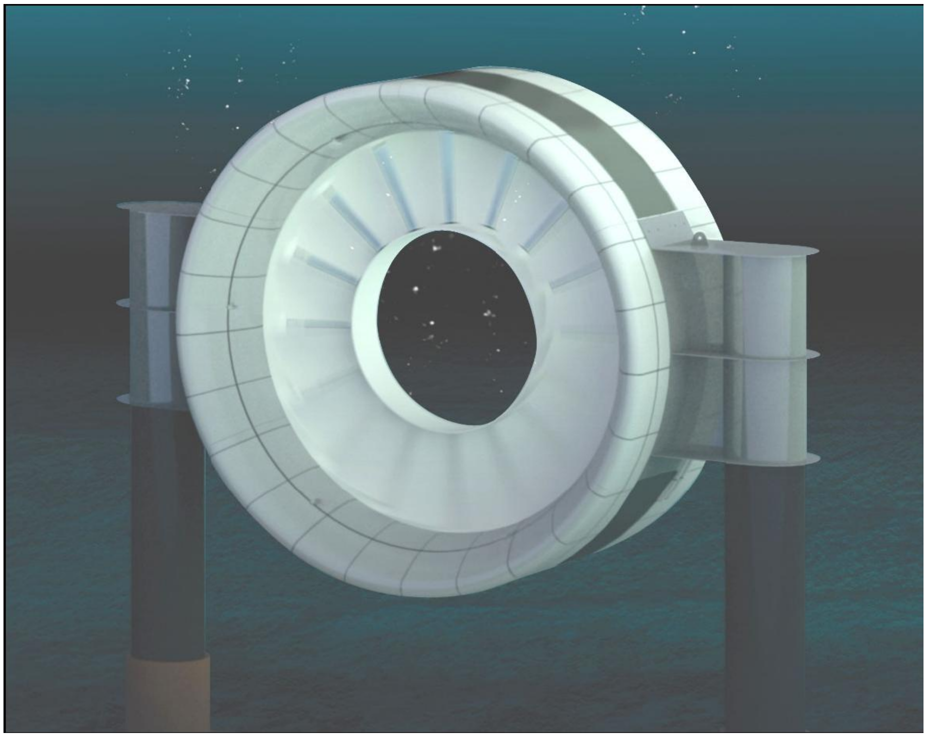

Figure 6.1-1. Open center current/tidal turbine with encased moving parts (Source: Open Hydro Group Limited).

Several other ocean current technologies are being developed. Those designs are tethered to the seabottom using anchors or on poles that extend from seabed foundations (ABP, 2004). These technologies are in the very early stages of development; however, they may be the most promising design for deeper, offshore applications on the OCS.

Solar technology

(Excerpted from MMS 2007 final report)
Solar energy technology has been producing useable energy from land-based, full-scale, grid connected power plants for more than a decade, but use of solar energy technology on the OCS is very limited. Economically feasible installation of full-scale solar energy projects on the OCS will depend on producing significant amounts of transmittable energy.

The possibilities for solar technology are not limited to large offshore solar plants; solar energy technology could be collocated with other alternative energy technologies. For example, solar collectors could be installed near the base of a wind turbine, and then used to augment energy output. Solar technology also could be installed as an alternative use for decommissioned oil and gas platforms on the OCS. Already some small, unmanned oil and gas platforms use solar panels for electricity needs. Solar panels are also used on buoys, platforms, and meteorological stations.

The potential for annual average solar power varies greatly by latitude and cloud cover; solar radiation is significantly greater in the lower latitudes. In the United States, solar radiation is greatest in southern parts of the country. A literature review yielded no information on solar radiation levels offshore and along the OCS (MMS 2006). However, unpublished solar radiation data may exist as shipboard information collected during routine or research operations.

Solar energy is converted into useable energy through two basic technologies: thermal and photonic. Thermal technologies convert solar energy to heat. Photonic technologies absorb solar photons, which are then converted into electricity through photovoltaic (PV) cells. Technology is also in the early stages of development to store the photonic energy as hydrogen for later use, rather than convert it directly to electricity (MMS 2006).

Some solar technologies use concentrating mechanisms to focus heat or photonic solar energy into a collector. Technology and application of concentrated PV are not as advanced as concentrated thermal technology, but it is under development. Concentrated PV and thermal systems use mirrors or lenses configured to concentrate solar radiation on receiving panels.

Current solar energy technology has limited application on the OCS. It is distributed only to power buoys, weather stations, and small, unmanned oil and gas platforms. A literature review revealed no solar energy projects on the OCS at any stage of planning or development. Any offshore solar energy project would need to be mounted onto some sort of large floating or fixed structure (MMS 2006). The number of solar panels, and therefore, the size of the structure necessary to support an offshore commercial solar energy facility would vary depending on the solar radiation level at the location, the orientation of the panels, and weather conditions.

Thermal solar technologies require dry, warm locations, and thus, current technologies likely would not be feasible on the OCS where humidity is high. PV solar technology surface area requirements also limit their application at OCS locations, where a floating platform would be required. Approximately 8 to 12 square meters is required for each kilowatt of capacity, meaning 0.8 to 1.2 hectares (0.008 to 0.012 km^2) of PV cells would be required for each 1 MW of power output (MMS 2006). Concentrated PV systems developed for thermal solar projects are in early development. Efficient concentrated PV technologies may increase the economic feasibility of OCS solar applications because PV is more effective in humid environments.

Hydrogen Technology

Hydrogen technology would be used on the OCS as a transport or storage mechanism for energy produced by one of the other alternative energy technologies (wind, wave, current or solar). No projects were identified at any stage of planning or implementation for this type of technology. The best source of information on the possibilities of using hydrogen technology for storage or transport of energy on the OCS is the MMS (2006) white paper.

Since the application of hydrogen technology is so undefined at this stage, and because there are no current plans or prototypes for OCS application, the potential impacts were not included in the MMS report (2007).

6.1.2.9 Non-native or nuisance species

Indo-Pacific Lionfish

Lionfish (*Pterois volitans/miles* complex) are venomous coral reef fishes from the Indian and western Pacific oceans, that are now found in the western Atlantic Ocean (Whitfield et al. 2002; Hare and Whitfield 2003; Meister et al. 2005; Ruiz-Carus et al. 2006; Whitfield et al. 2006). Adult lionfish have been observed from the Turks and Caicos Islands throughout the northern Bahamas and from Florida to Cape Hatteras, North Carolina, including Bermuda. There is also recent evidence to suggest that lionfish have been found near Tampa Bay, Florida in the Gulf of Mexico (Ramon Ruiz-Carus, pers. Comm.). Juvenile lionfish have been observed in increasingly high numbers off New Jersey, New York and Rhode Island, generally in the fall of the year. Lionfish reports from the public (beginning in 2000) combined with quantitative surveys conducted from Florida to North Carolina (2004-2006) suggest that the number of lionfish continues to increase along the east coast and their distribution is expanding both in the northern (juveniles in northeast) and southern range (Whitfield et al. 2006; Whitfield unpublished data). Due to the large geographic range now inhabited by lionfish this invasion is likely irreversible as removal of this invader across this region would be expensive and take unprecedented resources.

Introductions of marine species occur in many ways. Ballast water discharge is a very common method of introduction for marine invertebrates, and is responsible for many freshwater fish introductions. In contrast, most marine fish introductions have resulted from intentional stocking for fishery purposes. In the case of lionfish, all evidence points to an unintentional or intentional aquarium release (Hare and Whitfield 2003).

Currently no management actions have been taken to limit the effect of lionfish on the southeast United States continental shelf ecosystem. Under this scenario we predict that; 1) the lionfish population and geographic range will continue to increase; 2) as a result of this increasing abundance, the impacts of lionfish on the southeast United States continental shelf ecosystem will become more noticeable; 3) eventually, human impacts from lionfish ‘stings’ will occur along the southeast United States coast (Hare and Whitfield 2003; Whitfield et al. 2006).

The introduction and success of lionfish along the east coast may change the long-held perception that marine fish invasions are a minimal threat to marine ecosystems. The magnitude of this invasion as a stressor on marine ecosystems presently has not been quantified, but NOAA scientists have made a great deal of progress in understanding the lionfish introduction into the Western Atlantic. We have also made significant inroads in our understanding of many aspects of lionfish biology and ecology including reproduction, diet, population demographics and genetics. This section summarizes the current state of knowledge regarding the Atlantic lionfish population within five main topic areas: 1) Description and Distribution, 2) Reproduction, 3) Development, growth movement patterns and genetics, 4) Ecological relationships/Potential Impact and 5) Abundance and status of the stock.

Description and Distribution

The Indo-Pacific lionfish (*Pterois volitans/miles* complex, Scorpaenidae) is a venomous predator (Halstead 1970) native to the sub-tropical and tropical regions of the South Pacific, Indian Oceans and the Red Sea (Schultz, 1986). Lionfish are generally well known and recognized as a popular aquarium fish. Lionfish have venomous dorsal, anal, and pelvic spines, similar to other members of the family Scorpeanidae. The venomous spines are not known to be used in prey capture but are generally thought to be for self-defense and male/male agonistic displays during spawning (Fishelson 1975).

The present distribution (October 2006) of Indo-Pacific lionfish within the Atlantic is from southeast Florida to North Carolina, including Bermuda, the Bahamas, Turks and Caicos and along the northeast U.S. shelf as juveniles. Lionfish may have originated off the east coast of Florida in the early 1990's, but the actual source of the lionfish invasion remains unknown. In 2000, lionfish were first reported in North Carolina and Bermuda. In 2004, lionfish were first reported in the Bahamas, and in 2006 they were reported in the Turks and Caicos. Public reports combined with quantitative surveys suggest that both the number and geographic extent of the population continues to grow (Whitfield et al. 2006).

Within their native range lionfish are found on coral reefs and rocky outcrops from the surface to 50 meters (Schultz 1986). Within the South Atlantic Bight lionfish are widespread in abundance, found on all types of habitat (low relief hard bottom to high relief artificial structures) within water depths from 115 to 300 ft deep (Whitfield et al. 2006). By all accounts lionfish were already established (reproducing and dispersing) by the time the first surveys were conducted in 2004 and lionfish captures by hook and line are also on the rise within the past two years but these captures still vastly under-represent the extent of the lionfish population within the Atlantic. The large geographic extent of the lionfish distribution and the speed with which they occupied this area (since 2000) suggest they are very successful colonizers and competitors within their 'new' ecosystem (Atlantic).

At present the primary factors that can potentially limit their distribution are available habitat, availability of prey and winter bottom water temperatures. Both habitat and prey appear to be plentiful, especially with the potential increase in prey resources made available through overfishing of many grouper species (likely competitors for prey) (Huntsman et al. 1999; NMFS 2004). Thus the minimum bottom water temperatures remain the single most important factor in controlling the present lionfish distribution within the Atlantic. This is not only evidenced by the shift in depth distribution from their native habitat (shallower) to the Atlantic (deeper) but also by winter bottom water temperature data collected in both nearshore (colder) and offshore (warmer; Gulf Stream influenced) locations (Whitfield et al. 2002; Whitfield et al. unpublished data). Minimum winter bottom water temperatures collected from locations where lionfish are known to over-winter support the thermal minimums found in laboratory studies (Kimball et al. 2004). Based on laboratory thermal minimums, lionfish would not survive water temperatures that dip below 10º C (Kimball et al. 2004). In North Carolina, this equates to an inshore depth limit of approximately 80 to 90 ft, depending on winter temperatures overall. Nevertheless, lionfish can still recruit into shallower areas but they are not expected to over-winter in shallow water (less than 80-90ft) north of Florida (see Figure 5, Kimball et al. 2004). However, since the thermal tolerance of fishes is known to change with changes in fish size and age (Wootton 1992), a series of mild winters could interact with the advancing size and age of Atlantic lionfish, eventually establishing subpopulations inshore of those currently surveyed. Therefore, the actual inshore limit remains unresolved off the Mid-Atlantic states. At their southern limit (southeast Florida, Bahamas, Turks and Caicos and Gulf of Mexico) there are no such depth or temperature constraints as water temperature remains warm year round. Thus lionfish have been reported in water depths as shallow as 3 ft in the Bahamas and Jacksonville, FL (Ruiz-Carus et al. 2006).

It is important to mention that although connectivity between the Bahamas and the Caribbean is low, there are certain locations such as the Turks and Caicos where connectivity is higher (Cowen et al. 2006). Since lionfish have free-floating eggs and larvae even minimal larval connectivity from the southeast U.S. and Bahamas could lead to invasion of the Caribbean and the Gulf of Mexico through a stepping-stone effect (Carr & Reed 1993; Cowen et al. 2006).

Reproduction

Lionfish can be characterized as gonochoristic, iteroparous, asynchronous, indeterministic batch spawners. This mode of reproduction is consistent with other members of the *Pterois* and *Dendrochirus* genera. Lionfish appear to be summer spawners off North Carolina with a resting period lasting throughout the winter. The lionfish spawning season is likely to increase at the southern range of their distribution (i.e., Florida/Bahamas).

From observations in the Red Sea, Fishelson (1975) has reported that lionfish are pair-spawners exhibiting a complex courtship during mating. Laboratory and shipboard observations indicate that lionfish release two buoyant egg balls during each spawning event consisting of a batch fecundity of approximately 30,000 eggs. Lionfish eggs are released while encased in a gelatinous mucus which breaks apart releasing the developing embryos within 48 hours. Lionfish do not exhibit sexual dimorphism; however, males do grow significantly larger than females. Sex ratio of lionfish in the Atlantic is approximately 1:1. Female lionfish appear to be sexually mature within two years of age corresponding to approximately 150 mm standard length (Morris, J.A., Jr., pers. comm.).

In their native range lionfish are reported as being solitary defending their home range against conspecifics; groups were typically observed only during mating (Fishelson 1975). In contrast within the Atlantic, lionfish are regularly found in groups, but, to our knowledge no mating behavior has been observed (Whitfield, pers. obs.).

Development, growth, age, movement patterns and genetics

The early life history stages of lionfish are poorly known. Mito and Uchida (1958) and Fishelson (1975) describe the development and early larval stages of congenerics, while Imamura and Yabe (1996) describe five *P. volitans* larvae collected in the water column off of northwestern Australia. Lionfish settle from the water column to benthic habitats at about 10-12 mm. Laidig and Sakuma (1998) reported a larval growth rate of 0.3 mm d-1 for *Scorpaena*, a genus in the same family as lionfish, Scorpeanidae. Using this growth rate, the estimated planktonic larval duration (PLD) of lionfish is 25 to 40 d, which means that larvae may be in the water column and susceptible to transport by ocean currents for approximately one month. However, confirmation of PLD specific to *P. volitans* is needed as PLD can vary widely, even within members of the same genus (Victor 1986).

In 2004, a total of 149 lionfish were collected off North Carolina for life history analyses, These ranged in length from 5 to 45 cm (average length = 30.5 cm) and in weight from 25 to 1380 grams (3 lbs) with average wt of 480 grams. Several lionfish collected in this study were larger (45 cm) than the reported maximum length from their native range (38 cm) (Schultz 1986; Randall et al. 1997; Myers 1999), suggesting that lionfish growth along the southeast U.S. is not resource limited (Elton 1958). The growth rate of lionfish in the Atlantic or in their native habitat remains unknown.

Although preliminary, analyses of annual zones on sagittal otoliths suggest that the lionfish population off North Carolina is relatively young, (max. age 7 years old; 43 cm specimen). If confirmed, these results would support our general timeline of the invasion which we believe began around the year 2000, off North Carolina. However, age validation is still required to confirm this result.

As in most reef fishes, the major dispersal phase of lionfish probably occurs while eggs and larvae are in the plankton. The northward dispersal (i.e., from Florida to NC) of lionfish is thought to be greatly facilitated by the strong northerly flowing Gulf Stream currents. Dispersal further into the northeast is most likely facilitated by Gulf Stream eddies (e.g., cross shelf transport, Hare and Cowen 1996). Once settled to the benthos, observations from their native habitat suggest that lionfish exhibit site fidelity and do not migrate (Fishelson 1975, 1997; McBride and Able,1998.) In the Atlantic, however, the question of lionfish movement or migration, especially in response to cold water incursions, remains an important area of research but to date is unknown. If lionfish did move offshore in the winter in response to cold bottom water temperatures, this may increase their ability to survive thereby decreasing their natural mortality.

Genetics analyses of the Atlantic lionfish specimens revealed the presence of two closely related sister species *Pterois volitans* and *P. miles* within the Atlantic but 93.5% of collected specimens were *P. volitans*. We also found that the complexity of the haplotype network for Atlantic specimens was greatly simplified when compared to specimens in their native range. Twenty-eight different haplotypes were found within 43 native range *P. volitans* as opposed to 3 haplotypes within the 160 Atlantic *P. volitans* specimens. In addition, 95% of the Atlantic *P. volitans* shared the same haplotype. These data indicate a large decrease in genetic diversity within the Atlantic population most likely caused by a small founder population, but of no less than 3 female specimens. These data may indicate that a small release in the right environment can result in an invasion of impressive proportions.

Ecological relationships – Potential Impact

Within their native habitat the ecology of lionfish is not well known. A few studies on lionfish found they consumed a wide variety of smaller fishes, shrimps and crabs (Fishelson 1975), and occupy the upper levels of the food chain (Fishelson 1997). Moreover, few predators of lionfish have been reported in their native range (but see, Bernadsky and Goulet 1991; Moyer and Zaiser 1981). Although, potential lionfish predators along the southeast United States have no experience with the venomous spines of the lionfish (Ray and Coates 1958; Halstead 1967) there are other native venomous fishes such as scorpionfishes (same family as lionfish) which are consumed by native predatory fishes (Randall 1967; Ebert et al. 1991; Roel and Macpherson 1998; Bowman et al. 2000). However, the potential role of predation in decreasing the number of lionfish is unknown, as is the effect of lionfish on predators.

Lionfish could impact native ecosystems through direct predation, competition and overcrowding. Preliminary data on the diet of Atlantic lionfish specimens suggest that they are primarily generalist piscivores, similar to their native counterparts. The Atlantic lionfish diet is comprised mainly of prey from a variety of fish families including members of the Serranidae, Pomacentridae, Labridae, Scaridae, Blenniidae, Bothidae, Carangidae, and Monacanthidae. Ninety eight percent of stomachs examined contained fishes, and other prey items (decapod crustaceans, cephalopod and bivalve mollusks) make up only a fraction of prey contents by volume (approx. 0.5 % or less). The small serranids (sea basses) were substantially more important in terms of volume than other families of fishes (41% vs. 15% and lower for other prey families) (Munoz et al. in prep). Since lionfish are opportunistic predators feeding primarily on smaller fishes, there is potential for trophic overlap with native fishes (Sano et al. 1984; Naughton 1985; Matheson et al. 1986; Fishelson 1997) such as groupers in the genus Mycteroperca. Groupers comprising this genus feed almost exclusively on fishes (Dodrill et al. 1993). In particular, gag (*Mycteroperca microlepis*) and scamp (*M. phenax*) groupers are present in significant numbers off the North Carolina coast and scamp occur at size classes that appear to overlap size classes of lionfish. Serranids form one of the most important food items in the scamp diet (Matheson et al. 1986) so similarly sized scamp and lionfish may be targeting similar prey. In addition, lionfish have been confirmed to prey upon scad (Carangidae), one of the dominant fish species in the diet of gag (Naughton & Saloman 1985). If these prey fishes are already or became a limiting resource, a growing lionfish population could negatively impact the scamp and gag populations via competition for food resources. The style of lionfish predation, (i.e., ambush predator) is not unique on southeast United States reefs and wrecks (e.g., red grouper, frog fish, scorpion fish), but the lack of experience of prey species may increase the predation efficiency of lionfish. Moreover, continued mortality of groupers and other native predators through overfishing

(Huntsman et al. 1999; NMFS 2004) may open niche space and further increase resources for lionfish (Davis 2000).

Lionfish may also affect the use of habitat by other species through physical overcrowding and aggressive tendencies. Lionfish are often described as 'standing their ground' and male-male aggression is extremely high prior to and during reproductive activities, during which lionfish will even threaten divers (Thresher 1984; Myers 1991). If this behavioral characteristic was extended towards other organisms in their introduced range, the threat might be expected to increase with lionfish abundance and potentially cause native species displacement into sub-optimum habitats (Schumacher and Parrish 2005; Taylor et al. 1984).

<u>Abundance and status of the stock</u>
The total population abundance of lionfish in the Atlantic is currently unknown. Quantitative surveys combined with public reports suggest the population is growing in number and increasing in geographic extent and may potentially colonize the entire Caribbean and Gulf of Mexico (Whitfield et al. 2006). Within the last two years quantitative surveys at the same nineteen locations off North Carolina (95 to 150 fsw) indicate that lionfish densities have doubled. Moreover, yearly surveys from the same nineteen locations, off North Carolina, suggest lionfish densities may be similar to many native fish species (i.e., *Cephalopholis cruentatus*, *Epinephelus guttatus*, *E. adscensonis*, *Mycteroperca interstitialis*, *M. microlepis*) (Whitfield et al. 2006). At this point there is every expectation that the total population and geographic extent of lionfish will continue to increase. More information is clearly needed to determine the status of the entire population, but traditional fishery sampling methods are not appropriate because lionfish are not captured effectively in this manner. More detailed information on the amount and type of benthic habitat within the southeast region combined with a random program of quantitative visual surveys over a broad geographic area (Bahamas to NC) will assist in estimating the total population size of lionfish.

Summary
The southeast United States continental shelf ecosystem is already undergoing change. Many important reef fish predators are overfished (Huntsman et al. 1999). In the Snapper-Grouper Management Unit of the South Atlantic Fisheries Management Council, approximately half of the stocks for which the status is known are classified as overfished. The reef fish fauna of the southeast United States continental shelf is also becoming more tropical (Parker and Dixon 1998). From the 1970's to the 1990's, the number of tropical species and the abundance of individual tropical species increased off the coast of North Carolina. Both of these large-scale changes favor the continued growth and dispersal of the lionfish population along the southeast United States. The effect of climate change, overfishing and invasive species have been implicated in ecosystem decline and collapse in several marine ecosystems, (Harris & Tyrrell 2001; Stachowicz et al. 2002; Frank et al. 2005). Along the southeast U.S. shelf the high number of stressors acting in synergism may eventually have unexpected and irreversible consequences for the native communities and economically valuable fisheries in this region.

6.1.3 Natural Events and Climate Change

Potential Threats to EFH from Natural Events and Climate Change

Potential threats: Coastal and inland storms can cause severe acute and chronic perturbations including habitat erosion, burial of habitat and organisms by sediment deposition; creation of strong currents that alter habitats and remove biota; damage by wind and waves; creation of turbidity levels that can cause physiological damage and disrupt feeding, spawning migration, and other vital processes; and abrupt changes in salinity and other water quality characteristics such as fecal coliform levels and harmful algal blooms. Long-term climatological changes, such as, changes in weather patterns and ocean currents, can bring about similar changes by increasing storm activity, changing fresh water inputs and salinity in coastal systems, increasing ocean acidification which affects coral reef building, and changing water column productivity that can affect certain fish population. For example, the Atlantic Multidecadal Oscillation can cause large scale ecological changes called regime shifts where temperature alterations favor or harm a particular species or group. Changes that cause relocation of frontal boundaries, weed lines, and stratification and temperature boundaries may also cause substantial and undesirable environmental change.

Coastal processes may be dramatically altered by natural events. These include short term events such as severe storms, hurricanes, floods, etc. Effects vary from potentially positive to catastrophic. For example, a moderate storm may provide needed freshwater, flush and recharge stagnant water bodies, and transfer nutrients from uplands and high marsh surfaces to tidal waters. On the other hand, shoreline erosion, wetlands destruction and subsidence and substantial changes in the structure of coral communities (e.g., Bythyell et al. 1993) are possible.

Hurricanes and other severe climatological events and change can drastically alter shorelines and associated environments including wetlands. Some changes may be positive such as the flushing of stagnant systems. However, wind induced erosion and overwash can remove and fill large areas of SAV and emergent wetlands. In overwash areas, newly created "uplands" are often quickly developed and stabilized and geomorphological processes that lead to rebuilding of wetlands and shallow water areas may be precluded. As storm activity increases in severity and regularity, emergency shoreline protection response threatens coastal nearshore habitats primarily through burial by beach restoration efforts. Littoral sand drift has interrupted by the development of stabilized inlet jetties, which has reduced sand budgets. Decreased sand budgets coupled with increased severe storm activity (a known result of increased rates of global warming) necessitate an increase in large-scale beach dredge and fill projects. The direct, secondary and cumulative effects of these activities are known to have a profound effect on EFH through burial of nearshore hard bottom, worm reef, coral reef and sand bottom habitat areas. Loss of habitat areas utilized by various life stages of federally managed species and their prey species will continue to have a negative effect. As the need for such projects increases and the time between projects decreases adverse effects will be amplified.

Hurricanes also cause vertical mixing in coastal waters that results in cooling and nutrient enrichment of surface water and stimulation of algal growth. In estuaries, hurricanes suspend sediment and increase terrestrial runoff that can result in algal blooms and hypoxia in bottom waters (NOAA 2005). Algal blooms and hypoxia can cause fish die-offs and spread disease to other plants and animals.

Climate Change

This section was excerpted from the *Summary Report for Policymakers* based on the assessment carried out by the three Working Groups of the Intergovernmental Panel on Climate Change (IPCC). It provides an integrated view of climate change as the final part of the IPCC's Fourth Assessment Report, released in fall 2007. A complete elaboration of the topics covered in this summary can be found in this Synthesis Report and in the underlying reports of the three Working Groups available online at (http://www.coastalclimate.org/).

<u>Observed changes in climate and their effects</u>

Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level (**Figure 6.1-2**)**.**

Eleven of the last twelve years (1995-2006) rank among the twelve warmest years in the instrumental record of global surface temperature (since 1850). The 100-year linear trend (1906-2005) of 0.74 [0.56 to 0.92]°C 1 is larger than the corresponding trend of 0.6 [0.4 to 0.8]°C (1901-2000) given in the Third Assessment Report (TAR) (**Figure 6.1-2**). The temperature increase is widespread over the globe, and is greater at higher northern latitudes.

Land regions have warmed faster than the oceans (**Figure 6.1-3**). Rising sea level is consistent with warming (**Figure 6.1-2**). Global average sea level has risen since 1961 at an average rate of 1.8 [1.3 to 2.3]mm/yr and since 1993 at 3.1 [2.4 to 3.8]mm/yr, with contributions from thermal expansion, melting glaciers and ice caps, and the polar ice sheets. Whether the faster rate for 1993 to 2003 reflects decadal variation or an increase in the longer-term trend is unclear.

Observed decreases in snow and ice extent are also consistent with warming (Figure SPM.1). Satellite data since 1978 show that annual average Arctic sea ice extent has shrunk by 2.7% (2.1 to 3.3) per decade, with larger decreases in summer of 7.4% (5.0 to 9.8) per decade. Mountain glaciers and snow cover on average have declined in both hemispheres.

From 1900 to 2005, precipitation increased significantly in eastern parts of North and South America, northern Europe and northern and central Asia but declined in the Sahel, the Mediterranean, southern Africa and parts of southern Asia. Globally, the area affected by drought has likely increased since the 1970s.

It is very likely that over the past 50 years: cold days, cold nights and frosts have become less frequent over most land areas, and hot days and hot nights have become more frequent. It is likely that: heat waves have become more frequent over most land areas, the frequency of heavy precipitation events has increased over most areas, and since 1975 the incidence of extreme high sea level has increased worldwide.

There is observational evidence of an increase in intense tropical cyclone activity in the North Atlantic since about 1970, with limited evidence of increases elsewhere. There is no clear trend in the annual numbers of tropical cyclones. It is difficult to ascertain longer-term trends in cyclone activity, particularly prior to 1970.

Average Northern Hemisphere temperatures during the second half of the 20th century were very likely higher than during any other 50-year period in the last 500 years and likely the highest in at least the past 1300 years.

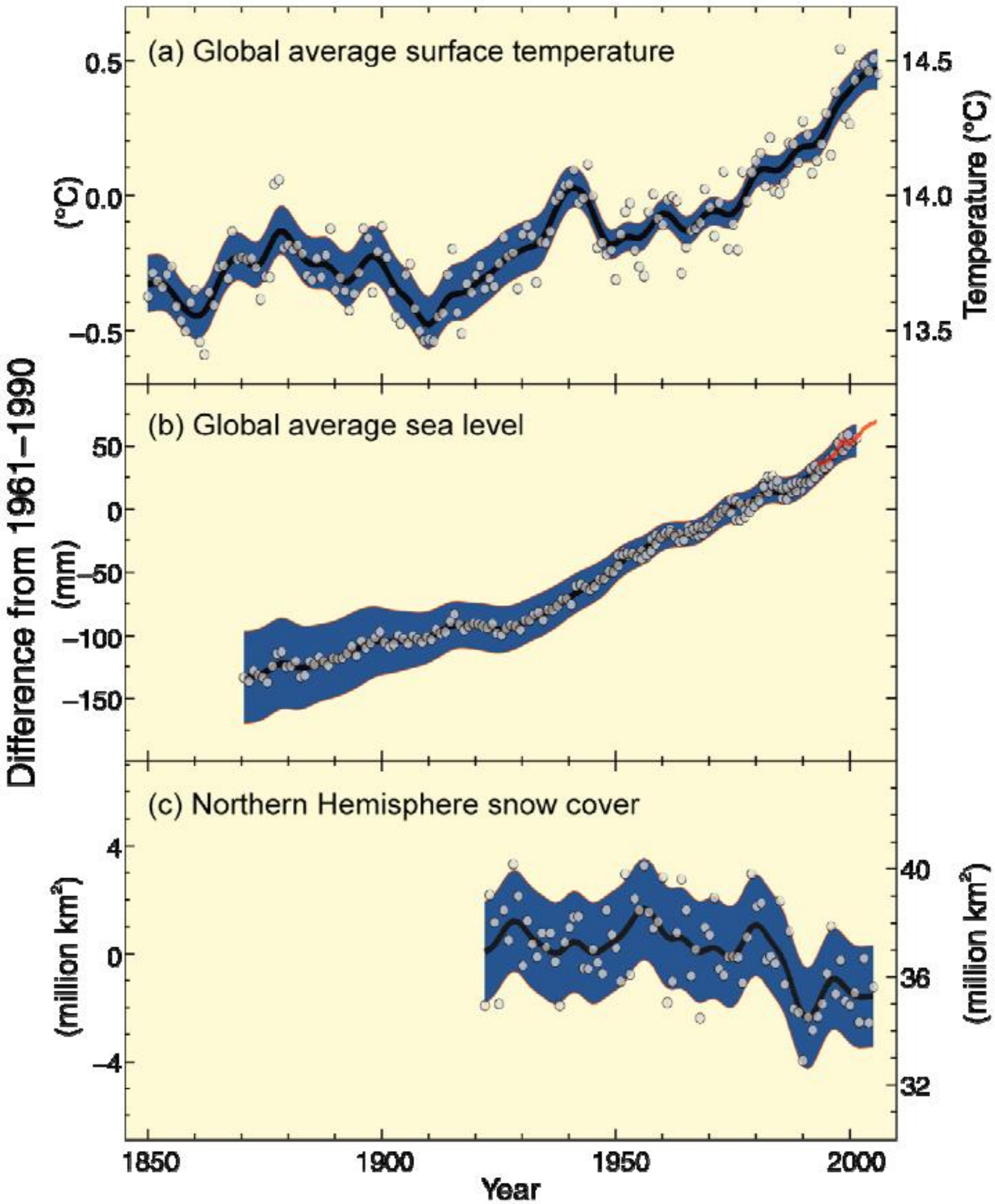

Figure 6.1-2. Observed changes in (a) global average surface temperature; (b) global average sea level from tide gauge (blue) and satellite (red) data and (c) Northern Hemisphere snow cover for March-April. All differences are relative to corresponding averages for the period 1961-1990. Smoothed curves represent decadal averaged values while circles show yearly values. The shaded areas are the uncertainty intervals estimated from a comprehensive analysis of known uncertainties (a and b) and from the time series (c).

Observational evidence from all continents and most oceans shows that many natural systems are being affected by regional climate changes, particularly temperature increases. Changes in snow, ice and frozen ground have with high confidence increased the number and size of glacial lakes, increased ground instability in mountain and other permafrost regions, and led to changes in some Arctic and Antarctic ecosystems.

There is high confidence that some hydrological systems have also been affected through increased runoff and earlier spring peak discharge in many glacier- and snow-fed rivers, and effects on thermal structure and water quality of warming rivers and lakes.

In terrestrial ecosystems, earlier timing of spring events and poleward and upward shifts in plant and animal ranges are with very high confidence linked to recent warming. In some marine and freshwater systems, shifts in ranges and changes in algal, plankton and fish abundance are with high confidence associated with rising water temperatures, as well as related changes in ice cover, salinity, oxygen levels and circulation.

Of the more than 29,000 observational data series, from 75 studies, that show significant change in many physical and biological systems, more than 89% are consistent with the direction of change expected as a response to warming. However, there is a notable lack of geographic balance in data and literature on observed changes, with marked scarcity in developing countries.

There is medium confidence that other effects of regional climate change on natural and human environments are emerging, although many are difficult to discern due to adaptation and non-climatic drivers. They include effects of temperature increases on:

- agricultural and forestry management at Northern Hemisphere higher latitudes, such as earlier spring planting of crops, and alterations in disturbance regimes of forests due to fires and pests
- some aspects of human health, such as heat-related mortality in Europe, changes in infectious disease vectors in some areas, and allergenic pollen in Northern Hemisphere high and mid-latitudes
- some human activities in the Arctic (e.g., hunting and travel over snow and ice) and in lower-elevation alpine areas (such as mountain sports).

<u>Causes of change</u>

Changes in atmospheric concentrations of greenhouse gases (GHGs) and aerosols, land-cover and solar radiation alter the energy balance of the climate system.

Global GHG emissions due to human activities have grown since pre-industrial times, with an increase of 70% between 1970 and 2004. Carbon dioxide (CO_2) is the most important anthropogenic GHG. Its annual emissions grew by about 80% between 1970 and 2004. The long-term trend of declining CO_2 emissions per unit of energy supplied reversed after 2000.

Global atmospheric concentrations of CO_2, methane (CH_4) and nitrous oxide (N_2O) have increased markedly as a result of human activities since 1750 and now far exceed pre-industrial values determined from ice cores spanning many thousands of years. Atmospheric concentrations of CO_2 (379ppm) and CH_4 (1774 ppb) in 2005 exceed by far the natural range over the last 650,000 years. Global increases in CO_2 concentrations are due primarily to fossil fuel use, with land-use change providing another significant but smaller contribution. It is very likely that the observed increase in CH_4 concentration is predominantly due to agriculture and fossil fuel use. Methane growth rates have declined since the early 1990s, consistent with total emissions (sum of anthropogenic and natural sources) being nearly constant during this period. The increase in N_2O concentration is primarily due to agriculture.

There is very high confidence that the net effect of human activities since 1750 has been one of warming.

Most of the observed increase in globally-averaged temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic GHG concentrations. It is likely there has been significant anthropogenic warming over the past 50 years averaged over each continent (except Antarctica) (Figure SPM.4).

During the past 50 years, the sum of solar and volcanic forcings would likely have produced cooling. Observed patterns of warming and their changes are simulated only by models that include anthropogenic forcings. Difficulties remain in simulating and attributing observed temperature changes at smaller than continental scales.

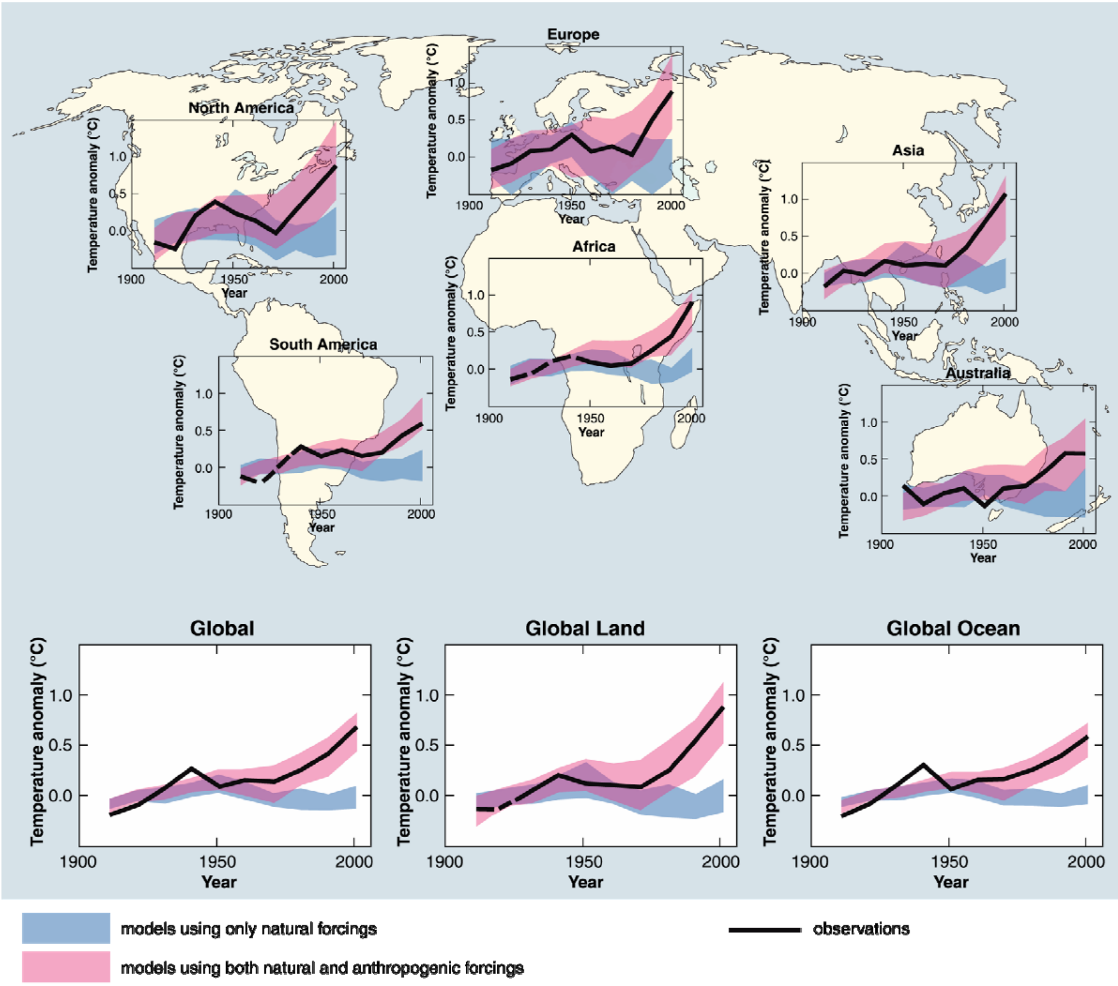

Figure 6.1-3. Comparison of observed continental- and global-scale changes in surface temperature with results simulated by climate models using either natural or both natural and anthropogenic forcings. Decadal averages of observations are shown for the period 1906-2005 (black line) plotted against the centre of the decade and relative to the corresponding average for the period 1901-1950. Lines are dashed where spatial coverage is less than 50%. Blue shaded bands show the 5-95% range for 19 simulations from 5 climate models using only the natural forcings due to solar activity and volcanoes. Red shaded bands show the 5-95% range for 58 simulations from 14 climate models using both natural and anthropogenic forcings.

Advances since the TAR show that discernible human influences extend beyond average temperature to other aspects of climate.

Human influences have:

- very likely contributed to sea level rise during the latter half of the 20th century
- likely contributed to changes in wind patterns, affecting extra-tropical storm tracks and temperature patterns

- likely increased temperatures of extreme hot nights, cold nights and cold days
- more likely than not increased risk of heat waves, area affected by drought since the 1970s and frequency of heavy precipitation events.

Anthropogenic warming over the last three decades has likely had a discernible influence at the global scale on observed changes in many physical and biological systems. Spatial agreement between regions of significant warming across the globe and locations of significant observed changes in many systems consistent with warming is very unlikely to be due solely to natural variability. Several modeling studies have linked some specific responses in physical and biological systems to anthropogenic warming.

More complete attribution of observed natural system responses to anthropogenic warming is currently prevented by the short time scales of many impact studies, greater natural climate variability at regional scales, contributions of non-climate factors and limited spatial coverage of studies.

Projected climate change and its impacts

There is high agreement and much evidence that with current climate change mitigation policies and related sustainable development practices, global GHG emissions will continue to grow over the next few decades.

The IPCC Special Report on Emission Scenarios (SRES, 2000) projects an increase of global GHG emissions by 25-90% (CO_2-eq) between 2000 and 2030, with fossil fuels maintaining their dominant position in the global energy mix to 2030 and beyond. More recent scenarios without additional emissions mitigation are comparable in range.

Continued GHG emissions at or above current rates would cause further warming and induce many changes in the global climate system during the 21st century that would very likely be larger than those observed during the 20th century. For the next two decades a warming of about 0.2°C per decade is projected for a range of SRES emission scenarios. Even if the concentrations of all GHGs and aerosols had been kept constant at year 2000 levels, a further warming of about 0.1°C per decade would be expected. Afterwards, temperature projections increasingly depend on specific emission scenarios.

For an explanation of SRES emission scenarios, see Box 'SRES scenarios' in Topic 3 of this Synthesis Report. These scenarios do not include additional climate policy above current ones; more recent studies differ with respect to UNFCCC and Kyoto Protocol inclusion.

There is now higher confidence than in the TAR in projected patterns of warming and other regional-scale features, including changes in wind patterns, precipitation, and some aspects of extremes and sea ice. Regional-scale changes include:

- warming greatest over land and at most high northern latitudes and least over Southern Ocean and parts of the North Atlantic Ocean, continuing recent observed trends **(Figure 6.1-4)**;

- contraction of snow cover area, increases in thaw depth over most permafrost regions, and decrease in sea ice extent; in some projections using SRES scenarios, Arctic late-summer sea ice disappears almost entirely by the latter part of the 21st century;
- very likely increase in frequency of hot extremes, heat waves, and heavy precipitation;
- likely increase in tropical cyclone intensity; less confidence in global decrease of tropical cyclone numbers;
- poleward shift of extra-tropical storm tracks with consequent changes in wind, precipitation, and temperature patterns; and
- very likely precipitation increases in high latitudes and likely decreases in most subtropical land regions, continuing observed recent trends.

There is high confidence that by mid-century, annual river runoff and water availability are projected to increase at high latitudes (and in some tropical wet areas) and decrease in some dry regions in the mid-latitudes and tropics. There is also high confidence that many semi-arid areas (e.g., Mediterranean basin, western United States, southern Africa and northeast Brazil) will suffer a decrease in water resources due to climate change.

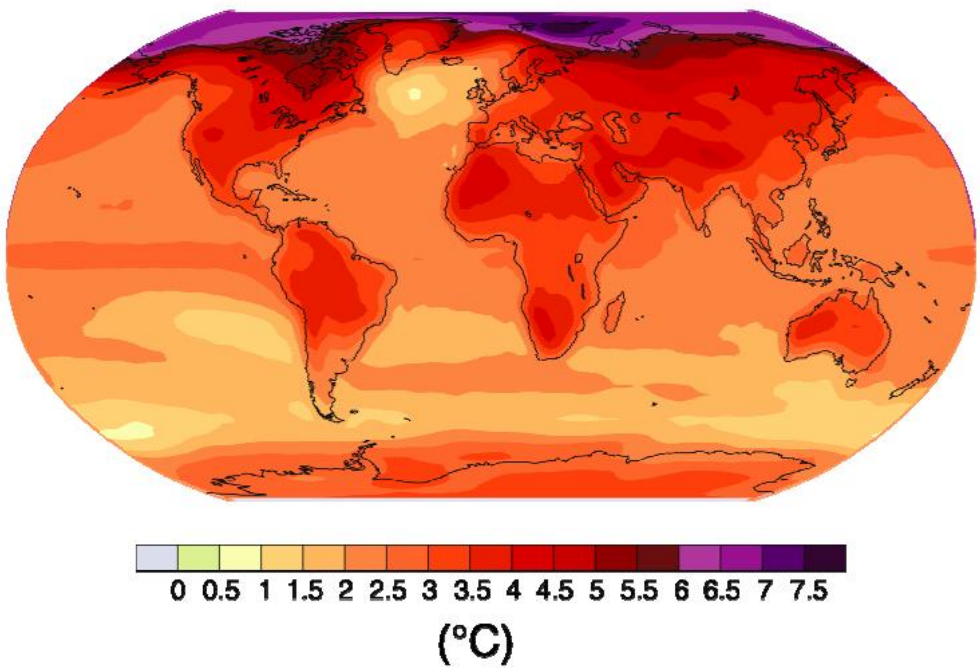

Figure 6.1-4. Projected surface temperature changes for the late 21st century (2090-2099). The map shows the multi- AOGCM average projection for the A1B SRES scenario. All temperatures are relative to the period 1980-1999.

Studies since the TAR have enabled more systematic understanding of the timing and magnitude of impacts related to differing amounts and rates of climate change.

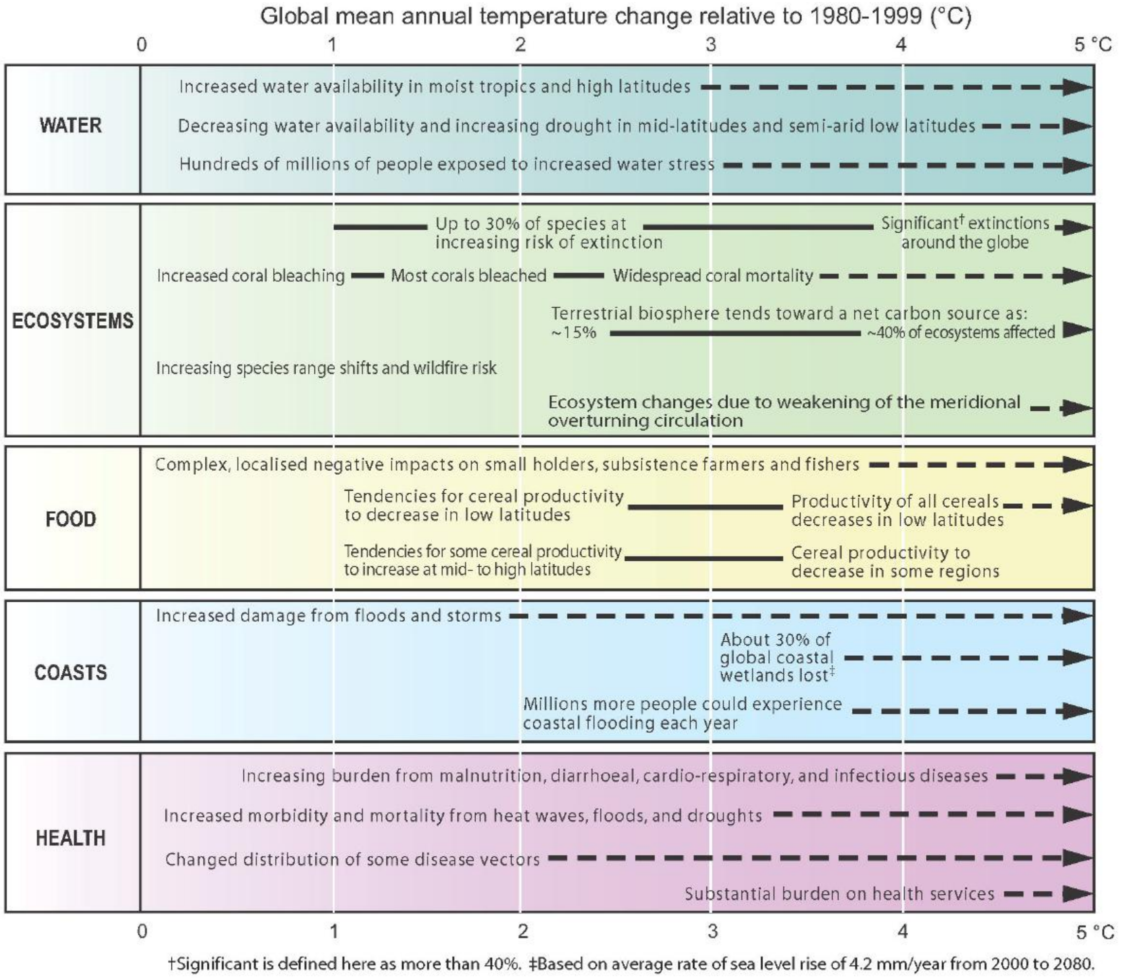

Figure 6.1-5. Illustrative examples of global impacts projected for climate changes (and sea level and atmospheric CO_2 where relevant) associated with different amounts of increase in global average surface temperature in the 21st century.

The black lines link impacts; broken line arrows indicate impacts continuing with increasing temperature. Entries are placed so that the left hand side of text indicates the approximate level of warming that is associated with the onset of a given impact. Quantitative entries for water scarcity and flooding represent the additional impacts of climate change relative to the conditions projected across the range of SRES model scenarios. Adaptation to climate change is not included in these estimations. *Confidence levels for all statements are high.*

Examples of some projected regional impacts in North America:

- Warming in western mountains is projected to cause decreased snowpack, more winter flooding, and reduced summer flows, exacerbating competition for over-allocated water resources.

- In the early decades of the century, moderate climate change is projected to increase aggregate yields of rain-fed agriculture by 5-20%, but with important variability among regions. Major challenges are projected for crops that are near the warm end of their suitable range or which depend on highly utilized water resources.
- During the course of this century, cities that currently experience heat waves are expected to be further challenged by an increased number, intensity and duration of heat waves during the course of the century, with potential for adverse health impacts.
- Coastal communities and habitats will be increasingly stressed by climate change impacts interacting with development and pollution.

Moreover, some systems, sectors and regions are likely to be especially affected by climate change.

- Particular ecosystems
    - terrestrial: tundra, boreal forest and mountain regions because of sensitivity to warming; Mediterranean-type ecosystems because of reduction in rainfall; and tropical rainforests where precipitation declines
    - coastal: mangroves and salt marshes, due to multiple stresses
    - marine: coral reefs due to multiple stresses; the sea ice biome because of sensitivity to warming
- Water resources in some dry regions at mid-latitudes and in the dry tropics, due to changes in rainfall and evapotranspiration, and in areas dependent on snow and ice melt agriculture in low-latitudes, due to reduced water availability.
- Low-lying coastal systems, due to threat of sea level rise and increased risk from extreme weather events.
- Human health in populations with low adaptive capacity.

Altered frequencies and intensities of extreme weather, together with sea level rise, are expected to have mostly adverse effects on natural and human systems.
Examples for selected extremes and sectors are shown in **Table 6.1-3.** These do not take into account any changes or developments in adaptive capacity. The likelihood estimates in column two relate to the phenomena listed in column one.

Table 6.1-3. Examples of possible impacts of climate change due to changes in extreme weather and climate events, based on projections to the mid- to late 21st century.

Phenomenon[a] and direction of trend	Likelihood of future trends based on projections for 21st century using SRES scenarios	Examples of major projected impacts by sector			
		Agriculture, forestry and ecosystems	Water resources	Human health	Industry, settlement and society
Over most land areas, warmer and fewer cold days and nights, warmer and more frequent hot days and nights	*Virtually certain*[b]	Increased yields in colder environments; decreased yields in warmer environments; increased insect outbreaks	Effects on water resources relying on snowmelt; effects on some water supplies	Reduced human mortality from decreased cold exposure	Reduced energy demand for heating; increased demand for cooling; declining air quality in cities; reduced disruption to transport due to snow, ice; effects on winter tourism
Warm spells/heat waves. Frequency increases over most land areas	*Very likely*	Reduced yields in warmer regions due to heat stress; increased danger of wildfire	Increased water demand; water quality problems, e.g. algal blooms	Increased risk of heat-related mortality, especially for the elderly, chronically sick, very young and socially isolated	Reduction in quality of life for people in warm areas without appropriate housing; impacts on the elderly, very young and poor
Heavy precipitation events. Frequency increases over most areas	*Very likely*	Damage to crops; soil erosion, inability to cultivate land due to waterlogging of soils	Adverse effects on quality of surface and groundwater; contamination of water supply; water scarcity may be relieved	Increased risk of deaths, injuries and infectious, respiratory and skin diseases	Disruption of settlements, commerce, transport and societies due to flooding; pressures on urban and rural infrastructures; loss of property
Area affected by drought increases	*Likely*	Land degradation; lower yields/crop damage and failure; increased livestock deaths; increased risk of wildfire	More widespread water stress	Increased risk of food and water shortage; increased risk of malnutrition; increased risk of water-and food-borne diseases	Water shortage for settlements, industry and societies; reduced hydropower generation potentials; potential for population migration
Intense tropical cyclone activity increases	*Likely*	Damage to crops; windthrow (uprooting) of trees; damage to coral reefs	Power outages causing disruption of public water supply	Increased risk of deaths, injuries, water- and food-borne diseases; post-traumatic stress disorders	Disruption by flood and high winds; withdrawal of risk coverage in vulnerable areas by private insurers, potential for population migrations, loss of property
Increased incidence of extreme high sea level (excludes tsunamis)[c]	*Likely*[d]	Salinisation of irrigation water, estuaries and freshwater systems	Decreased freshwater availability due to saltwater intrusion	Increased risk of deaths and injuries by drowning in floods; migration-related health effects	Costs of coastal protection versus costs of land-use relocation; potential for movement of populations and infrastructure; also see tropical cyclones above

Notes:
a) See WGI Table 3.7 for further details regarding definitions.
b) Warming of the most extreme days and nights each year.
c) Extreme high sea level depends on average sea level and on regional weather systems. It is defined as the highest 1% of hourly values of observed sea level at a station for a given reference period.
d) In all scenarios, the projected global average sea level at 2100 is higher than in the reference period. The effect of changes in regional weather systems on sea level extremes has not been assessed.

Anthropogenic warming could lead to some impacts that are abrupt or irreversible, depending upon the rate and magnitude of the climate change. Partial loss of ice sheets on polar land could imply meters of sea level rise, major changes in coastlines and inundation of low-lying areas, with greatest effects in river deltas and low-lying islands. Such changes are projected to occur over millennial time scales, but more rapid sea level rise on century time scales cannot be excluded.

Climate change is likely to lead to some irreversible impacts. There is medium confidence that approximately 20-30% of species assessed so far are likely to be at increased risk of extinction if increases in global average warming exceed 1.5-2.5°C (relative to 1980-1999). As global average temperature increase exceeds about 3.5°C, model projections suggest significant extinctions (40-70% of species assessed) around the globe.

Based on current model simulations, the meridional overturning circulation (MOC) of the Atlantic Ocean will very likely slow down during the 21st century; nevertheless temperatures over the Atlantic and Europe are projected to increase. The MOC is very unlikely to undergo a large abrupt transition during the 21stcentury. Longer-term MOC changes cannot be assessed with confidence. Impacts of large-scale and persistent changes in the MOC are likely to include changes in marine ecosystem productivity, fisheries, ocean CO_2 uptake, oceanic oxygen concentrations and terrestrial vegetation. Changes in terrestrial and ocean CO_2 uptake may feedback on the climate system.

The five “reasons for concern” identified originally in the IPCC’s Third Assessment Report (TAR) remain a viable framework to consider key vulnerabilities. These “reasons” are assessed here to be stronger than in the TAR. Many risks are identified with higher confidence. Some risks are projected to be larger or to occur at lower increases in temperature.

Understanding about the relationship between impacts (the basis for “reasons for concern” in the TAR) and vulnerability (that includes the ability to adapt to impacts) has improved. This is due to more precise identification of the circumstances that make systems, sectors and regions especially vulnerable, and growing evidence of the risks of very large impacts on multiple century time scales.

- **Risks to unique and threatened systems.** There is new and stronger evidence of observed impacts of climate change on unique and vulnerable systems (such as polar and high mountain communities and ecosystems), with increasing levels of adverse impacts as temperatures increase further. An increasing risk of species extinction and coral reef damage is projected with higher confidence than in the TAR as warming proceeds. There is medium confidence that approximately 20-30% of plant and animal species assessed so far are likely to be at increased risk of extinction if increases in global average temperature exceed 1.5-2.5°C over 1980-1999 levels. Confidence has increased that a 1-2°C increase in global mean temperature above 1990 levels (about 1.5-2.5°C above pre-industrial) poses significant risks to many unique and threatened systems including many biodiversity hotspots. Corals are vulnerable to thermal stress and have low adaptive capacity. Increases in sea surface temperature of about 1-3°C are projected to result in more frequent coral bleaching events and widespread mortality, unless there is thermal adaptation or acclimatization by corals. Increasing vulnerability of indigenous communities in the Arctic and small island communities to warming is projected.

- **Risks of extreme weather events.** Responses to some recent extreme events reveal higher levels of vulnerability than the TAR. There is now higher confidence in the projected increases in droughts, heat waves, and floods as well as their adverse impacts.
- **Distribution of impacts and vulnerabilities.** There are sharp differences across regions and those in the weakest economic position are often the most vulnerable to climate change. There is increasing evidence of greater vulnerability of specific groups such as the poor and elderly in not only developing but also developed countries. Moreover, there is increased evidence that low-latitude and less-developed areas generally face greater risk, for example in dry areas and megadeltas.
- **Aggregate impacts.** Compared to the TAR, initial net market-based benefits from climate change are projected to peak at a lower magnitude of warming, while damages would be higher for larger magnitudes of warming. The net costs of impacts of increased warming are projected to increase over time.
- **Risks of large-scale singularities.** There is high confidence that global warming over many centuries would lead to a sea level rise contribution from thermal expansion alone which is projected to be much larger than observed over the 20th century, with loss of coastal area and associated impacts. There is better understanding than in the TAR that the risk of additional contributions to sea level rise from both the Greenland and possibly Antarctic ice sheets may be larger than projected by ice sheet models and could occur on century time scales. This is because ice dynamical processes seen in recent observations but not fully included in ice sheet models assessed in AR4 could increase the rate of ice loss.

There is high confidence that neither adaptation nor mitigation alone can avoid all climate change impacts; however, they can complement each other and together can significantly reduce the risks of climate change.

Adaptation is necessary in the short and longer term to address impacts resulting from the warming that would occur even for the lowest stabilization scenarios assessed. There are barriers, limits and costs, but these are not fully understood. Unmitigated climate change would, in the long term, be likely to exceed the capacity of natural, managed and human systems to adapt. The time at which such limits could be reached will vary between sectors and regions. Early mitigation actions would avoid further locking in carbon intensive infrastructure and reduce climate change and associated adaptation needs.

Many impacts can be reduced, delayed or avoided by mitigation. Mitigation efforts and investments over the next two to three decades will have a large impact on opportunities to achieve lower stabilization levels.

Delayed emission reductions significantly constrain the opportunities to achieve lower stabilization levels and increase the risk of more severe climate change impacts.

In order to stabilize the concentration of GHGs in the atmosphere, emissions would need to peak and decline thereafter. The lower the stabilization level, the more quickly this peak and decline would need to occur.

Sea level rise under warming is inevitable. Thermal expansion would continue for many centuries after GHG concentrations have stabilized, for any of the stabilization levels assessed, causing an eventual sea level rise much larger than projected for the 21st century. The eventual contributions from Greenland ice sheet loss could be several meters, and larger than from thermal expansion, should warming in excess of 1.9-4.6°C above pre-industrial be sustained over many centuries. The long time scales of thermal expansion and ice sheet response to warming imply that stabilization of GHG concentrations at or above present levels would not stabilize sea level for many centuries.

Ocean Acidification

another global change issue relates to changes in the earth's carbon budget and cycle. Carbon cycles through the earth's ecosystems in organic and inorganic forms. Recent increasing trends in carbon dioxide in the earth's atmosphere is shifting the cycle of carbon in the ocean and increasing carbonic acid and a gradual decrease in ocean pH and calcium carbonate. Experimental evidence suggests that if these trends continue, key marine organisms, such as corals and some plankton, will have difficulty maintaining their external calcium carbonate skeletons (Orr et al. 2005).

According to the Intergovernmental panel on Climate Change (2007), the uptake of anthropogenic carbon since 1750 has led to the ocean becoming more acidic with an average decrease in pH of 0.1 units. Increasing atmospheric CO_2 concentrations lead to further acidification. Projections based on SRES scenarios give a reduction in average global surface ocean pH of between 0.14 and 0.35 units over the 21st century. While the effects of observed ocean acidification on the marine biosphere are as yet undocumented, the progressive acidification of oceans is expected to have negative impacts on marine shell-forming organisms (e.g., corals) and their dependent species.

6.2 Adverse impacts of fishing activities under South Atlantic Council Fishery Management Plans

(excerpted from Barnette 2001)

All fishing has an effect on the marine environment, and therefore the associated habitat. Fishing has been identified as the most widespread human exploitative activity in the marine environment (Jennings and Kaiser 1998), as well as the major anthropogenic threat to demersal fisheries habitat on the continental shelf (Cappo et al. 1998). Fishing impacts range from the extraction of a species which skews community composition and diversity to reduction of habitat complexity through direct physical impacts of fishing gear.

The nature and magnitude of the effects of fishing activities depend heavily upon the physical and biological characteristics of a specific area in question. There are strict limitations on the degree to which probable local effects can be inferred from the studies of fishing practices conducted elsewhere (North Carolina Division of Marine Fisheries 1999). The extreme variability that occurs within marine habitats confounds the ability to easily evaluate habitat impacts on a regional basis. Obviously, observed impacts at coastal or nearshore sites should not be extrapolated to offshore fishing areas because of the major differences in water depth, sediment type, energy levels, and biological communities (Prena et al. 1999). Marine communities that have adapted to highly dynamic environmental conditions (e.g., estuaries) may not be affected as greatly as those communities that are adapted to stable environmental conditions (e.g., deep water communities). While recognizing the pitfalls that are associated with applying the results of gear impact studies from other geographical areas, due to the lack of sufficient and specific information within the Southeast Region it is necessary to review and carefully interpret all available literature in hopes of improving regional knowledge and understanding of fishery-related habitat impacts.

In addition to the environmental variability that occurs within the regions, the various types of fishing gear and how each is utilized on various habitat types affect the resulting potential impacts. For example, trawls vary in size and weight, as well as their impacts to the seabed. Additionally, the intensity of fishing activities needs to be considered. Whereas a single incident may have a negligible impact on the marine environment, the cumulative effect may be much more severe. Within intensively fished grounds, the background levels of natural disturbance may have been exceeded, leading to long-term changes in the local benthic community (Jennings and Kaiser 1998). Collie (1998) suggested that, to a large extent, it is the cumulative impact of bottom fishing, rather than the characteristics of a particular gear, that affects benthic communities. Unfortunately, a limitation to many fishing-related impact studies is that they do not measure the long term effects of chronic fishing disturbance. Furthermore, one of the most difficult aspects of estimating the extent of fishing impacts on habitat is the lack of high-resolution data on the distribution of fishing effort (Auster and Langton 1999).

The effects of fishing can be divided into short-term and long-term impacts. Short-term impacts (e.g., sediment resuspension) are usually directly observable and measurable while long-term impacts (e.g., effects on biodiversity) may be indirect and more difficult to quantify. Even more difficult to assess would be the cascading effects that fishery-related impacts may have on the marine environment. Additionally, various gears may indirectly impact EFH. Bycatch disposal and ghost fishing are two of the more well-documented indirect impacts to EFH. While recognizing that these are serious issues that pertain to habitat, this review does not attempt to discuss these due to the secondary nature of the impacts.

The majority of existing gear impact studies focus on mobile gear such as trawls and dredges. On a regional scale, mobile gear such as trawls impact more of the benthos than any other gear. However, other fishing practices may have a more significant ecological effect in a particular area due to the nature of the habitat and fishery. Yet there are few studies that investigate other gear types, especially static gear. Rogers et al. (1998) stated that there are few accounts of the physical contact of static gear having measurable effects on benthic biota, as the area of sea bed affected by each gear is almost insignificant compared to the widespread effects of mobile gear. Regardless, static gear may negatively affect EFH and, therefore, must be considered.

The exact relationship that particular impacts have on the associated community and productivity is not fully understood. While it is clear that fishing activities impact or alter EFH, the result of those impacts or the degree of habitat alteration that still allow for sustainable fishing is unknown (Dayton et al. 1995; Auster et al. 1996; Watling and Norse 1998). Hall (1994) noted that not all impacts are negative. A negative effect at one level may sometimes be viewed as a positive effect at a higher level of biological organization – particular species may be removed in small-scale disturbances yet overall community diversity at the regional scale may rise because disturbance allows more species to coexist.

6.2.1 Fishing Gear Regulations under Council FMPs

The following is a list of gear currently in use (or regulated) in fisheries managed under the South Atlantic Council fishery management plans. In general, if gear is not listed it is prohibited or not commonly used in the fishery:

Snapper Grouper Fishery
Vertical hook-and-line gear, including hand-held rod and manual or electric reel or "bandit gear" with manual, electric or hydraulic reel (recreational and commercial).

Spear fishing gear without rebreathers (recreational and commercial).

Powerheads, except where expressly prohibited in Special Management Zones (SMZs). In addition, the use of explosive charges, including powerheads, is prohibited in the EEZ off South Carolina (recreational and commercial).

Bottom longlines (commercial). Prohibited south of a line running east of St. Lucie Inlet, Florida (27° 10' N. lat.) and in depths less than 50 fathoms north of that line. May not be used to fish for wreckfish.

Sea bass pots (commercial). May not be used or possessed in multiple configurations. Pot size, wire mesh size and construction restrictions. May not be used in the EEZ south of a line running due east of the NASA Vehicle Assembly Building, Cape Canaveral, Florida (28° 35.1' N. lat.).

Special Management Zones (created under the Snapper Grouper FMP). Sea bass pots are prohibited in all Special Management Zones. Fishing may only be conducted with hand-held hook-and-line gear (including manual, electric, or hydraulic rod and reel) and spearfishing gear in specified Special Management Zones; however, in other specified Special Management Zones a hydraulic or electric reel that is permanently affixed to a vessel ("bandit gear") and/or spear fishing gear (or only powerheads) are prohibited.

Shrimp

Penaeid shrimp trawls (commercial). The Shrimp Fishery Management Plan allows North and South Carolina, Georgia and east Florida to request a closure in federal waters adjacent to closed state waters for brown, pink or white shrimp following severe cold weather that results in an 80% or greater reduction in the population of white shrimp (whiting, royal red and rock shrimp fisheries are exempt from a federal closure for white shrimp). During a federal closure, a buffer zone is established extending seaward from shore to 25 nautical miles, inside of which no trawling is allowed with a net having less than 4" stretch mesh. Vessels trawling inside this buffer zone cannot have a shrimp net aboard (i.e., a net with less than 4" stretch mesh) in the closed portion of the federal zone. Transit of the closed federal zone with less than 4" stretch mesh aboard while in possession of penaeid (white, brown and pink) species will be allowed provided that the nets are in an unfishable condition, which is defined as stowed below deck. Specified areas are closed to trawling for rock shrimp.

Rock shrimp trawls (commercial). The minimum mesh size for the cod end of a rock shrimp trawl net in the South Atlantic EEZ off Georgia and Florida is 1-7/8 inches (4.8 cm), stretched mesh. This minimum mesh size is required in at least the last 40 meshes forward of the cod end drawstring (tie off strings), and smaller mesh bag liners are not allowed. A vessel that has a trawl net on board that does not meet these requirements may not possess a rock shrimp in or from the South Atlantic EEZ off Georgia and Florida.

Bycatch Reduction Devices (BRDs). On a penaeid shrimp trawler in the South Atlantic EEZ, each trawl net that is rigged for fishing and has a mesh size less than 2.5", as measured between the centers of opposite knots when pulled taut, and each try net that is rigged for fishing and has a headrope length longer than 16.0 ft. must have a certified BRD installed. The following BRDs are certified for use by penaeid shrimp trawlers in the South Atlantic EEZ: extended funnel, expanded mesh and fisheye.

As of January 12, 2007, on a vessel that fishes for or possesses rock shrimp in the South Atlantic EEZ, each trawl net or try net that is rigged for fishing must have a certified BRD installed.

Turtle Excluder Devices (TEDs). TEDs are required for the penaeid and rock shrimp fisheries.

<u>Red Drum</u>
No harvest or possession is allowed in or from the EEZ (no gear specified).

<u>Golden Crab</u>
Crab traps (commercial). May not be fished in water depths less than 900 feet in the northern zone and 700 feet in the middle and southern zones. Rope is the only allowable material for mainlines and buoy line. Max. trap size equals 64 cubic feet in volume in the Northern zone and 48 cubic feet in volume in the Mid and Southern zones. Traps must have at least 2 escape gaps or rings and an escape panel. Traps must be identified with a permit number.

Coral, Coral Reefs, and Live/Hard Bottom Habitat
Hand harvest only for allowable species (recreational and commercial). A toxic chemical may not be used or possessed in a coral area in the EEZ. A power-assisted tool may not be used to take prohibited coral, allowable octocoral or live rock.

Oculina Bank Habitat Area of Particular Concern: Fishing with bottom longlines, bottom trawls, dredges, pots or traps is prohibited. Fishing vessels may not anchor, use an anchor and chain, or use a grapple and chain.

Coastal Migratory Pelagics
Hook and line gear, usually rod and reel or bandit gear, hand lines, flat lines etc. (recreational and commercial).

Run-around gillnets or sink nets (commercial). A gillnet must have a float line less than 1,000 yards in length to fish for coastal migratory pelagic species. Gillnets must be at least 4-3/4 inch stretch mesh.

Purse seines for other coastal migratory species (commercial) with an incidental catch allowance for Spanish mackerel (10%) and king mackerel (1%).

For Atlantic king mackerel (commercial) north of the Cape Lookout, NC Light (34° 37.3' N. lat.) all gear is authorized except for drift gillnets and long gillnets. South of the Cape Lookout Light the following gear is authorized: **automatic reel, bandit gear, handline, rod & reel.**

For Spanish mackerel (commercial) **automatic reel, bandit gear, handline, rod & reel, cast net, run around gill net and stab net**. Minimum size of 3.5" stretch mesh required for all run around gill nets.

Spiny Lobster
Traps, hand harvest, dip nets and bully nets (recreational and commercial). No poisons or explosives are allowed. No spear, hooks or piercing devices are allowed. A degradable panel is required on non-wooden traps. Traps may not be tended at night. Buoy and trap identification is required.

Dolphin and Wahoo
Pelagic longline, hook and line gear including manual, electric, or hydraulic rod and reels, bandit gear, handline and spearfishing gear (including powerheads). Surface and pelagic longline gear for dolphin and wahoo is prohibited within any "time area closure" in the Atlantic EEZ which is closed to the use of pelagic gear for highly migratory pelagic species (HMS) (commercial).

Sargassum
Nets used to harvest Sargassum be constructed of 4" stretch mesh or larger fitted to a frame no larger than 4 x 6 feet.

6.2.2 Gear Descriptions

6.2.2.1 Mobile Gear

(excerpted from Barnette 2001)

Crab Scrape

A crab scrape is composed of a net bag attached to a rigid frame with short teeth (Figure 1). This gear, used exclusively in state waters, is dragged in the shallow water of bays and estuaries to catch crabs. There are no studies available that document potential damage to habitat. However, due to their design, their use in SAV would likely result in the potential uprooting of some plants, as well as leaf shearing (Barnette, personal observations). However, crab scrapes are not typically employed in vegetated areas due to the amount of plant litter that would fill the net. Penetration of the benthos by the teeth would result in sediment resuspension.

Frame Trawl

Roller frame trawls are primarily utilized to harvest bait shrimp in the State of Florida. They consist of a frame that holds open a net and supports slotted rollers that grip the bottom and turn freely. This motion prevents the scouring and scraping impacts primarily associated with otter trawls. Because participants in the fishery usually operate in shallow water, 9.14 m (30 ft) or less, frame trawls are typically limited to state waters.

A study by Futch and Beaumariage (1965) found that while frame trawls gathered large amounts of unattached algae and deciduous *Thalassia testudinium* leaves, no SAV with roots attached were found in the trawl catch.

Trawls with larger rollers (20.3cm; 8 in diameter) reduced the amount of bycatch material, with most drags uprooting SAV. Damage to SAV beds was noted on several occasions when the boats ran aground. The study concluded that side frame trawls do negligible damage to SAV beds. This conclusion was supported by Meyer et al. (1991; 1999), who found no significant trawl impacts on shoot density, structure, or biomass with increased trawling on turtlegrass (*Thalassia testudinium*). However, these studies did not evaluate the effects of repetitive trawling.

Woodburn et al. (1957) noted that the roller on the bottom of the trawl does cause the leaves ripe for shedding to break off, though this would not negatively impact the plant itself. Higman (1952) concluded that frame trawling is not sufficient to denude vegetated areas permanently or to damage the ecology of such locations. Additionally, Tabb and Kenny (1967), while not explicitly investigating habitat impacts, believed that roller frame trawls do no significant damage to habitat. In contrast to studies that assessed impacts to SAV, Tilmant (1979) found a high incidence of damage to stony corals in a study that investigated frame trawl impacts to hard bottom habitat in Biscayne Bay. Frame trawls turned over or crushed 80% of *Porites porites* and *Solenastrea hyades* and damaged over 50% of sponges and 38% of gorgonians in the trawl path. Macroalgae, including *Halimeda* and *Sargassum*, were heavily damaged. The primary impact on

Sargassum was that it was torn loose from the bottom resulting in an early release to the free floating state. Tilmant (1979) found it doubtful that this action was harmful to *Sargassum* unless it occurred during early column formation. It was concluded that frame trawls have a significant impact on certain benthic organisms (Tilmant 1979).

Furthermore, within dense SAV communities, removal of epibenthic algae, tunicates, sponges, and other primary producers may also be significant. Futch and Beaumariage (1965) recommended that the diameter of the rollers be no less than 15.2cm (6in) and that the teeth of the rakes on the trawls should not extend below the roller. Furthermore, they recommend that boats employed in the frame trawl fishery that operate in shallow water should be of tunneled construction to prevent damage to SAV from propeller scarring. Tabb (1958) recommended that strainer bars should be rigid and aimed into the roller so that regardless of how far forward the net frame tips, the bars cannot dig into the bottom. The results from Tilmant (1979) indicated that extensive damage occurs to hardbottom habitat from frame trawls.

A logical recommendation that can be extrapolated from this study is the prohibition of frame trawling in areas where hardbottom habitat exists. Frame trawls, while causing negligible damage to SAV, are not compatible with hardbottom areas due to the damage it causes to complex vertical habitat (e.g., sponges, corals, gorgonians).

Prohibition on the use of bottom trawls
The use of trawl gear to harvest fish in the directed snapper grouper fishery south of Cape Hatteras, North Carolina (35°15' N. Latitude) and north of Cape Canaveral, Florida (Vehicle Assembly Building, 28°35.1' N. Latitude) is prohibited (SAFMC 1987). A vessel with trawl gear and more than 200 lbs of fish in the snapper grouper fishery on board will be defined as a directed fishery. The amendment also establishes a rebuttable presumption that a vessel with fish in the snapper grouper fishery on board harvested its catch of such fish in the Exclusive Economic Zone.

The Council based the trawl prohibition on habitat destruction and the desire to prevent overfishing of vermilion snapper. Fishes present in live bottom areas are described by Grimes et al. (1982) and include 113 species representing 43 families of predominantly tropical and subtropical fishes. Vermilion snapper were more abundant on the shelf edge than on the open shelf (Grimes et al. 1982). Miller and Richards (1980) described the distribution of live bottom habitat in the South Atlantic Bight and reported the most productive area of the shelf for commercial reef fish as being in the open shelf zone between 33 and 40 meters. Parker et al. (1983) reported on a survey of the areas from Cape Canaveral, Florida to Cape Fear, North Carolina and from Cape Fear to Cape Hatteras, North Carolina. From Cape Hatteras to Cape Fear 14,486 square km between 27 and 101 m were surveyed and contained 2,040 square km (14%) of reef habitat of which only 204 square km (10%) had one meter or more relief (distance from the highest point of the live bottom to the ocean floor). In the area from Cape Fear to Cape Canaveral, 24,826 square km between 27 and 101 m were surveyed and contained 7,403 square km (30%) of reef habitat of which 1,743 square km (7%) had one meter or more relief. The Oregon II cruise report (Anon. 1978) supports the scattered nature of live bottom in the South Atlantic from Cape Canaveral, Florida to Cape Hatteras, North Carolina. The Fishery Management Plan reported that in terms of the entire shelf area, current data suggest that from three to 30% of the shelf is suitable bottom for snapper grouper species (SAFMC 1983a).

The report on effects of a research trawl on live bottom (Van Dolah et al. 1987) documents that habitat damage does occur from the use of trawl gear even in the case of one pass through an area in a controlled study. The abstract is as follows:

"The effects of a research trawl on several sponge and coral species was assessed in a shallow-water, hard-bottom area located southeast of Savannah, Georgia. The study entailed a census of the numerically dominant species in replicate 25-square meter quadrants located along five transects established across a trawling alley. The density of undamaged sponges and corals was assessed in trawled and non-trawled (control) portions of each transect immediately before, immediately after, and 12 months after a 40/54 roller-rigged trawl was dragged through the alley once. Some damage to individuals of all target species was observed immediately after trawling, but only the density of barrel sponges (*Cliona* spp.) was significantly reduced. The extent of damage to the other sponges (*Ircinia campana, Haliclona oculata*), octocorals (*Leptogorgia virgulata, Lophogorgia hebes, Titanideum frauenfeldii*) and hard corals (*Oculina varicosa*) varied depending on the species, but changes in density were not statistically significant. Twelve months after trawling, the abundance of specimens counted in the trawled quadrants had increased to pre-trawl densities or greater, and damage to the sponges and corals could no longer be detected due to healing and growth. Trawl damage observed in this study was less severe than the damage reported for a similar habitat in a previous study. Differences between the two studies are attributed to (1) differences in the roller-rig design of the trawls used, and (2) differences in the number of times the same bottom was trawled."

The authors point out that in a study by Tilmant (1979) looking at the effects of commercial bait shrimping with roller-frame trawls in a shallow-water area of Biscayne Bay, Florida damage was much more severe: "Tilmant observed severe damage (specimens crushed or torn loose) to more than 80% of the stony corals, 50% of the sponges and 38% of the soft corals along the trawl path." It should be noted however, that this frame trawl consists of a solid, rectangular frame to which a net is attached and is used to fish grass bed areas; it was not designed to "roll over" live bottom and would be expected to cause significant damage to corals, etc.

Importantly, habitat damage described by Van Dolah et al. (1987) resulted from one tow of trawl gear through the study area. That study was designed to evaluate the effects of a research trawl that does not typically cross the same bottom area more than once. Commercial trawling does not operate in this manner. Under commercial fishing conditions, a live bottom area would be fished over and over until the catches from such an area become unprofitable. Under such conditions, habitat damage would be expected to be much greater than is indicated from the above study.

The *Oregon II* cruise report (Anon. 1978) indicated that drags with a trawl yielded a total catch of 476 lbs which included 424 lbs of finfish and 46 lbs of sponges and corals (10% of the total catch). This area was reported to have been on a mud bottom but turned out to be a low profile live bottom of sand ridges, clumps of sponges and scattered corals. Further indication of habitat damage is reported by Wenner (1983):

"The 3/4 Yankee trawl net effectively covers a much wider area of the bottom than the measured sweep (8.7 m) due to the configuration of the otter doors, ground cables, and bottom leg lines. Although this arrangement cannot increase the actual spread of the net beyond the headrope length, the passage of these cables over the substrate creates a disturbance that serves to herd fish in the path of the net (Baranov 1969). This net does, however, damage the sponge-coral habitat by shearing off sponges, soft corals, bryozoans, and other attached invertebrates. The 56 trawl tows made in the sponge-coral habitat for this study collected 2,351 kg of attached invertebrates (including sponges, soft corals, tunicates, bryozoans, and hydroids) yielding an average 42 kg/tow. This is only the amount of bottom material actually removed from the habitat. An estimate of the total amount of bottom destroyed by the doors, ground cables, and leg lines cannot be ascertained from the current study.

Personal observations and interviews with commercial fishermen attest to the productivity of the sponge-coral habitat. Most studies indicate the importance of habitat availability and space in determining the abundance and diversity of reef fishes (Emery 1978). With this in mind, and given the knowledge that 1) the use of the 3/4 Yankee trawl net reduces the amount of attached invertebrate growth (the amount damaged by doors and ground cables is presently not quantifiable); 2) the places where the invertebrates had been attached may be sanded over and rendered unsuitable for recolonization; and 3) the removal of these attached invertebrates reduces refugees for decapods, polychaetes, etc., that are food items for *Centropristis striata* and other benthic feeders, one must conclude that the continued use of this trawl net reduces the amount of productive fish habitat. For these reasons, in addition to the ineffectiveness of the gear in sampling commercially important species, alternate nondestructive methods, such as direct observations or the use of mark-recapture techniques with trap catches, should be employed in assessment surveys of the commercially important species of this habitat."

Results of trawl survey work in Australia provide some insight into what can happen to catches in an area after the continued use of commercial trawl gear. Young and Sainsbury (1985) report that "At moderate to low levels of fishing effort, the main effect of fishing on the relative abundance of bottom shelf fishes is by alteration of the relative frequency and spatial distribution of habitat types. In particular this refers to the conversion of areas with dense epibenthos (sponge, corals, hydroids, gorgonians) to areas with sparse epibenthos. (It may be noted that even at the relatively low intensity of trawling of the past few years the fishing effort exerted on the main trawl grounds is sufficient to sweep 50 to 100 per cent of the area of those grounds per year.)." These results are from trawling conducted in 1982 as compared to trawl catches in 1966 from the same locations and at the same time of year. The catch composition shifted from species associated with sponges, soft corals, etc. (during 1966) to those associated with open sandy bottom (during 1982).

A similar type of scenario for the South Atlantic was suggested by Bob Low (pers. comm.):
"Parker et al. (1983) estimated that, in the area they surveyed between Cape Fear and Cape Canaveral, there were 7,403 square km of reef habitat. Of this, 1,743 square km had an average profile exceeding 1 m. Assuming that such ground could not be trawled, this leaves about 5,660 square km (1,398,000 acres) of trawlable reef habitat. The average boat might pull a net with a footrope of 120 feet, giving an effective sweep of the roller gear of about 72 feet maximum. A typical tow over open bottom is perhaps 3 hours at 2 knots. The area swept by the roller gear per tow is then about 20 acres/hour or 60 acres/tow. Assume that 20 boats participate for 4 months (January-April) each year. [Note: The actual number of vessels during 1987 was seven.] The average vessel makes 3 trips/month, with 3 days of fishing each trip. The average (24 hr) fishing day includes perhaps 4 tows. A typical trip therefore consists of 12 tows or 36 hr of fishing. The 20 boats make an aggregate of 240 trips. This equates to 2,880 tows, covering around 172,800 total acres. If each tow was over a previously unswept area, the total area covered by the roller gear would then amount to about 12% of the trawlable reef habitat estimated by Parker et al. (1983). Under one set of assumptions, the area affected by the doors, bridles, and warps would add to this. Under a second set, repetitive trawling over identical areas would reduce the total area impacted. Van Dolah et al. (1987) noted a substantial renewability within a year. There are likely to be 8 months of recovery time between trawling seasons. Doesn't that allow for significant restoration in many of the trawled areas?"

The above scenario indicated that about 12% of available habitat between Cape Fear and Cape Canaveral would be impacted annually by trawling, whereas in the Australian work the area impacted was between 50 and 100%. The Council has concluded that the level of damage to the live-bottom habitat in the South Atlantic is significant and that our available knowledge is not sufficient to risk impacting the long-term abundance of snapper and groupers by reducing their habitat. The results shown by Van Dolah et al. (1987) indicated that regeneration of tissue sufficient to have rounded off the tops of partially severed sponges and to have closed wounds on other sponges occurs within a year but that additional growth is limited as indicated by some of the sponges being obviously shorter than before the trawling damage. This supports the Council's concern because in a four month trawling season there would be a net loss of habitat (i.e., more damage than regrowth) with the effects being cumulative over time. By destroying habitat we destroy the productivity of the resource being harvested and we are in essence drawing on the principal, not just taking the interest so that next year the same amount of trawling will represent more than 12% of the habitat and the year after even more. Given this information, the South Atlantic Fishery Management Council concluded that over the long-term there would be a net loss of existing habitat, which is counter to the Council's habitat policy and the Magnuson-Stevens Act.

Indirect evidence of habitat damage is provided in Christian et al. (1985) where they report on attempts to use crab nets rigged with light chain and plastic mud rollers. These nets proved to be inadequate for offshore fish trawling on broken bottom because the light molded plastic mud rollers were not durable and did not prevent net damage. They further reported that captains who tried crab nets soon switched to nets with heavy netting, properly rigged sweep systems and steel vee-doors for trawling over rough bottom. Further indication of habitat damage was presented in Section II of Snapper Grouper Amendment 1 with the numerous references to gear damage, gear loss and the need to use rollers and modified doors to be able to trawl in rough and broken areas.

An additional reference concerning potential habitat damage is provided by Moore and Bullis (1960) when they reported on the discovery of a deep water reef in the Gulf of Mexico. The MV *Oregon* was cruising over the continental slope about 40 nautical miles due east of the Mississippi Delta and observed an unusual tracing on the depth recorder. They sampled this bottom area using a shrimp trawl and reported the following: "A drag, made over the area with a shrimp trawl, contained a large mass of coral, other invertebrates, and fish. The netting of the trawl was torn and most of its contents were lost, but about three hundred lbs of coral remained in the bag. A sample was brought back to the laboratory where it was identified by Moore as *Lophelia prolifera*."

Invertebrates associated with sponges and corals occur in disproportionately high densities which suggest that they may use sponges and corals as a food source or a refuge from predation (Wendt et al. 1985). These invertebrates in turn serve as a food source for various snapper and grouper species. In addition, corals are very slow growing with some such as *Oculina* sp. only growing between 11 and 16 mm per year (Reed 1981). Damage to these areas can negatively affect the food and shelter available to snappers and groupers. Further, Grimes et al. (1982) note the importance of the live bottom and shelf edge habitats in serving as reservoirs for recruits in shallow areas (less than 30 m).

The best estimate of the number of boats operating in the fishery during the winter of 1986/87 was four boats (one South Carolina boat fishing in South Carolina and three North Carolina boats fishing in South Carolina, Georgia and Florida). The number of vessels increased to seven during the winter of 1987/88. These vessels fished during the slow period for shrimp which is normally January to March/April. Even though the actual number of boats is small, the amount of habitat damage is significant when one realizes that these boats fish directly on the limited live bottom habitat in these areas. Productive snapper grouper habitat on the continental shelf is limited and trawl gear is fished repeatedly in these areas over this three to four month period. Most, if not all, fishermen use Loran which allows them to return to the exact spot and trawl a particular rock out-cropping repeatedly. The data previously described from Australia points out the changes to bottom habitat and catches resulting from such a fishery.

Vermilion snapper in the early 1980s were experiencing growth overfishing (see SAFMC 1983a p. 44-58 for a more detailed discussion). Yield per recruit (or yield per individual) analysis indicated that a 12 inch minimum size will increase yield per recruit from 132 g to 177 g which is equivalent to a 34% increase in yield if recruitment is constant.

Confidential data available to the South Atlantic Council indicated that the minimum mesh size of 4 inches is not being adhered to and as a result the Council's prior action establishing the mesh restriction has not been effective in releasing small vermilion (less than 12 inches). The trawl prohibition will result in an increase in yield for vermilion snapper. Catch data from South Carolina (Bob Low, pers. comm.) show a slight negative correlation between trawl landings and hook & line landings (r = -0.13). A good fishery independent index of abundance would allow us to examine the affect of trawl catches on abundance of vermilion snapper. Given the available information, the South Atlantic Fishery Management Council concluded that the trawl prohibition would increase yield; however, our ability to measure this increase is lacking.

The potential existed for more vessels to enter the fishery particularly if the calico scallop, shrimp and sea scallop fisheries have not been productive or are not active during this time period. The actual number of vessels during 1987/88 was seven, greater than the number expected. This further supported the Council's concern that effort could have increased rapidly.

Impacts on affected vessels from prohibiting use of trawl gear in the snapper grouper fishery were not significant. Input from public hearings, committee and Council meetings indicated that income from fish trawling made up a small portion of total income. No trawl fishermen came forward with information during the public hearing process indicating that impacts would be significant. Fishermen used this fishing method primarily as a fill-in activity and had the ability to utilize other gear (e.g., electric & hydraulic reels, black sea bass traps, longlines, etc.) to fish snappers and groupers. These general conclusions are supported by the following in Christian et al. (1985):

“The major seafood industry in the South Atlantic Bight is based on shrimp, and this dependence on one crop has made the industry financially precarious....Therefore, fishermen have looked to other activities such as bottom trawling for finfishes to supplement their income. This is not the single salvation for the whole industry. Although fish trawling can offer an alternative which may aid some shrimpers in maintaining year-round income, suitable trawling bottom in this area is limited, and target species of such a fishery (snapper, grouper, and porgies) are relatively long-lived, slow-growing, and can sustain only limited fishing pressure.”

Hydraulic Escalator Dredge

Hydraulic escalator dredges have been utilized since the 1940s to harvest shellfish such as clams and oysters and are designed expressly for efficient commercial harvest (Coen 1995). The dredge consists of a water pump supplying a manifold with numerous water jets mounted in front of a conveyer belt that dislodges buried organisms from the sediment (Figure 3). Hydraulic escalator dredges are currently only employed in a limited shellfish fishery in South Carolina state waters. Hydraulic escalator dredges may penetrate the benthos approximately 45.7cm (18in), thus disturbance to the sediment may be substantial (Coen 1995). Increased turbidity, burial/smothering, release of contaminants, increased nutrients, and removal of infauna were offered as potential effects from dredging activities (Coen 1995). Turbidity was found to be elevated only in the immediate vicinity of the harvester operation and downcurrent of the study area to a distance of between 1.5-1.75km. Turbidity values returned to baseline levels within a few hours (Maier et al. 1998). Manning (1957) stated that hydraulic clam dredging can result in severe damage to oysters within a distance of 7.6m (25ft) downcurrent from the site of dredging. Enough sediment was displaced and redeposited to a distance of at least 15.2m (50ft), but not more than 22.9m (75ft) downcurrent, to cause possible damage to oyster spat. Beyond about 22.9m (75ft) there was no visible or measurable change in the experimental area. Sediment plumes caused by dredge activity were found by Ruffin (1995) to range from less than 1 to 64 hectares. Although sediment plumes increased turbidity and light attenuation at all depths, plumes in shallow water (less than 1.0 m) caused greater increase in turbidity and light attenuation over background than did plumes in deeper waters. Plume decay is based largely on sediment size, with sand particles settling quickly while the silt/clay particles remain in suspension longer. Sites were monitored for storm disturbance to compare against dredge impacts. Storm events increased turbidity and light attenuation com pare d to calm days but not to the extremes obtained in sediment plumes.

Storm events affect a large area at a low intensity while dredging intensely affects a more localized area. SAV subjected to decreased light penetration will inhibit reproduction, reduce propagule abundance, and structurally weaken SAV due to the need of plants growing higher into the water column (Ruffin 1995). Ruffin (1995) concluded that clam dredging increased light attenuation to the point of inhibiting SAV growth. As may be expected, hydraulic clam dredges are highly destructive t o SAV within the immediate area of intensive dredging (Manning 1957; Godcharles 1971). Due to the capability of the water jets to penetrate the substrate to a depth of 45.7cm (18in), virtually all attached vegetation in its path is uprooted (Godcharles 1971). As the use of this gear is limited to a fishery in South Carolina where SAV does not exist, discussion of SAV impacts are included only to provide information on potential impacts should this gear type be considered in the future for other geographic area s where SAV may be found. Although there may be physical impacts associated with escalator dredge activity, the chemical effects apparently are not as dramatic. Dissolved oxygen, pH, and dissolved hydrogen sulfide were measured throughout the harvesting process at varying distances. No consistent patterns of depression or release were noted. Only in the direct plume of the harvester did they measure even a temporary reduction in dissolved oxygen and pH (Coen 1995). While it is recognized that there is infaunal and epifaunal species mortality associated with escalator dredge activity, based on all evidence, these community impacts appear to be short-term (Godcharles 1971; Peterson et al. 1987a; Coen 1995). Coen (1995) noted that the escalator possibly provides a tilling effect of the bottom that has been observed to be beneficial to subtidal oyster and clam populations. Typically, shellfish dredging operations have typically not been considered to have deleterious results, since its effects are perceived to be negligible compared to natural environmental variation (Godwin 1973). Coen (1995) concluded that based on all direct and indirect evidence, the short-term effects of subtidal escalator harvesters are minimal, with no long-term chronic effects, even under worst case scenarios. Observed effects were often indistinguishable from ambient levels or natural variability.

Recovery of the benthos may vary greatly depending on sediment composition. Shallower trenches with shorter residency times are typical of coarse sediments (i.e., sand), whereas trenches generated in muddy, finer sediments are typically deeper, often persisting for greater than 18 months (Coen 1995). Godcharles (1971) observed that trenches had filled in between 1 to 10 months, depending on bottom type. In regard to SAV, no trace of *Thalassia testudinium* recovery was evident after more than 1 year, though *Caulerpa prolifera* began to re-establish itself in dredge areas within 86 days (Godcharles 1971).

Otter Trawl

Perhaps the most widely recognized and criticized type of gear employed in the southeast region is the otter trawl. Utilized in both state and Federal waters of the Gulf of Mexico and South Atlantic, otter trawls pursue invertebrate species such as shrimp and calico scallops, as well as finfish species such as flounder and butterfish. As the most extensively utilized towed bottom-fishing gear (Watling and Norse 1998), trawls have been identified as the most wide-spread form of disturbance to marine systems below depths affected by storms (Watling and Norse 1998; Friedlander et al. 1999).

Jones (1992) broadly classified the way a trawl can affect the seabed as: scraping and ploughing; sediment resuspension; and physical habitat destruction, and removal or scattering of non-target benthos. The following discussion attempts to group documented impacts into either physical-chemical (e.g., sediment resuspension, water quality) or biological impact categories. In many instances documented habitat impacts overlap these categories.

Physical-Chemical Repercussions

The degree to which bottom trawls disturb the sediment surface depends on the sediment type and the relationship between gear type, gear weight, and trawling speed (ICES 1991). Various parts of trawl gear may impact the bottom including the doors, tickler chains, footropes, rollers, trawl shoes, and the belly of the net. While the components of trawl gear are similar, trawl design may vary greatly. Potential impacts may be shared by all otter trawls, but differences in the weight of trawl doors, footrope design, and operation (tow times), will result in a broad spectrum of impact severity. Furthermore, the number and weight of tickler chains vary the degree of disturbance. Margetts and Bridger (1971) concluded that the cumulative effect of tickler chains is likely to emulsify the sediment to a depth proportional to the number of chains. Additionally, the cumulative effect of intense otter trawling is as important as gear weight and design in impacting the benthos (Ball et al. 2000). Although the effect of one passage of a fishing (trawl) net may be relatively minor, the cumulative effect and intensity of trawling may generate long-term changes in benthic communities (Collie et al. 1997). Trawl gear disturbs the benthos as it is dragged along the bottom. Otter trawl doors, mounted ahead and on each side of the net, spread the mouth of the net laterally across the sea floor. The spreading action of the doors results from the angle at which they are mounted, which creates hydrodynamic forces to push them apart and, in concert with the trawl door's weight, also to push them toward the sea bed (Carr and Milliken 1998). The doors, due to their design and function, are responsible for a large proportion of the potential damage inflicted by a trawl. The footrope runs along the bottom of the net mouth and may be lined with lead weight and rollers. On relatively flat bottom, it is expected that the footrope would not have a major effect on the seabed and its fauna (ICES 1995). However, in areas of complex benthic habitat the footrope would likely have more impact with the benthos.

The South Atlantic Draft Calico Scallop FMP noted that during the early years of the calico scallop fishery, large quantities of benthic material were removed by trawlers. Reports were received during numerous meetings about entire “rocks” being removed. One individual provided a print-out from a depth sounder which indicated a large amount of bottom relief in a particular area prior to the calico scallop fishery. Similar bottom plots after the calico scallop fishery operated in that area indicated a relatively flat bottom (SAFMC 1998b). Additionally, while the footrope generally causes little physical substrate alteration aside from smoothing of bedforms and minor compression on relatively flat bottoms (Brylinsky et al. 1994), these minor compressions can lead to sediment “packing” after repeated trawling activity on the same general areas (Schwinghammer et al. 1996; Lindeboom and de Groot 1998). Further compression can result from the dragging of a loaded net (cod end) along the bottom. The remaining path of the trawl is influenced by the ground warps which, while not in direct contact with the seabed, can create turbulence that resuspends sediment (Prena et al. 1999).

Trawl gear, particularly the trawl doors, penetrates the upper layer of the sediments which liquefies the affected sedimentary layers and suspends sediment in the overlying water column. This sediment “cloud” generated by the interaction of the trawl gear with the benthos and the turbulence created in its wake contributes to fish capture (Main and Sangster 1979; 1981). The appearance of the sediment cloud, but not its size, is governed by the type of seabed. Brief observations on different seabed types show that soft, light-colored mud produces the most opaque and reflective type of cloud and the fine mud remains in suspension much longer than coarse sand. Studies of sediment disturbance by trawls vary greatly, though it can be concluded that benthic habitat areas composed of fine sediments (e.g., clay, mud) are affected to a greater degree than those with coarse sediments (e.g., sand). In sandy sediments, otter boards cannot penetrate deeply due to the mechanical resistance of the sediment, and the seabed in sandy areas is more rapidly restored by waves and currents (DeAlteris et al. 1999). Short-term alterations to sediment size distribution result from the various rates of redeposition of suspended sediments; as noted before, coarse grains (i.e., sand) settle out rapidly while fine grains (i.e., silt) settle out relatively slowly. In general, resuspended sediments settle out of the water column at a rate inversely proportional to sediment size (Margetts and Bridger 1971). Transport of fine-grained sediments away from trawled area s due to this slow settling period may result in permanent changes to the sediment grain size of a trawled area. Again, this effect will be more pronounced in mud/silt habitats than in habitat areas consisting of heavier sand. For example, suspended sediment concentrations of 100-500mgl-1 were recorded 100m astern of shrimp trawls in Corpus Christi Bay, Texas (Schubel et al. 1979), an estuary dominated by muddy sediments. The same study estimated that the total amount of sediment disturbed annually as a result of shrimp trawling was 25-209,000,000m^3, which is 10-100 times greater than the amount dredged during the same period for maintenance of shipping channels in the same area.

ICES (1973) concluded that the physical effects of trawling in tidal waters cannot be permanent. However, it is possible that frequently repeated trawling of one ground with a mixed sediment type bottom in strongly tidal waters might ultimately alter the nature of the bottom towards being predominantly coarse sand because the finer particles are carried away to settle elsewhere. In deeper waters, impacts may be more profound and longer lasting. Engel and Kvitek (1998) investigated two adjacent areas in 180m of water to determine the differences between a heavily trawled site and a lightly trawled site. The data indicated that intensive trawling significantly decreased habitat heterogeneity. Rocks and mound s were less common and sediments and shell fragments were more common in the highly trawled area. Rocks and mounds were more abundant in the lightly trawled area, as well as the amount of flocculent matter and detritus. They theorized that less trawling most likely results in an area with more topographical relief and allows for the accumulation of debris, whereas consistent trawling removes rocks, smoothes over mounds, and resuspends and removes debris. Likewise, Kenchington (1995) found that sand ripples were flattened and stones were displaced after a trawl passage. Churchill (1989) modeled sediment resuspension by trawling and found that this may be a primary source of suspended sediment over the outer shelf where storm-related bottom stresses are weak.

Otter trawl doors were found to have a maximum cutting depth of 50 - 300mm (Drew and Larsen 1994) and, according to Schubel et al. (1979), the footropes of shrimp trawlers in Texas disturbed approximately the upper 50mm of the sediment. Schwinghamer et al. (1996) observed that while the trawl doors may leave scours or depressions, trawling activity reduces the overall surface roughness. Ripples, detrital aggregations, and surface traces of bioturbation are smoothed over by the mechanical action of the trawl and the suspension and subsequent deposition of the surface sediment. In general, the passage of an otter trawl was found to have a minor physical and visual impact on the soft sedimentary sea bed, represented by a flattening of the normally mounded sediment surface and some disturbance of the sessile epifauna (Lindeboom and de Groot 1998). The potential to suspend sediments varies greatly, in large part due to the type of sediment a trawl is working on. Regardless, the suspension of sediments, whether fine silt or coarse sand, impacts the chemical and physical attributes of water quality. The resuspension of sediments may influence the uptake or release of contaminants and, depending on the frequency of disturbance, the nature of the contaminant(s). Clearly, such effects may be more significant where contaminant burdens are relatively high, (e.g., near areas affected by major industrialization,) (ICES 1995). Repetitive trawling on the same ground may enhance nutrient release from sediments and that estimates of average trawling effort for large areas may be unsuitable for estimating these effects (ICES 1995). This has important implications on nutrient cycling in areas that are regularly trawled. Pilskaln et al. (1998) found that impacts include burial of fresh organic matter and exposure of anaerobic sediments; large nutrient delivery to the water column, possibly impacting primary production; increase in nitrate flux out of the sediments; and reduced denitrification (conversion of remineralized nitrogen into $N2$ gas). All of these may have desirable or undesirable ecosystem impacts. An increase in nitrate fluxes to the water column may alter primary production (phytoplankton), potentially benefiting fisheries, or stimulating deleterious phytoplankton growth that results in harmful algal blooms (Pilskaln et al. 1998).

Increased water turbidity as a result of trawling activity has the potential to compress the width of the euphotic zone, wherein light levels are sufficient to support photosynthesis (North Carolina Division of Marine Fisheries 1999). The magnitude of this effect depends on sediment size, duration and periodicity of the trawling event, gear type, season, and site-specific hydrographic and bathymetric features (Paine 1979; Kinnish 1992).

Dredging studies would indicate that the effect of turbidity is greatly dependent on local conditions. Windom (1975) found that sediment resuspension caused by dredging operations significantly reduced phytoplankton growth in a naturally clear estuary (south Florida) but not in a naturally turbid estuary (Chesapeake Bay). Additionally, increased turbidity resulting from trawling activities may reduce primary production of benthic microalgae. This may have serious consequences as benthic microalgae support a variety of consumers and can be a significant portion of total primary production (Cahoon and Cooke 1992; Cahoon and Tronzo 1992; Cahoon et al. 1990; 1993). Increased turbidity also has may reduce the foraging success of visual predators (Minello et al. 1987) and contribute to the mortality of organisms by impeding the normal functioning of feeding and respiratory structures (Sherk et al. 1975). Sediment resuspension may increase the amount of organic matter resulting from enhanced primary production and may stimulate heterotrophic microbial production. If the amount of resuspended organic material is copious, sustained proliferation of heterotrophic microflora will reduce the dissolved oxygen content within the water, and widespread hypoxia or anoxia could ensue to the detriment of benthic and pelagic fauna (West et al. 1994). Conversely, oxygen penetration into the sediment might be enhanced through trawling activity, resulting in shifts in mineralization patterns and redox-dependent chemical processes. Among other consequences, a change from anaerobic to aerobic conditions facilitates the degradation of hydrocarbons. As Kaiser (2000) pointed out, bottom trawls are designed to stay in close contact with the seabed and an inevitable consequence of their design is the penetration and resuspension of the seabed to some extent. While it is possible to reduce the direct physical forces exerted on the seabed by modifying fishing practices, the benefits are questionable and catches would most certainly suffer. Despite attempts to improve gear design, as long as bottom dwelling species are harvested using towed gear, there will be inevitable sediment resuspension.

Biological Repercussions

The physical disturbance of sediment, such as the ones previously discussed, can also result in a loss of biological organization and reduce species richness (Hall 1994). In general, the heavier the gear and the deeper its penetration of the sediment, the greater the damage to the fauna. Impacts also will vary depending on type of habitat the gear is working. Gibbs et al. (1980) determined that shrimp trawling occurring within a sandy estuary had no detectable effect on the macrobenthos. After repeated trawls the sea bottom appeared only slightly marked by the trawl's passage. However, Eleuterius (1987) noted that scarring due to shrimp trawls in Mississippi SAV was common, especially in deeper water. Trawling activities left tracks and ripped up the margins of the beds, and great masses of seagrass were often observed floating on the surface following the opening of shrimp season. Furthermore, Wenner (1983) noted that the use of an otter trawl on hardbottom habitat may inflict considerable damage. The net damages the sponge-coral habitat by shearing off sponges, soft corals, bryozoans, and other attached invertebrates. Therefore, it is not necessarily that trawl gear is doing a constant level of damage, but rather particular habitats are more vulnerable to impacts than others.

Numerous studies cite specific, direct biological impacts to habitat such as the reduction of algal and SAV biomass (Tabb 1958; Fonseca et al. 1984; Bargmann et al. 1985; Peterson et al. 1987a; Sánchez-Lizaso et al. 1990; Guillén et al. 1994; Ardizzone et al. 2000). Gelatinous zooplankton and jellyfish, which provide habitat to juvenile and other fish species, are greatly impacted as they pass through the mesh of mobile gear (Auster and Langton 1999). Fishing activity may reduce the size and number of zooplankton aggregations and disperse associated fishes. Furthermore, there is a directed trawl fishery for cannonball jellyfish in the Gulf of Mexico.

While this fishery removes jellyfish which may provide habitat for juvenile fish, otter trawls utilized in this fishery do not interact with the benthos. Trawls in the Gulf of Mexico and South Atlantic have been noted to impact coral habitat, damaging and destroying various colonies (Moore and Bullis 1960; Gomez et al. 1987; Bohnsack, personal observation). Loss of sponges and associated cnidarian benthos has been documented to lead to a reduction in fish catch (Sainsbury 1988; Hutchings 1990). Sponges are particularly sensitive to disturbance because they recruit periodically and are slow growing in deeper waters (Auster and Langton 1999). Bradstock and Gordon (1983) observed that trawling virtually destroyed large areas dominated by encrusting coralline growths (bryozoans), reducing colony size and density. Probert et al. (1997) documented the bycatch of benthic species that occurs in a deep-water trawl fishery and noted the vulnerability of pinnacle communities and deepwater coral banks such as the Oculina habitat area of eastern Florida. Van Dolah et al. (1983; 1987) conducted experimental trawl surveys over hard bottom habitat consisting of coral and sponge off the coast of Georgia. A single pass of an otter trawl on this habitat damaged all counted species (Van Dolah et al. 1983; 1987).

However, only the density of barrel sponges was significantly decreased by trawling activities. It should be noted that these studies did not investigate the cumulative impacts of trawls. The repetitive effects of trawling over the same area can be expected to have more severe consequences to benthic habitat. While Moran and Stephenson (2000) estimated that a demersal otter trawl reduced benthos (greater than 20cm in maximum dimensions) density by 15.5% in a single pass, Cappo et al. (1998) estimated that complete denuding of the sea bottom structure occurs after 10-13 trawl passes over the same area. Of equal importance are the observations of Moran and Stephenson (2000), who noted variations among trawl studies, possibly due to differences of employed ground ropes. These variations are a warning against generalizations about the impact of otter trawls on attached benthos. As many epifaunal and infaunal organisms create structures which provide habitat for other species, summaries of these studies and their findings are included. For example, many infauna species and other bioturbators have an important role in maintaining the structure and oxygenation of muddy sediment habitats. Consequently, any adverse effects on these organisms would presumably lead to changes in habitat complexity and community structure (Jennings and Kaiser 1998). Furthermore, the loss of biogenic epifaunal species (epibenthic habitat) increases the predation risk for juveniles of other species, thereby lowering subsequent recruitment to adult stocks (Bradstock and Gordon 1983; Walters and Juanes 1993; Jennings and Kaiser 1998). Therefore, reduction in biomass of epifaunal species may be considered a reduction or degradation of habitat in certain instances and trawling has been documented to decrease mean individual biomass of epibenthic species (Sainsbury et al. 1993; Prena et al. 1999). While it may be hard to quantify the impact this loss presents to habitat-dependent organisms, it should be noted nonetheless. In a long-term study of Corpus Christi Bay, Texas, Flint and Younk (1983) noted that the continual minor and random disturbance, both in time and space, of channel sediments by large tanker traffic and shrimp trawling probably was sufficient to keep these communities in a state of constant disruption. This allowed the opportunists to persist more successfully than other species. The disturbed channel sites of the study, though viable, consistently had lower densities, lower numbers of species and corresponding low diversities contrasted to the lesser impacted shoal sampling sites (Flint and Younk 1983). Engel and Kvitek (1998) investigated two adjacent areas in 180 m of water to determine the differences between a heavily trawled site and a lightly trawled site.

They concluded that high-intensity trawling apparently reduces habitat complexity and biodiversity while simultaneously increasing opportunistic infauna and the prey of some commercial fish. The data indicated that intensive trawling significantly decreased habitat heterogeneity. All epifaunal invertebrates counted were less abundant in the highly trawled area. Bergman and Santbrink (2000) estimated direct mortality on various species of benthic megafauna from a single pass of an otter trawl (sole fishery) at between 0-52% for silty sediments and between 0-30% for sandy sediments. In general, small-sized species tend to show lower direct mortalities, when compared with larger sized species and smaller individuals of megafaunal species tend to show lower mortalities than larger-sized ones. Krost and Rumohr (1990) noted damage directly resulting from otter trawl doors. Benthic organisms were found to be reduced in number by 40 to 75% in otter board tracks, as compared to control sites. Biomass was also generally reduced. However, they found almost no differences in epibenthic species such as crustaceans. In shallow areas with densely packed sediments, inhabitants of the upper sediment layer were found to suffer most by the trawling impact.

In contrast to the above studies, there are several studies that document no significant habitat impact. Van Dolah et al. (1991) found no long-term effects of trawling on an estuarine benthic community; five months of shrimp trawling in areas previously closed to fishing were found to have no pronounced effect on the abundance, diversity, or composition of the soft bottom community when compared to nearby fished areas. They concluded that seasonal reductions in the abundance and numbers of species sampled had a much greater effect than fishing disturbance. In a power analysis of their sampling strategy, Jennings and Kaiser (1998) noted that Van Dolah et al. (1991) only considered changes in the abundance of individuals and the number of species. This assumes that the response of the infauna to trawling disturbance was unidirectional, whereas a consideration of changes in partial dominance might have been more sensitive to subtle changes in the fauna. Yet, Jennings and Kaiser (1998) stated that the results of Van Dolah et al. (1991) were plausible and that light shrimp trawls probably do not cause significant disturbance to communities in poorly sorted sediments in shallow water. Sanchez et al. (2000) determined that sporadic episodes of trawling in muddy habitats may cause relatively few changes in community composition. They found similar infaunal community changes in both fished and unfished control areas through time. Sanchez et al. (2000) also noted that the decrease in the abundance of certain species in the unfished control areas may indicate that the natural variability at the experimental site exceeds the effect s of fishing disturbance. Regardless, Ball et al. (2000) commented that epifauna are generally scarce in muddy sediment habitats, and detection of fishing effects on such species has therefore been limited.

While the passage of a trawl may damage or destroy macroinfauna, Gilkinson et al. (1998) suggested that smaller infauna are resuspended or displaced by a pressure wave preceding otter trawl doors and are redeposited to the sides of the gear path. Due to a buffer effect caused by a displacement field of sediment (sand), bivalves incur a low level of damage (5%) by the passing of a trawl door. In contrast to coarse sediment communities where the infauna are found within the top 10 cm, organisms in soft mud communities can burrow up to two meters deep (Atkinson and Nash 1990). Due to their depth, it is likely that these organisms are less likely impacted by passing trawls (Jennings and Kaiser 1998), though it should be noted that the energetic costs of repeated burrow reconstruction may have long-term implications for the survivorship of individuals.

Studies documenting impacts to habitat from successive trawling are not prevalent. However, a few studies suggest that shifts in species abundance and diversity are a result of the cumulative effects of trawling. Over a longer time scale (i.e., 50 years), Ball et al. (2000) suggested that fishing disturbance may ultimately lead to an altered, but stable, community comprising a reduced number of species, and hence, diversity. Sainsbury et al. (1993; 1997) noted that composition of a multispecies fish community in Australia was at least partially habitat-dependent and that historical changes in relative abundance and species composition in this region were at least in part a result of the damage inflicted on the epibenthic habitat by the demersal trawling gear. In summary, trawling has the potential to reduce or degrade structural components and habitat complexity by removing or damaging epifauna; smoothing bedforms which reduces bottom heterogeneity; and removing structure producing organisms. Trawling may change the distribution and size of sedimentary particles; increase water column turbidity; suppress growth of primary producers; and alter nutrient cycling. The magnitude of trawling disturbance is highly variable. The ecological effect of trawling depends upon site-specific characteristics of the local ecosystem such as bottom type, water depth, community type, gear type, as well as the intensity and duration of trawling and natural disturbances. It should also be noted that there is not a direct relationship between the overall amount of trawling effort and the extent of subsequent impacts or the amount of fauna removed because trawling is aggregated and most effort occurs over seabed that has been trawled previously (Pitcher et al. 2000). Yet, several studies indicate that trawls have the potential to seriously impact sensitive habitat areas such as SAV, hardbottom, and coral reefs. In regard to hard bottom and coral reefs, it should be recognized that trawlers do no t typically operate in these areas due to the potential dam age their gear may incur.

While trawl nets have been documented to impact coral reefs, typically resulting in lost gear (Bohnsack, personal observation), these incidents are usually accidental. Partially in response to accusations of trawl activity on hard bottom habitat, a recent research effort to investigate potential impacts on the Florida Middle Ground Habitat Area of Particular Concern concluded that there was no evidence of trawl impacts or other significant fishery related impacts to the bottom (Mallinson, unpublished report). However, low-profile, patchy hard bottom or sponge habitat areas are more likely impacted from trawls due to the gear's ability to work over these habitat types without damaging the gear. Regardless, while it may be concluded that trawls have a minor overall physical impact when employed on sandy and muddy substrates, the available information does not provide sufficient detail to determine the overall or long-term effect of trawling on regional ecosystems.

Recovery of substrate depends on sediment type, depth, and natural influences such as currents and bioturbation. Schoellhamer (1996) investigated sediment resuspension within Tampa Bay, a shallow estuary with fine non-cohesive material (muds absent), and found that sediment concentrations returned to pre-trawl conditions approximately 8 hours after disturbance. The cumulative effects of several trawlers operating were not investigated. DeAlteris et al. (1999) found that scars similar to those that occur from otter trawl boards disappear relatively quickly in a shallow sand environment, while those occurring in a deeper mud habitat took as long as two months to disappear. DeAlteris et al. (1999) also found that natural disturbances to mud substrate in 14 m of water are rarely capable of disturbing the seabed. Therefore, recovery of fishery-related impacts in deeper water may be protracted due to the lack of natural events that help deposit sediments and fill trawl scars. Ball et al. (2000) determined that intensive demersal trawling over muddy seabeds leads to apparent long –term alteration of the seabed. Trawl tracks in muddy sediments may last up to 18 months; however, in areas of strong tidal or wave action, they are likely to disappear rapidly. Also, in areas where levels of bioturbation are high, and regular turnover of sediment produces large numbers of mounds on the seabed, trawl tracks will be filled relatively quickly (Ball et al. 2000). Habitats in deeper water tend to recover at a slower rate. Berms and furrows generated by trawl doors generally disappeared within one year in sandy habitats in depths of approximately 120-146 m (Schwinghamer et al. 1998; Prena et al. 1999). More dramatic is the estimate of 50-75 years to fill a typical trawl mark (~15 cm scour depth) in deep water (greater than 175m) by Friedlander et al. (1999). The greater the water movement, the faster the scars will be filled in (Jones 1992). Churchill (1989) and Krost et al. (1990) reported an increase in the frequency of tracks attributed to trawl doors in deeper water, presumably where water movement and natural impacts are less pronounced.

In general, few studies document recovery rates of habitat. Those that do investigate recovery usually only do so after a single treatment which does not reflect the reality of fishing impacts which are ongoing and cumulative. For example, Van Dolah et al. (1983; 1987) noted that hard bottom habitat in his trawl study recovered within one year. However, the experiment did not investigate the cumulative and repetitive effects of trawling at commercial intensities. As noted by an ICES (1995) study, due to the cumulative effects of trawling, focus on the scale of individual trawl impacts may be inadequate for estimating the importance of impacts on benthic communities. ICES (1994) stated that deep water coral banks (e.g., *Oculina varicosa*), due to their fragility, long life spans, and infrequent recruitment, may be nearly exterminated by a single passage of a trawl and are unlikely to recover "within a foreseeable future." Likewise, SAV would also have a protracted recovery time in comparison to sediments. SAV recovery may vary by species and can be greater than two years if the rhizomes of the plant are removed (Homziak et al. 1982). Regardless, the majority of studies concur that shallow communities have proved to be resilient due to their adaptation to highly variable environmental conditions and thus, recovery is usually swift. Kaiser et al. (1996a) found epifaunal communities in 35m of water that were experimentally trawled were indistinguishable from control sites after six months.

In areas of low current or great tidal exchange (e.g., deep ocean), where the benthos is not adapted to high sediment loads, the adverse effects of sediment resuspension by gear could persist for decades (Jones 1992). Recovery of small epibenthic organisms may be relatively rapid, but recovery of larger epibenthic organisms would be expected to be much slower. Though they did not discuss depth as a controlling factor, Sainsbury et al. (1993; 1997) indicated that there would be a considerable time lag after trawling ceases before recovery of large epibenthic organisms is substantial. Boesch and Rosenberg (1981) predicted that recovery times for macrobenthos of temperate regions would be less than five years for shallow waters (including estuaries) and less than ten years for coastal areas of moderate depth.

The majority of management recommendations indicate that marine reserves or gear zoning may be the most effective at reducing habitat impacts. However, other specific recommendations can be extracted from several studies. Tabb (1958) recommended that otter trawls not be permitted to operate in the bait shrimp fishery due to potential impact to SAV communities. Van Dolah et al. (1987) suggested that trawls with doors attached directly to the nets would greatly reduce the bottom area damaged by trawling activities. The use of artificial reefs to protect the seabed, in particular along the perimeter of SAV habitat areas, from trawling has also been offered (Guillén et al. 1994; Ardizzone et al. 2000). The use of semi-pelagic trawls would avoid the majority of habitat impacts that demersal trawls are associated with. However, while the use of semi-pelagic nets does not significantly impact the benthos, catch efficiency may be greatly reduced.

Furthermore, enforcement on the use of semi-pelagic nets remains difficult (Moran and Stephenson 2000). Carr and Milliken (1998) offered more straightforward recommendations: target certain species and modify gear appropriately; encourage the use of lighter sweeps; reduce the sea bottom available to trawlers that fish very irregular terrain; and opt for stationary gear over mobile gear. It is suggested that where fishing effort is constrained within particular fishing grounds, and where data on fishing effort are available, studies that compare similar sites along a gradient of effort have produced the types of information on effort impact that will be required for effective habitat management (Collie et al. 1997; Auster and Langton 1999). Additionally, the use of an indicator species (e.g., quahogs) that provides a historical record of fishing disturbance events could greatly enhance the interpretation of perceived changes ascertained from samples of present-day benthic communities (Macdonald et al. 1996; Kaiser 1998). Finally, the use of tracking devices (VMS) would provide a means for identifying the most heavily fished areas and those, if any, that are presently unfished (Macdonald et al. 1996; Kaiser 1998).

Comprehensive mapping of benthic habitats may provide the necessary information to determine what areas are at risk from fishery-related impacts. Utilized in conjunction with information that details fishing effort and area, gear zoning that limits the vulnerability of sensitive habitats while minimizing economic impacts to fishery participants should be considered.

Oyster Dredge

An oyster dredge consists of a metal rectangular frame to which a bag-shaped net of metal rings is attached. The frame's lower end is called the raking bar, and is often equipped with metal teeth used to dig up the bottom. The frame is connected to a towing cable and dragged along the seabed. Oyster dredges are widely utilized in state waters along the Gulf of Mexico, as well as the South Atlantic. Mechanical harvesting of oysters using dredges extracts both living oysters and the attached shell matrix and has been blamed for a significant proportion of the removal and degradation of oyster reef habitat (Rothschild et al. 1994; Dayton et al. 1995; Lenihan and Peterson 1998). Lenihan and Peterson (1998) observed that less than one season of oyster dredging reduced the height of restored oyster reefs by ~30%. Reduction in the height of natural oyster reefs is expected to be less than that of restored reefs because the shell matrix of natural reefs is more effectively cemented together by the progressive accumulation of settling benthic organisms, while restored reefs are initially loose piles of shell material. Regardless, it is likely that the height of natural reefs is also reduced by dredging because a large portion of extracted material from natural reefs by dredges is shell matrix. Lenihan and Peterson (1998) stated that it was probable that reduction in reef heights in a Neuse River, North Carolina estuary was due to decades of fishery-related disturbances caused by oyster dredging. At an annual removal rate of 30%, restored reefs would be completely destroyed after less than 4 years of harvesting. Furthermore, they determined that the height reduction of oyster reefs through fishery disturbance impacted the quality of habitat due to the seasonal bottom-water hypoxia/anoxia which caused a pattern of oyster mortality and influenced the abundance and distribution of fish and invertebrate species that utilize this temperate reef habitat (Lenihan and Peterson 1998). Their results illustrated that tall experimental reefs – those mimicking natural, ungraded reefs – were more dependable habitat for oysters and other reef organisms than short reefs – those mimicking harvest-degraded reefs – because tall reefs provided refuge above hypoxic/anoxic bottom waters. Chestnut (1955) also documented that intensive dredging over a period of years resulted in the removal of the productive layer of shell and oyster, leaving widely scattered oysters and little substrate for future crop of oysters.

Glude and Landers (1953) noted that dredges mixed the sandy-mud layer and the underlying clay. Fished areas were found to be softer and have less odor of decomposition than the unfished control site. Glude and Landers (1953) also found a decrease in benthic fauna in the fished sites versus the unfished control sites. Conversely, a study conducted by Langan (1998) which looked at the impacts oyster dredging had on benthic habitat, as well as sediment resuspension resulting from dredging activity, concluded with different results. He noted that the size-frequency of oysters from the control site was biased towards older and larger specimen s with poor recruitment. Oysters from the dredged site illustrated good recent recruitment, while larger specimens were not as abundant as the control site. No significant differences between the two areas were found in number, species richness, or diversity of epifaunal and infaunal invertebrates, indicating that dredge harvesting had no detectable effect on the benthic community. Sediment suspension resulting from dredging activity appeared to be localized. It should be noted that the study failed to evaluate fishing activity (number of participants, effort) on the dredged site.

Due to overfishing and disease, oysters may now be more economically valuable for the habitat they provide for other valued species than they are for the oyster fishery (Lenihan and Peterson 1998). Rothschild et al. (1994) suggested the establishment of broodstock sanctuaries that includes the designation of “no-fishing” restrictions in specific areas. Lenihan and Micheli (2000) also recommended the closure of some oyster reefs to harvest. Maintaining high densities of oysters on some intertidal reefs may help to preserve future oyster harvests and broodstock. Furthermore, protecting some reefs will also preserve the ecological functions that oyster reef provide such as improving water quality and providing essential recruitment, refuge, and foraging habitat for numerous marine species.

Scallop Dredge (Inshore)

Scallop dredges are similar to crab scrapes, though scallop dredges utilized in the southeast generally do not have teeth located on the bottom bar. Scallop dredges are predominately used on SAV beds where bay scallops can be efficiently harvested, and thus, are primarily limited to state waters. Popular bay scallop fisheries exist both off Florida and North Carolina. This gear, while similar, is not the same type of dredge utilized offshore to harvest calico scallops (*Argopecten gibbus*) or Atlantic sea scallops (*Placopecten magellanicus*).

Though scallop dredges do not have teeth that would easily uproot SAV, studies have noted a reduction of algal and SAV biomass from their use (Fonseca et al. 1984; Bargmann et al. 1985). The reduction of SAV (*Zostera marina*) biomass was linearly related to the number of times a particular area was dredged, and the effects of dredging were proportionately greater on soft bottom than hard bottom (Fonseca et al. 1984). The Fonseca et al. (1984) study utilized an empty dredge that was 60% of the legal limit for a commercial dredge, and was not employed in conjunction with a boat as the commercial fishery does. Hand dredging was done to eliminate propeller scour which commonly occurs in shallow SAV beds. In commercial scalloping, the added dredge and scallop weight, as well as the propeller wash, could be expected to have a greater imp act (Fonseca et al. 1984). In general, more damage from scallop dredging occurred to SAV in soft substrates (i.e., mud) than hard substrates (i.e., sand). In softer sediments, plants were uprooted and damage to underground plant tissues, including meristems, occurred. In harder sediments, damage was found to be generally greater for above ground parts; underground meristems were left intact and able to begin to repair shoots or produce new ones after impacts had ceased (Fonseca et al. 1984).

Fonseca et al. (1984) determined that in a lightly harvested SAV area, with less than 25 % biomass removal, recovery occurred within a year. In areas where harvesting resulted in the removal of 65% of SAV biomass, recovery was delayed for two years. After four years, preharvesting biomass levels were still not obtained. These estimates were based on termination of fishery-related impacts. Continued fishing activity would likely lead to prolonged recovery and continued degradation. Homziak et al. (1982) estimated that SAV recovery can be greater than two years if the rhizomes of the plant are removed.

Due to the importance of SAV beds as a nursery area to other species, loss of eelgrass meadows should be avoided. Fonseca et al. (1984) suggested that harvest area rotation may minimize habitat impact.

Scallop Dredge (Offshore)

Scallop dredges (Figure 7) utilized to harvest calico or sea scallops consist of a metal frame that supports tickler chains and a metal ring bag that collects the shellfish. Though not widely utilized in the southeast, the gear has been included in this review due to their inclusion as an approved gear in the South Atlantic. The majority of studies on scallop dredge impacts originate from areas with extensive scallop fisheries such as the northwest and northeast Atlantic.

Due to the potential for the gear to have considerable weight and the fact that it is dragged along the bottom, habitat impacts are expected to occur. Drew and Larsen (1994) estimated that a scallop dredge maximum cutting depth would be 40 - 150mm. Kaiser et al. (1996a) found that scallop dredging greatly reduced the abundance of most species, causing significant changes in the community. It was noted that a large proportion of some animals (such as echinoderms) were not captured or passed through the mesh of the gear. The scallop dredge catches contained a low proportion of non-target species which indicates that the belly rings allow the bycatch to escape. However, the study did not investigate the extent of damage/injury to organisms that were not captured. Likewise, Collie et al. (1997) found areas on Georges Bank that were impacted by scallop dredges to have lower species diversity, lower biomass of fauna, and dominated by hard-shelled bivalves, echinoderms, and scavenging decapods. Areas less impacted by dredges had higher diversity indices. However, it should be noted that portions of Georges Bank consist of cobble habitat which is encrusted with a diverse array of epibenthic species.

Perhaps more applicable to the areas in the southeast where calico scallops are harvested off North Carolina and Florida, would be a study conducted by Butcher et al. (1981), who determined that scallop dredges had little or no environmental effect when they were used on large-grained, firm sand bottom that was shaped in roughly parallel ridges. The area in this study was also noted to be a fairly uniform, low species diversity community. Turbidity caused by the turbulence of the dredge quickly dissipated due to the nature of the substrate. Additionally, Jolley (1972) found no detrimental dredging effects on sand substrates. Yet, there is a potential for dredges to impact coral adjacent to scallop beds, especially the scallop grounds which occur in close proximity to the Oculina Bank off eastern Florida. Should a scallop dredge impact *Oculina* coral, there would be severe results, similar to the conclusion s reached by ICES (1994) for trawls. This study determined that deep water coral banks such as those composed of *Oculina varicosa*, due to their fragility, long-life spans, slow growth, and infrequent recruitment, may be nearly exterminated by a single passage of a trawl. Recovery of this habitat area, "within a foreseeable future," is unlikely (ICES 1994).

Skimmer Trawl

Skimmer trawls are positioned along the side of a boat and pushed through the water to harvest shrimp. Two nets are typically used, one on each side of the boat. Skimmer trawls are supported by a tubular metal frame that skims over the bottom on a weighted metal shoe or skid. Tickler chains are also utilized along the base of the net. Because of the construction attributes of this gear type, skimmer trawls are generally restricted to water 3.05m (10 ft) or less which would limit them to state waters.

Skimmer trawls work on mud bottoms in water generally 3.05m (10ft) or less. The weighted shoe and tickler chains impact the bottom, resulting in sediment resuspension. Skimmer trawls may cause bottom damage due to improperly tuned or poorly designed gear (skids and bullets) or prop damage in shallow areas (Steele 1994). Furthermore, because skimmer trawls are used in shallow water, they may have a detrimental impact on critical nursery areas such as the marsh/water interface, SAV, or other sensitive submerged habitats. However, skimmer trawls are expected to impact the bottom less than otter trawls due to the absence of doors (Nelson 1993; Steele 1993). Coale et al. (1994) believed that the skimmer trawl would not have any greater effects on SAV than the otter trawl. They found it doubtful that the inside weight and outer shoe of the skimmer trawl would cause greater detrimental effects to the benthos than the heavy doors of an otter trawl. Based on underwater observations, Coale et al. (1994) suggested that the weight and shoe combination may be less-damaging than otter trawls. However, habitat such as sponges and SAV are cut off by tickler chains and lead lines whereas otter trawl doors can dig in and tear up the bottom. Given the difference in the amount of area covered by each on normal tows, Kennedy, Jr. (1993) found it doubtful that there would be much difference in the amount of habitat loss between skimmer trawls and otter trawls.

Kennedy, Jr. (1993) recommended that the use of skimmer trawls in Florida should be restricted to those areas currently approved for otter trawls. Due to the associated impacts to SAV, a prudent recommendation would be to limit skimmer trawl use to non-vegetated substrates.

6.2.2.2 Static Gear

Channel Net

Channel nets are fixed to pilings, docks, or shore installation and utilize current flow to capture shrimp, therefore, channel nets are limited to use within state waters. Though impacts of channel nets were not discussed specifically, it may be inferred from Higman (1952) that channel nets have negligible impact on habitat due to catch composition and the lack of interaction with the benthos.

Gillnet and Trammel Net

Gillnets (Figure 9) consist of a wall of netting set in a straight line, equipped with weights at the bottom and floats at the top, and is usually anchored at each end. As fish swim through the virtually invisible monofilament netting, they become entangled when their gills are caught in the mesh, hence the name. Gillnets may be fixed to the bottom (sink net) or set midwater or near the surface to fish for pelagic species. A trammel net is made up of two or more panels suspended from a float line and attached to a single lead line. The outer panel(s) are of a larger mesh size than the inner panel. Fish swim through the outer panel and hit the inner panel which carries it through the other outer panel, creating a bag and trapping the fish. Smaller and larger fish become wedged, gilled, or tangled. Gillnet s are widely used in numerous fisheries, both in state waters and in Federal waters. Trammel nets are primarily used in state waters, though they are an authorized gear in the Caribbean for both the spiny lobster and shallow water reef fish fisheries.

The majority of the studies that have investigated impacts of fixed gillnets have determined that they have a minimal effect on the benthos (Carr 1988; ICES 1991; ICES 1995; Kaiser et al. 1996b). An ASMFC (2000) report determined that impacts to SAV from gillnets would be minimal. Likewise, West et al. (1994) stated that there was no evidence that sink net (gillnet) activities contributed importantly to bottom habitat disturbance. However, Carr (1988) noted that ghost gillnet s in the Gulf of Maine could become entangled in rough bottom. He observed one net that had its leadline and floatline twisted around each other and tightly stretched between boulders. Furthermore, Williamson (1998) noted that gillnets can snag and break benthic structures. Gomez et al. (1987) noted that gill nets set near reefs occasionally results in accidental snaring often resulting in damage to coral. Bottom set gillnets have led to habitat destruction in different regions (Jennings and Polunin 1996). Bottom gillnets set over coral may cause negative impacts as the weighted lines at the base of the net often become entangled with branching and foliaceous corals. As the nets are retrieved, the corals are broken (Öhman et al. 1993). This observation has also been noted in a study by Munro et al. (1987), which documented that reefs are frequently damaged by the hauling of set (gill) nets, and the problem has been exacerbated by the use of mechanical net haulers or power blocks. Aside from the potential impacts cited on coral reef communities, the available studies indicate that habitat degradation from gillnets is minor.

Several studies note that lost gillnets are quickly incorporated by marine species. Cooper et al. (1988) found ghost gillnets in the Gulf of Maine covered with a heavy filamentous growth, exceeding 75% coverage on some nets. Anemones, stalked ascidians and sponges were attached to and growing to the net float lines (Carr et al. 1985; Cooper et al. 1988). Erzini et al. (1997) found that lost trammel nets and gill nets in shallow water (15-18m) on rocky habitat (analogous to coral reefs and hard bottom habitat) were colonized by various species, primarily macrophytes, which after three months completely blocked the meshes of some parts of the nets. Some netting would contact reef habitat, becoming heavily overgrown and eventually blended into the background. After a year, most of the netting was destroyed; those remnants that remained were completely colonized by biota (Erzini et al. 1997). Erzini et al. (1997) also noted that the nets eventually became incorporated into the reefs, acting as a base for many colonizing plants and animals. The colonized nets then provided a complex habitat which was attractive to many organisms. For example, large schools of juvenile fish were often observed in the vicinity of these heavily colonized nets, which may provide a safe haven from predators. Johnson (1990) and Gerrodette et al. (1987) noted that as gillnets tend to collapse and "roll up" relatively quickly, they may form a better substrate for marine growths and thereby attract fish and other predators which may get entangled, ultimately causing the net to sink. Therefore, one may assume that gillnets may be more of a ghostfishing problem and entanglement hazard to marine life than as an impact to habitat.

Catch by entanglement nets during 1988 was 1,398 lbs from North Carolina through Georgia (less than 1% of the combined state catch) and 253,739 lbs from the Florida East Coast (6% Florida East Coast catches). Much of the Florida landings are from a directed stab net fishery for gray snapper that operates in the EEZ. The Gulf Council and the State of Florida have prohibited entanglement nets. Florida regulations read as follows: "No person shall harvest in or from state waters any snapper of the family of Lutjanidae or any member of the genera *Epinephelus* or *Mycteroperca* by or with the use of any gear other than those types of gears specified in Subsection 1, provided however that snapper and grouper harvested as an incidental bycatch of other species lawfully harvested with other types of gears shall not be deemed to be unlawfully harvested in violation of this section, if the quantity of snapper/grouper so harvested does not exceed the bag and possession limits as specified elsewhere." The South Atlantic Council's actions track the Florida regulations in intent with respect to limiting possession to the bag limit and for species without a bag limit, no possession is allowed. Florida prohibited entanglement nets because it is an inappropriate gear to use on live bottom. Some of the reef fish are not necessarily found on the live bottom, however, many are and fishermen use stab nets to catch gray snapper on the live bottom areas.

The Council has concluded that entanglement nets are not an appropriate gear for the snapper grouper fishery and the prohibition will prevent use and/or expansion from North Carolina through Florida's East Coast. Entanglement nets targeting species other than those included in the management unit are limited to the bag limit if the species is under a bag limit, and if no bag limit is applicable, then no retention is allowed.

SAFMC Prohibition on the Use of Entanglement Nets
Snapper Grouper Amendment 4 prohibits the use of entanglement nets including, but not limited to, gill nets and trammel nets, for the harvest of species in the snapper grouper management unit (SAFMC 1991a). The simultaneous possession of entanglement nets and species in the management unit is prohibited.

Hoop Net

A hoop net is a cone-shaped or flat net which may or may not have throats and flues stretched over a series of rings or hoops for support. The net is set by securing the cod or tapered end to a post or anchored to the bottom. The net is played out with the current until fully extended, and then is allowed to settle to the bottom. The net is marked with a buoy for easy retrieval and identification purposes. The duration of time that a hoop net is set depends on the same factors that influence the duration of the set of a gill net and should be determined in a similar fashion. To harvest, the hoop net is raised at the cod end and the fish are removed.

While there are no studies that document the effect of hoop nets on habitat, due to its use primarily on flat bottoms the gear probably has less of an impact than traps.

Longline

Longlines use baited hooks on offshoots (gangions or leaders) of a single main line to catch fish at various levels depending on the targeted species. The line can be anchored at the bottom (Figure 12) in areas too rough for trawling or to target reef associated species, or set adrift, suspended by floats (Figure 13) to target swordfish and sharks. Longlines are widely utilized in numerous fisheries throughout the southeast region.

When a vessel is retrieving a bottom longline it may be dragged across the bottom for some distance. The substrate penetration, if there is any, would not be expected to exceed the breadth of the fishhook, which is rarely more than 50mm (Drew and Larsen 1994). More importantly is the potential effect of the bottom longline itself, especially when the gear is employed in the vicinity of complex vertical habitat such as sponges, gorgonians, and corals.

Bottom longlines in the snapper grouper fishery
The Council prohibited the use of bottom longline gear for snapper grouper in the South Atlantic EEZ within 50 fathoms (SAFMC 1994). Catch by bottom longlines during 1988

was 470,306 lbs from North Carolina through Georgia (6% of the combined state catches) and 576,310 lbs from the Florida East Coast (13% Florida East Coast catch). The Council was concerned about the use of bottom longline gear targeting species in the snapper grouper management unit in live bottom areas. Habitat damage and intense competition among users are problems that arise when this gear is used within 50 fathoms where significant live bottom occurs and where competition with hook and line vessels occurs. The Council concluded that this gear is appropriate for use in the deep-water snowy grouper/tilefish fishery where much of the bottom is mud with sparse live bottom areas. Allowing use of this gear deeper than 50 fathoms would preserve the traditional fishery which takes place in deeper water out to 50 fathoms. Based on information from South Carolina, up until 1983 the snapper grouper fishery was limited to vertical hook and line or bandit reels. Bottom longlines were introduced in the Gulf of Mexico after hook and line gear became less effective due to decreases in resource abundance; use of the gear grew rapidly. Up until this point there has been no gear prohibition on bottom longlines. After the golden tilefish and snowy grouper fisheries were developed, bottom longlines became the predominant gear, again as resource abundance declined. For species like snowy grouper and tilefish, it was not very efficient to use vertical hook and lines as the resource abundance declined from unfished levels. As the tilefish and snowy grouper stocks off South Carolina declined, the number of people using longlines decreased. Off South Carolina virtually all of the golden tilefish occurred well outside the 50-fathom mark and there was more than enough gear to adequately harvest these resources in the mid-depth zone. Vertical lines are much more environmentally acceptable and less damaging than bottom longlines.

This regulation essentially segments the mid-shelf and the deep-water complex to the bottom longlines. This measure was supported during the public hearing process and the Council concluded that prohibiting use of longline gear within 50 fathoms will prevent the problems of habitat damage and intense competition while at the same time allow fishermen using this gear to continue fishing in deeper water. This action effectively limits longlines to targeting the deep water component of the snapper grouper fishery and keeps the use of longlines outside of the rough bottom habitat.

The Council very briefly considered moving the line in to the 40 fathom contour but was concerned that there are substantial Oculina coral banks along this depth zone. It was further noted that the 50 fathoms was a compromise from the 100 fathom contour (which was mentioned) and that the 50 fathom contour effectively separates the inshore and deep water snapper grouper complexes.

Impacts on habitat

Observations of halibut longline gear off Alaska included in a North Pacific Fishery Management Council Environmental Impact Statement (NPFMC 1992) provide some insight into the potential interactions longline gear may have with the benthos. During the retrieval process of longline gear, the line was noted to sweep the bottom for considerable distances before lifting off the bottom. It snagged on whatever objects were in its path, including rocks and corals. Smaller rocks were upended and hard corals were broken, though soft corals appeared unaffected by the passing line. Invertebrates and other light weight objects were dislodged and passed over or under the line. Fish were observed to move the groundline numerous feet along the bottom and up into the water column during escape runs, disturbing objects in their path. This line motion has been noted for distances of 15.2m (50ft) or more on either side of the hooked fish. Based on these observations, it is logical to assume that longline gear would have a minor impact to sandy or muddy habitat areas. However, due to the vertical relief that hardbottom and coral reef habitats provide, it would be expected that longline gear may become entangled, resulting in potential impacts to habitat. Due to a lack of interaction with the benthos, pelagic long lines would have a negligible habitat impact.

SAFMC Prohibition on the Use of Bottom Longlines
The Council prohibits bottom longlining in the wreckfish fishery in the entire South Atlantic EEZ (SAFMC 1991a). A bottom longline is a stationary, buoyed, and anchored groundline with hooks attached. Regulations prohibit simultaneous possession of wreckfish and all the necessary components for bottom longlining.

The Council was concerned about wastage of fish, gear loss, gear conflict, habitat damage, and negative economic effects (both short and long run) attributable to the use of bottom longline gear in the wreckfish fishery. The bottom habitat on the wreckfish fishing grounds, which comprise an area of the Blake Plateau of approximately 50-75 square nautical miles, is characterized by a rocky ridge system having a vertical relief greater than 50 meters and a slope greater than 15° (SAFMC 1993). The depth range in this area is 450-600 meters; the substrates in areas of the Blake Plateau exhibiting significant relief are generally characterized as composed of manganese phosphate pavements, phosphorite slabs and coral banks (Pratt and McFarlin 1966; Stetson et al. 1969). This high relief, in conjunction with the strong tidal effects, makes gear loss probable (as reported by fishermen who have already tried longlines in the wreckfish fishery) which results in the loss of all fish on the gear as well as those which get hooked subsequently. Testimony from fishermen indicated gear loss on wreckfish longline sets was as great as 100% of the gear taken out on a single trip. According to accounts from fishermen, extensive lengths of lost longline gear have been observed on their fathometers. Fishermen can apparently see fish hooked on parted longline gear but are unable to recover the parted gear and its catch. Wreckfish fishermen use circle hooks that virtually prevent fish from working the hook free. The Council recognized that there was also some ghost fishing potential from lost vertical gear but believes that the extent of potential loss with vertical gear is much smaller by virtue of the fewer number of hooks used and the greater control over the gear.

Although the area is 50-75 square nautical miles, virtually all wreckfish fishing takes place along limited, high relief ledge areas within this area because wreckfish are found along the ledges and are not evenly distributed over the wider area. The sub-areas that produce wreckfish are typically 300 yards wide and 1-4 nautical miles long. Thus far, fishermen fishing vertical drop gear have been able to work in relatively close proximity without any major conflicts. If bottom longlines had been allowed to be used in this area, vessels would have not only lost gear due to the rough bottom, but this lost gear would create a hazard for those using vertical lines which would result in loss of that gear. This problem would have become progressively worse over time as more gear was lost, the more hangs were created for both longline and vertical gear, creating even more gear loss. This condition could have continued until much of the ground is unfishable. The wire cable that is used will remain a hazard for many years as the rate of decay is slow. While extensive hangs may ultimately provide protection for the resource due to much of the fishing grounds being unfishable, it may well result in the loss of the fishery. The use of longlines will result in gear losses to vertical hook and line fishermen that far exceed their losses prior to the introduction of longlines. This will serve to reduce benefits to those fishing with the traditional vertical gear.

The potential for gear entanglement and gear conflict also raised the issue of vessel safety. It was the Council's opinion that this situation would have lead to conflicts that jeopardize the safety of the vessels and fishermen participating in the wreckfish fishery.

Longline cable on the bottom has the potential to break some of the ledges, overhangs and associated organisms, and otherwise damage the habitat on which the wreckfish depend. Habitat damage caused by the longlines would violate the SAFMC habitat policy and should be avoided.

The wreckfish fishery has employed efficient vertical gear since its inception, and the addition of longlines would have eroded benefits to the majority of fishermen and adversely impact the resource and habitat. If longlines had been allowed, then all or at least many wreckfish fishermen may have been forced to adopt the gear in order to compete resulting in more gear loss from parted longlines. The Council determined that bottom longlines were not in the best interest of the wreckfish resource, habitat, fishermen or society at large. Further, the problems outlined justified prohibiting this gear/fishing method in the wreckfish fishery.

Pound net

A pound net consists of a fence constructed of netting that runs perpendicular to shore which directs fish to swim voluntarily into successive enclosures known as the heart, pound, or pocket. Pound nets are exclusively utilized in state waters.

An ASMFC (2000) report determined that impacts to SAV from pound nets are expected to be minimal, unless the net is constructed directly on SAV. West et al. (1994) also stated that pound nets do not contribute to benthic disturbance. Due to the limited amount of space a pound net may impact, it is expected that pound nets have minimal impact on habitat.

Trap and Pot

Traps and pots are rigid devices, often designed specifically for one species, used to entrap finfish or invertebrates. Depending on the type of fishing a trap is used for, most traps are generally baited and equipped with one or more funnel openings, they are left unattended for some time before retrieval. Traps and pots are weighted to rest on the bottom, marked with buoys at the surface, and are sometimes attached to numerous other traps to one long line called a trot line. Traps and pots are widely used on a variety of habitats in both state and Federal waters to commercially harvest species such as lobster, blue crabs, golden crabs, stone crabs and black sea bass. Wire-mesh fish traps are one of the principal fishing gears used in coral reef areas in the Caribbean (Appledorn 2000).

SAFMC Prohibition on the use of fish traps

It should be noted that many of the studies used in forming this document refer to fish trap fisheries outside of the continental US. These fisheries are different from crustacean trap fisheries operating on the South Atlantic coast in that the traps are built to selectively capture crabs and lobster and avoid bycatch of untargeted finfish. There are few studies to date regarding the bycatch rate of finfish but anecdotal information from fishermen and fisheries managers point out that spiny lobster traps do not capture significant amounts of snapper, grouper and other ornamental reef fish.

The Council prohibited the use of fish traps in the South Atlantic EEZ; however, black sea bass traps may be used north of Cape Canaveral (Vehicle Assembly Building, 28° 35.1' N Latitude). Fish traps were banned in federal waters off the South Atlantic states in 1992 and banned in the Gulf of Mexico west of Cape San Blas (located at about the middle of the Florida Panhandle) in 1997.

In general, pots can cost anywhere between $30-$50 USD to construct. It does take some skill in determining an appropriate location for fishing trap gear, and efficiency is based on how many traps a fishermen can service in one working day. Traps will soak an average of 1-2 weeks before they are checked. While traps can catch a wide variety of marine organisms, fishermen place traps in specific areas to avoid bycatch of untargeted species. One downfall to trap fishing is that the gear can be lost in storm events, so to avoid “ghost fishing” most traps have degradable panels and escape rings that rot off allowing fish to exit the trap. While trap fishing gear has created user-group conflicts in the past, managers are in the process of choosing particular fishing zones which will help the general public become more aware of trap fishing areas.

Due to their use to harvest species associated with coral and hard bottom habitat, traps and pots have been identified to impact and degrade habitat. Gomez et al. (1987) noted the incidental breakage of corals on which traps may fall or settle constitute the destructive effects of this gear. Within the Virgin Islands State Park, Garrison (1998) found 86% of the fish traps were set on organisms (live coral, soft coral, SAV) living on the sea floor. Damage to the live substrate has far-reaching negative effects on the marine ecosystem because the available amount of shelter and food often decreases as damage increases. Another study conducted by Garrison (1997) had similar results, as 82% of traps rested directly on live substrate, with 17% resting on stony corals. It is important to note that the aforementioned statistics (Garrison, 1987-1998) do not reflect the way trap based crustacean fisheries operate within the continental United States. Studies from the Florida Fish and Wildlife Conservation Commission (Tom Matthews, personal communication) confirm that only 2% of spiny lobster traps are fished on top of stony coral reef habitats.

Hunt and Matthews (1999) found that lobster and stone crab traps reduce the abundance of gorgonian colonies from rope entanglement. Furthermore, seagrass smothering occurs from trap placement on SAV beds, resulting in SAV "halos." ." Studies also confirm that traps set for no longer than a two week period do not pose an adverse threat to seagrass ecology as the seagrass subsequently recovers. Van der Knapp (1993) noted that fish traps set on staghorn coral easily damaged the coral. It appeared that in all observed cases of injury due to traps, the staghorn coral regenerated completely, although the time for regeneration varied from branch to branch. The greatest impact noted from the setting of traps was observed when the point of the trap's frame ran into coral formations. Several different species of coral were observed to suffer damage from fish traps. Observations of at least one damaged coral specimen noted that algae growth prevented regeneration in the damaged portion of the coral. Additionally, complete deterioration of a vase sponge was observed after it had been severely damaged by a trap. Traps are not placed randomly, rather they are fished in specific areas multiple times before fishing activity moves to other grounds. Therefore, the damage caused by wire fish traps in this study has a concentrated cumulative effect in particular areas rather than being uniform over all coral reef habitat

Appledorn et al. (2000) commented that fish traps may physically damage live organisms, such as corals, gorgonians, and sponges, which provide structure and in some cases, nutrition for reef fish and invertebrates. Damage may include flattening of habitats, particularly by breaking branching corals and gorgonians; injury may lead to reduced growth rates or death, either directly or through subsequent algal overgrowth or disease infection. During initial hauling, a trap may be dragged over more substrate until it lifts off the bottom. Traps set in trotlines can cause further damage from the trotline being dragged across the bottom, potentially shearing off at their base those organisms most important in providing topographic complexity.

Traps that are lost or set unbuoyed are often recovered by dragging a grappling hook across the bottom. This practice can result in dragging induced damage from all components (grappling hook, trap, trotline). The area swept by trotlines upon recovery is orders of magnitude greater than the cumulative area of the traps themselves. Appledorn et al. (2000) documented that single-buoyed fish traps off La Parguera, Puerto Rico, have an impact footprint of approximately 1 m^2 on hard bottom or reef. Of the traps investigated in the study, 44% were set on hard bottom or reef, resulting in 23% damage to coral colonies (70 cm^2 average), 34% damage to gorgonian colonies (56 cm^2 average), and 30% damage to sponges, though sponges were less frequently impacted due to their patchy distribution. Hauling these wire fish traps resulted in 30% of the traps inflicting additional damage to the substrate. In a similar study focusing on fish trap impacts conducted off St. Thomas, U.S.V.I., by Quandt (1999), 40% of all traps investigated were found to be resting on reef substrate. On average, 4.98% of all hard corals and 47.17% of all gorgonians were damaged; tissue damage averaged 20.03% to each gorgonian. Secondary impacts, such as trap hauling and movement due to natural disturbances were not investigated. However, the effects of pulling a string of two or more wire fish traps would most likely be much greater than one trap alone.

Eno et al. (1996) found pots that landed on, or were hauled through beds of bryozoans caused physical damage to the brittle colonies. It was noted that several species of sea pens bent in response to the pressure wave created by a descending pot and were lying flat on the seabed. When the pot was removed, the sea pens were able to reestablish themselves in the sediment. A species o f sea fan also was found to be flexible and specimens were not severely damaged when pots were hauled over them. This suggests that in some instances the direct contact of certain gears may not be the primary cause of mortality, rather the frequency and intensity may be more important. Additionally, Sutherland et al. (1983) cited little apparent damage to reef habitats inflicted from fish traps off Florida. The study found four derelict traps sitting atop high profile reefs with four other traps observed within a live-bottom area. There was no visual evidence that traps on the high profile reef killed or injured corals or sponges. One uprooted gorgonian was observed atop a ghost trap in a live bottom area. However, these observations were made on randomly located derelict traps. Thus, the primary impacts that may occur during deployment and recovery could not be evaluated.

Trap loss

Gear failure, theft, and improper placement are several of the many reasons why traps are lost both inshore and offshore. Gear failure can occur because of pot warp (line) parting, buoys separating from the pot warp, or buoys breaking up. Normal wear and tear, powerboat propellers, and sea turtles or sea gulls biting the buoys or pot warp can cause gear failure. Theft is also a major cause of lost traps in many areas. Losses also occur because of setting the traps too deep or on too steep a slope. Storm surge and wave action can cause loss of traps, particularly in shallow inshore waters during hurricane and foul weather events. Traps without buoys are less susceptible to storm damage, but may be moved from a site by currents or wave action and become irretrievable. In coralline areas, the buoy lines may become entangled on coral, chafe, and break. Offshore, losses are primarily caused by large vessels cutting or dragging gear, gear failure, and storms. Strong currents submerging buoys or sweeping traps away from the locations where they were set and traps becoming entangled with other fishing gear and anchors have also been cited as causes of trap loss.

The percentage of traps lost varies considerably among studies by both area and depth fished. Wolf and Chislett (1974) reported fish trap losses of 10-20% per trip in exploratory efforts in deep water shelf edges in the Virgin Islands. They attributed these losses to pots tumbling down steep slopes. Craig (1976) reported a fish trap loss rate of about 20% for a period of six months with some loss due to theft while trap fishing off Boca Raton, Florida. In Broward County, Florida, the same study reported that fish trap fishermen reported an average of 20.3% annual loss due mainly to strong currents, entanglement and theft. Dade County, Florida trap fishermen reported losing 1-5 traps per trip, with an annual loss of 100%. Losses were due to theft or loss of buoys. Trap theft was such a problem that traps were brought back to port at the end of each fishing day in Dade (Sutherland and Harper 1983).

Sutherland and Harper reported that Monroe County, Florida trap fishermen had estimated average annual trap losses of 63%. The losses were mainly from currents and severance of buoys by large ships in deep water and from vandalism inshore. Trap loss in the spiny lobster fishery was not a problem in Collier County, Florida with an annual loss of only 5% due to the fact that fishermen brought back traps to the dock after each trip (Taylor and McMichael 1983). About 85% of traps used off Key Biscayne, Florida were lost with most losses attributed to theft (Sutherland et al. 1987). Fish trap loss from theft and severed fouling lines was reported as a major problem in the Virgin Islands (Swingle et al. 1970; Olsen et al. 1974; Sylvester 1972).

In Jamaica, Munro and Thompson (1973) had such a theft problem in their study that the use of buoyed traps had to be abandoned. Losses due to theft, storms, and vessels cannot easily be controlled, but fish trap fishermen can inspect gear frequently for wear and tear and use more durable materials.

Fish traps that fishermen cannot locate and retrieve or that are abandoned but are still capable of catching fish, are often referred to as ghost traps. Ghost traps have long been a subject of concern, but opinions have changed considerably over time. Since Olsen et al. (1978) made their observations that if traps were lost, juvenile and forage species mortality could decimate a fishing ground, they suggested that considerable mortality could take place over the 1-2 years before the wire mesh corroded away, and indicated corrosion time would be longer and mortality would be greater for small sizes of mesh. A study by Harper and McClelland (1983) estimated the average fishing life of eight traps observed off Key Biscayne to be from 5.5 to 157 days before becoming unable to capture fish. They also found that 19.2% of the fish that entered the trap died (Harper and McClelland 1983). While the decay and catch rates of ghost traps are not well documented, at least some evidence indicates that lost traps quickly become damaged and ineffective (Sutherland et al. 1978). Most reports of injury and mortality from lost ghost traps are anecdotal but underwater video presented to the South Atlantic Fishery Management Council on June 11, 1990 documented dead and injured fish in ghost traps in the Florida Keys. The video was presented by Capt. Fernand Braun (a charter fishing guide) in an effort to persuade the Council to ban fish traps.

Derelict traps are lost or abandoned traps that are incapable of catching fish due to structural damage or deterioration. Derelict traps may have small holes or breaks and gaps between ceiling and floor panels and walls, or entire panels degraded or missing (Smolowitz 1978). Traps become derelict in a number of ways. Predator damage, corrosion, escape windows opening, and materials fastened to escape devices decomposing have all been documented.

Munro et al. (1971) speculated that lost fish traps that have accumulated large numbers of fish may be attacked and rendered ineffective by large predators such as nurse sharks (*Ginglymostoma cirratum*). Harper and McClelland (1983) found funnel openings enlarged with the prongs bent back and speculated that the damage was by large predators such as cubera snapper (*Lutjanus cyanopterus*), great barracuda (*Sphyraena barracuda*), yellow jacks (*Caranx bartholomae*), and lemon sharks (*Negaprion* *brevirostris*) attempting to escape and that mortality of these fish was high. Craig (1976) found that escapement through trap holes caused by predators became a problem if traps were not hauled after five or six days. Fish are rarely caught in traps with holes or breaks in the mesh and even small holes or breaks in the wire mesh apparently render them ineffective (Craig 1976; Sutherland and Harper 1983; Ward 1983).

Sutherland et al. (1983) found juvenile fish numerous in and around derelict fish traps. The derelict traps and other manmade objects appeared to serve as artificial reefs on barren sand sea floor areas (Sutherland et al. 1983; Harper and McClelland 1983). Sutherland et al. (1983) observed that fish were absent or rare near traps on or adjacent to reefs.

Impacts on habitat

The Council concluded that the issue of wire fish traps was a critical issue to the State of Florida and in the long term to the entire South Atlantic as well. Florida deliberated the issue of fish traps for many years and the Florida State Legislature prohibited the use of wire fish traps in 1980. The snapper grouper stocks are more overfished off Florida than they are anywhere else in the South Atlantic.

The Council concluded that fish traps are non-selective by size and by species (e.g., red grouper recruit to the hook and line fishery at around 19" and to the trap fishery at around 11"). Bohnsack et al. (1989) notes that modifications to mesh size will alter the size of fish caught. This study concluded that total value, species caught, number of individuals and mean total weight per haul declined with meshes larger or smaller than 1.5" hexagonal mesh. The mesh sizes required to correlate with the 20" minimum sizes would be so large as to result in de facto prohibition on use of fish traps.

Based on studies regarding fish traps between 1980-1990, the SAFM Council has concluded that wire fish traps capture a significant amount of bycatch. Information contained in Bohnsack et al. (1989) documents the bycatch of these species. Unfortunately, a variety of ornamental reef fish were not recorded separately in the commercial landings data until recently, thus the commercial landings data are not available to quantify the extent to which catches of these species have increased. We also expect that there has been a decline in the amount of ornamental reef fish caught as bycatch since wire fish traps were banned from federal waters (and state waters in Florida).

Since March 1, 1991 the State of Florida has prohibited the harvest of tropical fish: “The purpose and intent of this Chapter is to protect and conserve Florida’s tropical marine life resources and to ensure the continued health and abundance of these species. . The affect of selective removal of herbivores on the health of coral reefs was discussed by LaPointe (1989). These species were harvested by fish traps more frequently than by hook and line gear. Again, due to the fact that commercial statistics did not record these fish by species, data was unavailable to document the level of harvest by fish traps or by hook and line.

The further intent of this Chapter is to ensure that the harvesters in this fishery use non-lethal methods of harvest and that the fish, invertebrates and plants so harvested be maintained alive for the maximum possible conservation and economic benefits." Allowing fish traps in federal waters would make Florida's regulations difficult, if not impossible, to enforce and would not address Problem #5 which is, that "the existence of inconsistent state and federal regulation makes it difficult to coordinate, implement and enforce management measures and may lead to overfishing. Inconsistent management measures create public confusion and hinder voluntary compliance."

The way in which fish traps were used made enforcement extremely difficult. All other kinds of fishing gear are eventually brought back to the dock where they can be examined by state marine patrol officers or other law enforcement personnel. Once traps are placed in the water, they were seldom are brought back to the dock. Testimony documents the various kinds of violations recorded in the Key West area (e.g., biodegradable panel requirement violations). The loss of traps was high ranging from 20% to 63% and in certain sectors trap loss may be as high as 100%.

The SAFMC Law Enforcement Committee and Advisory Panel were established to advise the Council on enforceability of various management approaches. They noted that the existing system is difficult to enforce and is incompatible with Florida state law, that the 100-foot contour limitation is difficult to enforce and that poaching is a big law enforcement problem in the fish trap fishery. These two bodies recommended to the Council that a total prohibition on use of fish traps in the South Atlantic EEZ was the most enforceable of all alternatives considered.

The enforcement issue was summarized by Kelley (1990): "Enforcement is the largest problem of all. There are widespread abuses of the regulations governing the use of fish traps. There seems to be no effective way to enforce regulations in a fishery, such as fish trapping fishing, where gear can't be observed readily by enforcement officials. The largest present day problems in the Florida Keys and southeast Florida are the extensive trap poaching and the use of illegally constructed or deployed traps."

The Council recognized that gear that is not brought back to shore at the end of a fishing trip makes enforcement more difficult. The Council considered other, less drastic measures that would allow traps to be used but concluded that the at-sea enforcement required to effectively monitor and ensure compliance with existing regulations does not and will not exist. Therefore, the Council was persuaded that nothing short of a total ban on fish traps would be enforceable.

There is evidence that fish trapping causes habitat damage where fish traps are set in trawls on live bottom and where grappling hooks are dragged across live bottom to retrieve them. Testimony and video records of damaged *Oculina* reefs off Palm Beach County, provided to the Council at the February 1991 meeting, depicted significant and measurable damage to coral reef and live bottom communities. These activities leave an imprint of the trap upon the bottom communities and trenches caused by grappling hooks dragged over the bottom for the purpose of locating and recovering traps. Lost traps not only continue to fish, as it has been pointed out in the ghost trap discussion, but may contribute considerable secondary habitat damage by becoming mobilized at times of storm activity and impacting delicate bottom communities.

The affect of selective removal of herbivores on the health of coral reefs was discussed by LaPointe (1989). These species were harvested by fish traps more frequently than by hook and line gear. Again, due to the fact that commercial statistics did not record these fish by species, data was unavailable to document the level of harvest by fish traps or by hook and line.

Prohibiting fish traps was determined to be consistent with Florida's Coastal Zone Management Plan. Also, internationally, a number of countries (e.g., Bermuda) have tried to manage fish trap gear only to end up prohibiting their use. Bermuda has managed their snapper grouper fishery for a number of years and imposed a limited entry system with trap limitation. In addition, modifications to mesh size were also attempted. The Bermudian Government concluded that regulation the fish trap fishery was not effective and recently imposed a total ban on use of fish traps. The Council concluded that a total prohibition on the use of fish traps was the most effective alternative to address the stated problems and to achieve the plan's stated objectives.

6.2.2.3 Other Gear

Allowable Chemical

Collectors of live tropical reef fish commonly employ anesthetics such as quinaldine. Quinaldine (2-methy lquinoline, $C_{10}H_9N$) is the cheapest and most available of several substituted quinolines (Goldstein 1973). As a result of using this compound near corals where tropical species shelter, there may be residual effects which was discussed in a study by Japp and Wheaton (1975). Short-term impacts of quinaldine include increased flocculent mucus production, retraction of polyps and failure to re-expand with a five minute observation period, and tissue discoloration in certain species. At both study sites, octocorals were found to suffer no long-term impacts. However, a minority of Scleractinians displayed minor damage, including mild discoloration and small patches of dead tissue, three months after quinaldine treatment. Two of these specimens degraded to poor condition or displayed areas of dead tissue more than six months after initial treatment. Overall, Japp and Wheaton (1975) determined that quinaldine exposure resulted in minimal damage to corals.

Barrier Net

Barrier nets are used in conjunction with small tropical nets or slurp guns to collect tropical aquarium species. The net is deployed to surround a coral head or outcropping and may or may not have a pocket or bag that fish are “herded” into for capture. Barrier nets may be utilized by tropical fish collectors in both state and Federal waters.

The American Marine Life Dealers Association conducted a survey (Tullock and Resor 1996) that focused on tropical collection practices. The survey defined a sustainable fishing practice as one that a) does not cause physical damage to the reef environment; b) does not impair the captured specimen's longevity in a properly maintained aquarium environment; and c) does not damage non-target species such as coral polyps, other invertebrates, or non-aquarium fish. The survey concluded that barrier nets were a sustainable fishing practice. However, a study conducted by Öhman et al. (1993) summarized that moxy nets, a type of barrier net that is used in other regions to collect ornamental fish species, may break corals during their use. However, it is likely that damage inflicted by barrier nets would be infrequent and incidental in nature, and therefore, the gear would have a negligible effect on habitat.

Castnet

Used to capture baitfish and shrimp, castnets (Figure 18) are circular nets with a weighted skirt that is thrown over a schooling target. Castnets are primarily used in shallow areas such as estuaries, though they may be used to catch baitfish offshore in Federal waters. Castnets have the potential to dislodge organisms or become entangled if utilized over heavily encrusted substrates. Observations by the author have noted numerous castnets entangled amongst sponges and other growth around rough bottom. However, a study conducted by DeSylva (1954) determined that castnets have no detrimental effect on habitat.

Clam Kicking

Clam kicking is a mechanical form of clam harvest primarily practiced in the state waters of North Carolina. The practice involves the modification of boat engines in such a way as to direct the propeller wash downwards instead of backwards. The propeller wash is sufficiently powerful in shallow water to suspend bottom sediments and clams into a plume in the water column, which allows clams to be collected in a trawl net towed behind the boat (Peterson et al. 1987a).

Several studies have noted that the practice of clam kicking reduces algal and SAV biomass (Fonseca et al. 1984; Bargmann et al. 1985; Peterson et al. 1987a). Reduction of SAV biomass was noted to increase with harvest intensity. Intense clam kicking treatments reduced SAV biomass by approximately 65% (Peterson et al. 1987a). Because of the importance of SAV to coastal fisheries and estuarine productivity, Peterson et al. (1987a) noted that intense clam kicking could have long-lasting and serious impacts on many commercially important fisheries. However, clam harvesting had no detectable effect on the abundance of small benthic invertebrates and outside of SAV habitat, clam kicking does not appear to have any serious negative impacts on parameters of ecological value (Peterson et al. 1987a).

SAV recovery can be greater than two years if the rhizomes of the plant are removed (Homziak et al. 1982; Peterson et al. 1987a). Peterson et al. (1987a) observed that SAV had yet to recover after four years of an intense clam kicking treatment. Although Peterson et al. (1987a) designated their heavier clam kicking treatment as “intense,” they conceded that it probably falls well short of the effort that commercial clammers would apply to a productive SAV bed. Limiting the intensity of clam fishing in SAV habitat would probably be beneficial. Peterson et al. (1987a) offered that a restriction of mechanical clam harvesters to unvegetated bottoms may be a suitable mechanism to minimize habitat damage.

Clam Rake, Scallop Rake, Sponge Rake and Oyster Tong

Rakes are used to harvest shellfish and sponges from shallow areas such as bays and estuaries. Oyster tongs, similar to two rakes fastened together and facing each other like scissors, are used by fishermen from the deck of a boat. As these gears are limited by water depth, they are exclusively utilized in state waters.

Lenihan and Micheli (2000) reported that the harvest of shellfish utilizing clam rakes and oyster tongs significantly reduce oyster populations on intertidal oyster reefs. Both types of shellfish harvesting, applied separately or together, reduced the densities of live oysters by 50-80% compared with the densities of unharvested oyster reefs. While oysters are removed, Rothschild et al. (1994) concluded that hand tongs probably have a minor effect on the actual oyster bar structure. Peterson et al. (1987b) compared the impacts of two types of clam rakes on SAV biomass. The bull rake removed over 89% of shoots and 83% of roots and rhizomes in a completely raked area while the pea digger removed 55% of shoots and 37% of roots and rhizomes. Loss or impact on SAV by bull rake was estimated to be double the impact of the smaller pea digger rake. Peterson et al. (1987a) found raking with a pea digger rake reduced SAV biomass by approximately 25%. An earlier study conducted by Glude and Landers (1953) noted that bull rakes and clam tongs mixed the sandy-mud layer and the underlying clay. Fished areas were also softer and had less odor of decomposition than the unfished control site. A decrease in benthic fauna was noted in the fished sites versus the unfished control sites.

Sponges are an important fishery in the Florida Keys and along the west coast of Florida (NOAA 1996). Sponges are dominant organisms in deepwater passes and along hard bottom habitat communities. Sponges create vertical habitat which provides shelter and forage opportunities for other invertebrates and tropical fish species. The fishery in the Keys typically employs a four-pronged iron rake attached to the end of a 5–7 m pole, which hooks the sponges from the bottom. While no studies document the extent of habitat damage from this gear type, it may be concluded that the harvest of sponges directly reduces the amount of available habitat, and thus may present a negative localized impact.

Peterson et al. (1987a) found that SAV biomass recovered to equal and even exceeded expected values within one year. Lenihan and Micheli (2000) recommended the closure of some oyster reefs to shellfish harvest. Maintaining high densities of oysters on some intertidal reefs may help to preserve future oyster harvests and broodstock. Furthermore, protecting some reefs will also preserve the ecological functions that oyster reef provide such as improving water quality and providing essential recruitment, refuge, and foraging habitat for numerous marine species. Due to the extensive habitat that sponges provide, further ecological study on the directed harvest of these organisms should be conducted.

Dipnet and Bully Net

Widely utilized to catch baitfish, crabs, or lobster, varieties of dipnets (Figure 22) consist of a long pole with a bag of netting of varying mesh size that are lowered into the water. Dipnets may also be employed to capture tropical reef fish (Figure 23), though these utilize a short handle and very fine mesh. Additionally, landing nets or hand bully nets (Figure 24) used to capture lobster can be considered a form of dipnet. Varieties of dipnets may be used both in state and Federal waters.

DeSylva (1954) determined that dipnets have no detrimental effect on habitat. However, the use of small dipnets (i.e., tropical fish nets and lobster hand bully nets) may result in minor isolated impacts to coral species as individuals attempt to capture specimens (Barnette, personal observation).

Hand Harvest

Hand harvest describes activities that capture numerous species such as lobster, scallops, stone crabs, conch, and other invertebrates by hand. As many small biogenic structures occur on the sediment surface, even gentle handling by divers can destroy them easily. Movements by divers were observed to cause demersal zooplankters to exhibit escape responses (Auster and Langton 1999). A study that assessed recreational SCUBA activity in the US Caribbean (Garcia-Moliner et al. 2000) concluded that approximately 2% of the total recreational divers in the USVI and 1.9% of the total recreational divers in Puerto Rico were lobstering. Potential impact of approximately 13,532 units occurred in the USVI and 14,946 units occurred in Puerto Rico. In this study, impact units consisted of two hands and two feet (4 units per diver) and impact was broadly defined as ranging from touching coral with hands to the resuspension of sediment by fins. No assessment of habitat degradation or long-term impacts was discussed. Divers pursuing lobster along coral or hard bottom communities have been observed to impact gorgonians and other encrusting organisms (Barnette, unpublished observations).

Harpoon

Harpoons, thrown from the decks of a vessel, are utilized to target swordfish and tuna. As this gear is employed to harvest pelagic species, there is no contact with the benthos and, thus, no impact to habitat.

Haul Seine and Beach Seine

A haul seine is an active fishing system that traps fish by encircling them with a long fence-like wall of webbing. It is made of strong netting hung from a float line on the surface and held near the bottom by a lead line. They are fished either along the shoreline (beach seine) where they are deployed in a semi-circle to trap fish between shore and net or, more typically, fish are encircled away from shore, worked into an even smaller pocket of net and lifted onto a boat for culling (Sadzinski et al. 1996). The use of this gear is limited to state waters. Sadzinski et al. (1996) found no detectable effects from haul seining on SAV. However, possible damage from haul seining to sexual reproduction, such as flower shearing, was not examined. There are possible long-term or cumulative impacts at established haul-out sites, resulting in loss of SAV biomass (Orth personal communication). As the seine is generally used in flat benthic areas to prevent the net becoming damaged, in most cases the impact from seines would be expected to be minor and temporary.

Hook and Line, Handline, Bandit Gear, Buoy Gear and Rod and Reel

These gear types are widely utilized by commercial and recreational fishermen over a variety of estuarine, nearshore, and marine habitats. Hook and line may be employed over reef habitat or trolled in pursuit of pelagic species in both state and Federal waters.

Few studies have focused on physical habitat impacts from these gear types. Impacts may include entanglement and minor degradation of benthic species from line abrasion and the use of weights (sinkers). Schleyer and Tomalin (2000) noted that discarded or lost fishing line appeared to entangle readily on branching and digitate corals and was accompanied by progressive algal growth. This subsequent fouling eventually overgrows and kills the coral, becoming an amorphous lump once accreted by coralline algae (Schleyer and Tomalin 2000). Lines entangled amongst fragile coral may break delicate gorgonians and similar species. Due to the widespread use of weights over coral reef or hardbottom habitat and the concentration of effort over these habitat areas from recreational and commercial fishermen, the cumulative effect may lead to significant impacts resulting from the use of these gear types.

Patent Tong

Similar to hand tongs, hydraulic patent tong s (Figure 26) are much larger and are assisted with hydraulic lift, allowing them to purchase more benthic area in pursuit of oysters. Patent tongs are utilized in the oyster fisheries that occur in state waters. Rothschild et al. (1994) found that hydraulic-powered patent tongs are the most destructive gear to oyster reef structure because of their capability to penetrate and disassociate the oyster reef. The capability arises from the gear weight and hydraulic power. Patent tongs operate much like an industrial crane with each bite having the ability to remove a section of the oyster bar amounting to $0.25m^3$.

Due to overfishing and disease, oysters may now be more economically valuable for the habitat they provide for other valued species than they are for the oyster fishery (Lenihan and Peterson 1998). Rothschild et al. (1994) suggested the establishment of broodstock sanctuaries that includes the designation of “no-fishing” restrictions in specific areas. Lenihan and Micheli (2000) also recommended the closure of some oyster reefs to harvest. Maintaining high densities of oysters on some intertidal reefs may help to preserve future oyster harvests and broodstock. Furthermore, protecting some reefs will also preserve the ecological functions that oyster reef provide such as improving water quality and providing essential recruitment, refuge, and foraging habitat for numerous marine species.

Purse Seine and Lampara Net

Purse seines are walls of netting used to encircle entire schools of fish at or near the surface. Spotter planes are often used to locate the schools, which are subsequently surrounded by the netting and trapped by the use of a pursing or drawstring cable threaded through the bottom of the net. When the cable has pulled the netting tight, enclosing the fish in the net, the net is retrieved to congregate the fish. The catch is then either pumped onboard or hauled onboard with a crane-operated dip net in a process called brailing. Purse seines are utilized to harvest menhaden in the Gulf and South Atlantic. Similarly, the lampara net has a large central bunt, or bagging portion, and short wings. The buoyed float line is longer than the weighted lead line so that as the lines are hauled the wings of the net come together at the bottom first, trapping the fish. As the net is brought in, the school of fish is worked into the bunt and captured. In the Florida Keys a modified lampara net is used to harvest baitfish near the top of the water column. The wing is used to skim the water surface as the net is drawn in and fish are herded into the pursing section to be harvested with a dip net. Purse seines in the Gulf menhaden fishery frequently interact with the bottom, resulting in sediment resuspension. Schoellhammer (1996) estimated that sediments resuspended by purse seining activities would last only a period of hours.

Pushnet

Employed to harvest shrimp in shallow water, pushnets (Figure 30) consist of netting supported by a frame that is mounted on to a pole, which is then pushed across the bottom. Pushnets are generally utilized on SAV beds where shrimp can be harvested in abundant numbers. DeSylva (1954) determined that push nets have no detrimental effect on habitat.

Slurp Gun

A slurp gun is a self-contained, handheld device that captures tropical fish by rapidly drawing seawater containing such fish into a closed chamber. Slurp guns are typically employed on hardbottom and coral reef habitat in both state and Federal waters. It is possible that tropical collectors may impact coral or other benthic invertebrates in pursuit of tropical species that are harvested on hardbottom or coral habitat areas. However, due to the limited force applied by a diver in an errant fin kick or hand placement, the likely effects to habitat would be minor.

Snare

Recreational divers pursuing spiny lobster often use a long, thin pole that has a loop of coated wire on the end called a snare. The loop is placed around a lobster that may be residing in a tight overhang or other inaccessible location, and then tightened by a pull toggle at the base of the pole in order to capture and extract the lobster.

While there are no studies that evaluate this gear type, it is probable that use of this gear may minimize impacts to habitat in comparison to divers that use no additional gear (hand harvest). Due to the more surgical precision with the snare, divers likely impact the surrounding habitat to a lesser extent than if capturing by hand only due to the required leverage needed by the divers to capture a lobster by hand.

Spear and Powerhead

Divers use pneumatic or rubber band guns or slings to hurl a spear shaft to harvest a wide array of fish species. Reef species such as grouper and snapper, as well as pelagic species such as dolphin and mackerel, are targeted by divers. Commercial divers sometimes employ a shotgun shell known as a powerhead at the shaft tip, which efficiently delivers a lethal charge to their quarry. This method is commonly used to harvest large species such as amberjack.

Gomez et al. (1987) concluded that spearfishing on reef habitat may result in some coral breakage, but damage is probably negligible. A study that assessed recreational SCUBA activity in the US Caribbean (Garcia-Moliner et al. 2000) concluded that approximately 0.7% of the total recreational divers in the USVI and 28% of the total recreational divers in Puerto Rico are spearfishing. Potential impact would be approximately 4,736 units in the USVI and 220,264 units in Puerto Rico. In this study, impact units consisted of two hands and two feet (4 units per diver) and impact was broadly defined as ranging from touching coral with hands to the resuspension of sediment by fins. No assessment of habitat degradation or long-term impacts was discussed. It may be assumed that divers pursuing pelagic species have no effect on habitat due to the absence of any interaction with the benthos.

6.3 Cumulative impacts of fishing and non-fishing activities

This section analyzes cumulative impacts, which are defined by the Council on Environmental Quality (CEQ) as “impacts on the environment that result from the incremental impact of an action when added to other past, present, and reasonably foreseeable future actions, regardless of who undertakes such actions.” Increasing evidence suggests that the most severe environmental effects may not result from the direct impacts of a particular action, but rather from cumulative environmental effects. The incremental loss of important habitat can irreversibly alter the structure and function of the nearshore marine ecosystem and ultimately affect human activities (Jackson 1997). Further, regional problems are highly vulnerable to small decision effects – the tyranny of small decisions, as evidenced in the Florida Everglades (Odum 1982).

The overall cumulative impact of human-induced activities and natural events remains poorly documented, understood, and in dire need of more study. Nationally, one report noted that “federal agencies have struggled with preparing cumulative effect analyses since the CEQ issued its National Environmental Policy Act (NEPA) regulations in 1978.” (CEQ 1997).

It is evident that the effect of human activity on aquatic systems has been substantial in locations where access and economically profitable modification could be readily accommodated. Dahl (1990) reports that in the 1780's there were about 20.3 million acres of wetlands in Florida, about 6.8 million acres in Georgia, about 6.4 million acres in

South Carolina, and about 11.1 million acres in North Carolina. By the 1980's Florida's wetlands had been reduced to 11.0 million acres, Georgia's to 5.3 million acres, South Carolina's to 4.7 million acres, and North Carolina's to 5.7 million acres. Overall about 36.3% of all wetlands in states under SAFMC purview have been eliminated. On a state-by-state basis this includes 46% of Florida's wetlands, 23% of Georgia's wetlands, 27% of South Carolina's wetlands, and 49% of North Carolina's wetlands. A 2001 National Research Council report found that, as a result, by the 1980s the area of wetlands in the contiguous United States had decreased to approximately 53% of its extent one hundred years earlier (NRC 2001).

According to the FWS Status and Trends of Wetlands in the Conterminous United States 1998 to 2004 there was an estimated net gain in wetlands of 191,750 acres, however the report did not draw conclusion regarding the quality of the nation's wetlands and counted over 700,000 acres of open water ponds as wetlands. Intertidal wetlands declined by an estimated 28,416 acres, with the greatest percent change attributed to marine intertidal wetlands. The overriding factor in the decline of estuarine and marine wetlands was the loss of emergent saltmarsh to open saltwater systems due to manmade activities such as dredging, water control, and commercial and recreational boat traffic. There was an estimated 800 acre gain of estuarine shrub wetlands, however most of this gain came from areas formerly classified as estuarine emergent wetland. Estuarine vegetated wetlands have continued to decline over time as losses to the estuarine emergent category have overshadowed the small gains to estuarine shrub wetlands (Dahl 2006).
As an indication of the scope of developmental pressure, hence one aspect cumulative effect on EFH (coastal and tributary wetlands), NOAA Fisheries Service data show receipt of more than 20,778 individual development proposals (COE permit applications, federal projects, etc.) in North Carolina, South Carolina, Georgia, and Florida between 1981 and 1996 (See Tables 26, 27, 28, & 29). A subsample of 4,000 of these development proposals involved over 13,856 acres of various wetland habitats. Between 1996 and 2006, NOAA Fisheries Service reviewed an additional 20,896 applications to impact areas known to support EFH.

In addition to the substantial loss of wetlands in the southeastern United States, Nocholls et al. (1999) determined that by the 2080s, sea-level rise could cause the loss of up to 22% of the world's coastal wetlands. When combined with other losses due to direct human action, up to 70% of the world's coastal wetlands could be lost by the 2080s, although there is considerable uncertainty. Therefore, sea-level rise would reinforce other adverse trends of wetland loss.

While it is believed that most regulated activities are implemented as planned, Mager and Thayer (1986) report that limited monitoring indicate that about 20% of the projects they examined did not comply with provisions of the associated permits. Notably, most of the differences observed related more to design of structures and not the area of habitat affected. As shown in the following tables, individually and cumulatively significant impacts to EFH can be moderated through the COE regulatory program; however, significant wetland perturbations persist. This situation is largely perpetuated by (1) regulatory provisions that exempt regulation of certain wetland types and activities and

(2) by severe staffing limitations within regulatory and environmental review agencies. In the absence of substantial correction in these two areas, significant wetland areas will continue to be adversely altered or eliminated, and regulatory and review agency effectiveness will be limited.

In addition to the direct cumulative effect incurred by developmental type activities, EFH is also jeopardized by persistent increases in certain chemical discharges. In that case incremental change in habitats, hydrology, and chemical inputs produced, over time, an enormous and extremely harmful result whose negative economic and social implications may far exceed any benefits related to the causative factors. Unfortunately, the effect of adding ever greater volumes and varieties of chemicals to surface waters is often insidious and resulting declines in the abundance and quality of affected and harvested resources may be slow and difficult to identify. As illustrated by Scott et al (1997), the effects may be realized at rudimentary trophic and ecological association levels in key portions (including EFH) of estuarine environments.

The rate and magnitude of anthropomorphic change on EFH, whether cumulative, synergistic, or individually large, is influenced by natural parameters such as temperature, wind, currents, rainfall, salinity, etc. Consequently, the level of threat posed by a particular activity or group of activities may vary considerably from location to location. This situation may be most acute in locations that are subject to extreme weather and oceanic conditions such as hurricanes and large waves, or where the effects of periodic or global change are most prevalent.

Nutrient over-enrichment has become a large cumulative problem for southeastern EFH. Excessive nutrients may be directly toxic. Even relatively low nitrate-nitrogen levels (as low as 3.5 uM NO3-N) have been found to cause impacts on both growth and survival in eelgrass (*Z. marina*) during spring and fall growing seasons (Burkholder et al. 1992). In contrast, Cuban shoal grass (*Halodule wrightii*) and widgeon grass (*Ruppia maritima*) were stimulated by nutrient enrichment (Burkholder et al. 1994). Eelgrass provides important brackish water habitat element for finfish, crustaceans and molluscs in North Carolina (Thayer et al. 1984). Nitrate toxicity to eelgrass in the field has yet to be documented, although nitrate concentrations in the range found to have an impact in mesocosm experiments certainly occurs in many estuarine settings.

The effects of nutrient enrichment and stimulation of toxic dinoflagellates and other algae, especially *Pfiesteria piscidida*, have been widely reported by the news media. The high abundance of small heterotrophic algae in southeastern estuaries was well known among plankton researchers during the 1980s and earlier; however, the toxic nature of *Pfiesteria* was not reported until the late 1980s (Burkholder et al. 1992, 1993, 1995; Noga et al. 1993). Analyses suggest that a large suite of *Pfiesteria*-like small heterotrophic dinoflagellates exist in most southeastern estuaries (P. Tester, personal communication). These organisms include toxic forms, like *Pfiesteria*, and may be responsible for a significant number of fish kills associated with eutrophic estuaries (Burkholder et al. 1992). Fish kills in North Carolina and Maryland have been attributed, at least in part, to these organisms (Burkholder et al. 1995), and analyses suggest that toxic dinoflagellates (and related organisms) are on the rise at a global scale (Paerl 1988; Smayda 1989; Paerl et al. 1995a).

The stimulation of toxic organism population growth by nutrient enrichment may be related to factors outside the South Atlantic region. The most notable recent case was the transport of the toxic dinoflagellate *Ptychodiscus brevis* in 1989 by the Gulf Stream and associated eddies into Onslow Bay, North Carolina. Among other impacts offshore and inshore, this seriously impacted scallop production in Bogue Sound, North Carolina (Tester et al. 1989).

Enrichment of estuarine algal and bacterioplanktonic communities by excessive nutrients is probably the most often cited example of estuarine degradation globally (Nixon 1995; NRC 1994; Ryther and Dunstan 1971). In general, the ecological pathway involves enhanced algal or bacterial production and metabolism followed by excessive oxygen uptake and subsequent deoxygenation. Anoxia and hypoxia have been identified as the fundamental problems facing Chesapeake Bay, the Gulf of Mexico, the Tar-Pamlico and Neuse River Estuaries, and other locations throughout the world (Paerl 1988).

Associated processes may be complex. For example, nutrient uptake and excessive autotroph production may result in deposition of organic material into benthic sediments, where increased sediment oxygen demand may occur at some later time. In stratified estuaries, the process may even be exacerbated by the re-release of nutrients as sediment oxygen demand is exerted in bottom, anoxic waters. The ecological effects of modification of production patterns also includes hypercapnia (elevated levels of carbon dioxide), which exerts powerful effects on some organisms (Burnett 1997).

Algal blooms in southeastern waters represent a major threat to EFH. Important algal blooms have been documented in Albemarle Sound, the Chowan River, the Tar-Pamlico River, the Neuse River Estuary, the New River Estuary, Bogue Sound, the St. Johns River, and Indian River (NOAA 1996). Algal levels can be extremely high in grossly enriched waters. A one-day survey of the Pamlico Estuary in 1988 found chlorophyll a (an algal pigment) in excess of 200 ug/l, compared to a North Carolina Water Quality Standard of 40 ug/l (15A NCAC 2B.0200). Another type of algal community stimulation occurs when airborne nitrogen from all sources, including agriculture, is deposited through wet and dry deposition into distant oceanic waters. This phenomenon was largely unrecognized until recently (Paerl 1985, 1993). Consequences of this type of deposition, where the majority of “new” primary production comes from this source, can be quite significant, both on patterns in primary and secondary production and in the taxonomic makeup of that production, including the toxic forms cited above.

Among the most serious problems caused by algal blooms and other effects of over enrichment is the removal of oxygen from the water. The extent of deoxygenation in southeastern estuaries has been well documented (Rader et al. 1987; Stanley 1985). A more recent survey of the South Atlantic region found periodic hypoxic conditions in 13 of the 21 estuaries surveyed, with bottom-water anoxia in 11 locations. Only one instance of anoxia was found along the Sea Island Coast of South Carolina and Georgia, and this was linked to stratified conditions in the Savannah River. Major anoxic events were documented in the Neuse River, the Tar-Pamlico River Estuary, the Indian River and St. Helena Sound (NOAA 1996). Although seasonal low-oxygen events may be natural in southeastern stratified estuaries, expansion in the size or persistence of deoxygenated areas has been identified for some of the above listed waters (Breitburg 1990; Rabalais et al. 1996).

Effects of deoxygenation on resident and post-larval fish, crustacean, and mollusc communities can be significant. The enormous fish kills that have plagued the Tar-Pamlico and Neuse River Estuaries have received abundant popular press since the late 1980's, and have recently been systematically analyzed (Pietrafesa and Miller 1997). This study identified 246 kills in the Pamlico during the period 1985-1995, and 73 in the Neuse, including many over 1,000,000 fish. Fish kills have also been documented in the St. John River, Florida and Charleston Harbor, South Carolina (Burkholder et al. 1995). Another possible manifestation of nutrient over enrichment is the occurrence of chitonoclastic shell disease in blue crabs. This is believed by some to be related to water pollution (either stress incurred after exposure to anoxic conditions or cadmium). Little is known absolutely (Noga et al. 1990). In addition, fish diseases have been implicated throughout polluted estuaries, but the link to pollution remains uncertain (Noga et al. 1989).

The impact of fish kills from nutrient over enrichment is difficult to assess in terms of their effect on stocks of commercially important fish. Many of the fish killed are juveniles and Atlantic menhaden appear especially vulnerable. If these stocks are density independent, then kills translate directly into reduced adult population sizes. Vaughan (1986) found that in Atlantic menhaden, catastrophic kills, where 10% mortality events occur periodically, coupled to the accumulating 1% annual losses from permanent habitat loss, could cause a loss of 60% of the fishery within 30 years.

Impacts of atmospheric deposition of nutrients on inshore EFH is well documented, as cited above (and in Fisher and Oppenheimer 1991). Some studies suggest that nutrient enrichment from atmospheric and more traditional surface water sources can also modify planktonic and epibenthic algal communities to the detriment of fish. Changes in the phytoplankton community lead to changes in the grazer community, including the reduction or elimination of preferred prey items for planktivorous fish and fish larvae. One example is the plankton community of Western Albemarle Sound, North Carolina, where nanoplankton (the small-celled algae that are the principal food source for crustacean zooplankters) are replaced in part in some years by blue-green algae of low food value, with a concomitant elimination of the zooplankters preferred by some anadromous fish larvae and juveniles (Rulifson et al. 1986).

Besides fish, plankton, and algae, vascular marine plants also are adversely affected by excessive nutrients and their consequences. Eutrophication may cause the reduction in coverage of SAV due to shading associated with water column turbidity and the growth of epiphytic filamentous algae. Although significant die-offs of SAV have occurred in some locations in the southeast, including the Pamlico River Estuary, the direct causes of algal growth stimulation has not been established (Davis et al. 1985). NOAA's 1996 survey of impacts on SAV found declines in 5 of 21 estuaries of the southeast, including Albemarle/Pamlico Sounds, but increases in Biscayne Bay and Charleston Harbor (NOAA 1996).

A major problem with regard to assessing cumulative effects is that the majority of the methods developed to evaluate cumulative effects were developed in a terrestrial context and the applicability to marine resources and EFH is not clear. However, new analytical approaches may advance management evaluations of cumulative environmental effects. Ecological risk assessment procedures provide a useful frame for comprehensively structured analyses of anthropogenic effects (EPA 1992). These procedures involve the systematic evaluation of stressors and effects using flexible methods that foster detailed evaluations of effects (Harwell et al. 1995). The application of risk assessment principles to environmental assessments could result in more comprehensive scientific products that also carry more administrative weight. In addition, systematic applications of decision support systems can offer logically consistent methods to evaluate multiple policy alternatives. Decision support systems aid the objective identification of appropriate decision combinations according to multiple priorities and they support group-based policy evaluations (Saaty 1990; Keyes and Palmer 1993; Schmoldt et al. 1994). Combined utilization of these approaches may identify previously underemphasized factors and objective policy alternatives (Lindeman 1997b). Ultimately, they may foster more logical and explicit decision-making regarding cumulative effects issues.

A cumulative assessment of population-scale fishing effects in the Florida Keys documents that 13 of 16 grouper species, 7 of 13 snappers, and 2 of 5 grunts are recruitment overfished (Ault et al. 1998). The cumulative result of technologically enhanced fishing effort has been the accelerated removal of those top predators with most economic value. Therefore, intensive effort is now being expended to obtain species that are lower on the food chain (Pauley et al. 1998). This has serious implications; as the lower levels of the food chain decline, the chances of revival at the top of the food chain are diminished even further (Williams 1998). Top-down ecosystem degradation can result in a variety of unfavorable species abundance shifts (Goeden 1982) and, potentially, outright ecosystem collapse (Pauley et al. 1998). Further cumulative assessments of managed species in the South Atlantic may reveal long-term declines similar to those now identified in the Keys. Under such circumstances, traditional management measures (e.g., size and harvest limits), may not be adequate to rebuild sustainable fisheries for the most desirable species.

7.0 Essential Fish Habitat Evaluation and Recommendations

7.1 Conservation and restoration

7.1.1 Estuarine Marshes

Efforts to restore or create salt marsh habitat have been underway for over 20 years, as losses of coastal wetlands through erosion, land subsidence, sea level rise and coastal development have increased (Nixon 1980; Matthews and Minello 1994). Salt marsh restoration has received much attention in recent years. This is likely due to the considerable acreage of salt marsh that has been lost along U.S. coastlines, recent recognition of the important functions provided by salt marshes, and the relative ease in which tidal marsh vegetation can be propagated at restored sites. Restoration or creation of marsh habitat begins with designing a site with the appropriate hydrology, tidal exchange, and sediment properties to support the growth of salt marsh plants. Analyses of current and projected land-use patterns, and socioeconomic factors are necessary and may be a critical factor in the final selection of possible restoration sites. Salt marsh restoration projects that lack clearly defined goals and objectives are less likely to achieve success.

Often, restoration of tidal flushing, combined with the existence or creation of appropriate marsh morphology (i.e., elevation, slope, grade, substrate, etc.) will be enough to rapidly revegetate the area with native salt marsh communities (see Sinicrope et al. 1990). However, if the site is isolated from sources of recolonizing vegetation, planting may be required in order to decrease the length of time before natural revegetation occurs. Planting, though potentially costly, is beneficial in the restoration of sites damaged by pollution, (e.g., an oil spill) (Matsil & Feller 1996), and can hasten re-establishment of target salt marsh vegetative communities.

Subsequent to physical modification of the site, plantings are often made of *Spartina alterniflora* or, less frequently, of other marsh plants. Planting growing or dormant plants, or plant propagules, is the most reliable planting method for salt marsh restoration projects (Broome et al. 1988; Garbisch et al. 1975). Given appropriate site selection and preparation, successful establishment of *Spartina* and/or other marsh species can occur within a few growing seasons.

An important, and still unanswered, question relative to marsh habitat restoration is how long it takes to restore marsh habitat function, as opposed to simply the replacement of marsh plants; this evaluation of habitat function is complex and time-consuming. Examples of marsh functions to be evaluated are food web support, provision of fishery nursery grounds, and the transformation of nutrients (Smith et al. 1995). Research on monitoring methods often is focused on determining the functions provided by a restored habitat and comparing the functions to those provided by natural systems. Evidence to date suggests that the time it takes a transplanted salt marsh to attain the ecological function of a mature natural marsh may be 10 to 20 years. If the hydrology and tidal elevation of the site are not maintained, then the transplanted marsh may never supply equivalent habitat function as a natural marsh. This is particularly important to recognize in cases where marsh restoration or creation is undertaken to mitigate for the loss of natural marsh via development, dredging, or other permitted activities. Most studies indicate that overall restored salt marshes are providing fish access to usable habitat and the systems are functioning to increase growth, production, and resilience of fish populations. However, in some cases restored systems may be structurally or functionally different from natural marshes. Continued research will help determine whether improved restoration methods could improve functional equivalency.

7.1.2 Mangroves

Threats

While much of the mangrove forest area is protected in the U.S. under the jurisdictions of parks, sanctuaries and refuges (Gilmore and Snedaker 1993; Thayer et al. 1999), this coastal habitat and resource is being progressively diminished by a variety of natural and anthropogenic actions such as removal, severe pruning, deprivation of freshwater from upland watersheds, severe freezes, water pollution, competitive exclusion by exotic tree species (e.g., Australian pine, Brazilian pepper), coastal erosion and sea-level rise. Most of these aspects have been discussed and/or documented by Odum et al. (1982) and Gilmore and Snedaker (1993), and are discussed under the section Essential Fish Habitat.

Removal and alteration to freshwater flow are the top threats to mangrove forests in Florida. Although both federal wetland regulations and local ordinances are in place to protect mangroves, legislation has not proved very effective. A burgeoning human population has increased the realized and potential negative impacts of human activities on coastal habitats in regions with limited land mass and a fragile ecology. As of 1991, development in the Florida Keys had destroyed roughly 40 % of mangrove forests and reduced mean forest size by 69% (Strong and Bancroft 1994). Further north towards Miami, the acreage of mangrove forest in Biscayne Bay's watershed has declined by as much as 82% since the 1970's (Teas et al. 1976; Snedaker and Biber 1996).

Substantial area of mangrove habitat has been lost by impoundment. Impoundment involves the creation of a dike and ditch system around the perimeter of the wetland so that water levels in the wetland can be artificially raised to prevent ovideposition on the substrate by marsh mosquitoes. From the mid-1950s to today, over 16,000 hectares of mangrove forests and salt marshes along the Indian River Lagoon System (Florida) have been impounded, making this method the most common technique used to prevent new generations of mosquitoes in Florida (Rey & Kain 1990; Rey et al. 1991). Permanent impoundment and high water levels prevented the effective gas exchange through mangroves root systems and resulted in chronic mortality similar to that an oil spill might cause. Permanent impoundment also severed the connection between resident mangroves and the surrounding ecosystem (i.e., effective removal). Today, a rotational impoundment system (RIM) is used, and culverts fitted with flapgates can be seasonally opened and closed (Carlson et al. 1991). RIM is a much more ecologically benign system of mosquito control and coastal marsh management because it allows for the seasonal exchange of water, nutrients, and aquatic fauna.

Mangroves are considered resilient and display characteristics of some “pioneer species” in that they have broad tolerances to environmental factors, rapid growth and maturity, continuous or almost continuous flowering and propagule production, high propagule outputs in a wide range of environmental conditions, and adaptations for short and long distance dispersal by tides (Cintron-Molero 1992). Even with these “r-strategist”, characteristics, mangroves are sensitive and vulnerable to disturbance. Changes to the freshwater flow from the Everglades to coastal mangrove forests since the late 1800s have coincided with ecological declines in the region (Light and Dineen 1994; Sklar et al. 2001). Marine intrusion into traditionally freshwater areas has resulted in a several-kilometer expansion of the coverage of mangrove forests in the region (Ross et al. 2000). The replacement of a narrow fringe and riverine forest (comparatively high production forests) with an expansive dwarf forest (a comparatively low production forest) complicates assessment of the change over time in the total productivity of the region’s mangroves.

7.1.3 Seagrass

Threats

Like all other organisms and habitats in estuarine-near shore environments, seagrasses occur at the end of all watershed inputs: the juncture between riverine inflow and oceanic inputs as well as the interface between land and sea. This situation makes them extremely susceptible to perturbations by natural processes as well as being susceptible to damage by human activities (Short and Wyllie Echeverria 1996).

In the South Atlantic region seagrasses experience natural disturbances such as bioturbation (stingray foraging), storm or wave-related scour (tropical storms and surges), and disease or disease-associated perturbations (*Labyrinthula*), as well as man-related impacts (Short and Wyllie-Echeverria 1996). Especially problematic are excessive epiphytic loads and smothering by transient macroalgae, both of which are often associated with nutrient enrichment and coastal eutrophication. Excessive nutrient discharges and suspended sediments can also disrupt seagrass systems by causing water column algal blooms that diminish the amount of light available for benthic dwelling seagrasses (Dennison et al. 1993). Often, nutrient enrichment will have detrimental effects that cascade up and down the food webs of seagrass meadows by diminishing the dissolved oxygen concentrations and stressing the faunal communities. Also toxic concentrations of hydrogen sulfide may be formed which kills seagrass and diminish the ability of a meadow to filter and stabilize sediments, thus altering the water column environment for filter feeders and other primary producers.

Subtidal seagrasses have suffered little damage from oil spills whereas impacts on intertidal beds have been significant (Durako et al. 1993; Kenworthy et al. 1993). Oil spill-related impacts on the seagrass-associated fauna can range from smothering to lowered stress tolerance, reduced market values and incorporation of carcinogenic and mutagenic substances into the food chain. Other well-known impacts such as newly permitted dredge and fill operations are no longer a primary cause of major losses of seagrass habitat due to the recognition of their ecological role and vigilance of state and federal regulatory activities to limit permits. Dredging activities which are grandfathered into water management plans are potential problems causing turbidity, resuspension of toxic compounds and direct removal of seagrass. This human-related impact, although still present, is now being replaced by a larger issue, that associated with propeller scouring (Sargent et al. 1995), vessel groundings (Kenworthy et al. 2002), and some fishing gear-related impacts (Fonseca et al. 1984). This physical damage is long-lasting and often results in sediment destabilization and continued habitat loss (Kenworthy et al. 2002; Whitfield et al. 2002). The increasing number of small boats plying estuarine and coastal waters has made vessel impacts more widespread, and there has been a recognized need in some regions for both enhanced management of these systems and increased awareness by the boating public.

Water quality and, in particular, water clarity is now considered among the most critical, if not the most critical, factor in the maintenance of healthy SAV habitats (Dennison et al. 1993). In the past few years it has become increasingly evident that, with few exceptions, seagrasses generally require light intensities reaching the leaves of 15-25% of the surface incident light (Kenworthy and Fonseca 1996; Gallegos and Kenworthy 1996; Onuf 1996; Dixon 1999; Gallegos 2001). However, water transparency standards historically have been based on light requirements of phytoplankton which typically require only 1% of surface light (Kenworthy and Haunert 1991). Many factors act to reduce water column transparency, with excess suspended solids and nutrients being considered to be among the most important and most controllable through watershed management practices (Gallegos 1991).

The loss of seagrasses, regardless of the cause, leads to several undesirable, and often difficult to reverse, situations that reflect on aquatic vascular plant ecological values (Moore 2004). Losses can and have led to reduced sediment binding and water motion baffling capability of the habitat allowing sediments to be more readily resuspended and moved (Fonseca 1996), eventually disturbing other components of coastal ecosystems such as coral reefs. The physical ramifications include reef degradation, increased shoreline erosion (e.g., as occurred in some areas after the eelgrass die-off in the 1930's) and water column turbidity. The loss of seagrasses, of course, eliminates all important associated habitat functions pertinent to fisheries use.

Aspects of Conservation and Restoration

The recognition of the ecological role of seagrass habitats has prompted a need to conserve, and more recently protect these habitats by avoiding impacts (i.e., proactive management) (Fonseca et al. 1998; Kenworthy et al. 2005). This is a less costly and an environmentally sounder means of protecting this important resource than either mitigation or restoration. None-the-less, seagrass habitats have been and continue to be impacted or lost, and restoration efforts have broadened to include development and evaluation of new approaches to seagrass restoration and measurements of recovery of functional values (Fonseca et al. 1998; Fonseca et al. 2000). In addition, programs are being developed to plant seagrasses for purposes of sediment stabilization, nutrient uptake, and fishery habitat (Kirsch et al. 2004). These programs and projects, which consult with experts, utilize scientifically based guidelines, and monitor their restoration success. Research continues to evaluate current techniques and develop new approaches. However, we have not found a restoration or mitigation project that has returned seagrass habitat equal to that which has been lost. Much has been written on techniques and evaluation of restoration tools for seagrasses along the South Atlantic coast of the U.S. (Fonseca et al. 1998). Data are showing that if seagrass transplanting is successful we can expect a similar faunal community to return within a few years (2-4 possibly), depending on the geographic area and rate of development of the transplant (Fonseca et al. 1996). There are many uncertainties associated with seagrass mitigation and restoration such as impacts of herbivory, but experience is showing that efforts can be successful if the well-founded guidelines available are followed.

7.1.4 Oyster reefs and shell banks

Shell bottom restoration in North Carolina
(Source: NCCHPP)
State efforts to restore oyster habitat and enhance oyster fishery production began around the turn of the century (Marshall et al. 1999). These efforts relied mostly on planting a variety of natural cultch, including oyster, clam, and scallop shells, and, more recently, limestone marl. Experimental oyster cultch plantings began in 1900, and state-sponsored cultch planting began in 1915 (Marshall et al. 1999). Between 1915 and 1934, a total of 1,856,379 bushels of shells and seed oysters were planted in North Carolina's estuaries. The Oyster Rehabilitation Program officially began in 1947 and resulted in planting 838,088 bushels of shell and 350,734 bushels of seed oysters over its first 10 years. Since 1970, North Carolina has relied almost exclusively on cultch planting as a means of enhancing oyster production (Figure 3.5). From 1958 to 1994, 12,475,000 bushels of shell material were planted, for an annual average of 337,162 bushels (Marshall et al. 1999). Over the entire period of cultch planting from 1915-1994, about 15 million bushels of oysters were planted in North Carolina waters. This volume of shells would contain the equivalent of 4.5 billion 2-inch oyster shells. Using a minimum 30% area coverage (100 2-inch shells/m2) as defining shell bottom, the volume of shell cultch planted from 1915-1994 could cover as much as 11,120 acres (45,000,000 m2). However, this is an overestimate of actual shell bottom area gained, because the shell plantings consist of piles of variable thickness rather than a single uniform layer. Also, many of the cultch areas are replanted due to flattening by waves and/or commercial harvesting. Despite these planting efforts, the oyster harvest continued to decline (Marshall et al. 1999).

Similar to natural shell bottom, restored oyster reefs provide bottom habitat for economically important species (Breitburg 1998; Lenihan et al. 1998; Coen et al. 1999; Harding and Mann 1999; Grabowski et al. 2000; Lenihan et al. 2001; Peterson et al. 2003a). Recent studies have examined the habitat value of constructed oyster reefs compared to natural oyster reefs. The researchers found that landscape characteristics seemed to influence fish species' relative abundance (i.e., connectivity with SAV and/or salt marsh). Fish abundance was significantly greater on restored oyster reefs adjacent to SAV than on mud flat and/or salt marsh restored reefs (Grabowski et al. 2000). Restored intertidal oyster reefs produced significantly more economically valuable oysters ($95.68/10 m2) than estimates of oyster production on subtidal reefs ($11.61/10 m2). The value of legal oysters present on mud flat reefs ($129.38/10 m2) exceeded that for oysters on salt marsh ($50.50/10 m2) or SAV restored reefs ($24.25/10 m2). They estimated that the long-term value of commercial fisheries landings from restored reefs was greater than the oyster harvest for both intertidal and subtidal shell bottoms.

The habitat benefits of cultch plantings may only be limited or temporary if the shell bottom is removed or damaged by towed fishing gears or other harvesting gears (Marshall et al. 1999). Cultch plantings in the southern areas (Onslow, Pender and New Hanover counties) are frequently replanted after harvesting to replenish cultch material for recruitment (Marshall et al. 1999). It generally takes about 3-4 years before oysters on planted sites reach harvestable size in the Pamlico Sound system, while oysters reach the minimum legal size of 3 inches in about two years in the southern coastal area. Faster growth in this area is due to higher rates of water exchange caused by greater tidal flow than in most of Pamlico Sound. The increased flow brings in more food and prevents oxygen depletion problems.

The majority of cultch planting sites during 1990-1994 were in Pamlico Sound, lower Neuse River and lower Pamlico River (Marshall et al. 1999). The same general areas were also planted in 2001 and 2002 (Maps 3.4a-b). Most of the recent (2001-2002) oyster restoration effort has been conducted in large bays around Pamlico Sound and in smaller tributaries of other estuaries (Maps 3.4a-b). The majority of these sites are "new" plantings on basically barren sediment (Marshall et al. 1999). Criteria for site selection include suitable sediment types, currents, protection from storm damage, historical productivity, salinity patterns, and existing shellfish concentrations. The presence of bottom disturbing fisheries, such as trawling, hydraulic clamming, and long haul seining, is also considered. Recommended sites for cultch plantings are often narrow bands of mixed sand and mud sediment between shallow, hard, nearshore sediment and soft offshore sediment. In deep water, large oyster mounds are constructed to increase recruitment and reduce effects of low oxygen on the bottom. The planting sites are monitored for oyster recruitment and survival over a period of three years (DMF 2001a). Using vessels currently in operation, cultch can be planted in water as shallow as two feet (Marshall et al. 1999). Since the early 1980s, the DMF has concentrated primarily on cultch plantings and small-scale, high quality seed transplanting activities, also referred to as the "relay program." In the relay program, oysters are removed from dense oyster populations in prohibited areas and relocated to open harvest areas with depleted resources. The relay program is very small and concentrated in the south, where there is very little effect on the seed source areas (M. Street, DMF, pers. com., 2003).

The primary purpose of the DMF cultch-planting program since it began has been oyster fishery enhancement. The DMF enhancement efforts have also been directed at providing stable long-term oyster habitat because research in recent years shows that oyster reefs have important ecological and economic value as coastal fisheries habitat. This broadening of focus for the protection/restoration program has occurred since the late 1990s. As of 2001, there were five constructed/artificial reef sanctuaries in North Carolina located in Bogue Sound, West Bay (Tump Island), Deep Cove (Swan Quarter), Croatan Sound, and behind Hatteras Village (DMF 2001a). Work is currently underway to enhance several existing restoration sites and create additional sites. These areas are no-take, no-disturbance sanctuaries (C. Hardy, DMF, pers. com.). In other states, sanctuaries are a major component of restoration efforts (CBP 2000). Creation of additional "no take" subtidal oyster sanctuaries has been recommended by Frankenberg (1995), the Chesapeake Research Consortium (1999), and Lenihan et al. (1998). There are multiple ecological benefits of constructed and natural oyster sanctuaries, including the following (Breitburg et al. 2000):

- Protection of brood stock,
- Enhancement of oyster populations in surrounding harvested areas through larval dispersion,
- Protection of disease-resistant oysters, improving the genetic pool for disease resistance, and
- Protection of associated fisheries and other organisms from predation through development and maintenance of maximum vertical relief and structural complexity.

The first true oyster reef restoration project in North Carolina occurred in 1992-1993 when 13 acres of oyster producing habitat were created as mitigation for the loss of 16 acres of estuarine bottoms and 1.5 acres of wetlands in Roanoke Sound (Marshall et al. 1999). The DMF monitored the site as part of a mitigation agreement with the U.S. Army Corps of Engineers (COE). The DMF also performed mitigation projects for the North Carolina Department of Transportation, and additional projects creating more than 70 acres of shell bottom with the COE (Marshall et al. 1999). Research is continuing on how to better construct these sites to provide effective oyster habitat. However, in the Pamlico Sound region where spatfall continues to decline (Marshall et al. 1999), more planting and longer protection of sites may be required to achieve the same results as previous restoration efforts. Restoration efforts must use knowledge of larval availability in order to be most effective. In southern waters, the amount of shell habitat is generally stable, but the amount of harvestable area is decreasing as closures increase because of contamination from storm water runoff (R. Carpenter, DMF, pers. com.).

Restoration of shell bottom is also undertaken by non-profit groups. One such project has been initiated in Pamlico Sound by The Nature Conservancy, in cooperation with NOAA's Community-Based Restoration Program and several partners. The goal of the Project is to enhance the biological diversity of Pamlico Sound by establishing a self-sustaining complex of living oyster reefs throughout the estuary. The Conservancy has enlisted the cooperation of marine scientists to ensure the most up-to-date techniques for siting, construction and management are used. Some criteria for site selection include depth, salinity, shellfishing-prohibited status, disease-resistant salinities, reef footprints, presence of larvae, and proximity to SAV, salt marsh, fish nursery areas, or Military Protected Areas. States and territories containing anadromous, estuarine, and marine species are eligible to compete for Community-Based Restoration grants typically ranging from $25,000 to $75,000. As the number of oyster restoration projects grows, the need for an overall strategy for shell bottom restoration also increases.

Any expansions of the current restoration/enhancement effort will require additional sources and funding for oyster cultch or limestone marl. Funding for acquisition of cultch material must be increased to more efficiently use the existing planting capabilities of DMF. The DMF began a voluntary shell-recycling program in 2004 using local coordinators to collect discarded shells from individuals and businesses. The shells are later transferred to stockpile facilities before being planted in new or expanding oyster sanctuaries. The amount of cultch volunteered could somewhat offset the amount of funding needed for additional cultch material. However, the amount of cultch volunteered is probably secondary to the public awareness gained from a shell-recycling program.

Shell Bottom Restoration in South Carolina

Note: The following text is excerpted from the SCDNR website and from Walker (2005). Human activities, in concert with natural phenomena, have greatly affected the distribution and abundance of oysters in the United States. In many areas, oyster habitats have declined precipitously in recent years due to numerous causes, including over-harvesting, destruction of habitat, water pollution, and other effects related to coastal development.

South Carolina's shellfish resources, particularly its subtidal oyster beds, have diminished over the years due to salinity regime changes resulting from a variety of factors including Atlantic Intracoastal Waterway construction; Santee/Cooper River diversion and rediversion; and, accelerated freshwater inflow into estuaries caused by wetland drainage projects and the clearing of land for forestry and agricultural purposes (Walker 2005). While the intertidal oysters of South Carolina may still appear to be abundant there is increasing evidence of negative effects from anthropogenic (man-made) stressors such as nonpoint source runoff, construction of docks and marinas, improper harvesting techniques, and wakes from recreational boat traffic. In fact, in many of the more heavily utilized creek systems, essentially no oysters remain.

South Carolina oyster resources also suffer from a lack of husbandry (conservation), particularly in the common property grounds managed by the state. Appropriate husbandry includes replanting of oyster shell to provide substrate for subsequent generations. If removal of oysters by harvesting is not offset by replanting, the resource declines due to insufficient substrate. A shortage of shell for replanting and a lack of funds for staff and equipment have severely limited the scope of shell replanting by the state of South Carolina (Walker, 2005).

<u>Oyster Restoration Activities in South Carolina</u>

Oysters will readily recruit to planted shell substrate in areas that otherwise have little or no recruitment due to lack of suitable attachment sites. In South Carolina there are adequate breeding populations (adult stocks) but recruitment is limited by substrate.

Although a fully functional reef requires at least 3 to 5 years to develop, a remarkable suite of invertebrates (over 85 species) quickly colonizes the oyster reefs, providing food sources for larger invertebrates and finfish and beginning the natural process of stabilizing the reef.

Planting of shell can also help to trap sediments and absorb wave energy, reducing erosion of adjacent salt marshes. With careful site selection, replanting of shell can restore oyster habitat by providing substrate for juvenile oysters, which grow to form a self-sustaining reef.

Oyster restoration and enhancement efforts in South Carolina are conducted by the South Carolina Department of Natural Resources (SCDNR) and include large-scale replanting in public shellfish grounds supported by saltwater license revenues, small-scale community-based restoration through the SC Oyster Restoration and Enhancement (SCORE) program, and the shell recycling program. The latter two programs are described in greater detail below.

SCORE - South Carolina Oyster Restoration and Enhancement Program
The South Carolina Department of Natural Resources (SCDNR) is responsible for managing the state's oyster resources. Appropriate management includes the planting of material to provide substrate, known as cultch, for recruitment of juvenile oysters. The best cultch material is oyster shell.

In order to increase oyster habitat at the minimum cost to taxpayers, SCDNR has initiated the South Carolina Oyster Restoration and Enhancement (SCORE) program. There are two major components to the SCORE program: oyster shell recycling and community-based restoration. By working together, community members and biologists can restore oyster populations while 1) enhancing habitat for fish, shrimp, and crabs, 2) improving water quality of estuarine areas, and 3) informing and educating children, industry, and the general public.

Oyster Shell Recycling
Immature oysters at the free-swimming larvae stage require a solid surface or substrate for attachment, which is called "setting." Once attached, oysters cannot relocate. Not surprisingly, oysters have evolved a preference for setting on other oyster shell. Adult oysters and even shells of dead oysters emit chemicals that attract oyster larvae. By selecting oyster shells as a substrate, the larvae maximize the likelihood of setting near other oysters (a requirement for reproduction) and of setting in a suitable habitat.

Unfortunately, there is a nationwide shortage of oyster shell to be used as cultch. That which is available is often not readily accessible because it is spread out in many locations. SCDNR has initiated an effort to encourage the public to recycle oyster shell for use in resource management. Recycling centers have been established at several sites along the coast.

Consumers are encouraged to deposit clean shell (i.e., no trash) in designated bins at the recycling centers, which are periodically emptied by SCDNR. The shell collected in this manner is then used for restoration and enhancement of shellfish resources, thus reducing the cost of these activities. Community groups and youth organizations may wish to recycle shell as a community service project. An abundance of oyster shell ends up being discarded by restaurants, caterers, resorts, and from private oyster roasts, so it is important to recapture it before it is sent to the landfill.

Community-Based Restoration
The restoration component of the SCORE program depends on local citizen groups working closely with SCDNR staff to construct oyster reef habitat, and to monitor the success of those efforts. Since May 2001, more than 2000 volunteers have used more than 250 tons of recycled shell to construct approximately 2,369 m2 of oyster reef habitat at 30 sites along the South Carolina coast, from Murrells Inlet to Pinckney Island. After the reefs are constructed, volunteers are trained to monitor water quality, reef development, and reef/shoreline interactions. The overall goal of the SCORE program is to protect oyster reef habitats by increasing citizen awareness of the ecological importance of these habitats and the potential negative effects of human activities on these fragile ecosystems. By involving citizens in the restoration process the SCDNR hopes to accomplish the following:

- Develop a citizen constituency for oysters
- Initiate a grass-roots effort to restore oysters
- Increase public awareness of the value of oysters to the ecosystem
- Influence public policy to provide greater protection for oyster habitats
- Influence lawmakers to provide adequate funding for proper management of oyster resources
- Expand the scope of our endeavors by utilizing volunteer labor.

<u>Recommendations for shellfish management</u>
Intertidal oyster reefs serve to buffer shorelines from coastal erosion, improve water quality, and provide habitat for other species. Oysters are also highly prized for human consumption, and should be managed sustainably to allow for continued harvesting, as well as to provide ecological services. Walker (2005) lists recommendations for shellfish management changes in South Carolina, which are based on comparisons with other states and interviews with agency staff and other stakeholders within South Carolina. These recommendations include considering the importance of shellfish resources beyond their consumptive value when making management decisions, increasing the number of inter and intra-agency planning meetings to streamline management, increasing replanting funds and efforts, reviewing Culture Permit and State Shell Shellfish Ground management, and continuing information exchange with the industry.

7.2 Description and use of EFH, EFH-HAPCs and Coral HAPCs

7.2.1 Penaeid and deepwater shrimp

7.2.1.1 Essential Fish Habitat

Penaeid Shrimp
For penaeid shrimp, Essential Fish Habitat includes inshore estuarine nursery areas, offshore marine habitats used for spawning and growth to maturity, and all interconnecting water bodies as described in the SAFMC Habitat Plan (SAFMC 1998a). Inshore nursery areas include tidal freshwater (palustrine), estuarine, and marine emergent wetlands (e.g., intertidal marshes); tidal palustrine forested areas; mangroves; tidal freshwater, estuarine, and marine submerged aquatic vegetation (e.g., seagrass); and subtidal and intertidal non-vegetated flats. This applies from North Carolina through the Florida Keys.

Rock Shrimp
For rock shrimp, essential fish habitat consists of offshore terrigenous and biogenic sand bottom habitats from 18 to 182 meters in depth with highest concentrations occurring between 34 and 55 meters. This applies for all areas from North Carolina through the Florida Keys. Essential fish habitat includes the shelf current systems near Cape Canaveral, Florida which provide major transport mechanisms affecting planktonic larval rock shrimp. These currents keep larvae on the Florida Shelf and may transport them inshore in spring. In addition, the Gulf Stream is an essential fish habitat because it provides a mechanism to disperse rock shrimp larvae.

The bottom habitat on which rock shrimp thrive is thought to be limited. Kennedy et al. (1977) determined that the deepwater limit of rock shrimp was most likely due to the decrease of suitable bottom habitat rather than to other physical parameters including salinity and temperature. Cobb et al. (1973) found the inshore distribution of rock shrimp to be associated with terrigenous and biogenic sand substrates and only sporadically on mud. Rock shrimp also utilize hard bottom and coral or more specifically, Oculina coral habitat areas. This was confirmed with research trawls capturing large amounts of rock shrimp in and around the Oculina Bank HAPC prior to its designation.

Other than Kennedy et al. (1977), no characterization of habitat essential to rock shrimp has been conducted. A list of species associated with the benthic habitat inhabited by rock shrimp was compiled from research trawling efforts (1955-1991) that captured harvestable levels of rock shrimp. In addition, Kennedy et al. (1977), during research efforts sampling the major distribution area of rock shrimp off the east coast of Florida, compiled a list of crustacean and molluscan taxa associated with rock shrimp benthic habitat.

Royal Red Shrimp
Essential fish habitat for royal red shrimp include the upper regions of the continental slope from 180 meters (590 feet) to about 730 meters (2,395 feet), with concentrations

found at depths of between 250 meters (820 feet) and 475 meters (1,558 feet) over blue/black mud, sand, muddy sand, or white calcareous mud. In addition, the Gulf Stream is an essential fish habitat because it provides a mechanism to disperse royal red shrimp larvae.

7.2.1.2 Essential Fish Habitat-Habitat Areas of Particular Concern

Penaeid Shrimp

Areas which meet the criteria for essential fish habitat-habitat areas of particular concern (EFH-HAPCs) for penaeid shrimp include all coastal inlets, all state-designated nursery habitats of particular importance to shrimp (for example, in North Carolina this would include all Primary Nursery Areas and all Secondary Nursery Areas), and state-identified overwintering areas.

Estuarine tidal creeks and salt marshes that serve as nursery grounds are perhaps the most important habitats occupied by penaeid shrimp. The major factor controlling shrimp growth and production is the availability of nursery habitat. Remaining wetland habitat must be protected if present production levels are to be maintained. In addition, impacted habitats must be restored if future production is to be increased. Other areas of specific concern are the barrier islands since these land masses are vital to the maintenance of estuarine conditions needed by shrimp during their juvenile stage. Passes between barrier islands into estuaries also are important since the slow mixing of sea water and fresh water are also of prime importance to estuarine productivity.

In North Carolina, essential fish habitat-habitat areas of particular concern include estuarine shoreline habitats since juveniles congregate here. Seagrass beds, prevalent in the sounds and bays of North Carolina and Florida, are particularly critical areas. Core Sound and eastern Pamlico Sound, based on a preliminary aerial survey funded through the Albemarle-Pamlico Estuarine Study, have approximately 200,000 acres of seagrass beds making North Carolina second only to Florida in abundance of this type of habitat (Department of Commerce 1988b). In subtropical and tropical regions shrimp and spiny lobster postlarvae recruit into grass beds from distant offshore spawning grounds (Fonseca et al. 1992).

South Carolina and Georgia lack seagrass beds. Here, the nursery habitat of shrimp is the high marsh areas with shell hash and mud bottoms. In addition, there is seasonal movement out of the marsh into deep holes and creek channels adjoining the marsh system during winter. Therefore, the area of particular concern for early growth and development encompasses the entire estuarine system from the lower salinity portions of the river systems through the inlet mouths.

Section 600.815 (a) (8) of the final rule on essential fish habitat determinations recognizes that subunits of EFH may be of particular concern. Such areas, termed Essential Fish Habitat- Habitat Areas of Particular Concern (EFH-HAPCs), can be identified using Identification of habitat areas of particular concern. FMPs should identify specific types or areas of habitat within EFH as habitat areas of particular concern based on one or more of the following considerations: (i) The importance of the ecological function provided by the habitat; (ii) The extent to which the habitat is sensitive to human-induced environmental degradation; (iii) Whether, and to what extent, development activities are, or will be, stressing the habitat type; and (iv) The rarity of the habitat type. The following is a summary evaluation of the EFH-HAPC as it relates to the criteria:

Table 7.2-1. EFH-HAPC and Criteria Evaluation, Penaeid Shrimp

EFH-HAPC and Criteria Evaluation	Ecological Function	Sensitivity to Environmental Degradation	Threat from Development Activities	Rarity of Habitat
Coastal inlets	High	Low	Medium	Medium
State-designated nursery habitats	High	High	Medium	High
State-identified overwintering habitats	Medium	Low	Medium	Medium
Seagrass beds in NC and FL	High	High	Medium	High
High marsh areas with shell hash and mud bottom in SC and GA	High	Medium	Medium	Medium

Rock Shrimp

No essential fish habitat areas of particular concern have been identified for rock shrimp; however, deep water habitat (e.g., the rock shrimp closed area/proposed expanded Oculina Bank HAPC) may serve as nursery habitat and protect the stock by providing a refuge for rock shrimp.

Royal Red Shrimp

Although no essential fish habitats of particular concern have been identified specifically for royal red shrimp, they are caught in association with deep water corals on the continental slope. Deep sea corals support high levels of marine biodiversity by providing habitat for numerous benthic species. As structure-forming animals, deep sea corals enhance habitat complexity by growing in the form of "reefs", fans, stalks, and "bushes". The *Enallopsamia* reefs off South Carolina, the *Oculina* habitat off Florida, and the *Lophelia* reefs from North Carolina to Florida may be important in the life history of royal red shrimp. Bottom impacting mobile gear such as trawls will likely impact these important habitats.

To obtain maps of EFH-HAPCs please visit the Council's Internet Map Server on the South Atlantic Council's website at www.safmc.net.

7.2.2 Snapper Grouper

7.2.2.1 Essential Fish Habitat

EFH utilized by snapper grouper species in this region includes coral reefs, live/hard bottom, submerged aquatic vegetation, artificial reefs and medium to high profile outcroppings on and around the shelf break zone from shore to at least 183 meters [600 feet (but to at least 2,000 feet for wreckfish)] where the annual water temperature range is sufficiently warm to maintain adult populations of members of this largely tropical fish complex. EFH includes the spawning area in the water column above the adult habitat and the additional pelagic environment, including Sargassum, required for survival of larvae and growth up to and including settlement. In addition, the Gulf Stream is also EFH because it provides a mechanism to disperse snapper grouper larvae.

For specific life stages of estuarine dependent and near shore snapper grouper species, EFH includes areas inshore of the 30 meters (100-foot) contour, such as attached macroalgae; submerged rooted vascular plants (seagrasses); estuarine emergent vegetated wetlands (salt marshes, brackish marsh); tidal creeks; estuarine scrub/shrub (mangrove fringe); oyster reefs and shell banks; unconsolidated bottom (soft sediments); artificial reefs; and coral reefs and live/hard bottom habitats.

7.2.2.2 Essential Fish Habitat-Habitat Areas of Particular Concern

Areas which meet the criteria for essential fish habitat-habitat areas of particular concern (EFH-HAPCs) for species in the snapper grouper management unit include medium to high profile offshore hard bottoms where spawning normally occurs; localities of known or likely periodic spawning aggregations; nearshore hardbottom areas; The Point, The Ten Fathom Ledge, and Big Rock (North Carolina); The Charleston Bump (South Carolina); mangrove habitat; seagrass habitat; oyster/shell habitat; all coastal inlets; all state-designated nursery habitats of particular importance to snapper grouper (e.g., Primary and Secondary Nursery Areas designated in North Carolina); pelagic and benthic Sargassum; Hoyt Hills for wreckfish; the Oculina Bank Habitat Area of Particular Concern; all hermatypic coral habitats and reefs; manganese outcroppings on the Blake Plateau; and Council-designated Artificial Reef Special Management Zones (SMZs). Areas that meet the criteria for designating essential fish habitat-habitat areas of particular concern include habitats required during each life stage (including egg, larval, postlarval, juvenile, and adult stages).

Section 600.815 (a) (8) of the final rule on essential fish habitat determinations recognizes that subunits of EFH may be of particular concern. Such areas, termed Essential Fish Habitat- Habitat Areas of Particular Concern (EFH-HAPCs), can be identified using Identification of habitat areas of particular concern. FMPs should identify specific types or areas of habitat within EFH as habitat areas of particular concern based on one or more of the following considerations: (i) The importance of the ecological function provided by the habitat; (ii) The extent to which the habitat is sensitive to human-induced environmental degradation; (iii) Whether, and to what extent, development activities are, or will be, stressing the habitat type; and (iv) The rarity of the habitat type. The following is a summary evaluation of the EFH-HAPC as it relates to the criteria:

Table 7.2-2. EFH-HAPC and Criteria Evaluation, Snapper Grouper

EFH-HAPC and Criteria Evaluation	Ecological Function	Sensitivity to Environmental Degradation	Threat from Development Activities	Rarity of Habitat
The Point, NC	Medium	Low	Medium	High
The Ten Fathom Ledge, NC	High	Low	Low	High
Big Rock, NC	High	Low	Medium	High
Charleston Bump, SC	High	Low	Medium	High
Mangrove habitat	High	High	High	High
Seagrass habitat	High	High	High	High
Oyster/shell habitat	High	Medium	High	High
All coastal inlets	Medium	Low	Medium	Medium
All state-designated nursery habitats	High	High	High	High
Pelagic and benthic Sargassum	High	Low	Low	High
Hoyt Hills (wreckfish)	High	Low	Medium	High
Oculina HAPC, FL	High	Medium	Low	High
All hermatypic coral habitats and reefs	High	High	Low	High
Manganese outcroppings of the Blake Plateau	High	Low	Medium	High
Artificial reef SMZs	Medium	Low	Low	High

To obtain maps of EFH-HAPCs please visit the Council's Internet Map Server on the South Atlantic Council's website at www.safmc.net.

7.2.3 Coastal Migratory Pelagics

7.2.3.1 Essential Fish Habitat

Essential fish habitat for coastal migratory pelagic species includes sandy shoals of capes and offshore bars, high profile rocky bottom and barrier island ocean-side waters, from the surf to the shelf break zone, but from the Gulf stream shoreward, including Sargassum. In addition, all coastal inlets, all state-designated nursery habitats of particular importance to coastal migratory pelagics (for example, in North Carolina this would include all Primary Nursery Areas and all Secondary Nursery Areas).

For Cobia, essential fish habitat also includes high salinity bays, estuaries, and seagrass habitat. In addition, the Gulf Stream is an essential fish habitat because it provides a mechanism to disperse coastal migratory pelagic larvae.
For king and Spanish mackerel and cobia, essential fish habitat occurs in the South Atlantic and Mid-Atlantic Bights.

Refer to Section 3.0 in the Habitat Plan for a more detailed description of habitat utilized by the managed species. Also, it should be noted that the Gulf Stream occurs within the EEZ.

7.2.3.2 Essential Fish Habitat-Habitat Areas of Particular Concern

Areas which meet the criteria for essential fish habitat-habitat areas of particular concern (EFH-HAPCs) include sandy shoals of Capes Lookout, Cape Fear, and Cape Hatteras from shore to the ends of the respective shoals, but shoreward of the Gulf stream; The Point, The Ten-Fathom Ledge, and Big Rock (North Carolina); The Charleston Bump and Hurl Rocks (South Carolina); The Point off Jupiter Inlet (Florida); *Phragmatopoma* (worm reefs) reefs off the central east coast of Florida; nearshore hard bottom south of Cape Canaveral; The Hump off Islamorada, Florida; The Marathon Hump off Marathon, Florida; The “Wall” off of the Florida Keys; Pelagic Sargassum; and Atlantic coast estuaries with high numbers of Spanish mackerel and cobia based on abundance data from the ELMR Program. Estuaries meeting this criteria for Spanish mackerel include Bogue Sound and New River, North Carolina: Bogue Sound, North Carolina (Adults May-September salinity greater than 30 ppt); and New River, North Carolina (Adults May-October salinity greater than 30 ppt). For Cobia, they include Broad River, South Carolina; and Broad River, South Carolina (Adults & juveniles May-July salinity greater than 25ppt).

Section 600.815 (a) (8) of the final rule on essential fish habitat determinations recognizes that subunits of EFH may be of particular concern. Such areas, termed Essential Fish Habitat- Habitat Areas of Particular Concern (EFH-HAPCs), can be identified using Identification of habitat areas of particular concern. FMPs should identify specific types or areas of habitat within EFH as habitat areas of particular concern based on one or more of the following considerations: (i) The importance of the ecological function provided by the habitat; (ii) The extent to which the habitat is sensitive to human-induced environmental degradation; (iii) Whether, and to what extent, development activities are, or will be, stressing the habitat type; and (iv) The rarity of the habitat type. The following is a summary evaluation of the EFH-HAPC as it relates to the criteria:

Table 7.2-3. EFH-HAPC and Criteria Evaluation, Coastal Migratory Pelagics

EFH-HAPC and Criteria Evaluation	Ecological Function	Sensitivity to Environmental Degradation	Threat from Development Activities	Rarity of Habitat
Sandy shoals of Cape Lookout, Cape Fear and Cape Hatteras (from shore to the end of shoals but shoreward from Gulf Stream)	Medium	Low	Medium	Medium
The Point, NC	Medium	Low	Medium	High
The Ten Fathom Ledge, NC	Medium	Low	Medium	Medium
Big Rock, NC	Medium	Low	Low	Medium
Charleston Bump, SC	Medium	Low	Medium	Medium
Hurl Rocks, SC	Medium	Low	Medium	Medium
The Point off Jupiter Inlet, FL	Medium	Low	Low	Low
Phragmatopoma (worm reefs) reefs off central E. coast of FL	High	Medium	Medium	High
nearshore hardbottom south of Cape Canaveral, FL	High	High	High	High
The Hump off Islamorada, FL	Medium	Low	Low	Medium
The Marathon Hump, FL	High	Low	Low	Medium
Pelagic Sargassum	High	Low	Low	Medium
Bogue Sound and New River estuaries, NC (Spanish mackerel)	High	High	High	Medium
Broad River, SC (cobia)	High	High	High	Medium

To obtain maps of EFH-HAPCs please visit the Council's Internet Map Server on the South Atlantic Council's website at www.safmc.net.

7.2.4 Golden Crab

7.2.4.1 Essential Fish Habitat

Essential fish habitat for golden crab includes the U.S. Continental Shelf from Chesapeake Bay south through the Florida Straits (and into the Gulf of Mexico). In addition, the Gulf Stream is an essential fish habitat because it provides a mechanism to disperse golden crab larvae. The detailed description of seven essential fish habitat types (a flat foraminferan ooze habitat; distinct mounds, primarily of dead coral; ripple habitat; dunes; black pebble habitat; low outcrop; and soft-bioturbated habitat) for golden crab is provided in Wenner et al. (1987).

Refer to Section 3.0 in the Habitat Plan for a more detailed description of habitat utilized by the managed species. Also, it should be noted that the Gulf Stream occurs within the EEZ.

7.2.4.2 Essential Fish Habitat-Habitat Areas of Particular Concern

There is insufficient knowledge of the biology of golden crabs to identify spawning and nursery areas and to identify HAPCs at this time. As information becomes available, the Council will evaluate such data and identify HAPCs as appropriate through the framework.

7.2.5 Spiny Lobster

7.2.5.1 Essential Fish Habitat

Essential fish habitat for spiny lobster includes nearshore shelf/oceanic waters; shallow subtidal bottom; seagrass habitat; unconsolidated bottom (soft sediments); coral and live/hard bottom habitat; sponges; algal communities (Laurencia); and mangrove habitat (prop roots). In addition the Gulf Stream is an essential fish habitat because it provides a mechanism to disperse spiny lobster larvae.

Refer to Section 3.0 in the Habitat Plan for a more detailed description of habitat utilized by the managed species. Also, it should be noted that the Gulf Stream occurs within the EEZ.

7.2.5.2 Essential Fish Habitat-Habitat Areas of Particular Concern

Areas which meet the criteria for essential fish habitat-habitat areas of particular concern (EFH-HAPCs) for spiny lobster include Florida Bay, Biscayne Bay, Card Sound, and coral/hard bottom habitat from Jupiter Inlet, Florida through the Dry Tortugas, Florida.

Table 7.2-4. EFH-HAPC and Criteria Evaluation, Spiny Lobster

EFH-HAPC and Criteria Evaluation	Ecological Function	Sensitivity to Environmental Degradation	Threat from Development Activities	Rarity of Habitat
Florida Bay	High	High	Medium	Medium
Biscayne Bay	High	High	Medium	Medium
Card Sound	High	High	Medium	Medium
Coral/hardbottom habitat from Jupiter Inlet through the Dry Tortugas, FL	High	High	High	High

To obtain maps of EFH-HAPCs please visit the Council's Internet Map Server on the South Atlantic Council's website at www.safmc.net.

7.2.6 Coral, Coral Reefs and Live/Hard Bottom Habitat

7.2.6.1 Essential Fish Habitat

Essential fish habitat for corals (stony corals, octocorals, and black corals) must incorporate habitat for over 200 species. EFH for corals include the following:

A. Essential fish habitat for hermatypic stony corals includes rough, hard, exposed, stable substrate from Palm Beach County south through the Florida reef tract in subtidal to 30 m depth, subtropical (15°-35° C), oligotrophic waters with high (30 35o/oo) salinity and turbidity levels sufficiently low enough to provide algal symbionts adequate sunlight penetration for photosynthesis. Ahermatypic stony corals are not light restricted and their essential fish habitat includes defined hard substrate in subtidal to outer shelf depths throughout the management area.

B. Essential fish habitat for Antipatharia (black corals) includes rough, hard, exposed, stable substrate, offshore in high (30-35o/oo) salinity waters in depths exceeding 18 meters (54 feet), not restricted by light penetration on the outer shelf throughout the management area.

C. Essential fish habitat for octocorals excepting the order Pennatulacea (sea pens and sea pansies) includes rough, hard, exposed, stable substrate in subtidal to outer shelf depths within a wide range of salinity and light penetration throughout the management area.

D. Essential fish habitat for Pennatulacea (sea pens and sea pansies) includes muddy, silty bottoms in subtidal to outer shelf depths within a wide range of salinity and light penetration.

Refer to Section 3.0 in the Habitat Plan for a more detailed description of habitat utilized by the managed species.

7.2.6.2 Essential Fish Habitat-Habitat Areas of Particular Concern

Areas which meet the criteria for essential fish habitat-habitat areas of particular concern (EFH-HAPCs) for coral, coral reefs, and live/hard bottom include The 10-Fathom Ledge, Big Rock, and The Point (North Carolina); Hurl Rocks and The Charleston Bump (South Carolina); Gray's Reef National Marine Sanctuary (Georgia); The *Phragmatopoma* (worm reefs) reefs off the central east coast of Florida; Oculina Banks off the east coast of Florida from Ft. Pierce to Cape Canaveral; nearshore (0-4 meters; 0-12 feet) hard bottom off the east coast of Florida from Cape Canaveral to Broward County; offshore (5-30 meter; 15-90 feet) hard bottom off the east coast of Florida from Palm Beach County to Fowey Rocks; Biscayne Bay, Florida; Biscayne National Park, Florida; and the Florida Keys National Marine Sanctuary.

Table 7.2-5. EFH-HAPC and Criteria Evaluation, Coral, Coral Reefs, and Live/Hard Bottom Habitat

EFH-HAPC and Criteria Evaluation	Ecological Function	Sensitivity to Environmental Degradation	Threat from Development Activities	Rarity of Habitat
Ten Fathom Ledge, NC	Medium	Low	Medium	Medium
Big Rock, NC	Medium	Low	Medium	Medium
The Point, NC	Medium	Low	Medium	Medium
Hurl Rocks, SC	Medium	High	High	Medium
Charleston Bump, SC	Medium	Low	Medium	Medium
Gray's Reef NMS, GA	High	Low	Low	Medium
Phragmatopoma worm reefs, FL	Medium	High	Medium	High
Oculina Banks from Ft. Pierce to Cape Canaveral, FL	High	Low	Low	High
Nearshore hardbottom off from Cape Canaveral to Broward County, FL	High	Medium	High	Medium
Offshore hardbottom from Palm Beach County to Fowey Rocks, FL	High	Low	Medium	Medium
Biscayne Bay, FL	Medium	Low	Medium	Medium
Biscayne National Park, FL	Medium		Medium	Low
Florida Keys NMS, FL	High	High	High	High

To obtain maps of EFH-HAPCs please visit the Council's Internet Map Server on the South Atlantic Council's website at www.safmc.net.

7.2.7 Dolphin Wahoo

7.2.7.1 Essential Fish Habitat

EFH for dolphin and wahoo is the Gulf Stream, Charleston Gyre, Florida Current, and pelagic Sargassum.

Note: This EFH definition for dolphin was approved by the Secretary of Commerce on June 3, 1999 as a part of the South Atlantic Council's Comprehensive Habitat Amendment (SAFMC, 1998b) (dolphin was included within the Coastal Migratory Pelagics FMP). This definition does not apply to extra-jurisdictional areas. A detailed description of the pelagic habitats used by dolphin and wahoo is presented in Section 3.0 Affected Environment.

7.2.7.2 Essential Fish Habitat-Habitat Areas of Particular Concern

EFH-HAPCs for dolphin and wahoo in the Atlantic include The Point, The Ten-Fathom Ledge, and Big Rock (North Carolina); The Charleston Bump and The Georgetown Hole (South Carolina); The Point off Jupiter Inlet (Florida); The Hump off Islamorada, Florida; The Marathon Hump off Marathon, Florida; The "Wall" off of the Florida Keys; and Pelagic Sargassum.

Note: This EFH-HAPC definition for dolphin was approved by the Secretary of Commerce on June 3, 1999 as a part of the South Atlantic Council's Comprehensive Habitat Amendment (dolphin was included within the Coastal Migratory Pelagics FMP).

Section 600.815 (a) (8) of the final rule on essential fish habitat determinations recognizes that subunits of EFH may be of particular concern. Such areas, termed Essential Fish Habitat- Habitat Areas of Particular Concern (EFH-HAPCs), can be identified using Identification of habitat areas of particular concern. FMPs should identify specific types or areas of habitat within EFH as habitat areas of particular concern based on one or more of the following considerations: (i) The importance of the ecological function provided by the habitat; (ii) The extent to which the habitat is sensitive to human-induced environmental degradation; (iii) Whether, and to what extent, development activities are, or will be, stressing the habitat type; and (iv) The rarity of the habitat type. The following is a summary evaluation of the EFH-HAPC as it relates to the criteria:

Table 7.2-6. EFH-HAPC and Criteria Evaluation, Dolphin Wahoo

EFH-HAPC and Criteria Evaluation	Ecological Function	Sensitivity to Environmental Degradation	Threat from Development Activities	Rarity of Habitat
The Point	High	Medium	Medium	High
The Ten Fathom Ledge	High	Medium	Low	Medium
Big Rock	High	Medium	Medium	High
The Charleston Bump	High	Low	Medium	High

The Georgetown Hole	High	Low	Low	High
The Point off Jupiter Inlet	High	Medium	Low	High
The Hump off Islamorada	High	Low	Low	High
The Marathon Hump	High	Medium	Low	High
The Wall off of the Florida Keys	Medium	Medium	Low	Medium
Pelagic *Sargassum*	High	Medium	Low	High

The EFH-HAPCs for dolphin and wahoo all meet at least one or more of the above criteria. This action enables the Councils to protect these EFH-HAPCs effectively and take timely actions when necessary. This could prevent further decreases in biological productivity and may lead to possible increases in yield of fish stocks.
This evaluation is based in part on information presented in this Action and Section 3.3.1.2.1 describing the general characteristics of the unique habitat type and where available specific descriptions of the habitat associated with the area proposed for designation as an EFH-HAPC. In addition, supporting rationale for designation including identified threats from fishing and non-fishing activities is presented in Habitat Plan (SAFMC, 1998b), the Comprehensive Habitat Amendment (SAFMC, 1998c) and the Sargassum Fishery Management Plan (SAFMC 2002) and included by reference. The following figures present maps for areas which for dolphin and wahoo ranked high in terms of ecological function, sensitivity, probability of stressor introduction and rarity of habitat (criteria established for designation of EFH-HAPCs). Based on the criteria in Section 600.815 (a) (9), it is concluded that they represent Essential Fish Habitat-Habitat Areas of Particular Concern for species managed under the Fishery Management Plan for Dolphin Wahoo of the Atlantic Region.

To obtain maps of EFH-HAPCs please visit the Council's Internet Map Server on the South Atlantic Council's website at www.safmc.net.

7.2.8 Other managed species in the South Atlantic

7.2.8.1 Atlantic Menhaden

(ASMFC 2001)

Essential Fish Habitat

Almost all of the estuarine and nearshore waters along the Atlantic coast from Florida to Nova Scotia, serve as important habitat for juvenile and/or adult Atlantic menhaden. Spawning occurs in oceanic waters along the Continental Shelf, as well as in sounds and bays in the northern extent of their range (Judy and Lewis 1983). Larvae are carried by inshore currents into estuaries from May to October in the New England area, from October to June in the mid-Atlantic area, and from December to May in the South Atlantic area (Reintjes and Pacheco 1966). After entering the estuary, larvae congregate in large concentrations near the upstream limits of the tidal zone, where they undergo metamorphosis into juveniles (June and Chamberlin 1959). The relative densities of juvenile menhaden have been shown to be positively correlated with higher chlorophyll a levels in the lower salinity zones of estuaries (Friedland et al. 1996). As juvenile menhaden grow and develop, they form dense schools and range throughout the lower salinity portions of the estuary, most eventually migrating to the ocean in late fall-winter. Many factors in the estuarine environment affect the behavior and well-being of menhaden. The combined influence of weather, tides, and river flow can expose estuarine fish to rapid changes in temperature and salinity. It has been reported that salinity affects menhaden temperature tolerance, activity and metabolic levels, and growth (Lewis 1966; Hettler 1976). Factors such as waves, currents, turbidity, and dissolved oxygen levels can impact the suitability of the habitat, as well as the distribution of fish and their feeding behavior (Reintjes and Pacheco 1966). However, the most important factors affecting natural mortality in Atlantic menhaden are considered to be predators, parasites and fluctuating environmental conditions (Reish et al. 1985).

It is clearly evident that estuarine and coastal areas along the Atlantic coast provide essential habitat for most life stages of Atlantic menhaden. However, an increasing number of people live near the coast, which precipitates associated industrial and municipal expansion, thus, accelerating competition for use of the same habitats. Consequently, estuarine and coastal habitats have been significantly reduced and continue to be stressed adversely by dredging, filling, coastal construction, energy plant development, pollution, waste disposal, and other human-related activities.

Estuaries of the mid-Atlantic and South Atlantic states provide almost all of the nursery areas utilized by Atlantic menhaden. Areas such as Chesapeake Bay and the Albemarle-Pamlico system are especially susceptible to pollution because they are generally shallow, have a high total volume relative to freshwater inflow, low tidal exchange, and a long retention time. Most tributaries of these systems originate in the Coastal Plain and have relatively little freshwater flow to remove pollutants. Shorelines of most estuarine areas are becoming increasingly developed, even with existing habitat protection programs. Thus, the specific habitats of greatest long-term importance to the menhaden stock and fishery are increasingly at risk.

7.2.8.2 Anadromous and Catadromous Species

Alosine species (from ASMFC habitat docs on anadromous species)

Essential Fish Habitat-Habitat Areas of Particular Concern

Habitats described as EFH for other managed species (spawning adult, egg, larval, juvenile, sub-adult, and adult resident and migratory) are deemed essential to the sustainability of anadromous alosine stocks as they presently exist. Nursery habitat for anadromous alosines consists of areas in which the larvae, postlarvae, and juveniles grow and mature. These areas include the spawning grounds and areas through which the larvae and postlarvae drift after hatching, as well as the portions of rivers and adjacent estuaries in which they feed, grow, and mature. Juvenile alosines, which leave the coastal bays and estuaries prior to reaching adulthood also use the nearshore Atlantic Ocean as a nursery area (ASMFC 1999).

Sub-adult and adult habitat for alosines consists of the nearshore Atlantic Ocean from the Bay of Fundy, Canada to Florida; inlets, which provide access to coastal bays and estuaries; and riverine habitat upstream to the spawning grounds (ASMFC 1999). American shad and river herring have similar seasonal distributions, which may be indicative of similar inshore and offshore migratory patterns (Neves 1981). Although the distribution and movements of hickory shad are essentially unknown after they return to the ocean, (Richkus and DiNardo 1984) because they are harvested along the southern New England coast in the summer and fall, (Bigelow and Schroeder 1953) it is assumed that they also follow a migratory pattern similar to American shad (Dadswell et al. 1987).

Klauda et al. (1991) concluded that the critical life history stages for American shad, hickory shad, alewives, and blueback herring are the egg, prolarva (yolk-sac or prefeeding larva), postlarva (feeding larva), and early juvenile (through the first month after transformation). Critical habitat in the state of North Carolina is defined as "The fragile estuarine and marine areas that support juvenile and adult populations of economically important seafood species, as well as forage species important in the food chain." Among these critical habitats are anadromous fish spawning and anadromous nursery areas, in all coastal fishing waters (NCAC 3I.0101 (20) (NCDEHNR 1997). Although most states have not formally designated essential or critical alosine habitat areas, most states have identified spawning habitat, and some have even identified nursery habitat.

Tables 1-4 summarize significant environmental, temporal, and spatial factors that affect the distribution of American shad, hickory shad, alewife, and blueback herring. Tables 5-8 contain confirmed, reported, suspected, or historical state habitat for American shad, hickory shad, alewife, and blueback herring. Appendix C contains information about past, current, or proposed actions to restore alosine habitat by state. Appendix D contains a discussion of habitat in the Exclusive Economic Zone (EEZ) and international waters. Alosines spend the majority of their life cycle outside of state waters, and the Commission recognizes that all habitats used by these species are essential to their existence.

American eel

Essential Fish Habitat-Habitat Areas of Particular Concern

Habitat types that qualify as Habitat Areas of Particular Concern for American eel include the spawning and hatching area, nursery and juvenile habitat, and adult habitat.

Ocean - The spawning and hatching area for American eel occurs in the oceanic waters of the Sargasso Sea. This is the only suspected location of reproduction for American eel, and therefore, is essential to the survival of the species. Little is known about American eel habitat in the Sargasso Sea, and the exact location of spawning and hatching has not been identified.

Continental Shelf - The Continental shelf waters are important to the American eel because it is final stage of the larval eel migration route, where eels begin entering coastal waters, and is important to larval feeding and growth. It is also where American eel metamorphose into the glass eel stage.

Estuaries/Freshwater Habitat – Estuaries and any upstream freshwater habitat, including rivers, streams, and lakes serve as juvenile, sub-adult, and adult migration corridors, as well as feeding and growth areas for juveniles and sub-adults (ASMFC 2000). After American eel larvae transform into glass eels over the continental shelf, they enter estuaries, and ascend the tidal portions of rivers. Glass eels change into the elver life stage and either continue upstream movements, or cease migrating in the lower saline portions of estuaries and rivers. These estuaries and freshwater habitats serve as the foraging grounds for American eels and are important to the eel growth and maturation. American eels can remain in these systems for up to twenty years before maturing and returning to sea.

While estuarine/riverine habitats have been identified as important for the rearing and growth of American eels, many studies have failed to find specific American eel-habitat associations within them (Huish and Pardue 1978; Meffe and Sheldon 1988; Smogor et al. 1995; Bain et al. 1988; Wiley et al. 2004). Huish and Pardue (1978) found no difference in American eel abundance in relation to width, substrate, flow, and depth in North Carolina streams. Likewise, Bain et al. (1988) found that eel habitat use was not related to specific habitat features including depth, water velocity, and substrate in two Connecticut River tributaries. Wiley et al. (2004) also did not find any eel-stream habitat relations. They found that eel density was correlated with distance from the ocean. Since eels have the ability to survive in a wide variety of habitats, the phase of their lives when they live in estuarine, riverine, stream, and lake habitats are less limited, but water quality is an important factor in their health and survival.

Given the great variation in demographics that occurs across latitudinal and distance-inland gradients, it's unlikely that all areas contribute equally to eel production/recruitment. Despite this, geographic patterns of differential recruitment are unexplored. This problem needs to be addressed before identifying specific Habitat Areas of Particular Concern.

7.2.8.3 Red Drum

For red drum, important fish habitat includes all the following habitats to a depth of 50 meters offshore: tidal freshwater; estuarine emergent vegetated wetlands (flooded saltmarshes, brackish marsh, and tidal creeks); estuarine scrub/shrub (mangrove fringe); submerged rooted vascular plants (sea grasses); oyster reefs and shell banks; unconsolidated bottom (soft sediments); ocean high salinity surf zones; and artificial reefs. The area covered includes Virginia through the Florida Keys.

Other important habitats for red drum include all coastal inlets, all state-designated nursery habitats of particular importance to red drum (for example, in North Carolina this would include all Primary Nursery Areas and all Secondary Nursery Areas); documented sites of spawning aggregations in North Carolina, South Carolina, Georgia, and Florida described in the Habitat Plan; other spawning areas identified in the future; and habitats identified for submerged aquatic vegetation.

7.2.8.4 Bluefish

The following present life history and habitat characteristics in the EFH Source Document (NEFSC 2006).

Table 7.2-7. Summary of life history and habitat characteristics for bluefish, *Pomatomus saltatrix*.

Life History Stage	Habitat (Spatial and Temporal)	Temperature	Salinity	Light/Vertical Distribution	Currents/ Circulation	Prey	Estuarine Use
Eggs [1]	*spring cohort*: unknown. *summer cohort*: occurs across continental shelf, southern New England to Cape Hatteras. Most in mid-shelf waters.	*spring cohort*: unknown. *summer cohort*: most in 18-22°C.	*spring cohort*: unknown. *summer cohort*: 31.0 ppt or more (minimum 26.0 ppt).	*spring cohort*: unknown. *summer cohort*: peak spawning in the evening (1900-2100 hrs).	*spring cohort*: unknown. *summer cohort*: in southern MAB, surface currents transport eggs south and offshore.	--	None
Larvae [2]	*spring cohort*: near edge of continental shelf, Cape Hatteras-Cape Canaveral, FL. Peak April-May. *summer cohort*: most 30-70 m depths, May-Sept, peak in July.	*spring cohort*: smallest larvae in > 24°C. *summer cohort*: near Cape Hatteras 22.1-22.4°C; in MAB 18-26°C.	*spring cohort*: smallest larvae in > 35 ppt. *summer cohort*: in MAB in 30-32 ppt.	*spring cohort*: > 4 mm strongly associate with surface. *summer cohort*: near surface at night, mostly at about 4 m during day.	*spring cohort*: subject to northward advection by Gulf Stream. Some retained in SAB by southerly counter-current. *summer cohort*: southwest winds in MAB may facilitate cross-shelf transport.	*summer cohort*: mostly copepod life history stages. Guts full during day.	None
Pelagic Juveniles [3]	*spring cohort*: smallest near 180 m contour; larger near shore. April-May. *summer cohort*: cross MAB shelf from Slope Sea to shore, early- to mid-June.	*spring cohort*: 19.0-24.0°C (or higher well offshore). *summer cohort*: in MAB 15.0-20.0°C (most > 18.0°C). As low as 13.0°C when cross shelf.	*spring cohort*: Near 180 m contour, > 35.0 ppt. *summer cohort*: During June, range 36.0-31.0 ppt.	*both cohorts*: strongly associated with the surface.	*spring cohort*: shoreward movement with growth unless advected north. *summer cohort*: move shoreward with growth. Currents important, but active swimming indicated.	--	*both cohorts*: enter estuarine nurseries during this stage
Juveniles [4] ***(summer cohort only)***	Several estuarine study areas between Narragansett Bay, RI and Delaware Bay and Delaware River. Also coast beaches and surf zones.	In most studies, arrive > 20°C, remain in temperatures up to 30°C, emigrate when declines to 15°C. Can not survive below 10°C or above 34°C. Fall migration in 18-22°C on inner continental shelf.	Usually 23.0-33.0 ppt but can intrude to as low as 3.0 ppt.	Day: usually near shorelines or in tidal creeks. Night: usually in open bay or channel waters.	Can occur in surf zone or clear to turbid back-estuarine zones.	Atlantic silversides, bay anchovy, clupeids, striped bass, sand shrimp, mysids, other fish, invertebrates.	Mostly sand, particularly along coast, but some mud, silt, clay. Also uses *Ulva*, *Zostera* beds, and *Spartina* or *Fucus*. In Chesapeake Bay includes oyster bars and beds.
Adults [5]	Generally oceanic, nearshore to well offshore over continental shelf.	Warm water, usually > 14-16°C. Can tolerate 11.8-30.4°C but are stressed at either extreme.	Oceanic salinities.	--	--	Sight feeders, prey on other fish almost exclusively.	Not uncommon in bays, larger estuaries, as well as coastal waters.

[1] Norcross et al. (1974); Berrien and Sibunka (1999); data from present report.
[2] Norcross et al. (1974); Kendall and Walford (1979); Kendall and Naplin (1981); Powles (1981); Collins and Stender (1987); Hare and Cowen (1996); data
from present report.
[3] Fahay (1975); Kendall and Walford (1979); Powles (1981); Collins and Stender (1987); Hare and Cowen (1996).
[4] Lund and Maltezos (1970); Olla et al. (1975); Milstein et al. (1977); Nyman and Conover (1988); Rountree and Able (1992a, b); McBride et al. (1995); Able
et al. (1996); Buckel and Conover (1997); Harding and Mann (2001), Buckel and McKown (2002), Secor et al. (2002), Able et al. (2003).
[5] Bigelow and Schroeder (1953); Olla and Studholme (1971).

7.2.8.5 Horseshoe Crab

(from ASMFC's Horseshoe Crab FMP 1998)
Beach areas that provide spawning habitat are considered essential habitats for adult horseshoe crabs. Nearshore, shallow water, intertidal flats are considered essential habitats for the juvenile development. Delaware Division of Fish and Wildlife's 16-foot bottom trawl survey data indicated that over 99% of juvenile horseshoe crabs (less than 160 mm prosomal width) were taken at salinities greater than 5 parts per thousand (Michels 1997).

Larger juveniles and adults use deep water habitats to forage for food, but these are not considered essential habitat. Of these habitats, the beaches are the most critical (Shuster 1994). Optimal spawning beaches may be a limiting reproductive factor for the horseshoe crab population. Based on geomorphology Botton et al. (1992) estimated that only 10% of the New Jersey shore adjacent to Delaware Bay provided optimal horseshoe crab spawning habitat. The densest concentrations of horseshoe crabs in New Jersey occur on small sandy beaches surrounded by salt marshes or bulkheaded areas (Loveland et al. 1996).

Prime spawning habitat is widely distributed throughout Maryland's Chesapeake and coastal bays, including tributaries. Horseshoe crabs are restricted to areas that exceed 7 ppt salinity (Maryland Department of Natural Resources 1998). In the Chesapeake Bay, spawning habitat generally extends to the mouth of the Chester River, but can occur farther north during years of above normal salinity levels. Prime spawning beaches within the Delaware Bay consist of sand beaches between Maurice River and the Cape May Canal in New Jersey and between Bowers Beach and Lewes in Delaware (Shuster 1994).

7.2.8.6 HMS Species – Species in SA

Tunas

(excerpted from the Consolidated HMS FMP, chapter 10, section titled "Tunas" under "Summary of Review and Findings.)"

In recent years, archival tags and popup satellite tags (PSATs) have been used to successfully monitor ocean-wide movements of giant bluefin tuna as well as other HMS (Block et al. 2001, 2005; Lutcavage et al. 1999). This technology has greatly expanded the understanding of migratory patterns, reproductive behavior, and habitat use for bluefin tuna as well as other HMS such as blue and white marlin (NMFS 2004). However, despite these advances, there are considerable gaps in the understanding of habitat requirements as they relate to identifying Essential Fish Habitat (EFH) for tunas. Accurate identification of certain species of tunas can be difficult unless one has sufficient knowledge to check for appropriate distinguishing characteristics. This is particularly true for planktonic larval stages of all tuna species and adult stages of bigeye and blackfin tuna. For example, bigeye tuna may easily be mistaken for blackfin or juvenile yellowfin tuna, and can only be positively distinguished from one another by examining the liver and gill rakers. Reviewers raised concerns regarding presence of a high number of bigeye tuna in the Gulf of Mexico, which are rarer than blackfin tuna, and which may have been misidentified. The distribution maps for bigeye tuna indicate a significant number of observations in the Gulf of Mexico that may need to be reviewed and reanalyzed for accuracy prior to any modifications being made to existing boundaries (J. Lamkin, pers. comm.).

The Tag A Giant (TAG) program is a collaborative effort among scientists from Stanford University, the Monterey Bay Aquarium, and NOAA Fisheries Service which continues to place electronic tags internally and externally on Atlantic bluefin tuna in the North Atlantic to continuously record data. Tag A Giant deployed 201 archival and 37 pop-up satellite archival tags (PSATs) over two years, during which time 21 archival tags were recovered, more than a third of which were recaptured east of the 45 degree management line. The program has collected over 13,000 geopositions obtained from 330 bluefin tuna. It is now possible to examine data in relation to year class, season, and spawning grounds visited. Bluefin tuna tagged in the western Atlantic have migrated to both the Mediterranean and Gulf of Mexico spawning grounds. Most migration to spawning grounds in the Gulf of Mexico occurred in the spring months where spawning fish appear to prefer mesoscale cyclonic eddies in the western Gulf. Results indicate that spawning occurs in the Gulf of Mexico primarily during the months of April to June (Block et al. 2005).

The results attained from the TAG program detail the movements and behaviors of Atlantic bluefin tuna. These data answer questions about habitat preferences, spawning and feeding grounds, spawning site fidelity, the level of mixing between eastern and western stocks, and how movements are influenced by age class and season. Linking biological data with environmental data can assist in understanding relationships between the bluefin's physical environment and its behavior, movements, abundance and distribution, leading to predictive models enabling researchers to estimate the abundance and distribution of bluefin based on oceanographic features, season, and year class. This information is being collected primarily for ICCATs consideration in updating management strategies and quotas that reflect the bluefin tunas life history in the Atlantic Ocean.

Data collected to date consistently show that spawning occurs primarily after the bluefin reach 10 years of age. Bluefin tuna that are 8.5 years and younger tend to remain near New England in the summer and fall whereas older fish move offshore, many traveling to the east of the 45 degree management zone to the Mid-Atlantic Bight and Flemish Cap. Seasonal patterns are also apparent. Bluefin tuna remained in the coastal and offshore waters of North Carolina and the South Atlantic Bight throughout the winter months, predominately over the shallow continental shelf. In the spring, most fish move north depending on age class, where they remain for the summer before returning to the south in the fall. The movements among regions appear to be dependent on temperature.
In 2002 and 2003, the TAG program expanded tagging efforts to New England, off the coast of Nantucket to spread efforts over a broader area. In 2003, efforts were expanded to the eastern Atlantic off the coast of Ireland where the program has obtained the first

data on a new group of fish that have not yet been studied with this technology. Deploying tags off Ireland also increases the likelihood of documenting the behaviors of fish spawning in the Mediterranean for comparison to those spawning in the Gulf of Mexico. The improved understanding of bluefin movements and behaviors has important applications for management and can serve as the basis for necessary changes in current management strategies.

Beginning in 1997, studies led by the New England Aquarium have implanted pop-up and pop-up archival satellite tags (PSATs) on western Atlantic bluefin tuna. Recent studies involved the implantation of PSATs into 68 Atlantic bluefin tuna in the southern Gulf of Maine and off the coast of North Carolina between July 2002 and January 2003 (Wilson et al., In Press). Most of the fish tagged in the southern Gulf of Maine in late summer/early fall remained in that area until late October, consistent with previous studies. Of the 33, 14 remained in northern shelf waters (between Maryland and Nova Scotia), 14 moved south to waters off the coasts of Virginia and North Carolina, and five were in offshore waters of the northwestern Atlantic Ocean. In the spring, six of the 11 fish either stayed in northern waters or moved to that area from Virginia and North Carolina waters, and the other five fish moved offshore into the Mid-Atlantic Ocean. Similar seasonal movement patterns have been shown by individuals tagged in coastal waters off North Carolina. During the winter months, these fish remained either on the Carolina shelf or in offshore waters of the northwestern Atlantic Ocean and moved offshore along the path of the Gulf Stream in spring. By summer, many were in northern shelf waters.

Swimming depth was significantly correlated with location, season, size class, time of day, and moon phase. The greatest depth recorded was 672 m (2,218 ft), and fish experienced temperatures ranging from 3.4° to 28.7°C (38° to 83.7° F). The data show that Atlantic bluefin tuna spend the majority of their time in the top 20 m (66 ft) of the water column, descending occasionally to depths in excess of 500 m (1,650 ft). The vertical behavior of bluefin tuna differed among locations, with shallower swimming depths occurring when the fish were in inshore waters.

A recent study of the diet and trophic position of bluefin tuna in coastal Massachusetts and the Gulf of Maine used stable isotope analyses to investigate feeding habits of bluefin tuna. The results suggest that bluefin tuna feed on a variety of schooling fish, including silver hake, Atlantic mackerel, and Atlantic herring (Estrada et al. 2005). Juvenile bluefin tuna appear to have isotopic nitrogen signatures similar to those of suspension feeders, suggesting that nektonic crustaceans or zooplankton may contribute significantly to the diet of juvenile bluefin tuna (Estrada et al. 2005).

Combined, all of the studies and data are providing a higher resolution of potential spawning, feeding, and other important habitat areas for bluefin tuna. Given that there is a considerable and growing body of science on bluefin tuna, it may be one of the species for which NOAA Fisheries Service may consider modifying the boundaries in the future. For example, although bluefin tuna spawning habitat has been described as encompassing nearly all of the Gulf of Mexico by Block et al. (2005), adult bluefin tuna EFH is limited to a smaller portion of the western Gulf of Mexico, and the adult EFH areas may not necessarily correspond to areas considered most likely as bluefin tuna spawning habitat (Block et al. 2005). NOAA Fisheries Service may need to reconsider these boundaries to account for new information being developed through PSAT technology and other means. Similarly, some of the highest individual counts of adult bluefin tuna (per 100 nm2) have been observed off of North Carolina, yet these areas are not currently included as adult bluefin tuna EFH. Furthermore, the SEFSC is currently conducting a comprehensive review of larval distributions from 1984 to the present from ichthyoplankton collections in the northern Gulf of Mexico. Once larval movement due to local currents is accounted for these data may prove useful in the review of potential modification of EFH boundaries for other tunas as well.

In addition, the distribution and abundance of other tuna species (i.e., albacore, bigeye, skipjack, and yellowfin tunas) have been attained through fishery data combined with other information, such as remote sensing data. Many of these species have similar bioecological responses (i.e., many species are specialized in high energy foraging strategies of sustained fast swimming, searching over large areas (Sharp and Dizon 1978; Au 1986) and therefore, have similar physiological responses to oceanographic conditions (Ramos et al. 1996). Skipjack and albacore are highly migratory tunas with active thermic exchanges with the environment (Sharp and Dizon 1978). Consequently, their distribution is influenced by changes in marine features at different spatial and temporal scales (Ramos et al. 1996). For instance, both species are visual predators and are unable to efficiently capture small pelagic prey in colder turbid upwelled waters (Ramos et al. 1996). Therefore, over small spatial and temporal scales, the most suitable areas based on the physiology and feeding strategies for these two species are the boundary between warm and cold water where food and other abiotic features are physiologically optimal (Ramos et al. 1996). Over longer temporal and spatial scales, such as migration pathways, sea surface temperatures generated by the Intertropical Zone of Convergence play an important role (Ramos et al. 1996). In addition, concentration of food and water quality (i.e., higher temperature, high concentration of oxygen and low level of turbidity) lead to the concentration of skipjack and albacore in their respective fishing grounds (the northeast Atlantic for albacore and Senegal waters 10° North to the Canarian area 28° North for skipjack; Ramos et al. 1996).

Yellowfin tuna is a cosmopolitan species mainly distributed in the tropical and subtropical oceanic water of the three oceans. In the Atlantic Ocean, tagging and catch-at-size data analyses have shown that yellowfin tuna move at different scales in the whole tropical Atlantic Ocean (Maury et al. 2001). Environmental conditions are probably the main causes driving migration phenomena and massive population movements (Mendelssohn and Roy 1986; Lehodey et al. 1997). Recent work by Maury et al. (2001) showed that on a large spatiotemporal scale (the whole ocean), low salinity was a good predictor of yellowfin habitat. Juveniles were mainly distributed in low-salinity waters (less than 35 parts per thousand) whereas adults extend their range to water of 36 parts per thousand. This can be due to two reasons; for young tuna (less than 3 yrs old), salinity could be a marker of favorable feeding areas, such as low salinity levels in the Gulf of Guinea where freshwater runoff contains high levels of nutrients. Secondly, the metabolic cost of osmotic regulation could prevent young yellowfin tuna from reaching high salinity levels (Maury et al. 2001). After breeding in the Gulf of Guinea, adults, however, disperse in an east-west fashion related to salinity and warmwater seasonal oscillations (Maury et al. 2001). On a mesoscale (1000 km), north-south seasonal movements are clearly related to warmwater seasonal oscillations. Such seasonal migrations should be due to surface water temperatures where adults preferentially stay in zones of water temperature between 26 to 29° C and where deeper waters are warmer than 15° C. Juveniles stay in surface waters where the sea surface temperature is 27° C or higher (Maury et al. 2001). Finally, at the local level (100 km), yellowfin tuna seem to be influenced by both local hydrological and biological features, such as tuna prey distribution and the spatial stability of water masses. For instance, the presence of floating objects, and the existence of small-scale hydrological events like local fronts or convergences can all be responsible for yellowfin concentrations (Bakun 1996).

Lastly, bigeye tuna are large epi-and mesopelagic fish that are found in surface waters ranging in temperatures from 13 to 29°C (Collette and Nauen 1983). However major concentrations coincide with the temperature range of the permanent thermocline, between 17 and 22°C. Therefore, temperature and thermocline depth appear to be important environmental factors governing the vertical and horizontal distribution of bigeye tuna (Alvarado Bremer et al. 1998). Such oceanographic features can have important implications for fisheries management; for instance, water temperature can prevent movement of fish between ocean basins, influencing stock structure (Alvarado Bremer et al. 1998). On the basis of fisheries data, geographic distribution, tagging results, and the location of spawning and nursery areas, a single population is assumed to inhabit the Atlantic Ocean (ICCAT 1997). For management purposes, both the Indian Ocean and Pacific populations are considered to be single units. Recent molecular work has indicated that the Atlantic and Indo-Pacific populations are two regions and genetically distinct (Alvarado Bremer et al. 1998), confirming a single spawning stock of bigeye in the Atlantic and a single spawning stock in the Indo-Pacific. In the Atlantic Ocean, juvenile bigeye tuna have been observed only in the Gulf of Guinea (ICCAT 1997). Tagging studies indicate trans-Atlantic movements of bigeye from the Gulf of Guinea to the central Atlantic north of Brazil, and northerly migration from the Gulf of Guinea to the eastern Atlantic (ICCAT 1997).

As with most other HMS, salinity and temperature appear to be primary factors influencing the distribution of tunas and may ultimately determine EFH. The challenge remains in identifying specific EFH areas based solely on environmental parameters; in most cases, distribution data may still provide the best indication of habitat preference of these different species.

Swordfish

(text below excerpted from the Consolidated HMS FMP, chapter 10, section titled "Swordfish" under "Summary of Review and Findings."

Based on a review of the swordfish maps and current distribution points, reviewers commented that additional research may be needed to validate the current size ranges for juvenile and adult swordfish. In addition, further analysis may be needed to determine whether certain areas have been used consistently over time. Analyzing spawning areas that are consistently used over a number of years may provide a better understanding of swordfish EFH. Several discrepancies in distribution points and EFH areas delineated in 1999 were noted, including a high concentration of observed occurrences of juvenile swordfish in an area north of Long Island Sound that was not defined as EFH in 1999. NOAA Fisheries Service may consider modifying swordfish EFH boundaries in the future, particularly in the Long Island Sound area, and conversely, areas currently delineated as EFH that have few if any observed occurrences in the data sets being analyzed.

Pinpointing definitive EFH for spawning swordfish is difficult because research indicates that presence of larvae may not always be a sign that spawning occurred in the vicinity of the collection. Adult swordfish, and HMS in general, may move significant distances during spawning, and eggs and larvae may be transported substantial distances by currents as well. Govoni et al. (2000) determined that since a swordfish egg's incubation period is 3 days at 24°C, with an additional three or four days for posthatch growth, along with an average velocity of the Gulf Stream of 1.5 m/s (Olson et al. 1994), larvae of four to five mm SL in the Atlantic could have been transported from as far away as 900 km. A similar trajectory was projected for small larvae of bluefin tuna (McGowan and Richards 1989).

Billfish

Similar to other HMS, billfish EFH is not easily identified due to a lack of association with readily identifiable features such as benthic habitat or other underwater structures. Billfish tend to aggregate in areas with dynamic features such as temperature gradients, ocean fronts or currents resulting from interactions between a number of factors. Many of these water column features are dynamic, making detailed delineation of billfish spawning, nursery, and feeding habitats difficult. Adding to the difficulty of designating billfish EFH is that most of the literature on billfish larvae and juveniles mention them as incidental catches in studies that were directed at other species or that were concerned with characterizing ichthyofaunal or plankton communities as a whole (NMFS, 2004). Comments received during the Draft FMP indicate that *Sargassum* may be an important component of billfish habitat, particularly during early life stages, and that NOAA Fisheries Service should investigate this further. If the NOAA Fisheries Service determines that EFH for some or all HMS needs to be modified, then that would be addressed in a subsequent rulemaking, at which point *Sargassum* could also be considered as potential EFH. With regard to harvest, the final South Atlantic Fishery Management Council FMP for Pelagic *Sargassum* Habitat in the South Atlantic Region was approved in 2003 and implemented strict restrictions on commercial harvest of Sargassum. The approved plan includes strong limitations on future commercial harvest. Restrictions include prohibition of harvest south of the NC/SC state boundary, a total allowable catch (TAC) of 5,000 lbs wet weight per year, limiting harvest to November through June to protect turtles, requiring observers onboard any vessel harvesting *Sargassum*, prohibiting harvest within 100 miles of shore, and gear specifications.

One of the key issues associated with delineating billfish EFH is the difficulty of accurately identifying billfish larvae. However, new molecular techniques are being developed that show promise (Luthy et al. 2005). Without accurate identification of larvae, it is difficult to draw conclusions on spawning areas, habitat associations, and requirements. Billfish larvae may be swept miles from actual spawning grounds before they are sampled. Thus, even though peak spawning periods for blue and white marlin are known to occur from May to June, there are significant issues related to positive identification of larvae that must be overcome to verify spawning locations. Research off Punta Cana, Dominican Republic, is one of the few instances on record where spawning by blue and white marlin was confirmed through simultaneous collections of both larvae and tracking of spawning adults using pop-up satellite tags (Prince et al. 2005).

Collaborative studies conducted by NOAA Fisheries Service and University of Miami scientists using PSATs while simultaneously conducting adult and larval sampling off the Dominican Republic in the spring of 2003 have revealed important information concerning white and blue marlin spawning locations as well as horizontal and vertical movements. Co-occurrence of larval blue marlin and white marlin in samples suggest that the two species share a spawning location in the vicinity of Punta Cana, Dominican Republic. Adult white and blue marlin caught in the area appear to have similar vertical and horizontal movement patterns in terms of time at depth, time at temperature, average horizontal displacement per day, net horizontal displacement, and directional dispersion (compass heading).

Displacements of seven white marlins tagged with PSATs ranged from 31.7 to 267.7 nm (58.7 to 495.8 km), while displacement of one blue marlin was 219.3 nm (406.2 km). In general, all marlin spent a high proportion of the monitoring time in the upper 25 m (82 ft) and at temperatures at or above 28°C (82°F). Minimum and maximum depth and temperatures monitored show that on most days marlin visited depths of 100 m (330 ft) or more, but generally stayed at these depths less that 10% of the time. Minimum temperatures ranged from 16.8° to 20.6°C (62.2° to 69°F), while maximum temperatures ranged from 28.2° to 30.0°C (82.7° to 86°F). Additional research in other areas of the Gulf of Mexico and U.S. Atlantic coast would help improve understanding and delineation of billfish EFH (Prince et al. 2005).

The characterization of adult movements and larval distribution in a potentially important spawning area is paramount for establishing improved management and rebuilding strategies for depressed Atlantic billfish stocks. However, more information on the distribution of reproduction and nursery areas and on adult movement patterns is needed to help managers make more informed decisions regarding conservation of the resource. Scientists at VIMS have been involved with electronic tagging of blue and white marlin since 1999, some of which has been conducted in conjunction with the NOAA SEFSC. More recently, VIMS deployed over 60 PSAT on white marlin from both recreational sport boats and a commercial pelagic longline vessel to determine post-release survival

(Prince et al. 2005). In addition to this work, VIMS is also in the process of updating information regarding habitat preferences and vertical movements of white marlin using environmental data obtained from the PSAT work as well as other environmental data. Most of the work at VIMS, however, remains focused on the interactions of billfish with the various fisheries.

There are a few considerations and limitations of these data that reviewers should keep in mind as they look at EFH determinations (E. Prince, pers. comm.). Inaccurate EFH maps for billfish can be created because of boat side misidentification of billfish, sexual dimorphism, and criteria used in defining groups can result in both under and overestimates and ultimately impact the accuracy of the maps. The CTS is the main source of data for most of the billfish EFH maps and it obtains size information of tagged, released, and recovered fish from constituents based mostly on boatside estimates of fish size. This approach introduces a significant amount of error.

In addition, most size estimates are made when the fish is underwater and the reflective index biases these estimates upwards by as much as 30% (E. Prince, pers. comm.). Billfish are sexually dimorphic (size difference between sexes), with this being most severe for blue marlin. The maps provided in this amendment do not include a consideration of sexually dimorphic differences in size and thus the characterization of juvenile size limits on the maps may be quite different for male and female marlin. The tagging data only infrequently have recoveries that include gender, so separating the maps into males and females would not likely be practical, even though it would probably be more accurate (E. Prince, pers. comm.). Furthermore, the accuracy of the maps for defining juvenile marlin based on size could vary depending on the criteria used in this definition.

Data from the CTS, which account for a significant portion of the overall data points for billfish, were historically recorded only to the nearest degree, and did not include minutes or seconds. As a result, reviewers will notice that certain data points that reflect a high number of observations are lined up along major lines of latitude or longitude, both in the Gulf of Mexico and the Atlantic coast. This may be an artifact resulting from the way in which tagging locations were recorded rather than the true points of highest observed occurrence. Depending on reviewer comments received on this aspect of the data, NOAA Fisheries Service may consider removing these data points during future considerations of EFH boundaries. Therefore, as a result of technical reviewer comments, several changes to EFH boundaries may be considered in the future. These include, but are not limited to, potential modifications of EFH boundaries for blue and white marlin for the reasons stated above (E. Prince, pers. comm.).

Sharks

Significant progress has been made in recent years in identifying habitat requirements and EFH for sharks. The proximity of nursery and pupping grounds to coastal areas has provided research opportunities that do not exist for other HMS that spawn much farther from shore. Sampling has increased in a number of different locations under the auspices of several different programs (Cooperative Atlantic States Shark Pupping and Nursery Survey (COASTSPAN), Cooperative Gulf of Mexico States Shark Pupping and Nursery Survey (GULFSPAN), and others). Considerable research has been devoted to determining the size ranges of the different shark life stages (neonate, juvenile, and adult). The size ranges for each species' lifestage used in this review as well as size ranges used in the 1999 FMP are presented in Table B.1, Appendix B. The table reflects new information and updates to the 1999 FMP size ranges. Based on these size ranges, the distribution data have been mapped for each species and life stage.

The 1999 FMP highlighted the importance of coastal nursery and pupping areas in maintaining viable shark populations. It also identified continued delineation of shark nurseries as a research priority. As a result, several studies and cooperative research projects aimed at improving NOAA Fisheries Service's understanding of EFH and shark reproductive habitat requirements have been undertaken since the 1999 HMS FMP.
In 2002, the COASTPAN project initiated a synthesis document of information on shark nursery grounds along the U.S. Atlantic east coast and the Gulf of Mexico. Researchers from universities and state and Federal agencies in twelve different states from Massachusetts to Texas contributed information to the preliminary report (McCandless et al. 2002; McCandless et al. 2005). This information was included in updates to EFH for several shark species in Amendment 1 to the FMP, and is being incorporated into the data for the current review. Results for the 2003 sampling year were compiled and synthesized, and the final report is currently under review. Participants in the 2003 COASTSPAN survey included the North Carolina Division of Marine Fisheries, the South Carolina Department of Natural Resources, Coastal Carolina University, the University of Georgia's Marine Extension Service and the University of Florida's Program for Shark Research. Researchers from the NOAA Fisheries Service's Apex Predators Program and the University of Rhode Island conducted the survey in Delaware Bay. A total of 3,698 sharks were sampled in the 2003 COASTSPAN survey. Juvenile sharks sampled, tagged and released during the survey were the Atlantic sharpnose, blacknose, blacktip, bonnethead, bull, dusky, finetooth, nurse, sandbar, sand tiger, scalloped hammerhead, silky, spinner, and tiger sharks, and also the smooth and spiny dogfish. Environmental parameters for each sampling location were also measured to indicate habitat preferences. There were a number of tag recaptures returned by fishery biologists and commercial and recreational fisherman in 2003 from sharks that were tagged by COASTSPAN cooperators in previous years.

A final synthesis document entitled "Shark Nursery Grounds of the Gulf of Mexico and the East Coast Waters of the United States" is currently under review for publication by the American Fisheries Society (AFS). It is a compilation of 20 individual papers documenting shark distributions in coastal habitats similar to the project described above, but expanded to include several new studies. This document provides valuable information for the possible modification or inclusion of additional shark EFH.

In 2003, NOAA Fisheries Service initiated the GULFSPAN Survey to expand upon the Atlantic COASTSPAN Survey. States involved in the program during 2004, the second year of the program, include Florida, Mississippi, Alabama, and Louisiana. Sharks sampled, tagged, and released during the surveys included the Atlantic sharpnose, blacknose, blacktip, bonnethead, bull, finetooth, great hammerhead, sandbar, scalloped hammerhead, and spinner sharks. In addition, environmental parameters were measured qualitatively. The most abundant sharks included the Atlantic sharpnose, blacktip, and bull sharks. Results of this study are under review in the AFS synthesis document as well.

In Florida waters, most species captured were juveniles and young-of-the-year. Among sharks for all areas combined, the Atlantic sharpnose shark, a member of the small coastal shark (SCS) management group, was the most abundant shark captured, while the blacktip shark was the most abundant species captured in the LCS management group. The bonnethead shark was the second most abundant species captured in the SCS group and overall was the third most encountered species. The remaining species commonly captured in decreasing order of abundance were the finetooth, spinner, scalloped hammerhead, blacknose, and sandbar sharks. Other species infrequently caught were bull shark, great hammerhead shark, and the Florida smoothhound.

In Mississippi and Alabama waters, 75% of the sharks captured were immature. The blacktip shark was the most abundant species caught, followed by the Atlantic sharpnose, finetooth, and bull sharks. In Louisiana in the 2004 sampling season, most species captured were juveniles. The blacktip shark was the most abundant species caught, followed by the bull shark. A single adult specimen of the finetooth shark in addition to young-of-the-year Atlantic sharpnose shark was also collected in 2004.

New information on habitat preferences is also emerging from this study. Juvenile bonnethead sharks appear to prefer habitat dominated by seagrass (in northwest Florida) or mangroves (Louisiana), although these areas have not yet been identified as EFH. In areas where neither of these habitat types is available, juvenile bonnetheads are in very low numbers or absent (i.e. Mississippi Sound). Adult bonnethead sharks, however, are found in diverse habitats ranging from areas with a mud or sand bottom to areas dominated by seagrass. Evidence indicates bull sharks are found among the most diverse environmental conditions with salinities ranging from 15 ppt (in Louisiana and Mississippi) to 33 ppt (in northwest Florida), and over all habitat types. Within the Gulf of Mexico, most juvenile sandbar sharks are still predominately caught in the northwest portion while blacktip, finetooth, and Atlantic sharpnose sharks are found throughout all areas. Although bull sharks can be found over a variety of habitats, the areas of highest abundance are those adjacent to freshwater inflow.

Obtaining information regarding trophic relationships and feeding habits of sharks, also critical to understanding essential fish habitat, is another goal of the GULFSPAN program. A quantitative examination of feeding ecology from different areas can assist in understanding how juvenile sharks use nursery habitats, and which habitats are more valuable as nursery areas than others.

Mote Marine Laboratory's CSR program is focusing on identifying and understanding shark nursery areas of the U.S. Gulf of Mexico and southeast Atlantic coasts. Through tagging studies, this program aims to characterize these nursery areas, obtain estimates of juvenile shark relative abundance, distribution, and growth rates, and reveal the movement patterns of these sharks. As of fall 2004, the CSR has collected data on 20,732 sharks of 16 species that utilize these coastal waters as pupping and nursery areas. More than half of the captured sharks (12,241) comprise neonate, young-of-the-year (YOY) or older juvenile sharks. The studies found that most pupping activity in the region occurs in the late spring and early summer, and the neonate and YOY animals inhabit the primary nurseries throughout the summer and into the fall. Typically, declining water temperatures in the fall are associated with the southward movement of sharks from these natal waters to warmer and in some cases offshore, winter nurseries. Tag returns of Year-1 sharks have demonstrated travel distances to winter nursery areas of at least 500 km (311 mi). Tag return data have further demonstrated annual cycles of philopatric behavior whereby juveniles of both large and small coastal species migrate back to their natal nurseries in spring and summer (Hueter and Tyminski, in review).

In the 1999 HMS FMP, the smallest size class of sharks was described as "neonates and early juveniles." This definition has been modified to include primarily neonates and only small young-of-the-year sharks in order to better define and identify nursery areas. The total length cutoff for this size class is determined as the maximum embryo size in term females plus 10%. This criteria was used because it helps to eliminate some of the small one-year-old sharks that fall within the young-of the-year size range, making it easier to identify primary nursery areas (where pupping occurs and young-of-the-year are present). These criteria can also be more easily applied to other species given the lack of published data on growth rates for many species, especially during the first year. This modification should also better represent the habitat shift between primary nursery areas and secondary nursery areas (occupied by age 1+ sharks), although many species do overlap habitat use between these two size classes.

The middle size class designated in the 1999 HMS FMP, "late juveniles and subadults," has been renamed "juveniles". This size class includes all immature sharks from young juveniles to older or late juveniles. Some overlap between the "neonate and early juveniles" and the "adult" EFH areas may occur, depending on the species, due to the return to primary nursery areas by many juveniles, age 1+, and the developing conformity to adult migration patterns by late juveniles. As in the 1999 HMS FMP, the largest size class, "adults," still consists of mature sharks based on the size at first maturity for females of the species. Changes to the size range of the adult size class for some species have been made based on new information on the size at first maturity for females of those particular species.

As a result of technical reviewer comments of the 2006 Consolidated Highly Migratory Species FMP, several changes to EFH boundaries may be considered in the future. These include, but are not limited to, potential modification of EFH boundaries for basking, hammerhead, white, bull, Caribbean reef, lemon, spinner, tiger, Atlantic sharpnose, blacknose, longfin mako, shortfin mako, oceanic whitetip, and thresher sharks (J. Castro and J. Carlson, pers. comm.). In summary, based on the preliminary examination of new information acquired since the original EFH identifications in 1999, and on comments from technical reviewers, modifications to some of the existing EFH descriptions and boundaries may be warranted. Any proposed modifications to existing boundaries, as well as consideration of any new HAPC areas, would be addressed by the NOAA Fisheries Service's Highly Migratory Species Division in a subsequent document to the 2006 Consolidated HMS FMP.

7.3 Essential Fish Habitat and Environmental Protection Policy

In recognizing that managed species are dependent on the quantity and quality of their essential habitats, it is the policy of the SAFMC to protect, restore, and develop habitats upon which species fisheries depend; to increase the extent of their distribution and abundance; and to improve their productive capacity for the benefit of present and future generations. For purposes of this policy, "habitat" is defined as the physical, chemical, and biological parameters that are necessary for continued productivity of the species that is being managed. The objectives of the SAFMC policy will be accomplished through the recommendation of no net loss or significant environmental degradation of existing habitat. A long-term objective is to support and promote a net-gain of fisheries habitat through the restoration and rehabilitation of the productive capacity of habitats that have been degraded, and the creation and development of productive habitats where increased fishery production is probable. The SAFMC will pursue these goals at state, Federal, and local levels. The Council shall assume an aggressive role in the protection and enhancement of habitats important to species, and shall actively enter Federal, decision-making processes where proposed actions may otherwise compromise the productivity of fishery resources of concern to the Council.

7.4 Essential Fish Habitat Policies and Policy Statements

7.4.1 Policy Statements of Essential Fish Habitat Types

7.4.1.1 Policy for the Protection and Enhancement of Marine Submerged Aquatic Vegetation (SAV) Habitat

The South Atlantic Fishery Management Council (Council) and the Habitat and Environmental Protection Advisory Panel has considered the issue of the decline of Marine Submerged Aquatic Vegetation SAV (or seagrass) habitat in Florida and North Carolina as it relates to Council habitat policy. Subsequently, the Council's Habitat Committee requested that the Habitat Advisory Panel develop the following policy statement to support Council efforts to protect and enhance habitat for managed species.

Description and Function

In the South Atlantic region, SAV is found primarily in the states of Florida and North Carolina where environmental conditions are ideal for the propagation of seagrasses. The distribution of SAV habitat is indicative of its importance to economically important fisheries: in North Carolina, total SAV coverage is estimated to be 200,000 acres; in Florida, the total SAV coverage is estimated to be 2.9 million acres. SAV serves several valuable ecological functions in the marine systems where it occurs. Food and shelter afforded by SAV result in a complex and dynamic system that provides a primary nursery habitat for various organisms that is important both to the overall system ecology as well as to commercial and recreationally important fisheries. SAV habitat is valuable both ecologically as well as economically; as feeding, breeding, and nursery ground for numerous estuarine species, SAV provides for rich ecosystem diversity. Further, a number of fish and shellfish species, around which is built several vigorous commercial and recreational fisheries, rely on SAV habitat for a least a portion of their life cycles. For more detailed discussion, please see Appendix 1

Status

SAV habitat is currently threatened by the cumulative effects of overpopulation and consequent commercial development and recreation in the coastal zone. The major anthropogenic threats to SAV habitat include:

1. mechanical damage due to:
    a. propeller damage from boats,
    b. bottom-disturbing fish harvesting techniques,
    c. dredging and filling;

2. biological degradation due to:
    a. water quality deterioration by modification of temperature, salinity, and light attenuation regimes;
    b. addition of organic and inorganic chemicals.

SAV habitat in both Florida and North Carolina has experienced declines from both natural and anthropogenic causes. However, conservation measures taken by state and federal agencies have produced positive results. The NOAA Fisheries Service has produced maps of SAV habitat in the Albemarle-Pamlico Sound region of North Carolina to help stem the loss of this critical habitat. The threats to this habitat and the potential for successful conservation measures highlight the need to address the decline of SAV. Therefore, the Council recommends immediate and direct action be taken to stem the loss of this essential habitat. For more detailed discussion, please see Appendix 2.

Management

Conservation of existing SAV habitat is critical to the maintenance of the living resources that depend on these systems. A number of federal and state laws and regulations apply to modifications, either direct or indirect, to SAV habitat. However, to date the state and federal regulatory process has accomplished little to slow the decline of SAV habitat. Furthermore, mitigative measures to restore or enhance impacted SAV have met with little success. These habitats cannot be readily restored; the Council is not aware of any seagrass restoration project that has ever prevented a net loss of SAV habitat. It has been difficult to implement effective resource management initiatives to preserve existing seagrass habitat resources due to the lack of adequate documentation and specific cause/effect relationships. (for more detailed discussion, please see Appendix 3).

Because restoration/enhancement efforts have not met with success, the Council considers it imperative to take a directed and purposeful action to protect remaining SAV habitat. The Council strongly recommends that a comprehensive strategy to address the disturbing decline in SAV habitat in the South Atlantic region. Furthermore, as a stepping stone to such a long-term protection strategy, the Council recommends that a reliable status and trend survey be adopted to verify the scale of local declines of SAV.

The Council will address the decline of SAV, and consider establishing specific plans for revitalizing the SAV resources of the South Atlantic region. This may be achieved by the following integrated triad of efforts:

Planning

- The Council promotes regional planning which treats SAV as an integral part of an ecological system.
- The Council supports comprehensive planning initiatives as well as interagency coordination and planning on SAV matters.
- The Council recommends that the Habitat Advisory Panel members actively seek to involve the Council in the review of projects which will impact, either directly or indirectly, SAV habitat resources.

Monitoring and Research

Periodic surveys of SAV in the region are required to determine the progress toward the goal of a net resource gain.

The Council supports efforts to:

- standardize mapping protocols,
- develop a Geographic Information System databases for essential habitat including seagrass, and
- research and document causes and effects of SAV decline including the cumulative impacts of shoreline development.

Education and Enforcement

- The Council supports education programs designed to heighten the public's awareness of the importance of SAV. An informed public will provide a firm foundation of support for protection and restoration efforts.
- Existing regulations and enforcement need to be reviewed for their effectiveness.
- Coordination with state resource and regulatory agencies should be supported to assure that existing regulations are being enforced.

SAFMC SAV Policy Statement- Appendix 1

Description and function

Worldwide, Submerged Aquatic Vegetation (SAV) constitutes one of the most conspicuous and common shallow-water habitat types. These angiosperms have successfully colonized standing and flowing fresh, brackish, and marine waters in all climatic zones, and most are rooted in the sediment. Marine SAV beds occur in the low intertidal and subtidal zones and may exhibit a wide range of habitat forms, from extensive collections of isolated patches to unbroken continuous beds. The bed is defined by the presence of either aboveground vegetation, its associated root and rhizome system (with living meristem), or the presence of a seed bank in the sediments, as well as the sediment upon which the plant grows or in which the seed back resides. In the case of patch beds, the unvegetated sediment among the patches is considered seagrass habitat as well.

There are seven species of seagrass in Florida's shallow coastal areas: turtle grass (*Thalassia testudium*); manatee grass (*Syringodium filiforme*); shoal grass (*Halodule wrightii*); star grass (*Halophila engelmanni*); paddle grass (*Halophila decipiens*); and Johnson's seagrass (*Halophila johnsonii*) (Distribution maps in Appendix 4 SAFMC, 1998a). Recently, *H. johnsonii* has been proposed for listing by the NOAA Fisheries Service as an endangered plant species. Areas of seagrass concentration along Florida's east coast are Mosquito Lagoon, Banana River, Indian River Lagoon, Lake Worth and Biscayne Bay. Florida Bay, located between the Florida Keys and the mainland, also has an abundance of seagrasses, but is currently experiencing an unprecedented decline in SAV distribution.

The three dominant species found in North Carolina are shoalgrass (*Halodule wrightii*), eelgrass (*Zostera marina*), and widgeongrass (*Ruppia maritima*). Shoalgrass, a subtropical species has its northernmost distribution at Oregon Inlet, North Carolina. Eelgrass, a temperate species, has its southernmost distribution in North Carolina. Areas of seagrass concentration in North Carolina are southern and eastern Pamlico Sound, Core Sound, Back Sound, Bogue Sound and the numerous small southern sounds located behind the beaches in Onslow, Pender, Brunswick, and New Hanover Counties (See distribution maps in Appendix 4 SAFMC, 1998).

Seagrasses serve several valuable ecological functions in the marine estuarine systems where they occur. Food and shelter afforded by the SAV result in a complex and dynamic system that provides a primary nursery habitat for various organisms that are important both ecologically and to commercial and recreational fisheries. Organic matter produced by these seagrasses is transferred to secondary consumers through three pathways: herbivores that consume living plant matter; detritivores that exploit dead matter; and microorganisms that use seagrass-derived particulate and dissolved organic compounds. The living leaves of these submerged plants also provide a substrate for the attachment of detritus and epiphytic organisms, including bacteria, fungi, meiofauna, micro- and macroalgae, macroinvertebrates. Within the seagrass system, phytoplankton also are present in the water column, and macroalgae and microalgae are associated with the sediment. No less important is the protection afforded by the variety of living spaces in the tangled leaf canopy of the grass bed itself. In addition to biological benefits, the

SAVs also cycle nutrients and heavy metals in the water and sediments, and dissipate wave energy (which reduces shoreline erosion and sediment resuspension).

There are several types of association fish may have with the SAVs. Resident species typically breed and carry out much of their life history within the meadow (e.g., gobiids and syngnathids). Seasonal residents typically breed elsewhere, but predictably utilize the SAV during a portion of their life cycle, most often as a juvenile nursery ground (e.g., sparids and lutjanids). Transient species can be categorized as those that feed or otherwise utilize the SAV only for a portion of their daily activity, but in a systematic or predictable manner (e.g., haemulids).

In Florida many economically important species utilize SAV beds as nursery and/or spawning habitat. Among these are spotted seatrout (*Cynoscion nebulosus*), grunts (Haemulids), snook (*Centropomus* sp.), bonefish (*Albula vulpes*), tarpon (*Megalops atlanticus*) and several species of snapper (Lutjanids) and grouper (Serranids). Densities of invertebrate organisms are many times greater in seagrass beds than in bare sand habitat. Penaeid shrimp, spiny lobster (*Panulirus argus*), and bay scallops (*Argopecten irradians*) are also dependent on seagrass beds.

In North Carolina, 40 species of fish and invertebrates have been captured on seagrass beds. Larval and juvenile fish and shellfish including gray trout (*Cynoscion regalis*), red drum (*Sciaenops ocellatus*), spotted seatrout (*Cynoscion nebulosus*), mullet (*Mugil cephalus*), spot (*Leiostomus xanthurus*), pinfish (*Orthopristis chrysoptera*), gag (*Mycteroperca microlepis*), white grunt (*Haemulon plumieri*), silver perch (*Bairdiella chrysoura*), summer flounder (*Paralichthys dentatus*), southern flounder (*P. lethostigma*), blue crabs (*Callinectes sapidus*), hard shell clams (*Mercenaria mercenaria*), and bay scallops (*Argopecten irradians*) utilize the SAV beds as nursery areas. They are the sole nursery grounds for bay scallops in North Carolina. SAV meadows are also frequented by adult spot, spotted seatrout, bluefish (*Pomatomus saltatrix*), menhaden (*Brevoortia tyrannus*), summer and southern flounder, pink and brown shrimp, hard shell clams, and blue crabs. Offshore reef fishes including black sea bass (*Centropristis striata*), gag (*Mycteroperca microlepis*), gray snapper (*Lutjanus griseus*), lane snapper (*Lutjanus synagris*), mutton snapper (*Lutjanus annalis*), and spottail pinfish (*Diplodus holbrooki*). Ospreys, egrets, herons, gulls and terns feed on fauna in SAV beds, while swans, geese, and ducks feed directly on the grass itself. Green sea turtles (*Chelonia mydas*) also utilize seagrass beds, and juveniles may feed directly on the seagrasses.

SAFMC SAV Policy Statement- Appendix 2

Status

The SAV habitat represents a valuable natural resource which is now threatened by overpopulation in coastal areas. The major anthropogenic activities that impact seagrass habitats are: 1) dredging and filling, 2) certain fish harvesting techniques and recreational vehicles, 3) degradation of water quality by modification of normal temperature, salinity, and light regimes, and 4) addition of organic and inorganic chemicals. Although not caused by man, disease (“wasting disease” of eelgrass) has historically been a factor.

Direct causes such as dredging and filling, impacts of bottom disturbing fishing gear, and impacts of propellers and boat wakes are easily observed, and can be controlled by wise management of our seagrass resources (See Appendix 3 below). Indirect losses are more subtle and difficult to assess. These losses center around changes in light availability to the plants by changes in turbidity and water color. Other indirect causes of seagrass loss may be ascribed to changing hydrology which may in turn affect salinity levels and circulation. Reduction in flushing can cause an increase in salinity and the ambient temperature of a water body, stressing the plants. Increase in flushing can mean decreased salinity and increased turbidity and near-bottom mechanical stresses which damage or uproot plants.

Increased turbidity and decreasing water transparency are most often recognized as the cause of decreased seagrass growth and altered distribution of the habitats. Turbidity may result from upland runoff, either as suspended sediment or dissolved nutrients. Reduced transparency due to color is affected by freshwater discharge. The introduction of additional nutrients from terrigenous sources often leads to plankton blooms and increased epiphytization of the plants, further reducing light to the plants. Groundwater enriched by septic systems also may infiltrate the sediments, water column, and near-shore seagrass beds with the same effect. Lowered dissolved oxygen is detrimental to invertebrate and vertebrate grazers. Loss of these grazers results in overgrowth by epiphytes.

Large areas of Florida where seagrasses were abundant have now lost these beds from both natural and man-induced causes (this is not well documented on a large scale except in the case of Tampa Bay). One of these depleted areas is Lake Worth in Palm Beach County. Here, dredge and fill activities, sewage disposal and stormwater runoff have almost eliminated this resource. North Biscayne Bay lost most of its seagrasses from urbanization. The Indian River Lagoon has lost many seagrass beds from stormwater runoff has caused a decrease in water transparency and reduced light penetration. Many seagrass beds in Florida have been scarred from boat propellers disrupting the physical integrity of the beds. Vessel registrations, both commercial and recreational, have tripled from 1970-71 (235, 293) to 1992-93 (715,516). More people engaged in marine activities having an effect on the limited resources of fisheries and benthic communities, Florida’s assessment of dredging/propeller scar damage indicates that Dade, Lee, Monroe, and Pinellas Counties have the most heavily damaged seagrass beds. Now Florida Bay, which is rather remote from human population concentrations, is experiencing a die-off of seagrasses, the cause of which has not yet been isolated. Cascading effects of die-offs cause a release of nutrients resulting in algal blooms which, in turn, adversely affect other seagrass areas, and appear to be preventing recolonization and natural succession in the bay. It appears that Monroe County’s commercial fish and shellfish resources, with a dockside landing value of $50 million per year, is in serious jeopardy.

In North Carolina, total SAV coverage is estimated at 200,000 acres. Compared to the state’s brackish water SAV community, the marine SAVs appear relatively stable. The drought and increased water clarity during the summer of 1986 apparently caused an increase in SAV abundance in southeastern Pamlico Sound and a concomitant increase in bay scallop densities. Evidence is emerging, however, that characteristics of "wasting disease" are showing up in some of the eelgrass populations in southern Core Sound, Back Sound, and Bogue Sound. The number of permits requested for development activities that potentially impact SAV populations is increasing. The combined impacts of a number of small, seemingly isolated activities are cumulative and can lead to the collapse of large seagrass biosystems. Also increasing is evidence of the secondary removal of seagrasses. Clam-kicking (the harvest of hard clams utilizing powerful propeller wash to dislodge the clams from the sediment) is contentious issue within the state of North Carolina. The scientific community is convinced that mechanical harvesting of clams damages SAV communities. The scallop fishery also could be harmed by harvest-related damage to eelgrass meadows.

SAFMC SAV Policy Statement- Appendix 3

Management

Conservation of existing SAV habitat is critical to the maintenance of the living resources that depend on these systems. A number of federal and state laws require permits for modification and/or development in SAV. These include Section 10 of the Rivers and Harbors Act (1899), Section 404 of the Clean Water Act (1977), and the states' coastal area management programs. Section 404 prohibits deposition of dredged or fill material in waters of the United States without a permit from the U.S. Army Corps of Engineers. The Fish and Wildlife Coordination Act gives federal and state resource agencies the authority to review and comment on permits, while the National Environmental Policy Act requires the development and review of Environmental Impact Statements. The Magnuson-Stevens Fisheries Conservation and Management Act has been amended to require that each fishery management plan include a habitat section. The Council's habitat subcommittee may comment on permit requests submitted to the Corps of Engineers when the proposed activity relates to habitat essential to managed species. State and federal regulatory processes have accomplished little to slow the decline of SAV habitat. Many of the impacts cannot be easily controlled by the regulations as enforced. For example, water quality standards are written so as to allow a specified deviation from background concentration, in this manner standards allow a certain amount of degradation. An example of this is Florida's class III water transparency standard, which defines the compensation depth to be where 1% of the incident light remains. The compensation depth for seagrass is in excess of 10% and for some species is between 15 and 20%. The standard allows a deviation of 10% in the compensation depth which translates into 0.9% incident light or an order of magnitude less than what the plants require. Mitigative measures to restore or enhance impacted areas have met with little success. SAV habitats cannot be readily restored; in fact, the Council is not aware of any seagrass restoration project that has ever avoided a net loss of seagrass habitat. It has been difficult to implement effective resource management initiatives to preserve seagrass habitat due to the lack of documentation on specific cause/effect relationships. Even though studies have identified certain cause/effect relationships in the destruction of these areas, lack of long-term, ecosystem-scale studies precludes an accurate scientific evaluation of the long-term deterioration of seagrasses. Some of the approaches to controlling propeller scar damage to seagrass beds include: education, improved channel marking restricted access zones, (complete closure to combustion engines, pole or troll areas), and improved enforcement. The Council sees the need for monitoring of seagrass restoration and mitigation not only to determine success from plant standpoint but also for recovery of faunal populations and functional attributes of the essential habitat type. The Council also encourages long-term trend analysis monitoring of distribution and abundance using appropriate protocols and Geographic Information System approaches.

SAFMC SAV Policy Statement- Appendix 4
(SAV Distribution Maps in SAFMC 1995 and Revised in Appendix C of the Habitat Plan)

7.4.2 Policy Statements on Non-fishing Activities Affecting Habitat

7.4.2.1 Policies for the Protection and Restoration of EFH from Beach Dredging and Filling and Large-Scale Coastal Engineering

Policy Context

This document establishes the policies of the South Atlantic Fishery Management Council (SAFMC) regarding protection of the essential fish habitats (EFH) and habitat areas of particular concern (EFH-HAPCs) impacted by beach dredge and fill activities, and related large-scale coastal engineering projects. The policies are designed to be consistent with the overall habitat protection policies of the SAFMC as formulated and adopted in the Habitat Plan (SAFMC, 1998a) and the Comprehensive EFH Amendment (SAFMC, 1998b).

The findings presented below assess the threats to EFH potentially posed by activities related to the large-scale dredging and disposal of sediments in the coastal ocean and adjacent habitats, and the processes whereby those resources are placed at risk. The policies established in this document are designed to avoid, minimize and offset damage caused by these activities, in accordance with the general habitat policies of the SAFMC as mandated by law.

EFH At Risk from Beach Dredge and Fill Activities
The SAFMC finds:

1. In general, the array of large-scale and long-term beach dredging projects and related disposal activities currently being considered for the United States southeast together constitute a real and significant threat to EFH under the jurisdiction of the SAFMC.

2. The cumulative effects of these projects have not been adequately assessed, including impacts on public trust marine and estuarine resources, use of public trust beaches, public access, state and federally protected species, state critical habitat, SAFMC-designated EFH and EFH-HAPCs.

3. Individual beach dredge and fill projects and related large-scale coastal engineering activities rarely provide adequate impact assessments or consideration of potential damage to fishery resources under state and federal management. Historically, emphasis has been placed on the logistics of dredging and economics, with environmental considerations dominated by compliance with the Endangered Species Act for sea turtles, piping plovers and other listed organisms. There has been little or no consideration of hundreds of other species affected, many with direct fishery value.

4. Opportunities to avoid or minimize impacts of beach dredge and fill activities on fishery resources, and offsets for unavoidable impacts have rarely been proposed or implemented. Monitoring is rarely adequate to develop statistically appropriate impact evaluations.

5. Large-scale beach dredge and fill activities have the potential to impact a variety of habitats across the shelf, including:

    a. waters and benthic habitats near the dredging sites
    b. waters between dredging and filling sites
    c. waters and benthic habitats in or near the fill sites, and
    d. waters and benthic habitats potentially affected as sediments move subsequent to deposition in fill areas.

6. Certain nearshore habitats are particularly important to the long-term viability of commercial and recreational fisheries under SAFMC management, and potentially threatened by large-scale, long-term or frequent disturbance by dredging and filling:

    a. the swash and surf zones and beach-associated bars
    b. underwater soft-sediment topographic features
    c. onshore and offshore coral reefs, hardbottom and worm reefs
    d. inlets

7. Large sections of South Atlantic waters potentially affected by these projects, both individually and collectively, have been identified as EFH or EFH-HAPC by the SAFMC, as well as the Mid-Atlantic Fishery Management Council (MAFMC) in the case of North Carolina. Potentially Affected species and their EFH under federal management include (SAFMC, 1998b):

    a. summer flounder (various nearshore waters, including the surf zone and inlets; certain offshore waters)
    b. bluefish (various nearshore waters, including the surf zone and inlets)
    c. red drum (ocean high-salinity surf zones and unconsolidated bottoms nearshore waters)

d. many snapper and grouper species (live hardbottom from shore to 600 feet, and – for estuarine-dependent species [e.g., gag grouper and gray snapper] – unconsolidated bottoms and live hardbottoms to the 100 foot contour).
e. black sea bass (various nearshore waters, including unconsolidated bottom and live hardbottom to 100 feet, and hardbottoms to 600 feet)
f. penaeid shrimp (offshore habitats used for spawning and growth to maturity, and waters connecting to inshore nursery areas, including the surf zone and inlets)
g. coastal migratory pelagics [e.g., king mackerel, Spanish mackerel] (sandy shoals of capes and bars, barrier island ocean-side waters from the surf zone to the shelf break inshore of the Gulf Stream; all coastal inlets)
h. corals of various types (hard substrates and muddy, silt bottoms from the subtidal to the shelf break)
i. areas identified as EFH for Highly Migratory Species (HMS) managed by the Secretary of Commerce (e.g., sharks: inlets and nearshore waters, including pupping and nursery grounds)

In addition, hundreds of species of crustaceans, mollusks, and annelids that are not directly managed, but form the critical prey base for most managed species, are killed or directly affected by large dredge and fill projects.

8. Beach dredge and fill projects also potentially threaten important habitats for anadromous species under federal, interstate and state management (in particular, inlets and offshore overwintering grounds), as well as essential overwintering grounds and other critical habitats for weakfish and other species managed by the Atlantic States Marine Fisheries Commission (ASMFC) and the states. The SAFMC also identified essential habitats of anadromous and catadromous species in the region (inlets and nearshore waters).

9. Many of the habitats potentially affected by these projects have been identified as EFH-HAPCs by the SAFMC. The specific fishery management plan is provided in parentheses:

    a. all nearshore hardbottom areas (SAFMC, snapper grouper).
    b. all coastal inlets (SAFMC, penaeid shrimps, red drum, and snapper grouper).
    c. near-shore spawning sites (SAFMC, penaeid shrimps, and red drum).
    d. benthic *Sargassum* (SAFMC, snapper grouper).
    e. from shore to the ends of the sandy shoals of Cape Lookout, Cape Fear, and Cape Hatteras, North Carolina; Hurl Rocks, South Carolina; *Phragmatopoma* (worm reefs) reefs off the central coast of Florida and nearshore hardbottom south of Cape Canaveral (SAFMC, coastal migratory pelagics).
    f. Atlantic coast estuaries with high numbers of Spanish mackerel and cobia from ELMR, to include Bogue Sound, New River, North Carolina; Broad River, South Carolina (SAFMC, coastal migratory pelagics).
    g. Florida Bay, Biscayne Bay, Card Sound, and coral hardbottom habitat from Jupiter Inlet through the Dry Tortugas, Florida (SAFMC, Spiny Lobster)

h. Hurl Rocks (South Carolina), The *Phragmatopoma* (worm reefs) off central east coast of Florida, nearshore (0-4 meters; 0-12 feet) hardbottom off the east coast of Florida from Cape Canaveral to Broward County; offshore (5-30 meters; 15-90 feet) hardbottom off the east coast of Florida from Palm Beach County to Fowey Rocks; Biscayne Bay, Florida; Biscayne National Park, Florida; and the Florida Keys National Marine Sanctuary (SAFMC, Coral, Coral Reefs and Live Hardbottom Habitat).
i. EFH-HAPCs designated for HMS species (e.g., sharks) in the South Atlantic region (NOAA Fisheries Service, Highly Migratory Species).

10. Habitats likely to be affected by beach dredge and fill projects include many recognized in state-level fishery management plans. Examples of these habitats include Critical Habitat Areas established by the North Carolina Marine Fisheries Commission, either in FMPs or in Coastal Habitat Protection Plans (CHAs).

11. Recent work by scientists in east Florida has documented important habitat values for nearshore, hardbottom habitats often buried by beach dredging projects, is used by over 500 species of fishes and invertebrates, including juveniles of many reef fishes. Equivalent scientific work is just beginning in other South Atlantic states, but life histories suggest that similar habitat use patterns will be found.

Threats to Marine and Estuarine Resources from Beach Dredge and Fill Activities and Related Large Coastal Engineering Projects

The SAFMC finds that beach dredge and fill activities and related large-scale coastal engineering projects (including inlet alteration projects) and disposal of material for navigational maintenance, threaten or potentially threaten EFH through the following mechanisms:

1. Direct mortality and displacement of organisms at and near sediment dredging sites
2. Direct mortality and displacement of organisms at initial sediment fill sites
3. Elevated turbidity and deposition of fine sediments down-current from dredging sites
4. Alteration of seafloor topography and associated current and waves patterns and magnitudes at dredging areas
5. Alteration of seafloor sediment size-frequency distributions at dredging sites, with secondary effects on benthos at those sites
6. Elevated turbidity in and near initial fill sites, especially in the surf zone, and deposition of fine sediment down-current from initial fill sites (ASMFC, 2002)
7. Alteration of nearshore topography and current and wave patterns and magnitudes associated with fill
8. Movement of deposited sediment away from initial fill sites, especially onto hardbottoms
9. Alteration of large-scale sediment budgets, sediment movement patterns and feeding and other ecological relationships, including the potential for cascading disturbance effects
10. Alteration of large-scale movement patterns of water, with secondary effects on water quality and biota

11. Alteration of movement patterns and successful inlet passage for larvae, post-larvae, juveniles and adults of marine and estuarine organisms
12. Alteration of long-term shoreline migration patterns (inducing further ecological cascades with consequences that are difficult to predict)
13. Exacerbation of transport and/or biological uptake of toxicants and other pollutants released at either dredge or fill sites

In addition, the interactions between cumulative and direct (sub-lethal) effects among the above factors certainly triggers non-linear impacts that are completely unstudied.
SAFMC Policies for Beach Dredge and Fill Projects and Related Large Coastal Engineering Projects

The SAFMC establishes the following general policies related to large-scale beach dredge and fill and related projects, to clarify and augment the general policies already adopted in the Habitat Plan and Comprehensive Habitat Amendment (SAFMC 1998a; SAFMC 1998b):

1. Projects should avoid, minimize and where possible offset damage to EFH and EFH-HAPCs.

2. Projects requiring expanded EFH consultation should provide detailed analyses of possible impacts to each type of EFH, with careful and detailed analyses of possible impacts to EFH-HAPCs and state CHAs, including short and long-term, and population and ecosystem scale effects. Agencies with oversight authority should require expanded EFH consultation.

3. Projects requiring expanded EFH consultation should provide a full range of alternatives, along with assessments of the relative impacts of each on each type of EFH, HAPC and CHAs.

4. Projects should avoid impacts on EFH, HAPCs and CHAs that are shown to be avoidable through the alternatives analysis, and minimize impacts that are not.

5. Projects should include assessments of potential unavoidable damage to EFH and other marine resources, using conservative assumptions.

6. Projects should be conditioned on the avoidance of avoidable impacts, and should include compensatory mitigation for all reasonably predictable impacts to EFH, taking into account uncertainty about these effects. Mitigation should be local, up-front and in-kind, and should be adequately monitored, wherever possible.

7. Projects should include baseline and project-related monitoring adequate to document pre-project conditions and impacts of the projects on EFH.

8. All assessments should be based upon the best available science, and be appropriately conservative so follow and precautionary principles as developed for various federal and state policies.

9. All assessments should take into account the cumulative impacts associated with other beach dredge and fill projects in the region, and other large-scale coastal engineering projects that are geographically and ecologically related.

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7.4.2.2 Policy Statement Concerning Dredging and Dredge Material Disposal Activities

Ocean Dredged Material Disposal Sites (ODMDS) and SAFMC Policies

The shortage of adequate upland disposal sites for dredged materials has forced dredging operations to look offshore for sites where dredged materials may be disposed. These Ocean Dredged Material Disposal Sites (ODMDSs) have been designated by the U.S. Environmental Protection Agency (EPA) and the U.S. Army Corps of Engineers (COE) as suitable sites for disposal of dredged materials associated with berthing and navigation channel maintenance activities. The South Atlantic Fishery Management Council (SAFMC; the Council) is moving to establish its presence in regulating disposal activities at these ODMDSs. Pursuant to the Magnuson-Stevens Fishery Conservation and Management Act (the Magnuson-Stevens Act), the regional fishery management Councils are charged with management of living marine resources and their habitat within the 200 mile Exclusive Economic Zone (EEZ) of the United States. Insofar as dredging and disposal activities at the various ODMDSs can impact fishery resources or essential habitat under Council jurisdiction, the following policies address the Council's role in the designation, operation, maintenance, and enforcement of activities in the ODMDSs:

The Council acknowledges that living marine resources under its jurisdiction and their essential habitat may be impacted by the designation, operation, and maintenance of ODMDSs in the South Atlantic. The Council may review the activities of EPA, COE, the state Ports Authorities, private dredging contractors, and any other entity engaged in activities which impact, directly or indirectly, living marine resources within the EEZ. The Council may review plans and offer comments on the designation, maintenance, and enforcement of disposal activities at the ODMDSs.

ODMDSs should be designated or redesignated so as to avoid the loss of live or hard bottom habitat and minimize impacts to all living marine resources.

Notwithstanding the fluid nature of the marine environment, all impacts from the disposal activities should be contained within the designated perimeter of the ODMDSs.
The final designation of ODMDSs should be contingent upon the development of suitable management plans and a demonstrated ability to implement and enforce that plan. The Council encourages EPA to press for the implementation of such management plans for all designated ODMDSs.

All activities within the ODMDSs are required to be consistent with the approved management plan for the site.

The Council's Habitat and Environmental Protection Advisory Panel when requested by the Council will review such management plans and forward comment to the Council. The Council may review the plans and recommendations received from the advisory sub-panel and comment to the appropriate agency. All federal agencies and entities receiving a comment or recommendation from the Council will provide a detailed written response to the Council regarding the matter pursuant to 16 U.S.C. 1852 (i). All other agencies and entities receiving a comment or recommendation from the Council should provide a detailed written response to the Council regarding the matter, such as is required for federal agencies pursuant to 16 U.S.C. 1852 (i).

ODMDSs management plans should indicate appropriate users of the site. These plans should specify those entities/ agencies which may use the ODMDSs, such as port authorities, the U.S. Navy, the Corps of Engineers, etc. Other potential users of the ODMDSs should be acknowledged and the feasibility of their using the ODMDSs site should be assessed in the management plan.

Feasibility studies of dredge disposal options should acknowledge and incorporate ODMDSs in the larger analysis of dredge disposal sites within an entire basin or project. For example, Corps of Engineers analyses of existing and potential dredge disposal sites for harbor maintenance projects should incorporate the ODMDSs as part of the overall analysis of dredge disposal sites.

The Council recognizes that EPA and other relevant agencies are involved in managing and/or regulating the disposal of all dredged material. The Council recognizes that disposal activities regulated under the Ocean Dumping Act and dredging/filling carried out under the Clean Water Act have similar impacts to living marine resources and their habitats. Therefore, the Council urges these agencies apply the same strict policies to disposal activities at the ODMDSs. These policies apply to activities including, but not limited to, the disposal of contaminated sediments and the disposal of large volumes of fine-grained sediments. The Council will encourage strict enforcement of these policies for disposal activities in the EEZ. Insofar as these activities are relevant to disposal activities in the EEZ, the Council will offer comments on the further development of policies regarding the disposal/ deposition of dredged materials.

The Ocean Dumping Act requires that contaminated materials not be placed in an approved ODMDS. Therefore, the Council encourages relevant agencies to address the problem of disposal of contaminated materials. Although the Ocean Dumping Act does not specifically address inshore disposal activities, the Council encourages EPA and other relevant agencies to evaluate sites for the suitability of disposal and containment of contaminated dredged material. The Council further encourages those agencies to draft management plans for the disposal of contaminated dredge materials. A consideration for total removal from the basin should also be considered should the material be contaminated to a level that it would have to be relocated away from the coastal zone.

Offshore and Nearshore Underwater Berm Creation
The use of underwater berms in the South Atlantic region has recently been proposed as a disposal technique that may aid in managing sand budgets on inlet and beachfront areas. Two types of berms have been proposed to date, one involving the creation of a long offshore berm, the second involving the placement of underwater berms along beachfronts bordering an inlet. These berms would theoretically reduce wave energy reaching the beaches and/or resupply sand to the system.

The Council recognizes offshore berm construction as a disposal activity. As such, all policies regarding disposal of dredged materials shall apply to offshore berm construction. Research should be conducted to quantify larval fish and crustacean transport and use of the inlets prior to any consideration of placement of underwater berms. Until the impacts of berm creation in inlet areas on larval fish and crustacean transport are determined, the Council recommends that disposal activities should be confined to approved ODMDSs. Further, new offshore and near shore underwater berm creation activities should be reviewed under the most rigorous criteria, on a case-by-case basis.

Maintenance Dredging and Sand Mining for Beach Renourishment
The Council recognizes that construction and maintenance dredging of the seaward portions of entrance channels and dredging borrow areas for beach re-nourishment occur in the EEZ. These activities should be done in an appropriate manner in accordance with the policies adopted by the Council.

The Council acknowledges that endangered and threatened species mortalities have occurred as a result of dredging operations. Considering the stringent regulations placed on commercial fisherman, dredging or disposal activities should not be designed or conducted so as to adversely impact rare, threatened or endangered species. NOAA Fisheries Service's Protected Resources Division should work with state and federal agencies to modify proposals to minimize potential impacts on threatened and endangered sea turtles and marine mammals.

The Council has and will continue to coordinate with Minerals Management Service (MMS) in their activities involving exploration, identification and dredging/mining of sand resources for beach renourishment. This will be accomplished through membership on state task forces or directly with MMS. The Council recommends that live bottom/hard bottom habitat and historic fishing grounds be identified for areas in the South Atlantic region to provide for the location and protection of these areas while facilitating the identification of sand sources for beach renourishment projects.

Open Water Disposal
The SAFMC is opposed to the open water disposal of dredged material into aquatic systems which may adversely impact habitat that fisheries under Council jurisdiction are dependent upon. The Council urges state and federal agencies, when reviewing permits considering open water disposal, to identify the direct and indirect impacts such projects could have on fisheries habitat.

The SAFMC concludes that the conversion of one naturally functioning aquatic system at the expense of creating another (marsh creation through open water disposal) must be justified given best available information.

7.4.2.3 Policies for the Protection and Restoration of EFH from Energy Exploration, Development, Transportation and Hydropower Re-Licensing

Policy Context

This document establishes the policies of the South Atlantic Fishery Management Council (SAFMC) regarding protection of Essential Fish Habitat (EFH) and Essential Fish Habitat - Habitat Areas of Particular Concern (EFH-HAPCs) from threats associated with energy exploration, development, transportation and hydropower licensing. The policies are designed to be consistent with the overall habitat protection policies of the SAFMC as formulated and adopted in the Habitat Plan (SAFMC 1998a), the Comprehensive EFH Amendment (SAFMC 1998b) and the various Fishery Management Plans (FMPs) of the Council.

The findings presented below assess the threats to EFH potentially posed by activities related to energy development and hydropower licensing in offshore and coastal waters, riverine systems, and adjacent wetland habitats, and the processes whereby those resources are placed at risk. The policies established in this document are designed to avoid, minimize, and offset damage caused by these activities, in accordance with the general habitat policies of the SAFMC as mandated by law. To address any future energy projects in the South Atlantic region, the SAFMC reserves the right to revise this policy when more information becomes available.

EFH at Risk from Energy Exploration, Development Transportation and Hydropower Licensing Activities

The SAFMC finds:

1. That oil or gas drilling for exploration or development on or closely associated with EFH including – but not limited to – coral, coral reefs, and live/hardbottom habitat at all depths in the Exclusive Economic Zone (EEZ), EFH-HAPCs, or other special biological resources essential to commercial and recreational fisheries under SAFMC jurisdiction, be prohibited.

2. That all facilities associated with oil and gas exploration, development, and transportation be designed to avoid impacts on coastal ecosystems and sand sharing systems.

3. That adequate spill containment and cleanup equipment be maintained for all development and transportation facilities and, that the equipment be available on-site or located so as to be on-site within the landing time trajectory. An environmental bond should be required to assure that adequate resources will be available for

unanticipated environmental impacts, spill response, clean-up and environmental impact assessment.

4. That exploration and development activities should be scheduled to avoid migratory patterns, breeding and nesting seasons of endangered and threatened species, including – but not limited to – northern right whales in coastal waters off the southeastern United States.

5. That the Environmental Impact Statement (EIS) for any Lease Sale address impacts from activities specifically related to natural gas production, safety precautions required in the event of the discovery of "sour gas" or hydrogen sulfide reserves and the potential for transport of hydrocarbons to nearshore and inshore estuarine habitats resulting from the cross-shelf transport by Gulf Stream spin-off eddies. The EIS should also address the development of contingency plans to be implemented if problems arise due to oceanographic conditions or bottom topography, the need for and availability of onshore support facilities in coastal areas, and an analysis of existing facilities and community services in light of existing major coastal developments.

6. That EISs prepared for liquefied natural gas (LNG) pipeline projects or other energy-related projects must fully describe direct and cumulative impacts to EFH, including deepwater coral communities. Impact evaluations should include quantitative assessments for each habitat based on recent scientific studies pertinent to that habitat, and the best available information.

7. That construction and operation of open-loop (flow-through) LNG processing facilities be prohibited in areas that support EFH.

8. That hydropower project licenses issued by the Federal Energy Regulatory Commission include specific terms and conditions to ensure that the amount and timing of river flows mimic natural conditions to the extent possible for protection of migratory diadromous fish species and their spawning habitats. In addition, the best available technologies that allow for safe, timely, and effective upstream and downstream fish passage should be integrated into the project design as specified in prescriptions issued by NOAA Fisheries Service.

9. That projects requiring expanded EFH consultation provide a full range of alternatives, along with assessments of the relative impacts of each on each type of EFH, EFH-HAPC and state-designated Critical Habitat Areas (CHAs).

10. That energy development activities have the potential to cause impacts to a variety of habitats across the shelf and to nearshore, estuarine, and riverine systems and wetlands, including:

a) waters and benthic habitats in or near drilling and disposal sites, including those potentially affected by sediment movement and by physical disturbance associated with drilling activities and site development;
b) waters and benthic habitats in or near LNG processing facilities or other energy development or transportation sites,
c) exposed hardbottom (e.g., reefs and live bottom) in shallow and deep waters,
d) coastal wetlands and
e) riverine systems and associated wetlands.

11. That certain offshore, nearshore and riverine habitats are particularly important to the long-term viability of commercial and recreational fisheries under SAFMC management, and potentially threatened by oil and gas and other energy exploration, development, transportation, and hydropower licensing activities:

a) coral, coral reef and live/hardbottom habitat, including deepwater coral communities,
b) marine and estuarine waters,
c) estuarine wetlands, including mangroves and marshes,
d) submersed aquatic vegetation,
e) waters that support diadromous fishes, and their spawning habitats
f) waters hydrologically and ecologically connected to waters that support EFH.

12. That siting and design of onshore receiving, holding, and transport facilities could have impacts on wetlands and endangered species' habitats if they are not properly located.

13. Sections of South Atlantic waters potentially affected by these projects, both individually and collectively, have been identified as EFH or EFH-HAPC by the SAFMC. Potentially affected species and their EFH under federal management include (SAFMC, 1998b):

a) summer flounder (various nearshore waters, including the surf zone and inlets; certain offshore waters),
b) bluefish (various nearshore waters, including the surf zone and inlets),
c) red drum (ocean high-salinity surf zones and unconsolidated bottoms in the nearshore),
d) many snapper and grouper species (live hardbottom from shore to 600 feet, and – for estuarine-dependent species (e.g., gag grouper and gray snapper) – unconsolidated bottoms and live hardbottoms to the 100 foot contour),
e) black sea bass (various nearshore waters, including unconsolidated bottom and live hardbottom to 100 feet, and hardbottoms to 600 feet),
f) penaeid shrimp (offshore habitats used for spawning and growth to maturity, and waters connecting to inshore nursery areas, including the surf zone and inlets), How about including estuarine emergent wetlands and deepwater habitats??

g) coastal migratory pelagics (e.g., king mackerel, Spanish mackerel) (sandy shoals of capes and bars, barrier island ocean-side waters from the surf zone to the shelf break inshore of the Gulf Stream; all coastal inlets),
h) corals of various types and associated organisms (on hard substrates in shallow, mid-shelf, and deepwater),
i) muddy, silt bottoms from the subtidal to the shelf break, deepwater corals and associated communities),
j) areas identified as EFH for Highly Migratory Species managed by the Secretary of Commerce (e.g., sharks: inlets and nearshore waters, including pupping and nursery grounds), and
k) riverine areas that support diadromous fishes, including important prey species such as shad, herring and other alosines in addition to shortnose and Atlantic sturgeon.

14. Many of the habitats potentially affected by these activities have been identified as EFH-HAPCs by the SAFMC. Each habitat, type of activity posing a potential threat and FMP is provided as follows:

a) all nearshore hardbottom areas – exploration, transportation and development (SAFMC snapper grouper);
b) all coastal inlets – transportation and development (SAFMC penaeid shrimp, red drum, and snapper grouper);
c) nearshore spawning sites – transportation and development (SAFMC penaeid shrimps and red drum);
d) benthic Sargassum – exploration, transportation and development (SAFMC snapper grouper);
e) from shore to the ends of the sandy shoals of Cape Lookout, Cape Fear, and Cape Hatteras, North Carolina; Hurl Rocks, South Carolina; and *Phragmatopoma* (worm reefs) reefs off the central coast of Florida and near shore hardbottom south of Cape Canaveral – transportation and development (SAFMC coastal migratory pelagics);
f) Atlantic coast estuaries with high numbers of Spanish mackerel and cobia from ELMR, to include Bogue Sound, New River, North Carolina; Broad River, South Carolina – transportation and development (SAFMC coastal migratory pelagics);
g) Florida Bay, Biscayne Bay, Card Sound, and coral hardbottom habitat from Jupiter Inlet through the Dry Tortugas, Florida – exploration, transportation and development (SAFMC spiny lobster);
h) Hurl Rocks (South Carolina); The *Phragmatopoma* (worm reefs) off central east coast of Florida; nearshore (0-4 meters; 0-12 feet) hardbottom off the east coast of Florida from Cape Canaveral to Broward County; offshore (5-30 meters; 15-90 feet) hardbottom off the east coast of Florida from Palm Beach County to Fowey Rocks; Biscayne Bay, Florida; Biscayne National Park, Florida; and the Florida Keys National Marine Sanctuary – transportation and development (SAFMC Coral, Coral Reefs and Live Hardbottom Habitat); and

i) EFH-HAPCs designated for HMS species (e.g., sharks) in the South Atlantic region – exploration, transportation and development (NOAA Fisheries Service Highly Migratory Species).

15. Habitats likely to be affected by oil and gas exploration, development and transportation, and hydropower re-licensing activities include many recognised in state level fishery management plans. Examples of these habitats include Critical Habitat Areas (CHAs) established by the North Carolina Marine Fisheries Commission, either in FMPs or in Coastal Habitat Protection Plans.

16. Scientists in east Florida have documented exceptionally important habitat values for nearshore hardbottom used by over 500 species of fishes and invertebrates, including juveniles of many reef fishes. Equivalent scientific work is just beginning in other South Atlantic states, but life histories suggest that similar habitat use patterns will be found.

17. Proposed Deepwater Coral HAPCs and the pelagic and benthic species including their early life stages are potentially affected by oil and gas exploration, development and transportation, LNG development and alternative energy development including ocean current and wave energy facilities.

Threats to Marine and Estuarine Resources from Energy Exploration, Development, Transportation and Hydropower Licensing Activities (Revised Draft March 2008)

The SAFMC finds that energy exploration, development, transportation and hydropower licensing activities threaten or potentially threaten EFH through the following mechanisms:

1. Direct mortality and displacement of organisms at and near drilling, dredging, and/or trenching sites,

2. Deposition of fine sediments (sedimentation) and drilling muds down-current from drilling, dredging, trenching, and/or backfilling sites,

3. Chronic elevated turbidity in and near drilling, dredging, trenching, and/or backfilling sites,

4. Direct mortality of larvae, post-larvae, juveniles and adults of marine and estuarine organisms occurring from water intake, spills from pipelines, or from vessels in transit near or close to inlet areas,

5. Alteration of long-term shoreline migration patterns (with complex, often indeterminable, ecological consequences),

6. Burial of sensitive coral resources and associated habitat resulting from "frac-outs" associated with horizontal directional drilling,

7. Permanent conversion of soft bottom habitat to artificial hardbottom habitat through installing a hard linear structure (i.e., a pipe covered in articulated concrete mats),

8. Impacts to benthic resources from placement and shifting of pipelines and cables, and from other types of direct mechanical damage,

9. Alterations in amount and timing of riverflow and significant blockage or reduction in area of critical spawning habitat resulting from damming or diverting rivers, and

10. Alteration of community diversity, composition, food webs and energy flow due to addition of structure.

In addition, the interactions between cumulative and direct (lethal and sub-lethal) effects among the above-listed can affect the magnitude of the overall impacts. Such interactions may result in a scale of effect that is multiplicative rather than additive. Those effects are at present nearly completely unstudied.

Potential Impacts of Offshore Ocean Current Energy Installations on Benthic Resources (USDOI, MMS 2007a):

Construction

- Bottom disturbances from installation of foundations or anchoring systems and anchoring of construction and maintenance vessels
- Sediment disturbance and suspension during installation of foundations or anchoring systems
- Sound during pile driving or drilling
- Habitat loss from foundations and units attached to the seafloor to gather the power and feed to the transmission cable to shore
- Habitat disturbance during cable laying
- Introduction of hard substrates
- Habitat disturbance resulting from scour

Operation

- Operational sound and vibration
- Introduction of contaminants from use of antifouling coatings and cleaning of marine fouling

- Introduction of different communities from fouling growth on monopiles and scour protection around the foundation or anchoring systems

Potential Impacts to Fishery Resources from Ocean Current Installations:

Construction activities

- Habitat disturbance or loss from foundations, moorings, anchors, and cable laying
- Sound associated with pile driving and drilling

Operations activities

- Introduction of artificial hard substrates
- Scour impacts on benthic habitats
- EMF effects on sensitive species
- Collisions with moving parts
- Changes in water flow and pressures

Potential Impacts to Fishery Resources from Wave Installations:

- anchored on hard bottom, a more sensitive habitat than soft sediments, and could affect essential fish habitat and Habitat Areas of Particular Concern

- transmission cable cannot be buried in hard bottom areas, creating concerns for those species that have EMF sensitivities

- antifouling agents (e.g., Tri-butyl tin) have toxic effects on many marine and estuarine organisms, and specifically different life stages of fishes

- some of the devices that use overtopping as part of their process might entrain fish, primarily embryos and larvae, that live at the surface of the ocean

SAFMC Policies for Energy Exploration, Development, Transportation and Hydropower Licensing Activities

The SAFMC establishes the following general policies related to energy exploration, development, transportation, and hydropower licensing activities and related projects, to clarify and augment the general policies already adopted in the Habitat Plan and Comprehensive Habitat Amendment (SAFMC 1998a; SAFMC 1998b):

1. Projects should avoid, minimize, and – where possible – offset damage to EFH and EFH-HAPCs. This should be accomplished, in part, by integrating the best available and least impactive technologies into the construction design.

2. Agencies with oversight authority should require expanded EFH consultation for projects with the potential to significantly damage EFH. Projects requiring expanded EFH consultation should include detailed analyses for a full range of alternatives of possible impacts to each type of EFH, each EFH-HAPC and each CHA, including short and long-term effects and cumulative impacts at local, population and ecosystem scales. These analyses should utilize resource-protective assumptions and the best available science.

3. Projects should utilize the alternative that minimizes total impact EFH, EFH-HAPCs, and CHAs.

4. Projects should include detailed assessments of potentially unavoidable damage to EFH and other marine resources associated with the preferred or selected alternative and cumulative impacts, using conservative assumptions and the best available science.

5. Compensatory mitigation should not be considered until avoidance and minimization measures have been duly demonstrated. Compensatory mitigation should be required to offset losses to EFH, including losses associated with temporary impacts, and should take into account uncertainty and the risk of the chosen mitigation measures inadequately offsetting the impacts. Mitigation should be local, "up-front," and "in-kind," and include long-term monitoring to assess and ensure the efficacy of the mitigation program selected.

6. Projects should include pre-project, project-related, and post-project monitoring adequate to document pre-project conditions and the initial, long-term and cumulative impacts of the project on EFH.

7. All EFH assessments should be based upon the best available science, be conservative, and follow precautionary principles as developed for various Federal and State policies.

8. All EFH assessments should document the cumulative impacts associated with all natural and anthropogenic stressors on EFH, including other energy exploration, development, transportation, and re-licensing projects that are geographically and ecologically related.

9. Projects should comply with existing standards and requirements regulating domestic and international transportation of energy products including regulated waste disposal and emissions which are intended to minimize negative impacts on and preserve the quality of the marine environment.

10. Open-loop LNG processing facilities should be avoided in favor of closed-loop systems. Water intake associated with closed-loop should be minimized and the

effects to fishery resources should be determined through baseline studies and project monitoring.

11. The original licensing or re-licensing of hydropower projects should provide for adequate and ecologically based instream flows, and safe, timely, and effective upstream and downstream fish passage.

12. Third party environmental inspectors should be required on all projects to provide for independent monitoring and permit compliance.

13. Resource sensitivity training modules should be developed specific to each project, construction procedures and habitat types found within the project impact area. This training should be provided to all contractors and sub-contractors that are anticipated to work in or adjacent to areas that support sensitive habitats.

The SAFMC recommends the following specific concerns and issues be addressed by the Federal Energy Regulatory Commission, Minerals Management Service, and/or the U.S. Army Corps of Engineers prior to approval of any license, application, or permit.

A. The following requirements should apply to any permit to drill any exploratory well or wells in any Lease Sale with the potential to affect EFH in the SAFMC's jurisdiction. These concerns and issues should also be included in a new EIS for any future Outer Continental Shelf (OCS) Leasing Plan:

1. Identification of the on-site fisheries resources, including both pelagic and benthic communities, that inhabit, spawn, or migrate through the lease sites with special focus on those specific lease blocks where industry has expressed specific interest in the pre-lease phases of the leasing process. Particular attention should be given to critical life history stages (i.e., eggs and larvae) that are most sensitive to oil spills and seismic exploration.

2. Identification of on-site or potentially affected state or federally-listed species (e.g., endangered, threatened, special concern, etc.), marine mammals, pelagic birds, diadromous fishes, and all species regulated under federal fishery management plans.

3. Determination of impacts of all exploratory and development activities on the fisheries resources prior to MMS approval of any applications for permits to drill in the Exploratory Unit area, including effects of seismic survey signals on fish behavior, eggs and larvae.

4. Identification of commercial and recreational fishing activities in the vicinity of the lease or Exploratory Unit area, their season of occurrence and intensity, and any impacts whether temporary or permanent on the potential to continue those activities associated with the project or activity.

5. Determination of the physical and chemical oceanographic and meteorological characteristics of the area through field studies by MMS or the applicant, including on-site direction and velocity of currents and tides, sea states, temperature, salinity, water quality, wind storms frequencies, and intensities and icing conditions. Such studies must be required prior to approval of any exploration plan submitted in order to have adequate information upon which to base decisions related to site-specific proposed activities. Studies should include detailed characterization of seasonal surface currents and likely spill trajectories.

6. Description of required monitoring activities to be used to evaluate environmental conditions, and assess the impacts of exploration activities in the lease area or the Exploratory Unit.

7. Identification of the quantity, composition, and method of disposal of solid and liquid wastes and pollutants likely to be generated by offshore, onshore, and transportation operations associated with oil and gas exploration development and transportation.

8. Development of an oil spill contingency plan which includes oil spill trajectory analyses specific to the area of operations, dispersant-use plan including a summary of toxicity data for each dispersant, identification of response equipment and strategies, establishment of procedures for early detection and timely notification of an oil spill, and "chain-of-command" and notification procedures inclusive of all local, state and federal agencies and agency personnel to be notified when an oil spill is discovered, as well as defined and specific actions to be taken after discovery of an oil spill.

9. Mapping of environmentally sensitive areas (e.g., spawning aggregations of snappers and groupers); coral resources and other significant benthic habitats (e.g., tilefish mudflats) along the edge of the continental shelf (including the upper slope); calico scallop, royal red shrimp, and other productive benthic fishing grounds; other special biological resources; and northern right whale calving grounds and migratory routes, and subsequent deletion from inclusion in the respective lease block(s).

10. Planning for oil and gas product transport should be done to determine methods of transport, pipeline corridors, and onshore facilities.

11. The applicant, or MMS, must provide an analysis of biological community dynamics, and pathways and flows of energy, to ascertain accumulation of toxins and impacts on biological communities.

12. Due to the critical nature of canyons and steep relief to important fisheries (e.g., billfishes, swordfish and tunas) an evaluation of shelf-edge and down-slope dynamics, and a resource assessment to determine transport and fate of contaminants should be required.

13. Discussion of the potential adverse impacts upon fisheries resources of the discharges of all drill cuttings and all drilling muds that may be approved for use in the lease area or the Exploration Unit, as well as discharges associated with production activities (i.e., produced waters). This should include: physical and chemical effects upon pelagic and benthic species and communities, including spawning behavior, effects on eggs and larval stages; effects upon sight-feeding species of fish; and analysis of methods and assumptions underlying the model used to predict the dispersion of discharged muds and cuttings from exploration activities.

14. Discussion of secondary impacts affecting fishery resources associated with onshore oil and gas related development such as storage and processing facilities, dredging and dredged material disposal, roads and rail lines, fuel and electrical transmission line routes, waste disposal, and others.

B. The following requirements should apply to any permit or license to construct LNG gas pipelines and related facilities with the potential to affect EFH in the SAFMC's jurisdiction:

1. The least damaging construction method for traversing reef tracts and deepwater corals should be integrated into the project design.

2. Hydrotest chemicals that may be harmful to fish and wildlife resources shall not be discharged into waters of the United States.

3. Geotechnical studies shall be completed to ensure that the geology of the area is appropriate for the construction method and that geological risks are appropriately mitigated.

4. All work vessels associated with construction that traverses any reef system should be equipped with standard navigation aids, safety lighting and communication equipment. A vessel monitoring system with global positioning system will be employed to continuously monitor all vessel movements and locations in real time.

5. Any anchor placement should completely avoid corals and be diver verified. In addition, measures to avoid anchor sweep should be developed and implemented.

6. Appropriate exclusion zones should be designated around sensitive marine habitats.

7. Pre- and post-project monitoring should be completed in addition to monitoring during construction. The pre-project monitoring should establish pre-project conditions; project monitoring should examine if unanticipated impacts are occurring and if corrective actions are needed; and post-project (immediate and

long-term) monitoring should document impacts to resources resulting from the project, and any recovery from those impacts.

8. All feasible avoidance and minimization measures must be used to protect deepwater coral communities. Those measures must be fully described in detail prior to authorization of any permit or license.

9. A contingency plan should be required to address catastrophic blowouts or more chronic material losses from LNG facilities, including trajectory and other impact analyses and remediation measures and responsibilities.

10. Periodic long-term monitoring of pipelines and nearby deepwater resources should be conducted to evaluate the environmental effects of these installations on deepwater marine communities.

11. Appropriate mitigation should be developed in concert with the NOAA Fisheries Service Habitat Conservation Division to offset unavoidable impacts.

C. The requirement listed below should apply to any relevant permit or license to construct windfarms or hydroturbine energy producing facilities with the potential to affect EFH in the SAFMC jurisdiction. To date, such projects are conceptual, yet reasonably foreseeable as future proposed actions. Given the existing information, it is reasonable to conclude that such projects may have an impact on EFH. However, at this time sufficient information is not available to make general project-type recommendations.

1. Submarine cables should be placed in a manner that avoids impacts to EFH; use of existing conduits is preferred over creating new conduits. The best available technologies should be used to install such cables to avoid and minimize temporary and long-term impacts to EFH. If placed on the seabed, cables should be anchored and/or stabilized, and stability analyses should be conducted to ensure that the cable can withstand a 100-year storm event in appropriate water depths.

2. Many of the areas designated as EFH are important to protected resources (e.g., endangered and threatened species and marine mammals) in the region. Direct and indirect impacts may result from noise, electromagnetic fields, vessel traffic, pollutants/water quality issues, alteration of the benthos and habitat degradation or habitat exclusion. The degree of impact can depend on the species, the type of turbine, the method of installation, site characteristics and the layout and size of the facility. Therefore, any EIS prepared for the construction, operation or decommissioning of a wind energy generating facility should include maps of species' ranges, migratory pathways, and use of habitat as part of an evaluation of direct and cumulative impacts to protected resources.

Alternative Energy Environmental Information Needs (USDOI, MMS 2007a):

1. Finer-grained data on the distribution and life history for key species in each regional ecosystem; environmental assessments for specific projects need more detailed data on benthic habitats and multiyear studies of seasonal abundance and distribution of key species of each resource.

2. Development of better field data collection methods for baseline studies and Post-construction monitoring surveys to improve the confidence of impact detection; study of highly mobile species in offshore areas is particularly difficult, requiring new approaches and technologies.

3. Focused laboratory studies to determine thresholds for potential effects resulting from exposure to the types and levels of sound and electromagnetic fields likely to be generated by different types of alternative energy devices in full-scale installations.

4. Development of protocols for field studies on potential effects from exposure to sound, electromagnetic fields, and obstructions on the behavior and survival of key species of each resource of concern.

5. Development of guidelines to set acceptable limits of direct, indirect, and cumulative impacts resulting from the installation and operation of offshore alternative energy projects; guidelines are needed for all types of potential impacts such as changes to the hydrodynamic climate, erosion of adjacent shorelines, habitat loss and alteration, avoidance and attraction behavior, mortality, aesthetics, and lost use.

D. The following requirements should apply to the initial licensing or re-licensing of hydropower plants on rivers draining to waters under SAFMC jurisdiction:

1. The construction of adequate fish passage facilities (ladders, lifts, bypasses and screens) should be provided to ensure safe, timely and effective passage of fish to and from vital upstream spawning and maturation habitats.
2. Adequate, ecologically based instream flows approximating natural conditions should be provided to protect, enhance, or restore important riverine spawning and maturation habitats affected or potentially affected by hydropower projects.

SAFMC Policy and Position on Previous Oil and Gas Exploration Proposals

The SAFMC urged the Secretary of Commerce to uphold the 1988 coastal zone inconsistency determination of the State of Florida for the respective plans of exploration filed with MMS by Mobil Exploration and Producing North America, Inc. for Lease OCS-G6520 (Pulley Ridge Block 799) and by Union Oil Company of California for Lease OCS-G6491/6492 (Pulley Ridge Blocks 629 & 630). Both plans of exploration involved lease blocks lying within the lease area comprising the offshore area encompassed by Part 2 of Lease Sale 116, and south of 26° North latitude. The Council's objection to the proposed exploration activities was based on the potential degradation or loss of extensive live bottom and other habitat essential to fisheries under Council jurisdiction.

The SAFMC also supported North Carolina's determination that the plans of exploration filed with MMS by Mobil Exploration and Producing North America, Inc. for Lease OCS Manteo Unit are not consistent with North Carolina's Coastal Zone Management program.

The Council has expressed concern to the Outer Continental Shelf Leasing and Development Task Force about the proposed area and recommended that no further exploration or production activity be allowed in the areas subject to Presidential Task Force Review (the section of Sale 116 south of 26° N latitude).

The following section addresses the recommendations, concerns and issues expressed by the South Atlantic Council (Source: Memorandum to Regional Director, U.S. Fish and Wildlife Service, Atlanta, Georgia from Regional Director, Gulf of Mexico OCS Region dated October 27, 1995):

"The MMS, North Carolina, and Mobil entered into an innovative Memorandum of Understanding on July 12, 1990, in which the MMS agreed to prepare an Environmental Report (ER) on proposed drilling offshore North Carolina. The scope of the ER prepared by the MMS was more comprehensive than an EIS would be. The normal scoping process used in preparation of a NEPA-type document would not only 'identify significant environmental issues deserving of study' but also 'de-emphasize insignificant issues, narrowing the scope' (40 CFR 1500.4) by scoping out issues not ripe for decisions.

Of particular interest to North Carolina are not the transient effects of exploration, but rather the downstream and potentially broader, long-term effects of production and development. The potential effects associated with production and development would normally be "scoped out" of the (EIS-type) document and would be the subject of extensive NEPA analysis only after the exploration phase proves successful, and the submittal of a full-scale production and development program has been received for review and analysis. The ER addressed three alternatives: the proposed Mobil plan to drill a single exploratory well, the no-action alternative and the alternative that the MMS approve the Mobil plan with specific restrictions (monitoring programs and restrictions on discharges). The ER also analyzes possible future activities, such as development and production, and the long-term environmental and socioeconomic effects associated with such activities. The MMS assured North Carolina that all of the State's comments and concerns would be addressed in the Final ER (USDOI 1990).

The MMS also funded a Literature Synthesis study (USDOI MMS 1993a) and a Physical Oceanography study (USDOI MMS 1994), both recommended by the Physical

Oceanography Panel and the Environmental Sciences Review Panel (ESRP). Mobil also submitted a draft report to the MMS titled *Characterization of Currents at Manteo Block 467 off Cape Hatteras, North Carolina*. The MMS also had a Cooperative Agreement with the Virginia Institute of Marine Science to fund a study titled *Seafloor Survey in the Vicinity of the Manteo Prospect Offshore North Carolina* (USDOI MMS 1993b). The MMS had a Cooperative Agreement with East Carolina University to conduct a study titled *Coastal North Carolina Socioeconomic Study* (USDOI MMS 1993c). The above-mentioned studies were responsive to the ESRP's recommendations as well as those of the SAFMC and the State of North Carolina."

Copies of these studies can be acquired from the address below:
Minerals Management Service, Technical Communication Services
MS 4530 381 Elden Street
Herndon, VA 22070-4897 (703) 787-1080

In addition, by letter dated November 21, 2003, the SAFMC provided the following recommendations on the AES Ocean Express LNG pipeline project:

- The deepwater touch down route should be pre-inspected by ROV and the pipeline right of way shall be clear of all deepwater resources;
- Adjust deepwater touchdown position to maintain an appropriate buffer from any such deepwater resources;
- Require deepwater resources, other EFH and the deepwater touchdown position be mapped by ROV to confirm the resource position in relation to the installed pipeline;
- Conduct pre-installation video surveys to select the route that maximizes avoidance of these deepwater coral and live bottom habitats; and
- Monitor pipelines and nearby deepwater resources after installation to evaluate the environmental effects of these installations on deepwater marine communities.

References

SAFMC. 1998a. Final Habitat Plan for the South Atlantic region: Essential Fish Habitat requirements for fishery management plans of the South Atlantic Fishery Management Council. South Atlantic Fishery Management Council, 1 Southpark Cir., Ste 306, Charleston, SC 29407-4699. 457 pp. plus appendices.

SAFMC. 1998b. Final Comprehensive Amendment Addressing Essential Fish Habitat in Fishery Management Plans of the South Atlantic Region. Including a Final Environmental Impact Statement /Supplemental Environmental Impact Statement, Initial Regulatory Flexibility Analysis, Regulatory Impact Review, and Social Impact Assessment/Fishery Impact Statement. South Atlantic Fishery Management Council, 1 Southpark Cir., Ste 306, Charleston, SC 29407-4699. 136pp.

USDOI, MMS. 1990. Atlantic Outer Continental Shelf, Final Environmental Report on Proposed Exploratory Drilling Offshore North Carolina, Vols. I-III.

USDOI, MMS. 1993a. North Carolina Physical Oceanography Literature Study. Contract No. 14-35- 0001-30594.

USDOI, MMS. 1993b. Benthic Study of the Continental Slope off Cape Hatteras, North Carolina. Vols. I-III. MMS 93-0014, -0015, -0016.

USDOI, MMS. 1993c. Coastal North Carolina Socioeconomic Study. Vols. I-V. MMS 93-0052, -0053, -0054, -0055, and -0056.

USDOI, MMS. 1994. North Carolina Physical Oceanographic Field Study. MMS 94-0047.

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USDOI, MMS 2007b. Michel, J. and Burkhard, E. 2007. Workshop to Identify Alternative Energy Environmental Information Needs: Workshop Summary. U.S. Department of the Interior, Minerals Management Service, Herndon, VA, MMS OCS Report 2007-057. 50 pp. + appendices.

7.4.2.4 Policies for the Protection and Restoration of EFH from Alterations to Riverine, Estuarine and Nearshore Flows

Policy Context

This document establishes the policies of the South Atlantic Fishery Management Council (SAFMC) regarding protection of the essential fish habitats (EFH) and habitat areas of particular concern (EFH-HAPCs) associated with alterations of riverine, estuarine and nearshore flows. Such hydrologic alterations occur through activities such as flood control reservoir and hydropower operations, water supply and irrigation withdrawals, deepening of navigation al channels and inlets, and other modifications to the normative hydrograph. The policies are designed to be consistent with the overall habitat protection policies of the SAFMC as formulated and adopted in the Habitat Plan (October 1998) and the Comprehensive EFH Amendment (October 1998).

The findings presented below assess the threats to EFH potentially posed by activities related to the alteration of flows in southeast rivers, estuaries and nearshore ocean habitats, and the processes whereby those resources are placed at risk. The policies established in this document are designed to avoid, minimize and offset damage caused by these activities, in accordance with the general habitat policies of the SAFMC as mandated by law.

EFH at Risk from Flow-Altering Activities

The SAFMC finds:

1. In general, the array of existing and proposed flow-altering projects being considered for the southeastern United States for states with river systems that drain into the South Atlantic Fishery Management Council area of jurisdiction together constitutes a real and significant threat to EFH under the jurisdiction of the SAFMC.

2. The cumulative effects of these projects have not been adequately assessed, including impacts on public trust marine and estuarine resources (especially diadromous species), use of public trust waters, public access, state and federally protected species, state critical habitat, SAFMC-designated EFH and EFH-HAPCs.

3. Individual proposals resulting in hydrologic alterations rarely provide adequate assessments or consideration of potential damage to fishery resources under state and federal management. Historically, emphasis has been placed on the need for human water supply, hydropower generation, agricultural irrigation, flood control and other human uses. Environmental considerations have been dominated by compliance with limitations imparted by the Endangered Species Act for shortnose sturgeon, and/or through provisions of Section 18 of the Federal Power Act, as administered by the Federal Energy Regulatory Commission, which applies to the provision of passage for anadromous species, as well as the provisions of the Fish and Wildlife Act.

4. Opportunities to avoid and minimize impacts of hydrologic alterations on fishery resources, and offsets for unavoidable impacts have rarely been proposed or implemented.

5. Hydrologic alterations have caused impacts to a variety of habitats including:
    a. waters, wetlands and benthic habitats near the discharge and withdrawal points, especially where such waters are used for spawning by anadromous species;
    b. waters, wetlands and benthic habitats in the area downstream of discharge or withdrawal points;
    c. waters wetlands and benthic habitats in receiving estuaries of southeast rivers; and
    d. waters and benthic habitats of nearshore ocean habitats receiving estuarine discharge.

6. Certain riverine, estuarine and nearshore habitats are particularly important to the long-term viability of commercial and recreational fisheries under SAFMC management, and threatened by large-scale, long-term or frequent hydrologic alterations:
    a. freshwater riverine reaches and/or wetlands used for anadromous spawning;
    b. downstream freshwater, brackish and mid-salinity portions of rivers and estuaries serving as nursery areas for anadromous and estuarine-dependant species; and
    c. nearshore oceanic habitats off estuary mouths.

7. Large sections of South Atlantic waters potentially affected by these projects, both individually and collectively, have been identified as EFH or EFH-HAPC by the SAFMC, as well as the Mid-Atlantic Fishery Management Council (MAFMC) in the case of North Carolina. Potentially affected species and their EFH under federal management include (SAFMC 1998) include:
    a. summer flounder (various nearshore waters, including the surf zone and inlets; certain offshore waters).
    b. bluefish (various nearshore waters, including the surf zone and inlets)
    c. red drum (ocean high-salinity surf zones and unconsolidated bottoms in the nearshore).
    d. many snapper and grouper species (live hard bottom from shore to 600 feet, and – for estuarine-dependent species [e.g., gag grouper and gray snapper] – unconsolidated bottoms and live hard bottoms to the 100 foot contour).
    e. black sea bass (various nearshore waters, including unconsolidated bottom and live hard bottom to 100 feet, and hard bottoms to 600 feet).
    f. penaeid shrimp (offshore habitats used for spawning and growth to maturity, and waters connecting to inshore nursery areas, including the surf zone and inlets).
    g. coastal migratory pelagics (e.g., king mackerel, Spanish mackerel) (sandy shoals of capes and bars, barrier island ocean-side waters from the surf zone to the shelf break inshore of the Gulf Stream; all coastal inlets).
    h. corals of various types (hard substrates and muddy, silt bottoms from the subtidal to the shelf break).

i. areas identified as EFH for Highly Migratory managed by the Secretary of Commerce (e.g., sharks / inlets and nearshore waters, including pupping and nursery grounds).

8. Projects which entail hydrologic alterations also threaten important fish habitats for anadromous species under federal, interstate and state management (in particular, riverine spawning habitats, riverine and estuarine habitats, including state designated areas such as Primary and Secondary Nursery Areas of North Carolina), as well as essential overwintering grounds in nearshore and offshore waters. All diadromous species are under management by the Atlantic States Marine Fisheries Commission and the states. The SAFMC also identified essential habitats of anadromous and catadromous species in the region (inlets and nearshore waters).

9. Numerous habitats that have been by these projects causing hydrologic alterations have been identified as EFH-HAPCs by the SAFMC. The specific fishery management plan is provided in parentheses:
   a. all nearshore hard bottom areas (SAFMC, snapper-grouper).
   b. all coastal inlets (SAFMC, penaeid shrimps, red drum, and snapper-grouper).
   c. nearshore spawning sites (SAFMC, penaeid shrimps, and red drum).
   d. benthic *Sargassum* (SAFMC, snapper-grouper).
   e. from shore to the ends of the sandy shoals of Cape Lookout, Cape Fear, and Cape Hatteras, North Carolina; Hurl Rocks, South Carolina; *Phragmatopoma* (worm reefs) reefs off the central coast of Florida and near-shore hard-bottom south of Cape Canaveral (SAFMC, coastal migratory pelagics).
   f. Atlantic coast estuaries with high numbers of Spanish mackerel and Cobia from ELMR, to include Bogue Sound, New River, North Carolina; Broad River, South Carolina (SAFMC, coastal migratory pelagics).
   g. Florida Bay, Biscayne Bay, Card Sound, and coral hard bottom habitat from Jupiter Inlet through the Dry Tortugas, Florida (SAFMC, Spiny Lobster)
   h. Hurl Rocks (South Carolina), The Phragmatopoma (worm reefs) off central east coast of Florida, nearshore (0-4 meters; 0-12 feet) hard bottom off the east coast of Florida from Cape Canaveral top Broward County); offshore (5-30 meters; 15-90 feet) hard bottom off the east coast of Florida from Palm Beach County to Fowey Rocks; Biscayne Bay, Florida; Biscayne National Park, Florida; and the Florida Keys National Marine Sanctuary (SAFMC, Coral, Coral Reefs and Live hard Bottom Habitat).
   i. EFH-HAPCs designated for HMS species (e.g., sharks) in the South Atlantic region (NOAA Fisheries Service, Highly Migratory Species).

10. Habitats likely to be affected by projects which alter hydrologic regimes include many recognized in state level fishery management plans. Examples of these habitats include Critical Habitat Areas established by the North Carolina Marine Fisheries Commission, either in FMPs or in Coastal Habitat Protection Plans.

Threats to Marine and Estuarine Resources from Hydrologically-Altering Activities

The SAFMC finds that activities which alter normative hydrologic regimes of rivers, estuaries, inlets and nearshore oceanic habitats threaten or potentially threaten EFH through the following mechanisms:

1. Direct mortality of organisms at withdrawal points through hydrologic regimes

In addition, the interactions between cumulative and direct (sub-lethal) effects among the above factors certainly trigger non-linear impacts that are completely unstudied.

SAFMC Policies for Flow-altering Projects

The SAFMC establishes the following general policies related projects resulting in hydrologic alterations, to clarify and augment the general policies already adopted in the Habitat Plan and Comprehensive Habitat Amendment (SAFMC 1998a; SAFMC 1998b):

1. Projects should avoid, minimize and where possible offset damage to EFH and EFH-HAPCs.
2. Projects requiring expanded EFH consultation should provide detailed analyses of possible impacts to each type of EFH, with careful and detailed analyses of possible impacts to EFH-HAPCs and state Critical Habitat Areas (CHAs), including short and long term, and population and ecosystem scale effects. Agencies with oversight authority should require expanded EFH consultation.
3. Projects requiring expanded EFH consultation should provide a full range of alternatives, along with assessments of the relative impacts of each on each type of EFH, HAPC and CHAs.
4. Projects should avoid impacts on EFH, HAPCs and CHAs that are shown to be avoidable through the alternatives analysis, and minimize impacts that are not.
5. Projects should include assessments of potential unavoidable damage to EFH and other marine resources, using conservative assumptions.
6. Projects should be conditioned on the avoidance of avoidable impacts, and should include compensatory mitigation for all reasonably predictable impacts to EFH, taking into account uncertainty about these effects. Mitigation should be local, up-front and in-kind, and should be adequately monitored, wherever possible.
7. Projects should include baseline and project-related monitoring adequate to document pre-project conditions and impacts of the projects on EFH.
8. All assessments should be based upon the best available science, and be appropriately conservative so follow and precautionary principles as developed for various federal and state policies.
9. All assessments should take into account the cumulative impacts associated with other projects in the same southeast watershed.

References

SAFMC. 1998a. Final habitat plan for the South Atlantic region: Essential Fish Habitat requirements for fishery management plans of the South Atlantic Fishery Management Council. 457 pp plus appendices.

SAFMC. 1998b. Final Comprehensive Amendment Addressing Essential Fish Habitat in Fishery Management Plans of the South Atlantic Region. Including a Final Environmental Impact Statement /Supplemental Environmental Impact Statement, Initial Regulatory Flexibility Analysis, Regulatory Impact Review, and Social Impact

Assessment/Fishery Impact Statement. South Atlantic Fishery Management Council, 1 Southpark Cir., Ste 306, Charleston, S.C. 29407-4699. 136pp.

7.4.2.5 Policies for the Protection and Restoration of EFH from Marine Aquaculture

Policy Context

This document establishes the policies of the South Atlantic Fishery Management Council (SAFMC) regarding protection of Essential Fish Habitat (EFH) and Essential Fish Habitat - Habitat Areas of Particular Concern (EFH-HAPCs) from potential impacts associated with marine aquaculture. The policies are designed to be consistent with the overall habitat protection policies of the SAFMC as formulated in the Habitat Plan (SAFMC 1998a) and adopted in the Comprehensive EFH Amendment (SAFMC 1998b) and the various Fishery Management Plans (FMPs) of the Council.

The findings presented below assess potential impacts, negative and positive to EFH and EFH-HAPCs posed by activities related to marine aquaculture in offshore and coastal waters, riverine systems and adjacent wetland habitats, and the processes which could place those resources at risk. The policies and recommendations established in this document are designed to avoid, minimize, and offset potential impacts from these activities, in accordance with the general habitat policies of the SAFMC as mandated by law. To address any future marine aquaculture projects in the South Atlantic region, or as legislation is developed to provide additional guidelines, the SAFMC will revise this policy when more information becomes available.

The recommendations presented here should be applied to aquaculture facilities in reasonable proximity to EFH and EFH-HAPCs, however managed. Current laws, regulations and policies differ for offshore aquaculture, and for aquaculture activities in nearshore and inshore waters managed by the various states. As the federal FMPs in the region are amended to address offshore aquaculture as "fishing" activities, then these recommendations should be factored into those FMPs. Where aquaculture remains outside federal FMP-based management, then EFH protection mechanisms for "non-fishing" activities should be used to protect EFH, wherever possible.

EFH Potentially At Risk from Marine Aquaculture Activities

The SAFMC finds that:

EFH Potentially At Risk from Marine Aquaculture Activities

The SAFMC finds that:

1. Properly sited, designed and managed marine aquaculture operations can have beneficial economic and environmental outcomes. However, marine aquaculture activities or associated support facilities can have the potential to cause adverse impacts to a variety of habitats across the shelf and to nearshore systems including:

    a) waters and benthic habitats in or near marine aquaculture sites,

b) exposed hardbottom (e.g., reefs and live bottom) in shallow and deep waters,
c) submerged aquatic vegetation beds,
d) shellfish beds,
e) spawning and nursery areas,
f) coastal wetlands, and
g) riverine systems and associated wetlands.

2. Certain offshore, nearshore and riverine habitats are particularly important to the long-term viability of commercial and recreational fisheries under SAFMC management, and are potentially threatened by marine offshore aquaculture activities, including:

   a) coral, coral reef and live/hardbottom habitat, including deepwater coral communities;
   b) marine and estuarine waters;
   c) estuarine wetlands, including mangroves and marshes;
   d) submerged aquatic vegetation;
   e) waters that support diadromous fishes, and their spawning and nursery habitats; and
   f) waters hydrologically and ecologically connected to waters that support EFH.

3. Construction and operation of poorly sited and/or designed aquaculture support facilities could adversely impact wetlands, other EFH and protected species' habitats.

4. Sections of South Atlantic waters potentially affected by these projects, both individually and collectively, have been identified as EFH or EFH-HAPC by the SAFMC. Potentially affected species and their EFH under federal management include (SAFMC, 1998b):

   a) summer flounder (various nearshore waters; certain offshore waters);
   b) bluefish (various nearshore waters);
   c) red drum (unconsolidated bottoms in the nearshore);
   d) many snapper and grouper species (live hardbottom from shore to 600 feet, and – for estuarine-dependent species (e.g., gag grouper and gray snapper) – unconsolidated bottoms and live hardbottoms to the 100 foot contour);
   e) black sea bass (various nearshore waters, including unconsolidated bottom and live/hardbottom to 100 feet, and hardbottoms to 600 feet);
   f) penaeid shrimp (offshore habitats used for spawning and growth to maturity, and waters connecting to inshore nursery areas);
   g) coastal migratory pelagics (e.g., king mackerel, Spanish mackerel) (sandy shoals of capes and bars, barrier island ocean-side waters from the surf zone to the shelf break inshore of the Gulf Stream);

h) corals of various types and associated organisms (on hard substrates in shallow, midshelf, and deep water);
i) muddy, silt bottoms from the subtidal to the shelf break, deepwater corals and associated communities; and
j) areas identified as EFH for Highly Migratory Species managed by the Secretary of Commerce (e.g., sharks: inlets and nearshore waters, including pupping and nursery grounds).

5. Many of the habitats potentially affected by these activities have been identified as EFH-HAPCs by the SAFMC. Each habitat and FMP is provided as follows:

a) all hardbottom areas (SAFMC snapper grouper);
b) nearshore spawning and nursery sites (SAFMC penaeid shrimps and red drum);
c) benthic Sargassum (SAFMC snapper grouper);
d) from shore to the ends of the sandy shoals of Cape Lookout, Cape Fear, and Cape Hatteras, North Carolina; Hurl Rocks, South Carolina; and Phragmatopoma (worm reefs) reefs off the central coast of Florida and near shore hardbottom south of Cape Canaveral (SAFMC coastal migratory pelagics);
e) Hurl Rocks (South Carolina); the Phragmatopoma (worm reefs) off central east coast of Florida; nearshore (0-4 meters; 0-12 feet) hardbottom off the east coast of Florida from Cape Canaveral to Broward County; offshore (5-30 meters; 15-90 feet) hardbottom off the east coast of Florida from Palm Beach County to Fowey Rocks; Biscayne Bay, Florida; Biscayne National Park, Florida; and the Florida Keys National Marine Sanctuary (SAFMC Coral, Coral Reefs and Live Hardbottom Habitat);
f) EFH-HAPCs designated for HMS species (e.g., sharks) in the South Atlantic region (NOAA Fisheries Service Highly Migratory Species);
g) Oculina Bank HAPC and proposed deepwater coral HAPCs (SAFMC Coral, Coral Reefs and Live Hardbottom Habitat); and
h) HAPCs for diadromous species adopted by the Atlantic States Marine Fisheries Commission (ASMFC).

6. Habitats likely to be affected by marine aquaculture activities include many recognized in state-level fishery management plans and interstate fishery management plans of the ASMFC. Examples of these habitats include state-designated Critical Habitat Areas (CHAs) or Strategic Habitat Areas (SHAs) established by the North Carolina Marine Fisheries Commission, either in FMPs or in Coastal Habitat Protection Plans. Many state-managed and interstate-managed species serve as key prey for SAFMC-managed species.

7. Scientists have documented exceptionally important habitat values for East coast Florida nearshore hardbottom used by over 500 species of fishes and invertebrates, including juveniles of many reef fishes. Equivalent scientific work

is just beginning in other South Atlantic states, but life histories suggest that similar habitat use patterns will be found.

Threats to EFH from Marine Aquaculture Activities

Aquaculture-related development without adequate safeguards may threaten wild stocks and the habitats that support them. The future of some aquaculture sectors is inextricably intertwined with fisheries and the health of marine ecosystems. Some coastal forms of aquaculture are known to degrade marine ecosystems, and may result in a net loss of fish. Finfish netpens in offshore waters may pose risks similar to netpens in inshore waters, where several potential environmental issues have been documented (summarized in Naylor et al. 2000; and Nash, ed. 2005).

Experimental or small-scale commercial fish farms are unlikely to have major environmental effects. However, if marine aquaculture booms, and becomes a major means of food production, the potential impacts on marine ecosystems and wild fisheries – and the communities that depend upon them – could be significant. An analysis of the potential cumulative impacts of aquaculture development in the southeast region is essential prior to any large-scale expansion, onshore or offshore.

<u>The SAFMC finds the following to constitute potential threats to EFH:</u>

1) Escapement: Ecological damage caused by escaped organisms has been documented, including the introduction of non-native species, and reduced fitness of wild stocks as a result of interbreeding with escapees of the same species. The likelihood of escapes from farms may be high, if cages are sited in storm-prone areas, either offshore on nearshore.

Moreover, species potentially targeted for offshore or nearshore production may spawn in netpens. Ocean fish cages are incapable of containing fish eggs. The impacts of fertilized egg releases on the health of wild fisheries could be significant if farmed fish are genetically less well adapted to the ocean environment, as a result of selective breeding, genetic engineering, or simply because animals being farmed were taken from a geographic area with different ecological conditions

2) Spread of pathogens and use of antibiotics and other drugs: Concentration of large numbers of animals in a small area can facilitate outbreaks of disease and parasites, potentially jeopardizing wild stocks. Disease and parasite outbreaks can also lead producers to administer antibiotics and other drugs, usually via feed. Drugs can end up in marine ecosystems where they can select for resistant bacteria, sometimes in species targeted by fisheries (Ervik et al. 1994). Note that the U.S. Food and Drug Administration regulates the use of drugs in aquaculture and there are only a very few drugs approved for controlled and limited use.

3) Water pollution: Concentrated animal production operations use substantial amounts of feeds. Even very efficient operations may lose a portion of the nutrients in feeds through uneaten food and through oxygen-demanding wastes, which are transmitted to surrounding waters.

Nitrogen is the nutrient primarily responsible for eutrophication in marine waters in the U.S. southeast, resulting in algal blooms and deoxygenation. In inshore waters, both nitrogen and phosphorus are nutrients of concern.

Nutrient impacts can be considerable in oligotrophic oceanic systems at levels significantly below those used as benchmarks for pollution in inshore and estuarine waters. The importance of the surface microlayer to larval ecology and its vulnerability to perturbations from airborne or locally-sourced excess nutrients cannot be overstated. Standards and criteria for nutrient-related water quality impacts on these oceanic ecological functions do not yet exist, and compliance with state-based water quality standards and national water quality criteria for nutrients may not prevent loading-based impacts.

Fish farms may cluster geographically near infrastructure such as processing plants and transportation, like terrestrial hog farms, concentrating potential impacts. However, widely-spaced marine farms sited in areas with strong currents and strong mixing would have less localized impact.

Finally, other feed additives, including metals and persistent organic pollutants, may contribute to longer-term bioaccumulation.

SAFMC Policies for Marine Aquaculture Projects

The SAFMC establishes the following general policies related to marine aquaculture projects, to clarify and augment the general policies already adopted in the Habitat Plan and Comprehensive Habitat Amendment (SAFMC 1998a; SAFMC 1998b):

1. The Council strongly supports thorough public review and effective regulation of marine aquaculture activities in the South Atlantic EEZ. South Atlantic fisheries are exceptionally dependent upon healthy habitat already under attack from many sources.

2. Permits should be for at least a ten-year duration with annual reporting requirements (activity reports) and a five-year comprehensive operational review with the option for revocation at any time in the event there is no prolonged activity or there are documented adverse impacts to marine resources. Given the changes underway in coastal ecosystems in response to storm events, rising seas and introduced species, such a review cycle is essential.

3. Environmental review and performance expectation are paramount. This is a new and totally optional class of private uses being imposed on already at-risk ecosystems where unacceptable ecological cascades could occur. The Council is

committed to ensuring that marine aquaculture activities are held to the same level of EFH conservation protections as are other non-fishing[*] activities.

4. The Council approves of use of therapeutic agents and feed additives that have been approved by the FDA specifically for use in offshore open-water or net pen aquaculture.

5. The use of genetically modified and non-native species should be prohibited.

6. Given the critical nature of proper siting, the applicant should provide all needed information to evaluate in full the suitability of potential sites. If sufficient information is not provided in the application review time allotted by existing processes, the permit should be denied or held in abeyance until required information is available.

7. Monitoring plans should be developed by the applicant/permit holder and approved by NOAA Fisheries Service with input from the Council. Monitoring plans should be reviewed, approved, and funded prior to implementation.

8. Permitees must have adequate resources legally committed to ensure proper decommissioning of obsolete or storm-damaged facilities.

9. The issuing agency should have clear authority to repeal or condition permits in order to prevent environmental damage and exercise its authority to repeal permits if it becomes evident that environmental damage is occurring or if permit conditions are not met.

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[*] The reference to non-fishing activities is meant to clarify that the Council's role is to comment on aquaculture activities similar to process the Council uses for non-fishing activities. The MSA currently defines aquaculture as a fishing activity. However, the proposed Aquaculture Bill would remove aquaculture as a fishing activity. The Council applies the same EFH standards to both fishing and non-fishing impacts.

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7.4.3 Activity-based Policies

(Source: the Habitat Plan SAFMC, 1998a)

7.4.3.1 Docks and Piers

Docks and piers, whether built over or floating on the water, are generally acceptable methods of gaining access to deep water. General considerations include:

1. Docks and piers should be constructed so that waterflow restriction and blockage of sunlight on wetland surfaces is avoided or minimized;

2. Docks and piers should be of adequate length to reach navigational depths without increasing dredging needs; and

3. Docks and piers should be designed and located to avoid areas that support submerged aquatic vegetation, shellfish beds and harvest areas, and other fragile and productive habitats.

7.4.3.2 Boat Ramps

1. Sites should be located along shorelines that do not support wetland vegetation and where adjacent waters have adequate navigational depths. Acceptable sites may include existing marinas; bridge approaches and causeways (with highway agency approval) where construction access channels exist; and natural and previously created deep water habitats;

2. Preferably, sites should be restricted to areas that do not require dredging to gain access to navigable waters. When located in the vicinity of seagrass beds, adequate navigation channels must exist and should be clearly marked. Boat ramps should not be located in areas where boats will encroach on sensitive and productive habitats;

3. Ramps should not be located in areas where encroachment into wetlands is likely to occur. Sites should contain adequate upland area for parking and for boat launching/removal; and

4. Adequate waste collection facilities should be required at public facilities.

7.4.3.3 Marinas

All marinas adversely affect aquatic habitats to some degree. These effects can be minimized through proper location and design. In addition to applicable recommendations for boat ramps, bulkheads, and seawalls, the following apply:

1. Marinas should be located in areas where suitable physical conditions exist. For example, potential sites should be located close to navigable waters and in locations where marina-related activities would not affect living marine resource forage, cover, harvest, and/or nursery habitats. Attention also should be given to sediment deposition rates and maintenance dredging requirements;

2. Marinas should be located at least 1,000 feet from shellfish harvest areas, unless state regulations or other considerations specify differently;

3. Dry-stack storage is generally preferable to wet mooring of boats. Open dockage extending into deep water is generally preferable to basin excavation;

4. Mooring basins should be sited in uplands rather than wetlands, and they should be designed so that water quality degradation does not occur. This may require consideration of basin flushing characteristics and incorporation of other design features such as surface and waste water collection and treatment facilities;

5. Turning basins and navigation channels should not create sumps and other slack-water areas that could degrade water quality nor should they be located in areas where circulation is poor. Depths generally should not exceed those of adjoining waters and, where practicable, they should provide for light penetration that is capable of sustaining benthic plant life. Dissolved oxygen levels in channels and basins should be adequate for fish and macroinvertebrate survival;

6. Consideration should be given to aligning access channels and configuring marinas to take full advantage of circulation from prevailing summer winds;

7. Permanent dredged material disposal sites (for use in initial and maintenance dredging) that do not impact wetland areas should be identified and acquired. Suitable disposal alternatives include placing dredged material on uplands, and using dredged material to create/restore wetlands. Projects that lack permanent disposal sites should not be authorized if maintenance dredging is needed and disposal sites/options are not available;

8. Catchment basins for collecting and storing surface runoff should be included as components of the site development plan. Marine railways or upland repair facilities should be equipped with hazardous material containment facilities so that biocides such as marine paints, oil and grease, solvents, and related materials are not directly or indirectly discharged into coastal waters and wetlands;

9. Consideration should be given to parking and other support facilities when it appears that available uplands are not adequate to support such needs and wetland encroachment is anticipated;

10. Marinas with fueling facilities should be designed to include practical measures for reducing oil and gas spillage into the aquatic environment. Spill control plans may be needed when marina facilities are to be located in the vicinity of large, emergent wetland areas, shellfish harvest sites, and other fragile/productive aquatic sites; and

11. Facilities for collection of trash and potential marine debris should be required. Where vessels with marine toilets will be moored, pump out facilities and notices regarding prohibition of sewage and other discharges should be provided.

7.4.3.4 Bulkheads and Seawalls

Bulkheads are used to protect adjacent shorelines from wave and current action and to enhance water access. Applications for bulkheads usually specify construction in open water followed by placing fill material behind the structure. Bulkheads may adversely impact wetlands through direct filling; through isolation; and through exacerbation of wave scour. Adverse impacts may be reduced by applying the following criteria:

1. Except in cases of recent and rapid erosion, structures should be aligned at or shoreward of the normal high waterline. Structures should be constructed so that reflective wave energy does not scour or otherwise adversely affect adjacent EFH or wetlands. For example, in areas that support fringing wetlands consideration should be given to the use of breakwaters (with regular openings -- see item 3 below) or placement of riprap at the toe of the bulkhead or along the waterward edge of eroding wetlands;

2. Where possible, sloping (3:1) riprap, gabions, or vegetation should be used rather than vertical seawalls; and

3. Shoreline protection devices that are located in areas having fringe wetlands should have openings that allow for fish ingress and egress and water circulation. Recommended spacing for structure openings is no less than one linear foot per five linear feet of structure.

7.4.3.5 Cables, Pipelines, and Transmission Lines

Wetland excavation is sometimes required for installing submerged cables, pipelines, and transmission lines. Construction also may require temporary or permanent wetlands filling. The following recommendations apply:

1. Wetland crossings should be aligned along the least environmentally damaging route. Submerged aquatic vegetation, shellfish beds, coral reefs, etc., must be avoided;

2. Construction of permanent access channels should be avoided since they disrupt natural drainage patterns and destroy wetlands through direct excavation, filling, and bank erosion. The push-ditch method, in which the trench is immediately backfilled, reduces the impact duration;

3. Excavated wetlands should be backfilled with either the same material as removed or a comparable material that is capable of supporting suitable replacement wetlands. Original marsh elevations should be restored and, where practicable, excavated vegetation should be stockpiled, kept viable, and returned to the excavated site. After backfilling, erosion protection measures should be implemented where needed to prevent fish habitat degradation and loss;

4. Excavated materials should be stored on uplands. If storage in wetlands cannot be avoided, discontinuous stock-piles should be used to allow continuation of sheet flow. Where practicable, stockpiled materials should be stored on construction cloth rather than bare marsh surfaces. Topsoil and organic surface material such as root mats should be stockpiled separately and returned to the surface of the restored site;

5. In open-water areas, excavated materials should be deposited in discontinuous piles to preclude significant blockage of water movement. Back-filling is recommended if the excavated material would alter circulation patterns or interfere with fishing;

6. Use of existing rights-of-way should be recommended when use of these areas would lessen overall wetland encroachment and disturbance; and

7. Directional drilling, a technique that allows horizontal, sub-surface, placement of pipelines should be used in situations where normal trenching and backfill would cause unacceptable levels of habitat loss or alteration.

7.4.3.6 Transportation

State and federal highway agencies generally have the capability of conducting advanced planning with road, causeway, and bridge construction. To the extent possible, NOAA Fisheries Service Branch Office and USFWS personnel should participate in early planning efforts. Since highway projects are generally considered to be in the public interest and frequently require wetland crossings, identification of mitigation needs, and development of suitable mitigation plans should be undertaken early in the planning process. The following criteria should be considered:

1. Transportation corridors/facilities should avoid wetlands. Where wetland crossings cannot be avoided, bridging should be used rather than filling, and the least environmentally damaging route, preferably along existing rights-of-way and road beds, should be followed;

2. Disrupting or reducing fish and invertebrate migration routes should be avoided. In areas that support or could support anadromous fish migrations, low, narrow, and/or dark passageways such as culverts and small bridges should not be utilized unless aligned and designed so that elimination of or significant reductions in fish migrations do not occur;

3. Structures should be designed to prevent shoaling and alteration of natural water circulation. Suitable erosion control and vegetation restoration should be implemented at wetland crossings; and

4. Transportation facilities should be designed to accommodate other public utilities, thus avoiding the need for additional wetland alteration. An example would be using bridges to support transmission lines and pipelines.

7.4.3.7 Navigation Channels and Boat Access Canals

Construction and maintenance of navigation channels and boat access canals may cause severe environmental harm. In addition to direct habitat losses associated with wetland and deepwater excavation and filling, these activities may significantly modify salinity and water circulation patterns. These changes could greatly modify the distribution and abundance of living marine resources. The following criteria should be followed:

1. Where possible, dredging should be minimized through the use of natural and existing channels;

2. Alignments should avoid sensitive habitats such as shellfish beds, finfish and invertebrate nurseries, submerged aquatic vegetation, and emergent wetlands;

3. Permanent dredged material disposal sites should be located in non-wetland areas. Where long-term maintenance excavation is anticipated, disposal sites should be acquired and maintained for the entire project life;

4. Boat access canals should be designed to ensure adequate flushing and should be uniform in depth or made progressively deeper in the direction of receiving waters. Where possible, they should be aligned to take advantage of wind and lunar tides;

5. Construction techniques that minimize turbidity and dispersal of dredged materials into sensitive wetland areas (e.g., submerged grasses and shellfish beds) are encouraged. Work should be scheduled to avoid periods of high biological activity such as fish and invertebrate migration and spawning;

6. Care should be taken to avoid adverse alteration of tidal circulation patterns, salinity regimes, or other factors that influence local ecological and environmental conditions;

7. Channels and access canals should not be constructed in areas known to have high sediment contaminant levels. If construction must occur in these areas, consideration should be given to the use of silt curtains or other techniques needed to contain suspended contaminants; and

8. Use of sidecast dredges should be confined to areas such as inlets and open water areas where benthic communities are limited and hopper or pipeline dredging is not possible.

7.4.3.8 Disposal of Dredged Material

Previous and on-going disposal of dredged material is a major contributor to wetland losses in marine and estuarine ecosystems. Recognizing that most navigation channels and access canals require periodic maintenance dredging, it is important that long-range plans be developed and that they provide for mitigation of unavoidable adverse environmental impacts. Implementing the following criteria would minimize adverse impacts associated with most dredged material disposal activities:

1. Dredged material should be viewed as a potentially reusable resource and beneficial uses of these materials should be encouraged. Materials that are suitable for beach replenishment, construction, or other useful purposes should be placed in accessible non-wetland disposal areas;

2. Disposal sites that are located in unprotected coastal areas and adjacent to wetlands are especially susceptible to wind and water erosion. These forces can carry substantial quantities of dredged material into aquatic habitats. If located near wetlands, disposal site surfaces should be stabilized using vegetation or other means to eliminate possible erosion or encroachment onto adjacent wetlands;

3. Dredged material should be placed in contained upland sites or approved open-water locations where adverse impacts to living marine resources are minimal. When placed in open water, dredged material should be used to enhance marine fishery resources. For example, materials could be used to renourish eroding wetlands or to fill previous borrow sites;

4. The capacity of existing disposal areas should be used to the fullest extent possible. This may necessitate increasing the elevation of embankments to augment the holding capacity of the site and applying techniques that render dredged material suitable for export or for use in reestablishing wetland vegetation;

5. Where possible, outfalls should be positioned so that they discharge into the dredged area or other sites that lack biological/ecological significance. When evaluating potential upland disposal sites, the possibility of saltwater intrusion into ground water and surrounding freshwater habitats should be assessed by the construction/regulatory agencies. Groundwater contamination could necessitate

redesign of disposal practices, with subsequent harm to living marine resources; and

6. Toxic and highly organic materials should be disposed in impervious containment basins located on upland. Effluent should be monitored to ensure compliance with state and federal water quality criteria and measures should be incorporated to ensure that surface runoff and leachate from dredged material disposal sites do not enter aquatic ecosystems.

7.4.3.9 Impoundments and Other Water-Level Controls

1. Wetland impoundments:

Thousands of wetland acres are impounded each year in the southeast for purposes such as waterfowl habitat creation, aquaculture, agriculture, flood control, hurricane protection, mosquito control, and control of marsh subsidence and erosion. Projects range in size from minor, such as repair of existing embankments, to large-scale marsh management projects where constructing dikes and water- control structures may affect thousands of wetland acres.

Proposals to impound or control marsh water levels should contain water management plans with sufficient detail to determine the accessibility of impounded areas to marine organisms and the degree to which detrital and nutrient export into adjacent estuarine areas will be affected. Significant adverse impacts can be avoided or minimized with implementation of the following recommendations:

a. Proposals to impound or reimpound previously unimpounded wetlands are unacceptable unless designed to accommodate (1) normal access and wetland use by marine fish and invertebrates and (2) continuation of other biological interaction, such as nutrient exchange, and other similarly important physical and chemical interactions; and

b. Proposals to repair or replace water control structures will be assessed on a case-by-case basis.

2. Watershed Impoundments:

Water-development agencies sometimes propose impounding rivers, bayous, and tributaries for such purposes as flood control or creation of industrial, municipal, and agricultural water supplies. Activities of this type are usually unacceptable because associated alteration of the quality, quantity, and timing of freshwater flow into estuaries may cause large-scale adverse modification or elimination of estuarine and marine habitats. Such actions also may block fish and invertebrate migrations.

7.4.3.10 Drainage Canals and Ditches

Drainage canals may be important components of upland development. Their potential to shunt polluted runoff and fresh water directly into tidal waters requires intermediate connection to retention ponds or wetlands. This allows natural filtration and assimilation of pollutants and dampening of freshwater surges prior to discharge into tidal waters. Recommendations include:

1. Drainage canals that dewater or cause other adverse wetland impacts are unacceptable and should not be built;

2. Drainage canals and ditches from upland development generally should not extend or discharge directly into wetlands;

3. Constructing upland retention ponds and other water management features such as sheet-flow diffusers is encouraged. A retention pond or other pollution elimination/assimilation structure should be required if the effluent contains or may contain materials that are toxic to marsh vegetation or other aquatic life,

4. Excavated materials resulting from canal and retention pond construction should be placed on upland or used to restore wetlands;

5. Proposed drainage plans should be in accordance with comprehensive flood plain management plan(s) and applicants should be encouraged to consult with the EPA and appropriate state agencies to ensure that federal and state water quality standards are met;

6. Locating mosquito control ditches in wetlands should be discouraged. If built, they should be designed so that they do not drain coastal wetlands. They also should be designed to avoid water stagnation, and they should provide access for aquatic organisms that feed on mosquito larvae; and

7. Use of innovative techniques such as rotary ditching, spray dispersal of dredged materials, and open-water marsh management should be encouraged where appropriate.

7.4.3.11 Oil and Gas Exploration and Production

Exploration and production of oil and gas resources in wetlands usually have adverse impacts since excavation and filling are generally required to accommodate access and production needs. In open marine waters, dredging and filling is usually not necessary, but special stipulations are required to minimize adverse impacts to living marine resources. In addition to the above recommendations for navigation channels, access canals, and pipeline installation, the following apply:

1. In coastal wetlands:
    a. Activities should avoid wetland use to the extent practicable. Alternatively, the use of uplands, existing drilling sites and roads, canals, and naturally deep waters should be encouraged. When wetland use is unavoidable, work in unvegetated and disturbed wetlands is generally preferable to work in high quality and undisturbed wetlands;

b. Temporary roadbeds (preferably plank roads) generally should be used instead of canals for access to well sites;

c. Water crossings should be bridged or culverted to prevent alteration of natural drainage patterns;

d. Culverts or similar structures should be installed and maintained at sufficient intervals (never more than 500-feet apart) to prevent blockage of surface drainage or tidal flow;

e. Petroleum products, drilling muds, drill cuttings, produced water, and other toxic substances should not be placed in wetlands;

f. If the well is productive, the drill pad and levees should be reduced to the minimum size necessary to conduct production activities; and

g. Defunct wells and associated equipment should be removed and the area restored to the extent practicable. Upon abandonment of wells in coastal wetlands, the well site, various pits, levees, roads, and work areas should be restored to preproject conditions by restoring natural elevations and planting indigenous vegetation whenever practicable. Abandoned well access canals should generally be plugged at their origin (mouths) to minimize bank erosion and saltwater intrusion, and spoil banks should be graded back into borrow areas or breached at regular intervals to establish hydrological connections.

2. In open estuarine waters:
   a. Activities in estuarine waters should be conducted as follows:

   b. Existing navigable waters already having sufficient width and depth for access to mineral extraction sites should be used to the extent practicable;

   c. Petroleum products, drilling muds, drill cuttings, produced water, and other toxic substances should not be placed in wetlands; and

   d. Defunct equipment and structures should be removed.

3. On the continental shelf:
   a. Activities should be conducted so that petroleum-based substances such as drilling mud, oil residues, produced waters, or other toxic substances are not released into the water or onto the sea floor. The following measures may be recommended with exploration and production activities located close to hard banks and banks containing reef building coral:

b. Drill cuttings should be shunted through a conduit and discharged near the sea floor, or transported ashore or to less sensitive, NOAA Fisheries Service-approved offshore locations. Usually, shunting is effective only when the discharge point is deeper than the site that is to be protected;

c. Drilling and production structures, including pipelines, generally should not be located within one mile of the base of a live reef;

d. All pipelines placed in waters less than 300 feet-deep should be buried to a minimum of three feet beneath the sea floor, where possible. Where this is not possible and in deeper waters where user-conflicts are likely, pipelines should be marked by lighted buoys and/or lighted ranges on platforms to reduce the risk of damage to fishing gear and the pipelines. Pipeline alignments should be located along routes that minimize damage to marine and estuarine habitat. Buried pipelines should be examined periodically for maintenance of adequate earthen cover.

7.4.3.12 Other Mineral Mining/Extraction

1. Proposals for mining mineral resources (sand, gravel, shell, phosphate, etc.) from or within 1,500 feet of exposed shell reefs and vegetated wetlands, and within 1,500 feet of shorelines are unacceptable except when the material is to be used for oyster cultch; and

2. All other proposals will be considered on a case-by-case basis.

7.4.3.13 Sewage Treatment and Disposal

Urbanization and high density development of coastal areas has resulted in a substantial increase in proposals to construct sewage treatment and discharge facilities in coastal wetlands. Since many of these facilities utilize gravity flow systems for movement of waste water and materials, wetlands and other low-lying areas are often targeted as sites for placement of pipelines and treatment facilities. Since pipelines and treatment facilities are not water dependent with regard to positioning, it is not essential that they be placed in wetlands or other fragile coastal habitats. The guidance provided in the Section on "Cables, Pipelines, and Transmission Lines," also applies to sewage collector and discharge pipelines. The following guidance should be considered with other aspects of sewage treatment and discharge:

1. Discharges should be treated to the maximum extent practicable, including implementation of up-to-date methodologies for reducing discharges of biocides (e.g., chlorine) and other toxic substances;

2. Use of land treatment and upland disposal/storage techniques should be implemented where possible. Use of vegetated wetlands as natural filters and pollutant assimilators for large scale discharges should be limited to those

instances where other less damaging alternatives are not available and the overall environmental and ecological suitability of such an action has been demonstrated;

3. Discharging into open ocean waters is generally preferable to discharging into estuarine waters since discharging into estuarine waters is more likely to result in living marine resources contamination and nutrient overloading. Discharge points in coastal waters should be located well away from shellfish beds, seagrass beds, coral reefs, and other similar fragile and productive habitats. Proposals to locate outfalls in coastal waters must be accompanied by hydrographic studies that demonstrate year round dispersal characteristics and provide proof that effluents will not reach or affect fragile and productive habitats.

7.4.3.14 Steam-Electric Plants and Other Facilities Requiring Water for Cooling or Heating

Facilities that require substantial intake and discharge of water, especially heated and chemically-treated discharge water, are generally not suited for construction and operation in estuarine and near-shore marine environments. Major adverse impacts may be caused by impingement of organisms on intake screens; entrainment of organisms in heat-exchange systems or discharge plumes; and through the discharge of toxic materials in discharge waters. Protected Species Branch personnel should be notified of such projects early in the planning process since the operation of steam-electric plants often affects endangered species such as shortnose sturgeon and West Indian manatee. Projects that must be sited in the coastal zone and utilize estuarine and marine waters are subject to the following recommendations:

1. Facilities that rely on surface waters for cooling should not be located in areas such as estuaries, inlets, or small coastal embayments where fishery organisms are concentrated. Discharge points should be located in areas that have low concentrations of living marine resources, or they should incorporate cooling towers that employ sufficient safeguards to ensure against release of blow-down pollutants into the aquatic environment;

2. Intakes should be designed to minimize impingement. Velocity caps that produce horizontal intake/discharge currents should be employed and intake velocities across the intake screen should not exceed 0.5 feet per second;

3. Discharge temperatures (both heated and cooled effluent) should not exceed the thermal tolerance of the majority of the plant and animal species in the receiving body of water;

4. The use of construction materials that may release toxic substances into receiving waters should be minimized. The use of biocides (e.g., chlorine) to prevent fouling should be avoided where possible and least damaging antifouling alternatives should be implemented; and

5. Intake screen mesh should be sized to avoid entrainment of most larval and post-larval marine fishery organisms. Acceptable mesh size is generally in the range of 0.5 mm and rarely exceeds 1.0 mm in estuarine waters or waters that support anadromous fish eggs and larvae.

7.4.3.15 Mariculture/Aquaculture

The culture of estuarine and marine species in coastal areas can reduce or degrade habitats used by native stocks of commercially and recreationally important fisheries. The following criteria should be employed to reduce or eliminate adverse impacts:

1. Facilities should be located on upland. Tidally influenced wetlands should not be enclosed or impounded for mariculture purposes. This includes hatchery and grow-out operations;

2. Water intakes should be designed to avoid entrainment and impingement of native fauna;

3. Water discharge should be treated to avoid contamination of the receiving water, and should be located only in areas having good mixing characteristics;

4. Where cage mariculture operations are undertaken, water depths and circulation patterns should be investigated and should be adequate to preclude the buildup of waste products, excess feed, and chemical agents; and

5. Mariculture sites should be stocked with hatchery-reared organisms only. Non-native species should be certified to be disease free, and project design features that minimize escape or accidental release of cultured species should be required. The rearing of ecologically undesirable species is unacceptable since escape and accidental release of these species is virtually assured.

7.4.3.16 Mitigation

Sections 7.4.3.1 – 7.4.3.15 provide specific guidance for avoiding and reducing adverse impacts to fishery resources and their habitats. Compensatory mitigation is considered in cases where a resource is not unique and irreplaceable and only after a project has been demonstrated to be water-dependent, has no feasible alternative, is clearly in the public interest, and all significant impacts are found to be unavoidable. In all cases, mitigation shall comply with the definition of mitigation that is provided at 40 CFR 1508.20 of the Council on Environmental Quality Recommendations. Those recommendations define mitigation as a sequential process whereby impacts are avoided, minimized, rectified, reduced over time, or are offset through compensation.

Despite increasing use of mitigation to offset wetland and other losses, there are situations (e.g., projects affecting seagrass) where the affected habitats are of such enormous value that the anticipated adverse impacts cannot be offset. In instances involving such unique and irreplaceable resources, mitigation is not acceptable. There is also disagreement over the functional equivalency of created and natural wetlands and it should not be assumed they are equivalent in habitat value.

As a general rule, mitigation that restores previously existing habitats is more desirable and likely to succeed than that which seeks to create new habitat. The numerous impacted wetlands that exist in the southeast provide substantial opportunity for wetlands restoration. Restoration may be relatively simple, such as restoring tidal flows to an impounded wetland area, or more complex such as restoring dredged cuts and disposal areas. Restoration of destroyed emergent and, to a lesser degree, submerged vegetation is a feasible and recognized option when implemented with the services of experienced restoration personnel.

The creation of new wetland habitat involves conversion of uplands or, in some situations, submerged bottom to vegetated wetlands or another desirable habitat such as oyster reef. Generation of wetland habitat should not involve converting one valuable wetland type to another. For example, building emergent wetlands in shallow water is unacceptable unless it can be demonstrated that the site is insignificant with regard to habitat or water quality function(s) or it previously supported wetland vegetation and restoration is desirable in terms of the ecology of the overall hydrological unit (e.g., estuary). Regardless of which option is used (restoration or creation), a ratio of at least two acres of mitigation for each acre of habitat destroyed should be recommended. Four basic considerations involved in the planning for habitat generation are type of habitat to be created, and its location, size, and configuration. Each of these considerations must be applied to the specific ecological setting and in accordance with the following recommendations:

1. Habitat type - As a general rule the created habitat should be vegetatively, functionally, and ecologically comparable to that which is being replaced. For example, a smooth cordgrass marsh should be created if a smooth cordgrass marsh is eliminated. The principal exception would be those cases where a different habitat is shown to be more desirable based on overall ecological considerations.

2. Location - Except in the case of overriding ecological considerations, the new site should be located as near as possible to the site that would be eliminated. In any event, the new site should be in the same estuarine system as the habitat that is being replaced. The replacement wetland should consider physical implications such as shoaling and existing circulation and drainage patterns.

   NOAA Fisheries Service and USFWS consider the overall ecological and environmental implications of its recommendations, including upland impacts. Mitigation that may alleviate impacts to aquatic environments, but cause significant adverse impacts to important upland habitats should be carefully evaluated.

3. Size - The habitat to be restored or created should be at least twice the (areal) size of that which would be destroyed. This requirement is designed to offset differences in productivity and habitat functions that may exist between established project site wetlands and newly developed replacement wetlands. This size difference is also designed to address the possibility that the overall, long-term functional and ecological value of replacement habitats may be less than those of the impacted wetlands at the worksite.

4. Configuration - The configuration of replacement habitats is determined by the ecological setting and physical factors such as existing drainage and circulation patterns. Consideration should be given to maximizing edge habitat and to the needs of desirable biota that may inhabit the site.

   Interest in the use of "mitigation banks" or created/restored wetlands that are intended for use in offsetting anticipated future wetland losses is increasing nationwide. Because of the complexity of developing and administering mitigation banks, guidance concerning their creation is beyond the scope of this document. NOAA Fisheries Service Southeast Region Habitat Conservation Division Branch Office personnel that are participating in such efforts should consult early with other NOAA Fisheries Service office personnel that have undertaken or are involved in such efforts since reliance on existing mitigation banking agreements may be beneficial. Habitat Conservation Division Branch Office personnel also should notify other participating agencies that signatory authority for mitigation bank agreements rests with the Regional Director. In all cases, consideration of mitigation banks should be guided by the principle that no net-loss of wetlands would be incurred.

7.5 Interagency and Interstate Policies

7.5.1 Joint Agency Habitat Statement

The SAFMC has endorsed a "Joint Statement to Conserve Marine, Estuarine, and Riverine Habitat" to promote interagency coordination in the preservation, restoration, and enhancement of fishery habitat. This statement as adopted by state, Federal, and regional bodies concerned over fishery habitat, is presented in Appendix VII of The Fishery Management Plan for Shrimp (SAFMC 1993a).

7.5.2 Atlantic States Marine Fisheries' Commission Seagrass Policy and Implementation Plan

The Atlantic States Marine Fisheries Commission seagrass policy (June 1997) is available at http://www.asmfc.org/publications/habitat/savpolicy.pdf
The Policy is based on a collection of review papers that investigated the ecological value of SAV, its importance to Commission managed species, human impacts to SAV, and its regulation by state agencies. The SAV Policy establishes recommendations for protection and conservation of SAV by emphasizing assessment of SAV resources, protection of existing SAV, SAV restoration, public education, and scientific research.

As directed in the SAV Policy, the Commission developed a document titled *Evaluate Fishing Gear Impacts to Submerged Aquatic Vegetation and Determining Mitigation Strategies* (July 2000). This document is available at http://www.asmfc.org/.

7.6 Federal Habitat Protection Laws, Programs and Policies

(Source: SAFMC Habitat Plan 1998).

The Clean Water Act (CWA) 33 U.S.C. s/s 121 et seq. (1977)

The Clean Water Act is a 1977 amendment to the Federal Water Pollution Control Act of 1972, which set the basic structure for regulating discharges of pollutants to waters of the United States. This law gave EPA the authority to set effluent standards on an industry-by-industry basis (technology-based) and continued the requirements to set water quality standards for all contaminants in surface waters. The CWA makes it unlawful for any person to discharge any pollutant from a point source into navigable waters unless a permit (NPDES) is obtained under the Act. The 1977 amendments focused on toxic pollutants. In 1987, the CWA was reauthorized and again focused on toxic substances, authorized citizen suit provisions, and funded sewage treatment plants (POTWs) under the Construction Grants Program. The CWA provides for the delegation by EPA of many permitting, administrative, and enforcement aspects of the law to state governments. In states with the authority to implement CWA programs, EPA still retains oversight responsibilities.

The Comprehensive Environmental Response, Compensation and Liability Act (CERCLA or Superfund) 42 U.S.C. s/s 9601 et seq. (1980)

CERCLA (pronounced SERK-la) provides a federal "Superfund" to clean up uncontrolled or abandoned hazardous waste sites as well as accidents, spills, and other emergency releases of pollutants and contaminants into the environment. Through the Act, EPA was given power to seek out those parties responsible for any release and assure their cooperation in the cleanup. EPA cleans up orphan sites when potentially responsible parties (PRPs) cannot be identified or located, or when they fail to act. Through various enforcement tools, EPA obtains private party cleanup through orders, consent decrees, and other small party settlements. EPA also recovers costs from financially viable individuals and companies once a response action has been completed. EPA is authorized to implement the Act in all 50 states and U.S. territories. Superfund site identification, monitoring, and response activities in states are coordinated through the state environmental protection or waste management agencies.

The Emergency Planning and Community Right-to-know Act (EPCRA) 42 U.S.C. 11011 et seq. (1986)

Also known as Title III of SARA, EPCRA was enacted by Congress as the national legislation on community safety. This law was designed to help local communities protect public health, safety, and the environment from chemical hazards. To implement EPCRA, Congress required each state to appoint a State Emergency Response Commission (SERC). The SERCs were required to divide their states into Emergency

Planning Districts and to name a Local Emergency Planning Committee (LEPC) for each district. Broad representation by fire fighters, health officials, government and media representatives, community groups, industrial facilities, and emergency managers ensures that all necessary elements of the planning process are represented.

The Endangered Species Act 7 U.S.C. 136; 16 U.S.C. 460 et seq. (1973)
The Endangered Species Act provides a program for the conservation of threatened and endangered plants and animals and the habitats in which they are found. The U.S. Fish and Wildlife Service (FWS) of the Department of Interior maintains the list of 632 endangered species (326 are plants) and 190 threatened species (78 are plants). Species include birds, insects, fish, reptiles, mammals, crustaceans, flowers, grasses, and trees. Anyone can petition FWS to include a species on this list or to prevent some activity, such as logging, mining, or dam building. The law prohibits any action, administrative or real, that results in a "taking" of a listed species, or adversely affects habitat. Likewise, import, export, interstate, and foreign commerce of listed species are all prohibited. EPA's decision to register a pesticide is based in part on the risk of adverse effects on endangered species as well as environmental fate (how a pesticide will affect habitat). Under FIFRA (see below), EPA can issue emergency suspensions of certain pesticides to cancel or restrict their use if an endangered species will be adversely affected. Under a new program, EPA, FWS, and USDA are distributing hundreds of county bulletins which include habitat maps, pesticide use limitations, and other actions required to protect listed species. In addition, we are enforcing regulations under various treaties, including the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). The U.S. and 70 other nations have established procedures to regulate the import and export of imperiled species and their habitat. The Fish and Wildlife Service works with U.S. Customs agents to stop the illegal trade of species, including the Black Rhino, African elephants, tropical birds and fish, orchids, and various corals.

The Federal Insecticide, Fungicide and Rodenticide act (FIFRA) 7 U.S.C. s/s 135 et seq. (1972)
The primary focus of FIFRA was to provide federal control of pesticide distribution, sale, and use. EPA was given authority under FIFRA not only to study the consequences of pesticide usage but also to require users (farmers, utility companies, and others) to register when purchasing pesticides. Through later amendments to the law, users also must take exams for certification as applicators of pesticides. All pesticides used in the U.S. must be registered (licensed) by EPA. Registration assures that pesticides will be properly labeled and that, if used in accordance with specifications, will not cause unreasonable harm to the environment.

The (Federal) Freedom of Information Act (FOIA) U.S.C. s/s 552 (1966)
The Freedom of Information Act provides specifically that "any person" can make requests for government information. Citizens who make requests are not required to identify themselves or explain why they want the information they have requested. The position of Congress in passing FOIA was that the workings of government are "for and by the people" and that the benefits of government information should be made available to everyone. All branches of the federal government must adhere to the provisions of

FOIA with certain restrictions for work in progress (early drafts), enforcement confidential information, classified documents, and national security information.

The National Environmental Policy Act (NEPA) 42 U.S.C. s/s 4321 et seq. (1969)
The National Environmental Policy Act was one of the first laws ever written that establishes the broad national framework for protecting our environment. NEPA's basic policy is to assure that all branches of government give proper consideration to the environment prior to undertaking any major federal action which significantly affects the environment. NEPA requirements are invoked when airports, buildings, military complexes, highways, parkland purchases, and other such federal activities are proposed. Environmental Assessments (EAs) and Environmental Impact Statements (EISs), which are assessments of the likelihood of impacts from alternative courses of action, are required from all federal agencies and are the most visible NEPA requirements.

The Occupational Safety and Health Act 29 U.S.C. 61 et seq. (1970)
Congress passed the Occupational and Safety Health Act to ensure worker and workplace safety. Their goal was to make sure employers provide their workers a place of employment free from recognized hazards to safety and health, such as exposure to toxic chemicals, excessive noise levels, mechanical dangers, heat or cold stress, or unsanitary conditions. In order to establish standards for workplace health and safety, the Act also created the National Institute for Occupational Safety and Health (NIOSH) as the research institution for the Occupational Safety and Health Administration (OSHA). OSHA is a division of the U.S. Department of Labor which over-sees the administration of the Act and enforces federal standards in all 50 states.

The Pollution Prevention Act 42 U.S.C. 13101 and 13102, s/s 6602 et seq. (1990)
The Pollution Prevention Act focused industry, government, and public attention on reducing the amount of pollution produced through cost-effective changes in production, operation, and raw materials use. Opportunities for source reduction are often not realized because existing regulations, and the industrial resources required for compliance, focus on treatment and disposal. Source reduction is fundamentally different and more desirable than waste management or pollution control. Pollution prevention also includes other practices that increase efficiency in the use of energy, water, or other natural resources, and protect our resource base through conservation. Practices include recycling, source reduction, and sustainable agriculture.

The Resource Conservation and Recovery Act (RCRA) 42 U.S.C. s/s 321 et seq. (1976)
RCRA gave EPA the authority to control hazardous waste from "cradle-to-grave." This includes the generation, transportation, treatment, storage, and disposal of hazardous waste. RCRA also set forth a framework for the management of non-hazardous solid wastes. The 1986 amendments to RCRA enabled EPA to address environmental problems that could result from underground tanks storing petroleum and other hazardous substances. RCRA focuses only on active and future facilities and does not address abandoned or historical sites (see CERCLA).

The 1984 Federal Hazardous and Solid Waste Amendments (HSWA) to RCRA required phasing out land disposal of hazardous waste. Some of the other mandates of this strict law include increased enforcement authority for EPA, more stringent hazardous waste management standards, and a comprehensive underground storage tank program.

The Safe Drinking Water Act (SDWA) 43 U.S.C. s/s 300f et seq. (1974)
The Safe Drinking Water Act was established to protect the quality of drinking water in the U.S. This law focuses on all waters actually or potentially designated for drinking use, whether from above ground or underground sources. The Act authorized EPA to establish safe standards of purity and required all owners or operators of public water systems to comply with primary (health-related) standards. State governments, which assume this power from EPA, also encourage attainment of secondary standards (nuisance-related).

The Superfund Amendments and Reauthorization Act (SARA) 42 U.S.C. 9601 et seq. (1986)
The Superfund Amendments and Reauthorization Act of 1986 reauthorized CERCLA to continue cleanup activities around the country. Several site-specific amendments, definitions, clarifications, and technical requirements were added to the legislation, including additional enforcement authorities. Title III of SARA also authorized the Emergency Planning and Community Right-to-Know Act (EPCRA).

The Toxic Substances Control Act (TSCA) 15 U.S.C. s/s 2601 et seq. (1976)
The Toxic Substances Control Act of 1976 was enacted by Congress to test, regulate, and screen all chemicals produced or imported into the U.S. Many thousands of chemicals and their compounds are developed each year with unknown toxic or dangerous characteristics. To prevent tragic consequences, TSCA requires that any chemical that reaches the consumer market place be tested for possible toxic effects prior to commercial manufacture. Any existing chemical that poses health and environmental hazards is tracked and reported under TSCA. Procedures also are authorized for corrective action under TSCA in cases of cleanup of toxic materials contamination. TSCA supplements other federal statutes, including the Clean Air Act and the Toxic Release Inventory under EPCRA.

7.7 State Habitat Protection Programs

7.7.1 North Carolina

The Coastal Area Management Act was passed in 1974 to protect North Carolina’s fragile coastal resources through planning and management at the state and local level. The Department of Environment, Health and Natural Resources administers the program. Policy direction is provided by the Coastal Resources Commission, a group of citizens appointed by the Governor. The Division of Coastal Management (DCM), under authority from the Coastal Resources Commission (CRC), is responsible for implementing the North Carolina Coastal Management Program for the protection, preservation, orderly development and management of the state's twenty coastal counties. DCM is part of the Department of Environment, Health and Natural Resources. Activities of DCM include: permitting and enforcing regulations in areas of environmental concern; reviewing consistency of government and larger private activities in the coastal zone for compliance with the Coastal Area Management Act; planning for the ocean resources in North Carolina's jurisdictional waters; providing for effective disposal of boat sewage; identifying high priority watersheds; developing strategies for managing secondary and cumulative impacts; Transferring technology and information to local governments; identifying wetlands in the coastal area; assessing the relative significance of wetlands on the landscape; and identifying and prioritizing wetland restoration sites.

7.7.2 South Carolina

The Office of Ocean and Coastal Resource Management implements the Coastal Management Act. The Office has authority to formulate and implement a comprehensive coastal management program and direct control through a permit program that oversees activities in critical areas that include coastal waters, tidelands, beaches, and primary ocean-front sand dunes. Indirect management authority of coastal resources is granted to the Office in counties containing one or more of the critical areas. In issuing permits, the Coastal Management Act requires that the Office consider the effects of proposed alterations on the production of fish, shrimp, oysters, crab, or any marine life, wildlife, or other natural resources.

7.7.3 Georgia

On April 22, 1997, Governor Miller signed the Georgia Coastal Management Act into law which established the Department of Natural Resources Coastal Resource Division as the authority to create the program, receive and dispense funds, and to coordinate with federal and state agencies regarding Coastal Management issues. On January 26, 1998 the Georgia Coastal Management Program received official approval. This approval marked the end of a six year combined effort by state and local government in partnership with private citizens to develop an integrated, networked program. The program uses existing State laws to manage Georgia's critical coastal resources. With the approval of the Georgia Coastal Management Program comes over $1 million in federal funds annually. Most of the funds are allocated to local communities and organizations through the "Coastal Incentive Grant" program. Incentive grants are presented to local governments and universities to address critical local issues in coastal Georgia such as water management, local government planning and small scale construction projects.

7.7.4 Florida

The Florida Legislature adopted the Florida Coastal Management Act in 1978. This act authorized the development of a coastal management program and its submittal to the appropriate federal agency. In 1981, the Florida Coastal Management Program (FCMP) was approved by the Secretary of the United States Department of Commerce. Florida’s goal in creating the FCMP was not to create a new agency or new statutes concerned with coastal issues, but instead to use existing agencies and laws to address Florida’s coastal needs. Florida's rules and laws adequately protected the coast, but were not always effectively implemented because of breakdowns in communication between agencies and administrative shortcomings. The FCMP was created to bridge these gaps and to open the lines of communication among the agencies so that their actions could be coordinated. The FCMP, as it exists today, is a network of ten state agencies and five water management districts using 23 statutes to protect Florida's coastal interests. The agencies most directly involved in issues that affect Essential Fish Habitat are listed below.

The Department of Community Affairs (DCA) is the lead agency for the FCMP, serving as coordinator of coastal issues and as the liaison between the state agencies and the federal government. DCA also houses the State Clearinghouse and serves as the state's land planning agency and emergency management agency.

The Department of Environmental Protection (DEP), formed by the merger of the former Department of Environmental Regulation and the former Department of Natural Resources, serves as the state's chief environmental regulatory agency and the manager and steward of many of its natural resources. Among the natural resources over which the DEP has jurisdiction are submerged lands within state estuarine and marine waters. The Department of Health regulates on-site sewage disposal. The Marine Fisheries Commission exercises jurisdiction over saltwater fisheries and marine mammals. The five water management districts, organized along watershed lines, act in partnership with DEP in regulating activities in wetlands and waters of the state and the use of water resources.

8.0 Fisheries Management Evaluation and Recommendations

8.1 Area Management in the South Atlantic Region

8.1.1 South Atlantic Fishery Management Council

8.1.1.1 SMZs

Since 1983, the Council has allowed the designation of SMZs as an incentive to create artificial reefs and fish attraction devices to increase the numbers of fish in an area and/or create fishing opportunities that would not otherwise exist.

Designation of an area as a SMZ allows for gear restrictions in the area to prevent overexploitation. Many of these areas have been established through cooperation with fishing organizations and local governments and serve as a means to promote localized conservation and positive fishing experiences. A total of 51 SMZs have been designated off South Carolina, Georgia and Florida.

8.1.1.2 MPAs

(Source: Historical Overview of the South Atlantic Fishery Management Council's Marine Protected Areas Related Activities: 1990-2006)

The timeline below summarizes the Council's activities pertaining to the designation of Marine Protected Areas in the South Atlantic region from 1990 through 2006. This timeline highlights the transparency of the process that the Council undertook. For more information, including minutes from meetings and background documentation, please go to www.safmc.net.

1990 - The potential for using marine reserves within the snapper grouper fishery first originated with the Council's Snapper Grouper Plan Development Team (PDT). This technical group prepared a report (April 1990) entitled "The Potential of Marine Fishery Reserves for Reef Fish Management in the U.S. South Atlantic." The Plan Development Team offered this approach because they believed it was the only viable option for maintaining optimum size, age, and genetic structure of slow growing, long-lived species over the long-term. The Council received an extensive briefing on marine reserves at the February 1990 Council meeting. This provided an opportunity for the Council to discuss marine reserves as a concept and to hear about experiences with marine reserves in other parts of the world.

1992 - Marine reserves were initially considered as a possible option in early discussions on Amendment 4 to the Snapper Grouper Fishery Management Plan, however the Council determined the reserve concept should be addressed separately and scheduled scoping meetings in each of the states. During 1992 the Council held scoping meetings. Scoping meetings are less formal than public hearings and occur prior to the Council taking any position on a management issue. When the Council is considering the need for management, scoping meetings provide an opportunity for members of the public to make suggestions BEFORE the Council has made any decisions.

1993 - During the 1992 scoping process support for and against the concept surfaced. The Council reviewed the scoping information at the January 1993 meeting and decided to (1) recommend to National Marine Fisheries Service that they convene a Scientific Review Panel to review the concept of Marine Reserves and (2) drop consideration of the marine reserve concept at that time.

1994 - The previously designated Oculina Bank Habitat Area of Particular Concern (HAPC) off Ft. Pierce in eastern-central Florida was declared the Experimental Oculina Research Reserve (EORR). This area, measuring 4 x 23 nautical miles with depths between 30 and 75 fathoms, was closed to bottom fishing for a period of 10 years to allow for scientific studies in a closed area. The 10 year "sunset" was specified to ensure establishment of a proper research and evaluation program. In 1995, the closure was extended to include all anchoring within the boundaries of the experimental closed area. The area was closed to bottom fishing to enhance stock stability and increase recruitment by providing an area where deep water species (snowy grouper, golden tilefish, speckled hind and Warsaw, misty and yellowedge groupers) can grow and reproduce without being subjected to fishing mortality. Virtually any level of fishing mortality results in a large reduction in numbers of males and an altered size, age, and genetic structure. This effect is magnified when fishing in areas where these groupers gather for spawning.

Such spawning aggregations have been observed in the Oculina Habitat Area of Particular Concern.

1995 - A scientific review of the 1990 Snapper Grouper Plan Development Team report was completed by the Scientific Review Panel as requested by the Council. The panel consisted of international experts with different experience in fishery science, marine reserves, ecology, fish genetics, sociology, and economics.

The Scientific Review Panel concluded that properly designed marine reserves in combination with other management measures can be an effective management tool for reef fish resources in the U.S. South Atlantic region subject to the following conditions: (a) biological, ecological, social, and economic objectives of the reserves are clearly specified; (b) the relative biological, ecological, and economic impacts of reserves in the context of other fishery management measures have been estimated for various constituents; and (c) the development of marine reserve proposals proceed with the involvement of all constituencies and stakeholders.

Also the scientific review panel concluded that recognizing the alarming declines in stocks of key fishery species, the panel would urge that reserve options be considered immediately as part of a comprehensive fisheries management plan to prevent irreversible loss to species and fisheries.

1997 - In further developing Snapper Grouper Amendment 8 (and later Amendment 9), the Council realized that severe impacts would be felt by fishermen if necessary percentage reductions in catches of overfished species were imposed to achieve the mandated fishery management goals. Marine reserves once again surfaced as a potential alternative to fisheries closures.

Also in 1997 the Council accepted portions of the final Management Plan for the Florida Keys National Marine Sanctuary that designated one larger reserve that extended into the Council's jurisdiction and 12 small "preservation areas" that also function as marine reserves. These areas are being evaluated and will be reexamined at a five year review.

1998 - After deciding to reconsider the possibilities of marine reserves, the Council proceeded to take steps to initiate a fact-finding process using the Marine Reserves Committee and the Advisory Panel.

1999 - In May,, the Marine Reserves Advisory Panel unanimously passed a motion confirming that the Panel believes there is potential in using marine reserves as a fishery management tool.

2000 - The Council then laid out a deliberative process by which they would determine if marine protected areas were a tool that they should use to manage fisheries in the South Atlantic. This process included a series of informal meetings that Council members and staff attended in the spring of 2000. Any organizations that requested to could have a Council member and/or staff member come and talk with them about the potential use of marine protected areas. It was the Council's intent to begin a dialogue with stakeholders on ways to solve the overfishing problems in the South Atlantic Snapper Grouper Fishery and to ask the public if they thought marine protected areas may be one answer to a complex problem.

The stakeholders voiced many different opinions on the use of marine protected areas. There was an equal amount of support and opposition for no-take marine protected areas, but many variations were offered from all sides. Many groups were in support of protecting known spawning areas from fishing, and creating artificial habitats and prohibiting fishing in these areas. The responses the Council heard from the more formal scoping meetings they held later in the spring of 2000 were similar.

In September 2000, after reviewing comments received from the informal meetings and scoping meetings, the Council voted to move forward with the use of marine protected areas.

2001 through 2003 - In the Spring of 2001 the Council held a final round of nine scoping meetings. The public was provided charts that showed known hardbottom areas off the South Atlantic coast and was asked to use their experience and knowledge of snapper grouper species (specifically deepwater snapper grouper species) to suggest areas the Council may want to consider designating as marine reserves. As a part of this scoping process, the Marine Reserves Advisory Panel was asked to also suggest areas. As a result of this process over 40 sites were suggested and originally considered as potential marine reserves.

At their February 2001 meeting, the Council's Marine Reserves Committee discussed the difficulty managers and stakeholders were facing given that many different agencies were looking at marine reserves, marine sanctuaries, marine protected areas, etc. The different nomenclature associated with this management tool made things very confusing to the public and managers alike. The Committee determined that the term "marine reserves" was coming to imply an area that allowed no fishing. This was contrary to the Council's definition and intent. In order to be more consistent with national definitions the Council adopted the term Marine Protected Areas (MPAs).

During 2001 and into 2002 the Council, with help from its advisors, began working to determine which sites would best meet the Council's management objective to protect deepwater snapper grouper species. In August of 2001 the Council held an unprecedented "Mega-AP" meeting of the Habitat, Coral, Snapper Grouper, MPA, Law Enforcement, and Wreckfish Advisory Panels (APs). The APs were asked to help the Council select sites that would be the most beneficial for overfished, deepwater snapper grouper species using their various and vast knowledge, understanding that the Council's intent was to look at sites that protect more inshore snapper grouper species further down the line (that is, in the future).

Later in 2001 the Snapper Grouper Assessment Group, the Scientific and Statistical Committee, and the Snapper Grouper AP met with the Council's Snapper Grouper

Committee to provide additional input on possible MPA sites. Based on input from the SSC, APs, and the Snapper Grouper Committee, the Council instructed staff to develop an options paper for Snapper Grouper Amendment 14 with an initial level of analysis of sites the Council felt met the criteria of protecting overfished, deepwater snapper grouper species.

2004 - The sites that met the criteria of protecting overfished, deepwater snapper grouper species were included in the Informational Public Hearing Document and taken out to public hearings in early 2004. At those public hearings social and economic data were collected to help staff refine sites and analyze the impacts of the proposed sites. The information gathered at the Informational Public Hearings was useful in helping staff begin to assess the social and economic impacts of each individual site. It became clear that the location of a few of the sites may need to be tweaked in order to achieve the Council's goals and lessen social and economic impacts.

2005 - At their September 19-23 Council meeting in Charleston, South Carolina the Council voted to include MPAs as an approach to manage deepwater snapper grouper species in Snapper Grouper Amendment 13B. Of the nine sites originally proposed to be considered, only eight were to be included in Amendment 13B. The site not carried forward was a proposed artificial reef MPA two miles off the North Carolina coast. The Council felt that this site did not meet the criteria of protecting deepwater snapper grouper species.

At the December 5-9 Council meeting in Carolina Beach, North Carolina the Council voted to move consideration of MPAs into a separate Snapper Grouper Amendment 14 to address deepwater Type II MPAs.

2006 - At the March 2nd Council meeting in Jekyll Island, Georgia the Council reviewed a draft of Snapper Grouper Amendment 14 and approved motions to: (a) add a monitoring plan to the research needs section and (b) add alternatives to look at Vessel Monitoring Systems (VMS) for snapper grouper vessels with a snapper grouper permit and bottom longline gear onboard.

At their June 12-17, 2006 Council Meeting in Miami, Florida the Council approved Snapper Grouper Amendment 14 for public hearing. Council may want to consider designating as marine reserves. As a part of this scoping process, the Marine Reserves Advisory Panel was asked to also suggest areas. As a result of this process over 40 sites were suggested and originally considered as potential marine reserves.

2008 - On September 2, 2008 Snapper Grouper Amendment 14 was approved establishing deepwater MPAs in the South Atlantic region.

8.1.2 National Marine Sanctuaries

The National Marine Sanctuary Program (NMSP) is responsible for identifying, designating, and managing ocean and Great Lake areas of special national significance as national marine sanctuaries. Sanctuaries are managed to protect and conserve their resources and to allow uses that are compatible with resource protection. Management of sanctuaries is composed of a number of components:

- authorizing legislation (National Marine Sanctuaries Act - NMSA);
- regulations;
- management plans;
- management effectiveness programs;
- permitting;
- conservation policy; and
- strategic planning.

Legislation

The NMSA authorizes the existence of the NMSP, describes the purposes and policies of the NMSP, and provides authorization for appropriations. The NMSA is reauthorized every four to five years, allowing for updating and adaptation as necessary. While the NMSA provides the basis for everything else that follows, the NMSP must also develop regulations, management plans, policies, and operational procedures.

Regulations

Regulations represent the detailed implementation of the NMSA in the protection and conservation of sanctuary resources. Upon designation of a sanctuary or during a management plan review, site-specific regulations are issued that restrict a narrow range of activities, because an activity has already been found to be incompatible with the primary mandate of resource protection or is a proactive step necessary for the protection of a specific resource. The NMSP can also revise existing regulations or issue new regulations after the designation of a site. This may occur after a sanctuary has been in operation for several years and either a new activity is identified that did not exist prior to the sanctuary's designation, or new information about an existing activity reveals it is incompatible with resource protection or is resulting in user conflict. Under certain circumstances, the NMSP can also issue emergency regulations. Although the NMSP would generally seek non-regulatory means to address an issue, circumstances may warrant the issuance of a new regulation.

Management Plans

Management plans are site-specific documents that the NMSP uses to manage individual sanctuaries. Management plans:

- summarize existing programs and regulations;
- guide preparation of annual operating plans;
- articulate visions, goals, objectives, and priorities;
- guide management decision making;
- guide future project planning;

- ensure public involvement in management processes; and
- contribute to the attainment of system goals and objectives.

The NMSP has begun a comprehensive process that will lead to the review and possible revision of management plans at all 13 Sanctuaries. Reviews of management plans have been undertaken because:

- most existing management plans are 10 years old or older and evolving issues may not be adequately addressed;
- most existing management plans do not incorporate state-of-the-art concepts and practices associated with management of marine protected areas; and
- the NMSA has a statutory requirement that management plans should be reviewed on a periodic basis.

Management Effectiveness

Assessing management effectiveness (the achievement of a planned effort or action) is a critical element of the management of sanctuaries, and is done both internally by the NMSP and by external sources. It is part of routine sanctuary management efforts in order to foster a feedback loop that encourages an internal approach to problem solving and improved performance.

Internal Performance Evaluation

The NMSP has developed a suite of "program performance measures" to measure progress on several representative functions of the program dictated by the mandate of the National Marine Sanctuaries Act. Each sanctuary undergoing management plan review also develops site-specific performance measures that measure progress toward the goals and objectives of the individual sanctuary.

Performance evaluation contributes to the overall management process by:

- fostering the development of clear, concise problem statements and measurable outcomes;
- providing a tool that allows managers to comprehensively evaluate their sites in both the short and long term;
- allowing site staff to make decisions based on more accurate and relevant information;
- promoting accountability;
- supporting sanctuary efforts with an informed resource-allocation process; and
- motivating staff with clear policies and a focused direction.

Program performance measures are reported on and reviewed annually. The result of that effort is used in the internal resource-allocating process as a means to inform NMSP leadership on performance-based priorities.

External Evaluations on Management Effectiveness

Every few years, the NMSP commissions an external evaluation by an independent organization in order to obtain fresh insights, and to assess and support programmatic improvements in the broad operation of the NMSP. External evaluations work to help assess, adjust, and guide the NMSP. Five independent, external evaluations have been conducted on the NMSP since passage of the NMSA in 1972: the General Accounting Office in 1981, an External Review Team in 1993, the National Research Council (NRC) in 1997, and the National Academy of Public Administration in 2000 and 2006.

In 2004, the NMSP also completed the Program Assessment Rating Tool (PART), a government-wide performance evaluation process implemented by the Office of Management and Budget (OMB). The PART's primary function is to determine whether federal programs are meeting the mandated requirements identified for them in their enabling legislation and if mechanisms are in place to track their progress in doing so (namely, performance measures). The NMSP was "PARTed" with the Marine Protected Area Center (MPAC) under the rubric "NOAA Protected Areas Program." The NMSP will be "PARTed" again in the near future, following OMB's schedule for reviewing all federal agencies.

Permits
The NMSP has the authority to issue permits to allow some types of activities that are otherwise prohibited by sanctuary regulations, but which generally present a public benefit by furthering the management and protection of sanctuary resources. Permits usually include conditions that are designed to minimize or eliminate impacts to sanctuary resources. Permit conditions may also be included to minimize user conflict.

Conservation Policy
The NMSP conducts policy planning to provide a framework for the development of policies at both the national (system-wide) and individual sanctuary level. While this proactive approach to resource management is best, in reality most policies are developed in response to something that has already become a problem. The simple scale of some issues may seem prohibitive (e.g., invasive species), while in other cases the newness of an issue makes response difficult since little information may be available about its impacts (e.g., alternative energy). Policies are often used not only to address issues by themselves, but they also provide guidance in the use of other management tools, such as marine zoning, permits, and regulations. Sites should, for complex issues or those with broad national implications, work within the guidelines of national policies that have been or are being developed.

Strategic Planning
Since 2004, the National Marine Sanctuary Program has invested a great deal of staff time and effort in developing and implementing a comprehensive and efficient program planning, execution, and reporting system. This system is coordinated by the Senior Policy Advisor for Strategic Planning and Program Integration and the NMSP Strategic Planning Team (SPT), which has representatives from all HQ units, regions, and cross cutting programs across the NMSP. Although originally established to institutionalize the annual operating plan process and the structure and operations that support it, the

overall purpose of the SPT now is to facilitate the NMSP strategic planning process and provide information on areas of subject matter expertise, while thinking about innovative ways to better integrate operations of the NMSP. Specifically, the SPT focused in three areas:

1) NMSP planning and operations -- refining the NMSP AOP process, schedule and components

2) Agency-level budget and administrative requirements – integrating NMSP activities and requirements within the Coastal and Marine Resource Program (CMRP), Ecosystem Goal Team, and other NOAA matrix/goal teams.

3) Emerging opportunities – responding to high priority activities or issues that must be addressed due to high visibility or public expectations.

8.1.2.1 Gray's Reef

Gray's Reef National Marine Sanctuary (GRNMS) started reviewing its existing management plan in 1999. As part of the process, the Sanctuary Advisory Council was formed in August 1999. By 2001, the council consisted of 11 members representing education, research, sport diving, sport fishing, conservation, and selected government agencies. Since then, additional members have been added to the council representing charter/commercial fishing and two governmental seats.

Once in place, the advisory council and sanctuary staff considered the original list of GRNMS goals and objectives from the 1983 plan, and modified them to be consistent with the most recent reauthorization of the National Marine Sanctuaries Act (2000), as well as contemporary issues.

The management plan review process also relied on active public participation. In addition to producing a revised plan, the process brought together diverse stakeholder interests and expertise to shape and support new program directions that address current priority resource issues and conservation objectives.

Eight public scoping meetings were held at which sanctuary users, members of the public and agencies identified issues and problems they said they thought GRNMS might be able to address. Approximately 2,000 people made comments on the draft plan. They expressed concerns and provided recommendations in person and via fax, telephone and email. The comments were incorporated into a summary report which was presented to the advisory council and distributed to all participants, the media, and other interested parties. Seven additional, separate public meetings were held to review the draft plan. The final GRNMS management plan is available at
http://graysreef.noaa.gov/management.html

8.1.2.2 Florida Keys

The Florida Keys National Marine Sanctuary (FKNMS) was designated in accordance with the National Marine Sanctuaries Act (NMSA). Regulatory and enforcement powers of National Marine Sanctuaries are specified in the Act. The National Oceanic and Atmospheric Administration (NOAA) has been assigned responsibility for managing the nation's National Marine Sanctuaries and has developed regulations uniquely suited to protect the resources at each sanctuary. The primary regulations governing management of the FKNMS are described in the United States Code of Federal Regulations, Title 15, Part 922.

Ecological Reserves (ER's): Western Sambo and Tortugas. In addition to Sanctuary-wide regulations, special regulations have been set in place in these areas in order to protect resources.

Sanctuary Preservation Areas (SPA). There are 18 small SPAs that protect popular shallow coral reefs. In addition to Sanctuary-wide regulations, special regulations have been set in place in these areas in order to protect resources. Activities that will be prohibited in the Sanctuary Preservation Areas include spearfishing, shell collecting, tropical fish collecting, fishing and other activities that result in the harvest of marine life by divers, snorkelers, and fishermen. In addition, direct physical impact to corals in these areas is restricted.

Wildlife Management Areas (WMA). There are 27 WMA's. The majority of these areas (20) fall under the jurisdiction of the U.S. Fish and Wildlife Service (USFWS) and Sanctuary regulations have been established to complement the existing USFWS management plan. Public access restrictions in these areas include idle speed only/no wake, no access buffer, no motor, and limited closures.

Existing Management Areas (EMA). Sanctuary regulations have been established to complement those in existing management areas, including Looe Key and Key Largo Management Areas as well as the Great White Heron and Key West National Wildlife Refuges, and all the State Parks and Aquatic Preserves.

Special Use Areas. There are four areas designated: Conch Reef, Tennessee Reef, Looe Key (patch reef), and Eastern Sambo Reef. These are all designated as research-only areas. No person may enter these areas except as specifically authorized by a valid permit.

The FKNMS Management Plan is available at
http://floridakeys.noaa.gov/regs/welcome.html

8.1.2.3 Monitor

Management of the Monitor National Marine Sanctuary is composed of a number of components including authorizing legislation, regulations, management plans and permitting. Management plans are site-specific documents that the NMSP uses to manage individual sanctuaries. Sanctuaries are managed to protect and conserve their resources and to allow uses that are compatible with resource protection. The public management plan review process will begin for the Monitor NMS in 2008.

8.1.3 Minerals Management Service

8.1.3.1 OCS Leasing

(from MMS website: http://www.mms.gov/5-year/2007-2012main.htm#Proposed_Program)
The OCS Lands Act requires the Department of the Interior (DOI) to prepare a 5-year program that specifies the size, timing and location of areas to be assessed for Federal offshore natural gas and oil leasing. It is the role of DOI to ensure that the U.S. government receives fair market value for acreage made available for leasing and that any oil and gas activities conserve resources, operate safely, and take maximum steps to protect the environment.

OCS oil and gas lease sales are held on an area-wide basis with annual sales in the Central and Western Gulf of Mexico with less frequent sales held in the Eastern Gulf of Mexico and offshore Alaska. The program operates along all the coasts of the United States - with oil and gas production occurring on the Gulf of Mexico, Pacific and Alaska OCS. The MMS is also responsible for other mineral production offshore, which currently includes using sand and gravel for coastal restoration projects.

The following planning areas are still subject to a 1998 Presidential withdrawal from leasing through June 30, 2012, under the authority of Section 12 of the OCS Lands Act (43 USC 1341). All but North Aleutian Basin, Alaska, are also subject to annual Congressional moratoria, some from as early as Fiscal Year (FY) 1982:

- Washington-Oregon
- Northern, Central and Southern California
- Eastern Gulf of Mexico, except for the portion located off Alabama and more than 100 miles off Florida that was proposed, but not offered, for Lease Sale181 in 2001
- South, Mid and North Atlantic

In addition, in 1998 President Clinton withdrew indefinitely all National Marine Sanctuaries.

The first Congressional moratorium was enacted in FY 1982, prohibiting leasing off the Central and Northern California coast. In 1984, Southern California, the North Atlantic, and part of the Eastern Gulf Of Mexico, basically south of the 26 degree N latitude, were subject to moratoria. In FY 1990, the North Aleutian Basin, Alaska, and the Mid-Atlantic became moratoria areas. Washington/Oregon and the Florida Panhandle area of the Easter Gulf of Mexico were added to the moratoria list in FY 1991. The South

Atlantic was added in 1992. These areas have been continued to be subject to annual congressional moratoria, with the exception of the North Aleutian Basin, Alaska, which has not been included since FY 2004.

8.1.4 Environmental Protection Agency

8.1.4.1 ODMDSs

In 1972, Congress enacted the Marine Protection, Research, and Sanctuaries Act (MPRSA) to prohibit the dumping of material into the ocean that would unreasonably degrade or endanger human health or the marine environment. The MPRSA, also known as the Ocean Dumping Act, implements the requirements of the London Convention, which is the international treaty governing ocean dumping.

Virtually all material dumped in the oceans off the United States today is dredged material. Other materials that are currently ocean-disposed include fish wastes, human remains, and vessels. Certain materials, such as high-level radioactive waste, medical waste, sewage sludge, and industrial waste, may not be dumped in the ocean.

Ocean dumping cannot occur unless a permit is issued under the MPRSA. In the case of dredged material, the decision to issue a permit is made by the U.S. Army Corps of Engineers (COE), using the Environmental Protection Agency's (EPA) environmental criteria and subject to EPA's concurrence. For all other materials, EPA is the permitting agency. EPA is also responsible for designating recommended ocean dumping sites for all types of materials (http://www.epa.gov/Region4/water/oceans/).

Site Selection of ODMDS's

Twenty-one commercial ports and four military ports are located within EPA Region 4. Millions of cubic yards of sediments are dredged from these ports each year, much of which is disposed in the ocean off the southeastern United States. Regulation of dredged material disposal within ocean waters in the southeast is a shared responsibility of EPA Region 4 and the COE South Atlantic Division. Under the MPRSA, the COE is the permitting authority for the proposed disposal of dredged material. Permits for ocean disposal of dredged material are subject to EPA review and concurrence. EPA is also responsible for designating and managing ocean disposal sites for dredged material.

Most of the dredged material disposed in the ocean is disposed at ocean dumping sites specifically designated by EPA for dredged material disposal under section 102 of the Marine Protection, Research, and Sanctuaries Act (MPRSA). EPA designated sites are to be used for ocean disposal to the extent feasible.

All ocean dumping sites (Figure 1) are required to have a site management and monitoring plan (SMMP). Appropriate management of ocean dumping sites is aimed at assuring that disposal activities will not unreasonably degrade or endanger human health, welfare, the marine environment or economic potentialities.

Management of ocean dredged material disposal sites involves:

1. Regulating the times, the quantity, and the physical/chemical characteristics of dredged material that is dumped at the site;
2. establishing disposal controls, conditions, and requirements to avoid and minimize potential impacts to the marine environment; and
3. monitoring the site environs to verify that unanticipated or significant adverse effects are not occurring from past or continued use of the disposal site and that permit terms are met.

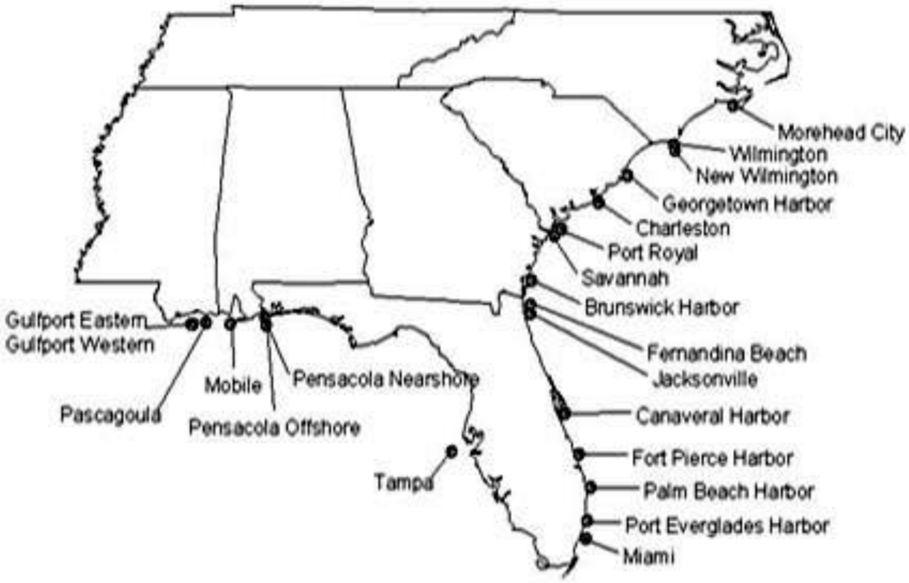

Figure 8.1-1. Disposal sites in the Southeast
(http://www.epa.gov/Region4/water/oceans/sites.html).

Permitting Procedures
Marine Protection, Research and Sanctuaries Act (MPRSA) Section 103 permits for the ocean dumping of dredged materials are issued by the Corps of Engineers (COE) subject to EPA approval. The COE District office is responsible for coordination of all federal actions, including EPA concurrences, pertaining to MPRSA Section 103 applications. All applications should be coordinated with EPA Region 4. Applicants are encouraged to arrange for a pre-application conference with the District and EPA in order to fully understand the process and requirements for obtaining the permit. EPA will not approve the permit unless the proposed dredged material has been shown to meet the ocean dumping criteria. Data requirements for ensuring this compliance can be extensive and the permitting process typically takes from 6 to 18 months (http://www.epa.gov/Region4/water/oceans/).

The permit process is outlined below and consists of 10 main steps:
Pre-application Consultation: Includes discussion of alternatives and the information required for use in evaluating the proposed dredged material.

Evaluation of Dredged Material Proposed for Ocean Disposal: Includes development, approval and implementation of a sampling and analysis plan and an assessment of compliance with the ocean dumping criteria.

Permit Application: Title 33 Code of Federal Regulations Part 325.1 (33 CFR 325.1) describes the requirements of the permit application. In addition, the application should include:

a. An evaluation of dredged material disposal alternatives including an examination of potential beneficial uses of the proposed dredged material.
b. Written documentation of the site dredging history and a general survey of other prior or current dredging activities at or near the site.
c. References to existing or prior MPRSA Section 103 permits.

Review of Application for Completeness: Additional information is requested if the application is incomplete.

Issuance of Public Notice by District: Public Notices must include all of the information required in 33 CFR 325.3(a)

EPA Review: EPA has 45 days with an optional additional 45 day extension to review the information and to determine compliance with the ocean dumping criteria. If additional information is needed, EPA has 30 days to request that information.

District Engineer Completes Evaluation: The COE addresses comments and holds a public meeting if needed.

Public Interest Review: The COE considers all comments and incorporate them into the administrative record of the application.

Permit Issued: A decision to issue or deny a permit is discussed in either a Statement of Findings or Record of Decision and the permit is issued.

Permit Public Notice: A list of permit decisions is published.

Evaluation of dredged material for ocean disposal under the MPRSA relies largely on biological (bioassay) tests. The ocean testing manual, commonly referred to as the Green Book, provides national guidance for determining the suitability of dredged material for ocean disposal. Regional guidance is provided in the EPA Region 4 - U.S. Army Corps of Engineers South Atlantic Division Regional Implementation Manual PDF (RIM) (http://www.epa.gov/Region4/water/oceans/).

The Green Book sets out a framework containing the procedures approved by EPA and the Corps for evaluating the dredged material. The framework provides that the intensity of evaluation increases with the risk of contaminants and/or absence of existing information. If an evaluation in one level (tier) is not adequate to determine the material's suitability for ocean disposal, the evaluation proceeds to the next tier(s), and the protocols of the next tier(s) must be followed (Appendix K, SAFMC 1998a).

The following is a general summary of the testing and evaluation procedures included in each tier:

Tier I - Evaluation of Existing Information
Tier I specifies when and how existing information, such as results from previous tests on the material, can be used to evaluate the material. If the existing information is inadequate, the evaluation must go to the next tier(s).

Tier II - Conservative Screening Tools
Tier II specifies when and how sediment chemistry can be used in evaluating material by using worst case water column modeling and Theoretical Bioaccumulation Potential (TBP) calculations for the dredged material. (Because there is no model for evaluating toxicity, all sediments entering Tier II must also be tested for toxicity in Tier III.) The 1991 manual includes updated scientific models for evaluating compliance with water quality criteria issued by EPA to help protect marine species. The dumping must meet the applicable water quality criteria. The 1991 manual includes use of TBP, which is a scientifically valid approach for evaluating the potential bioaccumulation of certain specific, non-ionic compounds (such as PCBs and dioxin). There is no counterpart model available for metals or polar compounds so if their presence is a concern, actual bioaccumulation testing in Tier III is still necessary.

Tier III - Laboratory Bioassays
Tier III specifies approved testing procedures for toxicity and bioaccumulation. The acute toxicity tests employ 10 day exposures. The 1991 manual stresses the use of amphipods, which are sensitive bottom-dwelling organisms, and describes standardized test methods that were not available when the 1977 manual was developed. The bioaccumulation tests employ 28 day exposures if contaminants with the potential to bioaccumulate are present in the material. The 1977 manual specified 10 day exposures for all compounds. Use of 28 day exposures to assess bioaccumulation of contaminants was found to be more appropriate.

Tier IV - Advanced Biological Evaluations
Tier IV consists of laboratory and field tests and other evaluations to reduce specific uncertainties about the potential impacts of proposed projects. Tests conducted under this tier are not considered routine in the regulatory program, and can require significant time and expense.

The Green Book includes evaluation methods which can be tailored to the material and location. This is intended to ensure that material is adequately evaluated to make a scientifically sound decision regarding the potential environmental impacts of the proposed ocean dumping, without requiring unnecessary or inappropriate tests in any given case.

Corps Districts and EPA Regional offices work together to develop Regional Implementation Manuals providing supplemental site-specific refinements to the national guidance, such as: identifying the contaminants of concern for the harbors within the region; and identifying the specific species of organisms to be tested (from the list of organisms in the national manual). Testing procedures used to evaluate ocean dumping must be approved by EPA and the Corps. No permit is issued unless the agencies have enough information to determine that the ocean dumping will not cause significant harmful effects. (Appendix K, SAFMC 1998a)

8.1.4.2 National Estuary Program

As part of the 1987 amendments to the Clean Water Act, Section 320 National Estuary Program (NEP) promotes comprehensive planning efforts to help protect nationally significant estuaries in the United States that are deemed to be threatened by pollution, development, or overuse. Since the inception of the program, 28 estuaries have been nominated by their respective state Governors and officially designated as NEP estuaries (National Estuary Program Coastal Condition Report, Executive Summary, June 2007). As one of the U.S. EPA most successful watershed programs, the NEP demonstrates the effectiveness of a stakeholder-driven, collaborative process to address water quality problems and to target habitat restoration. Individual NEPs are required to monitor the effectiveness of their management activities to address estuary-specific priority actions. The Clean Water Act also requires that EPA report periodically on the condition of the nation's estuarine waters. Coastal states provide EPA with valuable information about the condition of their estuarine resources; however, because the individual states, the NEPs, and their partners use different approaches for data collection and the evaluation of estuarine condition, it has been difficult to compare this information among states, NEPs, or on a regional or national basis (National Estuary Program Coastal Condition Report, Executive Summary, June 2007).

The purpose of the NEP is to identify, restore, and protect the nationally significant estuaries of the United States. The southeast coast is home to two NEP estuaries: the Albemarle-Pamlico Estuarine Complex and the Indian River Lagoon (National Estuary Program Coastal Condition Report, Chapter 4: Southeast National Estuary Program Coastal Condition, June 2007).

Albemarle-Pamlico National Estuary Program (APNEP)

The Albemarle-Pamlico Estuarine Complex drains approximately 30,000 mi^2 of watershed and comprises the largest lagoonal estuarine system in the United States. This NEP has a 23,000-mi^2 study area that extends south from Prince George County, VA, to Carteret County, NC, and includes 7 sounds (Albemarle, Bogue, Core, Croatan, Currituck, Pamlico, and Roanoke) (APNEP, 2006) (National Estuary Program Coastal

Condition Report, Chapter 4: Southeast National Estuary Program Coastal Condition, Albemarle-Pamlico National Estuary Program, June 2007).

The Albemarle-Pamlico Estuarine Complex NEP study area contains large tracts of forested and undeveloped land, including 11 National Wildlife Refuges (e.g., Great Dismal Swamp, Back Bay, Mackay Island, Currituck, Roanoke River, Alligator River, Pocosin Lakes, Pea Island, Mattamuskeet, Swan Quarter, and Cedar Islands). The Complex's watershed also contains the Cape Lookout and Cape Hatteras National Seashores; the Croatan National Forest; and many state-owned parks, forests, and research reserves (Martin et al. 1996). In addition, several U.S. Department of Defense (DoD) lands are located in this watershed.

Freshwater inputs to this system are provided by five major rivers — the Pasquotank, Chowan, and Roanoke rivers that flow into Albemarle Sound and the Tar-Pamlico and Neuse rivers that flow into Pamlico Sound. This region features a variety of habitat types, including significant pocosins (southeastern shrub bogs), pine savannahs, hardwood swamp forests, bald cypress swamps, salt marshes, brackish marshes, freshwater marshes, and beds of submerged aquatic vegetation (SAV) (Martin et al. 1996). On the eastern side of the Albemarle-Pamlico Estuarine Complex, a chain of islands forms a barrier with the Atlantic Ocean. The Complex is uniquely characterized by random wind-driven tides, which result in less predictable variations in water circulation and salinity patterns (Focazio 2006a). Economically, this estuarine system represents the southeast region's key resource base for commercial fishing, tourism, recreation, and resort development. Economic benefits are also derived from the use of the area's natural resources for mining, forestry, and agriculture (APNEP 2006).

The Albemarle-Pamlico National Estuary Program (APNEP) was among the first NEPs established by EPA in 1987. Its overall condition is good to fair based on the four indices of estuarine condition used by the NCA (National Coastal Assessment). The water quality index for the Complex is rated good, the sediment quality and fish tissue contaminants indices are rated good to fair, and the benthic index is rated fair. However, factors such as chlorophyll a, dissolved oxygen, and sediment quality may signal declining health, especially in some tributary river areas.

The APNEP continues to work toward fulfilling its goals and has already seen some major accomplishments, including the following:

- Restoration of more than 1,100 miles of anadromous fish habitat through the removal of three dams.
- Enhancement of interagency and interstate coordination through creation of the APNEP.
- Organizational restructuring to promote region-wide interstate citizen involvement through collaboration and coordination.
- Development of bycatch reduction gear (e.g., sea turtle exclusion devices) and practices to reduce fisheries impacts.

- Restoration of two miles of riparian habitat along the Roanoke River through livestock fencing and riverbank-stabilization practices (APNEP 2006).

Indian River Lagoon National Estuary Program

The Indian River Lagoon is located along Florida's east coast and stretches 156 miles from Volusia County to Palm Beach County, FL. This area comprises one of the most diverse estuaries in North America and one of Florida's most popular fishing destinations, with more than 1 million anglers visiting the Lagoon area each year (U.S. EPA 2000c). The Lagoon and its surrounding watershed include a wide variety of habitats that support a diverse assemblage of plants and animals (SJRWMD 2004). These habitats range from xeric scrub through pine flatwoods, tropical and temperate hardwood hammocks, salt marshes, mangrove swamps, and other intertidal communities such as seagrass meadows and other SAV communities (Hill 2002) (National Estuary Program Coastal Condition Report, Chapter 4: Southeast National Estuary Program Coastal Condition, Indian River Lagoon National Estuary Program, June 2007).

This region's broad diversity of habitats support more than 4,300 different species, including 700 saltwater and freshwater fish species and 310 bird species (SJRWMD 2004). Thirty-six of the species found in this region are classified as threatened or endangered, including the southeastern beach mouse, Atlantic saltmarsh snake, bald eagle, and Florida scrub jay (SJRWMD 2004; U.S. EPA 2006d). In addition, an estimated one-third of Florida's endangered West Indian manatees live in the Indian River Lagoon.

Commercially, the estuary is one of the most important waterways in Florida and is a productive nursery ground for an estimated $300 million in annual commercial fishing revenues, including $100 million from inshore species. The Indian River Lagoon accounts for 50% of Florida's total East Coast fisheries landings (SJRWMD 1994). Also, tourism and recreation contribute $540 million to the local economy, and the influx of tourists and part-time residents to the area is considerable (SJRWMD 2002).

In 1987, the Florida Legislature passed the Surface Water Improvement and Management (SWIM) Act, which designated the Indian River Lagoon as a priority water body in need of restoration and special protection (Florida Statutes, Chapter 373.451–373.4595). Created in 1990, the Indian River Lagoon NEP (IRLNEP) fosters active participation by other federal agencies, notably the FWS, NASA, and USACE. It also manages a local government cost-share program that assists counties and municipalities with planning and implementing pollution-abatement projects, typically small-scale efforts with an emphasis on stormwater treatment. For instance, both the St. John's River Water Management District (SJRWMD) and South Florida Water Management District (SFWMD) focus on projects designed to improve water and sediment quality, restore or enhance the seagrass community in the Lagoon, or rehabilitate wetlands, recovering many of the natural functions of these areas.

The overall condition of the Indian River Lagoon is rated good based on three of four indices of estuarine condition used by the NCA. The water quality, sediment quality, and benthic indices were each rated good for the Indian River Lagoon, and data was unavailable to calculate the fish tissue contaminants index for this estuary.

The greatest tangible improvement to date in the Indian River Lagoon is the hydrologic reconnection of more than 23,000 acres of impounded wetlands since 1989 under the SWIM Act (in addition to nearly 5,000 acres reconnected through other programs). These impoundment reconnections restore many natural functions provided by salt marshes and mangrove wetlands (Steward et al. 2003).

There is also a noticeable increase in public awareness of the Lagoon's problems and its ecology, as well as an understanding of the projects that are underway to benefit the Lagoon's recovery and management. Much has been accomplished, but the IRLNEP recognizes that more work remains to be done to reach restoration targets established for seagrass and coastal wetlands. Preventative safeguards, vigilance, and education are needed to ensure that achievements in addressing problems in the Indian River Lagoon are maintained and that progress continues in protecting and restoring the water quality and natural resources of the Lagoon (Steward et al. 2003).

There is also progress taking place within the Indian River Lagoon watershed. More than 56,000 acres of wetlands and uplands have been acquired for various purposes (such as water quality remediation projects and habitat preservation). The various agencies and local governments with jurisdiction over the Indian River Lagoon basin have made advancements in ending discharges of treated wastewater, removing harmful muck deposits, and making incremental improvements in stormwater management throughout the basin.

In recent years, the IRLNEP has tackled some of the most important and controversial issues to address pollution in the Indian River Lagoon basin including addressing the impact of septic tanks on water quality, promoting the acquisition of environmentally sensitive lands, promoting the development of regional stormwater management plans, and participating in the development of local management plans for threatened and endangered species.

Some of the ongoing goals of the IRLNEP include:

- Attaining and maintaining water and sediment of sufficient quality to support a healthy, macrophyte-based estuarine Lagoon ecosystem.
- Attaining and maintaining a functioning macrophyte-based ecosystem that supports endangered and threatened species, fisheries, and wildlife.
- Improving the understanding and management of impacts of invasive and exotic species and the emerging challenges to aquatic animal health.
- Achieving heightened public awareness and coordinated interagency management of the Indian River Lagoon ecosystem (Steward et al. 2003).

Based on data collected by the NCA, the overall condition of the Indian River Lagoon is rated good. In general, the IRLNEP considers seagrass coverage in the Indian River Lagoon to be a key indicator of trends in environmental condition. Areas with good seagrass coverage are located adjacent to fairly undeveloped watersheds or close to inlets, whereas areas of extensive SAV loss and sparse seagrass are adjacent to highly developed watersheds or shoreline areas. The areas with poorest water quality are Cocoa to Melbourne/Palm Bay, the southern Banana River, and the Vero Beach, Fort Pierce, and St. Lucie River areas. Areas of the Indian River Lagoon adjacent to larger tributaries and major drainages systems experience elevated levels of nutrients and total suspended solids.

(All cited references found in National Estuary Program Coastal Condition Report, Appendix & Back Cover, June 2007)

8.1.6 National Estuarine Research Reserves

(Information from the NERR web pages http://www.nerrs.noaa.gov/welcome.html)
The National Estuarine Research Reserves System is a network of 27 areas representing different biogeographic regions of the United States that are protected for long-term research, water-quality monitoring, education and coastal stewardship. Established by the Coastal Zone Management Act of 1972, as amended, the reserve system is a partnership program between the National Oceanic and Atmospheric Administration and the coastal states. NOAA provides funding, national guidance and technical assistance. Each reserve is managed on daily basis by a lead state agency or university, with input from local partners.

North Carolina
In North Carolina the reserve is comprised of 10,000 acres in four sites located near Corolla (Currituck Banks), Beaufort (Rachel Carson) and Wilmington (Masonboro Island and Zeke's Island).

The North Carolina National Estuarine Research Reserve encourages researchers from universities and government laboratories to use the four sites for short or long-term investigations that will promote better understanding and management of estuaries. Data from monitoring stations, an annotated bibliography of work done on each site, species lists and GIS maps are offered to participating investigators. Projects have been completed on such diverse topics as estuarine eutrophication, productivity of benthic microalgae, use of dredge material to renourish salt marshes and effects of feral horses on salt marsh productivity.

The Graduate Fellows Program of the National Estuarine Research Reserve System fosters graduate student use of the reserves for their research projects. Fellows then contribute to other current reserve programs.

The research office initiates and conducts research into the dynamics of estuaries. Two ongoing projects are: 1) a Habitat Assessment Tool that can gather water quality data for a large body of water by the use of a towed instrument and 2) the National Telemetry Project that will provide real-time weather and water quality data accessibility throughout the National Estuarine Research Reserve System.

South Carolina

The North Inlet-Winyah Bay reserve encompasses 12,327 acres located in Georgetown County, SC. The reserve features the salt marshes and ocean dominated tidal creeks of the North Inlet Estuary plus the brackish waters and marshes of the adjacent Winyah Bay Estuary. North Inlet is a relatively pristine system in which water and habitat quality are much higher than those in Winyah Bay. As the estuary with the third largest watershed on the east coast, Winyah Bay has been greatly influenced by agriculture, industry and other human activities. More than 90% of North Inlet's watershed is in its natural forested state

The reserve is home to many threatened and endangered species, including sea turtles, sturgeons, least terns and wood storks.

Reserve resources range from tidal and transitional marshes to oyster reefs, beaches, and inter-tidal flats and from coastal island forests to open waterways.

More than 90 research and environmental monitoring projects involving more than 70 scientists are currently underway within the reserve. Long-term ecological data collections initiated more than 20 years ago continue to provide insights into patterns and mechanisms of both natural and human-related change in the estuaries. University based researchers use the System-wide Monitoring Program data to support field and laboratory studies, which range from the molecular to ecosystems level.

The Ashepoo-Combahee-Edisto (ACE) Basin reserve comprises134,710 acres located in Colleton, Charleston, Beaufort and Hampton counties. The ACE Basin is one of the largest undeveloped estuaries on the East Coast. The Ashepoo, Combahee and Edisto rivers, meander past cypress swamps, historic plantation homes, old rice fields and abundant tidal marshes to meet at South Carolina’s biologically rich St. Helena Sound.

The ACE Basin National Estuarine Research Reserve protects the natural beauty, abundant wildlife and unique cultural heritage of the area. In addition, the reserve preserves habitat for many endangered or threatened species, such as shortnose sturgeon, wood storks, loggerhead sea turtles and bald eagles.

Research conducted at the ACE Basin Reserve enhances the protection of these commercial and recreational uses by monitoring water quality, providing information on the abundance and types of important plant and animal species, and evaluating the overall health of the ACE Basin ecosystem.

Through a variety of educational programs, the reserve provides timely information to coastal decision makers, lawmakers, teachers, students and the general public. The reserve sponsors a summer lecture series, develops curriculum materials for teachers, offers a touch tank program for children and conducts educational cruises where students and teachers learn about estuaries and their values to marine life.

Georgia

The Sapelo Island National Estuarine Research Reserve, comprising 6,110 acres, is a coastal plain estuary, protected on its seaward side by a Pleistocene barrier island.

Sapelo Island is the fourth largest Georgia barrier island and one of the most pristine. The reserve is made up of salt marshes, maritime forests and beach dune areas. Not only is the island rich in natural history, but also in human history dating back 4,000 years.

The Sapelo Island Reserve habitats include a sand-sharing system comprised of shoreface, foreshore, backshore and dune components; an extensive band of salt marsh (comprising two-thirds of the reserve) and some 2,300 acres of upland forest, dominated by stands of oak hardwoods and pines.

Florida

The Guana Tolomato Matanzas National Estuarine Research Reserve encompasses approximately 55,000 acres of salt marsh and mangrove tidal wetlands, oyster bars, estuarine lagoons, upland habitat and offshore seas in northeast Florida. It contains the northern most extent of mangrove habitat on the east coast of the United States.

The coastal waters of the GTM Reserve are important calving grounds for the endangered Right Whales. Manatees, wood storks, roseate spoonbills, bald eagles and peregrine falcons also find refuge in the reserve.

The reserve is geographically separated into a northern section where the Tolomato and Guana rivers mix with the waters of the Atlantic Ocean, and a southern section along the Matanzas River, extending from Moses Creek south of Pellicer Creek. The unique Matanzas Inlet is one of the last natural, unaltered inlets on Florida's Atlantic coast.

The GTM estuary is rich with scenic beauty and economic value as it produces or supports the vast majority of the commercially and recreationally valuable fish and shellfish found in the region. The submerged lands, marshes, islands and conservation lands provide important habitat for a diversity of plants and animals, including the migrating birds stopping along the Atlantic Coastal Flyway.

Data generated from the research programs are used to assess the health of the ecosystem and guide future research efforts.

Visiting scientists utilize on-site field station for systems and baseline studies of the plant and animal communities of the reserve.

Long-term ecological monitoring efforts of the GTM Reserve include water quality monitoring (physical, chemical and biological), and meteorological and tidal conditions.

Geographic Information System (GIS) data and remote sensing are used to analyze natural resources within the reserve and human use of the coastal area.

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of the

Atlantic States Marine Fisheries Commission

Working towards healthy, self-sustaining populations for all Atlantic coast fish species or successful restoration well in progress by the year 2015

Prioritized Research Needs in Support of Interjurisdictional Fisheries Management

2008

Atlantic States Marine Fisheries Commission
Prioritized Research Needs
in Support of Interjurisdictional Fisheries Management

Prepared by Melissa Paine
Scientific Committee Coordinator

with assistance of the
Management and Science Committee

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Acknowledgments

The Atlantic States Marine Fisheries Commission (Commission) would like to thank all state, federal and university representatives who contributed to the completion of this document. Identification and prioritization of research needs was provided by members of various Commission committees, including species stock assessment subcommittees, technical committees, advisory committees, plan development and review teams, and management boards. Input was also provided by the Commission's Habitat Committee, Committee on Economics and Social Sciences, and Management and Science Committee. The research needs topics listed in this publication are consistent with those developed by the National Marine Fisheries Service Northeast Fisheries Science Center for organization and classification of Stock Assessment Workshop/Stock Assessment Review Committee (SAW/SARC) research recommendations.

The Commission extends its appreciation to the members of the Management and Science Committee for providing oversight to the effort to identify and prioritize Commission research needs.

Table of Contents

Introduction

Research needs listed in this document were identified from Atlantic States Marine Fisheries Commission (Commission) fishery management plans and amendments, annual plan reviews, special reports conducted by the Commission on species technical and stock assessment issues, Stock Assessment Workshop (SAW) documents conducted by the National Marine Fisheries Service (1996 - 1999), and Commission external peer reviews. This publication is an update of Special Report #62 Prioritized Research Needs in Support of Inter-jurisdictional Fisheries Management published by the Commission in January 1997. Updates are periodically published via the Commission's website at www.asmfc.org.

Research needs were prioritized by Commission stock assessment subcommittees and technical committees under the purview of the Plan Development/Review Teams. Additional input to priorities is provided periodically by Advisory Committees, Management Boards, the Habitat Committee, the Committee on Economics and Social Sciences, and the Management and Science Committee. The prioritized research needs in this document should not supplant any prioritization conducted by Commission technical committees or management boards on an annual basis, or in any way hinder the management process.

It is the intent of the Commission to periodically update this document as research needs are either met or as new research needs are identified. Research needs that have been met since previous publication of this document have been moved to a separate section for each species and appropriate references have been included. The overall purpose of this document is to encourage state, federal and university research programs to develop projects to meet the research needs of Commission-managed species and thereby improve the overall management of these fisheries. It also hoped that state, federal and non-profit organizations will utilize this document in prioritization of research projects for future funding programs.

American Eel

High Priority

- A coastwide fishery-independent sampling program for yellow and silver American eels should be formulated using standardized and statistically robust methodologies.
- Regular periodic stock assessments and establishment of sustainable reference points for eel are required to develop a sustainable harvest rate in addition to determining whether the population is stable, decreasing, or increasing.
- A stock assessment committee should identify the best stock assessment methods for American eel.[1]
- Research the effects of swim bladder parasite *Anguillacolla crassus* on the American eel's growth and maturation, migration to the Sargasso Sea, and the spawning potential.
- Investigate, develop, and improve technologies for American eel passage upstream and downstream at various barriers for each life stage. In particular, investigate low-cost alternatives to traditional fishway designs for passage of eel.
- Investigate: fecundity, length, and weight relationships for females throughout their range; growth rates for males and females throughout their range; age and maturity data

Medium Priority

- Evaluate the impact, both upstream and downstream, of barriers to eel movement with respect to population and distribution effects. Determine relative contribution of historic loss of habitat to potential eel population and reproductive capacity.
- Investigate survival and mortality rates of different life stages (leptocephalus, glass eel, yellow eel, and silver eel) to assist in the assessment of annual recruitment. Continuing and initiating new tagging programs with individual states could aid such research.
- Tagging Programs: A number of issues could be addressed with a properly designed tagging program. These include:
    - Local and regional movement and migration patterns
    - Natural, fishing, and/or discard mortality; survival
    - Growth
    - Validation of aging method(s)
    - Abundance
    - Reporting rates
    - Tag shedding or tag attrition rate

  A tagging study to examine local and regional movement has been completed by a graduate student at Delaware State University and other studies on local movements and abundance are currently being conducted by other Delaware graduate students.

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[1] Comment/question: The SAC included a table of stock assessment methods and minimum data requirements for each in Table 1 of the 2006 stock assessment report. Surplus production models had the least data requirements. However, there were convergence problems when ASPIC models were run with five relative abundance indices. Recently the SASC used the SLYME model to assess the impact of maximum size limits. Is SLYME a surplus production model? If so, perhaps the SASC and the TC could review the data needs and sensitivity analysis for SLYME and identify the most critical data needs. For example the model was very sensitive to the assumed value for proportion of future males. It would also be useful to know if data are required for every state (e.g. fecundity) and if long-term or short-term information is needed (biological sampling of a fishery in one year might be possible, but biological sampling every year might not be). A single SLYME model was developed, but perhaps regional version would be more appropriate?

- Research contaminant effects on eel and the effects of bioaccumulation with respect to impacts on survival and growth (by age) and effect on maturation and reproductive success.
- Investigate: predator-prey relationships; behavior and movement of eel during their freshwater residency; oceanic-behavior, movement, and spawning location of adult mature eel; and all information on the leptocephalus stage of eel.
- Assess characteristics and distribution of eel habitat and value of habitat with respect to growth and sex determination.
- Identify location and triggering mechanism for metamorphosis to mature adult, silver eel life stage, with specific emphasis on the size and age of the onset of maturity, by sex. A maturity schedule (proportion mature by size or age) would be extremely useful in combination with migration rates.

Low Priority

- Perform economics studies to determine the value of the fishery and the impact of regulatory management.
- Review the historic participation level of subsistence fishers in wildlife management planning and relevant issues brought forth with respect to those subsistence fishers involved with American eel.
- Examine the mechanisms for exit from the Sargasso Sea and transport across the continental shelf.
- Research mechanisms of recognition of the spawning area by silver eel, mate location in the Sargasso Sea, spawning behavior, and gonadal development in maturation.
- Examine age at entry of glass eel into estuaries and fresh waters.
- Examine migratory routes and guidance mechanisms for silver eel in the ocean.
- Investigate the degree of dependence on the American eel resource by subsistence harvesters (e.g., Native American Tribes, Asian and European ethnic groups).
- Examine the mode of nutrition for leptocephalus in the ocean.
- Provide analysis of food habits of glass eel while at sea.

Research Needs Identified As Being Met

Accurately document the commercial eel fishery so that our understanding of participation in the fishery and the amount of directed effort could be known. ***Trip-level reporting of catch and effort became mandatory in 2007.***

Evaluate the use of American eel as a water quality indicator.

Investigate practical and cost-effective methods of re-establishing American eel in underutilized habitat.

American Lobster

High Priority

- *Age and Growth*

All assessments of lobster stock status have been based on analyses of length data. Age is assumed by applying per-molt growth increments and molt frequencies to the length data. Based on these analyses, the American lobster has been treated as an extremely long-lived animal, reaching a reproductive maximum at a relatively old age. These assumptions are justified, but are based on no actual age data. Applying aging techniques developed in England and Australia for lobster and other crustaceans would greatly improve our understanding of how many year-classes support the current trap fishery, how length relates to age, and how variable the age structure is over stock area and time.

- *Ecosystem-based Management*

NOAA's 2004 Strategic Plan for Fisheries Research recommends the inclusion of ecosystem and environmental information in all stock assessments. Further examination of lobster mortality not related to the fishery would provide a better understanding of factors limiting productivity and longevity. Topics should include: predator/prey interactions and community structure, climatic shifts in ocean currents and temperature, and toxic substances causing chronic stress or disease.

- *Fishery-Dependent Information*

Accurate and comparable landings are the principal data needed to assess the impact of fishing on lobster populations. The quality of current landings data is not consistent spatially or temporally. Standardized mandatory reporting of landings data resource-wide would improve the assessment. Aligning stock management areas with area designations for landings is necessary. Enhanced sea sampling and port sampling to create a more complete record of biological characteristics of the catch and harvest would also improve the usefulness of these data. This is especially needed in offshore waters.

- *Investigation of Historical Levels of Stock Production*

It has been pointed out that one limitation of the proposed reference points is the period covered by the assessment. Investigations of past levels of stock size and size structure could provide additional insight in to setting reference points that relate to the full range of stock productivity.

- *Investigation of Trans-boundary Assessments*

Investigate conducting joint US and Canadian assessments.

Lower Priority

- *Model Development*

Size based models should be examined to determine their ability to match length frequencies and other biological characteristics observed in local lobster populations. Additionally, the utility of using yield and spawning biomass per recruit and surplus production models should be evaluated through simulation as a basis for developing alternative reference points.

Research Needs Identified as Having Been Met

Fishery-Independent Information

There is a need to develop consistent techniques that monitor distribution and abundance of lobster independent of the fishery. Current methods (e.g. trawls) are limited in area (gear conflicts) and habitat sampled (unable to access complex bottom). Additional methodologies should be investigated that cover a wide range of sizes and habitats. These could include ventless traps, dive/ROV, and settlement surveys.

American Shad/River Herring

High Priority

- Determine the impact of directed fisheries on American shad and river herring stocks and reduce F.
- Determine American shad and river herring bycatch within state and ocean waters.[2]
- Determine predation by fish, mammals and birds on American shad and river herring.
- Verify Juvenile indices of alosa species.
- Verify tag-based estimates of American shad.
- Mandate FMPs for rivers with active restoration plans for American shad or river herring.
- Continue to assess current aging techniques for American shad and river herring, using known age fish, scales, otoliths, and spawning marks.
- Validate the different values of M for shad stocks through verification of shad aging techniques and repeat spawning information and develop methods for calculating M.
- Determine which stocks are impacted by coastal intercept fisheries (including bycatch fisheries) and evaluate the fishing mortality on those stocks. Methods to be considered to differentiate among stocks could include otolith micro-chemistry, oxytetracycline otolith marking, tagging or DNA/RNA methods.
- Develop an integrated coastal remote telemetry system or network that would allow tagged fish to be tracked throughout their coastal migration and into the estuarine and riverine environments.
- Identify ways to improve fish passage efficiency including hydroacoustics to repel alosines or pheromones or other chemical substances to attract them. Test commercially available acoustic equipment at existing fish passage facility to determine effectiveness. Develop methods to isolate/manufacture pheromones or other alosine attractants.
- Refine techniques for tank spawning of American shad. Evaluate the use of hormone implants vs. natural spawning. Secure adequate eggs for culture programs using native broodstock, when possible.
- Conduct population assessments on river herring - particularly needed in the south.
- Evaluate effectiveness of fishways for American shad and river herring. Compare features of effective fishways and in-effective fishways and develop guidelines for fishway design.
- Conduct basic research on American shad behavior as it relates to fishways to assist in development of design parameters.
- Quantify fishing mortality (in-river, ocean bycatch, bait fisheries) for major river stocks.

Medium Priority

- Determine and update biological benchmarks used in assessment modeling (fecundity at age, mean weight at age for both sexes, partial recruitment vector/maturity schedules) for American shad and river herring stocks in a variety of coastal river systems, including both semelparous and iteroparous stocks.
- Develop effective culture and marking techniques for river herring.
- Develop and implement techniques to determine shad and herring population targets for tributaries.
- Characterize passage-associated mortality, migration delay, and sub-lethal effects on American shad at hydroelectric dams.
- Conduct studies of river herring egg and larval survival and development.

[2] ASMFC American Shad Stock Assessment, 2007

- Identify directed harvest and bycatch losses of American shad in ocean and bay waters of Atlantic Maritime Canada.
- Spatially delineate between mixed stock and Delaware stock areas within the Delaware system.

Low Priority

- Characterize tributary habitat quality and quantity for Alosa reintroductions and fish passage development.
- Evaluate and ultimately validate large-scale hydroacoustic methods to quantify American shad escapement (spawning run numbers) in major river systems. Identify how shad respond (attract/repelled) by various hydroacoustic signals.
- Identify and quantify potential American shad spawning and rearing habitat not presently utilized and conduct an analysis of the cost of recovery.
- Conduct studies on energetics of feeding and spawning migrations of shad on the Atlantic coast.
- Encourage university research on hickory shad.
- Conduct studies of shad egg and larval survival and development.
- Conduct and evaluate historical characterization of socio-economic development (potential pollutant sources and habitat modification) of selected shad rivers along the east coast.
- Review studies dealing with the effects of acid deposition on anadromous alosids.

Research Needs Identified as Being Met

Develop comprehensive angler use and harvest survey techniques for use by Atlantic states to assess recreational fisheries for American shad. ***To be accomplished through MRIP.***

Determine the stock/recruitment relationships for American shad and river herring stocks

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Atlantic Croaker

High Priority

- Studies of croaker growth rates and age structure need to be conducted throughout the species range.
- Age-length keys that are representative of all gear types in the fishery should be developed.
- Fishery dependent and independent size, age and sex specific relative abundance estimates should be developed to monitor long term changes in croaker abundance.
- Improve catch and effort statistics from the commercial and recreational fisheries, along with size and age structure of the catch.
- Examine reproductive biology of croaker with emphasis on developing maturity schedules and estimates of fecundity.
- Determine migratory patterns and mixing rates through cooperative, multi-jurisdictional tagging studies.
- Conduct stock identification research on croaker.

Medium Priority

- Cooperative coastwide croaker juvenile indices should be developed and validated to clarify stock status.
- Evaluate hook and release mortality under varying environmental factors and fishery practices.
- The effects of mandated bycatch reduction devices (BRD's) on croaker catch should be evaluated and compiled.
- In trawl fisheries or other fisheries that historically take significant numbers of croaker, states should monitor and report on the extent of unutilized bycatch and fishing mortality on fish less than age-1. Incorporate bycatch estimates into croaker assessment models.
- The optimum utilization (economic and biological) of a long term fluctuating population such as croaker should be evaluated.
- Continue monitoring of juvenile croaker populations in major nursery areas.
- Cooperatively develop a yield per recruit analysis to establish a minimum size that maximizes YPR.
- Determine the onshore vs. offshore components of the croaker fishery.
- Identify essential habitat requirements.

Low Priority

- Determine species interactions and predator/prey relationships for croaker (prey) and other more highly valued fisheries (predators).
- Determine the impacts of any dredging activity (i.e. for beach re-nourishment) on all life history stages of croaker.

Research Needs Identified as Being Met

Criteria should be cooperatively developed for aging croaker otoliths. ***To be met at October 2008 aging workshop.***

Atlantic Menhaden

High Priority

- Monitor landings, size, age, gear, effort and harvest area in the reduction and bait fisheries, and determine age composition by area. Continue biostatistical sampling of bait samples in purse seine fisheries for Virginia and New Jersey to improve stock assessment.
- Develop and test methods for estimating size of recruiting year-classes of juveniles using fishery-independent survey techniques.
- Re-evaluate menhaden natural mortality, by age and response to changing predator population sizes.
- Develop and improve fishery independent estimates of adult abundance at age on a coast-wide scale to replace or augment the existing pound net index.

Medium Priority

- Determine how loss/degradation of critical estuarine and nearshore habitat affects growth, survival and abundance of juvenile and adult menhaden abundance.
- Study the coast wide ecological role of menhaden (predator/prey relationships, nutrient enrichment, oxygen depletion, etc.) in major Atlantic coast embayments and estuaries.
- The feasibility of estimating yearclass strength using biologically stratified sampling design should be evaluated. The efforts could be supported by process studies linking plankton production to abundance of young menhaden (need resources).
- Monte Carlo simulations should be conducted to evaluate precision of current assessment models.
- Alternative measures of effort, including spotter pilot logbooks, trip length, or other variables, should be evaluated. Spotter pilot logbooks should be evaluated for spotter plane search time, GPS coordinates, and estimates of school sizes observed by pilots.
- Evaluate effects of selected environmental factors on growth, survival and abundance of juvenile and adult menhaden, particularly in Chesapeake Bay and other coastal nursery areas.
- Determine the effects of fish diseases (such as ulcerative mycosis and toxic dinoflagellates) on the menhaden stock.
- Update fecundity and maturity schedules.
- Update estuary-specific productivity estimates used to weight the juvenile abundance indices.

Low Priority

- Growth back-calculation studies should be pursued to investigate historical trends in growth rate. The NMFS has an extensive database on scale growth increments which should be utilized for this purpose.
- Determine the effects of regulations on the fishery, the participants and the stock.
- Monitor fish kills along the Atlantic coast and use the NMFS Beaufort Laboratory as a repository for these reports.
- Develop bycatch studies of menhaden by other fisheries. DISCARDS
- Periodically monitor the economic structure and sociological characteristics of the menhaden reduction industry.

Notes:
MSVPA model provides new insight on menhaden natural mortality, by age and response to changing predator population sizes.

Ongoing research in Chesapeake Bay to evaluate effects of selected environmental factors on growth, survival and abundance of juvenile and adult menhaden

Ongoing research is being conducted to develop and test methods for estimating size of recruiting year-classes of juveniles using fishery-independent survey techniques.

Ongoing research is being conducted to determine the effects of fish diseases (such as ulcerative mycosis and toxic dinoflagellates) on the menhaden stock.

Research Needs Identified as Being Met

Evaluate use of coastal power plant impingement data as a possible means to estimate young-of-the-year menhaden abundance.

Atlantic Sea Herring

High Priority

- Continue to utilize the inshore and offshore hydroacoustic and trawl surveys to provide an independent means of estimating stock sizes. Collaborative work between NMFS, DFO, state agencies, and the herring industry on acoustic surveys for herring should continue to be encouraged.
- Continue resource-monitoring activities, especially larval surveys to evaluate distribution and abundance of herring larvae, and to indicate the relative importance of individual spawning areas and stocks and the degree of spawning stock recovery on Georges Bank and Nantucket Shoals.
- Continue tagging and morphometric studies to explore uncertainties in stock structure and the impacts of harvest mortality on different components of the stock. Although tagging studies may be problematic for assessing survivorship for a species like herring, they may be helpful in identifying the stock components and the proportion of these components taken in the fishery on a seasonal basis.
- Investigate bycatch/discards in the directed herring fishery through both at-sea and portside sampling.
- Continue commercial catch sampling of Atlantic herring fishery according to ACCSP protocols.
- Continue to organize annual U.S.-Canada workshops to coordinate stock assessment activities and optimize cooperation in management approaches between the two countries.
- Synthesize predator/prey information and conduct investigations to address information gaps; investigate the role of herring in the Northwest Atlantic ecosystem and the importance of herring as a forage species for other commercial fish stocks; assess the importance of herring as forage relative to other forage species in the region. Re-evaluate Atlantic herring natural mortality by age and the response to changing predator population sizes through an ecosystem based assessment.

Medium Priority

- Develop new approaches to estimating recruitment (i.e. juvenile abundance) from fishery-independent data.
- Conduct a retrospective analysis of herring larval and assessment data to determine the role larval data plays in anticipating stock collapse and as a tuning index in the age-structured assessment.
- Develop socio-economic analyses appropriate to the determination of optimum yield.
- Develop a strategy for assessing individual spawning components to better manage heavily exploited portion(s) of the stock complex, particularly the Gulf of Maine inshore spawning component.

Low Priority

- Possible effects of density-dependence (e.g. reduced growth rates at high population size) on parameter estimates used in assessments should be examined.
- Investigate the natural mortality rate assumed for all ages, the use of catch-per-unit-effort tuning indices, and the use of NEFSC fall bottom trawl survey tuning indices in the analytical assessment of herring.
- Develop economic analyses necessary to evaluate the costs and benefits associated with different segments of the industry.

Maine DMR proposed Research Needs:

Investigate/evaluate the current herring spawning closure design in terms of areas covered, closure periods, catch at age within (before fishing prohibition in 2007) and outside of spawning areas to determine minimal spawning regulations.

Research Needs Identified as Being Met

Evaluate the merit of acoustic surveys and other techniques to achieve sub stock complex monitoring.

Atlantic Striped Bass

STOCK ASSESSMENT AND POPULATION DYNAMICS

High Priority

- Develop method to integrate VPA and tagging models to produce a single estimate of F and stock status (ongoing, G. Nelson)
- Develop a spatial and temporal catch at age model incorporating tag-based movement information
- Examine reporting rates by commercial and recreational fishermen using high reward tags (ongoing, J. Hoenig)
- Develop methods for combining tag results from programs releasing fish from different areas on different dates.
- Examine potential biases associated with the number of tagged individuals, such as gear-specific mortality (associated with trawls, pound nets, gill nets, and electrofishing), tag-induced mortality, and tag loss.

Medium Priority

- Improve methods for determining population sex ratio for use in estimates of spawning stock biomass and biological reference points.
- Evaluate the overfishing definition relative to uncertainty in biological parameters.
- Develop studies to provide information on gear-specific discard morality rates and to determine the magnitude of bycatch mortality (ongoing, G. Nelson).
- Develop refined and cost-efficient fisheries-independent coastal population index for striped bass stocks.
- Examine methods to estimate annual variation in natural mortality (ongoing, Striped Bass Tagging Subcommittee).
- Examine causes of different tag-based survival estimates among programs estimating similar segments of the population.
- Evaluate truncated matrices and covariate-based tagging models.
- Develop reliable estimates of poaching loss from striped bass fisheries.
- Develop maturity ogive applicable to coastal migratory stock.
- Improve estimates of striped bass harvest removals in coastal areas during wave 1 and in inland waters of all jurisdictions year-round.

Low Priority

- Develop simulation models to look at the implications of overfishing definitions relative to development of a striped bass population that will provide “quality” fishing. Quality fishing must first be defined.
- Examine issues with time saturated tagging models for the = 18 inch length group.

RESEARCH AND DATA NEEDS

High Priority

- Continue in-depth analysis of migrations, stock compositions, etc. using mark-recapture data (ongoing, e.g., Cooperative Winter Tagging Cruise 20 Year Report, W. Laney)
- Continue evaluation of striped bass dietary needs and relation to health condition.

Medium Priority

- Continue to conduct research to determine limiting factors affecting recruitment and possible density implications.
- Evaluate the percentage of fishermen using circle hooks.
- Conduct study to calculate the emigration rates from producer areas now that population levels are high and conduct multi-year study to determine inter-annual variation in emigration rates.

Low Priority
- Determine inherent viability of eggs and larvae.
- Conduct additional research to determine the pathogenicity of the IPN virus isolated from striped bass to other warm water marine species, such as flounder, menhaden, shad, and largemouth bass

Atlantic Sturgeon

High Priority

- Characterize size, condition, and relative abundance of Atlantic sturgeon by gear and season taken as bycatch in various fisheries.
- Develop methods to determine sex and maturity of captured sturgeon. [3]
- Develop sperm cryo-preservation techniques and refine to assure availability of male gametes. Refine induced spawning procedures.
- Evaluate aging techniques for Atlantic sturgeon with known age fish. Emphasis should be placed on verifying current methodology based on fin rays. Determine length, fecundity, and maturity at age for North, Mid and South Atlantic stocks.
- Conduct basic cultural experiments to provide information on: a) efficacy of alternative spawning techniques, b) egg incubation and fry production techniques, c) holding and rearing densities, d) prophylactic treatments, e) nutritional requirements and feeding techniques, and f) optimal environmental rearing conditions and systems.
- Establish stocking goals and success criteria prior to development of stock enhancement or recovery programs. *Partially done*.
- Conduct research to identify suitable fish sizes, and time of year for stocking cultured fish
- Conduct and monitor pilot-scale-stocking programs before conducting large-scale efforts over broad geographic areas.
- Establish tolerance of different life stages to important contaminants and levels of such environmental factors such as DO, pH, and temperature.
- Utilize pilot-scale stocking trials to evaluate available habitat, survival and distribution in potential restoration target tributaries
- Conduct assessments of population abundance and age structure in various river systems. Particular emphasis should be placed in documenting occurrence of age 0-1 juveniles and spawning adults as indicators of natural reproduction.

Medium Priority

- Obtain baseline data on habitat condition and quantity in important sturgeon rivers. Data should address both spawning and nursery habitat.
- Evaluate the exposure and effect of endocrine disrupting chemicals.
- Assess loss to ship/boat strikes.

Low Priority

- Determine the extent to which Atlantic sturgeon are genetically differentiable among rivers.
- Research should be conducted to determine the susceptibility of Atlantic sturgeon to sturgeon adenovirus and white sturgeon iridovirus. Methods should be developed to isolate the sturgeon Adenovirus and an Atlantic sturgeon cell line should be established for infection trials.
- Encourage shortnose sturgeon researchers to include Atlantic sturgeon research in their projects.
- Identify rates of tag loss and tag reporting.
- Evaluate existing sea sampling data to characterize at-sea migratory behavior. *Partially done.*

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[3] Partially done. Laparoscopic techniques have been developed to visually inspect gonads (Dr. Rob Bakal, USFWS, Aquatic Animal Health Coordinator, National Fish Hatchery System). The focus should be directed to blood chemistry analysis of compounds such as vitellogenin or sex steroids.

- Research should be conducted to identify the major pathogens of Atlantic sturgeon and a cell line for this species should be developed.
- Conduct a cost benefit analysis of various stocking protocols.
- Conduct further analyses to assess the sensitivity of F50 to model inputs.

Research Needs Identified As Being Met

Develop and implement long-term marking/tagging procedures to provide information on individual tagged Atlantic sturgeon for up to 20 years. ***PIT tags.***

Standardize collection procedures and develop suitable long-term repository for biological tissues for use in genetic and other studies.

Develop the capability to capture wild broodstock and develop adequate holding and transport techniques for large broodstock.

Establish a tag recovery clearinghouse and database for consolidation and evaluation of tagging and tag return information including associated biological, geographic, and hydrographic data. ***Uncertainty whether this includes acoustic tag information.***

Black Sea Bass

High Priority

- Sampling should be increased for commercial landing in black sea bass fisheries, specifically the fish pot fisheries in the Mid-Atlantic.
- Sampling should be increased in the recreational fisheries.
- Age sampling should be increased across all components of the fishery.
- Sampling should be done to characterize discards.
- Develop fishery independent surveys and expand existing surveys to capture all sizes and age classes in order to develop independent catch-at-age and CPUE.
- Investigate the effect of sex transition rates, sex ratio and differential natural mortality by sex on the calculation of spawning stock biomass per recruit and eggs per recruit.
- Investigate the impact of the removal of large males from the population has on reproduction.
- Studies on sex-specific mortality rates and growth are needed.
- Increase sea sampling to verify information from commercial logbooks to provide better estimates of discards.
- Consideration should be given to a pot survey for an index of abundance

Medium Priority

- Explore alternative assessment models, including non-age based alternatives.
- Further delineate essential fish habitat (EFH), particularly in nursery areas. Further investigate possible gear impacts on EFH.
- Identify transport mechanisms or behavior that move early juvenile black sea bass into estuaries.
- Evaluate habitat use by overwintering yearling, young-of-the-year, and adult black sea bass.
- Evaluate food habits of black sea bass larvae and overwintering adults.

Low Priority

- Develop mariculture techniques.
- A study determining the value of artificial reefs for increased production of black sea bass would be valuable in estimating potential yield.

***Notes*:**
Black sea bass are currently scheduled to take part in a data poor workshop to be scheduled for November-December 2008. The workshop participants will be looking for innovative ways to conduct stock assessments on species with little data.

Research Needs Identified as Being Met

A tagging program should be initiated through state fisheries agencies to estimate mortality independent of traditional methods. *Tagging study complete with peer reviewed results to be published in 2008, G. Shepherd, NMFS.*

Bluefish

High Priority

- Evaluate amount and length frequency of discards from the commercial and recreational fisheries.
- Initiate fisheries-dependent and independent sampling of offshore populations of bluefish during the winter months.
- Test the sensitivity of the bluefish assessment to assumptions concerning age-varying M, level of age-0 discard, and selection patterns.
- Measures of CPUE under different assumptions of effective effort should be evaluated to allow evaluation of sensitivity of results.
- Evaluate fishery-independent surveys to determine if the state surveys can be combined or coordinated to yield broader temporal and spatial representation of the stock.[1]
- Collect size and age composition of the fisheries by gear type and statistical area.[2]
- Target commercial and recreational landings for biological data collection when possible.[3]

Medium Priority

- Age any archived age data for bluefish and use the data to supplement North Carolina age keys.
- Increase intensity of biological sampling of the NER commercial and coastwide recreational fisheries.
- Conduct research on oceanographic influences on bluefish recruitment, including information on migratory pathways of larval bluefish.
- Increase sampling frequencies when bluefish are encountered, especially when medium size fish are encountered.
- Conduct studies on the interactive effects of pH, contaminants, and other environmental variables on survival of bluefish.
- Initiate research on species interactions and predator-prey relationships.
- Study tag mortality and retention rates for American Littoral Society dorsal loop and other tags used for bluefish.

Low Priority

- Continue work on catch and release mortality.
- Initiate a coastal surf-zone seine study to provide more complete indices of juvenile abundance.
- Investigate the long term, synergistic effects of combinations of environmental variables on various biological and sociological parameters such as reproductive capability, genetic changes, and suitability for human consumption.
- Explore alternative methods for assessing bluefish, such as length-based and modified DeLury models.

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[1] SARC-41. 2005. 41st Chair's Report from the Northeast Regional Stock Assessment Workshop (SAW-41) Stock Assessment Review Committee (SARC) Meeting, Northeast Fisheries Science Center, National Marine Fisheries Service, Woods Hole, Massachusetts, June 6-9, 2005.

[2] Perhaps this should continue and remain a priority (e.g., Robillard et al. (2008) have data on 36 fish in 2003 from the southernmost extent of range predominantly from the recreational fishery; analogously, Robillard et al. (2008) report that data from NC were primarily from commercial gillnet fishers in 2002 and 2003).

[3] Same comment as footnote 2.

Research Needs Identified as Being Met

- Complete a scale-otolith age comparison study.
  Robillard, E., et al. 2008. Age-validation and growth of bluefish (*Pomatomus saltatrix*) along the East Coast of the United States. Fish. Res.doi:10.1016/j.fishres.2008.07.012
- Conduct research to determine the timing of sexual maturity and fecundity of bluefish.
  Robillard, E. et al. Reproductive biology of bluefish (Pomatomus saltatrix) along the East Coast of the United States. Fish. Res. 90 (2008) 198-208.

Coastal Sharks

High Priority

- Continue to acquire better species-specific landings information on number of species, by weight, from dealers should be sought.
- Initiation or expansion of dockside sampling for sharks.
- Conduct species-specific assessments for all shark species, with a priority for smooth dogfish.
- Re-evaluate finetooth life history in the Atlantic Ocean in order to validate fecundity and reproductive periodicity.
- Determine bonnethead life history in Atlantic Ocean, spanning the range of the stock.
- Re-evaluate blacknose life history in Atlantic Ocean, spanning the range of the stock. Expand research efforts directed towards tagging of individuals in south Florida and Texas/Mexico border to get better data discerning potential stock mixing.
- Identify Essential Fish Habitat and nursery areas for shark species found along the Atlantic Coast of the U.S.

Medium Priority

- Develop empirically based estimates of natural mortality.
- Additional life history studies for all species of the shark complex should be carried out to allow for additional species specific assessments.
- Additional length sampling and age composition collection to improve information for developing selectivities.
- The Atlantic menhaden fishery data should be examined to determine shark bycatch estimates, if available.
- Additional life history research into sandbar sharks to supplement or replace the available data from the mid 1990's
- Coordinate a biological study for Atlantic sharpnose so that samples are made *at least* monthly, and within each month samples would be made consistently at distinct geographic locations. For example, sampling locations would be defined in the northern Gulf, west coast of Florida, the Florida Keys (where temperature is expected to be fairly constant over all seasons), and also several locations in the South Atlantic, including the east coast of Florida, Georgia, South Carolina, and North Carolina. This same sampling design could be applied to all small coastal sharks.
- Dockside sampling information would be helpful to verify landings information such as species composition.
- Population level genetic studies are needed that could lend support to arguments for stock discriminations using new loci and/or methodology that has increased levels of sensitivity.
- Develop a fishery-independent porbeagle shark survey to provide additional size composition and catch rate data to calculate index of abundance.

Low Priority

- Biological data should be collected on the illegal Mexican Shark catch confiscated in U.S. waters, including species, sex, and length.
- Gear-related information, including effort and gear used for each species should be collected on the interdicted Mexican vessels.
- One central electronic database for biological and gear data should be created to keep information regarding the confiscated sharks and vessels.

- Scientists should help the Coast Guard create the database and teach the agents how to identify the species and gear information.
- Determine reproduction biology for finetooth in the Gulf of Mexico.

Note: Work with NMFS on all priorities to ensure no duplication of efforts.

Horseshoe Crab

High Priority

- Investigate factors (habitat, harvest, sampling methods, etc) that might be causing the large discrepancies between DE and NJ in egg survey numbers.
- Expand or implement fishery-independent surveys to encompass the full range of horseshoe crabs along the coast including inland waters.
- Estimate juvenile age/size-specific survivorship for year 0 to adult.
- Estimate size-specific fecundity of Delaware Bay females.
- Estimate catchability for gear used in benthic trawl surveys and determine effect of size, sex, substrate, topography, timing, and temperature.
- Model relationship between egg availability and spawning biomass/abundance.
- Assess horseshoe crab prey availability and determine whether horseshoe crab population growth will be/is limited by prey availability.
- Determine stock composition of Virginia, Maryland, and New York landings.
- Conduct risk assessment for the effect of oil spill (timing, location, and amount) on horseshoe crab and shorebird populations and determine best practices to reduce risk.

Medium Priority

- Further evaluate life table information including sex ratio and population age structure.
- Evaluate the impacts of beach nourishment projects on horseshoe crab populations.
- Estimate the proportion of sub-tidal spawning and determine if this affects spawning success (i.e. egg survivability).
- Identify coastal populations through tagging studies (mark-recapture) and genetics work.
- Ground truth sub-sampling method used in DE Bay spawning survey for calibration to the “population” scale.
- Improve measures to characterize landings and bycatch in the commercial fisheries by life stage.
- Investigate analysis of tagging data to provide mortality rates and population abundance in addition to migration and movements.
- Characterize essential horseshoe crab habitat, other than spawning habitat, in different regions.
- Characterize abundance and size structure of juveniles coastwide as indicators of recruitment to adulthood.
- Investigate supplemental bait and alternative trap designs to reduce the commercial fisheries need for horseshoe crabs.
- Estimate mortality from the entire biomedical collection process, from capture to post-return.

Low Priority

- Evaluate the effect of mosquito control chemicals on horseshoe crab populations.
- Estimate fishing discard numbers and associated mortality rates.
- Evaluate the importance of horseshoe crabs to other marine resources such as sea turtles.

- Continue to conduct additional stock assessments and determine harvest mortality rates (F). Use these data to develop a more reliable sustainable harvest rate.

Notes:
Several priority research needs are currently being addressed through the following surveys:

Delaware Bay spawning beach survey:

a) Determine sampling frame or list of beaches in the Bay with a nonzero probability of being sampled in a given year.
b) Determine how many beaches need to be surveyed on how many days to meet survey objectives.
c) Determine whether subsampling effort (no. of quadrats per beach) was adequate.
d) Consider a survey design that includes both fixed and random beaches.

Delaware Bay egg count survey:

a) Set primary objective of egg count surveys to be shorebird food availability and focus on density of eggs at the surface (< 5cm).
b) Determine survey frequency (i.e., survey eggs annually, every 3 years, every 5 years, or other?).
c) Determine where, along the beach profile, eggs should be sampled.
d) Determine sample size for sampling eggs on a beach.
e) Determine the relationship between spawning activity and density of eggs at the surface (<5cm). Is there a threshold of spawning activity below which eggs remain buried and unavailable to shorebirds?

Offshore benthic survey:

a) Design comparative surveys or experiments to determine gear efficiencies.

Research Needs Identified as Being Met

- Evaluate the effectiveness of currently used benthic sampling gear for stock assessment (Qualitative evaluation completed through 2006 peer review)
- Determine beach fidelity by horseshoe crabs to determine habitat use.
- Develop a young-of-year or age 1 recruitment index from the Delaware 16-foot trawl survey.
- Conduct economic studies to determine the value of the commercial fishery and the impact of regulatory management. Such economic studies should also include an assessment of economic impacts on other fisheries as they relate to horseshoe crabs.

Northern Shrimp

High Priority

- Continue to examine values of natural mortality, M. Revisit older work that established M=0.25 (Rinaldo, Clark). Estimate M from year-sex-stage-class ratio data from surveys. Examine predation data and other environmental factors. Investigate possible annual variation in M. Benefits: better understanding of ecological role; more accurate model estimates of F and B. Resources required: several person-months for data analysis.
- Examine several survey issues: recalculate fall survey indices for shrimp, eliminating the nighttime tows; verify that summer survey tow bottom tending times have been consistent; investigate survey design for optimal number and stratification of tows; explore ways to quantify age 1 and younger shrimp. Benefits: more accurate survey indices for model estimates of F and B; earlier estimates of future recruitment. Resources required: several person-months for data analysis, and further research into collecting small shrimp, possibly development of a trap survey.
- Explore the stock-recruitment relationship and the impact of environmental factors on recruitment. Consider impacts of climate change. Benefits: better understanding of natural population fluctuations; better modeling of population dynamics. Resources required: many person-months for data analysis.
- Better characterize shrimp discards in the shrimp and other small-mesh (i.e., herring and whiting) fisheries. Benefits: more accurate estimate of shrimp removals for modeling. Resources required: more at-sea sampling; several person-months for analysis of existing VTR and sea-sampling databases.
- Evaluate the stock recruitment relationship for northern shrimp.
- Evaluate natural mortality, including relative impacts of predation and disease and variation at age and over time.
- Evaluate larval growth and survival in response to environmental conditions.
- Further research to refine annual estimates of consumption by predators could be useful in several ways. Consumption estimates could lead to annual estimates of *M* that would be more realistic than assuming constant *M*, for use in models that include *M* explicitly. Alternatively, consumption estimates could be used in production models as annual removals similar to fishery removals.
- Power analysis of estimates of mean weight from port sampling should be investigated to optimize sample design.
- Improve separator and excluder devices to reduce bycatch and discard of non-targeted species. Explore gear modifications, such as larger mesh, to minimize shrimp bycatch in finfish trawl fisheries.[1]
- Characterize demographics of the fishing fleet by area and season; perform comparative analysis of fishing practices between areas.
- Develop an understanding of product flow and utilization through the marketplace; identify performance indicators for various sectors of the shrimp industry.
- Efforts to quantify the magnitude of bycatch by species, area, and season should be continued and the steps necessary to limit negative impacts taken.

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[1] Some work has been done by Schick and He.

- Explore new markets for Gulf of Maine shrimp.[1]
- Develop a framework to aid evaluation of the impact of limited entry proposals on the Maine fishing industry.[2]
- Broad-based and detailed socioeconomic description and analysis of the structure, operations, markets, revenues and expenditures of the northern shrimp fishery itself and in relation to other commercial fisheries in northern New England.
- Ground-truthing for all of the data gathered via Federal and State databases. Contradictions and inaccuracies abound, so face-to-face interviews with a randomized sample of participants in all sectors of the fishery are needed.
- Determine the relative power relationships between the harvesting and processing sector and the larger markets for shrimp and shrimp products. Identify significant variables driving market prices and how their dynamic interactions result in the observed intraannual and inter-annual fluctuations in market price for northern shrimp.
- Study the effects of large-scale climatic events (like the North Atlantic Oscillation) on the cold water refuges for shrimp in the Gulf of Maine.

Medium Priority

- Recover/convert older port sampling data to useable database. Benefit: Data will be available for future queries re fishing locations, catch rates, size distributions, sex stage and timing of egg hatch, other shrimp species, etc. Resources required: several person-months for data entry, uploads, and proofing.
- Evaluate appropriate biological reference points and define sustainable harvest levels. The potential for improving estimates of mortality, abundance, and biomass from historical fishery and survey data from the 1960s should be investigated for further guidance on appropriate biological reference points.
- Target and threshold reference points for northern shrimp are set equal to one another at F = 0.22/yr. Using a buffer of zero between target and threshold reduces the relevance of reference points to management. Specifically, the distinction between desirable exploitation rates and those that indicate overfishing is blurred. The SARC recommends dialogue with managers and industry on this matter, as well as research to illustrate whether separating threshold from target would allow more stable or robust management techniques. When a common agreement exists about the function of each reference point, assessment scientists can calculate values to best serve each function
- Research on annual variation of size at age could increase precision of the assessment.
- The possibility of using a more detailed assessment model, such as the CASA model used for Atlantic sea scallop, should be studied. Use of a model with a more detailed treatment of northern shrimp population dynamics could increase accuracy and precision of assessment results.
- Evaluate maturation, fecundity and lifetime spawning potential.
- Evaluate growth, including frequency of molting and variation in growth rates as a function of environmental factors and population density.
- Evaluate distribution of larval, juvenile, and adult shrimp. Evaluate migration and local movements.[3]

[1] Maine Fishermen's Forum panel discussions, 2006 and 2007
[2] Maine Coastal Fishery Research Priorites, 2001, online at http://www.maine.gov/dmr/research/table_of_contents.htm, and Maine Fishermen's Forum panel discussion, 2007
[3] Some migration work has been done by Schick et al. 2006 NEC

- Estimates of fecundity at length should be updated, and the potential for annual variability should be explored.
- Investigate changes in transition and maturation as a function of stock size and temperature.[1]
- Evaluate competition and predator-prey relationships between species.
- Continue sea-sampling efforts.
- Evaluate vulnerability of shrimp to various fishing gear.
- Exploration of any spatial, depth, or temperature influences on survey catchability could contribute to better standardization of the survey abundance index.
- Environmental effects could likewise be examined through development of a surplus-production model that includes effects of environmental variation on per-capita production or carrying capacity.
- The CSA model as used here requires a parameter that is the ratio of catchabilities for the two age or size classes. Sensitivity analysis on the values used would contribute to a better understanding of model stability. A thorough evaluation of possible methods for better estimating this parameter could reduce uncertainty in the assessment.
- Develop a time series of standardized effort to corroborate patterns of estimated F.
- Methods for age determination from length and ontogenetic stage information should be continued to develop the possibility of using age-based assessment methods.
- Expand the time series of stock and recruitment data using catchability estimates from the production model.
- Modify sea sampling protocol to characterize discards of shrimp in the shrimp trawl fishery and the small-mesh whiting fishery.
- Perform cost-benefit analyses to evaluate management measures.
- Develop a bioeconomic model to study the interactions between four variables: movements of shrimp, catchability of shrimp, days fished, and market price.
- Develop an economic-management model to determine (1) the most profitable times to fish, (2) how harvest timing effects markets, and (3) how the market effects the timing of harvesting.
- Study specific habitat requirements for all life history stages.
- Evaluate effects of habitat loss/degradation on northern shrimp.
- Develop habitat maps for all life history stages.
- Identify migration routes of immature males offshore, and ovigerous females inshore.
- Determine the short and long-term effects of mobile fishing gear on shrimp habitat.[2]

Low Priority

- Increased sampling of commercial catches, ensuring good allocation of samples among ports and months, could provide better estimates of size composition.[3]

***Notes**:*

In 2008, the greatest problems facing the Gulf of Maine shrimp industry were not a lack of research on stock dynamics, assessment methods, or management practices; they were high fuel prices and poor shrimp prices. Government research efforts should target energy policy and the development of markets, as well as good fishery management.

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[1] Some work has been done by Wieland 2004, 2005

[2] Short term effects have been studied by A. Simpson and L. Watling, 2006.

[3] It would be useful to first analyze the existing sampling protocol, to determine whether more or less sampling is necessary, and whether existing sampling is representative.

Sea sampling effort to date has probably identified adequately the catch and bycatch in the shrimp fishery in the Gulf of Maine under current gear and season constraints. Until changes are made in gear and season, sea sampling may remain minimal. Research to improve on excluder devices to reduce bycatch is still a reasonable investment in that bycatch of small whiting and small flatfish is still a problem. Bycatch by species, area and season has been adequately quantified as long as the fishing season and gear remain generally the same. Limiting negative impacts is still a fairly important area of research focus.

Dunham and Muller at the University of Maine conducted an economic study of the shrimp fishery including the characterization of demographics of the fishing fleet by area and season in 1976. This study should be updated.

Some recent work has been done on the relative distribution of shrimp and juvenile groundfish along the Maine coast. Little is known of the distribution and/or life history of the juvenile stage of *P. borealis*, therefore the age structure of the population is less certain.

Migration of *P. borealis* is known to occur to a greater extent in the Gulf of Maine than anywhere else in the world. Several aspects of this migration remain an enigma.

Red Drum

High Priority

- Support fishery-independent sampling of sub-adult and adult red drum in each state from Virginia to Florida. The purpose of this survey would be to: 1) verify escapement to the spawning population, 2) provide an index of recruitment to age 1, and 3) provide an estimate of the biomass of adult red drum.
- Continue tagging studies to determine stock identity, inshore/offshore migration patterns and mortality estimation.
- Determine the survival rate of red drum following regulatory and voluntary discard from commercial and recreational gear, including recreational net fisheries. Evaluate effects of water temperature and depth of capture.
- Quantify relationships between red drum production and habitat.

Medium Priority

- Develop a more reliable estimate of natural and fishing mortality through directed sampling of the adult population.
- Identify spawning areas of red drum in each state from Virginia to Florida so these areas may be protected from degradation and/or destruction. Determine qualities of those areas (bottom type, depth, temperature, salinity, etc.). Determine the impacts of dredging and beach re-nourishment on red drum spawning and early life history stages.
- Improve catch/effort estimates and biological sampling from recreational and commercial fisheries for red drum, including increased efforts to intercept night-time fisheries for red drum by the NMFS MRFSS. Characterize magnitude of commercial and recreational discards.
- States with significant fisheries should be encouraged to collect socio-economic data on red drum fisheries through add-ons to the MRFSS or by other means so as to determine the economic value of the Atlantic coast recreational red drum fishery.
- Investigate and evaluate new stock assessment techniques as alternatives to age-structured models. Conduct yield modeling on red drum.
- Fully evaluate the efficacy of using cultured red drum to restore native stocks along the Atlantic coast, including cost-benefit analyses.
- Identify the effects of water quality degradation on the survival of red drum eggs, post-larvae, larvae, and juveniles.
- Refine maturity schedules on a geographic basis, determine relationships between annual egg production over a range of sizes, ages and across latitude.
- Determine methods for restoring red drum habitat and/or improving existing environmental conditions that adversely affect red drum production.

Low Priority

- Determine habitat preferences, environmental conditions, growth rates, and food habits of larval and juvenile red drum throughout the species range along the Atlantic coast. Assess the effects of environmental factors on stock density.
- Investigate the concept of estuarine reserves to increase the escapement rate of red drum along the Atlantic coast.
- Document and characterize schooling behavior for Atlantic coast red drum.

Scup

- Continue to support and fund both the RI commercial fish trap survey and the Fishery Independent Scup Survey of Hard Bottom Areas in Southern New England Waters. It is recommended that the fishery independent survey be expanded to include waters further west and that scales should be collected for aging.

- Increased and more representative sea and port sampling of the various fisheries in which scup are landed and discarded is needed to adequately characterize the length composition of both landings and discards. The current level of sampling, particularly of the discards, seriously impedes the development of analytic assessment and forecasts of catch and stock biomass for this stock. A pilot study to develop a sampling program to estimate discards should be implemented. Expanded age sampling of scup from commercial and recreational catches is required, with special emphasis on the acquisition of large specimens. *Improved sampling intensity for landings, increase in funding for observer program since 2004, this has improved discard sampling intensity in the directed and bycatch fisheries for scup, but* ***still need to increase observer coverage for winter I offshore directed scup fishery and bycatch squid fishery****.*

- Commercial discard mortality had previously been assumed to be 100% for all gear types. The committee recommends that studies be conducted to better characterize the mortality of scup in different gear types to more accurately assess discard mortality.

- Additional information on compliance with regulations (e.g. length limits) and hooking mortality is needed to interpret recreational discard data.

- Explore alternative biomass indices for development of biomass proxies for reference point determination based on multiple survey indices.

- Evaluate the current biomass reference point and consider alternative proxy reference points such as B_{MAX} (the relative biomass associated with F_{MAX}).

- Continue exploration of relative biomass and relative exploitation calculations based on CPUE data from the recreational private boat fishery. *Use a different CPUE measure than what is in the trawl survey, Paul will do it.*

- Surveys should be evaluated to test the assumption of equal catchability at age in projections (i.e. through forward projection methods).

- In the absence of reliable estimates of the catch, consideration should be given to simple forward projection models that rely on trends from the survey indices in the absence of catch information. 35th SAW Consensus Summary 141 Done, Done in AIM resulted in no improvement over VPA because inconstancy between fishery dependent and independent data.

- Design an optimal sampling plan that would be considered for implementation by the fishery observer sampling, recreational, and commercial port sampling program. Formal sampling design has been implemented in the at sea observer program (SBRM), Redesign of MRFSS (MRIP), For all sampling these programs are designed for multi-species and are designed for optimal sampling of all species and not a single species.

- Explore alternative decision support methodologies for updating TALs directly from relative trends in abundance without relying on direct estimates of F. *Explored but no alternatives have been acceptable.*

- Age backlog of samples. (NMFS, MA)

- Conduct an aging comparison/workshop to (1) compare ototliths and scales (2) compare state age length keys.

- Biological studies to investigate factors affecting annual availability of scup to research surveys and maturity schedules.

- Explore other approaches for analyzing survey data, including bootstrap resampling methods to generate approximate confidence intervals around the survey index point estimates. *Needs to be done, low priority*

Research Needs Identified as Being Met or in Progress

- The SARC discussed some of the reasons why the research recommendations from previous SARCs had not been adequately addressed. There is currently no mechanism for accountability, resulting in other research needs taking priority. It was suggested that summaries of research recommendations be forwarded to the NRCC for review and comment, followed by a feasibility analysis. At that point a list of priorities and perhaps assignments for research could be made. The SARC recommends that a working group be developed to assess what group would be best suited to address each research need. *This is now a TOR that must be responded to in each assessment.*
- Investigate the statistical properties of the three commercial discard estimation approaches presented for consideration in future analyses. *In progress.*
- Quantify the percentage of commercial fishery trips that had discards, but no landings, and evaluate how such trips contribute to the total commercial fishery discard estimate. *In progress*

Spanish Mackerel

High Priority

- Biological data collection should be increased and should include all states where Spanish mackerel are landed.
- Evaluation of weight and especially length at age of Spanish mackerel, including updated conversion equations (e.g., gutted to whole weight) and sampling of age-0 fish.
- Development of fishery-independent methods to monitor stock size of Atlantic Spanish mackerel (consider aerial surveys used in south Florida waters).
- Improved information on discard rates and discard mortality, including 5-10% observer coverage of commercial fisheries.
- Simulations on CPUE trends should be explored and impacts on VPA and assessment results determined.
- Determine the bycatch of Spanish mackerel in the directed shrimp fishery in Atlantic
- Coastal waters.
- Conduct an aging workshop to develop approved methods and reporting standards, include lab exchanges of structures
- More timely reporting of mid-Atlantic catches for quota monitoring.
- Provide better estimates of recruitment, natural mortality rates, fishing mortality rates, and standing stock. Specific information should include an estimate of total amount caught and distribution of catch by area, season, and type of gear.
- Develop methodology for predicting year class strength and determination of the relationship between larval abundance and subsequent year class strength.
- Commission and member states should support and provide the identified data & input needed to improve the SAFMC's SEDAR process.

Medium Priority

- Yield per recruit analyses should be conducted relative to alternative selective fishing patterns.
- Evaluate potential bias of the lack of appropriate stratification of the data used to generate age-length keys for Atlantic and Gulf Spanish mackerel.
- Evaluate CPUE indices related to standardization methods and management history, with emphasis on greater temporal and spatial resolution in estimates of CPUE.
- Evaluate whether catchability varies with abundance or environmental conditions
- Determine normal Spanish mackerel migration routes and changes therein, as well as the climatic or other factors responsible for changes in the environmental and habitat conditions, which may affect the habitat and availability of stocks.
- Determine the relationship, if any, between migration of prey species (i.e., engraulids, clupeids, carangids), and migration patterns of the Spanish mackerel stock.

Low Priority

- Complete research on the application of assessment and management models relative to dynamic species such as Spanish mackerel.
- Delineation of spawning areas and areas of larval abundance through temporal and spatial sampling.
- Consideration of MRFSS add-ons or other mechanisms for collection of socioeconomic data for recreational and commercial fisheries.
- The full implementation of ecosystem-based management and the implementation of monitoring /research efforts needed to support ecosystem-based management needs should be conducted.

Spiny Dogfish

High Priority

- Determine coastwide discard mortality rate for fixed and mobile gear fisheries that catch dogfish as bycatch.
- Characterize and quantify bycatch of spiny dogfish in other fisheries.
- Monitor the level of effort and harvest in other fisheries as a result of no directed fishery for spiny dogfish.
- Increase observer trips to document the level of incidental capture of spiny dogfish during the spawning stock rebuilding period.
- Continue work on the change-in-ratio estimators for mortality rates and suggest several options for analyses
- Standardize age determination along the entire East coast. Conduct an aging workshop for spiny dogfish, encouraging participation by NEFSC, NCDMF, Canada DFO, and other interested agencies, academia and other international investigators with and interest in dogfish aging (US and Canada Pacific Coast, ICES).
- Quantify effort directed on spiny dogfish in waters outside of the U.S.
- Conduct a coastwide tagging study to explore stock structure, migration, and mixing rates.

Medium Priority

- Increase the biological sampling of dogfish in the commercial fishery and on research trawl surveys.
- Identify how spiny dogfish abundance and movement affect other organisms.
- Monitor the changes to the foreign export markets for spiny dogfish, and evaluate the potential to recover lost markets or expand existing ones.

Low Priority

- Further analyses of the commercial fishery is also warranted, especially with respect to the effects of gear types, mesh sizes, and market acceptability on the mean size of landed dogfish.
- Continue to analyze the effects of environmental conditions on survey catch rates.
- Update on a regular basis the characterization of fishing communities involved in the spiny dogfish fishery, including the processing and harvesting sectors, based upon Hall-Arber et al. (2001) and McCay and Cieri (2000).
- Characterize the value and demand for spiny dogfish in the biomedical industry on a state-by-state basis.
- Characterize the spiny dogfish processing sector

Research Needs Identified as Being Met

- **Genetic analysis of spiny dogfish to determine if more than one unit stock exist along the Northwest Atlantic. *Canadian researchers are working on this but not published yet.***
- **Update maturation and fecundity estimates by length class.**
- **Recover and encode information on the sex composition prior to 1980 from the survey database.**

- **Quantify effort directed on spiny dogfish in waters outside of the U.S.** ***Canada should have numbers available on this soon.***

Spot

High Priority

- In trawl fisheries or other fisheries that take significant numbers of spot, states should monitor and report on the extent of unutilized bycatch and fishing mortality on fish less than age-1. Incorporate bycatch estimates into spot assessment models.
- The effects of mandated bycatch reduction devices (BRD's) on spot catch should be evaluated in those states with significant commercial harvests.
- Fishery dependent and independent size and sex specific relative abundance estimates should be developed.
- Cooperative coastwide spot juvenile indices should be developed to clarify stock status.
- Monitor long term changes in spot abundance, growth rates, and age structure.
- Continue monitoring of juvenile spot populations in major nursery areas.
- Improve spot catch and effort statistics from the commercial and recreational fisheries, along with size and age structure of the catch, in order to develop production models.
- Criteria should be cooperatively developed for aging spot otoliths and scales, and an age validation study should be conducted.

Medium Priority

- A yield per recruit analysis should be cooperatively developed.
- Develop stock identification methods.
- Determine migratory patterns through tagging studies.
- Determine the onshore vs. offshore components of the spot fishery.

Spotted Seatrout

High Priority

- Stock assessments should be conducted to determine the status of stocks relative to the plan objective of maintaining a spawning potential of at least 20%.
- Initiate fishery independent surveys of spotted seatrout.
- Emphasis should be placed on collecting the necessary biological data to be able to conduct stock assessments and to assist in drafting fishery management plans.
- Age structure analyses by sex should be utilized in stock assessments.
- Collect data on the size or age of spotted seatrout released alive by anglers and the size and age of commercial discards.
- Continue work to examine the stock structure of spotted seatrout on a regional basis, with particular emphasis on advanced tagging techniques.
- Expand the NMFS recreational fishery survey to assure adequate data collection for catch and effort data, increased intercepts, and state add-ons of social and economic data needs.

Medium Priority

- Collection of commercial and recreational landings data should be continued and expanded.
- Identify essential habitat requirements.
- Evaluate effects of environmental factors on stock density.
- Work should be continued to examine the stock structure of spotted seatrout on a regional basis, with particular emphasis on molecular techniques.
- Collection of social and economic aspects of the spotted seatrout fishery should be initiated.
- Improve precision of effort reporting through commercial trip ticket programs.

***Notes*:**

Florida Department of Environmental Protection developed a spotted seatrout stock assessment in January 1995 that addressed by sex yield modeling, spawning potential ratios, use of fishery independent monitoring to tune virtual population models.

Commercial effort is collected through Florida's Marine Fisheries Information System (Trip Tickets).

Trip level landings data is collected through North Carolina's Trip Ticket Program.

The North Carolina Division of Marine Fisheries is currently reviewing an assessment of spotted seatrout as part of the state's first FMP for the species, due for completion in late 2008.   A statistical catch-at-age model was used to determine the status of the NC spotted seatrout population.

Summer Flounder

High Priority

- Develop a program to annually sample the length and age frequency of summer flounder discards from the recreational fishery.
- Collect and evaluate information on the reporting accuracy of recreational discards estimates in the recreational fishery.
- The SDWG noted that more comprehensive collection of otoliths, for all components of the catch-at-age matrix, needs to be collected on a continuing basis for fish larger than 60 cm (~7 years). The collection of otoliths and the proportion at sex for all of the catch components could provide a better indicator of stock productivity.
- The SDWG recommends that a reference collection of summer flounder scales and otoliths be developed to facilitate future quality control of summer flounder production aging. In addition, a comparison study between scales and otoliths as aging structures for summer flounder should be completed.
- The SDWG noted that the observed change in the sex ratio in NEFSC survey samples may result in the SSB estimates not translating as directly to egg production since there are more males proportionally in those older age-categories. Collecting information on overall fecundity for the stock, both egg condition and production may be a better indicator of stock productivity.
- Investigate trends in sex ratios and mean lengths and weights of summer flounder in state agency and federal surveys catches.
- Examine mesh selectivity patterns for a range of commonly used mesh sizes greater than the currently mandated sizes (5.5 Diamond/6 inch square)
- Continue fishery independent surveys and expand existing surveys to capture all sizes and age classes in order to develop independent catch-at-age and CPUE.
- Continue to collect and analyze age/length samples and catch/effort data from the commercial and recreational fisheries throughout the range of summer flounder.

Medium Priority

- Use NEFSC fishery observer age-length keys for 1994 and later years (as they become available) to supplement NEFSC survey data in aging the commercial fishery discard.
- Consider use of management strategy evaluation techniques to address the implications of harvest policies that incorporate consideration of retrospective patterns (see ICES Journal of Marine Science issue of May 2007).
- Undertake research to determine hooking mortality on summer flounder by circle, kahle, and regular "J" hooks and make the results of work already completed available to the Management Board.
- Conduct a detailed socio-economic study of the summer flounder fisheries.
- Research directed at evaluating the mesh exemption program should be continued, with increased sample sizes to allow reliable statistical testing of results.
- Develop stock identification methods via meristics, morphometrics, biochemical research and tagging; particularly off Virginia and North Carolina.
- Develop fish excluder devices to reduce bycatch of immature flatfish in fisheries that target species other than flounder.
- Collect data to determine the sex ratio for all of the catch components

Low Priority

- Consider treating scallop-closed areas as separate strata in calculations of summer flounder discards in the commercial fisheries.
- Conduct the basic research necessary to develop land and pen culture techniques.
- Evaluate effects of dissolved oxygen and water current requirements for adult summer flounder and summer flounder eggs.
- Evaluate the relationship between recruitment of summer flounder to nursery areas and Ekman transport or prevailing directions of water flow.
- Examine the sensitivity of the summer flounder assessment to the various unit stock hypotheses and evaluate spatial aspects of the stock to facilitate sex and spatially-explicit modeling of summer flounder.
- Conduct further research to examine the predator-prey interactions of summer flounder and other species, including food habitat studies, to better understand the influence of these other factors on the summer flounder population.
- Examine male female ratio at age-0 and potential factors (eg. environmental) that may influence determination of that ratio.
- Evaluate potential changes in fishery selectivity relative to the spawning potential of the stock; analysis should consider the potential influence of the recreational and commercial fisheries.
- Determine the appropriate level for the steepness of the S-R relationship and investigate how that influences the biological reference points.

Tautog

High Priority

- Establish standardized state-by-state long-term fisheries independent surveys to monitor tautog abundance and length-frequency distributions, and to develop young-of-the-year indices.
- Initiate biological sampling of the commercial catch for each gear type over the entire range of the stock (Including weight, lengths, age, sex, and discards).
- Increase collection of effort data for determining commercial and recreational CPUE.
- Increase MRFSS sampling levels to improve recreational catch estimates by state and mode. Current sampling levels are high during times of the year when more abundant and popular species are abundant in catches, but much lower than in early spring/late fall when tautog catches are more likely.

Medium Priority

- Define larval diets and prey availability requirements. This information can be used as determinants of recruitment success and habitat function status. Information can also be used to support aquaculture ventures with this species.
- Define local and regional movement patterns and site fidelity in the southern part of the species range. This information may provide insights into questions of aggregation vs. recruitment to artificial reef locations. More clarification is required on what the southern part of the range is and to clarify the need for local and regional assessment.
- Define the role of prey type and availability in local juvenile/adult population dynamics over the species range. This information can explain differences in local abundance, movements, growth, fecundity, etc. Conduct studies in areas where the availability of primary prey, such as blue mussels or crabs, is dependent on annual recruitment, the effect of prey recruitment variability as a factor in tautog movements (to find better prey fields), mortality (greater predation exposure when leaving shelter to forage open bottom), and relationship between reef prey availability/quality on tautog condition/fecundity.
- Define the status (condition and extent) of optimum or suitable juvenile habitats and trends in specific areas important to the species. It is critical to protect these habitats or to stimulate restoration or enhancement, if required.
- Define the specific spawning and pre-spawning aggregating areas and wintering areas of juveniles and adults used by all major local populations, as well as the migration routes used by tautog to get to and from spawning and wintering areas and the criteria or times of use. This information is required to protect these areas from damage and overuse or excessive exploitation.
- Define the susceptibility of juveniles to coastal/anthropogenic contamination and resulting effects. This information can explain differences in local abundance, movements, growth, fecundity, and serve to support continued or increased regulation of the inputs of these contaminants and to assess potential damage. Since oil spills seem to be a too frequent coastal impact problem where juvenile tautog live, it may be helpful to conduct specific studies on effects of various fuel oils and typical exposure concentrations, at various seasonal temperatures and salinities. Studies should also be conducted to evaluate the effect of common piling treatment leachates and common antifouling paints on young of the year tautog. The synergistic effects of leaked fuel, bilge water, treated pilings, and antifouling paints on tautog health should also be studied.

Low Priority

- Define the source of offshore eggs and larvae (in situ or washed out coastal spawning).
- Confirm that tautog, like cunner, hibernate in the winter, and in what areas and temperature thresholds, for how long, and are there special habitat requirements during these times that should be protected or conserved from damage or disturbance. This information will aid in understanding behavior variability and harvest availability.

Research Needs Identified as Being Met

Ongoing effort to explore possible regional and local genetic differences (stock differentiation) and relate these to recruitment, growth, exploitation rates, and habitat differences. These differences can help support appropriate region-specific management strategies.

Ongoing effort to determine pot and trap escape vent dimensions needed to release tautog over a range of sizes.

Sample hard parts for annual aging from the catches of recreational and commercial fisheries and fishery independent surveys throughout the range of the stock. *Being conducted by all participating states.*

Weakfish

High Priority

- Collect catch and effort data including size and age composition of the catch, determine stock mortality throughout the range, and define gear characteristics. In particular, increase length-frequency sampling, particularly in fisheries from Maryland and further north.
- Derive estimates of discard mortality rates and the magnitude of discards for all commercial gear types from both directed and non-directed fisheries. In particular, quantify trawl bycatch, refine estimates of mortality for below minimum size fish, and focus on factors such as distance from shore and geographical differences.
- Conduct an age validation study.
- Identify stocks and determine coastal movements and the extent of stock mixing, including characterization of stocks in over-wintering grounds (e.g., tagging).
- Conduct spatial and temporal analysis of the fishery independent survey data. The analysis should assess the impact of the variability of the surveys in regards to gear, time of year and geographic coverage on their (survey) use as stock indicators.
- Analyze the spawner recruit relationship and examine the relationships between parental stock size and environmental factors on year-class strength.
- Develop latitudinal/seasonal/gear specific age length keys for the Atlantic coast. Increase sample sizes to consider gear specific keys.

Medium Priority

- The impact of aging errors and other statistical uncertainties in the catch-at-age matrix on virtual population analysis (VPA) should be included. Retrospective analyses are needed on all VPA approaches investigated.
- Biological studies should be conducted to better understand migratory aspects and how this relates to observed trends in weight at age. Test for individual growth differences and their geospatial pattern, as well as the geospatial pattern of the catch rate surveys.
- Define reproductive biology of weakfish, including size at sexual maturity, maturity schedules, fecundity, and spawning periodicity. Continue research on female spawning patterns: what is the seasonal and geographical extent of "batch" spawning; do females exhibit spawning site fidelity?[1]
- Compile existing data on larval and juvenile distribution from existing databases in order to obtain preliminary indications of spawning and nursery habitat location and extent.
- Conduct hydrophonic studies to delineate weakfish spawning habitat locations and environmental preferences (temperature, depth, substrate, etc.) and enable quantification of spawning habitat.
- Continue studies on mesh-size selectivity; up-to-date (1995) information is available only for North Carolina's gill net fishery. Mesh-size selectivity studies for trawl fisheries are particularly sparse.
- Assemble socio-demographic-economic data as it becomes available from ACCSP.

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[1] This is important information, but care must be taken in analysis. For instance, if a fish is captured in a net and used for fecundity, are there mechanical POFs present that would compromise assessments? Regarding maturity schedules, here is a prime example of how the NMFS survey, and NEAMAP survey, can be helpful. Right now NEFSC is cataloguing photos and histo samples of species to verify gross assessments of maturity (otos are taken for age). Consideration for this sampling should be given during the new NEAMAP survey. Most important, maturity assessments must be consistent among institutions.

- Continue studies on recreational hook-and-release mortality rates, including factors such as depth, warmer water temperatures, and fish size in the analysis. Studies are needed in deep and warm water conditions. Further consideration of release mortality in both the recreational and commercial fisheries is needed, and methods investigated to improve survival among released fish.

Low Priority

- Define restrictions necessary for implementation of projects in spawning and over-wintering areas and develop policies on limiting development projects seasonally or spatially.
- Document the impact of power plants and other water intakes on larval, post larval and juvenile weakfish mortality in spawning and nursery areas, and calculate the resultant impact to adult stock size.
- Develop a coastwide tagging database.
- Determine the onshore versus offshore components of the weakfish fishery.

Research Needs Identified as Having Being Met

Update the scale – otolith comparison for weakfish.

Winter Flounder

Coastwide

High Priority

- Expand sea sampling for estimation of commercial discards.
- Increase the intensity of commercial fishery discard length sampling.
- Focus research on quantifying mortality associated with habitat loss and alteration, contamination by toxics and power plant entrainment and impingement. Examine the implications of these anthropogenic mortalities on estimation of yield per recruit, if feasible.
- Provide reliable estimates of anthropogenic mortality from sources other than fishing. Both mortality sources should then be incorporated into fisheries yield/recruit models to simultaneously evaluate these dual mortality factors.

Lower Priority

- Conduct studies of flounder populations in impacted areas to fully quantify physiological adaptation to habitat alteration, and interactive effects, on an individual and population level.
- Evaluate the maturity at age of fish sampled in the NEFSC fall and winter surveys, as well as other inshore surveys (i.e., MEDMR, MADMF, NEAMAP, etc.).
- Develop mortality estimates from the American Littoral Society tagging data, if feasible.

Southern New England - Mid-Atlantic Stock Complex

High Priority

- Maintain or increase sampling levels and collect age information from MRFSS samples.
- Conduct studies to delineate all major substocks in terms of geographic spawning area and seasonal offshore movements (e.g. exposure to fishing pressure).
- Examine the sources of differences between NEFSC, MA, and CT survey maturity (validity of evidence for younger size/age at 50% maturity in NEFSC data). Compare NEFSC inshore versus offshore strata for differences in maturity. Compare confidence intervals for maturity ogives. Calculate annual ogives and investigate for progression of maturity changes over time. Examine maturity data from NEFSC strata on Nantucket Shoals and near George=s Bank separately from more inshore areas. Consider methods for combining maturity data from different survey programs. *Note that this work is in progress.*
- Conduct periodic maturity staging workshops involving state and NEFSC trawl survey staff.
- Examine the implications of anthropogenic mortalities caused by pollution and power plant entrainment in estimation of yield per recruit, if feasible.

Medium Priority

- Examine egg and larvae distribution and abundance to determine yield per recruit to predict future biomass development for the fishery.
- Understand distribution of winter flounder during each life stage by conducting tagging methods; in which majority of research focuses on juvenile to adult life stages, which would be useful for estimating yield per recruit and helpful to find answers as to why recruitment is at a vulnerable state.
- Examine winter flounder distribution, abundance, and productivity based on oceanographic and climatic warming temperatures and how that impacts biomass for the fishery in SNE/MA waters.

Low Priority

- Examine predator-prey relationships due to increased populations of cormorants seals, and striped bass (examine stomach contents of predators to get a better idea on the quantification of predation on winter flounder by these predators).
- Quantify adult female to male ratios to determine the possibility of populations decline due to a skewed gender ratio.

Gulf of Maine Stock

<u>High Priority</u>

- Process archived age samples from surveys and commercial landings, and develop analytical age based assessment.[1]
- Improve sampling for biological data (particularly hard parts for ageing) of commercial landings of winter flounder.
- Expand sea sampling in order to validate commercial discard estimates from Vessel Trip Reports (logbooks).
- Update or conduct regional maturity studies. This may require a maturity workshop to ensure the use of standardized criteria among regional studies.
- Develop a geographically more comprehensive data set to calculate maturity at age, reflecting any differential availability of mature fish to inshore and offshore surveys. Re-examine the maturity ogive to incorporate any recent research results. (see below also)
- Incorporate the results from the MEDMR research trawl survey (begun in 2000) into the assessment as they become available.
- Further examine the stock boundaries to determine if Bay of Fundy winter flounder should be included in the Gulf of Maine stock complex.
- Examine growth variations within the Gulf of Maine, using results from the Gulf of Maine Biological Sampling Survey (1993-94).[2]

<u>Medium Priority</u>

- Maintain or increase sampling levels and collect age information from MRFSS samples.
- Evaluate size-selectivity performance of survey gear compared to typical commercial gear, and implications for estimation of commercial discards from research survey length frequency information.
- Evaluate the feasibility of virtual population analysis based only on ages fully recruited to landings (i.e. no discards).

<u>Low Priority</u>

- Evaluate effects of smoothed length-frequency distributions on the relationship between survey and commercial catches at length.
- Estimate/evaluate effects of catch-and-release components of recreational fishery on discard at age.

[1] MEDMR has archived WF otoliths since 2002.
[2] Biological data on WF has been collected on the MEDMR trawl survey from 2000-2008, we need to use this data as well.

FUTURE HABITAT RESEARCH INFORMATION NEEDS FOR DIADROMOUS SPECIES

Group I. Research Needs for All Commission-Managed Diadromous Species

Dams and Other Obstructions

Fish Passage

1) Evaluate performance of conventional fishways, fish lifts, and eel ladders, and determine features common to effective passage structures and those common to ineffective passage structures.
2) Conduct basic research into diadromous fish migratory behavior as it relates to depth, current velocity, turbulence, entrained air, light, structures, and other relevant factors.
3) Use information from (1) and (2) to conduct computer fluid dynamics (CFD) modeling to develop more effective fishway designs.
4) Research technologies (barriers, guidance systems, etc.) for directing emigrating fish to preferred passage routes at dams.
5) Identify low-cost alternatives to traditional fishway designs.
6) Develop effective downstream passage strategies to reduce mortality.

Other Dam Issues

1) Document the impact of power plants and other water intakes on larval, postlarval, and juvenile mortality in anadromous fish spawning areas, and calculate the resultant impacts to adult population sizes.
2) Evaluate the upstream and downstream impacts of barriers on diadromous species, including population and distribution effects.

Water Quality and Contamination

1) Determine effects of change in temperature and pH for all life stages of all diadromous species. Use this information to model impacts of climate change on species.
2) Develop studies to document which contaminants have an impact on the various life stages of each diadromous species; also note the life stages that are affected, and at what concentrations.
3) Determine unknown optima and tolerance ranges for depth, temperature, salinity, dissolved oxygen, pH, substrate, current velocity, and suspended solids.

Habitat Protection and Restoration

1) Use multi-scale approaches (including GIS) to assess indicators of suitable habitat, using watershed and stream-reach metrics if possible (it should be noted, that where site-specific data is lacking, it may not be appropriate to assess at this scale).
2) Use multi-scale approaches for restoring diadromous fish habitat, including vegetated buffer zones along streams and wetlands, and implementing measures to enhance acid-neutralizing capacity.
3) Conduct studies on the effects of land use change on diadromous species population size, density, distribution, health, and sustainability.

4) Examine how deviation from the natural flow regime impacts all diadromous species. This work should focus on key parameters such as rate of change (increase and decrease), seasonal peak flow, and seasonal base flow, so that the results can be more easily integrated into a year-round flow management recommendation by state officials.
5) Investigate consequences to diadromous stocks from wetland alterations.

Other

1) Determine survival and mortality rates for all life stages of all diadromous species.
2) Investigate predator-prey relationships for all life stages of all diadromous species.
3) Determine the effects of channel dredging, shoreline filling, and overboard spoil disposal in the Atlantic coast on diadromous species.
4) Define restrictions necessary for implementation of energy projects in diadromous species habitat areas, and develop policies on limiting development projects seasonally or spatially.

Group II. Alosine-Specific Research Needs

Water Quality and Contamination

1) Review studies dealing with the effects of acid deposition on anadromous alosines.
2) Determine if intermittent episodes of pH depressions and aluminum elevations (caused by acid rain) affect any life stage in freshwater that might lead to reduced reproductive success of alosines, especially in poorly buffered river systems.
3) Determine if chlorinated sewage effluents are slowing the recovery of depressed shad stocks.

Habitat Protection and Restoration

1) Conduct research on habitat requirements for all life stages of hickory shad.

Migration

1) Determine factors that regulate and potentially limit downstream migration, seawater tolerance, and early ocean survival of juvenile alosines.
2) Conduct research on hickory shad migratory behavior.

Other

1) Focus research on within-species variation in genetic, reproductive, morphological, and ecological characteristics, given the wide geographic range and variation at the intraspecific level that occurs in alosines.
2) Research predation rates and impacts on alosines.
3) Evaluate the effect of bycatch on alosines.
4) Ascertain how abundance and distribution of potential prey affect growth and mortality of early life stages of alosines.

Group III. American Eel-Specific Research Needs

Dams and Other Obstructions

Fish Passage

1) Research the behavior of American eel approaching hydropower dams to determine searching behavior and preferred routes of approach to confirm best siting options for upstream passage.
2) Investigate, develop, and improve technologies for American eel passage upstream and downstream at various barriers for each life stage.
3) Investigate how river flow, lunar phase, water temperature, and behavior near artificial lighting impact the behavior of American eel, and influence the amount of time that the eels spend at a dam.
4) Research the behavior of silver eels at downstream passages; determine specific behavior of eels migrating downstream, and research how they negotiate and pass hydropower facilities.

Water Quality and Contamination

1) Determine the effects of contaminant bioaccumulation on American eel, including impacts on survival and growth (by age), maturation, and reproductive success.
2) Research the ability of contaminated eels to carry out successful breeding.
3) Examine the environmental conditions required for the hatching success of American eel.

Habitat Protection and Restoration

1) Establish characteristics and distribution of American eel habitat (using conventional methods as well as GIS), and the value of that habitat with respect to growth and sex determination.
2) Determine the effects of loss of historic habitat to potential American eel population and reproductive capacity.
3) Investigate the impact of seaweed harvesting on American eel.
4) Research the changes in ocean climate and environmental quality that might influence larval and adult eel migration, spawning, recruitment, and survival, including oceanic heat transport and interactions with the atmosphere and greenhouse gas warming.
5) Determine the importance of coastal lakes and reservoirs to American eel populations.

Migration

Silver-phase

1) Identify migratory routes and guidance mechanisms of silver eels migrating to the ocean.
2) Determine mechanisms for the recognition of the spawning area by silver eels, mate location in the Sargasso Sea, spawning behavior, and gonadal development in maturation.

3) Identify verify specific American eel spawning locations in the Sargasso Sea.
4) Research the factors that cause American eel to initiate downstream migration and affect their patterns of movement.

Leptocephalus

1) Identify the precise mechanisms of larval transport for American eel.
2) Examine the mechanisms for leptocephalus exit from the Sargasso Sea and transport across the continental shelf.
3) Determine mechanisms of recruitment of leptocephali and glass eels to coastal areas.

Glass Eel

1) Investigate the impact of stream velocity/discharge and stream morphology on upstream migration of glass eel and elvers.

Yellow-phase

1) Research behaviors and movements of American eel during their freshwater residency.

Parasitism

1) Evaluate the occurrence and impact of the nematode parasite, *Anguillicola crassus*, on all life stages.

Feeding

1) Examine the mode of nutrition for leptocephali in the ocean.
2) Examine food habits for glass eels at sea.

Other

1) Research all aspects of the leptocephalus life history stage.

<u>Group IV. Atlantic Sturgeon-Specific Research Needs</u>

Dams and Other Obstructions

Fish Passage

1) Fish passage requirements and appropriate structures for Atlantic sturgeon are largely unknown. Research all fish passage requirements for Atlantic sturgeon.

Bycatch

1) Determine levels of bycatch and compare to F_{50} target levels for individual Atlantic sturgeon populations.
2) Characterize Atlantic sturgeon bycatch in various fisheries by gear and season; include data on fish size, health condition at capture, and number of fish captured.
3) Develop markers that permit identification of bycatch of Atlantic sturgeon by population origin.

Population Status

1) Conduct assessments of population abundance and age structure in various river systems, with particular emphasis on documenting occurrence of age 0-12 juveniles and spawning adult Atlantic sturgeon as indicators of natural reproduction.
2) Continue to determine the extent to which Atlantic sturgeon are genetically differentiable among rivers, and interpret biological significance of findings.
3) Conduct further analyses to assess the sensitivity of F_{50} to model inputs for northern and southern stocks of Atlantic sturgeon.

Culture and Stock Enhancement

1) Further develop techniques for capture, transport, and long-term holding of wild Atlantic sturgeon brood stock.
2) Refine maturation-induced spawning procedures, and sperm cryo-preservation techniques for Atlantic sturgeon to assure availability of male gametes.
3) Continue basic cultural experiments at all life stages of Atlantic sturgeon to provide information on:
    a. Efficacy of alternative spawning techniques
    b. Egg incubation and fry production techniques
    c. Holding and rearing densities
    d. Prophylactic treatments
    e. Nutritional requirements and feeding techniques, and
    f. Optimal environmental rearing conditions and systems.
4) Identify suitable stocking protocols for hatchery-reared Atlantic sturgeon (e.g., individual size, time of year, site, and marking technique).
5) Conduct and monitor pilot-scale Atlantic sturgeon stocking programs before conducting large-scale efforts that encompass a broad geographic area.
6) Establish Atlantic sturgeon stocking goals and success criteria prior to development of large-scale stock enhancement or recovery programs.

Tagging and Tissues

1) Standardize collection procedures, and develop a suitable long-term repository for Atlantic sturgeon biological tissues for use in genetic and other studies.
2) Establish coordinated tagging programs to delineate migratory patterns and stock composition, giving priority to marking juveniles in important sturgeon rivers before they migrate to the ocean.
3) Maintain database for tagged Atlantic sturgeon.
4) Identify rates of tag loss and tag reporting for Atlantic sturgeon.
5) Analyze existing sea sampling data to characterize at-sea migratory behavior. Use electronic tagging to model coastal migrations of juvenile and adult Atlantic sturgeon.

Maturity and Aging

1) Develop methods to determine sex and maturity of captured Atlantic sturgeon.
2) Evaluate aging techniques for Atlantic sturgeon with known-age fish, with emphasis on verifying current methodology based on fin rays.

3) Determine length, fecundity, and maturity at age for all Atlantic sturgeon stocks.
4) Develop a protocol for ageing validation in Atlantic sturgeon.

Group V. Striped Bass-Specific Research Needs

To be identified shortly.

ASMFC Critical Research Needs in Support of Interjurisdictional Fisheries Management

2009

American Eel

- Formulate a coastwide fishery-independent sampling program for yellow and silver American eels using standardized and statistically robust methodologies.
- Investigate: fecundity, length, and weight relationships for females throughout their range; growth rates for males and females throughout their range; age and maturity data.
- Investigate, develop, and improve technologies for American eel passage upstream and downstream at various barriers for each life stage. In particular, investigate low-cost alternatives to traditional fishway designs for passage of eel.

American Lobster

- Develop reliable sex-specific estimates of molt frequency and molt increment for each stock.
    - Address problems associated with the growth matrix through aging studies or use of the extensive Canadian tag database for obtaining better estimates of growth and molt frequency. Apply the biochemical assessment of lipofuscin content to help estimate growth.
- Develop a reliable recruitment index, based on the ventless trap catches, larval/settlement indices, etc. A standardized coast-wide fishery-independent survey that is designed to target American lobster, such as the ventless trap survey, is critical for this.
- Increase biological sampling (either port or sea-sampling), especially in offshore areas of the Gulf of Maine, Georges Bank, and the Southern New England Canyons.

American Shad/River Herring

- Determine American shad and river herring bycatch within state and ocean waters.
- Determine which stocks are impacted by coastal intercept fisheries (including bycatch fisheries) and evaluate the fishing mortality on those stocks. Methods to be considered to differentiate among stocks could include otolith micro-chemistry, oxytetracycline otolith marking, tagging or DNA/RNA methods.
- Conduct population assessments on river herring, including biosampling - particularly needed in the south.
- Continue to assess current aging techniques for American shad and river herring, using known age fish, scales, otoliths, and spawning marks.
- Determine predation by fish, mammals and birds on American shad and river herring.

Atlantic Croaker

- Develop fishery-dependent and independent size, age and sex specific relative abundance estimates to monitor long term changes in croaker abundance.
- Improve catch and effort statistics from the commercial and recreational fisheries, along with size and age structure of the catch.
- Conduct stock identification research on croaker via otoliths microchemistry, tagging, or genetics.

Atlantic Menhaden

- Develop and improve fishery-independent estimates of adult abundance at age on a coast-wide scale to replace or augment the existing pound net index. Aerial survey has been discussed, perhaps in cooperation with the menhaden industry using spotter pilots.
- Develop and test methods for estimating size of recruiting year-classes of juveniles using fishery-independent survey techniques. State seine indices are used for juvenile abundance indices, but there is a need to update information on stream productivity for combining across state surveys for a coastwide index.

Atlantic Sea Herring

- Synthesize predator/prey information and conduct investigations to address information gaps; investigate the role of herring in the Northwest Atlantic ecosystem and the importance of herring as a forage species for other commercial fish stocks; assess the importance of herring as forage relative to other forage species in the region.
    - Re-evaluate Atlantic herring natural mortality by age and the response to changing predator population sizes through an ecosystem based assessment.
- Investigate bycatch/discards in the directed herring fishery through both at-sea and portside sampling.
- Continue tagging and morphometric studies to explore uncertainties in stock structure and the impacts of harvest mortality on different components of the stock. Although tagging studies may be problematic for assessing survivorship for a species like herring, they may be helpful in identifying the stock components and the proportion of these components taken in the fishery on a seasonal basis.

Atlantic Striped Bass

- Develop a spatial, temporal and sex specific catch-at-age model incorporating tag-based movement information.
- Compare scale and otolith ages and develop methodology to incorporate otolith ages into the assessment.
- Continue in-depth analysis of migrations, stock compositions, etc. using mark-recapture data (ongoing, e.g., Cooperative Winter Tagging Cruise 20 Year Report, W. Laney).
- Examine potential biases associated with the number of tagged individuals, such as gear-specific mortality (associated with trawls, pound nets, gill nets, and electrofishing), tag-induced mortality, and tag loss.

Atlantic Sturgeon

- Establish current spawning stock status in historic spawning rivers, and evaluate habitat use, or suitability.
    - Conduct assessments of population abundance and age structure in various river systems. Particular emphasis should be placed in documenting occurrence of age 0-1 juveniles and spawning adults as indicators of natural reproduction.
- Characterize size, condition, and relative abundance of Atlantic sturgeon by gear and season taken as bycatch in various fisheries.
- Establish stocking goals and success criteria prior to development of stock enhancement or recovery programs.

Black Sea Bass

- Develop fishery-independent surveys and expand existing surveys to capture all sizes and age classes in order to develop independent catch-at-age and CPUE. Expansion could include improvements or augmentation of existing trawl surveys and/or addition of a pot type survey to acquire older ages.
- Increase sea sampling to verify information from commercial logbooks to provide better estimates of discards. Should be part of a comprehensive fisheries dependent sampling program for both the recreational and commercial fisheries.
- Increase age sampling across all components of the fishery. Could be done through a comprehensive multispecies market and recreational catch sampling program.

Bluefish

- Collect size and age composition of the fisheries by gear type and statistical area.
- Initiate fishery-dependent and independent sampling of offshore populations of bluefish during the winter months.
- Evaluate amount and length frequency of discards from the commercial and recreational fisheries.

Coastal Sharks

- Continue to acquire better species-specific landings information on number of species, including smooth dogfish, by weight, from dealers.
- Conduct smooth dogfish assessment.
- Better identify and quantify the use of Essential Fish Habitat and nursery areas for shark species found along the Atlantic Coast of the U.S. Continue and expand long term shark monitoring programs to assess population status, and trends in demographic parameters.
- Identify and evaluate the effects of shark bycatch in other fisheries. Initiate or expand species identification of bycatch in shrimp trawls to allow for better bycatch estimates particularly of blacknose sharks and other shark species.

Horseshoe Crab

- Model relationship between egg availability and spawning biomass/abundance.
- Expand or implement fishery-independent surveys to encompass the full range of horseshoe crabs along the coast including inland waters.
- Assess horseshoe crab prey availability and determine whether horseshoe crab population growth will be/is limited by prey availability.

Northern Shrimp

- Refine annual estimates of consumption by predators. Consumption estimates could lead to annual estimates of *M* that would be more realistic than assuming constant *M*, for use in models that include *M* explicitly. Alternatively, consumption estimates could be used in production models as annual removals similar to fishery removals.
    - o Continue NEFSC bottom trawl survey finfish stomach sampling. Initiate a similar program for the ME/NH and MA surveys. Improve predator/prey spatial and temporal overlaps from available data.
- Better characterize shrimp discards in the shrimp and other small-mesh (i.e., herring and whiting) fisheries. Resources required: more at-sea sampling; several person-months for analysis of existing VTR and sea-sampling databases.
- Explore the stock-recruitment relationship and the impact of environmental factors on larval and juvenile abundance, growth, and survival.
    - o Extend the range of environmental variables and datasets used previously. Integrate the biological and environmental data sets and conduct multivariate analyses of effects of the environmental variables.

Red Drum

- Support fishery-independent sampling of sub-adult and adult red drum in each state from Virginia to Florida. The purpose of this survey would be to: 1) verify escapement to the spawning population, 2) provide an index of recruitment to age-1, and 3) provide an estimate of the biomass of adult red drum.
- Continue tagging studies to determine stock identity, inshore/offshore migration patterns and mortality estimation.

Scup

- Maintain the current level of sampling, particularly of the discards, to adequately characterize the length composition of both landings and discards, to ensure reliability of the analytic assessment and forecasts of catch and stock biomass for this stock.
  - Expanded age sampling of scup from commercial and recreational catches is required, with special emphasis on the acquisition of large specimens. Need to increase observer coverage for winter I offshore directed scup fishery and bycatch squid fishery.
- Continue to support and fund both the Rhode Island commercial fish trap survey and the Fishery Independent Scup Survey of Hard Bottom Areas in Southern New England Waters. Expand the fishery independent survey to include waters farther west and collect scales for aging.

Spanish Mackerel

- Evaluate weight- and especially length-at-age, including updated conversion equations (e.g., gutted to whole weight) and sampling of age-0 fish.
- Improved information on discard rates and discard mortality, including 5-10 % observer coverage of commercial fisheries.
- Increase biological sampling, especially hard parts for aging, from all states where Spanish mackerel are landed.
- Determine the bycatch of Spanish mackerel in the directed shrimp fishery in Atlantic Coastal waters.
- Develop fishery-independent methods to monitor stock size of Atlantic Spanish mackerel (consider aerial surveys used in south Florida waters).

Spiny Dogfish

- Characterize and quantify bycatch of spiny dogfish in other fisheries.
- Determine coastwide discard mortality rate for fixed and mobile gear fisheries that catch dogfish as bycatch.
- Conduct a coastwide tagging study to explore stock structure, migration, and mixing rates.
- Standardize age determination along the entire East coast. Conduct an aging workshop for spiny dogfish, encouraging participation by NEFSC, NCDMF, Canada DFO, and other interested agencies, academia and other international investigators with an interest in dogfish aging (US and Canada Pacific Coast, ICES).

Spot

- Improve spot catch and effort statistics from the commercial and recreational fisheries, along with size and age structure of the catch, in order to develop production models.
- Develop fishery-dependent and independent size- and sex-specific relative abundance estimates.
- Develop cooperative coastwide spot juvenile indices to clarify stock status.
- Monitor and report on the extent of unutilized bycatch and fishing mortality on fish less than age-1in trawl fisheries or other fisheries that take significant numbers of spot. Incorporate bycatch estimates into spot assessment models.
- Monitor long term changes in spot abundance, growth rates, and age structure.

Spotted Seatrout

- Initiate fishery-independent surveys of spotted seatrout, especially for juvenile abundance indices. Begin with a review of existing data and programs. States should conduct routine fishery-independent surveys using entanglement gear to generate annual indices of abundance for use in regional stock assessments.
- Collect the necessary biological data to be able to conduct stock assessments and to assist in drafting fishery management plans.

Summer Flounder

- Develop a program to annually sample the length- and age-frequency of summer flounder discards from the recreational fishery.
    - Expand MRIP for-hire survey to collect scale samples; expand to collect samples from other modes, or utilize existing volunteer angler surveys. Ideally, this would be part of a long term comprehensive fishery-dependent sampling program.
- Continue to collect and analyze age/length samples and catch/effort data from the commercial and recreational fisheries throughout the range of summer flounder. Increase the number of length samples taken by MRIP.
- Collect otoliths more comprehensively, for all components of the catch-at-age matrix, on a continuing basis for fish larger than 60 cm (~7 years). Collecting information on overall fecundity for the stock, both egg condition and production may be a better indicator of stock productivity.
- Continue fishery-independent surveys and expand existing surveys to capture all sizes and age classes in order to develop fishery-independent catch-at-age and CPUE.

Tautog

- Establish standardized state-by-state long-term fishery-independent surveys to monitor tautog abundance and length-frequency distributions, and to develop young-of-the-year indices.
- Increase MRIP sampling levels to improve recreational catch estimates by state and mode. Current sampling levels are high during times of the year when more abundant and popular species are abundant in catches, but much lower than in early spring/late fall when tautog catches are more likely.
- Initiate biological sampling of the commercial catch for each gear type over the entire range of the stock (including weight, lengths, age, sex, and discards).

Weakfish

- Conduct spatial and temporal analysis of the fishery-independent survey data. The analysis should assess the impact of the variability of the surveys in regards to gear, time of year and geographic coverage on the use of the surveys as stock indicators.
- Analyze the spawner-recruit relationship and examine the relationships between parental stock size and environmental factors on year-class strength.
  - Analyze the characteristics of the process error variability (noise) in the recruitment dynamics.
- Identify stocks and determine coastal movements and the extent of stock mixing, including characterization of stocks in over-wintering grounds (e.g., tagging).
  - Develop an operational model(s) that incorporates catch uncertainty, to improve on limitations of the currently used VPA model.

Winter Flounder

- Expand sea sampling for estimation of commercial discards.

FISHERY ECOSYSTEM PLAN OF THE SOUTH ATLANTIC REGION

VOLUME V: SOUTH ATLANTIC RESEARCH PROGRAMS AND DATA NEEDS

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ABBREVIATIONS AND ACRONYMS

ABC	Acceptable Biological Catch
ACCSP	Atlantic Coastal Cooperative Statistics Program
APA	Administrative Procedures Act
AUV	Autonomous Underwater Vehicle
B	A measure of stock biomass either in weight or other appropriate unit
B_{MSY}	The stock biomass expected to exist under equilibrium conditions when fishing at F_{MSY}
B_{OY}	The stock biomass expected to exist under equilibrium conditions when fishing at F_{OY}
B_{CURR}	The current stock biomass
CEA	Cumulative Effects Analysis
CEQ	Council on Environmental Quality
CFMC	Caribbean Fishery Management Council
CPUE	Catch per unit effort
CRP	Cooperative Research Program
CZMA	Coastal Zone Management Act
DEIS	Draft Environmental Impact Statement
EA	Environmental Assessment
EBM	Ecosystem-Based Management
EEZ	Exclusive Economic Zone
EFH	Essential Fish Habitat
EFH-HAPC	Essential Fish Habitat - Habitat Area of Particular Concern
EIS	Environmental Impact Statement
EPAP	Ecosystem Principles Advisory Panel
ESA	Endangered Species Act of 1973
F	A measure of the instantaneous rate of fishing mortality
$F_{30\%SPR}$	Fishing mortality that will produce a static SPR = 30%.
$F_{45\%SPR}$	Fishing mortality that will produce a static SPR = 45%.
F_{CURR}	The current instantaneous rate of fishing mortality
FMP	Fishery management plan
F_{MSY}	The rate of fishing mortality expected to achieve MSY under equilibrium conditions and a corresponding biomass of B_{MSY}
F_{OY}	The rate of fishing mortality expected to achieve OY under equilibrium conditions and a corresponding biomass of B_{OY}
FEIS	Final Environmental Impact Statement
FMU	Fishery Management Unit
FONSI	Finding Of No Significant Impact
GOOS	Global Ocean Observing System
GFMC	Gulf of Mexico Fishery Management Council
IFQ	Individual fishing quota
IMS	Internet Mapping Server
IOOS	Integrated Ocean Observing System
M	Natural mortality rate

MARMAP	Marine Resources Monitoring Assessment and Prediction Program
MARFIN	Marine Fisheries Initiative
MBTA	Migratory Bird Treaty Act
MFMT	Maximum Fishing Mortality Threshold
MMPA	Marine Mammal Protection Act of 1973
MRFSS	Marine Recreational Fisheries Statistics Survey
MSA	Magnuson-Stevens Act
MSST	Minimum Stock Size Threshold
MSY	Maximum Sustainable Yield
NEPA	National Environmental Policy Act of 1969
NMFS	National Marine Fisheries Service
NMSA	National Marine Sanctuary Act
NOAA	National Oceanic and Atmospheric Administration
NRC	National Research Council
OY	Optimum Yield
POC	Pew Oceans Commission
R	Recruitment
RFA	Regulatory Flexibility Act
RIR	Regulatory Impact Review
SAFE	Stock Assessment and Fishery Evaluation Report
SAFMC	South Atlantic Fishery Management Council
SEDAR	Southeast Data, Assessment, and Review
SEFSC	Southeast Fisheries Science Center
SERO	Southeast Regional Office
SDDP	Supplementary Discard Data Program
SFA	Sustainable Fisheries Act
SIA	Social Impact Assessment
SSC	Scientific and Statistical Committee
TAC	Total allowable catch
T_{MIN}	The length of time in which a stock could rebuild to B_{MSY} in the absence of fishing mortality
USCG	U.S. Coast Guard
USCOP	U.S. Commission on Ocean Policy
VMS	Vessel Monitoring System

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9.0 Data and Research Necessary to Support Ecosystem Management

9.1 Research Needs and Research and Monitoring Plans

The 2006 reauthorization of the Magnuson-Stevens Act includes the following language pertaining to research and monitoring needs for regional fishery management councils:

(c) COUNCIL FUNCTIONS.—Section 302(h) (16 U.S.C. 1852(h)) is amended—
''(6) develop annual catch limits for each of its managed fisheries that may not exceed the fishing level recommendations of its scientific and statistical committee or the peer review process established under subsection (g); and''.

(d) SCIENTIFIC RESEARCH PRIORITIES.—Section 302(h) (16 U.S.C. 1852(h)), as amended by subsection (c), is further amended—
(1) by striking ''(g); and'' in paragraph (6) and inserting ''(g);''; (2) by redesignating paragraph (7), as redesignated by subsection (c)(2), as paragraph (8); (2) by inserting after paragraph (6) the following: ''(7) develop, in conjunction with the scientific and statistical committee, multi-year research priorities for fisheries, fisheries interactions, habitats, and other areas of research that are necessary for management purposes, that shall—
''(A) establish priorities for 5-year periods;
''(B) be updated as necessary; and
''(C) be submitted to the Secretary and the regional science centers of the National Marine Fisheries Service for their consideration in developing research priorities and budgets for the region of the Council; and''.

SEC. 318. COOPERATIVE RESEARCH AND MANAGEMENT PROGRAM.
''(a) IN GENERAL.—The Secretary of Commerce, in consultation with the Councils, shall establish a cooperative research and management program to address needs identified under this Act and under any other marine resource laws enforced by the Secretary. The program shall be implemented on a regional basis and shall be developed and conducted through partnerships among Federal, State, and Tribal managers and scientists (including interstate fishery commissions), fishing industry participants (including use of commercial charter or recreational vessels for gathering data), and educational institutions.
''(b) ELIGIBLE PROJECTS.—The Secretary shall make funds available under the program for the support of projects to address critical needs identified by the Councils in consultation with the Secretary. The program shall promote and encourage efforts to utilize sources of data maintained by other Federal agencies, State agencies, or academia for use in such projects.
''(c) FUNDING.—In making funds available the Secretary shall award funding on a competitive basis and based on regional fishery management needs, select programs that form part of a coherent program of research focused on solving priority issues identified by the Councils, and shall give priority to the following projects:

‘‘(1) Projects to collect data to improve, supplement, or enhance stock assessments, including the use of fishing vessels or acoustic or other marine technology.
‘‘(2) Projects to assess the amount and type of bycatch or post-release mortality occurring in a fishery.
‘‘(3) Conservation engineering projects designed to reduce
bycatch, including avoidance of post-release mortality, reduction of bycatch in high seas fisheries, and transfer of such fishing technologies to other nations.
‘‘(4) Projects for the identification of habitat areas of particular concern and for habitat conservation.
‘‘(5) Projects designed to collect and compile economic and social data.
‘‘(d) EXPERIMENTAL PERMITTING PROCESS.—Not later than 180 days after the date of enactment of the Magnuson-Stevens Fishery Conservation and Management Reauthorization Act of 2006, the Secretary, in consultation with the Councils, shall promulgate regulations that create an expedited, uniform, and regionally-based process to promote issuance, where practicable, of experimental fishing permits.
‘‘(e) GUIDELINES.—The Secretary, in consultation with the Councils, shall establish guidelines to ensure that participation in a research project funded under this section does not result in loss of a participant’s catch history or unexpended days-at-sea as part of a limited entry system.
‘‘(f) EXEMPTED PROJECTS.—The procedures of this section shall not apply to research funded by quota set-asides in a fishery.’’.
ADDITION TO SEC 303(A) (FMP contents)
(a)(10)‘‘(15) establish a mechanism for specifying annual catch limits in the plan (including a multiyear plan), implementing regulations, or annual specifications, at a level such that overfishing does not occur in the fishery, including measures to ensure accountability.’’.
(b) EFFECTIVE DATES; APPLICATION TO CERTAIN SPECIES.—The amendment made by subsection (a)(10)—
(1) shall, unless otherwise provided for under an international agreement in which the United States participates, take effect—
(A) in fishing year 2010 for fisheries determined by the Secretary to be subject to overfishing; and
(B) in fishing year 2011 for all other fisheries; and
(2) shall not apply to a fishery for species that have a life cycle of approximately 1 year unless the Secretary has determined the fishery is subject to overfishing of that species; and
(3) shall not limit or otherwise affect the requirements of section 301(a)(1) or 304(e) of the Magnuson-Stevens Fishery
Conservation and Management Act (16 U.S.C. 1851(a)(1) or 1854(e), respectively).

9.1.1 South Atlantic Research and Monitoring Priorities 2008

Introduction

The 2006 reauthorization of the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) directs the Federal Regional Fishery Management Councils to develop a prioritized research plan for submission to the Secretary of Commerce. The following research and monitoring needs were developed by the South Atlantic Council in fulfillment of that requirement.

The goals of the South Atlantic Research and Monitoring Plan are:

1) to improve the quality and quantity of information available for stock assessment and management program development and evaluation; and

2) to encourage a proactive approach to fisheries monitoring and research with priorities based on management needs and intentions.

These goals can be fulfilled by achieving the following objectives:

- Obtain complete fisheries statistics (landings, effort, discards) for all managed resources.
- Obtain adequate landings characterization information (biological sampling of landings & discard, effort details) for priority species.
- Develop representative fishery-dependent abundance measures for priority species.
- Provide reliable and up-to-date species biology and life history information (reproduction, growth, habits, ecosystem role) for all managed resources.
- Obtain adequate economic and social characterization information for all fisheries.
- Obtain fishery and catch data necessary for the Council to monitor and evaluate its management programs.
- Document and quantify habitat usage and availability for all Southeast habitats.
- Develop robust yet documented and validated analytical models appropriate for South Atlantic resources, management requirements, and data availability.

The proposed research and monitoring plan is documented in the following sections in order of decreasing priority and is summarized as follows:

1) Collect basic data for all managed fisheries.
2) Collect biological and survey information for priority species to support qualitative stock assessments.
3) Collect specific information to support evaluation and refinement of SAFMC management programs and actions.
4) Collect basic social and economic information to support management impact evaluations.
5) Collect general habitat information to support habitat protection efforts.
6) Collect ecosystem information to support ecosystem management.

SAFMC Prioritized Research Recommendations for the first 5 years (2008-2012)

The South Atlantic Council recommends that the first priority is obtaining accurate fishery level information with increased spatial resolution for landings, discards, and effective effort. Research and monitoring programs must accommodate the multi-species nature of many South Atlantic fisheries.

To address the challenge of multi-species fisheries, the basic unit to sample proposed here is a fishery rather than a species. To address the many managed species of the SAFMC, individual species are separated into two groups: those requiring 'basic' data elements and those requiring 'detailed' data elements. Initial classification into these two groups is based on the SEDAR assessment schedule, indicator species identified by the Council, those species included in NOAA Fisheries' Fish Stock Status Indicators listing in the Report to Congress, and recommendations of the SAFMC Science and Statistics Committee.

1. Collect basic data elements by fishery

The following information applies for all fisheries listed:

- All catch and bycatch reporting to species level
- Per tow/set/site/deployment information for for-hire and commercial fisheries collected through an electronic logbook linked to GPS
- License i.d. information available for all participants/vessels linked to trip and set reports
- Global participant frame provided through licensing of all participants
- Location elements include latitude, longitude, depth, and duration of effort

1. Shrimp Trawl Fishery
   Per tow: duration, location, trawl details, catch estimate, discard estimate
   Per trip: landings by species, trip costs, price paid per lb, # crew
   Supplement: 5% observer coverage for discard, 20% coverage for detailed social & economic reporting.

2. Trap Fisheries (e.g., sea bass, golden crab, spiny lobster)
   Per trap/string: duration, location, trap details, catch estimate, discard count
   Per trip: landings by species, trip costs, price paid per lb, # crew
   Supplement: 2% observer coverage for discard, 10 % video discard coverage, 20% coverage for detailed social & economic reporting.

3. Dive or Spear Fisheries
   Per dive: duration, location, gear details, # divers, catch estimate
   Per trip: landings by species, trip costs, price paid per lb, # crew
   Supplements: 20% coverage for detailed social & economic reporting.

4. Handline Fisheries
   Per set/site: duration, location, gear details, catch estimate, discard count
   Per trip: landings by species, trip costs, price paid per lb, # crew
   Supplement: 5% observer coverage for discard, 10% video discard coverage, 20% coverage for detailed social & economic reporting.

5. Deepwater Longline Fishery
   Per set/deployment: duration, location, gear details, catch estimate, discard count
   Per trip: landings by species, trip costs, price paid per lb, # crew
   Supplement: 5% observer coverage for discard, 10% video discard coverage, 20% coverage for detailed social & economic reporting.

6. Pelagic Longline Fishery
   Per set/deployment: soak, location, gear details, catch estimate, discard count
   Per trip: landings by species, trip costs, price paid per lb, # crew
   Supplement: 5% observer coverage for discard, 10% video discard coverage, 20% coverage for detailed social & economic reporting.

7. Bottom Longline
   Per set/deployment: soak, location, gear details, catch estimate, discard count
   Per trip: landings by species, duration, trip costs, price paid per lb, # crew,
   Supplement: 5% observer coverage for discard, 10% video discard coverage, 20% coverage for detailed social & economic reporting.

8. Private Recreational
   Per trip: mode, location, gear details, duration, landings by species, discard by species, expenditures,
   Per Year: # trips by mode, location
   Supplement: Voluntary logbook for discard characteristics (e.g., size and reason for discarding), 20% coverage for detailed social & economic reporting.

9. Headboat Recreational
   Per set/site: location, duration, catch & discard estimate by species
   Per Trip: # anglers, # lines, duration, landings by species
   Supplement: 5% observer coverage for discard characteristics. Voluntary logbook for discard (size), 20% coverage for detailed social & economic reporting of owner/operators. 20% coverage for social & economic evaluations of participants.

10. Party/Charter Recreational Fishery
   Per trip: mode, location, gear details, duration, catch & discard by species
   Supplement: 5% observer coverage for discard characteristics. Voluntary logbook for discard (size), 20% coverage for detailed social & economic reporting of owner/operators. 20% coverage for social & economic evaluations of participants.

<u>2. Collect biological and survey information for priority species to support quantitative stock assessments.</u>

Detailed, species-specific information is required for species that support the bulk of fishery landings to enable high resolution assessment models (i.e., age structured models) and directed management. This information should be collected for individual species, with sampling effort allocated across time, space, and the fisheries listed above as appropriate to ensure useful and statistically valid data.

Additional Data Elements for Primary Species:

- Representative sampling by season, fishery, and area of length, age, sex, and weight for landed & discarded fish.
- Fishery-dependent CPUE, based on increased effort resolution collected through the basic elements (1)
- Survey-based fishery-independent CPUE
- Life history research: rates of growth, mortality, maturity, fecundity
- Movement, migration, and stock structure evaluations

Additional Data Elements for Secondary species:

- Fishery-dependent CPUE, based on increased effort resolution collected through the basic elements (1)
- Survey-based fishery-independent CPUE
- Life history details: rates of growth, mortality, maturity, fecundity
- Movements, migration, and stock structure evaluations

SAFMC Proposed Primary Data Collection Species:

Vermillion snapper	Yellowtail snapper
Red snapper	Gray triggerfish
Snowy grouper	Mutton snapper
Tilefish	Red porgy
Red grouper	Wreckfish
Black sea bass	King mackerel
Gag grouper	Spanish mackerel
Greater amberjack	Dolphin
White grunt	Spiny lobster

SAFMC Secondary Data Collection Species

Scamp	Yellowedge grouper
Black grouper	Goliath grouper
Blueline tilefish	Little tunny
Cobia	Wahoo
Speckled hind	Hogfish
Warsaw grouper	

3. Collect specific information to support evaluation and refinement of SAFMC management programs and actions.

The Council has implemented some management actions that cannot be adequately evaluated with the information in the previous sections alone. This section also includes recommendations that affect collection and dissemination of the information desired above.

1. Full implementation of ACCSP in the South Atlantic.

2. Resolve confidentiality issues that prohibit reporting of and access to basic catch statistics by species, state, and year.
3. Eliminate duplicative programs such as paper logbooks, which duplicate information provided in state trip ticket programs.
4. Restructure the FSSI stocks for the South Atlantic Council to include only those stocks listed in Section VI-2 above as target species.
5. Provide annual SAFE reports and 'Trends' reports for each FMP summarizing the data elements contained in Sections III.1 and III.2.
6. Resolve ongoing issues with recreational data collection; ensure that recreational statistics can be reported according to Council boundaries.
7. Reduce data dissemination delays by continuing to develop and implement automated and web-based data entry programs that can accommodate the set level information described above.
8. Monitor fish population abundance inside protected areas (Oculina Closed Area, MPAs).
9. Determine stock status for severely restricted species (Warsaw grouper, speckled hind and Goliath grouper) to enable the Council to evaluate its management program.
10. Develop education programs for all participants that stress the importance of accurate and timely reporting of fisheries data and improve species i.d. for self-reported data.
11. Collect information on enforcement activities and develop statistics to enable the Council to objectively evaluate enforcement.

<u>4. Improve Social and Economic Evaluations</u>

Fishery and species specific monitoring information necessary for social and economic information is addressed in the previous sections. Recommendations that cross multiple fisheries or that represent research needs are listed here.

1. Determine recreational value.
2. Develop improved bio-economic models.
3. Develop models to test between different management scenarios.
4. Develop methods to integrate socio-economic information with the management process.
5. Evaluate the impacts of imported fisheries products.

<u>5. Improve Habitat Evaluation and Documentation</u>

Extensive habitat research and monitoring recommendations are detailed in various Council FMPs. The items listed here cross multiple FMPs and help support the Council's place-based management approaches for South Atlantic fisheries. These are research needs that should only need occasional updating once initially addressed.

1. Develop maps of and quantify available habitat and seasonal usage by target species.
2. Develop maps describing habitat types in proposed HAPCs.

3. Develop maps describing available habitat in proposed MPAs.

6. Improve Ecosystem-level information

The Council's Fishery Ecosystem Plan (FEP) will address many ecosystem level research and monitoring needs in detail. The primary short-term need is to implement robust monitoring programs to start building the long-term time series of information that is needed to evaluate ecosystem-level issues. These are both monitoring needs that need to be conducted annually.

1. Initiate a comprehensive survey of South Atlantic living marine resources.
2. Develop long-term monitoring of diet, productivity, and species interactions as required for ecosystem-level modeling.

Long Term Research Needs

The items listed above address the most critical needs in the South Atlantic and are considered to represent the minimum information required for adequate management. There are other needs that are less pressing and are therefore considered long-term. The same list of general issues is repeated for consistency.

1. Basic Data Elements, Long Term Improvements

1. Evaluate the convenience, quality, and utility of set-level logbook reporting and supplemental data collection programs; refine data elements, sampling intensity, collection programs, and methods as needed.
2. Develop a process to enable changes to historic data sources that will enable resolution of errors, address misidentification of species, and allow elimination of 'unclassified' categories.

2. Improving Detailed Information for Primary Species

1. Evaluate data collected by fishery and from comprehensive surveys to ensure the appropriate species receive intensified sampling.
2. Develop a long-term plan for regularly evaluating life history characteristics of target species.
3. Develop robust QA/QC programs for age determination.
4. Evaluate sampling intensity and modify sampling targets as necessary.

3. Improving Evaluation of Specific Management Actions

1. Develop a long-term plan for regularly evaluating life history characteristics for all species included in Council FMPs.
2. Support monitoring and research programs necessary to develop and evaluate limited access programs.
3. Develop a long-term plan for regularly evaluating trends and indicators of stock status for secondary species and all other managed species to enable management to adapt to fisheries changes as necessary.

9.1.2 SAFMC Fishery Management Plans

9.1.2.1 Shrimp

1. Research to relate the fishery independent SFA parameters with stock health in specific geographic locations.
2. Determine the possible impacts on indigenous shrimp species of inadvertent introductions of exotic shrimp species and diseases from mariculture operations, and develop methods and protocol to prevent such introductions.
3. Assess the potential utility of releasing maricultured white shrimp into the environment to supplement natural reproduction, especially following cold kills.
4. Assess the potential of controlled closures and other measures to enhance the production and economics of the South Atlantic shrimp fishery.
5. Determine the effects of beach renourishment projects on subsequent shrimp production.
6. Evaluate the impacts of habitat and water quality alteration on shrimp growth, survival and productivity.
7. Investigate the costs, benefits and utility of limited entry programs in the shrimp fishery of the South Atlantic.
8. Determine the impact of shrimp trawl bycatch on the habitat and all non-target species of fish and invertebrates (i.e., expand the congressionally mandated study to include impacts on habitat and all incidental species, not just the impact on other "fishery resources").
9. Determine the relationship between absolute number of adults (or adult biomass) and subsequent recruitment to allow development of a threshold level of population size to serve as a trigger to request a closure of the EEZ.
10. Determine the biological, economic and sociological status of the rock shrimp fishery.
11. Research ways to better monitor the shrimp fishery effects on listed species.

Additional research requirements pertaining to the economic and social aspects of the shrimp fishery:

1. Demographic information may include but is not necessarily limited to: population; age; gender; ethnic/race; education; language; marital status; children (age & gender); residence; household size; household income (fishing/non-fishing); occupational skills; and association with vessels and firms (role & status).
2. Social structure information may include but is not necessarily limited to: historical participation; description of work patterns; kinship unit, size and structure; organization and affiliation; patterns of communication and cooperation; competition and conflict; spousal and household processes; and communication and integration.
3. Cultural information (from the perspective of the respondent) may include but is not necessarily limited to: occupational motivation and satisfaction; attitudes and perceptions concerning management; constituent views of their personal future of fishing; psycho-social well-being; and cultural traditions related to fishing (identity and meaning).
4. Fishing community information might include but is not necessarily limited to: identifying communities; dependence upon fishery resources (this includes recreational use); identifying businesses related to that dependence; and determining the number of employees within these businesses and their status.

9.1.1.2 Snapper Grouper Complex

Oculina Experimental Closed Area Research and Monitoring Plan

In April 2004, regulations were implemented through Amendment 13A to the South Atlantic Snapper Grouper Fishery Management Plan that extended the fishing restrictions for the designated 92-square mile Oculina Experimental Closed Area for an indefinite period. The amendment was developed by the South Atlantic Fishery Management Council to address the 10-year sunset provision for the closure of the area to snapper/grouper fishing. Located off the coast of Ft. Pierce, Florida, the area is part of the larger Oculina Habitat Area of Particular Concern (HAPC) designed to protect the *Oculina* coral found there. In addition to extending the closure, the amendment requires that the size and configuration of the Experimental Closed Area be reviewed within three years of the implementation date of Amendment 13A and that a 10-year re-evaluation be conducted for the area. The Council also stipulated that an Evaluation Plan be developed to address needed monitoring and research, outreach, and enforcement efforts within one year of implementation of the Amendment.

Research and Assessment Needs below are listed in priority order as indicated in the Evaluation Plan. For more detailed information, please refer to that document.

1. What and where are the major habitat types in the Oculina Experimental Closed Area, the Oculina Bank Habitat Area of Particular Concern and adjacent hardbottom areas? (short-term, 3 years)

Objective 1: Complete high definition bathymetric mapping 1) within the Oculina Experimental Closed Area; 2) coral areas adjacent to the Habitat Area of Particular Concern; 3) in Habitat Area of Particular Concern within coral zone 50-100 m; 4) soft bottom habitat east of the coral zone within the Habitat Area of Particular Concern and 5) suspected and known hard coral areas north and south of the Habitat Area of Particular Concern, specifically from Cape Canaveral to the north and from St. Lucie mound and Jupiter Inlet to the south.

Objective 2: Complete habitat characterization 1) within the Oculina Experimental Closed Area; 2) coral areas adjacent to the Habitat Area of Particular Concern; 3) in Habitat Area of Particular Concern within coral zone 50-100 m; 4) soft bottom habitat east of the coral zone within the Habitat Area of Particular Concern and 5) suspected and known hard coral areas north and south of the Habitat Area of Particular Concern, specifically from Cape Canaveral to the north and from St. Lucie mound and Jupiter Inlet to the south.

2. Will *Oculina* thicket habitat recover throughout the Oculina Experimental Closed Area without human intervention? What time frame will be needed for significant recovery? Will it be necessary to introduce artificial substrate to serve as an initial settlement surface? (short-term, 3 years)

Objective 1: Identify coral/fish recruitment pathways and compare settlement, growth, and survival rates on artificial substrate relative to settlement, growth, and survival rates on nearby unconsolidated coral rubble.

Objective 2: Model biophysical, chemical, and physiological characters. Previous studies have shown the benthic environment of the *Oculina* reefs to be very dynamic and widely fluctuating due to upwelling events and meandering of the Florida Current.

3. What are the magnitude and causes of changes in habitat structure and functionality over time? (short-term, 3 years)
Objective 1: Determine causes and timing of coral death.
Objective 2: Origin and functional characterization of rubble zone.

4. What are the key trophodynamic functional groups? (short-term, 5 years)
Objective 1: Identify food web structure and dynamics.

5. Determine and monitor the effect of the Oculina Experimental Closed Area on fish distribution and status? (long-term, 10 years)
Objective 1: Assess spawning aggregations of fishery species.
Objective 2: Track fish movement.
Objective 3: Identify Oculina Experimental Closed Area fish population demographics.

6. What is the effect of management measures in the Oculina Experimental Closed Area on the status of fishery stocks? (long-term, 10 years)
Objective 1: Characterize (including distribution and abundance patterns, size and age distribution, spawning aggregation presence, sex ratios, etc) major fishery species within the Oculina Experimental Closed Area compared to reference sites.
Objective 2: Characterize fish communities, inside and out, including habitat utilization patterns, trophic interactions, ontogenetic changes, predator-prey relationships, etc.
Objective 3: Examine connectivity to the broader seascape (larval sources and sinks, spill-over effects).
Objective 4: Determine pre-closure distribution of dominant harvested species in and outside the reserve areas, in order to provide historical context for subsequent assessments. Review landings; spillover effects (i.e., identify benthic and juvenile pathways, upwelling events, spill-over between deep and shallow reefs).
Objective 5: Determine age distribution, nursery grounds, migratory patterns, and mortality rates for dominant harvested fish stocks.

4. What are the stressors affecting the Oculina Experimental Closed Area? (long-term, 10 years)
Objective 1: Identify natural and anthropogenic stressors (i.e., disease, gear impacts, poaching, enforcement).
Objective 2: Determine the frequency and severity of sedimentation induced by benthic storms.
Objective 3: Identify physiological tolerances of the coral to environmental stressors

6. Develop index of physical and chemical parameters that characterize a healthy Oculina coral ecosystem. (long-term, 10 years)
Objective 1: Develop index for coral health (including structural damage, recruitment, genetics, physiology, life history).

Objective 2: Develop index of community health for entire biota including coral (biodiversity, richness, biocomplexity).
Objective 3: Determine indicator species that are intimately tied with *Oculina* (invertebrates or vertebrates).
Objective 4: What is the age of the coral substrate, and geological formations (last 15,000 years) (death rates)? Also look at associated mollusks and other biota and their changes.
Objective 5: Examine association of paleo-data (age) with past climate and oceanographic conditions.
Objective 6: Are there other paleo-data from elsewhere in the world that will give perspective on *Oculina* growth (ice cores, deep-water sediment cores)?
3. What is the population structure of corals? (long-term, 10 years)
Objective 1: Research population genetics of *Oculina varicosa.*
Objective 2: Identify cross-shelf relationships between shallow and deep *Oculina varicosa* populations.
Objective 3: Conduct biogeographic studies.

4. How do oceanographic conditions and episodic events affect production, coral condition, reproduction and growth? (long-term, 10 years)
Objective 1: Quantify the extent, intensity and frequency of episodic events (upwelling, storms, etc).
Objective 2: Assess the impact of episodic events (upwelling, storms, etc).
Objective 3: Optimize design of restoration efforts.
Objective 4: Characterize impacts from anthropogenic sources of pollution (nutrients/sedimentation).

7. Conduct research on coral feeding ecology (long-term, 10 years)
Objective 1: Define feeding dynamics.

9.1.2.3 Coral, Coral Reefs and Live/Hard Bottom Habitat

Deepwater Coral Research and Monitoring Plan

In developing a Deepwater Coral Research and Monitoring Plan, the Council is responding to recent amendments to the Magnuson-Stevens Act and NOAA's determination that an agency strategy is needed to effectively and efficiently address deepwater coral ecosystems issues. The primary goal of this Research and Monitoring Plan is to support conservation and management of deepwater coral ecosystems in the South Atlantic region while addressing NOAA's strategy to balance long-term uses of the marine ecosystem with maintenance of biodiversity. The Plan will also assist in meeting the new mandates of the Magnuson-Stevens Act.

This plan incorporates recommendations and needs developed through the Deep-Sea Corals Collaboration meeting held in Tampa, Florida in 2002 and the Deep Sea Corals workshop report (McDonough and Puglise 2003). This will allow the Council to build on the expertise and insight of the international deepwater coral research community. To focus the needs to the South Atlantic region, the Council has engaged regional experts to serve as the primary contributors of this Research and Monitoring Plan.

This Research and Monitoring Plan responds directly to mandates included in the 2006 reauthorization of the Magnuson-Stevens Act:

‘‘SEC. 408. DEEP SEA CORAL RESEARCH AND TECHNOLOGY PROGRAM.
‘‘(a) IN GENERAL.—The Secretary, in consultation with appropriate regional fishery management councils and in coordination with other federal agencies and educational institutions, shall, subject to the availability of appropriations, establish a program—

‘‘(1) to identify existing research on, and known locations of, deep sea corals and submit such information to the appropriate Councils;
‘‘(2) to locate and map locations of deep sea corals and submit such information to the Councils;
‘‘(3) to monitor activity in locations where deep sea corals are known or likely to occur, based on best scientific information available, including through underwater or remote sensing technologies and submit such information to the appropriate Councils;

‘‘(4) to conduct research, including cooperative research with fishing industry participants, on deep sea corals and related species, and on survey methods;
‘‘(5) to develop technologies or methods designed to assist fishing industry participants in reducing interactions between fishing gear and deep sea corals; and
‘‘(6) to prioritize program activities in areas where deep sea corals are known to occur, and in areas where scientific modeling or other methods predict deep sea corals are likely to be present.
‘‘(b) REPORTING.—Beginning 1 year after the date of enactment of the Magnuson-Stevens Fishery Conservation and Management Reauthorization Act of 2006, the Secretary, in consultation with the Councils, shall submit biennial reports to Congress and the public on steps taken by the Secretary to identify, monitor, and protect deep sea coral areas, including summaries of the results of mapping, research, and data collection performed under the program.’’

The president signed the reauthorized Magnuson-Stevens Act on January 12, 2007. Therefore, the first report is due to Congress on or before January 12, 2008. It is the Council’s intent to review the report at the December 2008 Council meeting. Table 1 presents a timeline for items contained in this Plan based solely on the South Atlantic Council’s priorities.

For purposes of this plan, Deepwater Coral Ecosystems (DWCE) are defined as:
Deepwater coral, coral reefs, and live/hard bottom habitat in waters extending from 200 m to the seaward boundary of the EEZ.

Goal
To protect deepwater corals by:
A. Refining existing (proposed) and designating new deepwater Coral HAPCs.
B. Increasing our understanding of DWCEs’ ecological role and function in the South Atlantic region to guide future management actions.

Phase I: Map and describe known and expected deepwater coral ecosystems in the South Atlantic region.

Phase II: Determine the ecological role of deepwater coral ecosystems in the South Atlantic region, especially the role of deepwater coral habitats as Essential Fish Habitat, and expand the understanding of structure-forming species' biology and ecology.

PHASE I: MAP AND DESCRIBE KNOWN AND EXPECTED DEEPWATER CORAL ECOSYSTEMS IN THE SOUTH ATLANTIC REGION

Justification/Background

Deepwater coral ecosystems (DWCEs) are herein defined as deepwater coral, coral reefs, and live/hard bottom habitat in waters extending from 200 m to the seaward boundary of the EEZ. Azooxanthellate cnidarians include branching stony corals (Scleractinia), gorgonians and soft corals (Octocorallia), black corals (Antipatharia) and lace corals (Stylasteridae). These DWCEs therefore include the constructional habitats generated chiefly by colonial scleractinians as well as the non-constructional "gardens" dominated chiefly by other anthozoans and sponges. DWCEs are common within the Exclusive Economic Zone (EEZ) off the southeastern U.S. and include a variety of high-relief, hard-bottom habitats at numerous sites from the Blake Plateau off North Carolina, southward through the Straits of Florida to the eastern Gulf of Mexico. Despite a series of exploratory expeditions during the last decade, only a few DWCEs in this region have been mapped in any detail, observed directly or have had their benthic and fish assemblages examined. The limited number of direct observations via submersible or Remotely Operated Vehicle (ROV) indicate that they provide hard substrates and habitat for a relatively unknown but biologically rich and diverse community of associated fishes and invertebrates, including commercial species such as wreckfish (*Polyprion americanus*), Warsaw grouper (*Epinephelus nigritus*), deepwater snappers and golden crab (*Chaceon fenneri*).

Two potential threats—fossil fuel development and bottom fishing—create a time-sensitive need to map and characterize these habitats. A moratorium on oil/gas exploration in Florida waters has long prevented impact from fossil fuel extraction; however, recent U.S. legislation directed at expanding energy production in the Gulf of Mexico, coupled with exploration by Cuba in waters adjacent to the Florida Keys, has expanded this threat. Liquefied natural gas re-gassification facilities and several proposed natural gas pipelines and offshore facilities could also directly impact local DWCEs. With respect to fishing, DWCEs worldwide have been seriously impacted by bottom trawls (Fosså et al. 2002, Freiwald et al. 2004). In Florida waters, unprotected portions of the Oculina Bank off the central east coast (75-100 m depth) have been severely affected both by overfishing and bottom trawling (Koenig et al. 2000, 2005; Reed et al. 2005b, Reed et al. in review).

Increasing our understanding of the distribution and composition of these assemblages; the physical, trophic and biochemical interactions of their components; and the environmental forcing factors that control distribution and composition across regional to local scales will enable effective ecosystem management. Such information will also provide the requisite baseline for examining ecosystem response to potential stressors and for investigating all aspects of component organism biology, including population dynamics, physiology, genetics and biopharmacology.

<u>Objective 1: Map the distribution of DWCEs in the Southeastern U.S. EEZ.</u>

1A. Determine the extent of known DWCEs in the South Atlantic region.

DWCEs occur along the southeastern coast of the United States from North Carolina to the southwestern Gulf of Mexico. Areas where DWCEs have been identified include: 1) North Carolina *Lophelia* mounds—three mound systems represent the northernmost DWCEs in the South Atlantic Bight; 2) Stetson Reefs—hundreds of pinnacles up to 152 m tall at depths of 640 to 900 m on the eastern Blake Plateau off South Carolina; 3) Savannah Lithoherms—numerous lithoherms at depths of 490 to 550 m with up to 60 m vertical relief; 4) East Florida *Lophelia* Reefs—hundreds of 15-152m tall coral bioherms and lithoherms at depths of 600 to 870 m along the shelf margin from southern Georgia to the Straits of Florida; 5-6) Miami and Pourtalès Terraces—relict phosphoritic limestone bank-margin hardgrounds and escarpments extending from Boca Raton to Key West at depths of 200 to 600 m; and 7) Southwest Florida Lithoherms—dozens of 15m tall *Lophelia* lithoherms at 500 m in the eastern Gulf of Mexico (Reed et al. 2004, 2005a, 2006). Only a small percentage of these sites has been investigated beyond fathometer transects; each new exploratory expedition discovers new sites. Many more coral sites are likely, and the full extent of topographic features on the Blake Plateau remains unknown. Similarly, the distribution of possible DWCEs along the southern margin of the Florida peninsula south of Miami and along the Florida shelf margin in the Gulf of Mexico are largely uninvestigated.

Increasingly sophisticated mapping technology, such as ship- and Autonomous Underwater Vehicle (AUV)-mounted multibeam sonar systems with backscatter data, side-scan sonar systems, and sub-bottom seismic profilers can be used to provide detailed bottom imagery with resolution from one-three meters. A simple light-weight digital camera system can also be lowered during fathometer or AUV transects of topographic features to provide first-order ground-truthing (i.e., to determine presence/absence of corals) (see Grasmueck et al. 2006, in review). Geographic Information Systems (GIS) can be used to integrate mapping data with other geo-spatial information (e.g., fishing pressure, management areas, biological, geological, physicochemical observations, geophysical structure, hydrodynamics) to generate detailed and precise maps and datasets and foundation for robust system analyses, predictions, and management protocols. Only a small portion of this region has been mapped using ship based multibeam sonar (S. W. Ross et al. 2006, unpubl. data); maps from the North Carolina coral mounds and a portion of the Stetson Banks revealed numerous new features, suggesting that the coral habitat is much more extensive than previously thought. Only a few days of multibeam mapping (Ross et al. 2006 cruise) provided more bottom type data than had been accumulated in 6 years of previous cruises.

<u>TASK 1</u>: Inventory existing literature and data with a focus on expanding work within existing (proposed) Coral Habitats of Particular Concern (CHAPCs) by:

a. Completing the Southeastern United States Deep Sea Corals (SEADESC) Initiative (Partyka et al. in press) and integrating data into Council IMS, and

b. Completing and integrating data sources identified by deepwater portion of the Southeast Area Monitoring and Assessment Program (SEAMAP) -- Recovery, Interpretation, Integration and Distribution of Bottom Habitat Information for the South Atlantic Bight, 200-2000m.

<u>TASK 2</u>: Rank areas to be mapped within proposed CHAPCs and potential DWCEs outside CHAPCs by:

a. Identifying data gaps based on above inventory,
b. Obtaining SAFMC input to rank priority areas for investigation, and
c. Conducting an ad hoc workshop to rank gaps based on proposed CHAPCs as well as outlying areas.

TASK 3: Conduct acoustic seabed mapping, and ground-truth with visual surveys within proposed CHAPCs and priority areas outside CHAPCs . Begin with low-resolution over wide areas followed by high-resolution mapping of targeted area (e.g., multibeam echo sounder, sidescan sonar) and ground-truthing (e.g., ROVs, AUVs, towed cameras, cores, samples) based on SAFMC recommendations.

1B. Map human activities that may impact DWCEs.

As noted in the Justification/Background section above, fossil fuel development and bottom fishing represent the primary potential near-term threats to local DWCEs. The continuing depletion of coastal fisheries may expand fishing efforts into deeper habitats in search of valuable commercial species such as royal red shrimp (*Hymenopenaeus robustus*), other shrimps and crabs, wreckfish, and other fish species (some not yet exploited). One of these, the Warsaw grouper, is a candidate for designation as a threatened or endangered species.

TASK 1: Obtain Vessel Monitoring System (VMS) access and produce maps showing fishing effort by location.

TASK 2: Assess fishing pressure in and outside CHAPCs through analysis of fisheries-dependent (e.g., NMFS landings) and fisheries-independent data. Produce maps showing fishing effort by location.

TASK 3: Map non-fishing activities that may affect DWCE resources (e.g., dredging, cables, outfalls, run-off, shipping routes and energy development and exploration activities).

1C. Assess condition of DWCEs in the South Atlantic.

Assessing the health and status of deepwater corals in the southeastern U.S. is difficult because there is a general lack of criteria on what constitutes good or bad conditions in these systems and a lack of historical data for comparisons. Dead corals are abundant at almost all locations, but whether this is normal or not, is unclear. Whether reefs are declining, stable, or building cannot be judged without additional studies. It seems clear that fairly strong currents coupled with bottom temperatures below 12º C are needed and monitoring these conditions may be good starting points. There is concern that changing ocean pH may negatively impact deepwater corals (Guinotte et al. 2006), and this should also be considered in monitoring or impact assessment.

Live coral coverage is generally low on the majority of deepwater *Lophelia* reefs in this region (1-10%); however, cover varies from nearly 100% living coral on portions of some reefs to extensive areas of 100% dead coral rubble on others (Reed et al. 2005b, 2006, in review; Grasmueck et al. in review). The deepwater *Oculina* reefs off eastern Florida have been designated a habitat area of particular concern (HAPC) for the protection of the coral habitat since 1984 (Reed 2002b, Reed et al. 2005b). A portion also has been designated a marine protected area (MPA) for management of the snapper grouper complex. Even so, extensive areas of the *Oculina* reefs have been severely impacted by both legal and illegal bottom trawling since 1984 (Koenig et al. 2005, Reed et al. 2005b, in review). Some areas in the northern section of the MPA that were documented as thriving reefs by photo transects in the 1970s had been found to be reduced to 100% rubble during submersible dives in 2001 (Reed et al. in review). However, some of the reefs in the southern portion that had been protected since 1984 are still thriving. So far we have no evidence that commercial bottom trawling has occurred on the *Lophelia* reefs in this region of the western Atlantic, and so it is still speculative as to whether the cause of the high percentage of dead coral could be due to natural senescence of the reefs, paleoclimatic factors, coral pathogens, or other unknown factors.

TASK 1: Identify and quantify natural and anthropogenic stressors (e.g., disease, gear impacts, energy development and exploration, nutrients, sedimentation, ocean disposal of dredge spoil, sewage sludge, paleoclimatic changes, temperature).
TASK 2: Conduct biological and environmental monitoring of indicator species at different scales.

a. Identify potential indicator species for deepwater corals and associated species, and
b. Identify monitoring programs for those species.

TASK 3: Monitor impacts of episodic events (e.g., changing currents, temperatures, pH, sediment dynamics, food dynamics).

Objective 2: Describe the physiographic environment of DWCEs.

2A. Describe abiotic features (i.e., hydrographic, chemical) of DWCEs.

The waters and seafloor of the continental margin of the southeastern U.S. have been investigated for over a century and a half, beginning with work by the U.S. Coast Survey and U.S. Navy (e.g., Agassiz 1888). The Gulf Stream, a principal oceanographic feature of the region, is among the most thoroughly studied of marine systems, and the physiography and underlying geology of much of the region are well documented. However, apart from instantaneous localized observations made during submersible or ROV operations -- and broad-scale datasets and models of geologic structure, hydrography and physicochemical parameters -- little if any information exists about how abiotic factors directly affect and control local DWCEs. No time-series data of the environmental factors (e.g., bottom currents, turbidity, upwelling, temperature, dissolved oxygen or sedimentation rates) have been collected on DWCEs that would contribute to understanding DWCE distribution, growth, and the composition and dynamics of associated assemblages. However, annual records of hundreds to thousands of years that are relevant to abiotic conditions in these habitats may be contained in several species of deepwater corals (see Williams et al. in press; Druffel et al. 1995; Holmes et al. unpubl. data). This research should be continued. Although much work has been done on the southeastern U.S. margin, relatively little is known about basic parameters compared to the mid-Atlantic and north Atlantic costs of the U.S. There is a need to conduct physical and chemical monitoring at multiple spatial (individual mound to regional) and temporal (tidal to decadal) scales, including identification of episodic oceanographic events (e.g., intrusions, upwelling) and physical disturbances (e.g., turbidity plumes, storms).

TASK 1: Inventory existing deepwater (seafloor) data sources in the South Atlantic region (e.g., Ocean Observing System, OOS).
TASK 2: Identify required data sets and observing technologies (e.g., OOS, benthic landers).

TASK 3: Establish and carry out a deepwater monitoring plan for CHAPCs in partnership with the Southeast Coastal Ocean Observing Regional Association (SECOORA), starting with a pilot observing station at a fairly well-described DWCE.

2B. Investigate the internal structure of DWCEs, particularly in relation to overlying hydrodynamic and physicochemical conditions, and changing climate over time.

TASK 1: Conduct sub-bottom acoustic profiling survey over various DWCE habitats.
TASK 2: Based on profile surveys, target specific DWCE types for follow-up coring from surface to base mounds.

Objective 3: Describe and inventory biota of DWCEs.

The dominant biogenic architectural components of local DWCEs are the azooxanthellate, colonial scleractinian corals *Lophelia pertusa* and *Enallopsammia profunda*, with *Madrepora oculata* and *Solenosmilia variabilis* occurring as isolated colonies (Reed 2002a, b). Both constructional DWCEs and non-biogenic hard substrates (e.g., Miami and Pourtalès Terraces) provide habitat for a wide diversity of sessile macrofauna including solitary Scleractinia, gorgonians and soft corals (Octocorallia), black corals (Antipatharia), hydrozoan corals (Stylasteridae) and sponges (Demospongiae and Hexactinellida), which in turn provide habitat and living space for a relatively unknown but biologically rich and diverse community of associated organisms, including fishes, anemones, zoanthids, crustaceans, mollusks, echinoderms, polychaete and sipunculan worms, and foraminiferans (Ross and Nizinski in press).

Qualitative studies of the DWCEs off the southeastern U.S. identified 142 taxa of invertebrates and 58 species of fish directly associated with these coral habitats (Reed et al. 2006). The deepwater fauna of the east Florida margin includes at least 53 species of Scleractinia (Cairns and Chapman 2001), ~15 stylasterids (Cairns 1986) and dozens of octocorals. The deep Gulf of Mexico fauna includes 84 Scleractinia (Cairns and Chapman 2001; Cairns in prep.), 5 stylasterids, and 115 octocorals (Cairns in prep.). Because Florida, and the Straits of Florida in particular, represents an important biogeographic boundary where different deepwater faunas meet to generate the greatest known species richness in the western (and perhaps entire) Atlantic Ocean (Carpenter 2002), it is expected that the complex three-dimensional habitats of local DWCEs will include important biodiversity "hotspots." However, current taxonomic information is scattered in the primary specialist literature. The fish fauna of the region (at least 98 species identified on and around deepwater coral habitat) was reviewed by Ross and Quattrini (in press and in review), but only preliminary notes of other fauna from scattered locations exist. This region may harbor a number of new species associated with deepwater corals, some described (e.g., McCosker and Ross in press; Fernholm and Quattrini in review) and some soon to be described (e.g., Nizinski et al. unpubl. data).

3A. Qualitatively and quantitatively describe the composition, diversity, assemblage organization and distributional patterns of DWCE benthic and water column fauna (invertebrates and vertebrates).

TASK 1: Develop a network of taxonomic experts and support comparative studies (e.g., validation, or inter-regional comparisons).
TASK 2: Assess biodiversity of all groups at different spatial scales (including molecular approaches for phylogeny, phylogeography, genetic connectivity, population dynamics and species boundary assessment).
TASK 3: Make products accessible through appropriate databases (e.g., Council's Internet Mapping Server, Ocean Planning and Information System, OPIS; Southeast Regional Taxonomic Center, SERTC; Coral Reef Information System, CORIS; Census of Marine Life).

3B. Determine relative abundance and occurrence of economically and ecologically important species associated with DWCE.
Sampling will require the use of multiple, standardized methods to allow for counting of individual species. Techniques will need to be adapted based on the fauna of interest and locations to be sampled (e.g., water column, benthic, surface). Methods may range from visual/video surveys with selective collections to quantitative sampling using coring devices or nets.

PHASE II: DETERMINE ECOLOGICAL ROLE OF DWCE, INCLUDING THE ROLE OF DEEPWATER CORAL HABITAT AS ESSENTIAL FISH HABITAT TO EXPAND UNDERSTANDING OF STRUCTURE-FORMING SPECIES' BIOLOGY AND ECOLOGY

Justification/Background
The southeastern United States may have the most extensive aphotic DWCEs in U.S. waters (Hain and Corcoran 2004); however, these large habitats are poorly documented and understood. Based on available data, DWCEs appear to occur abundantly on the southeastern United States slope (Stetson et al. 1962; Paull et al. 2000; Popenoe and Manheim 2001; Reed et al. 2005a, 2006; Ross and Nizinski in press). Prior to this century, these unique habitats had not been examined in detail in this region because of the great depths at which they are found, the rugged bottom topography, and extreme currents (e.g., Gulf Stream).

Ongoing research on DWCE in the southeastern United States has been based on the premise that these habitats are ecologically important and productive, yet very little is known about their ecological roles. The southeastern United States harbors over 100 deepwater coral species (Ross and Nizinski in press.), some of which create extensive, complex reef structures. These complexes are hotspots of increased biodiversity. Many coral species are very long lived (hundreds to thousands of years), and serve as natural repositories of data on climate, ocean physics, and ocean productivity (Adkins et al. 1998; Williams et al. 2006; Williams et al. in press). However, research on this topic is just beginning, as is research on population and community genetics. There are no studies on trophic ecology or energetic models for DWCE of the southeastern United States.

Deepwater coral habitat now appears to be more important to northwestern Atlantic slope species than previously known. However, it is unclear whether this habitat is essential to selected fishes or invertebrates or whether they occupy it opportunistically (Rogers 1999; Auster 2005; Costello et al. 2005). Coral thickets, coral rubble, and the less structured nearby non-reef habitat all support diverse faunas in the southeastern United States (Reed et al. 2002, Reed et al. 2005a, 2006; Ross and Quattrini in press.). Analyses indicate that many species of fishes (Ross and

Quattrini in press.) and invertebrates are closely associated with the unique deepwater reef habitat (Reed et al. 2006), including commercially-exploited deepwater species (e.g., wreckfish and golden crabs) and potentially exploitable species (e.g., royal red shrimps, blackbelly rosefish, bericiform fishes, eels). However, reef-invertebrate associations may be more opportunistic than those found in certain fishes (Ross et al. unpubl. data), but more data are required to confirm these associations.

Our understanding of DWCEs within the U.S. EEZ has progressed rapidly over the past decade, primarily though a series of exploratory cruises that have provided information on the distribution and general characteristics of these valuable resources. The next steps involve addressing ecosystem function and resilience to change, both anthropogenic and natural. In the South Atlantic region, DWCEs dominated by *Lophelia pertusa* and *Enallopsammia profunda* create extensive and complex structural framework, which provides settlement substrate and microhabitat for a diverse benthic fauna. An understanding of individual and population level biology of these foundation species is a pre-requisite to effective ecosystem management. All ecosystems are subject to disturbances of various types, both natural and anthropogenic. Pristine ecosystems are generally resilient to disturbance, meaning that they can return to an original state via natural recovery processes. Resilience is an important ecosystem characteristic that needs to be fostered and protected via proactive management. As far as we know, the DWCE of the southeast region are relatively unimpacted; this could change rapidly with the advent of new energy proposals (liquefied natural gas ports and pipelines), development of deepwater fisheries and more subtle impacts such as pH reduction through global alterations in CO^2 cycles. Increasing our understanding of the biology of the keystone species, at an individual and population level will provide baseline data from which to assess ecosystem response to future stressors. At the individual level, factors such as growth rate, skeletal density, and fecundity can change in response to environmental stress.

Resilience at the population level may be largely dependent on the genetic composition and richness. Genetic and genotypic diversity provide scope for species to adapt to changing conditions such as warmer temperatures and/or altered pH. Branching corals such as *L. pertusa* and *E. profunda* reproduce asexually via fragmentation (i.e., branches break off and reattach to the substrate to form a new colony that is genetically identical to the parent). It is important to understand the extent of genotypic diversity present in *L. pertusa* populations to assess their potential for adaptation to global changes. Understanding patterns of genetic connectedness (i.e., gene flow) is important to contextualize and predict larval recruitment pathways, and ultimately to incorporate such information into design of deepwater coral HAPCs.

Considering the above, research priorities of locating, describing, and mapping deepwater corals and conducting basic biological studies in these habitats are necessary baseline data for developing appropriate management schemes. The goal of research described herein is to address major data gaps to facilitate management of deepwater coral habitat and allow increased understanding of its role in deepwater ecology.

Objective 1: Describe logistic and coordination efforts that could improve the efficiency and effectiveness of deepwater coral biological studies.

Given the expense and difficulty of studying deepwater organisms it is prudent to consider aspects of coordination of data collection within the scientific community that would enhance the value and effectiveness of all possible observations and samples over a wide range of objectives. For example, video footage is probably the most common data collected from deepwater coral habitats, but it is not collected in a standardized format that will allow comparison of information from different sites or cruises (e.g., size, percent cover, proportion live/partial mortality, growth or color morphs). A handbook of 'Deep Sea Coral Collection Protocols' by Etnoyer et al. (2006) has been compiled in an effort to standardize data collection from deepwater coral habitats. This will be available on-line in the near future, and includes protocols for video and photographic documentation as well as sample preparation for different purposes. A cooperative effort among the scientific community to abide by common protocols will potentially increase the utility of data collected during each expedition. Another example of cooperation among groups that would maximize cruise time would be to formalize a chain-of-custody or clearing house for samples (e.g., corals, associated animals, pieces of skeleton etc.) that are collected during research cruises, and are not used by the cruise scientists. This would partition material to as many types of studies as possible (e.g., live material for lab experiments, ethanol-preservation for genetic analysis, surface treatments for microbial studies, tissue fixative for histological study, etc.) and make use of samples that would otherwise not be processed.

TASK 1: To the extent possible, use standardized protocols for data collection so that information may be exchanged among investigators and agencies.
TASK 2: Develop standardized chain-of custody for samples to optimize use of opportunistic or excess samples from deepwater coral habitats.

Objective 2: Describe the population dynamics, movements and habitat associations of both economically and ecologically important species (including potentially exploitable species) associated with DWCEs.

Many aspects of the ecology and biology of deepwater coral communities of the southeastern U.S. are either unknown or poorly understood, especially as it pertains to population dynamics. Population dynamics data are essential for understanding the historical and current status of populations, as well as modeling future population projections. For example, understanding how populations respond to extractive activities (fisheries) or respond to natural mortality requires knowledge of age and growth rates. Such studies are integral to understanding how populations might respond to climate change.

Information on spawning seasonality and locations are important for protecting reproductive integrity. Reproduction data (e.g., fecundity and spawning behavior) are needed to understand and model population fluctuations. Putting boundaries on population parameters requires studies on gene flow. Although determining barriers to gene flow that may isolate populations has been problematic for marine species (Palumbi 1994), various slope species exhibit unexpected degrees of population heterogeneity (Rogers 2002). Appropriate genetic techniques could facilitate inferences regarding organism dispersal and recruitment dynamics. Such data have important implications for how populations sustain themselves.

Many studies of the various aspects of population dynamics should concentrate (at least initially) on economically important, potentially economically important, and key ecological species.

Although an appropriate species lists needs to be developed, these taxa of interest should include wreckfish, scorpionfishes (particularly blackbelly rosefish), alphonsinos, roughies, conger eel, red crabs, shrimps, galatheid squat lobsters, squids, and sponges. To date the only species of this grouping that has published information for the southeastern U.S. slope is the wreckfish (Sedberry et al. 1994; Weaver and Sedberry 2001; Vaughn et al. 2001). For most deepwater reef organisms of the southeastern United States there are no published data on age, growth, reproduction, genetic structure, movements, recruitment, and habitat relationships.

Note: Sampling for trophodynamic patterns (see objective 3) could easily be adapted to gather data for most population dynamics aspects below. While this might require little additional funding for field efforts, accessory funding for laboratory analyses and reporting would be needed.

2A. Determine the habitat relationships between deepwater corals and the species associated with them.

The lack of habitat association data hampers our understanding of deepwater reef communities and the roles of complex habitats in structuring or maintaining deepwater communities. If fauna are less explicitly associated with habitats in deepwater, this supports the hypothesis that slope fauna are more opportunistic because the deep sea environment has fewer resources (compared to the shelf). However, in contrast to the northwestern Atlantic (Auster 2005), data support hypotheses that southeastern U.S. deepwater coral banks host a unique, probably obligate, fauna and that the reefs concentrate food resources (Ross and Quattrini in press.). How deep does this pattern extend and is it true throughout the southeastern United States' slope?

TASK 1: Characterize habitat associations of invertebrate and fish faunas on and surrounding DWCEs. Sampling should include the full geographic and depth ranges of this habitat in the southeastern U.S., as well as all seasons. Direct observation methods (submersible or ROV) coupled with collections of habitat and fauna are the best way to sample these rugged areas for habitat association data (see Parker and Ross 1986; Sulak and Ross 1996; Ross and Quattrini in press.). It is important in this task to sample non-reef and non-coral habitats in order to adequately judge degrees of habitat association.

2B. Determine the migratory pathways of the economically and ecologically important species associated with DWCEs.

TASK 1: Characterize both the vertical and horizontal movements (at different spatial and temporal scales) of species associated with DWCEs, including all relevant life history stages. To infer vertical movement, sample the water column for species associated with DWCE at various depths over the appropriate time scale. To infer horizontal movement (especially of benthic species), sampling would be required that is logistically difficult (tagging) in the deep-sea, intensive, and expensive. In the near-term, the inference of horizontal movements may not be feasible.

2C. Determine the age structure and growth rates of economically and ecologically important species associated with DWCE as well as the sex ratio within each species.

TASK 1: Collect the full size range (juvenile to adult) of the species available within the study site across seasons.
TASK 2: Determine appropriate aging methods based on taxa examined and age samples.
TASK 3: Construct growth models.

2D. Determine the recruitment processes for the economically and ecologically important species associated with DWCE.

TASK 1: Conduct high-intensity temporal sampling using appropriate methods (e.g., settling plates and traps) to determine larval settlement processes including sites, periodicity, and relevance to oceanography. For traps, samples should be collected by setting multiple settlement traps within the deepwater coral habitat of interest and the adjacent non-reef habitat. Replication and placement of the settlement traps is critical for determining whether settlement is random or based on specific cues. It would be important to record various physical data (e.g., current, temperatures) near these samples.
TASK 2: Determine larval duration, distribution, and vertical migration in the water column. Sample the water column for species associated with DWCE at various depths over the appropriate time scale. For fish species, determine daily ages of fishes from otoliths to determine larval duration. Understanding horizontal and vertical water column physics is important here, and if appropriate models are not available, they should be developed (see next task).
TASK 3: Model the information collected under the two previous tasks with horizontal scale physics (e.g., currents) to improve the understanding of recruitment processes and population connectivity.

2E. Examine the reproductive biology of economically and ecologically important species associated with DWCE.
Characterize the spawning seasonality and reproductive potential of the species of interest by collecting the full size range (juvenile to adult) of the species available within the study site. Adequate sampling will require collection of data on monthly or quarterly intervals and ensuring that there are sexual differences in the population. Samples should be analyzed for sex, reproductive state, and fecundity (for females only). Method details may vary by taxa examined.

2F. Determine the genetic structure of the economically and ecologically important species associated with DWCE.

TASK 1: Sample coral and associated species at a regional scale to make inferences about the mechanisms structuring local assemblages (e.g., community genetics). Using a community genetics approach (Agrawal 2003; Neuhauser et al. 2003; Whitman et al. 2003), patterns of genetic structuring should be compared among taxa and with environmental variables. This study should also include examining the genetic structuring of fauna closely associated with *Lophelia* and other habitat-forming corals and sponges, such as galatheid "crabs" (*Eumunida picta*), eunicid polychaetes (Roberts 2005), urchins and some fishes. If associations between *Lophelia* and co-occurring invertebrates are strong, similar genetic patterns may result, suggesting that similar mechanisms may influence community structure of associated organisms.

Objective 3: Describe food web dynamics of DWCEs.

To assess natural and anthropogenic impacts, the degree of connectivity among ocean zones (e.g., benthic, abyssal, and neustonic) must be better understood. The execution of research within these zones has led to an implicit assumption of compartmentalization. However, ocean waters and many of their inhabitants regularly move across perceived boundaries, and systems are much more connected than previously reported (Knight et al. 2005) as evidenced by improved tracking of animal movements and energy flow (trophodynamics).

Input of energy to the deep seafloor was thought to be from the top down and mostly passive. In the northeastern Atlantic, the energy source of *Lophelia pertusa* is derived from particulate matter drifting down from the upper water column (Duineveld et al. 2004), but trophic data for the broader community are lacking. A hypothetical trophic web was developed for the deepwater *Oculina* ecosystem which consists of the coral biogenic refuge for hundreds of species of invertebrates and fishes which in turn receives plankton/particulate input from the Florida Current (Gulf Stream) and cold-water upwelling events providing influxes of nutrients (George et al. in review). It is likely that active vertical movements of animals provide a substantial, regular flow of energy through the water column to the seafloor (Kinzer 1977; Genin 2004; Gartner et al. in review). Such movements may be diel, ontogenetic, or both and move resources in both directions, variously impacting a large section of the water column.

During past submersible observations (coupled with depth-discrete sampling) off the southeastern U.S. large concentrations of mesopelagic (midwater) fauna were noted on the bottom near deepwater (360 to 700 m) coral banks (Gartner et al. in review). Mesopelagic fauna were observed acting as both predator and prey of benthic organisms. Whether this activity is sporadic or whether various animals depend on such interactions is unknown. If the migrating mesopelagic fauna is a major conduit of energy through the water column, human (or other) perturbations of the bottom and midwater faunas may have significant impacts on pelagic fishes, seabirds, and marine mammals through effects on trophic relationships. However, open ocean ecological coupling (expressed by food web inter-connection among benthic and water column nekton) is poorly studied.

Research described here will begin to define faunal connectivity in terms of trophic linkages over and around DWCE. Characterization of trophodynamics and benthic-pelagic interactions of organisms associated with deepwater corals would provide important information on food resources and sources, feeding periodicity, and how various habitats from the bottom to the surface are linked. In addition to traditional diet analyses of collected specimens, stable isotope ratios (of carbon, nitrogen, and possibly sulfur) of deepwater coral area organisms (whole water column) would establish trophic signatures that help define community relationships (Thomas and Cahoon 1993; Kwak and Zedler 1997; MacAvoy et al. 2001). From these data we could answer important questions about the broad impacts to a particular habitat or group of organisms from natural or anthropogenic events. An added advantage of a trophodynamic study is that the process of collecting organisms to describe feeding relationships can provide valuable additional data (e.g., species-habitat associations, distributions, abundances, sizes, reproductive states, etc.).

3A: Characterize the trophodynamics and the benthic-pelagic interactions of organisms associated with deepwater coral habitat using both traditional and novel approaches.

The *traditional approach* is to capture organisms, determine species, and analyze their stomach contents.

A *novel approach* to couple with the above method is to analyze stable isotopes in the tissues of the captured fauna. Naturally occurring isotopic concentrations in various tissues identify sources of dietary components (e.g., from plankton or benthic sources) provided there is a good understanding of the isotopic signatures of potential food sources.

Sampling should be conducted using the appropriate temporal and spatial scales.

Temporal scale: For the traditional approach, it is important to collect data on a seasonal basis and if possible on a diel basis because stomach content data reflect only a snap-shot of the diet of a species. Sampling for the novel approach method can be conducted at any time of the year because isotopic signatures represent an integration of diet over time in the tissues.

Spatial scale: For both the traditional and novel approaches, organisms should be collected in both the water column above the deepwater coral habitat of interest, within that habitat itself, and in the adjacent benthic non-reef habitats. Since reef habitat varies throughout this region, the ideal sampling scheme would have replicate samples collected from a minimum of three previously studied sites between Cape Lookout and the Florida Straits in which preliminary analyses have suggested differing benthic populations.

Objective 4: Describe relationships among DWCE composition, structure and distribution and abiotic and biotic factors.

4A. Identify relationships between the distribution and development of DWCEs and abiotic and biotic factors.

As noted previously, no time-series data exist on the hydrographic or physicochemical characteristics of the water column associated with DWCEs in the region. Detailed data on temporal and spatial patterns and ranges of variation in abiotic factors, e.g., temperature, salinity, dissolved gases, hydrodynamics (bottom currents, upwelling, tides, eddies), turbidity levels and the nature of suspended material, represent a baseline of information required for understanding DWCE composition, growth, structure and distribution. Similarly, no data exist on the composition of seston (i.e., plankton, suspended organic detritus and inorganic particles) available to DWCEs or the patterns, abundances and rates of its import to DWCEs. Such data are critical to understanding DWCE trophodynamics and growth patterns.

TASK 1: Collect time-series data of abiotic and other water column factors using a variety of deployed instrument packages (e.g., time-lapse cameras, current meters, CTDs, sediment traps, larval settlement panels).

TASK 2: Conduct multivariate analyses of abiotic factors versus organism distributions and DWCE structure.

4B. Develop models to enable predictions of DWCE status and trends.

TASK 1: Identify suitable models and conduct model-data comparisons to validate models specifically for DWCE application:

a. Ocean circulation (physical, chemical parameters) and
b. Sedimentation.

4C. Determine long-term temporal (decadal to epochal scales) relationships between DWCE structure and distribution relative to overlying hydrodynamic regime.
Although the broad-scale geology of the region is reasonably well understood, no cores have been taken through local DWCEs that might contribute to understanding their development, particularly with respect to climate change. Such coring (or drilling) was quite valuable in determining the origins and history of deepwater coral banks in the northeastern Atlantic (Williams et al. 2006).

TASK 1: Examine historical records of pollution, productivity, climate and oceanography across the South Atlantic region.
TASK 2: Determine age, growth and senescence of DWCE (bioherms and lithoherms) by:
a. Radioisotope and amino acid racemization analysis of corals,
b. Cores of coral mounds and
c. Sub-bottom profiling across mounds and hard bottoms.

Objective 5: Describe reproductive strategies (gametogenic cycles, sex ratio, fecundity, larval development modes) of priority structure–forming groups, including scleractinians (*Lophelia pertusa*, *Enallopsammia profunda*, *Madrepora oculata*), octocorals, antipatharians and Stylasterines.
Gametogenesis has been described for several species of structure-forming scleractinians, from the Eastern and Western Atlantic and the Pacific. Generally they are gonochoristic (i.e., separate sexes), seasonal broadcast spawners, with small eggs, and probably dispersive larvae. This is the extent of our information for most of these species. *Lophelia pertusa* has been studied more extensively than other species, using samples from Norway, the Gulf of Mexico and the Florida Straits. Seasonality of gametogenesis appears to vary with location. The gametogenic cycle of samples collected from the Norwegian Fjords began in April and terminated with spawning in March the following year (Brooke and Jarnegren in prep.). In the Gulf of Mexico, however, gametogenesis begins in November and spawning probably occurs in late September/October (S. Brooke unpubl.). Fecundity of both sets of samples is high but quantified data have not yet been compiled. Research into reproduction of octocorals from Alaska and New England is also underway (Simpson unpubl), and some work has been done on reproduction in Alaskan stylasterines, which are all brooders and produce short-lived planulae (Brooke and Stone in review). Larval biology has been described for *O. varicosa* (Brooke and Young 2005) but not for any of the other deepwater corals.

Hydrodynamic models can provide probability distributions for larval dispersal under a variety of environmental scenarios but they require basic biological input data on parameters such as timing of spawning/larval release, larval duration, and behavior. Such data are not currently available for the southeastern U.S. deepwater corals but are needed to enhance the effectiveness of modeling efforts.

5A: Determine the gametogenic cycles and spawning periods for structure-forming corals.

TASK 1: Collect samples for histological examination. Characterization of these cycles requires repeated sampling at individual sites over time (e.g., monthly). Such sampling can be done opportunistically (i.e., haphazard collections during other cruises) but would be accomplished much more efficiently with targeted sampling effort.

5B: Determine larval development and settlement processes for structure-forming species.

TASK 1: Collect samples of important structure-forming species at the end of the gametogenic cycle to spawn for larval studies.

Objective 6: Describe patterns and processes of colony growth and mortality (e.g., calcification, carbon and energy budgets) of important structure-forming species, and determine how they are affected by environmental factors and stressors.

The growth of *L. pertusa* has been measured using various methods (Duncan 1877; Dons 1944; Freiwald 1998; Gass and Roberts 2006), which have estimated growth rates between 4-26 mm per year, with the most likely estimates at approximately 5mm per year (Mortensen and Rapp 1998). These methods have measured linear extension rather than calcification rates, but the latter could potentially be calculated from growth rates and skeletal density. Growth rates of some gorgonians and antipatharians have also been measured using rings in the gorgonian skeleton and isotopic analysis (e.g., Sherwood et al. 2005, Andrews et al. 2002, Risk et al. 2002; Williams et al. 2006) and in some cases the colonies are extremely old (hundreds to thousands of years) and have very slow growth rates (e.g., Druffel et al. 1995; C. Holmes et al. unpubl. data).

Field observations on distribution of *L. pertusa* indicate that the upper thermal limit for survival is approximately 12^{o}C, and laboratory studies on *L. pertusa* tolerance to temperature extremes corroborate these observations (S. Brooke unpubl. data). Preliminary experiments with heat shock proteins show expression of HSP-70 in response to exposure of temperature greater than 10^{o}C (S. Brooke unpubl. data). Experiments on tolerance to sediment load indicate that samples of *L. pertusa* from the Gulf of Mexico show >50% survival in sediment loads of 103 mgL-1 for 14 days, and can survive complete burial for up to 2 days (Continental Shelf Associates in review). Given the proximity of some coral habitats to oil and gas extraction sites, tolerance to drilling fluids and fossil fuels should also be investigated.

Further laboratory and field experiments are needed to examine the individual and interactive effects of environmental conditions such as temperature, sedimentation, and toxins. A range of responses or endpoints should be examined including more modern techniques such as cellular diagnostics. These include examination of levels of stress proteins produced by cells in response to external conditions such as heat shock proteins, ubiquitin, etc. There are general classes of cellular products that are known to be indicative of specific stressors such as nutritional stress, xenobiotics, metals, and temperature. These techniques are being increasingly used in shallow coral systems as a more sensitive organismal response to stress (i.e., more sensitive than mortality). These responses should be measured in combination with more standard parameters such as growth, respiration, and fecundity.

Coral growth rates provide information on the rates of habitat production in DWCEs while coral mortality and bioerosion counterbalance this production with destruction. Understanding the positive and negative sides of this balance, particularly under the changes in environmental conditions that are anticipated in the coming decade or two, is crucial to the management and conservation of deepwater coral habitat and habitat function (e.g., fishery production).

6A: Determine rates of colony growth (i.e. habitat production).

TASK 1: Conduct in-situ tagging or staining and revisit individual colonies for selected coral species. This activity should be in concert with in-situ monitoring station such as a benthic lander or other instrumentation to allow correlation of coral growth performance with in situ environmental conditions. Radiometric aging and growth estimates should also be conducted for selected corals (e.g., antipatharians)

6B: Determine physiological responses to stress (sediment, temperature, pollutants, CO^2) and how growth rate is affected by environmental factors (i.e., how is habitat production affected by environmental factors?).

TASK 1: Conduct manipulative laboratory dose-response experiments on live coral colonies, where various responses (e.g., molecular biomarkers, growth, and respiration) to stress levels can be documented under controlled conditions. This requires collection of live samples and post cruise maintenance in a temperature-controlled facility.

6C: Determine temporal patterns of coral mortality and bioerosion (habitat loss).

TASK 1: Characterize succession of boring/bioeroding community in coral skeleton. Ideally the degree of bioerosion would be correlated with ageing data to obtain information on bioeroder succession.
TASK 2: Drill cores and age dead skeletons from a range of sites and physiographic features.
TASK 3: Develop techniques for amino acid racemization or other techniques with high temporal resolution.

Objective 7: Describe the genetic characteristics of structure forming coral populations.
Little is known about basic biology of deepwater coral species, including larval dispersal potential and connectivity between reefs (hence vulnerability). Given the difficulty of tracking movements of coral larvae, especially at depth, genetic methods hold great promise for estimating important factors in the longevity of deepwater reefs that could not otherwise be inferred from their biology. Levels of gene flow among adjacent sites, relative contributions of clonal (asexual) and sexual reproduction and inferences regarding larval dispersal and levels of historical connectivity obtained from genetic data can provide valuable insights for appropriate management of these unique habitats.

Co-dominantly inherited genetic markers are required to fully assess population structure and to estimate parameters such as gene flow, the extent of clonal reproduction, and possible hybridization. Microsatellites are codominant markers made up of short (2-6 bases), tandemly repeated units of DNA that do not code for gene products (i.e., are effectively neutral to selection) and vary in number of repeats between individuals. Due to the relatively high mutation rate observed in microsatellite DNA markers, they have been useful in analysis of population structure at a finer level than is possible using DNA genomic sequences, and have been remarkably successful at identifying recently diverged lineages in marine invertebrates (e.g., King et al. 2005). Given sufficiently large numbers of microsatellite markers and sufficient sampling coverage from throughout the species range, microsatellites can be utilized to obtain a precise measure of population structure, including an assessment of gene flow between populations, allowing identification of sources of recruitment and estimation of effective population size.

An analysis of population structure of *L. pertusa* from the northeast Atlantic and Scandinavian fjords, based upon microsatellites and nuclear ITS DNA sequences, concluded that very low levels of gene flow occurred between offshore and fjord habitats, and that population structure among fjords was substantial, indicating localized recruitment of larvae (Le Goff-Vitry et al. 2004a). This has significant conservation implications, because destruction of reefs may be permanent if they are unlikely to be re-seeded with new larvae. Attempts to utilize the microsatellite markers developed by LeGoff-Vitry et al. (2004b) for Western Atlantic *L. pertusa* have not been successful, so additional markers have been developed (C. Morrison et al. unpubl. data) for the southeastern United States and Gulf of Mexico. Generally, microsatellite markers are species-specific, and additional markers may need to be developed for other reef-forming species in the future. Preliminary results from *L. pertusa* collected in the southeastern U.S. and Gulf of Mexico revealed high variability in population structure, low clonality, and variation over small spatial scales (C. Morrison et al. unpubl. data). Such results indicate that loss of any living *Lophelia* could seriously impact genetic diversity.

7A: Determine the clonal structure of *L. pertusa* across spatial scales.

<u>TASK 1</u>: Conduct targeted sampling on small spatial scales to characterize patterns of genotypic structure at as many geographical locations as possible.

7B: Determine the extent of genetic connectivity among populations of *L. pertusa*.

<u>TASK 1:</u> Conduct combined opportunistic and targeted (to fill in gaps) sampling across the entire geographic and depth range of the species.

<u>Objective 8: Determine the nature, patterns, and processes of communities of microbial coral associates.</u>

The role of microbes (bacteria, fungi and archaea) in the biology of *L. pertusa* is essentially unknown and yet these organisms likely play an important role. In tropical shallow-water coral species, some microbes appear unique markers of the surrounding water column and may be associated with certain coral species or tissues (Rohwer et al. 2001, 2002), suggesting ecological interactions between the microbes and corals. Lacking algal symbionts found in shallow-water corals, deepwater corals may rely more heavily on microbes in order to remain healthy, such as fixing nitrogen, carbon cycling, chelating iron, producing antibiotics to ward off harmful bacteria, or other beneficial roles yet to be defined (C. Kellogg, pers. comm.). Microbes have been found to play key chemosynthetic roles in cold seep communities (e.g., Boetius et al. 2000; Knittel et al. 2005) that are often found in close proximity to *Lophelia* corals. Preliminary microbial data from Gulf of Mexico *Lophelia* colonies indicated a unique and diverse community that exhibited considerable variability (C. Kellogg, unpubl. data).

A combination of techniques will be necessary to characterize the microbial communities found within *Lophelia* corals. First, since the microbial community can change when exposed to varying pressures, temperatures and light conditions during sampling (C. Kellogg, pers. comm.), some corals should be fixed at depth in order to establish a baseline dataset. This will require special, sterile sampling devices for submarine or ROV work. Both culturable (capable of growing on agar plates), and non-culturable (assayed through DNA sequencing) microbes should be surveyed from *Lophelia* in as many locations as possible. Characterization of microbes from Gulf of Mexico *Lophelia* is on-going and will provide interesting comparisons with *Lophelia* from the Southeastern Atlantic coast (C. Kellogg, pers. comm.). Molecular probes targeting certain microbes may eventually allow fast assessment of presence or absence of associated microbes. Other coral species and other fauna closely associated with corals should be sampled for microbial communities as well and comparisons made among microbes found in different species.

8A: Identify the symbiotic microbial community of coral colonies in different places and environmental conditions.

TASK 1: Conduct microbial screening of opportunistic coral (and other species) samples.
TASK 2: Target sampling with "clean" in-situ sampler.

9.1.2.4 Sargassum

Habitat and species-specific research needs identified in Council fishery management plans are presented below for pelagic Sargassum habitat.

Summarized from Pelagic Water Column Workshop, Research and Monitoring Workshop, and Settle (1997):

1. What is the areal abundance of pelagic Sargassum off the southeast U.S.?
2. Does the abundance change seasonally?
3. Can pelagic Sargassum be assessed remotely using aerial or satellite technologies (e.g., Synthetic Aperture Radar)?
4. What is the relative importance of pelagic Sargassum weedlines and oceanic fronts for early life stages of managed species?
5. Are there differences in abundance, growth rate, and mortality?
6. What is the age structure of reef fishes (e.g., red porgy, gray triggerfish, and amberjacks) that utilize pelagic Sargassum habitat as a nursery and how does it compare to the age structure of recruits to benthic habitats?
7. Is pelagic Sargassum mariculture feasible?
8. What is the species composition and age structure of species associated with pelagic Sargassum when it occurs deeper in the water column?

9. Additional research on the dependencies of pelagic Sargassum productivity on the marine species using it as habitat.
10. Quantify the contribution of nutrients to deepwater benthic habitat by pelagic Sargassum.

In addition, the following research needs were identified in the NMFS Biological Opinion and are included:

1. Studies should be performed on the abundance, seasonality, life cycle, and reproductive strategies of Sargassum and the role this species plays in the marine environment, not only as an essential fish habitat, but as a unique pelagic algae. The research recommendations of this FMP were based primarily on managing Sargassum as essential fish habitat for species managed under the MSFCMA. Research needs should also be identified that consider the Sargassum community, as well as the individual species of this community that are associated with, and/or dependent on, pelagic Sargassum. Human-induced (tanker oil discharge; trash) and natural threats (storm events) to Sargassum need to be researched for the purpose of protecting and conserving this natural resource.
2. Cooperative research partnerships should occur between the council, NMFS Protected Resources Division, and state agencies since many of the needs to a) research pelagic Sargassum, and b) protect and conserve pelagic Sargassum habitat, are the same for both managed fish species and listed sea turtles.
3. Specific research needs should be included in the plan which further address the association between pelagic Sargassum habitat and post-hatchling sea turtles.

9.1.2.4 Dolphin Wahoo

Prioritized EFH Research Needs (from 2003 FMP)
This determination was developed based on research needs identified through the Pelagic Water Column Workshop, Research and Monitoring Workshop, Settle (1997) and the NMFS Biological Opinion for the Sargassum FMP (SAFMC, 2002) as they apply to dolphin and wahoo.

1. What is the areal and seasonal abundance of pelagic Sargassum off the southeast U.S.?
2. Develop methodologies to assess remotely assess Sargassum using aerial or satellite technologies (e.g., Synthetic Aperture Radar)?
3. What is the relative importance of pelagic Sargassum weedlines and oceanic fronts for early life stages of dolphin and wahoo?
4. Are there differences in abundance, growth rate, and mortality?
5. What is the age structure of all fishes that utilize pelagic Sargassum habitat as a nursery and how does it compare to the age structure of recruits to pelagic and benthic habitats?
6. Is pelagic Sargassum mariculture feasible?
7. Determine the species composition and age structure of species associated with pelagic Sargassum when it occurs deeper in the water column?
8. Additional research on the dependencies of pelagic Sargassum productivity on the marine species using it as habitat.
9. Quantify the contribution of nutrients to deepwater benthic habitat by pelagic Sargassum.

10. Studies should be performed on the abundance, seasonality, life cycle, and reproductive strategies of Sargassum and the role this species plays in the marine environment, not only as an essential fish habitat, but as a unique pelagic algae.
11. Research to determine impacts on the Sargassum community, as well as the individual species of this community that are associated with, and/or dependent on, pelagic Sargassum. Human-induced (tanker oil discharge; trash) and natural threats (storm events) to Sargassum need to be researched for the purpose of protecting and conserving this natural resource.
12. Develop cooperative research partnerships between the Council, NMFS Protected Resources Division, and state agencies since many of the needs to a) research pelagic Sargassum, and b) protect and conserve pelagic Sargassum habitat, are the same for both managed fish species and listed sea turtles.
13. Direct specific research to further address the association between pelagic Sargassum habitat and post-hatchling sea turtles.

Prioritized Research Needs
The determination is based on Prager, 2000 and SAFMC, 1998a research workshop recommendations. Research needs include but are not limited to the following:

- In the short-term effort should be directed at examining all existing seasonality (effort and landings), mean size, and life history data for dolphin from the northern area.
- Additional data are needed to develop and/or improve estimates of growth, fecundity, etc. Research in this area is encouraged.
- There are limited social and economic data available. Additional data need to be obtained and evaluated to better understand the implications of fishery management options.
- Trophic data should be considered in support of an ecosystem management approach.
- Essential fish habitats for dolphin and wahoo need to be identified.
- An overall design should be developed for future tagging work. The Working Group could do this. In addition, existing tagging databases should be examined.
- Long-term work should continue and expand on current research investigating genetic variability of dolphin populations in the western central Atlantic.
- Observer programs should place observers on longline trips directed on dolphin. Catch and bycatch characterization, condition released (alive or dead), etc. should be collected. Observers could also be used to collect bioprofile data (size, sex, hard parts for aging, etc.).
- High levels of uncertainty in inter-annual variation in abundance of dolphin should be investigated through an examination of oceanographic and other environmental factors.
- Release mortality should be investigated as a part of the evaluation of the effectiveness of current minimum size limits in the dolphin fishery.
- Establish a list serve for dolphin and wahoo, which would facilitate research and the exchange of information.

Note: An additional recommendation of the workshop was to establish a regional working group to develop and implement a coordinated research program for dolphin and wahoo.

9.1.3 Other Managed Species

9.1.3.1 Interjurisdictional Prioritized Research Needs

(Source: ASMFC 2004) (Revised Draft presented in Appendix A)

American Eel

1. Documentation of the commercial eel fishery should be more accurate so that our understanding of participation in the fishery and the amount of directed effort could be known.
2. A stock assessment committee should identify the best stock assessment methods for American eel.
3. Investigate survival and mortality rates of different life stages (leptocephalus, glass eel, yellow eel, and silver eel) to assist in the assessment of annual recruitment. Such research could be aided by continuing and initiating new tagging programs with individual states.
4. Regular periodic stock assessments and determination of fishing mortality rates (F) are required to develop a sustainable harvest rate in addition to determining whether the population is stable, decreasing, or increasing.
5. Evaluate the impact, both upstream and downstream, of barriers on eel with respect to population and distribution effects. Determine relative contribution of historic loss of habitat to potential eel population and reproductive capacity.
6. Triggering mechanism for metamorphosis to mature adult, silver eel life stage with specific emphasis on the size and age of the onset of maturity, by sex. A maturity schedule (proportion mature by size or age) would be extremely useful in combination with migration rates.
7. A coast wide sampling program for American eel should be formulated using standardized and statistically robust methodologies. A critical review of the existing sampling plan should be conducted.
8. Investigate: fecundity, length and weight relationships for females throughout their range; growth rates for males and females throughout their range; predator-prey relationships; behavior and movement of eel during their freshwater residency; oceanic behavior, movement and spawning location of adult mature eel; and all information on the leptocephalus stage of eel.
9. Assess characteristics and distribution of eel habitat and value of habitat with respect to growth and sex determination.
10. Age at entry of glass eel into estuaries and fresh waters should be examined.
11. Location and triggering mechanism for metamorphosis from leptocephalus to eel should be examined.
12. The historic participation level of subsistence fishers in wildlife management planning needs to be reviewed, and relevant issues brought forth with respect to those subsistence fishers involved with American eel.
13. Investigate, develop, and improve technologies for American eel passage upstream and downstream of various barriers for each life stage. Emphasis should be placed on evaluation of low-cost alternatives for passage.
14. Economics studies are necessary to determine the value of the fishery and the impact of regulatory management.

15. Examination of the mechanisms for exit from Sargasso Sea and transport across the continental shelf.
16. Mechanisms of recognition of the spawning area by silver eel, mate location in the Sargasso Sea, spawning behavior, and gonadal development in maturation should be researched.
17. Contaminant effects on eel and the effects of bioaccumulation with respect to impacts by age on survival and growth and effect on maturation and reproductive success should be researched.
18. Migratory routes and guidance mechanisms for silver eel in the ocean should be examined.
19. Examine the mode of nutrition for leptocephalus in the ocean.
20. Provide analysis of food habits of glass eel while at sea.
21. The degree of dependence on the American eel resource by subsistence harvesters such as Native American Tribes, Asian and European ethnic groups, etc. needs to be investigated.
22. Workshop on aging and sexing techniques should be considered to increase the accuracy of data collected in coastwide sampling program.
23. Determine mortality rates at different life history stages (leptocephalus, glass eel, yellow eel, silver eel), and mortality rates with size of the yellow eel stage.
24. Determine sustainable fishing mortality rates (F) for eel.
25. Investigate fecundity, length and weight relationships for females throughout their range, and growth rates for males and females throughout their range.

Research Needs Identified As Being Met:

- Evaluate the use of American eel as a water quality indicator.
- Investigate practical and cost-effective methods of re-establishing American eel in underutilized habitat.

American Shad/River Herring

1. Continue to assess current aging techniques for American shad and river herring, using known age fish, scales, otoliths, and spawning marks. Conduct bi-annual aging workshops to maintain consistency and accuracy of aging of fish sampled in state programs.
2. Determine and update biological benchmarks used in assessment modeling (fecundity at age, mean weight at age for both sexes, partial recruitment vector/maturity schedules) for American shad and river herring stocks in a variety of coastal river systems, including both semelparous and iteroparous stocks.
3. Validate the different values of M for shad stocks through verification of shad aging techniques and repeat spawning information and develop methods for calculating M.
4. Determine which stocks are impacted by coastal intercept fisheries (including bycatch fisheries). Methods to be considered to differentiate among stocks could include otolith micro-chemistry, oxytetracycline otolith marking and/or tagging.
5. Identify pheremones or other chemical substances used by American shad to locate conspecifics. Develop methods to isolate or manufacture these chemicals and use them to attract shad into fish passage facilities to improve fish passage and efficiency.

6. Develop effective culture and marking techniques for river herring.
7. Develop and implement techniques to determine shad and herring population targets for tributaries undergoing restoration (dam removals, fishways, supplemental stocking, etc.).
8. Evaluate and ultimately validate large-scale hydroacoustic methods to quantify American shad escapement (spawning run numbers) in major river systems. Identify how shad respond (attract/repelled) by various hydroacoustic signals.
9. Refine techniques for hormone induced tank spawning of American shad. Secure adequate eggs for culture programs using native broodstock.
10. Characterize tributary habitat quality and quantity for Alosa reintroductions and fish passage development.
11. Identify and quantify potential American shad spawning and rearing habitat not presently utilized and conduct an analysis of the cost of recovery.
12. Develop comprehensive angler use and harvest survey techniques for use by Atlantic states to assess recreational fisheries for American shad.
13. Determine the effects of passage impediments on all life history stages of shad and river herring, conduct turbine mortality studies and downstream passage studies.
14. Evaluate additional sources of mortality for shad, including bait and reduction fisheries.
15. Conduct studies on energetics of feeding and spawning migrations of shad on the Atlantic coast.
16. Encourage university research on hickory shad.
17. Conduct studies of egg and larval survival and development.
18. Conduct and evaluate historical characterization of socio-economic development (potential pollutant sources and habitat modification) of selected shad rivers along the east coast.
19. Review studies dealing with the effects of acid deposition on anadromous alosids.
20. Conduct population assessments on river herrings -- particularly needed in the south.
21. Quantify fishing mortality (in-river, ocean bycatch, bait fisheries) for major river stocks after ocean closure of directed fisheries.

Research Needs Identified as Being Met:

- Determine the stock/recruitment relationships for American shad and river herring stocks.

Atlantic Croaker

High Priority

- Criteria should be cooperatively developed for aging croaker otoliths.
- Studies of croaker growth rates and age structure need to be conducted throughout the species range.
- Age-length keys that are representative of all gear types in the fishery should be developed.
- Fishery dependent and independent size, age and sex specific relative abundance estimates should be developed to monitor long term changes in croaker abundance.
- Improve catch and effort statistics from the commercial and recreational fisheries, along with size and age structure of the catch.
- Examine reproductive biology of croaker with emphasis on developing maturity schedules and estimates of fecundity.

Medium Priority

- Conduct stock identification research on croaker.
- Cooperative coastwide croaker juvenile indices should be developed and validated to clarify stock status.
- Evaluate hook and release mortality under varying environmental factors and fishery practices.
- The effects of mandated bycatch reduction devices (BRD's) on croaker catch should be evaluated and compiled.
- In trawl fisheries or other fisheries that historically take significant numbers of croaker, states should monitor and report on the extent of unutilized bycatch and fishing mortality on fish less than age-1. Incorporate bycatch estimates into croaker assessment models.
- The optimum utilization (economic and biological) of a long term fluctuating population such as croaker should be evaluated.
- Continue monitoring of juvenile croaker populations in major nursery areas.
- Cooperatively develop a yield per recruit analysis to establish a minimum size that maximizes YPR.
- Determine the onshore vs. offshore components of the croaker fishery.
- Identify essential habitat requirements.

Low Priority

1. Determine migratory patterns and mixing rates through cooperative, multi-jurisdictional tagging studies.
2. Determine species interactions and predator/prey relationships for croaker (prey) and other more highly valued fisheries (predators).
3. Determine the impacts of any dredging activity (i.e. for beach re-nourishment) on all life history stages of croaker.

Atlantic Menhaden

- Evaluate effects of selected environmental factors on growth, survival and abundance of juvenile and adult menhaden, particularly in Chesapeake Bay and other coastal nursery areas.
- Develop and test methods for estimating size of recruiting year-classes of juveniles using fishery-independent survey techniques.
- Determine how loss/degradation of critical estuarine and nearshore habitat affects growth, survival and abundance of juvenile and adult menhaden abundance.
- Monitor landings, size, age, gear, and harvest area in the reduction and bait fisheries, and determine age composition by area. Enhance biostatistical sampling of bait samples in purse seine fisheries for Virginia and New Jersey to improve stock assessment.
- Study the ecological role of menhaden (predator/prey relationships, nutrient enrichment, oxygen depletion, etc.) in major Atlantic coast embayments and estuaries. The feasibility of estimating year-class strength using biologically stratified sampling design should be evaluated. The efforts could be supported by process studies linking plankton production to abundance of young menhaden (need resources).

- Evaluate use of coastal power plant impingement data as a possible means to estimate young-of-the-year menhaden abundance.
- Monte Carlo simulations should be conducted to evaluate precision of VPA.
- Alternative measures of effort, including spotter pilot logbooks, trip length, or other variables, should be evaluated. Spotter pilot logbooks should be evaluated for spotter plane search time, GPS coordinates, and estimates of school sizes observed by pilots.
- Re-evaluate menhaden natural mortality, by age and response to changing predator population sizes.
- Determine the effects of fish diseases (such as ulcerative mycosis and toxic dinoflagellates) on the menhaden stock.
- Determine the effects of regulations on the fishery, the participants and the stock.
- Growth back-calculation studies should be pursued to investigate historical trends in growth rate. The NMFS has an extensive database on scale growth increments which should be utilized for this purpose.
- Monitor fish kills along the Atlantic coast and use the NMFS Beaufort Laboratory as a repository for these reports.
- Develop bycatch studies of menhaden by other fisheries.
- Periodically monitor the economic structure and sociological characteristics of the menhaden reduction industry.

Striped Bass

1. Develop refined and cost-efficient coastal monitoring regime for striped bass stocks, including spawning stock biomass modeling and virtual population analysis (VPA).
2. Conduct sensitivity analysis on current state and federal fishery dependent and independent monitoring programs to determine which, if any, may be eliminated.
3. An evaluation of the overfishing definition should be made relative to uncertainty in biological parameters.
4. Simulation models should be developed to look at the implications of overfishing definitions relative to development of a striped bass population, which will provide “quality” fishing. Quality fishing must first be defined.
5. Quota calculation methods should be refined which allow better estimates among various components of the fishery.
6. Examine differential reporting rates between commercial and recreational fishermen using high reward tags.
7. Develop studies to provide information on the magnitude of hook and release and bycatch mortality, including factors that influence their magnitude and means of reducing or eliminating this source of mortality.
8. Further study should be conducted on the discrepancy in ages between scale-based and otolith-based ages. Particular emphasis should be placed on comparisons with known age fish determined from coded wire tags. Comparisons should be made among age readers and areas.
9. Increase sea sampling of commercial fisheries, such as the dogfish gillnet fishery, which may have high levels of discards.
10. Continue in-depth analysis of migrations, stock composition, etc. using mark-recapture data.

11. Continue to conduct research to determine limiting factors affecting recruitment and possible density implications.
12. Determine inherent viability of eggs and larvae.
13. Additional research should be conducted to determine the pathogenicity of the IPN virus isolated from striped bass to other warm water and marine species, such as flounder, menhaden, shad, largemouth bass and catfish.
14. Juvenile and adult surveys should be continued to determine the most cost-effective release strategies including age at release and optimal release conditions such as salinity, temperature, and time of day for future potential stocking programs.
15. Review relationship between tag-based survival estimates and VPA estimate of mortality in a management framework.
16. Improve methods for determining population sex ratio for use in estimates of spawning stock biomass and biological reference points.
17. Develop maturity ogive applicable to coastal migratory stock.

Atlantic Sturgeon

1. Obtain baseline data on habitat condition and quantity in important sturgeon rivers. Data should address both spawning and nursery habitat.
2. Characterize size, condition, and relative abundance of Atlantic sturgeon by gear and season taken as bycatch in various fisheries.
3. Determine the extent to which Atlantic sturgeon are genetically differentiable among rivers.
4. Develop methods to determine sex and maturity of captured sturgeon.
5. Research should be conducted to determine the susceptibility of Atlantic sturgeon to sturgeon adenovirus and white sturgeon iridovirus. Methods should be developed to isolate the sturgeon adenovirus and an Atlantic sturgeon cell line should be established for infection trials.
6. Develop sperm cryo-preservation techniques and refine to assure availability of male gametes. Refine induced spawning procedures.
7. Encourage shortnose sturgeon researchers to include Atlantic sturgeon research in their projects.
8. Develop and implement long-term marking/tagging procedures to provide information on individual tagged Atlantic sturgeon for up to 20 years.
9. Evaluate aging techniques for Atlantic sturgeon with known age fish. Emphasis should be placed on verifying current methodology based on fin rays. Determine length, fecundity, and maturity at age for North, Mid and South Atlantic stocks.
10. Conduct basic cultural experiments to provide information on: a) efficacy of alternative spawning techniques, b) egg incubation and fry production techniques, c) holding and rearing densities, d) prophylactic treatments, e) nutritional requirements and feeding techniques, and f) optimal environmental rearing conditions and systems.
11. Establish stocking goals and success criteria prior to development of stock enhancement or recovery programs.
12. Conduct research to identify suitable fish sizes, and time of year for stocking cultured fish.
13. Conduct and monitor pilot-scale-stocking programs before conducting large-scale efforts over broad geographic areas.

14. Identify rates of tag loss and tag reporting.
15. Evaluate existing sea sampling data to characterize at-sea migratory behavior.
16. Establish tolerance of different life stages to important contaminants and levels of such environmental factors such as DO (dissolved oxygen), pH, and temperature.
17. Standardize collection procedures and develop suitable long-term repository for biological tissues for use in genetic and other studies.
18. Develop the capability to capture wild broodstock and develop adequate holding and transport techniques for large broodstock.
19. Research should be conducted to identify the major pathogens of Atlantic sturgeon and a cell line for this species should be developed.
20. Conduct a cost benefit analysis of various stocking protocols.
21. Conduct further analyses to assess the sensitivity of F50 to model inputs.

Research Needs Identified As Being Met:
Establish a tag recovery clearinghouse and database for consolidation and evaluation of tagging and tag return information including associated biological, geographic, and hydrographic data.

Black Sea Bass
High Priority

- Sampling should be increased for commercial landing in black sea bass fisheries, specifically the fish pot fisheries in the Mid-Atlantic. Age sampling should be increased across all components of the commercial fishery.
- Sampling should be increased in the recreational fisheries. Age data should be collected from the total catch, and length sampling should be done to characterize size structure of discards.
- Develop fishery independent surveys and expand existing surveys to capture all sizes and age classes in order to develop independent catch-at-age and CPUE.
- Investigate the effect of sex transition rates, sex ratio and differential natural mortality by sex on the calculation of spawning stock biomass per recruit and eggs per recruit. Also, investigate the impact on reproduction of removal of large males from the population.
- Studies on sex-specific mortality rates and growth are needed.
- Increase sea sampling to verify information from commercial logbooks to provide better estimates of discards.
- A tagging program should be initiated through state fisheries agencies to estimate mortality independent of traditional methods.
- Further delineation of essential fish habitat (EFH), particularly in nursery areas. Further investigation of possible gear impacts on EFH.

Medium Priority

- Explore alternative assessment models, including non-age based alternatives.
- Consideration should be given to a pot survey for an index of abundance.
- Identify transport mechanisms or behaviors that move early juvenile black sea bass into estuaries.
- Evaluate habitat use by overwintering yearling, young-of-the-year, and adult black sea bass.

- Evaluate food habits of black sea bass larvae and overwintering adults.

Low Priority

1. Develop mariculture techniques.
2. A study determining the value of artificial reefs for increased production of black sea bass would be valuable in estimating potential yield.

Bluefish

1. Data needs:
   a) Sampling of size and age composition of the fisheries by gear type and statistical area should be increased.
   b) Commercial and recreational landings of bluefish should be targeted for biological data collection wherever possible.
   c) Increase intensity of biological sampling of the NER commercial and coastwide recreational fisheries.
2. Continue research on species interactions and predator/prey relationships. A scale-otolith age comparison study needs to be completed for bluefish.
3. Explore alternative methods for assessing bluefish, such as length-based and modified DeLury models.
4. Measures of CPUE under different assumptions of effective effort should be evaluated to allow evaluation of sensitivity of results.
5. Initiate fisheries dependent and independent sampling of offshore populations of bluefish during winter months.
6. Conduct research to determine the timing of sexual maturity and fecundity of bluefish.
7. Work should continue on catch and release mortality.
8. Any archived age data for bluefish should be aged and used to supplement North Carolina DMF keys in future assessments.
9. Conduct research on oceanographic influences on bluefish recruitment, including information on migratory pathways of larval bluefish.
10. Study tag mortality and retention rates for the American Littoral Society dorsal loop and other tags used for bluefish.
11. A coastal surf-zone seine study needs to be initiated to provide more complete indices of juvenile abundance.
12. Test the sensitivity of the bluefish assessment to assumptions concerning age-varying M, levels of age 0 discard, and the selection pattern.
13. Increase sampling frequencies when bluefish are encountered, especially when medium size fish are encountered.
14. Scientific investigations should be conducted on bluefish to develop an understanding of the long term, synergistic effects of combinations of environmental variables on various biological and sociological parameters such as reproductive capability, genetic changes, and suitability for human consumption.
15. Studies on the interactive effects of pH, contaminants, and other environmental variables on survival of bluefish.
16. Investigate the relationship of epidemic dermatological disease of bluefish exhibited in the Tar-Pamlico estuary to environmental toxics or other parameters.

17. Investigate the distribution of adult bluefish (particularly the spring-spawned cohort) in the South Atlantic Bight and juvenile bluefish (including the pelagic stage); and develop precise information on the distribution and relative abundance of bluefish in inshore areas, especially estuaries and embayments.

Source: NEFSC EFH Source Document on Bluefish (NEFSC 2006).

We lack information on the reproductive biology of bluefish. Observed patterns of spawning may be based on the population level rather than on information on individual reproductive traits. We presently do not know whether individuals spawn serially, and if so, how many times they are capable of spawning in a year. We also do not know if these reproductive characteristics vary with age. It is apparent that more study of the distribution of older stages needs to be correlated with spawning events. Since bluefish school in like-sized (and supposedly like-aged) groups, we need to know what groups are where and when, and how those aggregations are associated with the observed densities of eggs. Simply describing how many spawning events are occurring cannot solve the issue of the number of manageable stocks.

Our understanding of the "pelagic-juvenile" stage is limited despite its obvious importance. We need to better understand the details of transport mechanisms that provide progeny of reproduction in the South Atlantic Bight (SAB) to nurseries in the Middle Atlantic Bight (MAB). Increased sampling of the neuston or near-surface layers of the ocean between production areas and estuarine nursery areas, associated with appropriate oceanographic observations, would provide much-needed insight into factors affecting transport and estuarine recruitment.

There has been a tight correlation between population size and the contribution of the spring spawned cohort to fall trawl collections in the last three decades. Yet our knowledge of reproduction in the SAB is limited to a brief, under-sampled period in the 1970s when the population was at a relatively low level of abundance. Furthermore, larvae produced in June in the southern part of the MAB appear not to survive [unless recruits to Maine estuaries result from this output, see Creaser and Perkins (1994)], the fate of the remaining MAB summer offspring remains enigmatic.

There is some evidence for spawning during the fall in the Cape Canaveral region of Florida that appears to be discrete, rather than a continuation of spawning in the MAB. This evidence has been demonstrated in this document with larval occurrences and a disjunct autumn distribution of fish between 26 and 40 cm. Hare and Cowen (1993) present gonadosomatic data that suggest the same thing. Admittedly, some of this evidence is weak and based on incomplete sampling, and should be improved to determine the origin of these spawning fish, the magnitude of spawning, and the fate of any progeny.

Horseshoe Crab

<u>High Priority</u>

Evaluate the effectiveness of currently used benthic sampling gear for stock assessment.

<u>Medium Priority</u>

1. Investigate larval and juvenile survival and mortality to assist in the assessment of annual recruitment.
2. Further evaluate life table information including sex ratio and population age structure.
3. Evaluate the effect of mosquito control chemicals on horseshoe crab populations.
4. Determine beach fidelity by horseshoe crabs to determine habitat use.
5. Evaluate the impacts of beach nourishment projects on horseshoe crab populations.
6. Evaluate the importance of horseshoe crabs to other marine resources such as sea turtles.
7. Estimate the proportion of sub-tidal spawning and determine if this affects spawning success (i.e., egg survivability).
8. Develop a young-of-year or age 1 recruitment index from the Delaware 16-foot trawl survey.
9. Conduct tagging studies (mark-recapture) to determine the incidence of repeated spawning and dispersal parameters.

<u>Low Priority</u>

10. Estimate fishing discard numbers and associated mortality rates.
11. Conduct additional stock assessments and determine harvest mortality rates (F). Use these data to develop a more reliable sustainable harvest rate.
12. Develop biological reference points (such as natural mortality rates, growth rates, fecundity, etc.).

Spanish Mackerel (from the 2006 ASMFC FMP review)

<u>High Priority</u>

- Length, sex, age, and CPUE data are needed for improved stock assessment accuracy. Simulations on CPUE trends should be explored and impacts on VPA and assessment results determined. Data collection is needed for all states, particularly those north of North Carolina.
- Evaluation of weight and especially length at age of Spanish mackerel.
- Development of fishery-independent methods to monitor stock size of Atlantic Spanish mackerel (consider aerial surveys used in south Florida waters).
- Timelier reporting of mid-Atlantic catches for quota monitoring.
- Provide better estimates of recruitment, natural mortality rates, fishing mortality rates, and standing stock. Specific information should include an estimate of total amount caught and distribution of catch by area, season, and type of gear.
- Develop methodology for predicting year class strength and determination of the relationship between larval abundance and subsequent year class strength.
- Commission and member states should support and provide the identified data and input needed to improve the SAFMC's SEDAR process.
- The full implementation of ecosystem-based management and the implementation of monitoring /research efforts needed to support ecosystem-based management needs should be conducted.

<u>Medium Priority</u>

- Yield per recruit analyses should be conducted relative to alternative selective fishing patterns.

- Determine the bycatch of Spanish mackerel in the directed shrimp fishery in Atlantic Coastal waters (partially met: Branstetter, 1997; Ottley et al., 1998; Gaddis et al., 2001; Page et al., 2004).
- Evaluate potential bias of the lack of appropriate stratification of the data used to generate age-length keys for Atlantic and Gulf Spanish mackerel.
- Evaluate CPUE indices related to standardization methods and management history, with emphasis on greater temporal and spatial resolution in estimates of CPUE.
- Consideration of MRFSS add-ons or other mechanisms for collection of socioeconomic data for recreational and commercial fisheries.
- Determine normal Spanish mackerel migration routes and changes therein, as well as the climatic or other factors responsible for changes in the environmental and habitat conditions, which may affect the habitat and availability of stocks.
- Determine the relationship, if any, between migration of prey species (i.e., engraulids, clupeids, carangids), and migration patterns of the Spanish mackerel stock.

Low Priority

- Final identification of Spanish mackerel stocks through multiple research techniques.
- Complete research on the application of assessment and management models relative to dynamic species such as Spanish mackerel.
- Delineation of spawning areas and areas of larval abundance through temporal and spatial sampling.

Red Drum

1. Support fishery-independent sampling of sub-adult and adult red drum in each state from North Carolina to Florida. The purpose of this survey would be to: 1) verify escapement to the spawning population, 2) provide an index of recruitment to age 1, and 3) provide an estimate of the biomass of adult red drum.
2. Develop a more reliable estimate of natural and fishing mortality through directed sampling of the adult population.
3. Determine habitat preferences, environmental conditions, growth rates, and food habits of larval and juvenile red drum throughout the species range along the Atlantic coast. Assess the effects of environmental factors on stock density.
4. Identify spawning areas of red drum in each state from North Carolina to Florida so these areas may be protected from degradation and/or destruction. Determine the impacts of dredging and beach re-nourishment on red drum spawning and early life history stages.
5. Continue tagging studies to determine stock identity, inshore/offshore migration patterns and mortality estimation.
6. Determine the survival rate of red drum following regulatory and voluntary discard from commercial and recreational gear, including recreational net fisheries. Evaluate effects of water temperature and depth of capture.
7. Improve catch/effort estimates and biological sampling from recreational and commercial fisheries for red drum, including increased efforts to intercept nighttime fisheries for red drum by the NMFS MRFSS. Characterize magnitude of commercial and recreational discards.

8. States with significant fisheries should be encouraged to collect socio-economic data on red drum fisheries through add-ons to the MRFSS or by other means so as to determine the economic value of the Atlantic coast recreational red drum fishery.
9. Quantify relationships between red drum production and habitat.
10. Investigate and evaluate new stock assessment techniques as alternatives to age-structured models. Conduct yield modeling on red drum.
11. Investigate the concept of estuarine reserves to increase the escapement rate of red drum along the Atlantic coast.
12. Fully evaluate the efficacy of using cultured red drum to restore native stocks along the Atlantic coast, including cost-benefit analyses.
13. Identify the effects of water quality degradation on the survival of red drum eggs, post-larvae, larvae, and juveniles.
14. Refine maturity schedules on a geographic basis, determine relationships between annual egg production over a range of sizes, ages and across latitude.
15. Determine methods for restoring red drum habitat and/or improving existing environmental conditions that adversely affect red drum production.
16. Document and characterize schooling behavior for Atlantic coast red drum.

(from 2006 ASMFC review of Red Drum FMP)
Prioritized Research & Monitoring Recommendations (H)=High, (M)=Medium, (L)=Low
Stock Assessment and Population Dynamics

- Design an appropriate state fishery-independent survey of sub-adult and adult red drum to be implemented in Virginia, North Carolina, South Carolina, Georgia, and Florida. (H) (in progress for sub-adult and adult surveys).
- Each state should develop an on-going red drum tagging program that can be used to estimate both fishing and natural mortality and movements. This should include concurrent evaluations of tag retention, tagging mortality, and angler tag reporting rates. (M)
- Improve catch/effort estimates and biological sampling from recreational and commercial fisheries for red drum, including increased effort to intercept night fisheries for red drum. This should include significant efforts to determine the size and age structure of regulatory discards of live red drum. (H)
- States should maintain annual age-length keys. (H)
- Determine the chronic mortality rate of red drum following regulatory and voluntary discard from commercial and recreational fishing gear, including recreational net fisheries. Evaluate effects of water temperature and depth of capture. (M)
- Evaluate alternatives to VPA for red drum stock assessment. (M)

Biological

- Fully evaluate the effects and effectiveness of using cultured red drum to restore native stocks along the Atlantic coast. (H)
- Explore methods to effectively sample the adult population in estuarine, nearshore, and open ocean waters. (H)
- Continue tagging studies to determine stock identity, inshore/offshore migration patterns of all life stages (i.e. basic life history info gathering). Specific effort should be given to developing a large-scale program for tagging adult red drum (M) (in progress)

- Determine habitat preferences, environmental conditions, growth rates, and food habits of larval and juvenile red drum throughout the species range along the Atlantic coast. Assess the effects of environmental factors on stock density/yearclass strength. (M)
- Refine maturity schedules on a geographic basis. Thoroughly examine the influence of size and age on reproductive function. Investigate the possibility of senescence in female red drum. (L)

Social

- Examine the effectiveness of controlling fishing mortality and minimum size in managing red drum fisheries.
- Encourage the NMFS to conduct socioeconomic add-on surveys via the MRFSS that are specifically oriented to red drum recreational fishing (Example: the 2000 Northeast Summer Flounder Survey).

Economic

- Encourage the NMFS to continue funding socioeconomic add-on surveys via the MRFSS that include data elements germane to red drum recreational fisheries management.
- Where appropriate, encourage member states to conduct studies to evaluate the economic costs and benefits associated with current and future regulatory regimes impacting recreational anglers including anglers oriented toward catch and release fishing trips.
- Fully evaluate the efficacy of using cultured red drum to restore native stocks along the Atlantic Coast including risk adjusted cost-benefit analyses.
- Conduct a special survey and related data analysis to determine the economic and operational characteristics of the "for-hire sector" targeting red drum especially fishing guide oriented businesses in the South Atlantic states.
- Estimate the economic impacts (e.g. sales, jobs, income, etc.) of recreational red drum fisheries at the state and regional level including the "for-hire sector" (e.g. fishing guides).
- Encourage the NMFS to continue funding research on projecting future participation in marine recreational fishing in the Atlantic states with an emphasis on forecasts for major fisheries such as red drum.
- States with significant fisheries (over 5,000 pounds recorded by MRFSS) should collect socioeconomic data on red drum fisheries through add-ons to the MRFSS or by other means.

Habitat

- Identify spawning areas of red drum in each state from North Carolina to Florida so these areas may be protected from degradation and/or destruction. (H) (In progress, NC State University)
- Identify changes in freshwater inflow on red drum nursery habitats. Quantify the relationship between freshwater inflows and red drum nursery/sub-adult habitats. (H)
- Determine the impacts of dredging and beach re-nourishment on red drum spawning and early life history stages. (M)
- Investigate the concept of estuarine reserves to increase the escapement rate of red drum along the Atlantic coast. (M)

- Identify the effects of water quality degradation (changes in salinity, DO, turbidity, etc.) on the survival of red drum eggs, larvae, post-larvae, and juveniles. (M)
- Quantify relationships between red drum production and habitat. (L)
- Determine methods for restoring red drum habitat and/or improving existing environmental conditions that adversely affect red drum production. (L)

Spot

High Priority

- In trawl fisheries or other fisheries that take significant numbers of spot, states should monitor and report on the extent of unutilized bycatch and fishing mortality on fish less than age-1. Incorporate bycatch estimates into spot assessment models.
- The effects of mandated bycatch reduction devices (BRD's) on spot catch should be evaluated in those states with significant commercial harvests.
- Fishery dependent and independent size and sex specific relative abundance estimates should be developed.
- Cooperative coastwide spot juvenile indices should be developed to clarify stock status.
- Monitor long term changes in spot abundance, growth rates, and age structure.
- Continue monitoring of juvenile spot populations in major nursery areas.
- Improve spot catch and effort statistics from the commercial and recreational fisheries, along with size and age structure of the catch, in order to develop production models.
- Criteria should be cooperatively developed for aging spot otoliths and scales, and an age validation study should be conducted.

Medium Priority

- A yield per recruit analysis should be cooperatively developed.
- Develop stock identification methods.
- Determine migratory patterns through tagging studies.
- Determine the onshore vs. offshore components of the spot fishery.

Summer Flounder

High Priority

- Monitor abundance of juvenile summer flounder on a yearly basis.
- The NEFSC domestic sea sampling program should continue the collection of data for summer flounder, with special emphasis on a) improved areal and temporal coverage, b) adequate length and age sampling, and c) continued sampling after commercial fishery areal and seasonal quotas are reached and fisheries are limited or closed.
- Encourage research to determine the length and age frequency and discard mortality rates of commercial and recreational fishery summer flounder discards.
- Investigate the source of bias in estimating terminal parameters of the VPA (fishing mortality and stock size). Partially addressed in SARC 25 assessment.
- Undertake research to determine hooking mortality on summer flounder by circle, kahle, and regular “J” hooks and make the results of work already completed available to the Management Board.

- Develop fishery independent surveys and expand existing surveys to capture all sizes and age classes in order to develop independent catch-at-age and CPUE.
- Further delineation of EFH particularly in nursery areas. Further investigation of possible gear impacts on EFH.
- Collect and analyze age/length samples and catch/effort data from the commercial and recreational fisheries throughout the range of summer flounder.

Medium Priority

- Develop a consistent and accurate sampling program to determine the mesh selectivity for summer flounder and other commercial fisheries taken in mixed fisheries, and to determine discard mortality.
- Conduct a detailed socio-economic study of the summer flounder fisheries.
- Research directed at evaluating the mesh exemption program should be continued, with increased sample sizes to allow reliable statistical testing of results.
- Continue research to determine if the maturity ogive accurately reflects spawning potential of summer flounder.
- Investigate allocation of NEFSC sea sampling trips to optimize sampling effort.
- Develop stock identification methods via meristics, morphometrics, biochemical research and tagging; particularly off Virginia and North Carolina.
- Develop fish excluder devices to reduce bycatch of immature flatfish in fisheries that target species other than flounder.

Low Priority

- Develop a standardized index of abundance from NEFSC sea sampling data to provide a commercial fishery index that accounts for all removals by the fishery.
- Investigate the utility of alternative strata sets for the NEFSC spring trawl survey time series for summer flounder.
- Develop information on optimum length/age at capture and optimum mesh size.
- Conduct the basic research necessary to develop land and pen culture techniques.
- Evaluate effects of DO and water current requirements for adult summer flounder and summer flounder eggs.
- Evaluate the relationship between recruitment of summer flounder to nursery areas and Ekman transport or prevailing directions of water flow.

Weakfish

High Priority

- Collect catch and effort data including size and age composition of the catch, determine stock mortality throughout the range, and define gear characteristics. In particular, increase length-frequency sampling, particularly in fisheries from Maryland and further north.
- Develop latitudinal / seasonal / gear specific age length keys for the Atlantic coast. Increase sample sizes to consider gear specific keys.
- Derive estimates of discard mortality rates and the magnitude of discards for all commercial gear types from both directed and non-directed fisheries. In particular,

quantify trawl bycatch, refine estimates of mortality for below minimum size fish, and focus on factors such as distance from shore and geographical differences. Update the scale – otolith comparison for weakfish.

Medium Priority

- Define reproductive biology of weakfish, including size at sexual maturity, maturity schedules, fecundity, and spawning periodicity. Continue research on female spawning patterns: what is the seasonal and geographical extent of "batch" spawning; do females exhibit spawning site fidelity?
- Conduct hydrophonic studies to delineate weakfish spawning habitat locations and environmental preferences (temperature, depth, substrate, etc.) and enable quantification of spawning habitat.
- Compile existing data on larval and juvenile distribution from existing databases in order to obtain preliminary indications of spawning and nursery habitat location and extent.
- Continue studies on mesh-size selectivity; up-to-date (1995) information is available only for North Carolina's gill net fishery. Mesh-size selectivity studies for trawl fisheries are particularly sparse.
- Assemble socio-demographic-economic data as it becomes available from ACCSP.
- Additional investigation is needed in developing consistent otolith-based catch matrices including the EM algorithm.
- The impact of aging errors and other statistical uncertainties in the catch-at-age matrix on virtual population analysis (VPA) should be included. Retrospective analyses are needed on all VPA approaches investigated.
- Develop a spawner recruit relationship and examine the relationships between parental stock size and environmental factors on year-class strength.

Low Priority

- Identify stocks and determine coastal movements and the extent of stock mixing, including characterization of stocks in overwintering grounds. (e.g. tagging).
- Biological studies should be conducted to better understand migratory aspects and how this relates to observed trends in weight at age.
- Continue studies on recreational hook-and-release mortality rates, including factors such as depth, warmer water temperatures, and fish size in the analysis. Further consideration of release mortality in both the recreational and commercial fisheries is needed, and methods investigated to improve survival among released fish.
- Document the impact of power plants and other water intakes on larval, post larval and juvenile weakfish mortality in spawning and nursery areas, and calculate the resultant impact to adult sock size.
- Define restrictions necessary for implementation of projects in spawning and overwintering areas and develop policies on limiting development projects seasonally or spatially.
- Determine the onshore versus offshore components of the weakfish fishery.
- Develop a coastwide tagging database.
- Develop a spawner recruit relationship and examine the relationships between parental stock size and environmental factors on year-class strength.

Research Needs Identified as Being Met:

- Study the north-south gradient in weakfish growth rates.
  The study of the north-south gradient in weakfish growth rates is partially being addressed by Charlie Wenner, SC, through a MARFIN grant.
- Monitor long-term changes in abundance, growth rates, and age structure.

9.1.3.2 Recent and Ongoing Research on HMS Species

(Source: NMFS 2006)

Atlantic Bluefin Tuna

As part of its commitment to the Bluefin Program, research supported by the United States has concentrated on ichthyoplankton sampling, reproductive biology, and methods to evaluate hypotheses about movement patterns, spawning area fidelity, stock structure investigations and population modeling analyses.

Ichthyoplankton surveys in the Gulf of Mexico during the bluefin spawning season were continued in 2004 and 2005. Data resulting from these surveys, which began in 1977, are used to develop a fishery-independent abundance index of spawning West Atlantic bluefin tuna. This index has continued to provide one measure of bluefin abundance that is used in ICCAT's SCRS assessments of the status of the resource. During the 2004 U.S. ichthyoplankton survey, a plankton net of a type used in the Spanish surveys was fished in addition to the nets normally used to determine the impact of using a wider net mouth and larger mesh on the size and catch rates of bluefin in the Gulf of Mexico. The results of this work will be reported as they become available. U.S. scientists also collaborated in development of the larval working group agenda for the Climate Impacts on Oceanic Top Predators (CLIOTOP) program managed by GLOBEC (Global Ocean Ecosystem Dynamics) initiated by SCOR and the IOC of UNESCO in 1991.

Since 1998, researchers from Texas A & M University and the University of Maryland with assistance of researchers from Canada, Europe, and Japan have studied the feasibility of using otolith chemical composition (microconstituents and isotopes) to distinguish bluefin stocks.

Recent research has investigated the value of using additional microconstituent elements (transitional metals) to enhance classification success. By themselves the transitional metals provided little discriminatory power, but when combined with the other trace elements (for 13 elements in all), the classification success for several year-classes has been moderate ranging from 60 – 90 percent, and classification functions show strong year-to-year variability. In SCRS/2005/083 the utility of an alternative chemical marker in otoliths, carbon and oxygen stable isotopes, to discriminate bluefin tuna from natal regions were reported upon. The discriminatory power of stable isotopes (δ13C, δ18O) in otoliths of yearlings (age-1) was high, with 91 percent of individuals classified correctly to eastern and western nurseries. These stable isotopes and in particular δ18O can be used to reliably predict nursery origin of Atlantic bluefin tuna. An initial application compared otolith core material (corresponding to the first year of life) of large school, medium, and giant category bluefin tuna to reference samples of yearling signatures to determine their origin. A large fraction (~43 – 64 percent) of the Atlantic bluefin tuna collected in the western Atlantic fishery (comprised primarily of large school and medium category fish) originated from nurseries in the east. Alternatively, medium and giant category bluefin tuna from the Mediterranean were largely (~82 – 86 percent) of eastern origin. Thus, initial evidence suggests that the western fishery received high input from the Mediterranean population. (See generally SCRS/2003/105, and Rooker et al 2001a, 2001b and 2003).

Scientists from the University of Maryland, Virginia Institute of Marine Science, and Texas A&M University have continued to sample specimens for genetic and otolith chemistry studies of stock structure. Roughly 10 – 20 young of the year were collected in 2004. In addition, limited sampling of ages 1 and older continues. Efforts are also continuing to obtain samples from juveniles and mature bluefin from the Mediterranean Sea and adjacent waters.

In response to the ICCAT Commission's request for options for alternative approaches for managing mixed populations of Atlantic bluefin tuna, SCRS/2005/108 further examined some implications of incorporating electronic tagging information on transfer rates into virtual population analyses. SCRS/2005/084 examined yield and spawner per recruit consequences of different assumed levels of mixing between eastern and western bluefin stocks to provide guidance to the Commission as requested at the 3rd Meeting of Working Group to Develop Coordinated and Integrated Bluefin Tuna Management Strategies. Researchers at the Imperial College, London, continue work with the University of Miami, the University of New Hampshire and the National Marine Fisheries Service to develop methods to estimate bluefin movement and fishing mortality rate patterns (SCRS/2005/048). Operating models are being developed which will use conventional and electronic tagging data and fishing effort by management area. These models will be used to examine possible harvest control rules and the evaluation of possible management procedures.

U.S. scientists from Stanford and Duke University along with the Monterey Bay Aquarium and NMFS have placed over 700 electronic tags in bluefin tuna in the region along the U.S. coast of North Carolina. The data from implantable archival tags has been critical for establishing the basic biology of Atlantic bluefin and the patterns of movements to feeding and breeding grounds. Results from a large number of these tags were interpreted in a paper in the journal Nature in 2005 (Block et al. 2005). Tagging off the Carolinas, in the Gulf of Maine, and elsewhere continued in 2004 and 2005 and more than 90 tags were placed in fish off the Carolinas in 2005. The tags are due to report 7 – 9 months from the deployment dates and will be further reported upon as results become available.

U.S. scientists from the University of New Hampshire have placed over 200 pop-up satellite archival tags on New England bluefin tuna. Ongoing efforts include examining short and long-term dispersals of bluefin in the Gulf of Maine, the identification of spawning grounds, the spatial correlation between bluefin locations and oceanographic features and continuing to determine Atlantic-wide migratory paths. Results from much of this tagging effort were recently published in the journal Marine Biology (Wilson, et al. 2005).

A new research initiative in 2005 involving scientists from the University of New

Hampshire, the Virginia Institute of Marine Science, and Virginia Sea Grant will place electronic tags on juvenile bluefin from off the U.S. coast of Virginia. As results become available, they will be reported upon.

A recent publication by Fromentin and Powers (2005), titled "Atlantic bluefin tuna: population dynamics, ecology, fisheries and management" provides an extensive summary of old and new information on the biology and ecology of Atlantic bluefin tuna and associated fishery management implications. The abstract reads as follows:

> *Both old and new information on the biology and ecology of Atlantic bluefin tuna have confronted scientists with research challenges: research needs to be connected to current stock-assessment and management issues. We review recent studies on habitat, migrations and population structure, stressing the importance of electronic tagging results in the modification of our perception of bluefin tuna population dynamics and behavior. Additionally, we question, from both scientific and management perspectives, the usefulness of the classical stock concept and suggest other approaches, such as Clark's contingent and metapopulation theories. Current biological information confirms that a substantial amount of uncertainty still exists in the understanding of reproduction and growth. In particular, we focus on intriguing issues such as the difference in age-at-maturity between West Atlantic and Mediterranean bluefin tuna. Our description of Atlantic bluefin tuna fisheries places today's fishing patterns within the two millennium history of exploitation of this species: we discuss trap fisheries that existed between the 17th and the early 20th centuries; Atlantic fisheries during the 1950s and 1960s; and the consequences of the recent development of the sushi–sashimi market. Finally, we evaluate stock status and management issues since the early 1970s. While important uncertainties remain, when the fisheries history is confronted with evidence from biological and stock-assessment studies, results indicate that Atlantic bluefin tuna has been undergoing heavy overfishing for a decade. We conclude that the current exploitation of bluefin tuna has many biological and economic traits that have led several fish stocks to extreme depletion in the past.*

In 1982, ICCAT established a line separating the eastern and western Atlantic management units based on discontinuities in the distribution of catches at that time in the Atlantic and supported by limited biological knowledge. The United States is allocated quota from the western Atlantic management unit where the U.S. fisheries primarily occur. However, the overall distribution of the catch in the 1990s is much more continuous across the North Atlantic than was seen in previous decades. Tagging evidence indicates that movement of bluefin across the current east/west management boundary in the Atlantic does occur, that movements can be extensive (including trans-Atlantic) and complex, that there are areas of concentration of electronically tagged fish (released in the west) in the central North Atlantic just east of the management boundary, and that fisheries for bluefin tuna have developed in this area in the last decade. At least some of these fish have moved from west of the current boundary.

Complementary studies, which might show east to west movement, are less advanced. The composition and natal origin of these fish in the central North Atlantic area are not known. The SCRS emphasizes that "it is clear that the current boundary does not depict our present understanding of the biological distribution and biological stock structure of Atlantic bluefin tuna." The SCRS also notes that "the current boundary is a management boundary and its effectiveness for management is a different issue." There has been an accumulation of evidence on bluefin tuna mixing in the last few years through the collection of tagging data and its examination through the modeling of mixing scenarios for evaluating their effect on management. However, the origin of fish older than one year still remains unknown. Mixing results were reviewed in 2001 by the Workshop on Bluefin Tuna Mixing. This research led to a long-term plan for modeling finer scale spatial mixing and to short-term strategies for assessment to assist the advice for management. The data and research were reviewed again in 2002.

ICCAT, at its 2002 Meeting in Bilbao, called for a Working Group to Develop Integrated and Coordinated Atlantic Bluefin Tuna Management Strategies, which met in 2003 and again in 2004. In response to the recommendations from these meetings, the SCRS is developing a revised proposal for initiating a coordinated Bluefin Tuna Research Program to address priority research and data needs for providing scientific advice to ICCAT related to revised management procedures for bluefin tuna. Uncertainty exists regarding the importance and impacts of mixing on western stocks. The most important uncertainty regarding management advice by the SCRS for the eastern stock is the uncertainty in the catch data that are being taken.

More than 20 scientific documents related to bluefin tuna biology were presented to the 2005 SCRS. Many of the contributions dealt with the important issue of stock structure and mixing, and new information is available for both stocks. In particular, studies of otolith microchemistry and genetics have resulted in advances in our understanding of this component of the biology of bluefin tuna. These results continue to advance our knowledge about the overlapping distribution of fish originating from the east and the west. Therefore, the SCRS continues to question present hypotheses on stock identification. While these results are promising, more complete sampling and development of appropriate analytical approaches are required. The SCRS also received contributions relating to age and growth, sampling, parasitology and condition of bluefin tuna.

Atlantic Bigeye Tuna

In addition to monitoring catch and effort statistics for tropical tunas that include bigeye tuna, United States scientists participated in the 2005 ICCAT Workshop on Methods to Reduce Mortality of Juvenile Tropical Tunas, held in Madrid from 4 – 8 July, 2005. Document SCRS/2005/063 used the ICCAT Task 2 catch and effort data to estimate expected changes in the catches of tropical tunas attributable to replacing the current moratorium with a time-area closure (Recommendation 04-01). The results indicate that catches of tropical tunas are expected to increase substantially if the time-area closure replaces the current moratorium. Considering that the current ICCAT hypothesis is that purse-seine fleet efficiency gains three percent per year, the net change could in fact be a large overall increase to levels above the pre-moratoria fishing mortality rate levels. SCRS/2005/079 explored the expectations for catches of undersized bigeye tuna considering the agreement reached in Recommendation 04-01. In all cases examined, total catches can be expected to increase from 5.5 to 6.7 percent as a result of Recommendation 04-01, and catches of bigeye tuna can be expected to increase from 16 to 22.1 percent. In all cases, catch of juvenile bigeye tuna increases.

U.S. scientists from the University of Miami's Rosenstiel School of Marine and Atmospheric Science continue to collaborate with EC scientists on the EU-funded assessment and management modeling project titled Framework for the Evaluation of Management Strategies (FEMS) project, on management strategy evaluations related to tropical tuna fisheries.

Atlantic Yellowfin Tuna

In addition to the United States research findings for tropical tunas discussed above under bigeye tuna, one document was presented to the SCRS in 2005 that gave an overview of fishery trends and stock status for yellowfin tuna worldwide. It was noted that the natural mortality vector used by ICCAT in the Atlantic, while the same as that used by the IOTC for the Indian Ocean, is lower than is used by other scientific bodies for other oceans, particularly for the youngest ages. It was further noted that more recent information and methodologies may be available to potentially improve the estimates of natural mortality. Another document considered the estimation of natural mortality from multi-species tagging data. Due to limitations in the data (such as unbalanced design and different size distributions of released fish) and potential fishing differences between fleets, conclusions were limited to ratios of total mortality between fishing periods rather than any direct statement about natural mortality.

Considering the importance of natural mortality estimates in the assessment of the stock, the improvement of natural mortality estimates remains a high research priority. It was noted that future stock assessments should include an evaluation of the sensitivity of results to the uncertainty in natural mortality estimates. Differences were also noted for other biological parameters used by the various scientific bodies, such as growth and maturity vectors, the extent to which these differences reflect estimation methodology, data quality, or real differences between stocks warrants investigation.

Atlantic Albacore Tuna

U.S. scientists prepared document SCRS/2005/081 which described population models for North Pacific albacore (*Thunnus alalunga*) that have been developed and reviewed within the North Pacific Albacore Workshop (NPALBW) forum since 2000. Currently, the NPALBW relies on a Virtual Population Analysis (VPA) model for the purposes of formulating an international-based consensus regarding the "status" of this fish stock. Recently, an equally important research directive from the NPALBW has been to develop alternative, more detailed statistical-based models, in efforts to evaluate more fully the relationship between this species' population dynamics and associated fishery operations (i.e., areas of uncertainty in an overall stock assessment). Participants on the NPALBW developed one candidate model based on the Age-structured Assessment Program (ASAP), which generally represents a maximum likelihood-based numerical approach for conducting relatively straightforward, forward-simulation catch-at-age analyses. In addition, the document presents a brief discussion concerning development of other alternative stock assessment models, particularly length-based/age-structured platforms (e.g., MULTIFAN-CL and Stock Synthesis 2).

Atlantic Skipjack Tuna

U.S. small tuna research is directed mainly on king and Spanish mackerel stocks, as the amount landed of other small tunas such by U.S. fishermen is generally low. The focus of research on skipjack research by the international scientific community is on basic stock structure and abundance and the influence of FADs on increase in efficiency of the various fleets.

During the ICCAT Workshop on Methods to Reduce Mortality of Juvenile Tropical Tunas in July 2005 (Document SCI-032), a re-analysis on the tagging data in the Senegalese area showed however that the parameters of the skipjack growth curve obtained in this region were in fact closer to the growth estimates made in the Gulf of Guinea or in other oceans than those done previously in Senegal. In 2004 and 2005, U.S. scientists collaborated with Caribbean nations under the banner of the Caribbean Regional Fisheries Mechanism in initiating stock assessment analyses for small tuna (and other) stocks of mutual concern.

Swordfish

In 2005, data from observer samples were compared against self-reported information from the U.S. large pelagic mandatory logbook reporting system, and estimates of discard mortality of swordfish, billfish, sharks and other species from the U.S. fleet were developed from that analysis for the 2005 SCRS. Estimates of small swordfish bycatch for 2002 – 2004 were compared to the average levels estimated for the late 1990's and were found to be substantially lower. Reported and observed swordfish catches, and size and catch rate patterns through 2004 were examined in support of monitoring the recovery of north Atlantic swordfish. Standardized indices of abundance were updated for the Western North Atlantic using data from the U.S. pelagic longline fleet (SCRS/2005/085). Collaborative research between various ICCAT nations and Venezuelan scientists continues on estimating the age-structure of the catch of swordfish. Results of this research will be available for the next assessment of north Atlantic swordfish.

Scientists from the United States collaborated with Brazilian scientists to improve catch rate standardization procedures by offering a course on the topic in Brazil in mid-2005. Central to this collaboration is development of fisheries research capacity in Brazil through graduate student training and of stronger scientific cooperation between Brazil and the United States.

Research on measures to mitigate the interactions between pelagic longline and bycatch of marine turtles continued under a cooperative research program involving the U.S. Atlantic pelagic longline fishery. The Northeast Distant Fishery Experiment was conducted from 2001 through 2003 on the high seas of the Western Atlantic Ocean, in an area off Newfoundland known as the Grand Banks. Results of this research which was focused on reducing mortality of marine turtles interacting with pelagic longlines was recently published (Watson et. al. 2005. Fishing methods to reduce sea turtle mortality associated with pelagic longlines. Can. J. Fish. Aquat. Sci. 62(5): 965-981). Additional cooperative research in the Gulf of Mexico was carried out in 2004 and in additional regions in 2005.

Atlantic Billfish

The NMFS SEFSC played a substantial role in the ICCAT Enhanced Research Program for Billfish in 2004, with SEFSC scientists acting as the coordinator for the western Atlantic Ocean. Major accomplishments in the western Atlantic in 2004 were documented in SCRS/04/028. Highlights include 11 at-sea sampling trips with observers on Venezuelan industrial longline vessels in September 2004. Of the trips accomplished to date, 4 observer trips were on Korean type vessels fishing under the Venezuelan flag. Most of these vessels are based out of Cumana targeting tuna, swordfish, or both at the same time. Biological sampling of swordfish, Istiophorids, and yellowfin tuna for reproductive and age determination studies, as well as genetics research were continued during the 2004 sampling season. Shore-based sampling of billfish landings for size frequency data, as well as tournament sampling was obtained from Venezuela, Grenada, U.S. Virgin Islands, Bermuda, Barbados, and Turks and Caicos Islands. Program participants in Venezuela, Grenada, and Barbados continued to assist in obtaining information on tag-recaptured billfish, as well as numerous sharks, in the western Atlantic Ocean during 2004; a total of 44 tag recovered billfish and sharks were submitted to the Program Coordinator in 2004. Age, growth, and reproductive samples from several very large billfish were also obtained during 2004.A study conducted by the Virginia Institute of Marine Science (VIMS) to evaluate post release survival and habitat use from the recreational fishery for Atlantic white marlin using popup satellite archival tags (PSATs) was finalized in 2004 and published in the peer review literature. A separate study conducted by VIMS on U.S. longline vessels to evaluate post release survival of marlin, as well as evaluating hook performance and related mortality was also finalized in 2004. These data have been submitted to a peer-reviewed journal and are currently under review.

The SEFSC has conducted several studies in the Northwest Atlantic and the Pacific coast of Central America to evaluate habitat use and reproductive biology of billfish using PSAT technology. About 200 PSATs have been deployed in this effort over the last 4 years with deployments ranging from a month to 5.5 months. Several peer-reviewed papers summarizing these results are in press at this time, while other papers are currently in preparation.

In addition, SEFSC is also currently conducting pelagic longline research to evaluate gear behavior, and the effects of gear modification on catch rate and survival of target and non-target species. Three cruises have been completed to date. This work in ongoing and should be finished in 2006. Cooperative billfish research between US and Brazilian scientists was initiated in 2005.

The Fishery Management Group of the University of Miami is carrying out research on Atlantic billfish on three areas, population parameter estimation, population modeling and development of socio-economic indicators. Others at the University of Miami's Rosenstiel School and elsewhere are conducting research on early life history, reproductive biology and ecology of billfishes, as well as age and growth estimation. Updates of standardized CPUE for blue and white marlin from the United States pelagic longline fishery in the NW Atlantic and Gulf of Mexico and the U.S. recreational tournament fishery in the NW Atlantic and Gulf of Mexico were developed and presented to ICCAT in 2005 (Document SCRS/2005/30 and SCRS/2005/31). Numerous additional papers were presented regarding standardization of CPUEs. Please see http//:www.iccat.es for additional information.

Multiple papers on habitat use were submitted to the ICCAT SCRS in 2005. These included papers on: vertical habitat use of white marlin in numerous locations of the western North Atlantic using PSAT tags (SCRS/2005/034); the depth distributions of 52 blue marlin in relation to exposure to longline gear using PSAT tags (SCRS/2005/035); and, a quantitative framework and numerical method for characterizing vertical habitat use by large pelagic animals using pop-up satellite tag data (SCRS/2005/). Additional information on spawning area research and other topics can be found at http//:www.iccat.es.

Atlantic Sharks

Stock Assessments of Pelagic, Large Coastal, and Prohibited Sharks

The ICCAT Subcommittee on Bycatch conducted a stock assessment of blue sharks and shortfin makos in Tokyo, Japan, in June 2004. All information available on biology, fisheries, stock identity, catch, CPUE, and size of these species was reviewed and an evaluation of the status of stocks conducted using surplus production, age-structured, and catch-free stock assessment models. U.S. scientists contributed eight working documents for this meeting on various aspects of shark biology and methods to assess stock status; SEFSC scientists participated in the assessment process and authored or co-authored six of those documents. A stock assessment of dusky shark, a prohibited species under the shark FMP and candidate for listing under the ESA, is under way with expected completion in summer of 2006. Biological and fishery information available for this species is being synthesized and stock status will be evaluated using multiple stock assessment methodologies. The next assessment of large coastal sharks is planned for FY06, but data collection, synthesis, analysis, and preliminary stock evaluations will begin in late FY05.

Update on Catches of Atlantic Sharks

An update on catches of large and small coastal and pelagic sharks in U.S. Atlantic, Gulf of Mexico, and Caribbean waters was generated in FY 05 for inclusion in the 2005 SAFE Annual Report and future shark stock assessments. Time series of commercial and recreational landings and discard estimates from several sources were compiled for the large coastal shark complex and sandbar and blacktip sharks. In addition, recent species-specific commercial and recreational landings were provided for sharks in the large coastal, small coastal, and pelagic groups. Species-specific information on the geographical distribution of commercial landings by gear type and geographical distribution of the recreational catches was also provided. Trends in length-frequency distributions and average weights and lengths of selected species reported from three separate recreational surveys and in the directed shark bottom-longline observer program were also included. Another update on catches of Atlantic sharks will be generated in FY 06.

Ecosystem Modeling

A dynamic mass-balance ecosystem model was used to investigate how relative changes in fishing mortality on sharks can affect the structure and function of Apalachicola Bay, Florida, a coastal marine ecosystem. Simulations were run for 25 years wherein fishing mortality rates from recreational and trawl fisheries were doubled for ten years and then decreased to initial levels. Effect of time/area closures on ecosystem components were also tested by eliminating recreational fishing mortality on juvenile blacktip sharks. Simulations indicated biomass of sharks declined up to 57 percent when recreational fishing mortality was doubled. Simulating a time/area closure for juvenile blacktip sharks caused increases in their biomass but decreases in juvenile coastal shark biomass, a competing multispecies assemblage that is the apparent competitor. In general, reduction of targeted sharks did not cause strong top-down cascades. Another update on catches of Atlantic sharks was generated in FY05.

Elasmobranch Feeding Ecology and Shark Diet Database

The current Fishery Management Plan for Atlantic Tunas, Swordfish, and Sharks gives little consideration to ecosystem function because there is little quantitative species-specific data on diet, competition, predator-prey interactions, and habitat requirements of sharks. Given this, several studies are currently underway describing the diet and foraging ecology, habitat use, and predator prey interactions of elasmobranchs in various communities. In 2005, a study on latitudinal variation in diet and daily ration of the bonnethead shark from the eastern Gulf of Mexico was completed and a manuscript is being prepared for publication. A database containing information on quantitative food and feeding studies of sharks conducted around the world has been in development for several years and presently includes over 200 studies. This fully searchable database will continue to be updated and fine-tuned in FY 06. The goal is to make this tool available to researchers in the relatively near future.

Cooperative Gulf of Mexico States Shark Pupping and Nursery Survey (GULFSPAN)

The SEFSC Panama City Shark Population Assessment Group manages and coordinates a survey of coastal bays and estuaries between the Panhandle of Florida and Texas. Surveys identify the presence/absence of neonate and juvenile sharks and attempt to quantify the relative importance of each area as it pertains to essential fish habitat requirements for sharks. The SEFSC Panama City Shark Population Assessment Group also initiated a juvenile shark abundance index survey in 1996. The index is based on random, depth-stratified gillnet sets conducted throughout coastal bays and estuaries in northwest Florida monthly from April to October. The species targeted for the index of abundance are juvenile sharks in the large and small coastal management groups.

Angel Shark Life History

The Atlantic Angel Shark is a benthic species inhabiting deep waters of the Gulf of Mexico and the Atlantic Ocean. This species is listed as prohibited by the 1999 Fisheries Management Plan for Atlantic Tunas, Swordfish, and Sharks due to the lack of biological data and a precautionary approach for species thought to be highly susceptible to exploitation. Life history studies began in 2003. Samples are obtained from commercial fishers and fishery independent surveys. Preliminary reproductive parameters were determined in 2004 and results presented at the annual American Elasmobranch Society meeting held in Norman, Oklahoma, in May 2004.

Life History Studies of Elasmobranchs

Biological samples are obtained through research surveys and cruises, recreational fishers, and through collection by onboard observers on commercial fishing vessels. Age and growth rates and other life history aspects of selected species are processed and data analyzed following standard methodology. This information is vital as input to population models incorporating variation and uncertainty in estimates of life-history traits to predict the productivity of the stocks and ensure that they are harvested at sustainable levels. The age and growth parameters of bull shark (*Carcharhinus leucas*) and spinner shark (*C. brevipinna*) were completed and submitted for publication in 2004.

Cooperative Research – Definition of Winter Habitats for Blacktip Sharks in the Eastern Gulf of Mexico

A collaborative effort between SEFSC Panama City Shark Population Assessment Group and Mote Marine Laboratory is underway to define essential winter habitats for blacktip sharks (*Carcharhinus limbatus*). Deployment of archival Pop-Up Archival Transmitting (PAT) tags on sharks during January and February of FY05 in the Florida Keys and north Florida will be executed with the cooperation of the charterboat industry. PAT tags will be programmed to detach from individuals during late spring and early summer when sharks have recruited to coastal areas.

Cooperative Research – Habitat Utilization among Coastal Sharks

Through a collaborative effort between SEFSC Panama City Shark Population Assessment Group and Mote Marine Laboratory, the utilization of coastal habitats by neonate and young-of-the-year blacktip and Atlantic sharpnose sharks will be monitored through an array of underwater acoustic receivers (VR2, Vemco Ltd.) placed throughout each study site.

Movement patterns, home ranges, activity space, survival, and length of residence of individuals will be compared by species and area to provide information to better manage critical species and essential fish habitats.

Cooperative Research – Characterization of Bycatch in the Gulf Butterfish, (*Peprilus burti*), Trawl Fishery, with an Emphasis on Identification of Life History Parameters for several Potentially High-Risk Species

A proposal with the SEFSC Panama City Shark Population Assessment Group and the University of Florida was submitted to MARFIN to quantify and qualify the elasmobranch bycatch in the butterfish, (*Peprilus triacanthus*), trawl fishery in the Gulf of Mexico. Determination of life history parameters for the roundel skate, (*R. texana*), the clearnose skate, (*R. eglanteria*), the spreadfin skate (*Dipturus olseni*), and the Atlantic angel shark, (*Squatina dumerili*) will be developed ultimately for the estimation of vital rates. Vital rate information will be used to determine the productivity of the stocks and ensure that they are harvested at sustainable levels.

Using elemental chemistry of shark vertebrae to reconstruct large-scale movement patterns of sharks

A project examining ontogenetic shifts in habitat utilization of bull sharks using Sr:Ca ratios of vertebrae will begin in FY06, funds permitting. Laser ablation ICPMS will be used to assay transects across the entire vertebral section along the corpus calcareum. Given the relationship of Sr:Ca to habitat developed from the reference samples, habitat type (freshwater, estuarine, or marine) will be assigned to each growth band, thereby reconstructing the migration history of the shark on a year-by-year basis over its lifetime.

Coastal Shark Assessment Research Surveys

The SEFSC Mississippi Laboratories in Pascagoula have been operating annual research cruises aboard NOAA vessels since 1995. The objectives of this program are to conduct bottom longline surveys to assess the distribution and relative abundance of coastal sharks along U.S. and Mexican waters of the Gulf of Mexico and the U.S. eastern seaboard. This is the only long-term, nearly stock-wide, fishery-independent survey of Atlantic sharks conducted in U.S. and neighboring waters. Ancillary objectives are to collect biological and environmental data, and to tag-and-release sharks. Starting in 2001 and under the auspices of the Mex-US-Gulf Program, the Pascagoula Laboratories have provided logistical and technical support to Mexico's Instituto Nacional de la Pesca to conduct a cooperative research cruise aboard the Mexican research vessel *Onjuku* in Mexican waters of the Gulf of Mexico. The cruise also took place in 2002, but was suspended in 2003 and 2004 because of mechanical problems with the research vessel and other issues.

A proposal was submitted in 2005 to gather data to help clarify the uncertainty on the current status of oceanic whitetip sharks in the western North Atlantic Ocean. Data on behavior and movement patterns will be collected using on-board observers on pelagic longline vessels. Archival satellite pop-up tags will be utilized to monitor the movement patterns, depth, and temperature preferences of this species. In addition, time-depth recorders, and hook-timers will be used to determine the depth and times at which sharks take baits. These data will be incorporated with sea surface temperature data from satellites and incorporated into new habitat-based analyses of the data to provide a better understanding of the status of oceanic whitetip sharks.

<u>Cooperative Research – The capture depth, time, and hooked survival rate for bottom longline caught large coastal sharks</u>
A collaborative effort between SEFSC Panama City Shark Population Assessment Group and the University of Florida to examine alternative measures in the shark bottom longline fishery to reduce mortality on prohibited sharks such as reduced soak time, restrictions on the length of gear, and fishing depth restrictions will be tested using hook timers. Funding is being sought through the NMFS Cooperative Research Program.

<u>Utilizing Bioenergetics and Matrix Projection Modeling to Quantify Population Fluctuations in Long-lived Elasmobranchs: Tools for Fisheries Conservation and Management</u>
Under the supervision of SEFSC scientists at the Panama City Laboratory, the NMFS Sea Grant Fellow in Population Dynamics and Resource Economics conducted research that sought to use a bioenergetics and matrix approach to examine the population dynamics of the cownose ray (*Rhinoptera bonasus*). Laboratory experiments and field data were used to obtain basic life history information, and that information configured the individual-based bioenergetics model. The bioenergetics model was coupled to a matrix projection model, and the coupled models were used to predict how warmer and cooler water temperatures would affect the growth and population dynamics of the cownose rays. Changes in growth rates under the warmer and cooler conditions lead to changes in age-specific survivorship, maturity, and pup production, which were used as inputs to a matrix projection model. Faster growth of individuals under the cooler scenarios translated into an increased population growth rate (4.4 – 4.7 percent/year versus 2.7 percent/year under baseline), shorter generation time, and higher net reproductive rates, while slower growth under the warmer scenarios translated into slower population growth rate (0.05 – 1.2 percent/year), longer generation times, and lower net reproductive rates.
Elasticity analysis indicated that population growth rate was most sensitive to adult survival. Reproductive values by age were highest for intermediate ages.

<u>Cooperative Research – Definition of Winter Habitats for Blacktip Sharks in the Eastern Gulf of Mexico</u>

A collaborative effort between SEFSC Panama City Shark Population Assessment Group and Mote Marine Laboratory is underway to define essential winter habitats for blacktip sharks (*Carcharhinus limbatus*). Deployment of two pop-off satellite archival tags (PAT) on sharks during January and February of 2005 in the Florida Keys was accomplished with the cooperation of the charter boat industry. Preliminary results from these two sharks indicate one shark remained in the Keys while the other moved to an area southwest of the coast of Cuba. Additional PAT tags will be placed on sharks during the summer of 2005.

<u>Cooperative Research – Definition of Summer Habitats and Migration Patterns for Bull Sharks in the Eastern Gulf of Mexico</u>
A collaborative effort between SEFSC Panama City Shark Population Assessment Group, University of Florida, and Mote Marine Laboratory is underway to determine summer habitat use and short-term migration patterns of bull sharks (*Carcharhinus leucas*). Sharks are being outfitted with Pop-Up Satellite Archival Tags (PSAT) during July and August of 2005 and scheduled to deploy in autumn. This project is driven by the lack of data for this species and its current prominence within the Florida coastal community. A better understanding of this species is required to effectively manage this species for both commercial and recreational fishers as well as the general public. Concerns regarding this species will continue to be an issue as fishers and the public demand that state and federal governments provide better information concerning the presence and movements of these sharks.

Other Agencies

9.1.5 The Clean Water Action Plan – Coastal Research and Monitoring Strategy

The Coastal Research and Monitoring Strategy Workgroup was formed in 1999 with representatives from Federal, State, Tribes, and Non-Governmental Organizations (NGO) to prepare the Coastal Research and Monitoring Strategy. Simply stated, the intent of the Strategy is to replace traditional single-issue, single-agency, single-discipline problem solving with a coordinated, multi-agency, interdisciplinary approach to address problems of coastal water quality and coastal resources.

As directed in the Clean Water Action Plan, EPA, NOAA, USGS, and the USDA led the development of this Coastal Research and Monitoring Strategy and provided leadership for strategic planning, coordination, and prioritization of research and monitoring objectives.

Executive Summary
In terms of surface area, coastal waters of the United States represent the largest economic and environmental zone of the Nation. Because a disproportionate percentage of the Nation’s population lives in coastal areas, the activities of municipalities, commerce, industry, and tourism have created environmental pressures that threaten the very resources that make the coast desirable.

To address these pressures, the Clinton Administration has called for a renewed effort to restore and protect our Nation’s estuarine and coastal areas. The Clean Water Action Plan, announced by President Clinton and Vice President Gore on February 19, 1998, is intended to redirect the Nation's water programs to "protect public health and restore our Nation's waterways". The Clean Water Action Plan specifically calls for the development of a strategy for coastal research (Action Item 59) and a plan for coastal monitoring (Action Item 60) including a comprehensive review of existing programs related to the generation, transport, and effect of pollutants on coastal waters, habitats, and living and economic resources. This document addresses both Action Items because they are intrinsically linked for the purposes of assessing regional and national trends, determining cause and effect relationships, and implementing adaptive management principles.

While the national investments made as a result of environmental legislation have had a dramatic effect on improving the Nation's coastal water quality, there are still environmental problems in the coastal zone. Examples of environmental issues common to most coastal States include nutrient enrichment, habitat change, protection of living aquatic resources, invasive species, pathogens, toxic contaminants, and harmful algal blooms.

The Federal government invests annually about $225 million conducting research and monitoring programs addressing these and other specific environmental issues in the coastal zone. Despite these investments, the importance of the coastal region to the Nation's economy, and the high potential for human use to adversely impact coastal resources and ecosystems, information about the status and trends of critical environmental variables in coastal regions is often lacking. Other than programs for coastal weather, water levels, commercial fisheries, and point source discharges, there are currently no nationally consistent, comprehensive monitoring programs to provide the information necessary for effective management of coastal systems.

The Coastal Research and Monitoring Strategy employs a monitoring-research-assessment-management cycle that integrates coastal monitoring and research objectives to enable cross-cutting and comprehensive assessments of the Nation's coastal resources. The objectives of the Strategy are to:

- Document the status and assess trends in environmental conditions at the scales necessary for scientific investigation and policy development;
- Evaluate the causes and consequences of changes in environmental status and trends;
- Assess environmental, economic, and sociological impacts of alternative policies for dealing with these changes; and
- Implement programs and policies to correct observed environmental problems.

The key attributes of the proposed Coastal Research and Monitoring Strategy include co-funding by Federal and State programs; nested designs to allow State-specific issues to be addressed in a national context; collective reporting; and cross-system comparisons.
The strategy for a national coastal monitoring design is based on the three-tiered approach developed by the U.S. Environmental Protection Agency (Messer et al. 1991) and a similar version was recommended by NSTC (1997) and has the following components:

- Characterization of Problem (Tier 1) -- Broad-scale ecological response properties as a base determined by survey, automated collection, and/or remote sensing;

- Diagnosis of Causes (Tier 2) -- Issue- or resource-specific surveys and observations concentrating on cause-effect interactions; and
- Diagnosis of Interaction and Forecasting (Tier 3) -- Intensive monitoring and research index sites with higher spatial and temporal resolution to determine specific mechanisms of interaction needed to build cause-effect models.

Data and information generated at each tier help interpretation of results from the other tiers. For example, Tier 1 (Characterization) data provide geographic context for data collected at Tiers 2 and 3 (e.g., how widespread is the problem and how much of the nation's resources are affected by its occurrence). Likewise, Tiers 2 (Diagnosis of Causes) and 3 (Diagnosis of Interactions and Forecasting) aid in understanding how serious a particular relationship or issue is.

The focus of the Strategy and conceptual framework is monitoring in the coastal zone. However, important research activities must occur concurrently at each level of the monitoring framework. Research plays a vital role in increasing our ability to interpret data from our monitoring programs and enhance our monitoring tools and methods. Research is the foundation underlying all tiers of the monitoring framework, and is critical to achieving the objectives of integrated assessments.

The objectives and the conceptual framework for a Coastal Research and Monitoring Strategy have been defined by the Workgroup and are included in this document. However, the Workgroup recognizes that further development of an implementation strategy which contains specific action plans for each of the following recommendations is necessary to execute the concepts of this Strategy. The final section of this document suggests issues that should be considered during implementation. However, development of an implementation plan is beyond the scope of this Workgroup.
The following six recommendations are offered:

1. Enhance and adapt existing programs to support an integrated and effective national coastal monitoring program. A high priority is placed on the development of a national coastal survey based on State-level coastal monitoring programs. The data collected from coastal States could provide a comprehensive and consistent picture of the "coastal health" of each State which would complement the partial requirements of Section 305(b) of the Clean Water Act. The data generated as a result of these monitoring activities could be used to support States' 303(d) listing processes.
2. Enhance and integrate interagency research efforts to fill data gaps, to increase the understanding of physical and ecological processes in the coastal zone, and to improve monitoring and assessment tools. Opportunities must be developed to foster interagency solicitation, review, and support of research proposals. Appropriate methods include both competitive and external grant processes, and internal Federal competition and interagency agreements.
3. Conduct periodic national and regional coastal assessments. These would include national summary assessments, national habitat assessments, national issue-specific assessments, and regional assessments.

4. Improve data management in support of the periodic assessments. These activities include development and maintenance of an Internet-based coastal environmental data clearinghouse and directory of meta-data resources, development of performance-based standards for data management and data submission, and development of national data quality standards.
5. Establish mechanisms to assess and adjust monitoring and research with changing national coastal priorities. User-advisory and technical committees, composed of representatives from Federal, State, and local governments; academia; not-for-profit organizations; and the private sector would be established to ensure that the products and services of the system are relevant and stay on track and to ensure that development and implementation of the system uses the best available scientific methods and technologies.
6. Establish a mechanism to define and develop an implementation plan for each of the Recommendations 1 -5 and to oversee efficient execution of a national program. To carry out the above recommendations and develop an implementation plan for a national strategy, the formulation of an interagency oversight committee is recommended. Long-term viability of the committee is essential.

To download a copy of the Clean Water Action Plan visit:
http://water.usgs.gov/owq/cleanwater/coastalresearch/

9.2 Research Programs

9.2.1 Fishery-Independent

9.2.1.1 MARMAP

For thirty years, the Marine Resources Research Institute (MRRI) at the South Carolina Department of Natural Resources (SCDNR), through the Marine Resources Monitoring, Assessment and Prediction (MARMAP) program, has conducted fisheries-independent research on groundfish, reef fish, ichthyoplankton, and coastal pelagic fishes within the region between Cape Lookout, North Carolina, and Ft Pierce, Florida. The overall mission of the program has been to determine distribution, relative abundance, and critical habitat of economically and ecologically important fishes of the South Atlantic Bight (SAB), and to relate these features to environmental factors and exploitation activities. Research toward fulfilling these goals has included trawl surveys (from 6-350 m depth); ichthyoplankton surveys; location and mapping of reef habitat; sampling of reefs throughout the SAB; life history and population studies of priority species; tagging studies of commercially important species and special studies directed at specific management problems in the region. Survey work has also provided a monitoring program that has allowed the standardized sampling of fish populations over time and development of an historical base for future comparisons of long-term trends.

Current Objectives

Annual MARMAP cruises to assess relative abundance of reef fishes in the sponge-coral and shelf edge (live bottom) habitats of the South Atlantic Bight (SAB) have been conducted since

1978. MARMAP currently samples natural live bottom habitat from Cape Lookout, NC to the Ft. Pierce area, FL. The current main MARMAP objectives are to:

- sample reef fishes in the snapper-grouper complex at using a variety of gears in live bottom, rocky outcrop, high relief, and mud bottom habitats,
- collect detailed data for time series description of species for annual composition and relative abundance,
- obtain population characteristics on fish species of interest through life history information analysis, including age and growth, sex ratio, size and age of sexual maturation and transition, spawning season, fecundity, and diet. Priorities are dictated by the SEDAR schedule and other management considerations,
- collect hydrographic data (e.g. depth, temperature, salinity, etc.) for comparison to fish abundance and composition indices,
- collect DNA samples from selected fish species for stock identification
- expand sampling area in North Carolina and south Florida as well as reconnoiter new live bottom areas with underwater video (UWTV) to add to the MARMAP site database.

Since the inception of the MARMAP program various gear types and methods of deployment have been used. In recent years MARMAP has mostly used the Chevron trap (CHV), short (or vertical) long line (VLL), and the long (or horizontal) long line (HLL) using standard deployment and retrieval methods. At each sampling site CTD profiles are taken to record water conditions (e.g. temperature, salinity, etc.). The gears and methodology has been consistent over the years to allow for long term analysis and comparisons.

Chevron fish trap

The chevron trap is an arrowhead-shaped trap (maximum dimensions of 1.5 m x 1.7 m x 0.6 m.; 0.91 m3 volume) constructed of 35 mm x 35 mm square mesh plastic-coated wire, with one funnel entrance and one release panel. Each trap is baited with a combination of whole or cut herrings (*Brevoortia*, family Clupeidae). Bait is suspended on 4 stringers (approximately 4 fish per string) within the trap, with 6-8 loosely placed fish in the in the trap. The traps are tethered individually using 8-mm (5/16 inch) polypropylene line to a polyball buoy and a Hi-Flyer buoy attached to a 10-m trailer line. Chevron traps are deployed during daytime hours at stations randomly selected by computer from a database of approximately 2,500 live bottom and shelf edge locations and soaked for approximately 90 minutes. Up to six traps, separated by a minimum distance of 200 m, are fished at the same time. Chevron traps have been used since 1988 and the majority of trap sampling has occurred between 16 to 91 m.

Short (vertical) long line

Short longlines have been used where bottom topography is rough at depths to about 220m. This gear type consists of a 26 m (84 ft) groundline with 20 baited hooks brommelled to an 8-mm (5/16 inch) polypropylene line attached to a polyball buoy and a Hi-Flyer buoy attached to a 10-m trailer line to the surface. The hooks, attached at 1.2 m intervals, are baited with double hooked squid. Weights are attached to each end of the groundline. The weights and groundline are deployed such that the line is draped over bottom relief. Each line is soaked for approximately 90 minutes and six lines may be fished at the same time. This gear type has been used since 1997.

Long (horizontal) long line
Horizontal longline is deployed at depths ranging from 180 to 235 m over smooth mud bottom, areas that are prime habitat for golden tilefish. The horizontal longline consists of 1500 to 1700m of 0.32 mm galvanized cable deployed from a longline reel. Approximately 1220 m of the cable is used as groundline and the remaining line is buoyed to the surface. Two weights are attached to the terminal end and 100 gangions baited with double hooked squid are attached at 12 m intervals. At the end of the groundline, two weights are attached and at the end of the cable one or two polyballs and a Hi-Flyer trailer buoy are attached. The gear is soaked for 90 minutes and two lines are soaked at the same time.

Underwater TV
UWTV recordings were made using a Simrad-Osprey Subsea low light camera attached to a vane stabilized frame during day light hours. The camera was maintained off the bottom 1 - 2 m off the bottom as the vessel either drifted with the wind and/or current or was towed at low speeds. Recordings for fish identification on bottom habitat and to document new live bottom sites for the MARMAP data base were made on VHS tape and archived for future analysis.

In addition to these gears, hook and line fishing is occasionally used to supplement sampling for life history studies. Historical hook and line data are currently used for the development of a possible standard hook and line survey in the future.

All individuals in each catch (trap or line) are sorted and identified to species level. All individuals of each species are weighed together, while length is individually measured for all fish. All Individuals of selected species are kept for life history work-up, but abundant species such as black sea bass, vermilion snapper, and red porgy are randomly subsampled. All other fish are returned to the ocean. Species selected for life history work-up are: all groupers and snappers, red porgy, white grunt, gray triggerfish, black sea bass, and occasionally other species of interest.

Life History
Fish used for life history studies are measured to the nearest mm (total length, fork length, and standard length) with an electronic fish measuring board interfaced with a personal computer. Individual weights are measured to the nearest gram. Otoliths (mostly sagittae) and gray trigger fish spines, and gonad sections are removed at sea. Otoliths and spines are stored dry in coin envelopes. The otoliths and spines are used to determine the age of the fish in the MARMAP laboratory. This is a done by examining the whole otolith or 0.5-1.0 mm thick sections of otoliths and spines, depending on the species. Increments, one translucent and one opaque zone, or "ring" in the otoliths are counted by independent readers to determine the age of each fish.

Each gonad section is fixed in 10% seawater formalin for 1-2 weeks, and then transferred to 50% isopropanol for 1-2 weeks. Gonad samples are then processed to produce thin, stained sections on microscope slides. These preparations are examined under the microscope to determine sex and reproductive state using histological criteria.

Data

MARMAP has developed a long-term database for reef fish that has proven valuable in interpreting fisheries landings data and developing regulations for protecting reef fish resources. Restrictions on minimum sizes of most commercially important species make it difficult to monitor life history parameters and abundance data from samples collected from the fishery landings. MARMAP has the only existing long-term program off the Atlantic coast of the southeastern United States that monitors reef fish composition, length frequency, abundance, and life history based on fishery-independent data. These data provide critical input for the assessments of stock status conducted by NOAA Fisheries, and greatly assist stock assessment scientists and the Council in the management of snapper/grouper complex of the South Atlantic Bight.

MARMAP Vessels

Three research vessels have been used by MARMAP since 1972: the R/V Dolphin, R/V Oregon I, and R/V Palmetto. During 1973-1980, MARMAP used the R/V Dolphin. This was a 105' converted ocean tugboat that was outfitted for trawling, plankton work, hydro casts, and trapping. The data collected were used to describe the seasonal distribution and abundance of groundfish and fish larvae throughout the region. The R/V Oregon I was used by MARMAP during 1981-1988. It was a 105' vessel that was outfitted for trawling, plankton work, hydro casts, and trapping. From 1989 to the present, MARMAP has used the R/V Palmetto. The R/V Palmetto is 110', maintains a 5 permanent member sea-going crew, 1 or 2 temporary deckhands, and has accommodations for 9 scientists. There is a 200 sq. ft. wet lab on the main deck with counter space, electronics rack, freshwater and seawater, and freezers. The main deck has 1,014-sq. ft. of open deck space. There is a Sea Crane 120 on the main deck for loading, distributing and deploying gear, as well as the zodiac. It has two hydraulic long-line reels, two hydraulic reels for CTD casts and plankton work and a pot-hauler for retrieving traps.

Table XX. List of commonly collected species.

Almaco Jack
Bank sea bass
Black sea bass
Blueline tilefish
Gag
Golden tilefish
Gray triggerfish
Greater amberjack
Knobbed porgy
Red grouper
Red porgy
Red snapper
Sand perch
Scamp
Scup
Snowy grouper
Speckled hind
Spottail pinfish

Spotted moray
Tomtate
Vermilion snapper
White grunt

9.2.1.2 SEAMAP

The Southeast Area Monitoring and Assessment Program (SEAMAP) is a cooperative State/Federal/university program for collection, management and dissemination of fishery-independent data and information in the southeastern United States. The organizational structure of the program presently includes three operational components, SEAMAP-Gulf of Mexico, which began in 1981, SEAMAP-South Atlantic, implemented in 1983 and SEAMAP-Caribbean, formed in 1988. Each SEAMAP component operates independently, planning and conducting surveys and information dissemination. Funding allocations to participants are administered through State/Federal cooperative agreements, managed by SERO and the Southeast Fisheries Science Center (SEFSC), National Marine Fisheries Service (NMFS).

SEAMAP has sponsored long-term (1982 to present) and standardized research vessel surveys that have become the backbone of fisheries and habitat management in the region. The long-term dataset obtained through SEAMAP surveys provides the only region-wide, inter-jurisdictional mechanism for monitoring the status of populations and habitats. Through its cooperative nature, SEAMAP has the ability to sample the entire coastline from North Carolina through Texas during the same time period and describe the distribution and abundance of fish populations throughout their range in order to better evaluate the status of recreational and commercially utilized fish stocks.

Surveys by each program component reflect distinct regional needs and priorities; however, survey operations in one geographic area often provide information useful to researchers in all three regions. In the South Atlantic region, surveys include Coastal Survey (previously known as the Shallow Water Trawl Survey), Pamlico Sound Survey, and Bottom-Mapping and Fish Characterization and Assessment (all described further below). In addition to these surveys, SEAMAP participates in a variety of other projects such as the Cooperative Winter Tagging Survey Cruise, a coordination role for assessing striped bass population structure and estimating fishing rates of the migratory Atlantic Coast stock. SEAMAP-SA also has a Crustacean Workgroup that continues to be a forum for state biologists and scientists from the South Atlantic region to discuss and address issues regarding shrimp and blue crab management and research.

SEAMAP-SA Coastal Survey

The SEAMAP-SA Coastal Survey collects fishery-independent data concerning species abundance, distribution, and habitat, which provide valuable fishery information to managers, scientists, and students in the South Atlantic Bight region. The South Atlantic Coastal Survey samples waters from 0-10 fathoms from Cape Canaveral, Florida to Cape Hatteras, North Carolina during the three seasonal quarters of spring, summer, and fall. Gear and survey procedures are standardized to ensure collection of quality data with a synoptic view of the relative abundance and distribution of the stocks. Effort is made to obtain age-growth and reproductive stage data, as well as analyze gut contents of key sciaenid species (weakfish, Atlantic croaker, and southern kingfish).

Current state surveys are directed primarily at shrimp and are sufficient for some basic management needs; however, the coordinated, standardized SEAMAP survey provides fishery and ecological data covering the entire region. Most sciaenids, king and Spanish mackerel, menhaden, mullet, bluefish, blue crabs, herrings, jacks, horseshoe crabs, sea turtles and numerous forage species spend part or most of their early life in shallow shrimp trawling grounds in the South Atlantic area. These species have immense commercial and recreational value and form the basis of many of the principal South Atlantic fisheries. Community level data obtained via the Coastal Survey are applicable to management and monitoring of all sampled species. Data collected include distribution and abundance of various life history stages, recruitment to nursery grounds and subsequent recruitment to fisheries, spawning stock size, and the effects of various environmental fluctuations on abundance and distribution.

FWC-FWRI is poised to assist South Carolina Department of Natural Resources (SCDNR) to enhance database usability and dissemination through the creation of GIS products. The SEAMAP data and associated GIS have been incorporated into the South Atlantic Habitat and Ecosystem Internet Mapping System (IMS) of the South Atlantic Fishery Management Council. This system is being developed in cooperation with the Florida Fish and Wildlife Research Institute. The IMS is a living repository of historic and current information to be used by the general public, recreational and commercial fishermen, researchers and resource managers.

North Carolina Pamlico Sound Survey

The North Carolina Pamlico Sound Survey (PSS) is a program component of the SEAMAP South Atlantic and is conducted by the North Carolina Division of Marine Fisheries (NCDMF). This seasonal trawl survey is designed to provide a long-term (since 1989) fishery-independent database on the distribution, relative abundance, and size composition of target species of estuarine fish and decapod crustaceans for the waters of Pamlico-Albemarle Sound. Cruises sample approximately 52 stations each in June and September. The data are processed by NCDMF and are made available to the SEAMAP DMS.

During FY 2007, fifty five species of finfish, and invertebrates, were captured during the June cruise. The top five species that are considered economically important include: spot, Atlantic croaker, blue crab, *Callinectes sapidus*, weakfish, and white shrimp which made up 91% of the catch by number. Seventy-one species of finfish and invertebrates were captured during the September cruise. The top five species of spot, Atlantic croaker, weakfish, pink shrimp and southern kingfish made up 84% of the total catch by number. More information on the results of these surveys is available at www.asmfc.org under the Research & Statistics section of the website.

Bottom-Mapping and Fish Characterization and Assessment

- *Mapping and Assessment of Hard Bottom Resources (Biotic and Abiotic)*

Because substrate is a major determinant of faunal distribution and composition, a detailed description of superficial geology is being compiled for the South Atlantic area. Knowledge of the presence and extent of hard bottom areas, coupled with fish abundance estimates from certain areas, are essential to determine standing stocks or carrying capacity estimates for reef species. A protocol for mapping hard bottom habitats has been developed by SEAMAP-SA (Ross et al. 1987a and b). Features of the data include the location and extent of hard bottom, water depth, relief of bottom type, and detailed information on the source and type of information available in order to facilitate investigators in querying original data sources. Once existing data sources are summarized to document known hard bottom areas, future surveys will focus on areas where no data exist and on determining whether hard bottom areas are stable, increasing, or diminishing due to both natural factors, such as storm waves and shifting sands, and human activities, such as mining and trawling. The Minerals Management Service, as well as other state and federal agencies have already gathered a great deal of information, but it has not been made generally available. The area from the shoreline to the 200m-depth contour from Cape Hatteras southward to Florida has been examined, and the data are included in the SEAMAP Information System, and are published in two SEAMAP-SA completion reports, and on a CD-ROM in a GIS format.

The South Atlantic Bottom Mapping Work Group has compiled a database of bottom habitats from North Carolina to the Florida Keys, in a searchable GIS format available on CD-ROM. Those data were adopted as the primary definition of essential fish habitat by the SAFMC. In addition, all SEAMAP surveys record data on the distribution of fish both geographically and within environmental variables such as temperature and salinity, which is the first step in defining environmental limits in essential habitats utilized by each species of fish. SEAMAP hardbottom data have been used by the SAFMC to develop alternative management options to protect coral areas from rock shrimp trawling, define essential fish habitat, and investigate marine protected areas.

- *Assessment of Adult Red Drum Populations on the Southeast Atlantic Coast*

SEAMAP-SA is designating some new funds towards work supporting the states of South Carolina, Georgia and Florida to continue their adult red drum survey. These efforts contribute to the understanding of adult red drum populations along the southeastern Atlantic coast (North Carolina to Florida) by expanding the currently available data, thereby allowing for more effective and responsible management of the stock. Access to important information on the red drum stock could be used for a coastal shark assessments in the South Atlantic.

The expansion of adult red drum sampling, both spatially and temporally, is essential to the development of area specific information on stock status. Fishery-independent surveys will allow for determination of catch per unit effort (CPUE), which is necessary to determine population size and trends in abundance. Age structure of the spawning stock permits the estimation on the level recruitment (escapement) into the spawning population. This will act as a check on the results of available assessments based on data for sub-adults. Additionally, better estimates of escapement and age composition will allow comparison of the findings with the recommended Spawning Potential Ratio (SPR). Tagging and releasing efforts will assist with identifying migration within and among strata. Combined efforts from North Carolina to Florida will be utilized to gain a better understanding of stock size, composition and movement so the species can be managed responsibly.

The proposed research was developed and adopted by the South Atlantic Committee to address high priority assessment needs for the region as highlighted by the SEDAR research and monitoring needs report.

- *Collaboration with MARMAP*

A major tenet of the SEAMAP program is to "maximize effective capability of fishery independent and associated survey activities to satisfy data and information needs of living marine resource management and research organizations in the region. The primary means of performing that task is to optimize coordination and deployment of sampling platforms used in the region to obtain regional, synoptic surveys and provide access to the collected data through documents and accessible computerized databases." Also, while the foundation of the program is in long-term data series, SEAMAP is also involved with special resource and environmental studies that may enhance survey information and are important to the region. Furthermore, the coupling of activities maximizes the cost-effectiveness of survey activities.

Forthcoming SEAMAP projects complement and expand from MARMAP sampling to address high priority needs for providing access to data and supporting refined stock assessments in the region. This collaboration between programs maximizes researchers' ability to collect data for high priority over-fished species in the snapper grouper complex managed by the South Atlantic Fishery Management Council in cooperation with their South Atlantic State partners.

Recommendations from a recent SEDAR report involve expanding and modifying the MARMAP and SEAMAP programs as well as initiating new programs. Besides developing comprehensive independent surveys in South Atlantic areas, it is also recommended that spatial and age composition information should be enhanced for existing surveys. Concerns have been raised with the MARMAP survey primarily related to geographic and temporal coverage and thus SEAMAP funds could include additional sites to expand this coverage.

SEAMAP-SA plans to develop a phased in SEAMAP sampling protocol for a nearshore ocean larval/sub-adult/adult finfish survey associated with live/hard bottom habitat from Cape Hatteras, North Carolina to Sebastian Inlet, Florida to complement offshore sampling conducted through the MARMAP survey. In addition, additional expansion of offshore site sampling through SEAMAP will result in more complete coverage and address identified shortfalls of the MARMAP sampling regime. Standardized regional fishery-independent sampling of representative live/hard bottom habitat identified in the bottom mapping project would provide extremely useful data that will enhance stock assessments and refine essential fish habitat information on early life stages use of nearshore live/hard bottom habitat. The SEAMAP survey would target larval, juvenile, sub-adult and adult finfish dependant on live/hard bottom habitat on a year-round basis with high priority target species including black sea bass, gag and red drum. Regional fishery-independent sampling through SEAMAP supported surveys will provide essential stock identification and characterization data (geographic distribution, relative abundance) needed to improve overall abundance indices and assessments of southeastern finfish populations and fully complement ongoing management and research efforts. The project would also conduct phase 1 of juvenile tagging to track movement through inlets to nearshore and mid-shelf bottom habitats (supplement North Carolina effort with companion test in South Carolina) and tagging of emigrants out of estuaries into nearshore and mid-shelf benthic habitats.

Additionally the SEAMAP-South Atlantic has been working towards complete bottom mapping in coastal waters (shore-200m) with associated bottom type -sediment and/or live bottom (including coral, leptogorgia, hydroids, SAV, shell bottoms, etc). Along with the mapping, fish/habitat characterization needs to be refined and thus coordination on this topic with MARMAP is very important. Expanding the scope of fishery independent sampling through a collaboration of MARMAP and SEAMAP program data collection would meet stock assessment needs and address several SEDAR recommendations, demonstrating the importance of new SEAMAP surveys and data collection.

9.2.1.3 NOAA Fisheries SEFSC

When fisheries scientists collect fisheries information independent of commercial or recreational fishing operations, this information is considered fisheries-independent data. Such data are needed to accurately assess marine fish populations and are used in conjunction with fisheries-dependent data for estimating total population size and mortality rates.

Fisheries independent data are collected by scientists conducting resource surveys, such as trawl and seine surveys. These surveys are specifically designed to sample in an objective manner. Consequently, the research vessels do not necessarily sample where fish are most abundant. Instead, the sampling objective is to collect information on a fish population throughout its entire geographic range.

Sea Turtle Program

Scientists in the Sea Turtle Program of the Southeast Fisheries Science Center implement research to support the conservation and recovery of threatened and endangered sea turtle species by conducting population assessments; research on stock structure (age and genetics); assessments of sea turtle mortality, strandings, and unusual events; and revision of Stock Assessment Reports for populations of sea turtles in the western North Atlantic Ocean. They also participate in research to reduce the bycatch of sea turtles and conduct in-water studies to evaluate population trends and habitat requirements. They participate in technology transfer of successful bycatch reduction measures. Scientists undertake this work in collaboration with other SEFSC and NOAA protected species staff, academic colleagues, and contractors. SEFSC scientists provide information and analytical results on species status and threats to the NMFS Southeast Regional Director and NMFS Headquarters for the effective management of marine turtles. The information is critical for evaluating the appropriate conservation measures, as required under the Endangered Species Act. Scientists also provide information to scientists in Mexico through MEXUS-GULF Turtle Working Group; and contribute to the proceedings of the

Annual Sea Turtle Symposia. Scientists also take part in implementing the NMFS Atlantic Sea Turtle Strategy that is aimed at addressing the incidental capture of turtles in commercial and recreational fisheries along the Atlantic coast.

Marine Mammal Strandings
The Marine Mammal Protection Act (MMPA) mandates that the National Marine Fisheries Service (NMFS) monitor the status of all marine mammals in the southeast region and maintain the Marine Mammal Health and Stranding Response Program. In compliance with that act, stranding programs, biomonitoring programs, and population surveys have been developed and implemented in the various regions of the United States and territories.

Specifically, the Southeast Fisheries Science Center is responsible for marine mammal responses in the southeast region of the United States including the beaches from North Carolina to Texas, Puerto Rico and the U.S. Virgin Islands.

The NMFS, Southeast Fisheries Science Center (SEFSC) is the base for the Southeast United States Marine Mammal Stranding Program. NMFS authorizes organizations and volunteers under the Marine Mammal Protection Act (MMPA) to respond to marine mammal stranding throughout the United States. These organizations form the stranding network whose participants are trained to respond to, and collect samples from live and dead marine mammals that strand along southeastern United State beaches. Scientists at the SEFSC are responsible for coordinating stranding events, monitoring stranding rates, monitoring human caused mortalities, maintaining a stranding data base for the southeast region, and conducting investigations to determine the cause of unusual stranding events including mass strandings and mass mortalities.

Ship surveys are used to assess the abundance and distribution of cetaceans over large areas of the Gulf of Mexico, Atlantic Ocean, and Caribbean Sea. Surveys are conducted from the 68-m NOAA Ship Gordon Gunter and the 52-m NOAA Ship *Oregon II*. Visual line-transect surveys are conducted from the ship's flying bridge using 25X binoculars during the day. Acoustic surveys are conducted day and night using towed hydrophone arrays and sonobuoys. Biopsy samples for genetic and contaminant studies are obtained during the surveys. Environmental and oceanographic data are also collected. From 23 ship surveys conducted since 1990, we have learned that about 30 cetacean species inhabit southeastern U.S. waters. These include large whales, such as the right whale, sperm whale, and humpback whale, and dolphins, such as the pantropical spotted dolphin, bottlenose dolphin, and spinner dolphin. Smaller whales, such as killer whales, pilot whales, and beaked whales, also inhabit these waters. Typically bottlenose dolphins and Atlantic spotted dolphins are found in continental shelf waters, whereas most of the other species occur in oceanic waters. Data from these surveys are used to make management decisions mandated by the Marine Mammal Protection Act.

Multi-year aerial surveys of the nearshore waters of the southeast Florida coast, including the Florida Keys, and of Florida Bay are being conducted by the SEFSC with the support of the U.S. Coast Guard Air Station Miami. Conducted since September 1992 and March 1995, respectively, these surveys from a Coast Guard HH65 helicopter provide opportunistic sightings of bottlenose dolphin that can be used as rough estimates of their relative abundance in these waters. A total of 1,851 sightings of bottlenose dolphins were recorded in 109 surveys from inception through

December 1997. Herd sizes, seasonality, and encounter rates were compared between the two areas, as well as with previous studies in nearby areas, in a SEFSC Technical Memorandum. These surveys were initiated to monitor marine animals along the southeast coast, to document vessel usage in Biscayne National Park and the Florida Keys National Marine Sanctuary, and to census water birds in Florida Bay.

The SEFSC also conducts a bottlenose dolphin, *Tursiops truncatus*, monitoring program in Biscayne Bay, Florida, using photo-identification techniques as a method of identifying individual dolphins for population studies. Initiated in August 1990, a total of 180 individuals have been identified from 390 sightings during 250 surveys. Of these, approximately 75% are considered to be full time residents of Biscayne Bay. The study area runs from Haulover Inlet, south to Card Sound Bridge encompassing an area of approximately 250 square miles. The behavioral studies component includes observing and monitor habitat use, movement patterns, and other behaviors exhibited by Biscayne Bay bottlenose populations. Currently, a website is being developed to allow researchers to compare dolphin dorsal fin images from the photo-id projects in adjoining study areas to determine the extent animal ranges.

SEFSC, Beaufort Lab, conducts small-vessel surveys in North Carolina and some nearby areas, including Georgia, Virginia, and New Jersey, focusing on bottlenose and Atlantic spotted dolphins. This research involves collection of skin samples for stock identification from a number of different estuarine, coastal and offshore habitats along the coast. The bottlenose dolphin work examines both latitudinal (inshore-offshore) distribution of the coastal form of bottlenose, examining the degree of overlap with the offshore form, and longitudinal (north-south) distribution of populations. Photographs taken during this work are also being used to examine movements between sites.

SEFSC, Beaufort Lab, is also coordinates an effort to define the number and range of stocks of the coastal morphotype of bottlenose dolphins along the Atlantic coast. This project involves the simultaneous application of multiple techniques, including genetics, stable isotope ratios, photo-identification (with over 20 collaborators along the coast), and telemetry. Preliminary results have identified seven management units. The data being collected will also help with defining habitat preferences and ranging patterns. In addition, the SEFSC Beaufort Lab, conducts studies of age, growth, and reproduction of a number of cetacean species. Particular emphasis is on the bottlenose dolphin because, despite its prevalence in coastal waters of the Atlantic and Gulf of Mexico, estimates of reproductive rates and other basic life-history parameters, do not exist.

9.2.2 Fishery-Dependent

9.2.2.1 MARFIN

(text below excerpted from http://sero.nmfs.noaa.gov/grants/marfin.htm)

The Marine Fisheries Initiative (MARFIN) program, administered through the National Marine Fisheries Service Southeast Regional Office, promotes and endorses programs which seek to optimize economic and social benefits from marine fishery resources through cooperative efforts that evoke the best research and management talents of the Southeast Region. Preference is given to cooperative planning efforts with up to 3-year time horizons. The intent is to focus projects funded by MARFIN into cooperative efforts that provide clear answers for fishery needs covered by the NMFS Strategic Plan, particularly goals one, two and four are important. For example, a geographically restricted age and growth study of a local fishery resource is of limited value unless it is coordinated with, or verified by, similar studies, which span the range of the resource. The value of such studies is also relatively limited unless the results can be combined with other studies to provide a regional assessment of the resource. MARFIN provides this necessary programmatic integration through cooperative planning, accomplishment of program activities and an annual MARFIN Conference.

History of the MARFIN program

The MARFIN program received its initial impetus from a 1983 discussion paper entitled "Research Needs For Information Leading To Full and Wise Use of Fishery Resources In The Gulf of Mexico" by Dr. Thomas D. McIlwain of the Gulf Coast Research Laboratory while he was in the office of Rep. Trent Lott. This paper, sometimes referred to as the Lott-McIlwain paper, proposed an additional investment in fisheries research and development in the Gulf of Mexico to increase the economic contribution of marine fisheries, develop more valuable products from existing fisheries, develop export markets, forecast variation in yields and conserve and maintain presently exploited resources.

The next step in the evolution of MARFIN was the preparation and publication of the Marine Fisheries Initiative - Gulf Of Mexico Phase. This plan was developed by a joint industry, federal, state and academic task force, detailing the research and development efforts necessary to enhance, restore and maintain fisheries in the Gulf of Mexico. The program focused on funding projects which had the greatest probability of maintaining and improving existing fisheries, increasing revenues for the domestic industry, increasing yields from fisheries and generating increased recreational opportunity and harvest potential.

In 1992, the MARFIN program was expanded to include a South Atlantic component (North Carolina, South Carolina, Georgia and the Atlantic coast of Florida). The goals and objectives of the South Atlantic phase of MARFIN are described in Special Report No. 13 of the Atlantic States Marine Fisheries Commission, Marine Fisheries Initiative (MARFIN) South Atlantic Phase.

MARFIN Program Organization and Administration

The NMFS Southeast Regional Administrator organized the MARFIN Panel in Fiscal Year 1992 when the program was expanded to cover the South Atlantic. Each member of the MARFIN Panel provides individual recommendations to the Regional Administrator on MARFIN priorities and financial assistance applications. The MARFIN Panel membership is as follows: One state marine conservation agency representative each, from the Gulf of Mexico and the South Atlantic areas; one representative each from the Gulf of Mexico and the South Atlantic commercial fishing industries; the Executive Directors of the Gulf of Mexico and South Atlantic Fishery Management Councils; the Executive Directors of the Gulf and Atlantic States Marine Fisheries Commissions; one representative each from the Gulf of Mexico and the South Atlantic recreational fishing industries; one representative each from the Gulf of Mexico and the South

Atlantic Sea Grant Universities and a NMFS Southeast Fisheries Science Center Technical representative.

The NMFS Southeast Financial Aid Program Officer provides guidance to the Regional Administrator and the MARFIN panels members concerning Federal, Department of Commerce and NOAA financial assistance administration requirements.

Alternate representatives to the MARFIN Panel serve when necessary. The MARFIN Panel Chair is elected for up to three-years. Individual Panel members are appointed by the NMFS Southeast Regional Administrator for staggered terms.

The Administrator of the NMFS Southeast Regional Office relies on recommendations from individual members of the MARFIN Panel, the NOAA Assistant Administrator for Fisheries, the public through their response to MARFIN Federal Register notices and the NMFS staff to develop each year's MARFIN program.

Each year the MARFIN Panel members and NMFS administrators and scientists identify areas of emphasis for the next year's competitive financial assistance program. These areas of emphasis are published in the Federal Register for public comment. After public review and comment, an announcement of funding availability through the competitive MARFIN financial assistance program is published as a solicitation in the Federal Register.

The NMFS Southeast Regional State/Federal Liaison Office staff is responsible for the overall administration of all NMFS Southeast grants and cooperative agreement programs, including MARFIN. Their responsibilities include planning, application and selection, negotiation, performance, monitoring and close-out of all assigned competitive and noncompetitive financial assistance programs. A NMFS Southeast scientific or technical expert is assigned as the Technical Monitor for each MARFIN project. The Technical Monitor is responsible for all technical and cooperative aspects of assigned projects. The NOAA Grants Officer is responsible for the overall administration of each NMFS financial assistance award issued to recipients outside of the Federal government and cooperates with the NMFS Southeast State/Federal Liaison Office in administering each financial assistance award.

9.2.2.2 Cooperative Research Program

(text below excerpted from the FY07 Federal Funding Opportunity announcement available through the SERO grants website)

The NMFS' Cooperative Research Program (CRP) is a competitive Federal assistance program that funds projects seeking to increase and improve the working relationship between researchers from NMFS, state fishery agencies, universities, and fishermen. The principal goal of the CRP is to provide a means of involving commercial and recreational fishermen in the collection of fundamental fisheries information to support the development and evaluation of management and regulatory options.

Applicants are encouraged to address one of the priority areas listed below as they pertain to federally managed species or species relevant to Federal fisheries management plans, but proposals in other areas will be considered. Projects funded through the CRP focus on collecting data that aids in recovering, maintaining, or improving the status of stocks upon which fisheries depend; improving the understanding of factors affecting recruitment success and long-term sustainability of fisheries; and/or generating increased values and opportunities for fisheries.

Projects are evaluated as to the likelihood of achieving these objectives, with consideration of the magnitude of the eventual economic or social benefits that may be realized.

Finfish
There are several priorities within this general category that pertain to the collection of catch, effort, size frequency, bycatch, and detailed data on fishing area by vessels in the fisheries for finfish species.

1. Characterize the total catch (from all fleets affecting the stocks), including catch composition and disposition of the catch.

    (a) Projects are needed to collect detailed information on the composition and disposition of bycatch and discards.

    (b) Investigations are needed to determine more efficient methods to record catches and associated effort accurately on a real-time basis during fishing operations (e.g. electronic logbooks).

    (c) Projects are needed to develop methods to increase the amount of at-sea observations without relying on direct observers. One suggested approach is to use electronic imaging systems.

    (d) Projects are needed to utilize fully scientific observers on-board vessels as a means of collecting detailed catch, effort and disposition data. In cases where vessel space does not permit adding an observer, it may be possible to designate the captain or a crew member to record these data. Projects must specify the type of training and equipment that is required to assure that reliable data are collected. (e) Data collection projects are needed to determine the effects on discard rates of increasing size limits or reducing possession limits. If discard mortality rates are high, changes in size or bag limits may unintentionally lessen conservation benefits. Discard mortality rates currently used in assessments are generally based on small numbers of observations or are unknown. Research is needed to improve estimates of discard mortality rates and must account for the effects of fish size, gear, area, season and depth of fishing.

    (f) Data collection projects are needed to improve life history information to improve stock assessments. Improved information about the age-structure of the catch (both retained and discarded), based on otolith or other hard-part aging techniques, will provide insight on a stock's resilience to fishing. Improved information on the reproductive characteristics of the stock will provide information to refine estimates of long-term biological productivity of the stock. Development of new techniques for age and growth and reproductive information are especially important. (g) Improved age sampling (i.e., representative, randomized collection of structures) is needed for many species. For some species (i.e., protogynous ones) information is needed to characterize landings by sex.

2. Population evaluation. Needs under this category include abundance measures and expanded age composition sampling across all fisheries. Other needs include: (1) Research is needed to identify stock boundaries and evaluate stock mixing. Methods could include tagging studies to evaluate movements, otolith microchemistry, and genetics. (2) Data are needed to characterize length, age and, for some species, sex composition of landings and discards in commercial and recreational fisheries. (3) Data are needed to estimate and characterize commercial and recreational discard removals.

3. Monitoring stock abundance through study-fleet applications. This type of cooperative research requires long-term commitment in terms of funding and application.

> (a) One objective is to develop a consistent sampling methodology that will permit monitoring of the relative abundance of a fishery resource over time. An initial step for such a project is to develop sampling designs and protocols for sampling fleet catches to estimate relative abundance, including standardization of fishing power of individual vessels.
>
> (b) Projects are needed to develop methods to determine appropriate sampling designs and pilot studies to estimate recruitment to selected fisheries. An example is the development of a recruitment index for Young-of-the-Year swordfish in the Gulf and along the southeastern U.S. coast - areas that are now closed to longlining.

4. Projects are needed to develop and test gear and fishing strategies designed to reduce or eliminate unintended catch.

5. Fishing Capacity Investigations. There appears to be a wide disparity between the current capacity of regional fishing fleets and the productivity of regional stocks.
Cooperative research to optimize the capacity of regional fishing fleets is needed. A number of possibilities ranging from Individual Quota Systems to Vessel Capacity
Control programs should be considered. It is likely that regional/fishery differences may require different approaches.

6. Monitor the effects of closed Marine Protected Areas. Research is needed to measure the response of marine resources to creation or expansion of Marine Protected Areas (MPAs). Projects should utilize fishermen's knowledge of critical habitat of harvested species. An example is the large MPA designed to protect small swordfish and other highly migratory species off the US southeastern coast.

> (a) Projects are needed to assess the impacts of time/area closures in the Southeast Region that have been designated to protect finfish spawning aggregations and/or concentrations of sub-legal fish.
>
> (b) Projects are needed to collect fine-scale catch-effort data to define the spatial and temporal dimensions of MPAs.

Recreational and Charter Fishery

1. Socioeconomic research.

> (a) Research is needed to determine the number of recreational fishermen and related trips.

(b) Data are needed to describe the socioeconomic characteristics of the recreational and charter boat industries.
(c) In addition to data collection activities, research is needed to determine the economic benefits and costs associated with recreational fishing.

2. Research on Management Alternatives. Investigations should include benefits and costs to the stocks, as well as socioeconomic benefits/costs to participants in the fishery.
(a) Research is needed to determine the effects of seasonal closures and MPAs on the recreational and charter boat industries.
(b) Research is needed to determine the effects of seasonal closures and MPAs on spawning stocks and resulting recruitment.
(c) Research is needed to determine the impacts of bag and size limits on species that are important to recreational and charter boat industries. Projects should emphasize the effects of alternative size limits.
(d) Research is needed to determine discard mortality rates. This research should include data on length and age composition of discarded fish. At-sea observers on recreational and charter boat trips are one way to perform this type of research and should be considered.

3. Catch/Effort Data. Projects are needed to improve catch and effort data for private recreational fishermen. The projects should identify sample sizes, including number of intercept interviews and dock samples, required to achieve statistical levels of accuracy and precision.

4. Habitat Research.
(a) Research is needed to evaluate the effectiveness of artificial reefs. Projects should examine the value of artificial reefs to fishing communities, and estimate associated economic impacts.
(b) Research is needed to determine the impacts and effects of harmful algal blooms, such as red tide, on recreational and charter boat fisheries.
(c) Investigations are needed to determine essential fishery habitat for certain species such as gag, goliath grouper and sharks. This encompasses more than just a recreational issue, could be moved to a general habitat section.

Commercial Shrimp Harvest

1. Social and economic impact of fluctuations in domestic shrimp values:
(a) Research is needed on the effects on the domestic shrimp fishery of shrimp imports from foreign countries.
(b) Research is needed to determine the social and economic impacts of imports on fishermen and fishing communities. Research should include impacts on communities and the industry as a whole.

2. Identifying Non-Trawlable Areas. Research is needed to investigate how habitat enhancements of non-trawlable areas could benefit shrimp fisheries. For example, artificial reefs could be established in non-trawlable areas and the impacts on shrimp and finfish populations could be evaluated. Such research should determine if enhancements would increase habitat for juvenile and adult fish (i.e. red snapper).

3. Quantification of Effort. Research is needed to improve shrimp effort data. Projects need to consider recommendations derived from negotiations with the shrimp industry. Areas of concern are insurance for at-sea observers, acceptable gear and protection of confidential data collected by the project.

4. Bycatch Reduction Device Testing Protocols. There is a need to develop more efficient methods to certify bycatch reduction devices. Protocols should benefit both the resource and the shrimp industry.

5. Quantification of Bycatch Rates. Statistical research is needed to ensure that extrapolation of the results of individual trawl bycatch surveys to the fleet are statistically valid. The procedures should account for the total range of conditions found in all major fishing areas. The research should estimate the number of scientific fishery observers that should be employed to collect bycatch information for prevailing conditions and areas. The project should describe the statistical accuracy and precision of estimates for each major fishing area in addition to the total fishing area. This is critical to improving stock assessments, especially in the Gulf of Mexico.

9.2.2.3 Saltonstall-Kennedy

(text below excerpted from online report to Congress doc available at http://www.ncseonline.org/NLE/CRSreports/04May/RS21799.pdf)
The Saltonstall-Kennedy (S-K) Act, as amended (15 U.S.C. §713c-3), established a fund (known as the S-K Fund) that the Secretary of Commerce uses to finance projects and cooperative agreements for fishery research and development. Under this authority, projects or cooperative agreements are selected annually on a competitive basis to assist the National Marine Fisheries Service in addressing concerns related to U.S. commercial and recreational fisheries. The S-K Fund is capitalized through annual transfers under a permanent appropriation to the Secretary of Commerce of 30% of the gross receipts collected by the Secretary of Agriculture under the customs laws on imports of fish and fish products.

The objective of the S-K program is to address the needs of fishing communities in providing economic benefits for rebuilding and maintaining sustainable fisheries, and in dealing with the impacts of conservation and management measures. The S-K program has become very important in addressing issues of immediate concern to the commercial fishing industry, by producing many new gear innovations, markets, and management options. Issues addressed have included fish harvesting, seafood quality improvements, domestic and foreign market development, efficiency and productivity improvements, and the costs/profitability of potential fishing industry investments.

In Fiscal Year 2004 appropriations, congressional earmarks designated funds for specific activities outside the regular competitive award process, and the S-K competitive program was cancelled.

9.2.2.4 Wallop-Breaux

(text below excerpted from USFWS site http://federalasst.fws.gov/sfr/fasfr.html)

The Federal Aid in Sport Fish Restoration Act, commonly referred to as the Dingell-Johnson Act -- passed on August 9, 1950 -- was modeled after the Pittman-Robertson Act to create a parallel program for management, conservation, and restoration of fishery resources.

The U.S. Fish and Wildlife Service's Sport Fish Restoration Program is funded by revenues collected from the manufacturers of fishing rods, reels, creels, lures, flies and artificial baits, who pay an excise tax on these items to the U.S. Treasury.

An amendment in 1984 (Wallop-Breaux Amendment) added new provisions to the Act by extending the excise tax to previously untaxed items of sport fishing equipment. The major element of the Wallop-Breaux Amendment established a new Trust Fund, named the Wallop-Breaux Trust Fund or the Aquatic Resources Trust Fund (ARTF). Funds are also received from import duties on sport fishing equipment, pleasure boats and yachts. Another source of revenue is a tax from motorboat fuel sales. These motorboat fuel taxes are collected by the U.S. Treasury and then transferred to the Fish and Wildlife Service for distribution among the States and territories.

Appropriate state agencies are the only entities eligible to receive grant funds. Each state's share is based 60 percent on its licensed anglers (fishermen) and 40 percent on its land and water area. No state may receives more than 5 percent or less than 1 percent of each year's total apportionment. The program is a cost-reimbursement program, where the state covers the full amount of an approved project then applies for reimbursement through Federal Aid for up to 75 percent of the project expenses. The state must provide at least 25 percent of the project costs from a non-federal source.

Since its creation, the Sport Fish Restoration Act has been refined and expanded by Congress. It is one of the most valuable federal legislation for anglers and fishery resources. In 2006, the total funding for national programs obtained through this legislation exceeded $5 billion according to the USFWS's annual allotment news release *(http://www.fws.gov/news/newsreleases/showNews.cfm?newsId=754069A2-D32C-3722-22DDAA5E1602C1D6).*

(excerpt below from FWC site http://myfwc.com/fishing/Fishes/SFR.html)
In 1994, passage of the Transportation Equity Act (TEA-21) authorized a National Outreach and Communications Program to increase participation in angling and boating and to impress on boaters and anglers the importance of healthy aquatic habitats. It also increased the minimum level of spending for boating access to 15% and raised the maximum allowable expenditure of SFR apportionments for aquatic education and outreach to 15%. TEA-21 further created a Boating Infrastructure Grant program (BIG) for construction, maintenance, or renovation of transient facilities for non-trailerable recreational boats (boats longer than 26 feet) TEA-21 raised the amount of Federal gas tax credited to the Wallop-Breaux Trust Fund and established a "permanent" appropriation for the Boating Safety Account. The result is one of the most successful "user pays--user benefits" programs in the world.

9.2.2.5 NOAA Fisheries SEFSC

Commercial Programs

Accumulated Landings System (ALS)

These data consists of information on the quantity and value of seafood products caught by fishermen and sold to established seafood dealers or brokers. These data are reported by dealers or brokers to the fisheries agency in each state. The National Marine Fisheries Service in the Southeast Region has established cooperative agreements with all of the states in the Southeast and rely on the states to collect and process these data. The general canvass data set maintained by the Southeast Fisheries Science Center is a continuous data set that begins in 1960. Landings data for some species and areas go further back in time and are available in print in the Fisheries of the United States.

The landings data, maintained by the SEFSC, are monthly totals of the quantities landed and the value of the landings for each species. Because these data are summaries, they do not contain information on the identification of the fishermen or vessel. However, several states in the Southeast do collect landings statistics for individual trips. The state of Florida was the first to implement a trip ticket program in 1985. In 1995, the state of North Carolina passed a license to sell law that required seafood dealers to report all landings statistics by trip and identify the vessel or individual that sold the product. In 1997, the state of Louisiana initiated their trip ticket program and in 1999 Georgia also initiated a trip ticket program.
In addition to the quantity and value (or price per pound), information on the gear used to catch the fish and the area where the fishing occurred are also recorded in the general canvass data.

In many coastal areas, trained field agents assist with the collection of fisheries statistics. These individuals are strategically located so they can maintain contact with the fishermen and are integrally involved with the fishing communities. Among other duties, these port agents provide information on the types of gear, fishing area and distance from shore for the general canvass data. The port agents are also involved in the collection of Gulf shrimp statistics, biological data collection and the operating unit survey.

There are two shortcomings associated with fishery statistics that are collected from seafood dealers. First, dealers do not always record the specific species that are caught and second, fish or shellfish are not always purchased at the same location where they are unloaded, i.e., landed.

Dealers have always recorded fishery products in ways that meet their needs, which sometimes make it ambiguous for scientific uses. Although the port agents can readily identify individual species, they usually are not at the fish house when fish were being unloaded and thus, cannot observe and identify the fish. Species identification is a critical part of the biological sampling program (also known as the Trip Interview Program) operated jointly by the National Marine Fisheries and the fishery agency in each coastal state in the Southeast Region. The second problem is accurate information on the gear used and the location where the fish were caught. For the states with trip ticket programs, information on the gear and area fished is collected on the trip ticket form. For other states, this information is estimated, usually by the local port agent.

U.S. Domestic Longline Database
Before the mid-1980s, only limited data on the fishing activities from the U.S. pelagic longline fleet were collected. Data were collected by various state agencies, Fishery Management Councils, and university biologists from 1978 to 1983. These data consisted of weights for individual swordfish (headed, gutted and tailed) recorded on the weigh-out receipts (tally sheets) for the sales to vessels for an individual trip. In 1984, this database became the responsibility of the NMFS Southeast Fisheries Science Center. As part of this transition, the data were standardized and entered into a computer database. In order to expand the coverage, biologists at the SEFSC contacted vessel captains/owners and fish dealers and requested that they voluntarily submit their tally sheets to the SEFSC for use in scientific investigations of the swordfish fishery.

All of the data are coded and stored for the individual vessel that caught the fish. Quality control procedures established to compare with data previously entered to avoid duplication. Although swordfish were the primary commercial species caught and recorded on the sales receipts, the weights of other species were also listed on the tally sheets. Prior to 1985, the weigh-out data for the other (non-swordfish) species were not recorded. Beginning in 1986, the SEFSC began to enter all the weigh-out data for all species listed on the tally sheets received. The individual dress weights of other species listed on tally sheets from earlier years were entered as well.

Each record includes a vessel code, date of landing, state and port landed, code of the dealer purchasing the catch, gear fished, data source, location code of general fishing area, total hooks fished, days of actual fishing, total number of sets, and a species code along with the individual carcass weights for each species. All records from a specific trip are identified by their respective vessel codes and date of landing. Prior to 1986, effort (hooks, days fished, number of sets) information was recorded from personal vessel logbooks voluntarily submitted by vessel captains/owners. Beginning in 1986, all pelagic longline vessels that actively fished are required to submit daily logbook set records for each trip. Based upon this information, fishing effort is determined and, subsequently, added to the longline database.

The database contains information from the early 1960s (limited data) to the present and is almost exclusively comprised from data collected from the U.S. domestic pelagic longline fishery. Other gear types (harpoon, gillnet, handline, rod and reel, etc.) have been recorded from vessels voluntarily submitting the information or that were mandated to report by regulations in the past years. This database is continually updated as new information becomes available.

Fisheries Logbook System (FLS)
The Fisheries Logbook System records the fishing and non-fishing activity of fishermen who are required to report their fishing activity via logbooks submitted for each trip.

As the need for conservation of the Nation's marine resources increases the need for more and better quality data on how these resources are utilized also increases. One of the most useful types of data is catch per unit effort. To meet these needs, the Southeast Fisheries Science Center has implemented several vessel logbook programs. In 1986, a comprehensive program was initiated for the pelagic longline fisheries along the eastern seaboard, in the Gulf of Mexico and in the Caribbean. In 1990, logbook reporting was initiated for the vessels catching species in the reef fish management plan managed by the Gulf of Mexico Fishery Management Council.

Similar to the logbook program for reef fish, a program for vessels catching species in the South Atlantic snapper-grouper fishery, managed by the South Atlantic Fishery Management Council, was initiated in 1992. In 1993, a comprehensive logbook was initiated for the federally managed shark fisheries (Highly Migratory Species, National Marine Fisheries Service). In 1999, logbook reporting was initiated for vessels catching king and Spanish mackerel (Gulf of Mexico and South Atlantic Fishery Management Councils).

Although these programs were initiated at various times and cover many different fisheries and types of gear, the SEFSC has attempted to make the logbooks relatively easy to complete. There are 2 types of reporting forms currently in use (although separate forms are used for the limited vessels that are permitted in the wreckfish and golden crab fisheries).

One form is used for the pelagic longline fisheries. Because this fishery uses gear that is deployed for a relatively long period (6 to 10 hours), catch and effort data are collected for each set. Thus, a separate form is required for each set. Fishermen are required to report the numbers of each species caught, the numbers of animals retained or discarded alive or discarded dead (longline gear is nonselective and unwanted or prohibited species such as, billfishes, sea turtles, etc., must be returned to the water), the location of the set, the types and size of gear, and the duration of the set.

Because some of the needed catch/effort information for pelagic longline fisheries remains the same for the entire trip (i.e., it would be redundant to report it for every set), a supplemental form is used to report this type of data. Information on the port of departure and return, unloading dealer and location, number of sets, number of crew, date of departure and landing are reported on the Trip Summary form. In addition, information on costs associated with the trip can be reported on this form.

This type of economic data is critical to the evaluation of existing and proposed management regulations. The National Marine Fisheries Service is required by law to assess (estimate) the economic consequences of proposed management regulations.
Without accurate data from the fishing industry, such estimates are not likely to reflect the true effects.

The second type of logbook form is used to report catch and effort data for the Gulf reef fish, South Atlantic snapper-grouper, coastal shark and king and Spanish mackerel fisheries. Because the soak time for these fisheries is relatively short, it is not feasible to require fishermen to complete a separate form every time the gear is deployed. Thus, the catch and effort data for the entire trip are reported on a single form (i.e., one form per trip).

The types of information required on this trip form are nearly the same as the pelagic longline logbook. Information on the quantity (reported in pounds) caught for each species, the area of catch, the type and quantity of gear, the date of departure and return, the dealer and location (county and state where the trip is unloaded), the duration of the trip (time away from dock), an estimate of the fishing time, and the number of crew are included on this form.

In response to the increased need for data on the amount of fish that are discarded, the Southeast Fisheries Science Center is now using a supplementary form that selected fishermen use to report quantities of fish that are discarded.

Trip Interview Program (TIP)
(text below excerpted from the SEFSC website)
Estimates of the age distribution of fish in the population and how the distribution has changed over time is critical information for the assessment of the population. The Trip Interview Program (TIP) was developed by the Southeast Fisheries Science Center as a shore-based sampling program. The primary focus of the TIP is the collection of random size-frequency data and biological samples from commercial marine fisheries. Biological samples include age, reproductive, prey, and genetic data. In addition to collecting biological data, the TIP serves as a quality assurance on catch and effort data. It validates species composition of catch and type and quantity of gear through first hand, trained observation. Other important information, obtained through personal interviews with the fishermen and dealers, also serves the quality assurance purpose. Like the other statistics gathering programs, this one is also a joint or cooperative effort with the state fishery agencies in the Southeast Region.

The Trip Interview Program was principally developed to provide two types of information: size frequency data and age at length data. In addition, this program also provides catch per unit effort data and information on the composition of the species being caught and landed.

The collection of data for this program is conducted by port agents located in coastal area in the South Atlantic and Gulf of Mexico. These field biologists visit docks and fish houses to interview the fishermen and take length and weight samples from their catch. For some trips, the port agents are at the location when the fish are being unloaded and can measure and weigh individual fish as they are being unloaded. At other times, the fish have already been unloaded and the port agent is given permission to measure and weigh a sample of the catch from the storage containers at the fish houses. In addition to the length and weight data, the port agents also attempt to interview the captain or a crew member to collect data on the fishing trip, i.e., fishing area, type and quantity of gear, fishing time, etc.

The port agents also take hard part and tissue samples for some of the fish they measure. These samples are sent to one of two Southeast Fisheries Science Center laboratories for biologists to analyze and determine the age of the fish. The age, along with the length of the fish, are used to determine the age-at-length for a sample of the fish population, which then is used to estimate the age distribution for the entire population or stock of the species.

The TIP is a major component of the Atlantic Coastal Cooperative Statistics Program (ACCSP) in the southeastern U.S. Atlantic coastal region and the Commercial Fisheries Information Network (COMFIN) in the U.S. Gulf of Mexico coastal region. It also collects data from Puerto Rico and the U.S. Virgin Islands.

Vessel Operating Units (VOU)
Prior to 1970 the Bureau of Fisheries and the U.S. Fish Commission, which were the predecessor agencies of the National Marine Fisheries Service, collected little information on vessels actively

participating in commercial fisheries. In 1979 NMFS initiated a system that provided data on vessels that actively participate in commercial fishing during each calendar year. The object of this system is to provide an inventory of vessels that answer two fundamental questions: How many vessels are fishing commercially? What are the characteristics of these vessels?

This inventory only includes vessels that are greater than five net tons and have a current US Coast Guard documentation number. This system is referred to as the NMFS vessel operating units. Data are available for the years from 1979 to 2002.

Because the vessel operating units data only include larger documented vessels, a count of the smaller, undocumented boats was conducted once a year by NMFS and state port agents from 1979 to 1995. Unlike the vessel operating units data, characteristics of the individual boats are not recorded. These annual counts of boats are referred to as boat and shore data.

Recreational Programs

Marine Recreational Fisheries Statistics Program (MRFSS)
The Marine Recreational Fisheries Statistics Program team provides essential marine recreational fisheries information to government, scientists, and the public.

The team of fisheries biologists, statisticians, and data managers provides accurate, precise, and timely fisheries-dependent information for US marine waters by:

- Conducting and evaluating the Marine Recreational Fisheries Statistics Survey (MRFSS) to produce catch, effort and participation estimates, and to provide biological, social and economic data,
- Ensuring quality control and quality assurance of the MRFSS,
- Researching new survey designs,
- Providing statistical advice and promoting quality recreational fisheries information within NMFS and to other natural resource management agencies and organizations,
- Participating in NMFS planning efforts to improve internal fisheries-dependent data collection and management,
- Participating in coastal State/Federal efforts to plan and implement coordinated and cooperative recreational fisheries data collection and management programs,
- Communicating survey and research results, and
- Educating the public about the survey and new research.

In September 2004 the NMFS requested the National Research Council (NRC) of the National Academy of Sciences (NAS) to review current recreational fishing surveys funded or conducted by NMFS. This review was completed and published in April 2006 and includes recommendations that will result in an improved survey program that will better meet the needs of fishery managers.
Beginning in January 2006, every fisherman who is interviewed dockside by the Marine Recreational Fisheries Statistical Survey receives a series of questions about the money they spent on that trip. They are also be asked to participate in a longer follow-up mail survey that collects information on annual expenditures and durable goods, like boats, trailers, rods and

reels. When completed, these data allow NOAA Fisheries to estimate daily expenditures by fishing mode (i.e. private boat, charter, shore) and resident type (resident and non-resident). These expenditure estimates are then used to estimate the economic impacts of saltwater recreational fishing. Economic impacts demonstrate the importance of recreational fishing and help managers make decisions to make recreational fishing better. The last time this survey was conducted in 2000, U.S. saltwater fishermen spent $22.6 billion generating an economic impact of over $30.5 billion and supporting 350,000 jobs (not including Texas, Alaska, and Hawaii).

Headboat Survey
Researchers at the SEFSC Beaufort Laboratory have studied reef fish off the southeastern United States since the late 1960s and have addressed both applied fishery issues and basic reef fish ecology. The Laboratory's Southeast Region Headboat Survey collects fisheries and biological data to support stock management activities. These data sets are also used to examine patterns in the fishery and to study the structure and distribution of reef fish communities.

Cooperative Tagging Center (CTC)
The Southeast Fisheries Science Center formed the Cooperative Tagging Center (CTC) in 1992 in response to the recent expansion of tag release and recapture activities, data requests from other tagging agencies, and domestic and international tagging research needs. The CTC encompasses a variety of functions and responsibilities. The CTC also includes the Cooperative Tagging System (CTS), as well as other research projects such as tag development and performance research and cooperative work with endangered species.

The NMFS Cooperative Tagging Center has been impacted by the downsizing of the Federal Government and is being restructured.

9.2.3 Habitat and Ecosystem Research

9.2.3.1 General Coral Reef Conservation Grant Program

Each year, subject to the availability of funds, the NOAA Coral Reef Conservation Program publishes its Coral Reef Conservation Grant Program Funding Guidance, as authorized by the Coral Reef Conservation Act of 2000, to solicit proposals for coral reef conservation activities.

Funds are awarded under the following six program categories:
- State and Territory Coral Reef Management (Applicants: State and Territory Management Agencies);
- State and Territory Coral Reef Ecosystem Monitoring (Applicants: State and Territory Management Agencies);
- Coral Reef Ecosystem Research (Applicants: Academia, NGO's, etc.);
- Projects to Improve or Amend Coral Reef Fishery Management Plans (Applicants: South Atlantic, Caribbean, Gulf of Mexico, and Western Pacific Fishery Management Councils);
- General Coral Reef Conservation (Applicants: Academia, NGOs, Local and Tribal governments, community organizations, etc.); and
- International Coral Reef Conservation (Applicants: International governments, NGOs).

9.2.3.2 Coral Reef Ecosystem Studies

9.2.3.3 NOAA Fisheries SEFSC

South Florida Ecosystem Restoration

South Florida Restoration Team provides oversight and coordination of NOAA research in Florida Bay to ensure that scientific information is provided to water management agencies in south Florida to improve the ecological functioning of Florida Bay and other Florida estuaries. Scientists also conduct ecological studies of south Florida species as indicators of water quality, conduct associated research, and provide scientific information to management plans for the Florida Keys National Marine Sanctuary.

9.2.3.4 EFH Research

Information/Research Needs for Mangrove Habitat

Thayer et al. (In press) discussed research needs for mangrove systems based on a NOAA Coastal Ocean Program-sponsored workshop held in 1988. The following summarizes this paper and is separated into six priority areas of information needed.

<u>Food web-related information needs</u>

The prevailing paradigm regarding food webs of mangrove-dominated estuarine ecosystems is that they are based on particulate mangrove detritus, but recent research indicates that dissolved organics may be equally important. Research is needed to determine the contribution of mangroves to estuarine secondary productivity relative to contributions by phytoplankton, benthic micro- and macroalgae, and seagrasses. The studies by Fry et al (1999) and Fry and Smith (2002) have yielded some information, but more stable isotope work is needed.. Food web research needs to evaluate the significance of dissolved organic matter relative to particulate organic matter in trophic linkages and the distribution of higher trophic level organisms in various mangrove habitats in relation to gut contents and food linkages (e.g., as through the use of multiple stable isotopes).

<u>Information needs on productivity and structure of mangroves</u>

Little effort has been devoted to understanding the relationships between structural and functional attributes of mangrove communities or how these relations change with development of the mangrove stand over time. There is a need to characterize the dynamic nature of mangrove productivity and its influence on the productivity of adjacent coastal habitats. Protocols need to be developed that will enable investigators to remotely characterize forest structure, successional status and type.. The proportional contribution of mangroves to the total primary production of a given watershed or estuary is not well known. Rates of primary production of various components should be quantified and predictive models of primary productivity, as controlled by major factors, should be developed and tested. Research is needed on the ecological processes associated with recovery and succession of mangrove ecosystems, including research on the restoration and resiliency of restored mangrove systems and research on the significance of hydrology on succession patterns in mangrove habitats. The close coupling of mangroves to other hydrologic units in the landscape suggests that alterations in regional hydrology may induce changes in mangrove vegetation and functional patterns.

Habitat use information needs
Past research on the importance of mangrove habitats for fishes and invertebrates has focused primarily on fringing red mangroves, and that has been limited. The white and black mangrove habitats have been poorly studied. Each habitat type may export organic matter that generates chemical cues regulating the presence or absence and abundance of estuarine organisms and thus, the predictable spatial and temporal patterns of marine life. Determining the types and numbers of organisms that exploit these habitats, the functional aspects of habitat use, and how mangrove organic matter is transferred to higher trophic levels is critical, as are requisites for modeling linkages between variations in mangrove productivity and variations in faunal abundances. This requires work that compares spatial and temporal variation in use, feeding ecology and growth patterns.

Nutrient cycling information needs
Mangroves may influence nutrient dynamics and associated coastal productivity by either removing or contributing nutrients to these systems, and data on their function in maintaining water quality of estuarine ecosystems is limited. Processes associated with the immobilization of nutrients within mangrove ecosystems such as microbial decomposition and enrichment processes, and recycling, need to receive attention.

Restoration and Succession of damaged mangrove ecosystems
The effectiveness of mangrove restoration and creation projects in terms of mangrove community productivity, stability and faunal utilization patterns are poorly understood. The time frame for reaching natural growth and production rates has not been followed nor have the time courses for development of biogeochemical cycles and natural fish and invertebrate communities. Research also is needed to determine the effects of natural and human-induced perturbations on microbial decomposition and enrichment processes and on the significance of sea-level variations as factors contributing to successional patterns, habitat loss, and nutrient cycling processes.

Synthesis and modeling needs
Ecological models can be used in conjunction with field and laboratory approaches to obtain a better understanding of the role of mangroves in coastal ecosystems and to develop predictions of success of restoration designs. Scientists and managers need to synthesize extant information of ecological processes that address key management issues of mangrove habitats. Mapping efforts need to be expanded to provide information on the distribution of this important habitat type.

9.2.4 NMS Research Programs

Gray's Reef

Characterization of the Fish, Benthos, and Marine Debris at the Grays Reef National Marine Sanctuary

Gray's Reef National Marine Sanctuary (GRNMS) expressed interest in obtaining a baseline characterization of the benthic resources within Gray's Reef. To meet this need, the Center for

Coastal Monitoring and Assessment's Biogeography Team, in consultation with the Sanctuary, is conducting a characterization to identify spatial correlations between fish communities, benthic features, and fishing impacts at Gray's Reef National Marine Sanctuary.

GRNMS encompasses approximately 58 square kilometers of seafloor located 17 nautical miles off the coast of Georgia in approximately 60 feet of water. Baseline characterization of GRNMS benthic fish and sessile invertebrates has not been conducted comprehensively throughout the Sanctuary. This project quantifies those resources through a robust, statistically defensible sampling design. The project builds upon the previously completed benthic maps for the sanctuary (completed in 2003 by CCMA Biogeography Team). Such an assessment is needed to support the many activities and responsibilities of sanctuary staff including natural resources management, education, research, and even for promoting responsible recreational use by fishermen and divers. An understanding of the distribution of benthic resources provides the spatial framework within which to conduct sanctuary monitoring activities, identify and protect essential fish habitat, and properly address other spatially explicit research and management goals. This baseline characterization is also the first step in monitoring temporal changes in the Gray's Reef landscape and understanding more about the dynamic nature of this region of the continental shelf. To meet this need, the Biogeography Team mapped benthic habitats of the Sanctuary using sonar imagery. Completed maps include ledges of varying heights, flat live bottom, flat sand, and rippled sand. These maps are used to stratify sampling design of fish and benthic cover. Fish communities, fishing gear, marine debris, and cover of sessile invertebrates are surveyed along diver transects within each habitat type.

Benthic Macroinfaunal Communities Assessment
The Center for Coastal Environmental Health and Biomolecular Research (CCEHBR), through its Coastal Ecology Program, conducts research within several sanctuaries to support long-term science and management needs within the National Marine Sanctuaries. At Gray's Reef NMS and surrounding shelf waters, they are assessing benthic macroinfaunal communities and chemical contaminant concentrations in sediments and biota. Key objectives are to document existing conditions of these resources as a benchmark for tracking changes due to natural or human disturbances; examine cross-shelf patterns in contaminant concentrations; and identify potential environmental factors associated with observed patterns.

Gray's Reef National Marine Sanctuary Assessment Project
In 2002, the Reef Environmental Education Foundation (REEF) initiated a fish-monitoring program within GRNMS. The project uses the REEF Advanced Assessment Team (AAT) to conduct annual visual fish surveys within GRNMS. The surveys are conducted using the Roving Diver Technique (RDT) to measure species composition and estimate abundances. Beginning in 2004, REEF added a quantitative size-monitoring component for targeted species (black sea bass, lutjanids and serranids). The primary goals of this project are to 1) to provide GRNMS with a taxonomic inventory of fish species found within the Sanctuary as well as a dataset that can be used through time to measure spatial and temporal trends, 2) to assess the size structure and biomass of key targeted fish species within the GRNMS, 3) to complement the current stationary visual fish counts that have been conducted at GRNMS since 1995, and 4) to increase local and national awareness on the Sanctuary resources and give constituents a comparative fish data resource that can be used for the better management of GRNMS.

This project has provided a substantial increase of effort in the REEF database. Prior to the start of this project in 2002, there were only 18 surveys from the Sanctuary in the database. As of July 2006, there are over 300 surveys from GRNMS in the REEF database. Several new fish records for the Sanctuary have also resulted from the REEF project.

Florida Keys

9.2.5 NOS NCCOS

Benthic Habitat Mapping of Florida Coral Reef Ecosystems
Southern Florida's coral ecosystems are extensive. They extend from the Dry Tortugas in the Florida Keys as far north as St Lucie Inlet on the Atlantic Ocean coast and Tarpon Springs on the Gulf of Mexico coast. Using 10 fm (18 m) depth curves on nautical charts as a guide, southern Florida has as much as 84 percent (30,801 sq km) of 36,812 sq km of potential shallow-water (<10 fm; <18 m) coral ecosystems the tropical and subtropical U.S. Moreover, southern Florida's coral ecosystems contribute greatly to the regional economy. Coral ecosystem-related expenditures generated $4.4 billion in sales, income, and employment and created over 70,000 full-time and part-time jobs in the region during the recent 12-month periods when surveys were conducted.

Working with state, local, university, and other federal partners, NOAA initiated an effort to map and characterize the coral ecosystems of southern Florida. The Southern Florida Shallow-water Coral Ecosystem Mapping Implementation Plan (MIP) that was recently finalized discusses the need to produce shallow-water (~0-40 m; 0-22 fm) benthic habitat and bathymetric maps of critical areas in southern Florida and moderate-depth (~40-200 m; 22-109 fm) bathymetric maps for all of Florida. The ~0-40 m depth regime generally represents where most hermatypic coral species are found and where most direct impacts from pollution and coastal development occur. The plan was developed with extensive input from over 90 representatives of state regulatory and management agencies, federal agencies, universities, and non-governmental organizations involved in the conservation and management of Florida's coral ecosystems.

The MIP summarizes the map product needs of the southern Florida coral ecosystem conservation and management community. These needs include detailed, georeferenced, thematically accurate shallow-water benthic habitat and bathymetry maps. While considerable scientific interest and management requirements exist for coral ecosystems of the entire southern Florida region, priority areas were identified. Priority areas include the approximately 13,000 sq km of shallow-water coral ecosystems found in Martin, Broward, Palm Beach, and Miami-Dade Counties, Biscayne National Park, Tortugas Ecological Reserve, Dry Tortugas National Park, Florida Bay, and the Florida Keys National Marine Sanctuary. While considerable scientific and management interest exists in the West Florida Shelf, this area was considered to be a secondary priority area. As opportunities arise, targeted mapping activities will be conducted to characterize this area.

Based on geographic priorities and costs, the MIP recommends developing maps of approximately 13,000 sq km of southern Florida's shallow-water coral ecosystems. The estimated cost to generate a detailed shallow-water benthic habitat map using high-resolution satellite or similar imagery is approximately $4.35 million. This cost estimate includes purchasing commercial high-resolution satellite imagery, producing the actual benthic habitat map from the imagery, and completing an independent thematic accuracy assessment of the map. Because of the technical and logistic challenges and financial costs associated with imagery collection and map production, it is anticipated that four or more years will be required to complete shallow-water benthic habitat maps of southern Florida.

National Coral Reef Ecosystem Monitoring Program

This suite of projects is accomplished through cooperative agreements between NCCOS and State, Territory, and Commonwealth partner programs to monitor the status and condition of coral reef ecosystems throughout the U.S. Past objectives focused on filling in gaps in local monitoring. However, based on program evolution via consultation with island partners, the National Coral Reef Ecosystem Monitoring Program has developed into a full cooperative partnership between states, territories, commonwealths, and NOS-NCCOS. The programs objectives are as follows:

1. To work closely with jurisdictional partners and stakeholders throughout the US and its Territories to develop and implement a nationally coordinated, long-term program to assess, inventory, and monitor U.S. coral reef ecosystems; and,
2. Prepare a biennial report on the State of U.S. Coral Reef Ecosystem condition, with particular emphasis on assessing the impacts of threats to coral reefs worldwide, including: climate change and coral bleaching, coral disease, tropical storms, coastal development, pollution, over fishing, and many others.

The objective of the State and Territory Coral Reef Monitoring Grant program is to provide support for NOAA partners towards implementing a nationally coordinated, comprehensive, long-term monitoring program to assess the condition of U.S. coral reef ecosystems, and to evaluate the efficacy of coral ecosystem management. This program was requested by the U.S. Coral Reef Task Force, which, along with the nation's coral reef program managers and the public, endorsed and called for implementation of "A National Program to Assess, Inventory, and Monitor U.S. Coral Reef Ecosystems."

NOAA began implementing the Program in 2000 and continues to administer it with Congressional appropriations for coral reef conservation. The Program includes the collection, analysis, and reporting of long-term coral reef ecosystem monitoring data pursuant to scientifically valid methodologies and protocols and is a key priority of the "National Coral Reef Action Strategy."

The Coral Reef Monitoring Grant Program, as authorized under the Coral Reef Conservation Act of 2000 (16 USC 6401-6409), provides matching grants to Governor - appointed point of contact agencies for the jurisdictions of Puerto Rico, the U.S. Virgin Islands (USVI), Florida, Hawaii, Guam, the Commonwealth of the Northern Mariana Islands (CNMI), the Republic of Palau, the

Federated States of Micronesia (including Chuuk, Yap, Kosrae, and Pohnpei), and American Samoa for State and Territory Coral Reef Monitoring activities.

NOAA's National Ocean Service (NOS), through the National Centers for Coastal Ocean Science (NCCOS) provides funding for cooperative agreements to support state and territorial coral reef monitoring activities under the priority areas listed below, which have been recommended by the Nation's coral reef resource managers. These key biotic and abiotic parameters should be monitored at all local sites in the National monitoring network:

1. Benthic habitat characterization: e.g., depth, habitat delineation, and/or percent live/dead cover of corals, submerged aquatic vegetation, macroalgae, sponges, rugosity, diversity, etc.);
2. Associated biological community structure: including fish condition (e.g., abundance, density, size, diversity, disease, harvest trends, etc.) and large motile and sessile invertebrates condition (abundance, density, size, diversity, disease, harvest trends, etc.); and,
3. Water/substrate quality: (e.g., temperature, nutrient enrichment, toxic chemicals, turbidity, etc.).

9.2.7 Ocean Exploration and Research

The Office of Ocean Exploration is NOAA's center for new activities to explore and better understand our oceans. This office supports expeditions, exploration projects, and a number of related field campaigns for the purpose of discovery and documentation of ocean voyages. Bringing scientists to ocean frontiers requires rigorous planning, mission staging, and well coordinated marine operations.

Education and outreach rank high as office priorities. Through ocean exploration, NOAA is committed to raising America's science literacy and developing the next generation of ocean explorers, scientists and educators.

Four crucial components comprise the NOAA Ocean Exploration Mission:

1. Mapping the physical, biological, chemical and archaeological aspects of the ocean;
2. Understanding ocean dynamics at new levels to describe the complex interactions of the living ocean;
3. Developing new sensors and systems to regain U.S. leadership in ocean technology, and;
4. Reaching out to the public to communicate how and why unlocking the secrets of the ocean is well worth the commitment of time and resources, and to benefit current and future generations.

National Undersea Research Center

The National Undersea Research Center at the University of North Carolina Wilmington is funded by a grant from the National Oceanic and Atmospheric Administration as part of the National Undersea Research Program (NURP). NURP includes headquarters in Silver Springs, MD and seven regional centers. The center at UNCW supports undersea research off the southeastern United States from North Carolina to Texas. Center facilities and staff are located at the university's Center for Marine Science in Wilmington, NC and Key Largo, FL.

9.3 Ocean Observing Systems and Fisheries Oceanography

Ocean Observing Systems are an integral part of the transition to ecosystem management in the Southeast region. A brief review of atmospheric and oceanographic characteristics is provided in Section 9.3.1; the present status of real time observing elements in the SE Coastal Ocean is reviewed in Section 9.3.2; Data Management considerations are provided in Section 9.3.3 and Modeling approaches in Section 9.3.4.

9.3.1 Fisheries Oceanography in the South Atlantic Region

The Southeast Coastal Ocean Report (2005; http://seacoos.org/documents/report) provides a basis for the atmospheric and oceanographic characteristics of the US Southeast Coastal Ocean.

Atmospheric Characteristics

The atmospheric characteristics of the southeast coastal ocean are summarized in terms of the wind fields, and severe storms including winter cold air outbreaks and hurricanes.

Seasonal Wind Fields: Five seasonal wind regimes have been associated with the South Atlantic Bight and East Florida Shelf regions (Weber and Blanton, 1980; *Journal of Physical Oceanography*, 10:1256-1263).

- *Winter* (November to February/March): winds are persistently southeastward in North Carolina and turn more southward over Florida;
- *Spring transition* (March to May): winds shift to westward from Florida to South Carolina, with the winds elsewhere in the region being more variable;
- *Summer* (June and July): westward winds dominate the southern reaches of the domain, and northward flow sets in for the central to northern portions of the SAB (Georgia to North Carolina);
- *Fall* (August): the summer wind patterns break down and become generally disorganized except for Florida's westward and southwestward winds; and,
- *"Mariner's fall"* (September and October): southwestward winds (at times strong) occur over the domain, with westward winds at times over Florida.

Winter Cold Air Outbreaks (extra-tropical winter cyclones). During the winter months, extra-tropical cyclones often travel across the southeastern states and out over the Atlantic Ocean and are known for the devastating weather they sometimes bring. These storms frequently produce ice, heavy snow and gale force winds that can cause property damage and loss of life. Perhaps the most infamous of these cold air outbreaks contributed to the tragic loss of the space shuttle Challenger in January of 1986. Coincidentally, also in 1986, the Genesis of Atlantic Lows

Experiment (GALE) investigated these storms and their effect on the SE coastal ocean (J. Geophysical Research, Vol. 94, number C8, 1989).

Hurricanes -- Tropical Cyclones: The Southeast US region typically experiences weekly easterly waves and several tropical cyclones (in some instances hurricanes) each year. Neumann (1993) quantified the mean direction of the tropical cyclone (TC) tracks from 1886-1989. Generally, if storms do not recurve east of 60°W, they will make landfall along the US coastline. The number of TC occurrences during this period was 70 in the Gulf of Mexico and 85 off Cape Hatteras, North Carolina. Given the high frequency of TC landfall in the SE and the large areas of low-lying land along the SE coast, accurate prediction of the oceanic interaction with, and response to, tropical storms is vital to ensure timely action by coastal emergency response personnel. The official Atlantic hurricane season runs from June 1 through November 30, with a peak from mid-August through mid-October.

Oceanographic Characteristics

Geographic Setting: We define the Southeast Coastal Ocean as the domain extending from the Florida Panhandle to the North Carolina shelf north of Cape Hatteras, acknowledging overlap with the Gulf of Mexico coastal ocean domain in the west and the Mid-Atlantic Bight north of Cape Hatteras. Major geographical sub-regions with the SE Coastal Ocean are the West Florida Shelf (WFS), Straits of Florida (SOF), and the South Atlantic Bight (SAB), with the common boundary point between the former two at the Dry Tortugas and between the latter two at Cape Canaveral. Within SEACOOS, the functional sub-regions are the West Florida Shelf, East Florida Shelf (EFS), and the Carolina-Georgia Shelf (CGS). As is the case with other large regional coastal ocean domains, there is overlap between sub-regions in a number of areas.

The regional geomorphology of the SE United States defines a number of the key oceanographic characteristics of the SE coastal ocean. Much of the coastal area of Florida, Georgia, South Carolina and North Carolina is relatively low relief topography. Two sub-regions have relatively broad continental shelves. The WFS is a gently sloping carbonate platform, extending to >200 km from the coast to the shelf break. The SAB shelf (largely lithogenic deposits, with some carbonate strata) reaches a width of 100-120 km off Georgia and South Carolina, tapering to a much narrower width at its northern and southern ends, at Cape Hatteras and Cape Canaveral, respectively. In contrast, the SE Florida shelf along the SOF is rather narrow, being only several km wide in parts.

Local and Deep-Ocean Forcing: One of the key considerations regarding variability in material property distributions and exchange processes in the SE coastal ocean is the relative influence of local and deep-ocean forcing. Here we refer to material properties in a broad sense, including physical characteristics, such as sea level, water velocity, temperature, salinity, as well as chemical and biological constituents, such as nutrients, non-living particulate and dissolved organic matter, inorganic materials such as suspended clay particles, and organisms of various trophic levels.

A very simplified picture of some of the key local and deep-ocean forcings is represented in Figure 1. Local forcings include inputs of momentum through winds and pressure gradients, and inputs of buoyancy resulting from river discharge at the coast (and by ground water), from local precipitation/evaporation differences, and through surface heat flux. Deep-ocean effects include the influence of the ocean boundary current and associated frontal eddies on the shelf circulation and material exchange, and through tides.

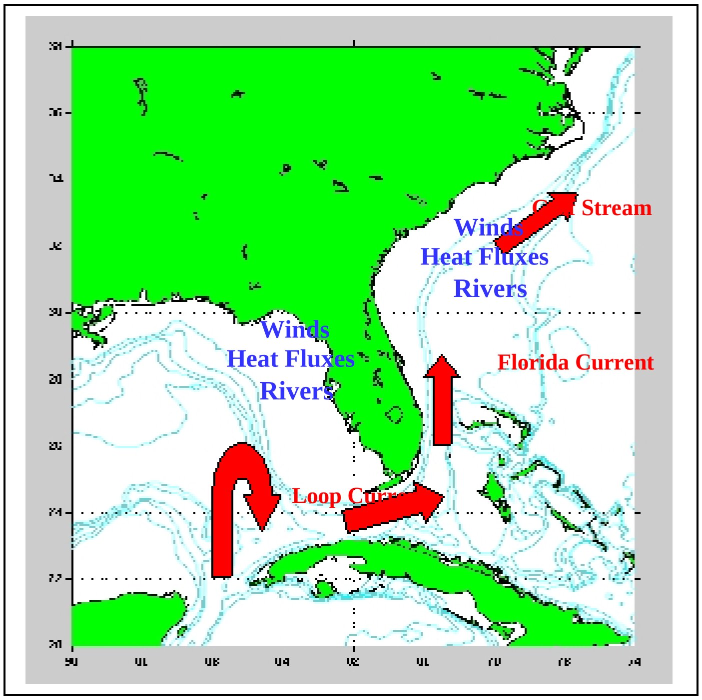

Figure 1. A simplified representation of some of the key local and deep-ocean forcings that drive water motions and determine material property distributions in the SE Coastal Ocean.

The coastal waters are linked by the Loop Current/Florida Current/Gulf Stream complex that runs along the shelf margin. Shelf waters respond strongly to atmospheric forcing by winds and air-sea fluxes. Freshwater is input along the coast from a number of rivers fed by the regional drainage basins.

Starting with the deep-ocean forcing, one of the defining characteristics of the SE Coastal Ocean is the presence of a major western boundary current system. The Loop Current/Florida Current/Gulf Stream complex (LC/FC/GS) provides a mechanism of rapid transport of materials along the ocean margin throughout the region, and strongly influences outer shelf circulation and material exchange processes along the shelf margins through formation and dissipation of meanders, fronts, eddies and sub-mesoscale vortices. Another deep-ocean forcing is from tides. The largest tides in the SE coastal ocean are found in the central portion of the South Atlantic Bight, with tidal ranges of 2.5-3.0 m near Savannah, Georgia and peak mid-shelf tidal currents of 40-50 cm/s. Tidal ranges are of the order of 1 m or less over much of the rest of the domain.

On the more local scale within the various sub-regions of the SE coastal ocean, variability in winds is obviously one of the major factors driving shelf circulation patterns. The general picture for seasonal and synoptic scale patterns of local wind forcing in the SE was summarized in the preceding section. Another local forcing is the input of buoyancy at the coast in the form of river discharge. Most of the river discharge along the coastline of the SE Coastal Ocean comes from drainage basins that are contained within the SE region. Thus, seasonal and interannual variability in regional rainfall and river discharge strongly influences coastal currents and hydrographic structure of the broader shelf region. However, the Mississippi River discharge can also impact the WFS and, at times is evident in lower salinity water along the shelf margin of the EFS and CGS due to transport in the LC/FC/GS system.

Known variations in cross- and along-shelf transports dictate regular monitoring at the shelf-break, mid-shelf, inner shelf at a minimum. In the more complex inshore waters, where spatial gradients are highly structured, relatively high-resolution observations will be required. There clearly is a need for ocean-side boundary conditions. This is particularly challenging for the Southeast coastal ocean domain because of the presence of the Loop Current - Florida Current - Gulf Stream system.

Summary Remarks on the Processes Defining Coastal Ocean Observing Systems

The basic design of an Ocean Observing System for the SE US coastal ocean must take into account a number of key geographic and physical characteristics of the region that control coastal ocean processes. These include:

- The presence of a western boundary current system (the Loop Current-Florida Current-Gulf Stream) along the shelf margin throughout most of the SE states (Florida-Georgia-South Carolina-North Carolina) coastal ocean, including the influence of its meandering jet and front and the mesoscale eddies it sheds;
- A wide range of shelf widths, from <10 km to >100 km;
- Several major estuaries and coastal lagoons (e.g., in Florida: Apalachicola, Tampa Bay, Charlotte Harbor, Florida Bay, Indian Lagoon, St. Johns River; in Georgia: Altamaha River, Savannah River; in South Carolina: Broad River, St. Helena's Sound, Charleston Harbor; and in North Carolina: Cape Fear River, Albemarle-Pamlico Sound) that exchange physical and biogeochemical properties and biota with the open shelf;
- Variable input of freshwater to the coastal zone from distributed SE river (and groundwater) sources, with the additional influence of the Mississippi River on the region that create cross-shelf density gradients;
- Seasonal patterns of heating and cooling that result in widely varying cross-shelf density structure which influence exchange with the deep ocean;
- The influence of synoptic weather systems, and especially major episodic storm events, including easterly waves and tropical cyclones in summertime and extra-tropical cyclones and frontal systems in wintertime, in producing turbulent mixing, coastal upwelling and downwelling, and other transient flows; and

- A highly variable diurnal and semidiurnal tide regime that is dominant in certain shallow water regimes.

Development of a complete system will likely take decades. What is described below is a design to be implemented over a 5-year timeline that concentrates on developing a viable information system for the continental shelf region of the SECOORA domain. Thorough testing of the adequacy of the system to satisfy the needs of the chosen applications is anticipated to result in revisions after the 5-year build-out. Designing an RCOOS for the SE US that can effectively address the IOOS societal goals requires consideration of a number of factors, including the SE environmental/oceanic setting, existing capabilities, and anticipated resources. Implementation of the SE RCOOS will be an incremental process. Due to the range of temporal and spatial scales over which coastal ocean processes operate, use of both observations and models is essential for creation of a robust and multi-purpose estimation (or prediction) system. The range of applications implied by the broad societal goals for the IOOS also dictates that a "nested" strategy will be required for the allocation of resources. Some degree of sub-regional to local focus will also be required for the RCOOS to serve in an R&D role for the RA (e.g., conducting data assimilation experiments, and providing technology testbeds).

While the initial focus for observations in the developing RCOOS will be physical variables, this does not imply that the RCOOS will serve only as a physical oceanographic estimation system. Rather, this reflects the present state of sensor development and maintenance issues for the existing biological and chemical sensors, and recognition of the importance of physical processes for driving biogeochemical and ecological processes. As more robust, cost-effective technologies become available for measuring chemical and biological properties, these will be incorporated into the RCOOS in a coordinated, multidisciplinary manner. Given the close coupling of physical processes with biogeochemical processes in the coastal ocean, an initial physics-based RCOOS observational design will also serve interdisciplinary needs, including implementing ecosystem-based management practices in the SE coastal ocean.

9.3.2 Status of Coastal Ocean Observing Systems in the Southeast

Some of the descriptions below on the status and possible enhancements of the southeast’s regional observing system are taken from the article by Seim, H.E., C.N.K. Mooers, J.R. Nelson, R.H. Weisberg and M. Fletcher (2008) “Towards a regional coastal ocean observing system design for the southeast coastal ocean observing regional association”, *Journal of Marine Systems*, in press.

Regional System

The definition of the structure of the U.S. Integrated Ocean Observing System (IOOS) has been developed in large part through the actions of Ocean.US, an interagency planning office established in 2000 to advance the development of IOOS. The U.S. coastal ocean component of the IOOS is envisioned to consist of a federal network (the “National Backbone”) which will provide sustained support for *in situ* and satellite remote sensing observations, predictive models, and data management elements on the national scale, augmented by Regional Coastal Ocean Observing Systems (RCOOSs) (Ocean.US, 2002). Each RCOOS will be an integral component of its respective regional association (RA) of stakeholders (*viz*., data providers and users), which in turn is a member of the National Federation of Regional Associations (NFRA) (Ocean.US, 2004). Through the RA, the RCOOS will be responsive to regional and local needs and augment the National Backbone accordingly. As a pioneering activity associated with the regional development of a coastal ocean observing system (COOS), the Southeast Atlantic Coastal Ocean Observing System (SEACOOS; Seim et al., 2003) has considered the scientific and technical design criteria of the operational RCOOS that will be a central element of the Southeast Coastal Ocean Observing Regional Association (SECOORA). SECOORA and its RCOOS are required to be fully interactive and interoperable with other regional associations, especially with the neighboring GCOOS for the Gulf of Mexico and MACOORA for the mid-Atlantic, as well as with the National Backbone provided by the federal agencies (Figure 2). Discussed here are preliminary thoughts on the design of a RCOOS for SECOORA, some aspects of how this RCOOS may interact with the National Backbone, and how elements of the RCOOS will transition to certified components of IOOS.

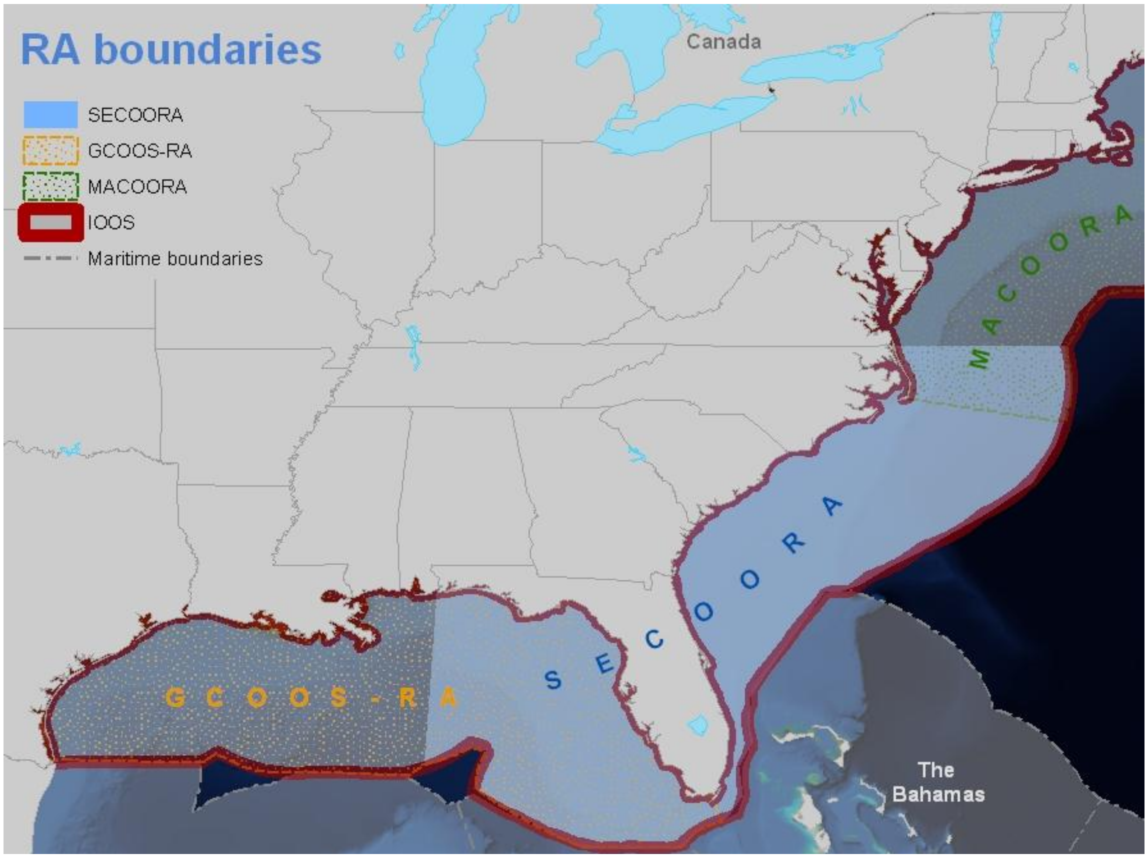

Figure 2. Approximate boundaries of regional associations (RAs) and the coastal component of the U.S. Integrated Ocean Observing System (IOOS).

Since ocean processes are three-dimensional, time-dependent, and occur on many space-time scales, no single measurement system (*in situ* or remote) will be sufficient for describing any of the ocean state variables. A "multi-platform, multi-variable" observational approach is required, integrated with models (including data assimilation approaches). Furthermore, the fundamental value of continuous time series data should be recognized in the design process, such that real-time telemetry systems are backed up with internal recording of data, and delayed-mode and historical data are also integrated into the regional data management structure.

The following sections describe the existing observing system in the southeast Atlantic and possible enhancements are broken out by observing platform. The inventory of existing assets indicates a wide range of observing activities shoreward of the coastline in estuarine waters; because of this little augmentation is suggested. On the continental shelf there is a relatively sparse set of observing assets; the federally-funded program provides some measure of atmospheric and ocean surface properties but provide no subsurface observations except for some experimental current profilers. Regional and sub-regional programs like SEACOOS have effectively doubled the number of observing platforms on the continental shelf and provide the only near real-time subsurface observations. As examples of the impact made by the regional programs, SEACOOS HF radar provide surface currents over more than 20,000 km^2 where no other observations exist, and regional buoys and moorings increase the number of locations where bottom temperature is monitored from zero to fifteen. Because the only sustained observing elements in the coastal ocean are the federally-operated assets, the proposed observing system design focuses on implementing consistent regional coverage to provide reliable information on physical ocean state that can also be used to assess the accuracy of coastal ocean models.

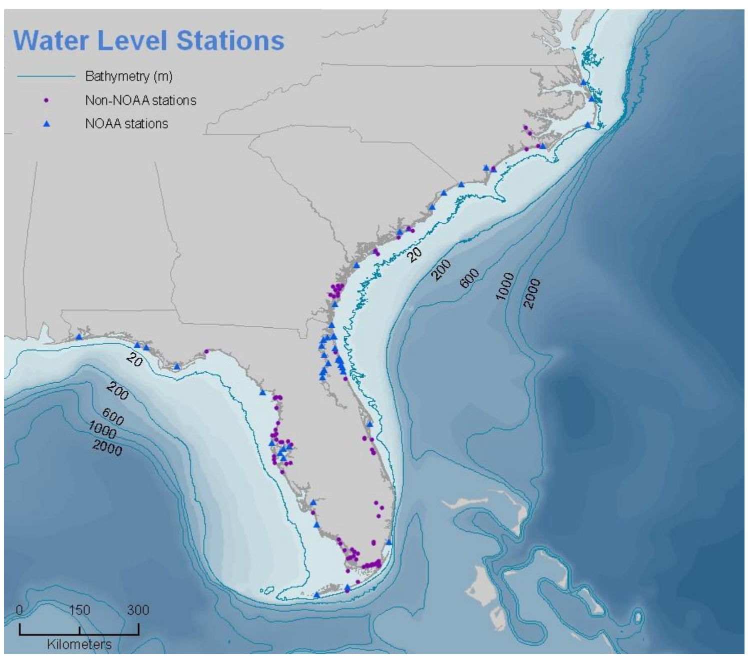

Figure 3. Distribution of existing water level observation stations that are tidally influenced.

<u>Coastal Stations.</u> Existing federally operated coastal stations, largely established by NOAA (in particular the National Water Level Observation Network of the National Ocean Service and the Coastal Monitoring Automated Network of the National Weather Service), US Geological Survey, National Park Service, and US Army Corps of Engineers are geared primarily to sea level and coastal meteorology. Within Florida the Water Management Districts also support a large number of water level gages. The distribution of stations that are tidally-influenced (Figure 3) indicates that these stations provide a foundation for further development of shore

stations by the RCOOS, which should be approached in coordination/partnership with federal agencies and state and local coastal management and emergency response agencies. At present three areas in Florida are heavily instrumented, the St. Johns River/Jacksonville area in the NE of the state, the Everglades in the south, and the Tampa Bay area on the west coast.

Noticeable gaps in coverage exist along the east coast of Florida and in the Big Bend of NW Florida. Augmentation of water level stations in these locations and at commercial ports is warranted, since even small changes in water depth can impact the efficiency and safety of deep-draft vessel operations. Ten additional water level stations should be sufficient to fill the existing major gaps. Further regional partnering with the NOAA Physical Oceanographic Real-Time System (PORTS) program could be an effective approach in the ports. In terms of spatial coverage, there is a need for sufficient coastal water level stations to assess the predictive skill of both (1) high-resolution coastal inundation models, and (2) lower resolution coastal ocean circulation models. For coastal inundation/storm surge applications, there is a practical need to "over-sample" sea level, since many stations are subject to failure of instruments or communications during major storm events.

Fixed Moorings. The SECOORA domain includes regions with very narrow shelves (near DeSoto Canyon, the SE Florida shelf from Key West to West Palm Beach, and near Cape Hatteras) and broad, gently sloping shelves (off West Florida and in the central South Atlantic Bight). Obviously the deployment of observational assets will have to take this variability in shelf width and coastal ocean properties into account. For the broader shelf sub-regions, three basic sub-domains can be defined:

- A baroclinic (density-stratified) outer shelf/slope zone where the physical state is directly influenced by the boundary current (Loop Current/Florida Current/Gulf Stream);

- An inner shelf/coastal zone where the water column is shallow enough that there is interaction between surface and bottom boundary (Ekman) layers and wind, wave, and tide forcing are significant; in many locations, there is also a near shore zone in which the influence of relatively fresh estuarine outflows leads to additional buoyancy-driven flows;

- An intermediate/mid-shelf zone (if the shelf is wide enough to separate the inner and outer portions) where circulation is largely forced by winds and tides.

Existing shelf observation platforms include the buoys and coastal stations of the National Data Buoy Center (NDBC) and a collection of academically-supported sub-regional systems off the west coast of Florida, off Georgia, and off the Carolinas (Figure 4). The type of sensors each platform supports varies but in general the NDBC buoys emphasize meteorological instrumentation and currently provide limited ocean measurements. Coverage of oceanic variables is very sparse with the possible exception of near-surface temperature.

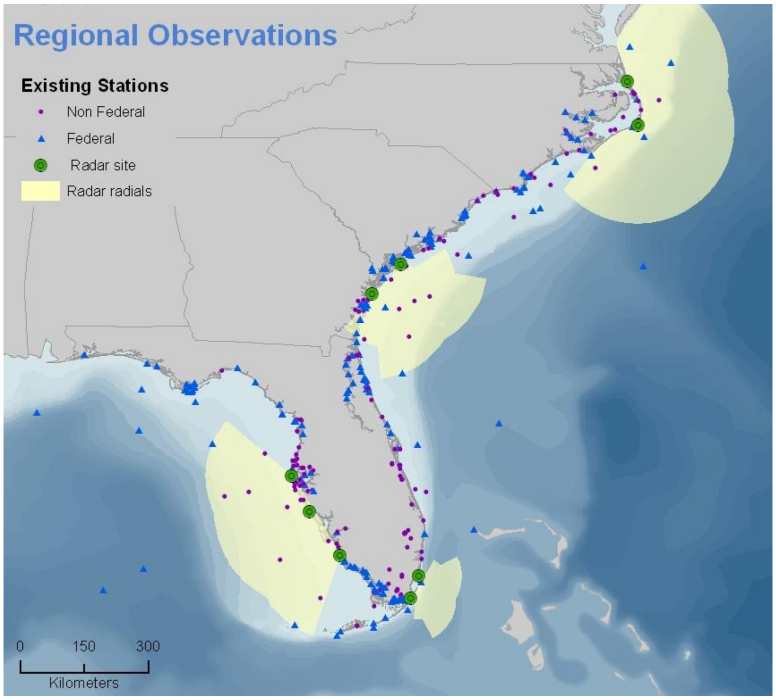

Figure 4. Depiction of the existing observing subsystem showing coastal stations, buoys, and radar coverage. Note that all radar sites are non-federal.

Based on the above considerations of the ocean physics, a regular array of moored or fixed platform offshore observing elements distributed over the SECOORA domain is advanced (Figure 5). A detailed description of possible platform and instrument configurations is beyond the scope of this discussion. Here the focus is on an initial distribution of these assets on the continental shelf and a set of core variables to be measured. The proposed initial array consists of a series of cross-shelf deployments, at roughly 150 km spacing in the along-shelf direction, and linked, to the extent possible, to seaports, major topographic anomalies, and other special features. The along-shelf spacing is needed to resolve

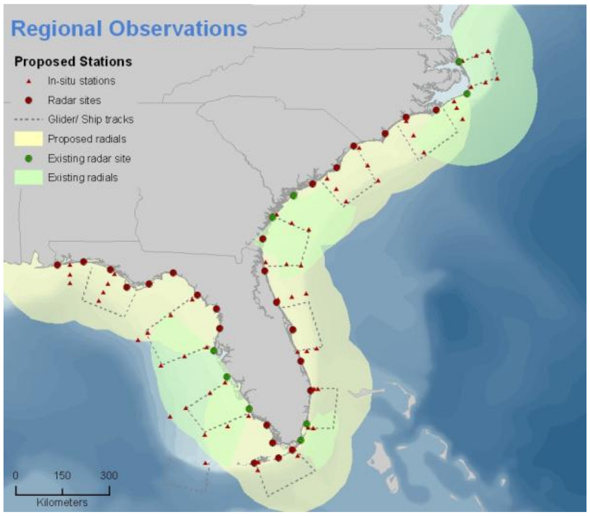

Figure 5. Proposed enhanced observing subsystem asset distribution to provide region-wide coverage on the continental shelf from HF radar, *in-situ* moorings and glider or ship transects. Note: these transects are for discussion purposes only. Local phenomenology will lead to finer tuning of the RCOOS array

variability in the circulation; many features of coastal circulation in the SE occur at this scale or smaller (e.g., Florida Current and Gulf Stream meanders). For all but the narrowest shelves, each cross-shelf section would have three measurement sites, supplemented in the near-shore with additional deployments at major locations of estuarine outflow or population centers. The core set of instrumented buoys or platforms should all be equipped for measurements of temperature and salinity at multiple depths, current profiles, wind, and some should be equipped to determine directional waves and net surface heat flux. Given the ten existing NDBC buoys there is a need for an additional 50 moorings under this scenario.

Full water column measurements of current, temperature and salinity in each of the three coastal ocean regimes defined above are necessary to specify the flow and hydrographic (temperature, salinity, and density) fields. The surface and bottom boundary (Ekman) layers warrant particular attention given their roles in cross-isobath exchange. Full water column measurements are also required to assess key processes, including boundary current interactions on the shelf-slope, exchange at the shelf break between the coastal ocean and the deep ocean, coastal responses to local wind forcing, transport of organisms by internal tides, and direct estuarine interactions with the coastal ocean.

Another essential observation throughout the coastal ocean domain is surface winds. Due to the complication of land-sea interactions, the quality of numerical weather predictions over the coastal ocean can often be compromised. Most *in situ* moorings or platforms should therefore be equipped with surface wind and barometric pressure sensors. The complete suite of sensors required for heat flux estimates (incoming short- and long-wave radiation, air and sea temperatures, relative humidity) should be supported at a distributed subset of the offshore sites.

Other ancillary measurements are recommended (although not required at all sites), the foremost among these being surface waves. Directional wave spectrum measurements at the shelfbreak can provide the boundary conditions needed for coastal ocean wave models, and wave measurements nearshore can be used both to gauge the performance of these models and provide real-time data of immediate societal importance. Provisions for incorporation of additional chemical, geological and biological sensors, as these evolve, should also be included in the design of instrument, power, and communications packages.

Not addressed in this initial mooring design is an observation program for the slope and deep-water regions of the domain. The presence of the western boundary current makes these areas particularly challenging environments in which to maintain conventional moorings. Coordination with the National Backbone will be critical to deploying and maintaining an adequate array of slope and deep-water moorings and a leading role for NDBC and associated federal agencies in establishing this portion of the regional network will be strongly encouraged by SECOORA. Other possible observing technologies include cable-based transport estimates and inverted echo sounders.

Additional moored and fixed platform *in situ* assets (not represented here nor budgeted for below) will likely be positioned in areas of regional and local interest (e.g., major ports and shipping lanes, inshore areas subject to shoreline erosion and rip currents, and Marine Protected Areas) and supported through local initiatives. Measured variables at these sites will necessarily be tailored to the local applications (e.g., directional waves, wind, and nearshore currents). There may also be a need for strategic (or "targeted") observational arrays in critical locales to support the requirements of data assimilation. It is recognized that the RCOOS should provide some discretion in the organization of observational resources to serve local needs, and to best exploit available resources and infrastructure, including those supported by the National Backbone and state and local agencies.

Coastal High Frequency (HF) Radar. Coastal HF radar mapping of surface currents provides one of the more important of the potential RCOOS measurement systems, offering a field of surface velocity vectors as opposed to the point measurements typical of fixed offshore assets (Paduan et al., 2004). Two commercially available systems are operated in the SECOORA domain by academic institutions, CODAR and WERA, each offering varying range and resolution based on frequency and bandwidth (Figure 4). There are presently no HF radar installations operated by federal agencies. HF radar is a topic area where the RCOOS can play an important role in technology assessment. Given the wide range of shelf widths off the SE U.S. and the rather unique oceanic configuration of a western boundary current on the continental slope, careful assessment of options to provide HF radar coverage over the entire region is advisable. Regional coverage using long-range systems is critical to achieve because of their ability to discern the position of the boundary current and its influence on the shelf and is a necessary first stage of development (Figure 5). In addition to surface currents, continued evaluation of other potential products from HF radar (such as a spatial grid directional wave estimates from WERA) should be pursued. Deploying HF radar on islands or offshore platforms and transmitting shoreward should also be tested as a means to provide nearshore surface current coverage that is otherwise difficult to obtain, especially for convex coastlines. Assuming the existing radar systems will continue to be operated, an additional 30 installations are needed to provide region-wide coverage.

Satellite Remote Sensing. While not an asset class to be deployed, operated or controlled by the RCOOS, satellite remote sensing represents a critical resource for coastal ocean applications. Sea surface temperature, surface ocean color products (including upper layer chlorophyll and suspended materials), sea surface height, surface winds and other products from passive and active satellite sensor systems are routinely available. Such satellite information is being used for assimilation into models and for descriptive purposes. While the satellite programs themselves would not be an RCOOS function, RCOOS support for utilization of satellite data and production of enhanced products, tuned and/or calibrated to regional applications, will provide strong justification for continued federal agency support of satellite missions targeting the coastal ocean. In the SE coastal ocean, applications of passive satellite imagery could include detection of near-surface phytoplankton blooms (some of which may be harmful algal bloom species), identifying and tracking waters of riverine origin and episodic cross-shelf transport, and detection of sediment resuspension events. An RCOOS role in the support of regional capabilities for downloading, processing, and distributing satellite data, as well as for analysis products and presentation tools, will be critical for effective integration of the satellite information with *in situ* observations and application in regional modeling programs.

Profilers and Gliders. The conventional method for observing 3D fields of temperature, salinity, and other properties (such as chlorophyll and nutrients) is by ship survey. This approach is, however, slow (and often non-synoptic) and costly. At present there are no regularly scheduled spatial surveys occurring on the continental shelf in the SECOORA domain. Needed are techniques for synoptic mapping at intervals sufficient for assimilation into models, particularly for the internal density (Temperature/Salinity) field. Through a combination of profiling floats, moored profilers, autonomous underwater vehicles (AUVs), and gliders it should be possible to obtain regular (i.e., routine, standardized, and sustained) mapping of the vertical and horizontal T/S structure, as well as that of other variables with the addition of appropriate sensors. Several systems are presently being assessed in field trials in the SE. It is envisioned that an appropriate mix of platforms would be used to occupy offshore transects that align roughly with the mooring lines (Figure 5). Ten operations areas are envisioned, each with a offshore leg that in most cases will be sampled while moving with the western boundary current.

Ship Transects. Since robust, accurate, automated biogeochemical sensors will likely not be available near-term, it will be necessary to include some repeated shipboard surveys of biogeochemical variables and biota. Such surveys should be designed to optimize synergy with the deployed observational elements and real-time prediction systems, and take into account what is known of natural variability in the coastal ocean. There may also be a role here for airborne surveys equipped with remote sensors, expendable profilers, and other air-deployable systems.

Voluntary Observing Ships. With the large volume of commercial shipping and recreational boating activity in the SE, it may be possible to obtain additional valuable regional coverage by installing automated instrumentation packages on a voluntary basis, as has been done in the International SeaKeepers program on a global scale on private vessels (www.seakeepers.org) and on commercial vessels. On the more local scale, the FerryMon (http://www.unc.edu/ims/paerllab/research/ferrymon/index.html) project in North Carolina has made use of an inshore ferry as a monitoring platform.

Surface Drifters. Satellite-tracked surface drifters provide a quasi-Lagrangian view of surface circulation and, with caveats regarding their performance relative to Lagrangian trajectories (not necessarily surface-confined), provide excellent tools for surface trajectory analyses. Drifters are essential for establishing the error attributes of predicted trajectories; conversely, they are invaluable for estimating the dispersive properties of varying coastal ocean circulation regimes. Nearshore deployments can be useful for filling data gaps in coastal HF radar coverage, and for examining connectivity between adjacent estuaries and sources of fresh water along many sections of the SECOORA domain. A regular program of drifter releases on the shelf that complements existing drifter programs in deep water should be initiated. Release of drifters from various locations in the domain is suggested, using 150 drifters per year (e.g. monthly releases at a dozen locations). Deep-water examples are the collation of drift tracks by the Atlantic Oceanographic and Meteorological Laboratory, NOAA and those tracks made available by Horizon Marine, Inc in the Gulf of Mexico. Coordination with the US Coast Guard, the marine services industry and NOAA will maximize coverage.

Sub-regional Systems

Smaller within-region observing systems exist and can be considered as contributing to the overall regional system.

Coastal Ocean Monitoring and Prediction System (COMPS) is based at the University of South Florida and includes the only Physical Oceanographic Real-Time System (PORTS) facility in the southeast (*http://comps.marine.usf.edu/index.html*). PORTS is a NOAA/NOS CO-OPS program. COMPS utilizes shore stations, coastal moorings with buoys and high frequency radar (HF radar, which measures surface current velocities) to observe the coastal ocean along the WFS. A broad range of variables is measured at the shore stations and offshore moorings. These include those measured by NDBC, plus additional variables at selected sites that may include short -and long-wave radiation, precipitation, water temperature and salinity at multiple depths, current profiles, and various optical properties.

The South Atlantic Bight Synoptic Offshore Observational Network (SABSOON, *http://www.skio.peachnet.edu/research/sabsoon*) is based at a set of offshore Navy air tactical control towers on the Georgia continental shelf. The system hosts a wide range of equipment, similar to COMPS, and includes underwater video used for fisheries studies. Additional nearshore sites off South Carolina and Georgia have been added by from the University of South Carolina and the Georgia Institute of Technology (Savannah campus; *http://wavebuoy.gtrep.gatech.edu*). These systems are focusing on nearshore directional wave measurements.

The North Carolina Coastal Ocean Observing System (NCCOOS, *http://nccoos.unc.edu/*) operates a HF radar system on the Outer Banks and has instrumented one of the Navy platforms off Georgia with meteorological sensors.

The Carolinas Coastal Ocean Observing and Prediction Systems (Caro-COOPS, *http://www.carocoops.org*) operates offshore moorings that report meteorological and ocean conditions and have installed three meteorological and augmented water level stations along the SC and south NC coast that are now considered part of NWLON.

The Coastal Ocean Research and Monitoring Program (CORMP, http://www.cormp.org) has deployed a series of real time weather and sea state buoys off of the NC coast, as well as partnering with Camp Lejune Marine Corp Base and the National Data Buoy Center (NDBC) to deploy a collaborative buoy in Onslow Bay, NC. In addition to the programs noted above, there are several other institutions making real-time observations available. These include the FDEP and a directional wave gauge at Melbourne Beach, Florida (*http://beach13.beaches.fsu.edu/melbourne/melbourne.asp*). Real-time but proprietary observing systems are operated by WeatherFlow (*www.weatherflow.com*) in North Carolina, South Carolina and Florida.

9.3.3 Regional Observing System Information Management

Information Management (IM) is fundamental to the operation of the RCOOS. Establishing a network of local-to-regional-to-national-to-global IM systems will enable the collection, aggregation, accessing, utilization, archival, and dissemination of coastal ocean data and information products. This has been an area of emphasis in Ocean.US IOOS planning. To advance the IOOS Data Management and Communications (DMAC) Subsystem, it will be necessary to establish a coordinated and cooperative network among the various regional systems and the users of IOOS products. New capacities will be needed to establish this network and ensure its functionality at a range of temporal and spatial scales. The IOOS DMAC is envisioned to comprise the following components (described in the first IOOS Development Plan, Ocean.US, 2006).

- *Metadata* -- These data describe data sets for the national system, including development and use of a common vocabulary, identification of required metadata fields, agreement upon sites for publication of metadata, and commitment to publish metadata in a timely fashion.
- *Data Discovery* -- The capacity for searching and locating desired data sets and products and for manipulating accessed data must be established.
- *Data Transport* -- Data and products must be capable of transport over the Internet in a transparent, interoperable manner.
- *On-Line Browse* -- Data must be readily accessed and evaluated through common Web browsers.
- *Data Archive* -- Mechanisms for secure, short-term and long-term data storage must be established.
- *Data Communications* -- The communications infrastructure for accessing and transporting data and data products must be identified and maintained to meet standards.

Regional and sub-regional observing systems in the SECOORA region have established a number of the necessary components described by IOOS DMAC. Where the capability for addressing specific requirements does not yet exist, progress has been made in identifying and characterizing those needs, with a view towards "filling the gaps." In general, efforts focused primarily in SEACOOS, with support from the Carolinas Coastal Ocean Observing and Prediction System (Caro-COOPS), have established a system that enables the aggregation, access, and dissemination of real-time and delayed-mode data from *in situ* observations, model output, and remotely sensed imagery. This aggregation and subsequent visualization of distributed data requires development of a process that can be utilized by other regional and sub-regional systems, and can help the community push towards interoperability. The steps being taken to establish this system of aggregated data include:

- Inventory of existing and potential data types;
- Identification of standard data ontologies, file formats, and transport protocols;

- Software for data applications and for interfacing different applications; e.g., Web mapping;
- Database schemas for the variety of data types.

Experience has shown that an effective approach toward a regional IM system is to engage distributed information providers through standards that promote interoperability. This type of construct has been commonly termed a "services-oriented architecture." Each of the observation and model data providers should be required to adhere to a set of standards and practices that enable information exchange among and between all of the partners. There is also a need to have a central aggregation site or hub that is a clearinghouse for standards and that maintains a database of the aggregated information and/or links to data sources. This central hub need not be physically located in a single location but does require a single presence on the Internet. Given the volume of information involved and the vulnerabilities related to natural and other hazards, it is strongly recommended that at least two physical locations be established that can support the central site activities. Two sites would enable a minimum level of redundancy and fail-over capability in case of interruptions in services.

Thus the design recommendations are that SECOORA should:

- Establish a regional "hub" for RCOOS IM that provides coordination, guidance, and centralized data aggregation, distribution, and storage functions;

- Maintain and strengthen distributed foci of IM expertise at the major observational and modeling sub-system locations. This step will provide in-house management of data, assurance of implementation of standards, and technical support, with assistance from the central hub;

- Establish one or two back-up sites to provide redundancy and ensure continuous operations in case of infrastructure failures at the central hub;

- Establish an agreement with a NOAA archive(s) (e.g., National Ocean Data Center or National Climatic Data Center) for long-term security and archival of observational and model data. Separate regional archives are needed for more "specialized" or region-specific data products (e.g., data aggregations, high-resolution model outputs);

- Identify robust satellite telemetry system(s) for transmission of real-time data, and establish or secure the necessary land-based connectivity and bandwidth for information dissemination;

- Identify appropriate standards with respect to common vocabulary, metadata format and content, metadata publishing protocol, data formats, and transport protocols; and

- Establish a portal that serves as a single site for accessing regional IOOS observational data and model/prediction products, as well as links to other user-targeted portals that utilize/provide specialized treatments of regional data.

9.3.4 Modeling systems

Within an initial build-out plan, the majority of applications envisioned to be served by Observing Systems can provide predictive capabilities through the development of a set of models:

Physical state models. These include models for circulation (3D time-varying representations of coastal ocean currents, sea level, temperature and salinity), waves (2D representation of the surface gravity wave field and sediment transport), and the marine atmosphere (3D time-varying representation of the coastal atmosphere). Enhanced spatial resolution can be provided and/or improved through the nesting of models. The model set includes tidal and storm surge inundation models (separate or components of circulation models) capable of incorporating wetting and drying and that can accurately represent the flooding of lowlands during high-water events (e.g., hurricanes, extra-tropical cyclones).

Biogeochemical and ecosystem models. These must be coupled to circulation models for prediction of nutrient fluxes and the responses of various trophic levels to environmental variability. The existing models are complicated, have many free parameters, and require a broad spectrum of observations to calibrate and validate. It will likely require many years of R&D to develop full operational capabilities in this area.

Socio-economic models. This broad class of models would address a range of topics, including the role of humans in the coastal ocean ecosystem (e.g., changes of land and water use, changes in population distributions), how socio-economic systems may respond to manifestations of climate and global change in the coastal ocean, and the broader implications of alternate management strategies. Some simple implementations exist but development of models that interface and are eventually coupled to physical state and biogeochemical/ecosystem models will also require many years of R&D to develop full operational capabilities.

At present there are no regional scale coastal ocean circulation, storm surge or surface gravity wave modeling activities that enjoy sustained support; the modeling efforts that are sustained are those that occur on a national or ocean basin scale. Existing elements of regional and basin-scale modeling systems that include the US Southeast coastal ocean are outlined below, focusing on components that provide near real-time hindcasts and forecasts of the coastal ocean includes:

HYCOM (*http://www7320.nrlssc.navy.mil/GLBhycom1-12/ATLANTIC.html*)*:* Output from the "toward-operational" HYCOM/GODAE North Atlantic model is available to downscale into regional model domains. The HYCOM products can provide estimates of the regional hydrography, as well as offshore surface elevations due to the proximity of the western boundary current to the continental shelf, on a frequency of once per week.

Though impressive depictions of the basin-scale ocean are possible, the existing implementations are limited to water depths greater than 15 m (and hence do not accurately represent nearshore or inland waters), and do not include tidal forcing. However, these types of basin-scale models are vital because they can provide boundary conditions for coastal models (Figure 6).

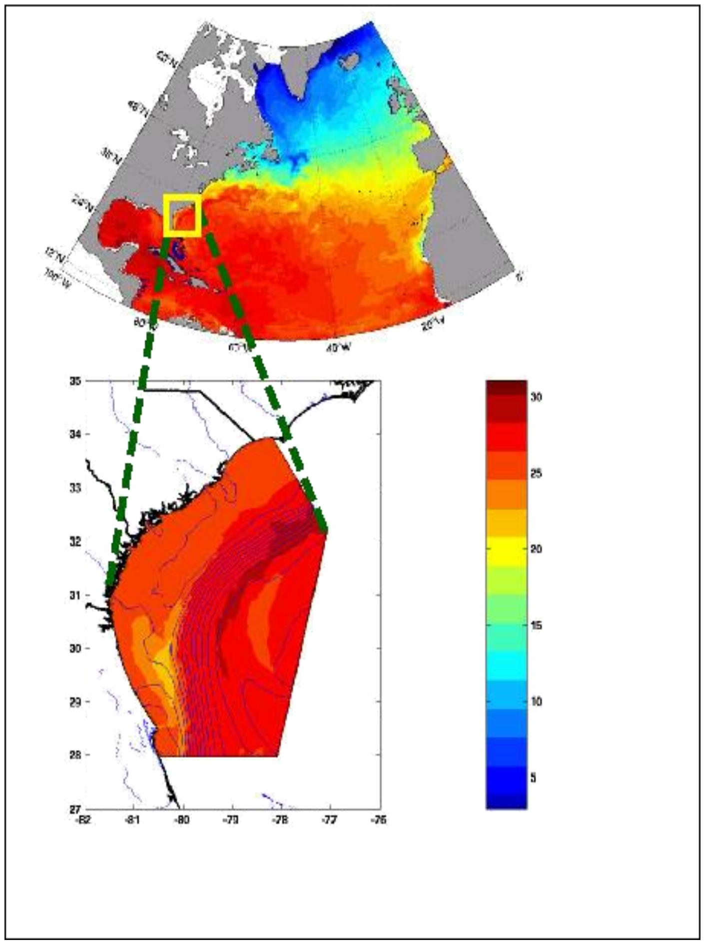

Figure 6. HYCOM model fields can be used as initial and boundary conditions for sub-regional model runs (the SAB in this case). Color scale is surface seawater temperature (˚C).

NLOM & NCOM (*http://www7320.nrlssc.navy.mil/global_nlom/*): An effort by the Naval Research Lab (NRL) Layered Ocean Models (NLOM) generates real-time nowcast/forecast results. Model products relevant to regional applications include sea surface height (SSH), sea surface temperature (SST) and surface currents. The 1/8° global Navy Coastal Ocean Model (NCOM) is an operational product run daily by the Naval Oceanographic Office (NAVOCEANO) with atmospheric forcing from the Navy Operational Global Atmospheric Prediction System (NOGAPS) and assimilation of SST and satellite altimeter data obtained via the NAVOCEANO Altimeter Data Fusion Center. As for the HYCOM model, the NLOM/NCOM forecast fields can be considered in the initialization and forcing of regional model solutions.

RTOFS (*http://polar.ncep.noaa.gov/ofs/*): The Real-Time Ocean Forecast System is based on HYCOM and simulates temperature, salinity, surface elevation, and currents for the North Atlantic. The model is driven at the ocean surface boundary by heat, moisture, and momentum fluxes provided by NCEP's Eta mesoscale atmospheric forecast model.

Next steps in establishing a regional circulation modeling system

Given the present state of development of regional-scale modeling systems for the SE coastal ocean, it is proposed that the initial focus be on creating, testing and operationalizing model systems to predict the physical state of the coastal ocean. The initial three ocean components to be emphasized are circulation modeling, storm surge modeling, and surface gravity wave modeling. There is also a need for regional-scale atmospheric modeling to better incorporate coastal ocean-atmosphere interactions. In all cases, adequate resolution to address specific applications is to be achieved through nesting regional or subregional scale models within national modeling systems. How best to achieve adequate resolution will need to be determined through thorough testing, but at a minimum there should be some redundancy in effort. It is suggested that several modeling groups in each of the modeling component areas be supported initially.

Based on the experiences gained through SEACOOS of operating three subregional-scale circulation models to nowcast coastal ocean conditions, a series of design principles are suggested.

- The importance of simulation experiments (e.g. OSSEs) to aid with the evolving design of the RCOOS should be recognized.
- The diversity of the model/prediction subsystem should be embraced. No one model is sufficient for the range of desired applications and this diversity provides the potential for ensemble forecasting.
- A hierarchical, distributed approach to operational modeling/prediction sub-systems should be followed. For example, Global-NCOM and Atlantic-HYCOM models can be sub-sampled for regional-scale circulation estimation products. Similarly, even higher-resolution local-scale models can use output from sub-regional models for open boundary conditions.
- The RCOOS design should foster the further evolution of modeling/prediction sub-systems. This would include: accommodation of the nesting of very high-resolution inner shelf and estuarine/lagoonal models; the coupling of dynamical models (coastal mesoscale meteorological, coastal hydrological, and coastal wave models); the coupling of (one-way, embedded) applications models (e.g., ecosystem, sediment transport, and wave models); and the utilization of advanced numerical modeling methods (e.g., data assimilation schemes, non-hydrostatic models, and unstructured and adaptive grids).
- The RCOOS modeling program must encompass comprehensive baroclinic operational circulation models (essential for advective and turbulent transport estimates, water quality and ecosystem models) and integrated barotropic operational tide, storm surge, and wave models (essential for coastal inundation estimates, sediment transport models).
- Output from sub-regional model/prediction sub-systems (together with in situ and satellite remote sensing observations) should be directed to sub-regional marine forecast centers. These should be operated in a partnership fashion with the NWS Weather Forecast Offices, value-added industry, media, and academia.

The models needed to predict the physical state of the coastal ocean have information requirements beyond the observations already identified. Access to accurate measures of freshwater fluxes (from rivers, precipitation and groundwater) is needed for the circulation models to accurately represent the mass field. For storm surge modeling, high-resolution bottom and coastal topography is required, registered to appropriate datums and with sufficient spatial resolution to support local emergency management needs. High-resolution bottom topography in the surf zone and nearshore is needed for surface gravity wave models to accurately represent modifications of the wave field near the coastline. Where existing information is lacking (e.g., poor quality bottom topography) the RCOOS can advocate for improvements.

Establishing an Ecosystem Modeling Approach

Ecosystem models are envisioned to describe the variability of nutrient and lower trophic levels (phytoplankton and zooplankton) and their links to target fish species in the SECOORA region. These activities will support the regional move to Ecosystem Based Fisheries Management as directed by the President's Ocean Action Plan and embraced by the South Atlantic Fishery Management Council's (SAFMC) Fishery Ecosystem Plan. One target fish species could be Gag (*Mycteroperca microlepis*) and is a member of the grouper family in the snapper/grouper complex managed by the SAFMC. (See below for a list of other target species to be considered.) Gag has high commercial and recreational fishery value; and its distribution ranges throughout the SECOORA region ranging from the continental shelf and shelf-edge, into the nearshore and estuarine regions. As such it requires integration across all SECOORA assets, to obtain sufficient information to aid the SAFMC in its assessments.

Considering gag as an example, a modeling approach would require that both abiotic and biotic effects be considered. The role of circulation on gag recruitment would be evaluated, including the effect of on- and offshore positions of the deep ocean currents (e.g., the Gulf Stream) on the transport of larvae from their spawning locations to the mid-shelf, where a combination of wind- and tidal currents modulated by larval behaviors, subsequently carries them to their juvenile estuarine habitats. Additionally the development and implementation of a suite of ecosystem models ranging from point- to 3D formulations, including uncoupled or dynamic linkages between lower and higher trophic levels.

Anticipated specific tasks include:

<u>Obtain hydrodynamic fields.</u> The fields need to be computed at ecologically relevant space and time scales to characterize the flow field in the SECOORA region relevant to the transport (dispersal and retention) of gag larvae from offshore spawning locations to estuarine nursery areas. The 3D circulation fields will be spatially and temporally comprehensive fields, including offshore forcing, meanders, gyres and upwelling events. Downscaling to "ecological hotspots", e.g., individual reefs or inlets will proceed with local higher resolution models forced by boundary conditions derived from the domain-wide circulation.

<u>Formulation of spawning model and model seeding.</u> Gag spawning aggregation sites have been identified throughout most of SECOORA's offshore/shelf edge regions at shelf break sites

between the 50-100 m isobaths. Spawning will be specified to occur over time based on hatch date distributions, and model runs will determine the temporal and spatial trajectories of particles onto the shelf and near-inlet regions.

Adapt Lower Trophic Level models (LTLs) to the SECOORA region. Presently there are no LTLs for the southeast Atlantic ecosystem. They need to be developed to represent the main phytoplanktonic and zooplanktonic groups in SECOORA, beginning with point models and building complexity to include the full 3D structure embedded in existing realistic circulation models. Computation of monthly-to-seasonal-to-yearly descriptions of the SECOORA region would serve as a baseline against which longer (interannual) variability can be assessed.

Develop a conceptual model of the food web. Characterize primary production in region for incorporation into Ecosystem models (e.g., Ecopath and Ecosim).

Combine circulation and LTL nowcast-forecast system. Combined with the circulation fields, the ecosystem model will provide short-term forecasts of oceanographic fields. This information will refine Essential Fish Habitat designations intended to reduce or eliminate the impact of fishing and non-fishing activities on habitats essential to managed species and their prey as federally mandated.

Recruitment forecasts. Development of nowcasting capabilities of the oceanographic and ecosystem models and provide relevant information for use in the South-East Data, Assessment, and Review (SEDAR) recruitment forecast process. Our model results will be used in the SEDAR process in its gag stock assessment for the region.

Other potential target species for the US Southeast Atlantic Coastal Ocean.

1. ***Reef fishes in general, Gag and Red Grouper in particular:*** Gag Grouper (and other reef fishes) spend their adult lives offshore and their juvenile phases in nearshore and inshore seagrass beds or oyster reefs. Evidence exists on adult spawning regions (shelf break) and times (late winter to spring) as well as on the juvenile settlement times (late spring to summer). However, the 3D pathways and mechanisms by which the larvae transit to settlement, both of these being significant factors in larval survival and recruitment, remain to be determined.
2. ***Shallow and Deep coral reefs:*** habitat characterization and restoration of shallow coral reefs, as well as deep *Oculina* and *Lophelia* coral reefs require understanding the physical and biological processes determining the environment at the shelf-edge, over the shelf, and near the coast, including the importance of self-seeding, sensitivity to changes in feeding and hydrographic fields, connectivity with other parts of a larger ecosystem, regional water quality, etc.
3. ***Interactions and linkages between various populations; scallops in particular:*** Bivalves such as scallops and other commercial species are not distributed uniformly along the coast. Are there relationships between species distributions and the seasonally varying currents and other physical factors such as temperature and salinity? Are there significant inter-annual variations that impact these population linkages and resultant abundances?
4. ***Forage species and their role in supporting pelagic species biomass:*** Pelagic fishes depend on the abundances and distributions of smaller forage species. What environmental factors control the abundances and distributions of the forage species and thus the migrations/distributions of the

pelagic species?

5. ***Species life history for those fish that spend part of their life in the estuaries and part offshore, i.e., estuarine-dependent species such as mullet, menhaden, spot, flounder, croaker, gag, gray snapper, Spanish mackerel, etc.:*** Specific pathways (to be determined) exist between the major estuaries and the coastal ocean that depend on buoyancy (salinity in particular), winds and tides. Mullet, menhaden and others may be target species; however, this topic pertains to many commercially and recreationally important species. Modeling and observational tools presently exist to make this a tractable problem for scientific investigation.
1. ***The benthic connection, e.g., shrimp:*** Three-dimensional studies must include the benthos since the bottom boundary layer likely provides an important connection in the general pathways/mechanisms framework. Hence primary and secondary productivity within the bottom boundary layer is likely important for the higher trophic levels considered above. Shrimp, as a commercially important species provides a focus.

9.4 Ecosystem Modeling

9.4.1 South Atlantic Ecopath Model

An Ecopath model is a quantitative description of energy flows in a food web. The model creates a static, mass-balanced snapshot of the resources in an ecosystem and their interactions, represented by trophically linked functional groupings. These groupings consist of a single or multiple species representing ecological guilds. The model is constructed by defining a model area and time, organizing species (and detritus) into the above mentioned functional groupings, and estimating the biological (i.e., energy) characteristics of each grouping. Ecopath models and their defined components are then 'balanced' in terms of mass or energy to gain insights into an ecosystem and its biotic components, and to obtain a whole-system view of the biological community. The Ecopath mass-balance approach was initially developed by Polovina (1984). Since that initial application, over 100 Ecopath models have been constructed, mostly in marine ecosystems, and the approach has been refined considerably.

Ecopath models can be analyzed in their static form (Christensen and Pauly 1992), but the dynamic simulation routines Ecosim and Ecospace (Walters et al. 1997, Walters et al. 1999) have expanded the utility of the approach considerably. These dynamic routines use the information in an Ecopath model to simulate how a the ecosystem's biota would respond to changes in fisheries harvest strategies or disturbance regimes (Ecosim). Such analyses can also be conducted in a habitat-based context (Ecospace). Ecosim also enables exploration of social, economic, and ecological trade-offs in harvest strategies.

These complimentary approaches, Ecopath and Ecosim, provide a rigorous and relatively simple framework to provide testable insights into the causes of ecosystem changes. Most importantly, they can be used to implement ecosystem-based management by aiding in the design of policies that account for indirect impacts of human activities. The relative importance of factors that shape communities can be explored by comparing (temporal and spatial) simulations to empirical information about such changes. Simulation results are often consistent with ecological theory (Christensen 1995, Vasconcellos et al. 1997), but they can be even more useful when simulation results are counterintuitive. Either way, Ecopath with Ecosim analyses can provide useful insights into marine ecosystem organization and functioning.

Physical forces are not explicitly included in Ecopath models, though they can be included in the Ecosim routine to distinguish their role from that of trophic forces. Approaches such as physical forcing, trophic mediation, and time-series fitting are available to compare and combine simulated biological and physical forces.
These approaches are discussed by Christensen et al. (2000).

Ecopath models are never final because ecosystem knowledge is never complete. The usefulness of such models can improve considerably, however, through iterative combinations of simulation and empirical research in a whole ecosystem context (Pauly et al. 2000).

The Ecopath master equation
The parameters necessary for the construction of an Ecopath model are found in the Ecopath master equation (Equation 1.1):

$$Bi \cdot (P/B)i \cdot EEi = Yi + \sum Bj \cdot (Q/B)j \cdot DCji + BAi + NMi \qquad \text{Equation 1.1}$$

where,
Bi and Bj = biomasses of prey (i) and predators (j) respectively;
P/Bi = production / biomass; equivalent to total mortality (Z) in most circumstances (Allen 1971);
EEi = ecotrophic efficiency; the fraction of the total production of a group that is utilized in the system;
Yi = fisheries catch per unit area and time (i.e., Y = F*B);
Q/Bj = food consumption per unit biomass of j; and
DCji = contribution of i to the diet of j;
BAi = biomass accumulation of i (positive or negative);
NMi = net migration of i (emigration less immigration).

This equation expresses a balance between a group's net production (terms to the left of the equal sign) with all sources of its mortality (terms to the right). It states that the net production of a functional group equals the sum of (1) the total mass (or energy) removed by predators and fisheries, (2) the group's total natural senescence (i.e., flow to detritus), (3) the net biomass accumulation of the group, and (4) the net migration of the group's biomass.

The thermodynamic constraints implied by Equation 1.1 underscore the power of Ecopath models as a focal point for refinement of ecosystem information. The need to reconcile energy production and demand among components of the food web narrows the possible ranges of parameter estimates for particular groups.

The law of conservation of mass or energy is expressed in this master equation, but the biomass accumulation and migration terms distinguishes this 'energy continuity' approach from a strictly 'steady state' approach. This basic 'continuity' constraint enables representation of changes in populations (i.e., functional groups) when expressed in dynamic form (not discussed here).

Because the Ecopath model of the entire system is a set of these linear (master) equations solved simultaneously, the Ecopath routine can solve for any of the four basic input parameters; B, P/B, Q/B, and EE (Christensen and Pauly 1992). These along with diet compositions, are the main parameters derived. Other information such as spatial and temporal distributions, habitat preferences, assimilation efficiencies, detritus fate, and other pertinent information are also covered in these parameter estimation sections.

Development of the South Atlantic Bight Ecopath Model
A preliminary South Atlantic Bight Ecopath model (Okey and Pugliese, 2001) was developed as part of the Sea Around Us project funded through the PEW Charitable Trust Foundation.

This preliminary Ecopath model covered the area from Cape Hatteras in North Carolina to the easternmost extent of the Florida Keys, and from the intertidal and the entrance of estuarine systems to the 500 m isobath. The time period characterized by this preliminary model is four years during in the late 1990s (1995-1998). The area covered was estimated to be 174,300 km^2. The slope of the sea floor steepens seaward of the 200 m isobath (and sometimes shallower); for example, the area delineated by the 200 m isobath is estimated to be 133,300 km^2, which is only 24% less than the area delineated by the 500 m isobath.

Four main sources were used to assemble the list of over 600 species for the area covered by the initial model: summary data from the Southeast Area Monitoring and Assessment Program (SEAMAP) including a species list reviewed by SEAMAP personnel (P. Webster), the National Marine Fisheries Service (NMFS) commercial and recreational fish landings for North Carolina, South Carolina, Georgia, and the east coast of
Florida (www.st.nmfs.gov/st1/); a species list developed for the West Florida Shelf system (Mackinson et al. 2000); the NMFS marine mammal stock assessments; and two sea turtle the web sites; www.nmfs.noaa.gov/prot_res/PR3/Turtles/turtles.html and www.cccturtle.org/species.htm.

A semi-systematic approach was taken to aggregate all species into 42 functional groups. This was accomplished by organizing the list of species into groupings that were based on the functional roles of the species. Usually, this was operationally defined by diet compositions, but also by natural history characteristics. Special groups in the model included groups managed under a federal fishery management plan and fish groups for which commercial or recreational landings exceeded 200 tonnes in any of the states within each area. Specialists were consulted to identify groups of special concern (e.g., baleen whales).

This preliminary Ecopath model of the South Atlantic continental shelf was constructed to provide a quantitative framework for the refinement of the model's input parameters so that a cohesive view of the whole marine ecosystem could emerge, and so that system-wide questions about the workings of the system could be explored. This model constituted a focal point for scrutiny and criticism of input parameters, and thus acted the foundation for further refinement and expansion. The refined model, will be expanded to cover the area that coincides with the South Atlantic Council's jurisdiction, i.e. from the NC/VA border through the Florida Keys, and from the upper reaches of wetlands to the 300 m isobath.

Procedure for model construction

Thomas A. Okey
CSRIO

Procedures for deriving model input parameters and constructing Ecopath models include literature reviews, empirical studies, or coordinated approaches by broad collaborations of experts (e.g., Okey and Pauly 1999). The South Atlantic Bight model was constructed by a core group of researchers based on contributions by expert collaborators. These regional and topical experts contributed written sections to this compendium describing basic parameter derivations for each functional group. Inputs to this model were based on the latest available information on the entire suite of biotic components of the South Atlantic Bight.

Eight steps can be taken to construct an Ecopath model:
1. Define the ecosystem in space and time – the spatial extent of the system and the represented time period must be clearly defined. Parameter estimates are expressed in annual units, but any time period can be represented.

2. Define functional groups – Myriad species comprise interaction webs, but these species must be aggregated into related groupings that make sense in terms of ecological function, and the types of questions of interest.

3. Estimate basic parameters for each functional group. These parameters are listed and documenting these derivations makes up the bulk of this chapter.

4. Estimate fisheries information – Landings, discards, discard fates, and economic information can be entered for each fisheries gear type.

5. Estimate additional Ecopath parameters – detritus fates, assimilation rates, multiyear trends, spatial and temporal distributions, and habitat associations.

6. Enter parameters into the windows-based input interfaces (see www.Ecopath.org).

7. Characterize model pedigree by ranking parameter quality (i.e., confidence).

8. Balance the model according to thermodynamic constraints.

The biological components of the ecosystem are generally represented in Ecopath using average values, or other meaningful measures of central tendency that take into account both annual (seasonal) changes and ontogenetic changes. Production rates, consumption rates, and diet compositions vary among seasons and life history stages for most species in aquatic systems. However, explicit inclusion of seasonal information into Ecopath with Ecosim modeling merely makes answers messy rather than changing the basic results of analyses (based on experience with a large number of Ecopath models; C. Walters, UBC Fisheries Centre, personal communication.).

Ontogenetic changes can be incorporated using Ecopath with Ecosim using two approaches. First, groups can be split into adult and juvenile 'pools' that are linked through and age structured growth and recruitment parameters; Second, numerous ontogenetic 'stanzas' can be specified for an integrated calculation of a given Ecopath parameter. This latter approach in particular enables real-time incorporation of variable growth, production, or consumption models into the representation of Ecopath parameters (C. Walters, UBC Fisheries Centre, personal communication).

Still, the assumption of 'average' representation of parameters is a useful convenience for modeling at the scale of entire systems because these values describe the basic interaction and energy structure of a food web. 'Energy continuity' offers a powerful mass-balance-type constraint to model parameterization and construction. Section X describes the balancing methodology employed for the South Atlantic Bight model.

Additional parameters
Steven Mackinson
CEFAS Fisheries Lab, Lowestoft, UK

(i) Unassimilated / Consumption
Only a fraction of the food eaten by organisms is assimilated to the body; non-assimilated food is expelled. Proportions of unassimilated food must be specified in Ecopath, and this fraction flows to specified detritus pools. A default value of 0.2 was used for carnivorous fish groups (Winberg 1960) since assimilation efficiency information for particular fish species was scarce. This means that 80% of the food was considered assimilated. Values of 0.4 and 0.3 were applied to herbivores and planktivores since these groups preying on harder-to-digest food.

(ii) Detritus Fate
The fate of detritus is the defined pool of detritus that unassimilated food and dead organisms are specified to flow in to. A portion of the dead and decaying animals falling through the water column (including fishery discards) is directed to 'dead carcasses.'
The specific proportions are assumed based on a subjective judgment relating to the habitat and niche of the various organisms (Appendix 2). The majority of detritus from non-assimilated food is directed to water column detritus and sediment detritus, but these ratios vary depending on the types of organisms. Approximately 50% of the detritus from birds is considered to be exported from the system (i.e., corpses and feces end up on land). All dead and decaying macroalgae and seagrasses contribute to the drift macrophytes detritus pool. Ultimately, detritus from the 4 detritus groups flow to the sediment detritus pool which is then exported from the system as sediment detritus is buried and rendered unavailable to the system.

"Balancing" the model
Steven Mackinson
CEFAS Fisheries Lab, Lowestoft, UK
Thomas A. Okey
University of British Columbia, Fisheries Centre

Ecopath models must be 'balanced' in the sense of achieving continuity among energy fluxes in the defined ecosystem, not in the sense of 'static equilibrium.' Continuity of energy fluxes must likewise be achieved for each particular group within the overall system.

Because an attempt is made to account for all fluxes, Ecopath models do not inherently assume 'steady state.' If the total combined demand of energy on a particular group exceeds the production of that group (plus the energy needed for respiration), the group is commonly said to be out of 'balance,' in the sense of energy discontinuity. Ecopath models constructed with good information for most or all components in a system tend to require minimal 'balancing.' This is because energy continuity is a true property of real world ecosystems.

The degree of discontinuity, or "imbalance," in each functional group is revealed by the calculated 'ecotrophic efficiency' values. Ecotrophic efficiency (EE) is the proportion of the net production of a group that is consumed by predators or fisheries (or directly exported). These EE terms are calculated after initial input parameters have been derived and entered. An ecotrophic efficiency value of greater than one is impossible, as it indicates that total energy demand on a functional group exceeds total production and maintenance of that group. EE values greater than one are thus used as diagnostic indicators of model discontinuity or "imbalance." This is the handle for balancing, and changes in these values are monitored while adjusting model inputs.

Model balancing strategies

Strategic approaches are implemented when balancing Ecopath models to optimize the representation of the system, and to avoid erosion of contributed information. For example, adjustments to input parameters are best made after prioritization according to 'degree of imbalance,' 'quality of estimates,' or other criteria applicable to the system at hand. The quality of estimates can be characterized by specified confidence bounds for each parameter or by ranking the data 'pedigree' of parameters.

Some experienced Ecopath modelers suggest that model balancing should focus on diet composition adjustments because diet composition data tends to be very high relative to other parameters (V. Christensen, UBC Fisheries Centre, personal communication). However, this relative uncertainty among parameters should be assessed on a case-specific basis. Indeed, for some functional groups, the uncertainty of input parameter estimates such as biomass might rival or surpass uncertainties associated with diet compositions. Finally, model users can introduce bias into the model through a one sided approach to balancing. For example, a model can be erroneously inflated by increasing prey biomasses, or production rates, or both, rather than taking a balanced approach by including the reduction of predator consumption rates, or by re-allocating diet compositions.

Commonly, 'top-down' balancing strategies have been applied to balancing Ecopath models, in that the production and/or biomass estimates of lower trophic levels (where uncertainty can be more common) is increased to meet the demands of upper trophic levels. The result of such a method is that the biomass or production rates at the lower trophic levels can be inflated unrealistically to achieve a balanced model (T. Dean in Okey and Pauly 1999). Clearly, such a result is unrealistic and this potential interjection of bias points to the need to make a conscious effort to apply a more evenhanded approach during balancing. Not only should the accounts tally, but more importantly they should stay within the specified bounds of confidence and make intuitive sense in terms of ecological interactions. The fundamental importance of the balancing procedure as a crucial bridge to the ecology of a system must be emphasized to users who might otherwise view the balancing step as merely a necessary technical modeling procedure.

Parameter pedigree assessment

Parameter 'pedigree' index values can be assigned to each input parameter of an Ecopath model. Ecopath's parameter pedigree routine is an approach to convert qualitative rankings of parameter quality to quantitative confidence intervals. The output of this routine can be used during manual balancing, automated balancing and analysis routines, such as the Monte Carlo routine 'Ecoranger,' or in meta-analyses that compare various models in terms of relationships between model attributes and overall data pedigree. Assigning pedigree values to functional groups whose parameters are derived from combined estimates from many data sources of varying quality is a subjective task, but nevertheless instructive. In a more general sense, it is informative to future users of the model to be as explicit as possible about the level of confidence in input parameters. The parameter pedigree routine thus enhances model transparency beyond a description of parameter derivation. The pedigree index value represents the quality or relative confidence assigned to each parameter estimate.

9.5 Indicators of Ecosystem Health and Habitat Conservation Targets

(Source: SARP Aquatic Habitat Plan, SARP, 2008)

The National Coastal Condition Report II (NCCR II) (USEPA 2004) utilized data from the EPA's National Coastal Assessment (NCA), which gathers data on biota and environmental stressors; NOAA's National Standards and Trends Program, which utilizes site-specific data on toxic contaminants and their ecological effects; and the Fish and Wildlife Service's National Wetlands inventory (NWI), which provides information on the status of the nation's wetlands. In the NCCR II, five primary indices were developed using these data sources for (1) water quality, (2) sediment quality, (3) benthic habitat quality, (4) coastal wetlands and (5) fish tissue contaminants. Although these indices do not address all characteristics of estuaries and coastal waters, they do provide

information on ecological conditions. Characterizing coastal condition was a two-step process. The first step was to assess conditions at individual sites for each indicator. In the second step a regional rating for each indicator using a scale of five (1= poor, 2-4 = fair, 5 = good) was determined, based on the percentage of the area of each region in a given condition. The mean of the indices for the five indicators was then calculated to yield an overall condition index for each region. Using these indices, the NCCR II found that the overall condition for the Southeast Coast estuaries North Carolina, South Carolina, Georgia and east Florida coasts) was 3.8, and for the Gulf Coast estuaries,

2.4. Although the more recent National Estuary Program Coastal Condition Report (USEPA 2006) also assessed estuarine condition for these same regions using this process, only four of the five indicators were used.

9.5.1 National Fish Habitat Action Plan

The National Fish Habitat Action Plan is addressing a crisis for fish nationwide: loss and degradation of aquatic habitats. The plan was initiated in 2001 through the efforts of the Sport Fishing and Boating Partnership Council to explore development of a partnership effort for fish similar to that implemented for waterfowl in the 1980s through the North American Waterfowl Management Plan. The waterfowl plan has been cited as the mechanism that, over the past two decades, has given rise to the boost in waterfowl populations by forming strong local and regional partnerships to protect key habitats.

In 2004 the International Association of Fish and Wildlife Agencies, which represents all state wildlife agencies, voted to lead the National Fish Habitat Action Plan with the U.S. Fish and Wildlife Service and NOAA Fisheries as principal Federal partners.

The plan is bringing together fisheries professionals and partners with a shared interest in protecting, restoring and enhancing our waterways and fisheries. The strength of the National effort is the unique and diverse blend of industry, government, tribal, academic, and conservation groups and individuals with a determination to focus national attention and resources on restoring fish habitats.

The Action Plan will be implemented through the following four strategies which together will lead to results that can be measured against protection, restoration and enhancement goals: 1) Support existing fish habitat partnerships and foster new efforts; 2) Mobilize and focus national and local support for achieving fish habitat conservation goals; 3) Measure and communicate the status and needs of aquatic habitats; and 4) Provide national leadership and coordination to conserve fish habitats.

9.5.2 National Fish Habitat Board

The National Fish Habitat Board which held its inaugural meeting on September 22, 2006, is charged with leading the implementation of the National Fish Habitat Action Plan. The Board includes representatives of outdoor industries, federal, regional and state natural resource agencies, Native American tribes, and conservation and recreation organizations.

The Board has met five times since its formation in 2006 and is closely coordinating with a Federal Caucus of nearly 20 federal agencies that are in the process of realigning priorities and resources to better support the plan. The Association of Fish and Wildlife Agencies is identified as a lead participant ensuring state agencies are well represented. The Board is addressing the criteria and process for formal recognition of Fish Habitat Partnerships which are the basic work units of the Action Plan. As the National Fish Habitat Action Plan is modeled after the North American Waterfowl Management Plan, the establishment of Fish Habitat Partnerships is integral to its success in protecting, restoring and enhancing fish and aquatic habitats. Board recognition as a Fish Habitat Partnership will be contingent upon meeting criteria that identify strong and diverse partnerships, work within a defined geographic focus, remain strategic and consistent with national goals, and contain the potential for measurable progress. In addition, each Fish Habitat Partnership will be expected to implement the National Fish Habitat Action Plan under the guidance from the board. Guidance for Establishing Fish Habitat Partnerships

9.5.3 Southeast Aquatic Resources Partnership Habitat/Ecosystem Conservation Targets

The Southeast Aquatic Resources Partnership (SARP) was initiated in 2001 to address issues related to the management of aquatic resources in the southeastern U.S.
These issues include significant threats to the aquatic resources and habitats of the Southeast.

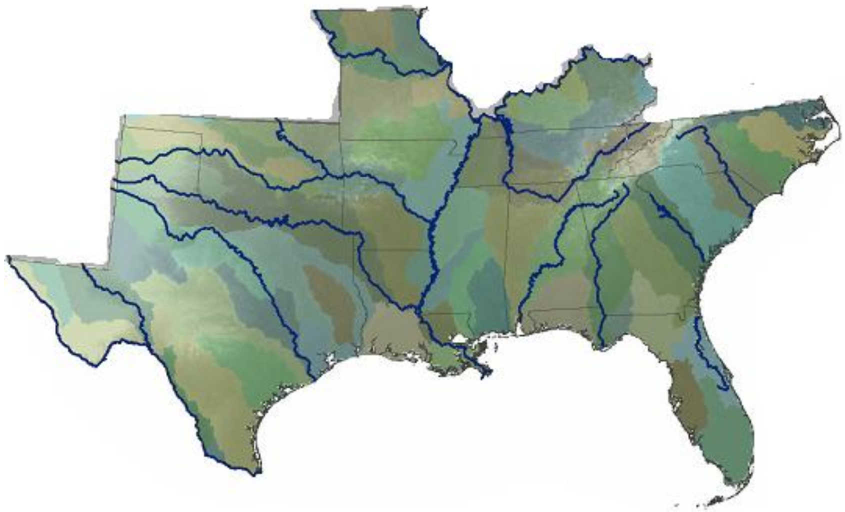

Figure 7. Watersheds and Marine Habitats Encompassed by the Southeast Aquatic Resources Partnership (SARP).

SARP is one of five Fish Habitat Partnerships named by the National Fish Habitat Action Plan and endorsed recently by the National Fish Habitat Board. As the regional partnership in the Southeast, SARP provides a method for state, regional and federal agencies, conservation groups, tribes, landowners, industry, and the public to interact in the development of regional aquatic habitat priorities and the implementation of projects to address those priorities. This partnership envisions a southeastern United States with healthy and diverse aquatic ecosystems that support sustainable public use. Relationships have developed between State and Federal agencies, private organizations, conservation groups, and other regional stakeholders that extend beyond the traditional boundaries of aquatic resource management agencies and establish a commitment to truly work together for the benefit of the resource. SARP is currently developing a regional aquatic habitat plan for the Southeast that will help guide the implementation of the National Fish Habitat Initiative efforts on a regional scale. Pilot watershed conservation action plans have already been developed for four major southeast river systems (Duck River, TN, Roanoke River, NC, Altamaha River, GA and Pascagoula River, MS) that detail specific actions to improve and protect aquatic habitats and biological integrity in these systems. SARP actively seeks funding and local partners to implement specific local actions that are prioritized on a regional and national scale.

The South Atlantic Fishery Management Council as a member of SARP, supports the implementation of aquatic habitat conservation and restoration projects including those proposed through the newly designated NOAA Community-based Restoration Program (CRP) run through SARP. The Council views this partnership as an effective mechanism to accomplish the National Fish Habitat Initiative's National Fish Habitat Action Plan goals on a regional scale in our coastal watersheds. The commitment of our federal and regional partners to work closely with the states is critical to achieving the National Fish Habitat Action Plan. The Council envisions the state habitat conservation recommendations included in the Fishery Ecosystem Plan for the South Atlantic region will serve as or expand on the South Atlantic portion of the SARPs Southeast Aquatic Habitat Plan (SAHP) to present recommendations on conservation, management and restoration of Essential Fish Habitat down to individual watersheds where possible.

Drawing on the technical expertise of regional ecosystem partners involved in the development of the Fishery Ecosystem Plan and on the recommendations presented in the FEP the SARP/NOAA partnership will find support in identifying, selecting and implementing coastal habitat restoration projects in the South Atlantic region.

SARP provides an excellent opportunity to strengthen federal-state partnership for implementation of projects that directly benefit living marine resources and to engage coastal communities throughout the Southeast. A fully realized SARP supported with enhanced funding through the National Fish Habitat Plan will achieve conservation of high priority fish habitat (including Essential Fish Habitat). This effort will be enhanced especially if South Atlantic State and regional conservation recommendations and projects are presented in both the Fishery Ecosystem Plan for the South Atlantic Region and SARP's Aquatic Habitat Plan.

9.5.4 Synergy of National and Regional Habitat Conservation and Ecosystem Based-Management

In addressing the habitat directives established by the Magnuson-Stevens Fishery Conservation and Management Act, the South Atlantic Fishery Management Council designated many priority aquatic fish habitats occurring primarily in State waters as Essential Fish Habitat or Essential Fish Habitat Areas of Particular Concern for federally managed species. The Council's Fishery Ecosystem Plan for the South Atlantic Region will bridge the gap between State and regional needs by highlighting priorities (to watershed where possible) for South Atlantic States developed with input from State Sub-Panels of the Council's Habitat and Environmental Protection Advisory Panel.
In addressing the directive of the National Habitat Plan, National Habitat Board, SARP has developed the Aquatic Habitat Plan to facilitate regional coordination on meeting high priority habitat conservation and restoration goals. Funded projects in South Atlantic watersheds from the headwaters of the rivers to the coastal ocean will support and facilitate conservation of Essential Fish Habitat and enhance biological, economic and social values provide by a healthy ecosystem structure and function in the region.

9.5.5 Southeast Aquatic Habitat Plan

SARP is developing a Southeast Aquatic Habitat Plan to identify regional priorities for aquatic habitat conservation and restoration, and facilitate action at the local level that addresses regional and national priorities. The development of the Southeast Aquatic Habitat Plan is currently underway with two of four pilot river basin conservation plans initially developed to serve as models for the development of a complete regional plan The Altamaha Watershed Report and

The Roanoke River Watershed Report are in the South Atlantic. Workshops were held by SARP in October 2006 and April 2007 to gain stakeholder input on the technical aspects of the Plan and develop the implementation and partnership aspects of the plan. The following public draft with stated conservation targets, was finalized in March 2008.

Southeast Aquatic Habitat Plan
Southeast Aquatic Resources Partnership - April 2008

This document was prepared by the Habitat Subcommittee of the partnership known as the Southeast Aquatic Resources Partnership (SARP). It was funded by the Multistate Conservation Grant Program (Grant GA M-1-P), a program supported with funds from the Wildlife and Sport Fish Restoration Program and jointly managed by the association of Fish and Wildlife Agencies and the U.S. Fish and Wildlife Service, 2007.

SARP was formed in 2001 to address the here-to-fore uncoordinated management of aquatic resource issues in the southeastern United States. It is a voluntary collaboration of natural resource managers and professionals, both inland and coastal, working together to protect, conserve and restore aquatic resources throughout the Southeast. The core members of the partnership include the natural resource agencies in Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, Missouri, North Carolina, Oklahoma, South Carolina, Tennessee, Texas and Virginia, the U.S. Fish and Wildlife Service, National Oceanic and Atmospheric Administration National Marine Fisheries Service, the Gulf States Marine Fisheries Commission, the Atlantic States Fisheries Commission, and the Gulf and South Atlantic Fishery Management Councils. Nongovernmental organizations, industries and private citizens with goals and objectives that parallel those of the SARP member agencies participate in the partnership as well.

The plan was developed as a joint effort of all the member agencies and partners of SARP plus many other stakeholders throughout the region. It is broad and regional in nature, given the geographic and biological range of SARP's 14 member states.

SARP is recognized as an official partnership of the National Fish Habitat Initiative to implement its Action Plan (NFHAP) to conserve inland and coastal fishery habitats throughout the nation. This plan will be support NFHI restoration projects in the Southeast.

For additional information about SARP, see http://www.sarpaquatic.org, and on NFHI, see http://www.fishhabitat.org.

Because this is a regional plan, the targets to quantitatively and qualitatively evaluate progress towards achievement of objectives are based upon the best available data at the regional level from scientifically respected sources. The majority of the data came from reports by the U.S. Environmental Protection Agency and the H. John Heinz III Center for Science, Economics and the Environment.

Executive Summary

Habitats are the cornerstones of wildlife resources and provide the necessary food, water, shelter and space for plants, animals, and other organisms to thrive. The southeastern United States harbors a diversity of aquatic habitats and species unparalleled in the nation, and the states of the Southeast Aquatic Resources Partnership (SARP) – Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Missouri, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, and Virginia – have recognized the importance of protecting habitats found in this region.

The quality and quantity of these spectacular and valuable aquatic resources have been in decline since European colonization. Deteriorating and disappearing habitats have led to reductions in biodiversity, as well as critical declines in some plant and animal populations. The problems and issues leading to these circumstances have many sources, natural and human-induced. Ongoing research is identifying new sources, like climate change, every day.

Government agencies, private organizations, businesses, and citizens recognize the value of aquatic resources and work every day to conserve aquatic habitats independently on state and local scales. By addressing aquatic habitat conservation at the regional and national scales, SARP will increase the effectiveness of individual efforts and bring greater funding and public support to aquatic habitat conservation.

During 2005, the SARP Aquatic Habitat Conservation Work Group sponsored research projects in four representative, geographically separate southeastern watersheds. Assessments of these ecosystems yielded much information about various aquatic habitats, and identified similarities and differences in the problems and issues plaguing them. The results of these studies on the Duck, Altamaha, Pascagoula and Roanoke watersheds led to development of this Southeast Aquatic Habitat Plan (the Plan). State Wildlife Action Plans (also known as Comprehensive Wildlife Action Strategies) provided a great deal of background and reference information for it, and the simultaneous development of the National Fish Action Plan (NFHAP) provided an opportunity to coordinate regional conservation and restoration efforts nationally. SARP is recognized as an official partnership to implement the National Fish Habitat Action Plan (NFHAP).

This science-based, landscape-style system for habitat conservation seeks to effectively apply limited resources to priority areas on a regional basis in order to reverse current trends and protect the Southeast's aquatic resources well into the future. The purpose of the Plan is to maintain, restore, and conserve the quantity and quality of freshwater, estuarine, and marine habitats to support healthy, sustainable fish and aquatic communities and sustain public use for the benefit of all in the southeastern region and the entire U.S. In order to achieve this goal, multiple projects at many different levels will focus on eight objectives:

Objective 1: *Establish, improve and maintain riparian zones*
Objective 2: *Improve or maintain water quality*
Objective 3: *Improve or maintain watershed connectivity*
Objective 4: *Improve or maintain appropriate hydrologic conditions for the support of biota in aquatic Systems*

Objective 5: *Establish, improve or maintain appropriate sediment flows*
Objective 6. *Maintain and restore physical habitat in freshwater systems*
Objective 7: *Restore or improve the ecological balance in habitats negatively affected by nonindigenous invasive or problem species*
Objective 8: *Conserve, restore, and create coastal estuarine and marine habitats*

The Plan is a living document, focused on adaptive management. It will be revised utilizing lessons and data from every project. For this initial version of the Plan, objectives are based on the major aquatic habitat types and attributes in the Southeast, focusing on broad indicators of habitat integrity, function and overall ecosystem health. Objectives and regional targets have been developed using the best available scientific data. These are described in detail in Section 2 of the Plan. Additional data and tools, currently under development, will assist SARP's adaptive management process of updating and maximizing the outcomes of this Plan.

Because of the size and variety of habitats in the southeastern region, habitat conservation needs are varied and spread out. In order to effectively use limited resources to reverse current trends and conserve the region's aquatic habitats, geographic priorities must be set periodically. Several tools will play a role in the prioritization process. In the long term, the implementation of the National Fish Habitat Science and Data Committee's assessment tool will allow a science-based approach for prioritizing aquatic habitat conservation and restoration projects nationwide. This assessment tool will help SARP refine its geographic priorities. SARP is developing a geo-referenced database with aquatic system condition data to help identify geographic priorities at a regional scale for the Plan. Details about this adaptive prioritization process are included in Section 3.

Conservation and restoration of specific aquatic habitats will be accomplished through many projects, utilizing implementation strategies to address location, threats, problems and issues. SARP members will be engaged in many of these projects, directly addressing the Objectives and Targets in Section 2, in partnership with other entities. However, effective implementation of the Plan depends upon SARP's collective management and facilitation at an integrated systems level. While on-the-ground projects will focus on the goal and one or more of the eight objectives, SARP must integrate and coordinate these projects to maximize outcomes and leverage dollars. To that end, stakeholders provided four strategies for SARP to integrate habitat conservation projects throughout the region. These four strategies are:

Integrated Conservation Strategy 1: *Information collection and dispersal*
Integrated Conservation Strategy 2: *Capacity building*
Integrated Conservation Strategy 3: *Management and restoration*
Integrated Conservation Strategy 4: *Law and policy.*

Details about each of these strategies are found in Section 4.

Monitoring will contribute to an understanding of the complex ecological systems within which the Plan's conservation and restoration projects are implemented. Analysis of these data will help SARP identify areas of habitat improvement and establish a record of conditions and trends. These data can also warn SARP of environmental decline, and identify gaps in existing scientific knowledge. Monitoring will provide the basis for a rigorous review of habitat project planning and implementation to determine whether project results are being achieved and if mid-course corrections are needed. Monitoring and evaluation will be conducted on two levels in order to assess the Plan's performance and each project's performance towards improving or sustaining the Southeast's aquatic habitats. Monitoring to provide data for both levels will be built into all projects at the planning stage. GIS-based data will play a large role in monitoring and evaluation and will be used along with other monitoring processes. Details about monitoring and evaluation are found in Section 5.

When SARP was established in 2001, members identified six areas upon which the partnership would focus: public use, fishery mitigation, imperiled fish and aquatic species recovery, interjurisdictional fisheries, aquatic habitat conservation, and aquatic nuisance species. Over time, members realized that many of the issues and problems in all six areas could be addressed through a regional habitat conservation plan. This Plan is a blueprint for that effort.

5 Southeast Aquatic Habitat Plan 2008

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Why the concern about the habitats in Southeast Region of the U.S. ?

The southeastern United States harbors a diversity of aquatic habitats and species unparalleled in the nation. Over 1,800 species of fishes, freshwater mussels, freshwater snails, turtles and crayfish can be found in southeastern watersheds. More than 500 of these are endemic to these states or in individual watersheds within them. More than 70 major river basins in the region link with the south Atlantic-Gulf of Mexico coastline to nourish and support rivers, streams, lakes, bays, estuaries, reservoirs, and the bulk of the country's wetlands. The drainage basin for the Gulf of Mexico, which includes the area drained by the Mississippi River, is almost 60% of the land in the Continental U.S. (Beck et al. 2000). In addition, approximately 16% of the nation's coastal wetlands are located in the South Atlantic region, which includes Florida (White et al. 2002), and almost half of the nation's coastal wetlands are in Louisiana.

The freshwater and marine systems in the region provide tremendous economic and aesthetic benefits through angling opportunities, recreational and commercial activities, water supply and natural assimilation of wastes. For example, in 2001, over 48% of the anglers in the U.S. fished in the Southeast, accounting for over 42% of the nation's total fishing days. These sportsmen spent over $13 billion, accounting for almost 37% of the total recreational fishing expenditures nationwide (USFWS/USCB, National Survey of Fishing, Hunting and Wildlife Associated Recreation 2001). Public lands like the region's 171 National Wildlife Refuges, over 700 state parks, multiple wildlife management areas and scenic waterways provide opportunities for nonconsumptive nature tourism (hiking, camping and birding) that also contribute to local economies. In 2005, despite the impacts of hurricanes on commercial fishing capacity, over 1.75 billion pounds of finfish and shellfish were harvested in the SARP member states, with a direct economic value of almost $900 million, representing some 23% of the economic value of all commercial fisheries in the United States (NMFS, Fisheries of the United States 2005).

Regrettably, the quality and quantity of these spectacular and valuable aquatic resources have been in decline since European colonization. Nearly 100 species have become extinct across the region in the last century. Further, in its 1998 report entitled *Rivers of Life: Critical Watersheds for Protecting Freshwater Biodiversity*, The Nature Conservancy, looking at more than 2000 small watersheds across the continental U.S., identified 87 subwatersheds in the U.S. with 10 or more "at risk" species of freshwater fish and mussels. Seventy-five of these 87 "hot spots" are contained in the 14 SARP states, and 18 of the top 19 are in four basins within their boundaries – the Tennessee, Ohio, Cumberland, and Mobile (Master et al. 1998).

These declines have many sources, including hydrologic alteration, habitat destruction, reduced water quality, loss of connectivity and the negative effects of nonindigenous species. Some sources of habitat stress are direct such as stream piping, relocation, shoreline armoring, excessive siltation, introductions of nonindigenous species and/or contaminants, and often associated with development, commerce, agriculture, forestry and mining. For example, roughly one half of the exotic fish species introduced into the Southeast have become established, stressing or altering ecological systems (Benson et al. 2001). In coastal areas, upstream alterations in freshwater flows and sediment supply, including reductions in volume, can result in loss of vegetative habitat and changes in sediment deposition and nutrient transport (Sklar and Browder 1998). The indirect stress from greenhouse gases may exacerbate these declines because many river basins have already lost their ability to adjust (Palmer et al. 2008).

Less direct stressors, especially human population growth and climate change, cumulatively exert a persistent and growing landscape-level effect on fish and their habitats. As more people use increasingly limited natural resources, habitats are impacted. U.S. Census data from April 2000 indicates the human population of the 14 SARP states exceeds 90 million (97,371,542) and, when compared to 1990 figures, points to an increase of over 14 million (14,656,552) people in 10 years. Significant population growth in the Southeast is expected.

The pressures from human population growth have been especially heavy on coastal areas. Populations along the Gulf Coast increased 45% between 1980 and 2003. Atlantic coastal counties experienced an increase of 58%, the largest increase during that period of any coastal region in the continental U.S. (U.S. Census 2000, Population in Coastal Counties).

In tandem with human population growth, climate change has already affected and will more profoundly affect aquatic habitats in the Southeast over the remainder of this century. Climate models project that the Southeast's temperatures will increase on average by 4-10 degrees F over this period, with increasingly hotter summers and higher heat indices (Carter 2000). Based on recent precipitation trends in the region, increases and decreases in precipitation and temperature will be variably manifested geographically, potentially exacerbating existing droughts and developing water shortages in parts of the region. There is also an existing measurable trend in the Southeast for precipitation to occur in more intense events. This trend could intensify during the remainder of the century.

Some predicted environmental effects of these climate changes in the Southeast include fewer continuous acres of forests, reduced agricultural productivity, diminished fish and shellfish populations, and increased electricity demand (Titus 1989). While uncertainties in precipitation projections make it difficult to predict effects on stream and river flows, areas experiencing drought may respond with greater pressure on groundwater for irrigation and water supply, exerting indirect consequent impacts on natural systems. A study of possible effects from climate change on the world's major river systems indicates that by 2050, every populated basin in the world will experience changes in river discharge and many will experience serious declines in water quality and quantity. (Palmer et al. 2008.)

It is reasonable to expect these climate trends to increasingly stress species that are near the upper ranges of their temperature tolerances in the Southeast and those requiring specific habitats that may be affected by the associated hydrological changes. These factors, combined with already fragmented and degraded habitats, will likely cause increased rates of extinction and imperilment of some native species across the region. Additionally, increasing temperatures may enlarge the area of the Southeast vulnerable to establishment of populations of tropical aquatic nuisance species currently restricted to south Florida.

The most dramatic and predictable effect of climate change in the Southeast will be coastal wetland loss and major coastline changes. During the 20th century sea levels rose by 4-8 inches (Burkett et al 2001). The International Panel on Climate Change predicts that this trend will increase 2-5 fold during the 21st century. Under this scenario a sea level rise of approximately one meter is possible by the end of the century. A one-meter rise in sea level would inundate all of coastal southeast Louisiana (UA 2006). The Louisiana coastline would variably move from 10 to over 100 miles inland, inundating New Orleans and many other coastal communities, while altering just about all of the coastal wetlands that support the bulk of the productive fisheries of the northern Gulf of Mexico. Similar impacts, but on a lesser scale would occur in all coastal areas of the Southeast, including all of the keys, the Everglades and much of the city of Miami, Florida, would be under water.

Although the earth has always undergone climate variation, and people have always affected natural systems, the effects from these indirect stressors appear to be in a period of acceleration. They must be considered in planning actions to ameliorate the effects of direct stressors (Technical Review Committee on Global Climate Change and Wildlife, 2004).

Clearly, the public supports actions to conserve and restore healthy aquatic habitats. A study conducted in 2005 by Responsive Management for the Southeastern Association of Fish and Wildlife Agencies indicated that the value placed by the public on programs to conserve fish and wildlife habitat and to protect threatened and endangered species transcends state and local levels of action. This study also noted that water quality is a major fish and wildlife issue facing the southeastern states, and that water resources are of concern for the health of people, fish and wildlife. (Responsive Management, 2005, Executive Summary). Many government agencies, private organizations, businesses, and citizens recognize the value of aquatic resources and work every day to conserve them, but past efforts to halt their decline have been conducted independently on state and local scales. A regional approach is necessary.

Multiscale Approach to Conservation

SARP, comprised of state natural resource agencies from 14 southeastern states plus several federal agencies with natural resource responsibilities, along with concerned nongovernmental organizations (NGOs), was formally organized in 2001 to effectively approach the decline in the region's aquatic resources by integrating state, federal and individual interests and efforts. SARP's mission is – *with partners, to protect, conserve, and restore aquatic resources including habitats throughout the Southeast, for the continuing benefit, use, and enjoyment of the American people.* This partnership takes a comprehensive and systemic approach to watershed conservation. It coordinates the use of new and existing science-based data and expertise, and combines conservation dollars to improve outcomes and stem or possibly reverse aquatic resource decline.

The need to address the decline in fisheries habitats throughout the nation was recognized on a national scale at the same time as SARP's formation, when the U.S. Fish and Wildlife Service (FWS), the Association of Fish and Wildlife Agencies, and the American Fisheries Society sponsored a series of aquatic habitat stakeholder meetings, resulting in the National Fish Habitat Initiative (NFHI) with a mandate to develop an integrated landscape approach to conserve inland and coastal fishery habitats throughout the nation. The National Fish Habitat Action Plan (NFHAP), a non-regulatory, science-based program, implemented through partnerships, has resulted from the NFHI.

SARP has embraced this national initiative while pursuing a similar approach in the region. During 2005, the SARP Aquatic Habitat Conservation Work Group sponsored conservation assessments led by The Nature Conservancy in four representative, geographically separate southeastern watersheds. Assessment of water, flora and fauna of the interconnected ecosystems yielded much information about various habitats, and identified similarities and differences in the problems and issues plaguing them. The results of these studies of the Duck, Altamaha, Pascagoula and Roanoke watersheds provided guidance and parameters for SARP to develop this Southeast Aquatic Habitat Plan (Plan). It offers a science-based, landscape-scale model for habitat conservation, aimed at the protection, restoration, recovery, and sustainable use of aquatic resources in the Southeast. (The assessments can be found at http://www.sarpaquatic.org.)

Also in 2005, by Congressional direction, SARP member states submitted their Comprehensive Wildlife Conservation Strategies (CWCS) to the FWS for approval. The state CWCS plans (also known as State Wildlife Action Plans, or SWAPs) encompassed the variety of problems facing state-identified species of greatest conservation need (SGCN) and strategic conservation actions aimed at improving habitats and

populations of SGCNs. Recognizing the importance and value of incorporating related issues and strategies from its member states' CWCS or SWAP plans into the regional plan, SARP and The Nature Conservancy compiled a database of information related to aquatic habitats from the state plans. These data will help to support habitat restoration and protection strategies at the ground level that cross programmatic and political boundaries, increasing the effectiveness of existing agencies and organizations while leveraging and maximizing available funding to achieve regional-scale conservation objectives.

Proper land and resource management is crucial at multiple levels to protect the natural aquatic treasures found throughout the SARP states and to ensure that future generations will be able to enjoy them. Selecting one scale at which to implement strategies is difficult, especially considering that rivers, lakes, reservoirs and streams may be integrated with estuarine and marine systems, and watersheds often cross multiple jurisdictions. Federal, state, local, public and private agencies and organizations must join together with coordinated strategies to abate current and future threats to the aquatic systems in a comprehensive, landscape manner that minimizes infringements on the rights and needs of specific user groups and maximizes the participation of all stakeholders. As research continues, restoration and management must be adapted to sustain the region's aquatic resources.

This Plan seeks to effectively apply limited resources and adaptive management to priority areas on a regional basis in order to reverse current trends and protect the region's aquatic resources far into the future. The Plan is a living document. It will be revised often, utilizing lessons and data from every project implemented under the Plan's sponsorship. Additional data and tools, currently under development, will assist SARP's adaptive management process of updating and maximizing the outcomes of this Plan.

How can this plan conserve the Southeast's aquatic habitats?

Vision

The Plan will engage stakeholders and the public in protecting, maintaining, restoring and enhancing the Southeast's fish and aquatic communities through partnerships that foster habitat conservation, and improve the quality of life for the American people. Implementation of the plan will result in habitats with the biological, chemical, and physical integrity to sustain healthy communities. As such, the Plan's vision, its overriding spirit, is the:

> *Cooperative conservation of southeastern streams, rivers, lakes and reservoirs, estuaries, and coastal marine habitats to support fish and aquatic resources, and sustainable public use.*

Guiding Principles

Five principles framed the crafting of the Plan and will provide the fundamental underpinnings for its implementation. They are:

•*Communicate the value of the Southeastern aquatic habitats and the imperative for conserving them.*

Properly functioning aquatic habitats are vital and necessary attributes of aquatic ecosystems. They support healthy fish and wildlife populations, and sustainable public use. Knowledge and awareness of desirable functions stimulate action. The regional plan will be a vital tool in efforts to obtain the funding, public and political support, and other resources necessary to meet the goal and objectives that will achieve the plan vision.

•*Provide regional aquatic conservation planning based on sound science, rigorous research, open and inclusive planning processes, and input from a broad and diverse group of stakeholders.*

Application of regional conservation strategies and implementation targets will be guided by the best available information on aquatic systems and species. The Plan will also recognize the importance of research that expands our knowledge base and increases our ability to craft meaningful land and water management strategies and measure the success of strategic implementation.

•*Establish regional aquatic conservation priorities.*

Identifying and articulating regional priorities for habitat conservation efforts will focus scarce resources to maximize conservation benefits in the Southeast. Establishment will be based upon abating threats and conserving balanced, healthy ecological conditions in aquatic habitats. Regional priorities, identified as focal geographic areas, habitat types and species or species groups, will change as conditions change, problems are addressed, and new issues arise.

•*Support existing partnerships, and facilitate new ones, to effectively conserve southeastern aquatic systems.*

The challenges facing the southeastern region's aquatic resources demand new approaches to conserve them.

This regional plan will be designed to support existing partnerships and foster effective creation of new ones at scales appropriate to meeting conservation challenges.

•Integrate conservation strategies and measures within identified watersheds and across scales from watershed to region to national plans.

The connectivity of aquatic ecosystems across local and state political boundaries improves consistency in conservation measures among different portions of watersheds, and the management of species across watersheds. This will be accomplished by increasing communication and project integration between freshwater, estuarine, and marine resource managers and practitioners to reduce the administrative barriers to working across ecosystem boundaries, and to ensure that the strategies implemented at all scales are mutually supportive, relevant, and effective in aquatic habitat conservation.

Goal

Living organisms and their habitats interact in changing ecological systems. These systems support human life by providing drinking water and food, and involve human activities such as farming, aquatic recreation, forestry and industry. Plants, animals, *and* people need healthy aquatic habitats. Although many healthy aquatic habitats thrive in the southeastern region of the U.S., some have disappeared. Others are endangered or declining. These losses in the Southeast have both natural and human-induced causes. Such reductions in habitat quantity, quality and function have negative impacts on animal, plant and human populations *and* their quality of life. Humans have the resources and abilities to conserve and restore these habitats. The goal is to:

Maintain, restore, and conserve the quantity and quality of freshwater, estuarine, and marine habitats to support healthy, sustainable fish and aquatic communities and sustainable public use for the benefit of all in the southeastern region and the entire U.S.

This goal of the Southeast Aquatic Habitat Plan will be achieved by taking collective action on eight primary objectives.

Limitations for all Objectives and Targets

Although the Plan was developed primarily to explain SARP's approaches in preserving, conserving and restoring aquatic habitat, it is designed for use by all groups with similar aims throughout the Southeast. Achievement of the Plan's objectives will be ongoing, with each project contributing in specific ways to the emergence of strong, healthy communities of fish, wildlife and people utilizing thriving aquatic habitats. While improving habitats, project results will also provide lessons learned and meet research needs to support continued planning and additional projects.

The relationship between healthy habitats and robust fish and wildlife populations is assumed in the Plan, and individual species will be one of many filters used to set project priorities and assess project outcomes. SARP

has captured data from the member states' CWCS or SWAP plans to effectively coordinate habitat restoration and protection strategies with states' identified species of greatest conservation need at the ground level across programmatic and political boundaries. However, it is important to remember that this is a plan to conserve and restore aquatic habitats in the region.

This Plan generally adheres to the principles of Strategic Habitat Conservation (SHC) (USGS 2006). However, this initial version of the Plan does not strictly apply that approach because data and models essential for doing so are incomplete or do not exist. In addition, the SHC approach utilizes population-based objectives, and at least for this initial version, the Plan's objectives are based on the major aquatic habitat types and attributes in the Southeast. The objectives focus on broad indicators of habitat integrity, function and overall ecosystem health. Consistent with SHC, objectives and regional targets have been developed using the best available scientific data. A systematic GIS-based system is being developed for refining future objectives and monitoring outcomes. Conservation delivery will be based on defined objectives and targets, and partnerships will be key to achieving those objectives. Adaptive management will be used to help refine objectives and conservation actions.

Although the following objectives focus individually on critical components of aquatic habitats, they function as an interrelated whole. The order of their mention in the document does not indicate any order of priority. All are important because the impacts from specific threats in a specific location must be considered cumulatively and on multiple scales. Using this Plan, individual threats to the health, quality, and function of aquatic habitats will be considered as part of interrelated processes, problems, and issues with interrelated outcomes.

Unless these outcomes can be measured, the effectiveness of actions to achieve outcomes cannot be assessed. Therefore, one or more resource targets (scientifically based quantitative and/or qualitative descriptions of desired changes) have been proposed for each objective. These targets attempt to establish a quantifiable basis for assessing progress in achieving the associated objective. In developing these regional targets, an attempt was made to adhere to the format and recommendations in the Proposed Interim National Targets (February 2007) developed by the National Fish Habitat Board's Science and Data Committee. The Plan's targets are primarily resource-based outcome targets, focusing on changes in the resource as a result of SAHP actions. Developing quantifiable targets for most of the objectives presents real challenges, primarily due to the lack of regionally analyzed and integrated data. For this reason some targets focus on measures that indirectly assess the resource attributes related to the objective and some targets are actions than can be pursued during implementation. The following quantitative targets are subjectively proposed as reasonable measures of improvement over 15 years, assuming that focused efforts are brought to bear and adequate resources are available. With the adaptive management process in mind, ideal targets are also described, even though the interim targets sometimes do not measure against them. Ideal targets provide the opportunity to identify data gaps for effective evaluation, and suggest needed research to better focus targets.

An additional challenge for some of the targets is presented when positive change may not be reflected in assessment and evaluation because of continuing research about various conditions. This challenge will be considered as applicable when assessing progress towards achieving each of the objectives.

It should be possible to develop resource-based targets that are more specific to the objectives once the first assessment of the nation's aquatic habitats, as proposed in *A Framework for Assessing the Nation's Fish Habitat* (NFHSDC 2006) is completed in about 2010. The targets in this version of the Plan should generally be viewed as interim targets subject to revision. Many of the current targets have their basis in information presented in *The State of the Nation's Ecosystems* (The Heinz Center 2002, 2003, 2005) and the *National Coastal Condition Report II* (USEPA 2004). The underlying data for both of these documents have been
 periodically updated, reassessed and published by the USEPA and the Heinz Center. The Plan assumes that
those updates will continue in the future. (Further explanation of these resources can be found on page 2.) In a

few cases, targets are based on local data or proposed need. Note that in a few cases, targets are not structured on five-year intervals due to insufficient data or it was not meaningful to do so for a specific target. Unless otherwise stated, all targets are intended to be achieved over a 15-year time period following plan adoption (i.e., by 2022).

Objective 1: *Establish, improve and maintain riparian zones*

Riparian zones buffer the impacts on adjacent waterbodies from human land use activities while supporting aquatic as well as terrestrial habitats. Wenger (1999) defines riparian zones as land areas located adjacent to waterbodies, often naturally vegetated with grasses, shrubs and trees. Effective riparian zones function as efficient traps, filtering out sediments and nutrients. They provide structure for ephemeral or intermittent channel flow. Vegetation closest to the waterbody provides cover and habitat for wildlife, helps maintain normal water temperatures, slows over-bank flows, and provides energy in aquatic systems. Vegetative roots, especially from woody plants and trees, decrease erosion of the banks and shorelines (Pollen and Simon 2005). During certain periods or under certain circumstances, riparian zones play significant roles in changing water quality as well as in the life stages and life-sustaining activities of many aquatic animals. Natural riparian areas also provide important habitat and travel corridors for terrestrial wildlife. Both grassed and forested buffers trap sediment. Forested buffers provide other benefits as well, such as better runoff control while also allowing input of large woody debris and other matter necessary for aquatic organisms (Wenger 1999).

Urbanization, industrialization, agriculture and other types of development often degrade or reduce the size or health of riparian areas. Ideally, appropriately sized riparian zones in every watershed in the southeastern region should be permanently protected. In areas where vegetated riparian areas are already lost or loss is unavoidable, such as urban areas, methods to restore or provide the functions of healthy, natural riparian areas should be explored and utilized. The challenge is to maintain, conserve, permanently protect, construct or restore riparian zones in the southeastern region that can support healthy aquatic habitats and their populations of fish and other aquatic organisms while meeting public needs.

Target

An ideal riparian zone would extend over all land adjacent to a waterbody to the extent necessary for effective buffer and support. Buffer slope and the presence of wetlands have been determined to be the most important and useful factors in determining ideal buffer width. Long-term studies suggest that a 30 m (100 foot) riparian buffer is sufficiently wide to trap sediments under most circumstances, although they can vary based on type of soil, hydrology, slope and vegetation. Native forest vegetation should be maintained or restored to provide optimal benefit (Wenger 1999). Riparian buffers should extend along both sides of rivers and streams, including intermittent and ephemeral channels, and completely around natural lakes and impounded waters.

One ideal target for this objective would include a measure of habitat quality and quantity utilizing satellite data and geographic information system (GIS) analysis to determine the magnitude of change in percentage of 100-year floodplain areas of natural vegetative cover. Other target strategies may involve assessing maintenance of acres of existing riparian areas or determining the percentage of or number of new riparian areas in a watershed or the southeastern region. Permanently protected riparian areas may be included in the assessment of change. However, regional data have not been compiled or analyzed in a fashion that would allow development of such targets at this time. The initial target for this objective is limited by available regional data on riparian areas.

Using data compiled and processed by the U.S. Environmental Protection Agency's (EPA) National Exposure Research Laboratory that used the U.S. Geological Survey's (USGS) National Hydrography Dataset, the Heinz Center (2002) determined that, nationally, 23% of the lands within 100 feet of the waters' edge along streams nationwide were either farmlands or urban development in the early 1990s. Although those data are for the nation as a whole rather than only the Southeast and appear low for the southeastern region, they were used when developing the following targets for this objective pending development of current regional data for assessing the Southeast's riparian condition.

Target 1A. Ensure that adequate non-urban/non-agricultural riparian buffer habitats exist on at least 85% of the lands within 100 feet of rivers and streams in the Southeast by 2022.

- By 2012 ensure that at least 78% of the lands within 100 feet of rivers and streams in the Southeast have adequate riparian buffers.
- By 2017 ensure that at least 81% of the lands within 100 feet of rivers and streams in the Southeast have adequate riparian buffers.
- By 2022 ensure that at least 85% of the lands within 100 feet of rivers and streams in the Southeast have adequate riparian buffers.

Objective 2: ***Improve or maintain water quality***

The quality of water includes physical, chemical, and biological characteristics that sustain plant and animal life and support a variety of human uses including drinking water, fishing and boating, agriculture and industry, and other types of recreation and transportation. Water quality characteristics can be altered by storms and seasonal changes; industrial, manufacturing or residential discharges and runoff; urbanization; agriculture; and other land uses, sometimes for many miles from the contamination site (e.g., the dead zone in Gulf of Mexico impacted by drainage from the Mississippi River Basin). Plants and animals in any aquatic community are sustained by the balance of temperature, nutrients, and organic material in the habitat. Maintaining good water quality and preventing, halting, or reversing alterations support these life-sustaining balances and reduce treatment costs for human use. The challenge is to maintain or adjust the balance of water quality characteristics in aquatic systems to meet the needs of fish, other aquatic and terrestrial organisms, and the public.

Targets

Ideally the magnitude of change for this objective will be measured by the maintenance of or increase in the percentage of, or the number of miles of, streams and rivers, or acres of estuaries, wetlands, lakes, reservoirs, and ponds with water quality characteristics that meet the designated use. An example of a designated use might be fishable/swimmable waters or waters supporting aquatic life and recreation, such as addressed in Section 303(d) of the federal Clean Water Act. A decrease in the percentage of waterbodies in the southeastern region with water quality unable to support healthy ecological systems is desirable.

The EPA maintains a database of waterbody segments/areas that are classified as impaired in accordance with Section 303(d). Although the data in that system are not consistently expressed quantitatively in terms of stream miles or areal extent, the 303(d) list includes a total number of impaired waterbody segments/areas. That number (7,073 as of June 2007) is used as an interim basis for Target 2A for this objective. Note that states have different listing criteria for these data. Some criteria are primarily anthropogenic in focus, some don't consider emerging contaminants such as pharmaceuticals, and some may be less suitable for describing impairment in some of the Southeast's low gradient systems, such as some habitats of the lower Mississippi River floodplain. However, these are the best available data upon which to base many of the following targets. In addition, ongoing research has resulted in an increase in the number of 303(d) listings of impaired waterbodies every two years, presenting the challenge described on page 13. Data are available to meet this challenge in the target's assessment.

Several other targets were also developed for this objective focusing on specific water quality characteristics, as further described below, using data from The Heinz Center (2002). Although those data apply to the nation as a whole and not to the Southeast specifically, they were, nevertheless, used when developing targets pending future development of more specific targets when better data are available. Note that these targets are regional, and are not meant to apply at every individual site.

Target 2A. Restore at least 710 waterbody segments/areas in the Southeast (10% of impaired segments/areas as of June 2007) to nonimpaired status per the EPA 303(d) list.

•By 2012 restore at least 140 waterbody segments/areas in the Southeast to nonimpaired status per the EPA 303(d) list.

•By 2017 restore at least 350 waterbody segments/areas in the Southeast to nonimpaired status per the EPA 303(d) list.

•By 2022 restore at least 710 waterbody segments/areas in the Southeast to nonimpaired status per the EPA 303(d) list.

According to the Heinz Center (2002), the USGS National Water Quality Assessment (NAWQA) found that 77% of stream sites nationwide during the period 1992-1998 were exceeding at least one standard or guideline for contaminants that may affect aquatic life in water. This was used as a basis for Target 2B.

Target 2B. Reduce to 70% the stream sites in the Southeast exceeding at least one standard or guideline for contaminants or emerging contaminants affecting aquatic life.

•By 2012 reduce to 76% the stream sites in the Southeast exceeding at least one standard or guideline for contaminants or emerging contaminants in water affecting aquatic life.

•By 2017 reduce to 75% the stream sites in the Southeast exceeding at least one standard or guideline for contaminants or emerging contaminants in water affecting aquatic life.

•By 2022 reduce to 70% the stream sites in the Southeast exceeding at least one standard or guideline for contaminants or emerging contaminants in water affecting aquatic life.

The NAWQA (Heinz Center 2002) also found that 48% of stream sites nationwide during 1992-1998 were exceeding at least one standard or guideline for contaminants in sediments that affect aquatic life. This was used as a basis for Target 2C.

Target 2C. Reduce to 45% the stream sites in the Southeast exceeding at least one standard or guideline for contaminants in sediments affecting aquatic life.

•By 2012 reduce to 47% the stream sites in the Southeast exceeding at least one standard or guideline for contaminants in sediments affecting aquatic life.

•By 2017 reduce to 46% the stream sites in the Southeast exceeding at least one standard or guideline for contaminants in sediments affecting aquatic life.

•By 2022 reduce to 45% the stream sites in the Southeast exceeding at least one standard or guideline for contaminants in sediments affecting aquatic life.

The NAWQA (Heinz Center 2002) also found that during 1992-1998 approximately 48% of farmland streams and 18% of urban/suburban streams nationwide had nitrate levels in excess of 2 parts per million (ppm). These data were used as bases for Targets 2D and 2E.

Target 2D. Reduce to 40% the farmland stream sites in the Southeast exceeding 2 ppm nitrate concentration.

•By 2012 reduce to 47% the farmland stream sites in the Southeast exceeding 2 ppm nitrate concentration.

•By 2017 reduce to 44% the farmland stream sites in the Southeast exceeding 2 ppm nitrate concentration.

•By 2022 reduce to 40% the farmland stream sites in the Southeast exceeding 2 ppm nitrate concentration.

Target 2E. Reduce to 10% the urban/suburban stream sites in the Southeast exceeding 2 ppm nitrate concentration.

•By 2012 reduce to 17% the urban/suburban stream sites in the Southeast exceeding 2 ppm nitrate concentration.

•By 2017 reduce to 15% the urban/suburban stream sites in the southeast exceeding 2 ppm nitrate concentration.

•By 2022 reduce to 12% the urban/suburban stream sites in the Southeast exceeding 2 ppm nitrate concentration.

The NAWQA also found that during 1992-1998, approximately 73% of farmland streams, 68% of urban/suburban streams, and 54% of large river [defined as having average flows over 1,000 cubic feet per second (cfs)] sampling sites nationwide exceeded the EPA's recommended goal of 0.1 ppm concentration for phosphorus in order to prevent excess algal growth. These data were used as bases for Targets 2F, 2G, 2H.

Target 2F. Reduce to 65% the farmland stream sites in the Southeast exceeding 0.1 ppm phosphorus concentration.

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•By 2012 reduce to 71% the farmland stream sites in the Southeast exceeding 0.1 ppm phosphorus concentration.

•By 2017 reduce to 68% the farmland stream sites in the Southeast exceeding 0.1 ppm phosphorus concentration.

•By 2022 reduce to 65% the farmland stream sites in the Southeast exceeding 0.1 ppm phosphorus concentration.

Target 2G. Reduce to 60% the urban/suburban stream sites in the Southeast exceeding 0.1 ppm phosphorus concentration.

•By 2012 reduce to 67% the urban/suburban stream sites in the Southeast exceeding 0.1 ppm phosphorus concentration.

•By 2017 reduce to 64% the urban/suburban stream sites in the Southeast exceeding 0.1 ppm phosphorus concentration.

•By 2022 reduce to 60% the urban/suburban stream sites in the Southeast exceeding 0.1 ppm phosphorus concentration.

Target 2H. Reduce to 45% the large river sampling sites in the Southeast exceeding 0.1 ppm phosphorous concentration.

•By 2012 reduce to 52% the large river sampling sites in the Southeast exceeding 0.1 ppm phosphorous concentration.

•By 2017 reduce to 49% the large river sampling sites in the Southeast exceeding 0.1 ppm phosphorous concentration.

•By 2022 reduce to 45% the large river sampling sites in the Southeast exceeding 0.1 ppm phosphorous concentration.

The NAWQA (Heinz Center 2002) found that 83% of farmland stream sites nationwide during 1992-1998 had at least one pesticide with concentrations exceeding aquatic life guidelines. This was used as a basis for Target 2J.

Target 2J. Reduce to 75% the farmland stream sites in the Southeast with at least one pesticide exceeding aquatic life guidelines.

•By 2012 reduce to 81% the farmland stream sites in the Southeast with at least one pesticide exceeding aquatic life guidelines.

•By 2017 reduce to 78% the farmland stream sites in the Southeast with at least one pesticide exceeding aquatic life guidelines.

•By 2022 reduce to 75% the farmland stream sites in the Southeast with at least one pesticide exceeding aquatic life guidelines.

Objective 3: ***Improve or maintain watershed connectivity***

Watershed connectivity in a habitat context can be described as physical, chemical, and biological conditions that accommodate the movements of aquatic organisms, nutrients, water, or energy into various necessary habitats or habitat types. Waterbodies, whether flowing or static, require regular and, at times, unrestricted movements of these to support their ecological systems. Watersheds need similar connectivity within and between rivers, streams, lakes and reservoirs, and between terrestrial and aquatic habitats. Some physical impediments to connectivity such as dams, levees, incised channels, armored shorelines, and culverts can block or change these movements. Impediments such as chemical, biological, and thermal barriers, invasive species, impervious areas, and reduction of the vegetated canopy can also affect connectivity. These impediments are more easily adjusted than the physical ones, although no adjustments are simple. Often barriers to connectivity have a positive use in one part of a watershed, but negatively affect the productivity of some ecosystems in other parts of the same watershed. Occasionally, the purpose for a barrier has disappeared altogether, but the barrier remains. The objective is to conserve or improve watershed connectivity in a manner that will maintain or improve the health of habitats, ecological systems, and populations of fish and other aquatic organisms and meet public needs within a watershed and the region.

Targets

For this objective the ideal targets would be measures of the maintenance of or increase in the number of watersheds in the Southeast with minimal (lowest number and degree of) impediments to connectivity. Since connectivity can be seen to support human needs as well as the life needs of aquatic plant and animal populations, an increase in the percentage or number of healthy aquatic habitats with minimal impediments to connectivity should demonstrate progress. Indicators of change might include chemical or physical changes in water quality, level or flow attributable to operations adjustments, number of dams removed, number of channels connected to floodplains, or alterations in land use patterns accompanied by increases in populations of certain species or functional guilds while continuing to meet human needs. While there are currently no compiled data on connectivity or aquatic habitat health as specific attributes per se, there are a few data sets that may be useful in assessing progress in meeting this objective. The FWS, in its Fish Passage Decision Support System database (FWS 2007), indicated as of June 2007 that there were at least 39,821 barriers to fish passage in the SARP states. Although the data in this database may not be complete, they have utility as a basis for identifying targets for this objective.

Target 3A. Restore 1,000 miles of fish access to rivers and streams in the Southeast by effectively removing* barriers to fish passage.

•By 2012 restore fish access to 500 miles of rivers and streams in the Southeast.

•By 2017 restore fish access to 750 miles of rivers and streams in the Southeast.

•By 2022 restore fish access to 1,000 miles of rivers and streams in the Southeast.

Target 3B. Restore 20,000 acres of fish access to lakes, reservoirs, and coastal estuaries in the Southeast by effectively removing* barriers to fish passage.

•By 2012 restore fish access to 10,000 acres of lakes, reservoirs and coastal estuaries in the Southeast.

* "Effectively removing" can mean physical removal, breaching of a barrier, installation of fish passage structures, or implementation of other fish passage strategies to result in effective fish passage around or through a barrier.

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•By 2017 restore fish access to 15,000 acres of lakes, reservoirs and coastal estuaries in the Southeast.

•By 2022 restore fish access to 20,000 acres of lakes, reservoirs and coastal estuaries in the Southeast.

Objective 4: ***Improve or maintain appropriate hydrologic conditions for the support of biota in aquatic systems***

The quantity and flow of freshwater in waterbodies varies naturally by season and precipitation, and unnaturally by human alteration and withdrawal of water from rivers and lakes as well as groundwater from aquifers. Both are important to aquatic communities. High flows and elevated water levels are part of the natural renewal of some habitats and coastal waters. In rivers, reservoirs or natural lakes, high flows during spring and summer greatly enhance reproductive success and survival of offspring for many species of fish and other animals. These same water levels support public needs for transportation, irrigation, drinking water and recreation.

Estuaries, highly productive habitats for fish and other aquatic organisms, are formed in protected coastal areas where fresh water flows into and mixes with tidally-driven saline waters. Estuarine habitats are supported by the regularity and balance of volume, timing, and periodicity of these occurrences. When people dredge rivers to enhance navigation, create reservoirs and build levees, they may change the hydrologic conditions of waterbodies and watersheds. (Sklar and Browder 1998). The objective is to maintain and/or adjust the quantity and flow of freshwater in rivers, streams, reservoirs and estuaries in a manner that will enhance or sustain the habitats and populations of fish and other aquatic organisms while meeting public needs.

Targets

The magnitude of change for this objective should be measured as a percentage of increase in or increased number of miles of freshwater streams and rivers with instream flow protection plans; or acres of lakes, reservoirs, ponds, aquifers, and estuaries with hydrologic conditions that support sustainable populations of fish and other aquatic organisms compared to a referenced condition. The number of miles or acres of permanently protected freshwater bodies may be included in the measurement. However, data to assess these measures are currently either not available or have not been compiled and assimilated in a manner to allow such assessments to be made. Specific, quantifiable targets may be established for individual watersheds but would require further study to establish.

The Heinz Center (2002) analyzed changes in high and low flows and timing of those flows for 1930-1949 as a reference period and compared those data to the 10-year periods of the 1970s, 1980s and 1990s using USGS stream gauge data nationwide. The data showed in the 1970s that 55.1% of rivers had experienced a greater than 75% increase or decrease in flows or more than a 60-day change in timing of flows. For the 1980s and 1990s the data showed that 56.9% and 60.8%, respectively of rivers had experienced those changes from the reference period. Although these data are nationwide rather than specific to the Southeast, they were, nevertheless, used to formulate Target 4A pending future development of more specific targets after better data are available.

Target 4A. Reduce the percentage of rivers in the Southeast that have experienced more than a 75% change in high or low flows or more than a 60-day change in timing of flows since the 1940s to 58%.

•By 2012 reduce the percentage of rivers in the Southeast that have experienced more than 75% change in high or low flows or more than a 60-day change in timing of flows since the 1940s to 60%.

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•By 2017 reduce the percentage of rivers in the Southeast that have experienced more than 75% change in high or low flows or more than a 60-day change in timing of flows since the 1940s to 59%.

•By 2022 reduce the percentage of rivers in the Southeast that have experienced more than 75% change in high or low flows or more than a 60-day change in timing of flows since the 1940s to 58%.

Using data from the USGS Circular Series *Estimated Use of Water in the United States*, which has been published every five years since 1950, The Heinz Center (2005) assessed freshwater withdrawals nationwide from all sources, for most purposes (such as public supply, domestic, irrigation, livestock, aquaculture, industrial, mining, and thermoelectric, not including freshwater diversions), using withdrawals in 1980 as an index. The year 1980 was chosen because it was the year of greatest water withdrawal (i.e., index value of 1.00) over the data series (1960-2000). Data showed that water withdrawals in the Southeast almost doubled between 1970 and 1980, declined to an index value of 0.77 in 1985, but then rose back to an index value of approximately 0.96 in 2000. Total freshwater withdrawals in the Southeast that year were 120.5 billion gallons per day (bgd). By contrast, human populations in the Southeast rose steadily in a nearly linear fashion from an index value of 0.72 in 1960 to 1.35 in 2000 (1.00 in 1980). These data were used as the basis for Target 4B.

Target 4B. Using freshwater withdrawal in 1980 as an index of 1.00 (125.56 bgd), reduce freshwater withdrawals in the Southeast from all sources to an index of 0.90 (113.0 bgd).

•By 2012 reduce freshwater withdrawals from all sources, using withdrawal in 1980 as an index of 1.00, to an index of 0.95 (119.2 bgd).

•By 2017 reduce freshwater withdrawals from all sources, using withdrawal in 1980 as an index of 1.00, to an index of 0.93 (116.7 bgd).

•By 2022 reduce freshwater withdrawals from all sources, using withdrawal in 1980 as an index of 1.00, to an index of 0.90 (113.0 bgd).

Areas of impervious surfaces (e.g., roads, parking lots, driveways, sidewalks, buildings) in urban and suburban areas can have major impacts on hydrology and water quality in these and downstream portions of watersheds. Although there are currently no data available to assess impervious surface area, The Heinz Center (2002), using data from the National Land Cover Dataset, a product of the Multi-Resolution Land Characterization Consortium [a partnership of USGS, U.S. Forest Service, the National Oceanic and Atmospheric Administration (NOAA) and EPA], determined the percentages of "natural" area patches in urban and suburban settings that fell into specified size groupings. Natural areas were defined as forest, grassland, shrubland or wetlands. They determined that in the Southeast 30% of urban/suburban natural areas in 1992 were patches of forest, grassland, shrubland or wetland, each 10-100 acres in size. Although not perfect, this approximate indicator for urban/suburban impervious area was used to formulate Target 4C.

Target 4C. Increase the percentage of urban/suburban natural area patches 10-100 acres in size in the Southeast to 35%.

•By 2012 increase the percentage of urban/suburban natural area patches 10-100 acres in size in the Southeast to 31%.

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•By 2017 increase the percentage of urban/suburban natural area patches 10-100 acres in size in the Southeast to 32%.

•By 2022 increase the percentage of urban/suburban natural area patches 10-100 acres in size in the Southeast to 35%.

Objective 5: *Establish, improve or maintain appropriate sediment flows*

In a watershed, some sediment is carried in suspension by flowing water from inland to coastal waters, while some is deposited on banks and channel beds, supporting and sustaining aquatic habitats and their ecological systems. Sediment can positively and negatively affect the size and health of wetlands, rivers, streams, lakes, reservoirs, and coastal areas. Increased sediment can raise costs of water purification and navigation channel maintenance as well as damage fisheries and aquatic habitat. It can also build or renew wetlands, banks and benthic areas. Sediment transport varies because of factors such as soil particle type and local geology, precipitation and runoff as well as barriers to flow due to channelization, roadways, dams and land-use-induced erosion. The challenge is to maintain or improve the balance of sediment flow within aquatic systems in a manner that sustains water resources and maintains or improves the health of the habitats and their populations of fish and other aquatic organisms. This multifaceted challenge includes the need to a) maintain or improve the balance of sediment transfer to support the waterbody's structure, habitats and their associated communities, and b) ensure sufficient sediment supply to nurture adjacent wetlands and coastal marshes, and offset subsidence and sea level rise while sustaining water resources for human use.

Targets

The magnitude of change for this objective could be measured by maintenance of or increase in the number of watersheds in the Southeast with a balance of sediment flows supporting healthy habitats with populations of fish and other aquatic organisms while meeting human needs. However, sediment needs vary from habitat to habitat, watershed to watershed. There is no regional norm. For example, White et al. (2002) concluded that upstream reservoirs have reduced sediment loads in the Trinity, Lavaca-Navidad, and Nueces river systems in Texas below those needed to maintain or improve the associated marshes and coastal areas. In some cases, the opposite is true within impounded areas. Reservoirs and small impoundments are especially susceptible to excessive sedimentation.

Determining a baseline to assess progress on this objective is equally difficult. On a nationwide basis The Heinz Center (2002) found in general that croplands most prone to water erosion decreased significantly from 30.3% in 1982 to 21.6% in 1997, but this measure does not address non-agricultural erosion that occurs along large rivers and stream banks. Under section 303(b) of the Clean Water Act, the regional offices of the EPA work with state water regulatory agencies to list impaired waterbodies and develop total maximum daily loads (TMDLs) for the contaminants (U.S. EPA 2007). TMDLs describe the amounts of a pollutant that a waterbody can receive and still meet water quality standards, and allocate loadings among point and nonpoint pollutant sources. Excess sediment can impair waterbodies. To establish a baseline for Targets 5A and 5B, SARP could work with data managed by EPA Regions 3, 4, 6, and 7 to identify those waters currently listed as impaired by excess sedimentation and in need of a load allocation strategy. Future targets and timelines for load reduction could be set in cooperation with EPA and state programs charged with implementing the load allocations.

Initially, the relationship of this objective with those on water quality, connectivity, and hydrologic condition, for which measurable targets have been proposed, can be used for indirect, qualitative assessment until baseline

data can be secured. Results from monitoring and assessing projects focusing on those objectives can, over time, provide some local and regional interim indicators that can be combined with emerging TMDL data. After 2010, development of additional data sources through the NFHI aquatic habitat assessment may provide other avenues to select targets. For this version of the Plan, Targets 5A and 5B are qualitatively described without specific milestones.

Target 5A. Reduce the number of stream miles impaired by excess sediment.

Target 5B. Rehabilitate estuarine or reservoir habitat where hydrological alteration has decreased sediment flows, resulting in aquatic habitat loss.

The portion of the Southeast where the lack of appropriate sediment transport is most profound and critical is the Louisiana coastal area. Since the 1930s, Louisiana has lost over 1.2 million acres (485,830 ha) of coastal wetlands (USACE 2004). In 2000 it was estimated this loss would continue at approximately 6,600 acres

(2,672 ha) per year over the next 50 years. The Mississippi River transports a suspended sediment load of about 70 million cubic yards (5.4 million cubic meters) to its mouth each year. However, most of the material flows to deep waters of the Gulf of Mexico instead of being deposited on surrounding wetlands. The lack of sediment and nutrient input has reduced deposition rates to a point where they are not able to offset relative sea level change being caused by marsh subsidence and actual sea level rise. Besides its impact on local habitats, fisheries and economies, this sediment transport through one of the largest watersheds in the nation most likely is affecting a large portion of the habitats in the Southeast.

The USACE and the State of Louisiana have developed the Louisiana Coastal Area (LCA) Plan (USACE 2004) as a large scale effort to offset much of the projected future loss from this condition. The LCA Plan recommended five near-term critical restoration features for authorization. These were determined to address the most critical needs to offset losses projected to occur over the next 50 years if no action was taken. Target 5C is based on the LCA Plan. Three of the LCA Plan features specifically incorporate attempts to increase sedimentation rates into coastal wetlands through relatively large-scale diversions of river water and sediment. They seek large scale action at specific locations: the Hope Canal Diversion, the Bayou Lafourche Reintroduction, and the Myrtle Grove Diversion. Because the effects from achievement of these could have a significant effect on the achievement of this objective at the regional level while providing data and information about methods and problems related to sediment flow restoration projects, they are included as milestones for Target 5C. This target is based on the LCA Plan.

Target 5C. By 2050 offset approximately 62.5 percent (288,750 acres/116,853 ha) of the 462,000 acres (186,965 ha) of wetlands projected to be lost within the Louisiana Coastal Area if no action is taken.

•Achieve an annual sedimentation rate of at least 1,000 grams per square meter per year using the Hope Canal Diversion for a total benefit of restoring 36,000 acres of freshwater swamp by 2050.

•Achieve a net gain of 2,500 acres of coastal marsh through the Bayou Lafourche Reintroduction by 2050.

•Create/preserve 6,563 acres (2,656 ha) of coastal marsh through the Myrtle Grove Diversion by 2050.

The LCA Plan specifically incorporates attempts to increase sedimentation rates into coastal wetlands and through medium-scale diversions of river water and sediment. These include a 5,000 cubic foot per second23
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project and two smaller-scale projects. Because these three projects would have a moderately significant effect on achieving the overall LCA objective while providing data and information on methods and problems related to sediment flow restoration, they are incorporated into this Plan.

Objective 6. *Maintain and restore physical habitat in freshwater systems*

Physical habitats are the structural elements that make streams, rivers, lakes, reservoirs and wetlands suitable for aquatic species. Examples of physical habitat in southeastern waters include stream channel morphology, substrate composition (gravel, rocks, sediment, etc.), benthic contours of lakes and reservoirs, aquatic vegetation, shoreline vegetation, overhead canopy cover, and woody debris. Physical habitat plays an important role in healthy ecosystems, providing shelter, spawning sites, nursery areas, and foraging areas for fish and other aquatic animals. It also affects water quality and energy production. When physical habitat is changed by natural storm or flood events, aging and decomposition, or anthropogenic activities, the health of the waterbody may change suddenly, slowly, or sometimes in stages following a 'domino' effect. Not all changes are bad, but some activities such as draining wetlands or rerouting streams through pipes or channels can result in destruction of physical habitat. Of major importance has been the large-scale loss of wetland habitats such as forested large-river floodplain, oxbow, and backwater areas, coastal marsh and seagrass beds. The structural elements of many streams and rivers, degraded by an assortment of land use practices or natural events, can be improved using stream restoration techniques. In reservoirs, managers add new structure to offset the loss of the original woody debris, but it is difficult to add enough to maintain optimum fisheries. Reservoirs also tend to develop problems related to the presence or absence of aquatic vegetation due to water level fluctuations. The challenge is to prevent the destruction of physical habitat and promote its restoration and improvement in a manner that meets both ecological and human needs.

Targets

Achievement of this objective will be measured as a reduction in alterations of aquatic habitats, and as the total amount (miles, acres and numbers) of protected, restored and enhanced habitat. Sources of data to help in establishing such baselines may include but are not limited to the AFS Reservoir Committee, U.S. EPA procedures for calculating stream habitat metrics, the U.S. Army Corps of Engineers (USACE) and the National Wetlands Inventory (NWI). Historical data may also be helpful. Note that only those habitat characteristics that can be attributed to maintenance, restoration or establishment of one or more identified structural elements will be used to determine the magnitude of change.

As noted by The Heinz Center (2002), there is general agreement on key elements that should be measured to evaluate aquatic habitat quality, and work is underway by entities such as the EPA, USGS and the USACE to assimilate data and develop habitat quality indices. However, generally accepted methodologies for assessing data on either a local or regional basis are not yet available. Habitat values for particular systems must also take into account the habitat needs of the biota in those areas, so habitat indices need to be tailored to different communities, habitat types or areas.   The FWS National Wetlands Inventory (NWI - http://www.fws.gov/nwi/) provides readily available data on wetlands nationwide. As of 2002, most of the wetlands data in the NWI were of 1980s vintage (FWS 2002), and it is not compiled regionally or by state. Hefner et al. (1994) provides the only regional compilation of wetland data for the Southeast, though these data do not correspond entirely to the Plan's area and were collected only through the 1980s. Development of additional data sources through the NFHI aquatic habitat assessment may provide additional avenues for development of targets following initial results of the assessment in 2010.24 Southeast Aquatic Habitat Plan 2008

Target 6A. Reduction in acreage of freshwater wetlands drained or converted.

•By 2022 reduce the number of acres of altered freshwater wetlands drained or converted through development annually in the Southeast by 30%.

Target 6B. Reduction in number of stream miles destroyed or converted to unnatural or managed drainage systems

•By 2022 decrease miles of streams destroyed or converted by permitted construction into unnatural drainage systems annually in the Southeast by 30%.

SARP is working through the Southern Division of the American Fisheries Society Reservoir Committee to establish methods of tracking reservoir structural enhancements commonly installed by state fisheries professionals and local fishermen. Beginning in 2008, SARP partners will report all stream and river restoration or enhancement projects to measure accomplishments for achieving Targets 6C and 6D.

Target 6C. Increase number of lakes and reservoirs with adequate physical habitat structure.

•By 2022 improve the physical habitat for fisheries in an increased number of affected reservoirs and lakes in the Southeast.

Target 6D. Increase in the number of miles of streams with improved instream physical habitat.

•By 2022 improve the physical habitat of reaches in streams and rivers containing structural improvements in the Southeast. (This would not include downstream affected areas.)

Objective 7: ***Restore or improve the ecological balance in habitats negatively affected by nonindigenous invasive or problem species***

Habitats and diverse populations of biota thrive in balanced, interdependent, natural and human-created systems. Occasionally, the addition of one or more non-native species to biotic communities within a habitat can alter systems and degrade habitats. These changes in the biotic communities of habitats have altered water quality characteristics, energy, nutrient, and sediment flow, and species composition. In addition to the damage to natural resources, such habitat degradation often negatively affects food and water resources, recreation, and economics for people (ISAC, 2006; Pimentel et al 2005). The absence or overabundance of a species or functional guild, especially invasive species, parasites or pathogens, can be major causes of such changes or imbalance (Sarakinos 1999). Pathogens can weaken or destroy whole populations. Invasive species, not native to the habitat, may have no natural enemies present to limit rapid population expansion. Their fecundity, early and rapid development, ability to thrive on available nutrition and tolerance of a broad range of conditions help them to out-compete, and often destroy native populations and disrupt interdependent systems (Williams &

Meffe 2005). Problem species can be introduced by natural occurrences such as storms and floods, and/or by human activities such as shipping, aquaculture, fishing, agriculture, horticulture, landscaping, exotic pet and aquarium trade, and stocking. Biota that improve the health of a system can be introduced in a similar manner. The objective is to encourage appropriate abundance of species or functional guilds within a watershed to establish or restore healthy ecological systems while supporting public use of resources. This will be achieved by controlling or preventing the introduction of new nonindigenous invasive or problem species.

Targets

Progress in meeting this objective will be assessed by using various state, regional, and national databases and management plans, as well as indices of population dynamics, aquatic community species composition, architecture function, and structure to identify problem species that threaten habitat health and establish baselines of habitat health in target watersheds. These changes may be expressed by an increase in the numbers of healthy essential species within a system, an increase in number or percentage of native animals or in acreage of native plants fitting unfilled niches, and/or a reduction in or eventual absence of populations of identified problem species within the target habitat. However, data on which to base such assessments are not yet available or compiled in a manner that can be readily analyzed, particularly for the SARP states as a whole. A suite of targets and strategies has been developed using available data. Development of additional data following initial results of the NFHI aquatic habitat assessment in 2010 may provide avenues for creation of more specific targets.

According to data from 1999 (Benson et al. 2001) for the FWS Southeast Region, the states in the FWS Southeast Region collectively reported, by individual state, a total of 564 nonindigenous aquatic species as having been introduced. However, some species are represented more than once in this total, as they have been introduced into more than one state. Based upon current (June 2007) data from the USGS Nonindigenous Aquatic Species (NAS) website (http://nas.er.usgs.gov/) for the 14 SARP states, comparable totals were 915 for the FWS Southeast Region states and 1,352 for the SARP states. Therefore, between 1999 and 2007 the numbers of introduced species increased in the FWS Southeast Region states by an average of 7.2% per year.

However, not all NAS that are introduced into a state become established and survive year to year, develop reproducing populations or cause problems. Those that do are the most problematic and are the ones referred to in the objective. Using the same data sources as described above, a total of 349 NAS were collectively reported by the FWS Southeast Region states, by individual state, as having become established in 1999. The 2007 comparable totals are 499 for the FWS Southeast Region states and 736 for the SARP states. Thus, between 1999 and 2007 the numbers of introduced species that had become established increased in the FWS Southeast Region states by an average of 5.3% per year. This figure was used as a proxy for the whole region when developing Target 7A since, at present, there is no regional baseline.

Target 7A. Reduce the average annual rate of increase for established NAS in states in the FWS Southeast Region to 3%.

•By 2012 reduce the average annual rate of increase for established NAS in states in the FWS Southeast Region to 5%.

•By 2017 reduce the average annual rate of increase for established NAS in states in the FWS Southeast Region to 4.5%.

•By 2022 reduce the average annual rate of increase for established NAS in states in the FWS Southeast Region to 3%.

Because some non-native species can cause habitat degradation while others may fill an unfilled niche or cause no apparent change to habitat health, additional targets might be set on the basis of certain watersheds or habitat types. These additional targets may be possible at a later date, when all of the SARP states have completed Aquatic Invasive Species Management Plans.

Objective 8: *Conserve, restore, and create coastal estuarine and marine habitats*

The southeastern region's watersheds are critical to the biological productivity and sustainability of coastal estuaries and nearshore waters, and to the economic and sociological health of the coastal communities that depend on them. Actions taken to achieve Objectives 1 through 7 above will have direct and indirect impacts on the overall health of coastal habitats. In a very real way, management actions adopted upstream affect ecosystem health and community resilience along the coast.

As evidence of their value, vital estuarine and marine habitats in the Southeast have been identified as essential fish habitat for federally managed species by the South Atlantic Fishery Management Council, the Gulf of Mexico Fishery Management Council, and the National Marine Fisheries Service. These habitats, also considered important to fisheries managed by the Gulf States Marine Fisheries Commission and the Atlantic States Marine Fisheries Commission, provide food, cover, shelter, spawning sites and nursery areas for marine and estuarine fish and other species. Essential fish habitats in the Southeast include oyster reefs, seagrasses and other submerged aquatic vegetation, estuarine wetlands, mangroves, coral reefs, intertidal flats, estuarine and marine water column, and their underlying sand, mud, and shell bottom substrates.

Coastal habitats, especially in the Southeast, have suffered significant historic losses and degradation due to coastal development, erosion and subsidence, and upstream changes in watersheds. Without well-coordinated, ecosystem-based habitat protection and restoration, these coastal wetland systems will suffer irreparable losses. The challenge is to stop and reverse the loss and degradation of coastal and marine fish habitats in order to maintain fish populations in healthy ecosystems supported by healthy coastal habitats while meeting the needs of all sectors of the U.S. population.

Targets

Achievement of this objective will be measured by percentage of positive change to specific aquatic systems from a baseline condition. Ideally, targets for this objective would be expressed in terms of numbers of acres or percent increases in acreages of specific habitat types, such as oyster reefs, seagrasses, mangroves, and emergent wetlands. Although data on the extent of such areas on a regional basis are incomplete or not compiled in a manner to allow efficient and timely analyses, the EPA has evaluated all estuarine areas on a regional basis nationwide and assigned condition ratings using a standardized format that has been utilized in three coastal condition reports (USEPA 2001, 2004, 2006). These data have been utilized in developing several targets for this objective.

The National Coastal Condition Report II (NCCR II) (USEPA 2004) utilized data from the EPA's National Coastal Assessment (NCA), which gathers data on biota and environmental stressors; NOAA's National Standards and Trends Program, which utilizes site-specific data on toxic contaminants and their ecological effects; and the Fish and Wildlife Service's National Wetlands inventory (NWI), which provides information on the status of the nation's wetlands. In the NCCR II, five primary indices were developed using these data sources for (1) water quality, (2) sediment quality, (3) benthic habitat quality, (4) coastal wetlands and (5) fish tissue contaminants. Although these indices do not address all characteristics of estuaries and coastal waters, they do provide information on ecological conditions. Characterizing coastal conditions was a two-step process. The first step was to assess conditions at individual sites for each indicator. In the second step a regional rating for each indicator using a scale of five (1= poor, 2-4 = fair, 5 = good) was determined, based on the percentage of the area of each region in a given condition. The mean of the indices for the five indicators was then calculated to yield an overall condition index for each region. Using these indices, the NCCR II found that the overall condition for the Southeast Coast estuaries (North Carolina, South Carolina, Georgia and east Florida coasts) was 3.8, and for the Gulf Coast estuaries, 2.4. Although the more recent National Estuary Program Coastal Condition Report (USEPA 2006) also assessed estuarine condition for these same regions using this process, only four of the five indicators were used. For this reason, the data from the NCCR II were used in developing Target 8A.

Target 8A. Increase the overall coastal condition indices for the Southeast Coast and Gulf Coast to 4.2 and 2.8, respectively.

•By 2012 increase the overall coastal condition indices for the Southeast coast and the Gulf coast to 3.9 and 2.5, respectively.

•By 2017 increase the overall coastal condition indices for the Southeast coast and the Gulf coast to 4.0 and 2.6, respectively.

•By 2022 increase the overall coastal condition indices for the Southeast coast and the Gulf coast to 4.2 and 2.8, respectively.

Targets 8B-8F are related to target 8A, but are identified for use in monitoring specific project performance.

The NCCR II found that 5% of the Southeast coast estuaries and 9% of the Gulf coast estuarine areas were in poor condition with respect to water quality. The water quality index was determined using dissolved oxygen, chlorophyll *a*, nitrogen, and phosphorus concentrations and water clarity as indicators. The Gulf coastal area that was rated did not include the large, seasonal hypoxic zone offshore of the Louisiana coast. These indices were used in developing Target 8B.

Target 8B. Reduce the percentage of Southeast coast and Gulf coast estuarine areas rated as being in poor condition with respect to water quality to 4% and 5%, respectively.

•By 2012 maintain the percentage of the Southeast Coast and reduce the percentage of Gulf Coast estuarine areas rated as being in poor condition with respect to water quality at/to 5% and 8%, respectively.

•By 2017 maintain the percentage of the Southeast Coast and reduce the percentage of Gulf Coast estuarine areas rated as being in poor condition with respect to water quality at/to 5% and 7%, respectively.

•By 2022 reduce the percentage of the Southeast Coast and Gulf Coast estuarine areas rated as being in poor condition with respect to water quality to 4% and 5%, respectively.

The NCCR II found that 8% of the Southeast coast estuaries and 12% of the Gulf coast estuarine areas were in poor condition with respect to sediment quality. The sediment quality index was determined using sediment toxicity, sediment contaminants, and sediment total organic carbon as indicators. These indices were used in developing Target 8C.

Target 8C. Reduce the percentage of Southeast Coast and Gulf Coast estuarine areas rated as being in poor condition with respect to sediment quality to 5% and 9%, respectively.

•By 2012 maintain the percentage of Southeast and Gulf Coast estuarine areas rated as being in poor condition with respect to sediment quality at 8% and 12%, respectively.

•By 2017 reduce the percentage of the Southeast and Gulf Coast estuarine areas rated as being in poor condition with respect to sediment quality to 7% and 11%, respectively.

•By 2022 reduce the percentage of the Southeast and Gulf Coast estuarine areas rated as being in poor condition with respect to sediment quality to 5% and 9%, respectively.

The NCCR II found that 11% of the Southeast coast estuaries and 17% of the Gulf coast estuarine areas were in poor condition with respect to benthic habitat quality. The benthic habitat quality index was determined using measures of benthic community diversity, the presence and abundance of pollution-tolerant species, and the presence and abundance of pollution-sensitive species. These indices were used in developing Target 8D.

Target 8D. Reduce the percentage of Southeast Coast and Gulf Coast estuarine areas rated as being in poor condition with respect to benthic habitat quality to 8% and 14%, respectively.

•By 2012 reduce the percentage of Southeast and Gulf Coast estuarine areas rated as being in poor condition with respect to benthic habitat quality to 10% and 16%, respectively.

•By 2017 reduce the percentage of Southeast and Gulf Coast estuarine areas rated as being in poor condition with respect to benthic habitat quality to 9% and 15%, respectively.

•By 2022 reduce the percentage of Southeast and Gulf Coast estuarine areas rated as being in poor condition with respect to benthic habitat quality to 8% and 14%, respectively.

The NCCR II found that indices for coastal wetland loss in the Southeast coast and Gulf coast estuarine areas were 1.06 and 1.30, respectively. These indices were calculated as the average of the mean long-term, decadal wetland loss (1780–1990) and the present decadal (1990–2000) wetland loss rate. These indices were used in developing Target 8E.

Target 8E. Reduce the wetland loss indices for the Southeast Coast and Gulf Coast estuarine areas, to 1.03 and 1.28, respectively.

•By 2012 reduce the wetland loss indices for the Southeast and Gulf coast estuarine areas to 1.05 and 1.29, respectively.

•By 2022 reduce the wetland loss indices for the Southeast and Gulf coast estuarine areas to 1.03 and 1.28, respectively.

The NCCR II found that 5% of the Southeast coast estuaries and 14% of the Gulf coast estuarine areas were in poor condition with respect to fish tissue contaminants. These indices were based on whole fish contaminants analyses and were used in developing Target 8F. Note that fish tissue contamination due to mercury is excluded from Target 8F as the element's presence is widespread and its sources range from historical to natural (including atmospheric deposition from inside and outside the focus area), and control is not currently included through any of the Clean Water Act programs.

Target 8F. Reduce the percentage of Southeast Coast and Gulf Coast estuarine areas rated as being in poor condition with respect to fish tissue contaminants to 4% and 11%, respectively.

•By 2012 maintain the percentage of the Southeast Coast and reduce the percentage of Gulf Coast estuarine areas rated as being in poor condition with respect to fish tissue contaminants at/to 5% and 13%, respectively.

•By 2017 maintain the percentage of the Southeast Coast and reduce the percentage of Gulf Coast estuarine areas rated as being in poor condition with respect to fish tissue contaminants at/to 5% and 12%, respectively.

•By 2022 reduce the percentage of the Southeast Coast and Gulf Coast estuarine areas rated as being in poor condition with respect to fish tissue contaminants to 4% and 11%, respectively.

A combination of these available data can be used to set regional targets that focus on specific wildlife or plants common to the Southeast coasts that respond rapidly, directly and similarly to environmental changes and support habitat health and human needs. Target 8G is an example.

Target 8G. Reduce the percentage of closures of Southeast Coast and Gulf Coast oyster reefs due to contamination of water/tissues to 3% and 11%, respectively

•By 2012 maintain the percentage of closures of oyster reefs due to contaminated water/tissues in the Southeast Coast and Gulf Coast to 5% and 13%, respectively

•By 2017 maintain the percentage of closures of oyster reefs due to contaminated water/tissues in the Southeast Coast and Gulf Coast to 4% and 12%, respectively

•By 2022 maintain the percentage of closures of oyster reefs due to contaminated water/tissues in the Southeast Coast and Gulf Coast to 3% and 11%, respectively.

Data on coastal conditions from many studies may be used to set regional targets as well. Survey data by USGS shows coastal erosion effects in every state. Long-term loss rates range from three to over 60 feet annually. In *Our Living Resources,* a report to the nation on the distribution, abundance, and health of U.S. plants, animals and ecosystems (LaRoe et al. 1995), coastal erosion was classified as severely eroding, moderately eroding or relatively stable. Approximately 40% of the southeast region's shorelines were classified as severely eroding, and only 20% as relatively stable. Target 8H utilizes this baseline.

Target 8H. Prevent additional coastal erosion along 10% of coastlines classified as "severely eroding by 2050.

There are many data resources that can be used on the project level to achieve Objective 8. For example, the USGS' and USEPA's *Seagrass Status and Trends in the Northern Gulf of Mexico: 1940-2002* (Handley et al. 2007), provides an update to their 1995 status and trends report. The World summit on sustainable development committed to reverse the trend of seagrass losses by 2010. Seagrass is valuable fisheries habitat, and some regional states have taken action on this issue. Similarly, an action plan for reducing, mitigating, and controlling hypoxia in the Northern Gulf of Mexico has been developed by the Mississippi River/Gulf of Mexico Watershed Nutrient Task Force.

Where in the Southeast will this Plan be implemented?

Plan Prioritization

The eight objectives in Section 2 of this Plan define the conditions to be addressed through the implementation of the Plan. Because of the size and variety of habitats in the southeastern region, these objectives can guide restoration projects in many areas simultaneously with a broad range of outcomes. However, to most effectively use limited resources to reverse current trends and conserve the region's aquatic habitats, geographic priorities must be set. Careful, periodic selection is required for this Plan's landscape approach to maximize the direct outcomes of every project and sustain the effects at the watershed and regional levels.

In the long term, GIS analysis, incorporating data that are only partially available at the present time, will be used to identify and prioritize aquatic habitats where conservation and restoration actions are most needed and, hopefully, will have the greatest opportunity for local and regional success. In the short term, a less comprehensive prioritization method will provide geographic guidance.

Long-term

The implementation of the National Fish Habitat Science and Data Committee's assessment tool will eventually allow a standardized approach for prioritizing aquatic habitat conservation and restoration projects nationwide. As noted in the Committee's draft science and data report of December 2006, *A Framework for Assessing the Nation's Fish Habitat* (NFHISDC 2006), projects "should be prioritized in the following order: 1) protection of fully functioning aquatic systems to include those that are "untouched" to those that have "manipulated," but fully working aquatic processes; 2) rehabilitation of aquatic systems that have only a minor number of problems that impair one or more of the key processes that sustain them; 3) rehabilitation of aquatic systems that have a number of problems impairing one or more of the key processes; and 4) re-engineering modified systems to improve them for fisheries and aquatic production" (NFHI SDC, p.7). SARP is working directly with the Committee to coordinate the aquatic habitat condition assessment for the southeastern U.S.; and this assessment will enable SARP to enrich its GIS analysis, as described above, and refine its geographic priorities.

Because healthy habitats also affect the ecology, economy and sociology of human communities in the region, data on economic and social elements in the region will also be considered, when available, for objective analysis; consistent with the Plan's goal for restoration undertaken "for the benefit of all in the southeastern region and the entire U.S."

Interim

The need to stem the decline in fisheries habitats throughout the SARP states is urgent. Rather than wait until 2010 to begin this vital work, the year that the aquatic habitat condition assessments are scheduled for completion, SARP is developing a geo-referenced database populated with currently available aquatic system condition data to provide interim geographic priorities for the Plan. This prioritization process – to be used by SARP until the aforementioned condition assessments and an operational priorities database are in place – has provides a less-than-perfect, but acceptable and immediately useful, graphic depiction of the Southeast's most at-risk geographic areas, as identified by one or more of four existing and reliable sources. These sources are:

1. Information on priority geographies from the State Wildlife Action Plans (SWAPs), wherein individual states have identified **priority habitats and habitats supporting species with the greatest conservation needs**. These data have been consolidated by SARP during the development of this Plan.

2. Information on priority watersheds from a 2006 USGS workshop, wherein recognized experts ranked and prioritized by **extant rareness of species and species richness** those southeastern watersheds most in need of protection and restoration. The process involved expert focus on critical areas in the Southeast. Rivers and drainages with the highest number of imperiled and/or at risk species (according to NatureServe), federally listed threatened and endangered species for each faunal group (fishes, crayfishes, mussels, snails, amphibians, turtles), and total richness of each major group were confirmed. Using this information and a set of agreed upon criteria, the workshop developed a list of the top freshwater biodiversity watersheds in the Southeast and the three highest priority watersheds for each state. (NatureServe represents an international network of biological inventories known as natural heritage programs or conservation centers. The objective scientific information about species and ecosystems developed by NatureServe is used by all sectors of the biological scientific community. Data are online at http://services.natureserve.org.)

3. Information on **freshwater, recreational fisheries, and identification of the specific waterbodies** supporting these fisheries, that would benefit the most from habitat enhancement, restoration or conservation activities has been provided by each SARP member state's fisheries management agency.

4. Information on the Southeast's most important estuarine and coastal habitats was also gathered. Each SARP member state with a coastline provided the names and locations of their **most important estuarine and coastal habitats** that could benefit the most from habitat restoration and conservation.

How can SARP facilitate and implement this Plan?

This Plan aims to conserve, protect and restore freshwater, estuarine, and marine habitats in the southeast region to preserve and restore healthy and diverse aquatic resources. Because habitat health depends upon the integration of geographical, geological, biological, sociological and economic systems, recovering and conserving aquatic habitats and communities is biologically complex and sociologically difficult. Watersheds are nested and cross political boundaries; lakes, reservoirs, rivers and estuaries are connected throughout the region. Therefore conservation strategies to accomplish the Plan's aims will be applied on multiple levels.

Habitat restoration, preservation or maintenance in a given geographic area will involve assessing the aquatic habitat's strengths and weaknesses, analyzing threats or problems, formulating partnership-driven action based upon the Plan's overall objectives, completing identified tasks, as well as monitoring and evaluating outputs at the project level and objectives at the Plan's regional level. Although implementation strategies will vary by conditions and time, all projects will utilize best management practices and the best available science of the time.

Science-based conservation strategies responding to causal effects addressed in the Plan's eight objectives are well known among aquatic habitat conservation leaders. These will be applied appropriately to achieve objectives and targets on a project level. As noted in Section 2, the targets will be redefined by new baseline data from research and lessons from individual projects. Through adaptive management, conservation strategies and actions on multiple levels will follow.

Conservation Strategies and Actions – SARP's Role

Although the individual members of SARP will be engaged in local conservation and restoration projects in partnership with other entities, effective implementation of the Plan depends upon SARP's collective management and facilitation at an integrated systems level as well. In this unique role, SARP must initiate, coordinate and lead partnership-driven actions toward the regional achievement of the Plan's goal and objectives.

The objectives and targets in the Plan were selected on the basis of SARP's earlier research in selected river basins, scientific literature, and reported conditions in the SARP states. A review of the SARP member states' SWAP identified common problems and strategies shared by the states in the region. SARP and stakeholders representing diverse habitat conservation and restoration experiences and expertise met and discussed conservation strategies, objectives and outputs. As the basis for these stakeholder discussions, a synthesis of the strategies and actions identified from SWAPs revealed six commonly applied strategic approaches that cross all levels: (1) information collection and distribution, (2) capacity building, (3) law and policy, (4) habitat acquisition, (5) commercial incentives, and (6) habitat management and restoration. The stakeholders advised that two of these strategies, commercial incentives and habitat acquisition, are most often applied on a local (i.e., project) level rather than on the broader, coordination level envisaged as SARP's role in the management and facilitation of this Plan. Therefore these two strategies have been incorporated into one or more of the other strategic approaches as they apply on the integrated systems level of Plan implementation. The strategy of commercial incentives has been incorporated primarily into Integrated Conservation Strategy 2 (capacity building), and the strategy of habitat acquisition into Integrated Conservation Strategies 1 (information collection and distribution) and 4 (law and policy).

The description of each integrated conservation strategy below includes a number of specific actions that SARP and other landscape-level conservation groups can undertake to achieve the goal and objectives of this Plan. These actions, formed by input from stakeholders during Plan development, should be viewed as prospective and contingent on sufficient funds and staff resources, either corporate or through partners. Although actions for SARP are identified for some of the integrated conservation strategies, they are not otherwise prioritized. They are numbered only for convenience. Also, the actions are neither definitive nor inclusive of all actions that SARP and its partners might do, over time, to support the Plan and its implementing partnerships. Rather, they illustrate the forms of integration, management and facilitation that are considered necessary at this point in time. This Plan should be viewed as a work in progress, and specific tasks being undertaken or initiated at any point will, in all likelihood, change in response to environmental, fiscal, and system-level factors, many of which currently cannot be known or predicted.

Integrated Conservation Strategy 1: *Information collection and dispersal*

Through the collection, availability and use of information, SARP can facilitate habitat conservation, restoration and maintenance in several important ways:

Data collection. Verified current and historical data about an area is used in research, and in planning project activities, monitoring projects and post project evaluation to determine the efficacy of achieving the Plan's goal and objectives. By facilitating information collection, developing guidelines to increase data integration, establishing archives, and making information accessible, SARP and its aquatic habitat partners can help project planners secure and integrate scientific data from educational institutions, federal and state databases and archives, as well as private and corporate records. In this way, SARP can enhance GIS analysis and various types of modeling. Such well organized and easily accessed data facilitates multiple-scale habitat planning and coordination. In addition, information about specific habitat conservation and restoration techniques facilitates regional consistency in their application and leads to a more effective use of tools, people, and funding while increasing compatibility between individual projects.

Information distribution. Broadly distributed information provides the basis for public support of a habitat project's actions – from land acquisition to limited use – and public enthusiasm for the general concept of habitat conservation. Information distribution is also an educational strategy. Individuals, corporate officers, and public officials can learn about and participate in a range of activities from planning active restoration of a habitat to applying project guidelines to policymaking. School curricula can evolve from project success stories, as well as from guidelines for particular restoration processes.

The following actions will be ***undertaken by the SARP Steering Committee*** in the first year to implement **ICS 1:**

> **ICS Action 1A.** Establish a Science and Data Committee to identify existing information and data gaps associated with the freshwater, estuarine, and marine aquatic habitat types in the Southeast for purposes of Plan implementation. Thereafter, this SARP committee will encourage data collection, and broad distribution and integrated use through ICS action items 1C and 1D to achieve the Plan's objectives.
>
> **ICS Action 1B.** Establish an Education and Outreach Committee to distribute and explain this Plan broadly among elected officials at all levels, government agency managers, NGOs, industry, stakeholders and the public throughout the Southeast. Thereafter, this SARP committee will integrate information distribution with efforts of project partners to accomplish ICS action items 1E, 1F, and 1G (below).

The following action items will be ***undertaken by the SARP Steering Committee, its committees and partners*** to implement **ICS1**:

> **ICS Action 1C.** Develop an Internet web site to serve as a portal for a variety of information and databases on aquatic habitat conservation in the Southeast, to encourage data sharing among partners, and to inform and educate stakeholders.
>
> **ICS Action 1D.** Support the National Fish Habitat Science and Data Committee in developing science-based tools for on-going assessment of fish habitats nationwide through the coordinated development of a process to better assess fish habitat conditions in the Southeast.

ICS Action 1E. Identify guidelines and guideline sources where needed, on specific aquatic habitat management tools and practices such as stream corridor restoration, fee-title land acquisition, easements, project permitting and monitoring.

ICS Action 1F. Develop educational and outreach tools for specific purposes such as facilitating establishment of conservation easements, or sharing and coordinating best management practices (BMP) in accomplishing aquatic habitat conservation in the Southeast.

ICS Action 1G. Develop general outreach and education tools to be used throughout the region regarding the protection of watersheds, importance of aquatic habitats, and methods for their protection and restoration.

The following action will be ***undertaken by the SARP Aquatic Habitat Plan Committee*** to implement **ICS1**:

ICS Action 1H. Assess progress at five-year intervals, using available information as identified in each objective's targets in the Plan, and report to agency and elected officials, partners, stakeholders and the public. This action will be supported by the Education and Outreach Committee and the Science and Data Committee, both created in the Plan's first year.

Integrated Conservation Strategy 2: *Capacity building*

Habitat conservation, maintenance and restoration projects require tactical alliances among public and private stakeholder groups, solid leadership and adequate funding. By building alliances, encouraging leadership and seeking funding, SARP can facilitate capacity building in the following ways:

Alliances. To build alliances, SARP will facilitate recruitment of new, project-specific partners by integrating groups with specific jurisdictional responsibilities (e.g., states, the EPA, U.S. Army Corps of Engineers and Natural Resource Conservation Service) with local landowners, municipal and county officials, and a variety of NGOs of all sizes, especially those with a Plan-related purpose.

Leadership. Responsible leadership doesn't just happen. A major part of SARP's strategic capacity building aims to identify and support (with funds and information) responsible leadership among project partners. Coordination and integration of these individuals builds leadership capacity. As one project leads to and/or affects another, good leaders can see such connections and, with support, integrate activities to make best use of available dollars and labor.

Funding. Restoration capacity depends heavily on available funds. Identification of funding resources includes encouraging use of federal incentives and stimulating private, state and local incentives. With SARP's coordination, it will be possible to leverage existing funds on a broad basis and possibly to integrate commercial with environmental goals. Sometimes bringing various groups to one table can create the resources needed for a project.

SARP itself is a strong partnership, and its members can contribute leadership, funding capacity, and in-kind resources for various habitat restoration projects and their coordination. Importantly, SARP and the Plan's stakeholders collectively understand that the specific actions needed to successfully support capacity building must be persistent and ongoing.

The following actions will be ***undertaken by the SARP Steering Committee*** to implement **ICS 2:**

ICS Action 2A. Maintain close coordination with existing partnerships, initiatives, and organizations (such as, but not limited to, the Upper and Lower Mississippi River Conservation Committees, the Gulf of Mexico Program, National Estuary Programs, Restore America's Estuaries, the Gulf of Mexico Alliance, the Mississippi River/Gulf of Mexico Watershed Nutrient Task Force, Chesapeake Bay Program, the Comprehensive Everglades Restoration Plan, migratory bird joint ventures, and all NFHAP-recognized partnerships) and identify new groups focused on specific aquatic habitat issues or southeastern geographic areas.

ICS Action 2B. Support the development and efforts of NFHAP implementation units in the Southeast to encourage participation by diverse partners, including groups that have not been directly involved with SARP in the past.

ICS Action 2C. Continue coordination with individual southeastern states, the Southeastern Association of Fish and Wildlife Agencies (SEAFWA) and other partners to assure that aquatic habitat conservation efforts are consistent and coordinated with each state's CWCS (SWAP).

ICS Action 2D. Serve as a catalyst to coalesce NGOs, professional societies and fisheries groups to develop projects, secure funding and build partnerships for aquatic habitat conservation in the Southeast.

ICS Action 2E. Develop and share tools to facilitate partner capacity building, such as templates for memoranda of agreement, grant proposals, bylaws, and operational procedures.

ICS Action 2F: Support and encourage opportunities for communication and coordination among leaders of implementation units to maximize outcomes of aquatic habitat conservation projects.

ICS Action 2G. Serve as a clearinghouse for public and private funding sources for aquatic habitat restoration and conservation.

ICS Action 2H. Work with state, regional, corporate and private partners to facilitate development of economic and other incentives for aquatic habitat restoration.

ICS Action 2J. Stimulate an increase in the level of funding for fish habitat conservation efforts throughout the Southeast from federal, state, and private sources using all appropriate approaches, including initiatives seeking public funds in order to leverage corporate and other private sources.

ICS Action 2K. Stimulate cooperative and integrated use of existing resources, especially habitat conservation funding programs by federal, state, tribal and local agencies, NGOs, landowners, and other stakeholders towards achieving the Plan's objectives.

Integrated Conservation Strategy 3: ***Management and restoration***

Multiple-scale coordination and integration of Plan and project objectives are necessary roles for SARP. Because changes made in one part of a watershed often affect other portions, regional integration on a higher level maximizes the effectiveness of all conservation efforts.

Thus, besides coordinating partnership-driven aquatic habitat restoration projects – which represent joint ventures on many different scales – SARP will take the lead in supporting and enhancing regional habitat management activities wherein all southeastern states can plan and participate together in the compatible uses of resources, integrating activities to protect threatened and endangered species, and control and prevent domination by invasive and problem species. Central to this process, regional priorities will be explored and agreed upon and various project approaches – such as integration by problem, objective, or habitat – investigated so as to maximize available leadership and resources.

The following actions will be ***undertaken by the SARP Steering Committee*** to implement **ICS 3:**

ICS Action 3A. In the first year, identify priority areas and habitats to best achieve the Plan's objectives, sharing conclusions with other aquatic habitat partnerships, organizations and programs throughout the Southeast to encourage compatibility in resource management decisions. Thereafter, the Science and Data Committee will use best available information to review and revise these priorities.

ICS Action 3B. In the first year, develop project prioritization and selection guidelines for specific projects to be implemented with funding from NFHI or similar initiatives or programs in which SARP is a direct participant or serving as a grantor. Thereafter, these guidelines will be revised by adaptive management.

ICS Action 3C. Continue to support SARP states, and the Gulf & South Atlantic and the Mississippi River Basin regional ANS panels in the development and implementation of state and regional ANS management plans. In conjunction with those plans, facilitate integration of early detection and rapid response plans and coordination of management activities to address the issues associated with invasive or problem species affecting watersheds of the Southeast.

ICS Action 3D. Coordinate the development and implementation of uniform standards for mitigating damages to wetlands and other aquatic habitats across the Southeast.

ICS Action 3E. Develop a comprehensive regional approach to reservoir habitat management, restoration, and enhancement.

ICS Action 3F. Facilitate implementation of appropriate activities to address the problematic habitat structure issues affecting watersheds of the Southeast.

ICS Action 3G. Collaborate with other fish habitat partnerships, state, federal, tribal and local agencies, NGOs, and other natural resource partnerships to protect through fee title acquisition, easement, or other arrangements the high quality freshwater, estuarine, and marine aquatic habitats in the Southeast.

The following actions will be ***undertaken by the SARP Education and Outreach Committee*** to implement **ICS 3**:

ICS Action 3H. Encourage use of quality, 'smart' or sustainable growth standards in local and regional land use planning and regulations associated with aquatic habitats.

ICS Action 3J. Facilitate the development and use of standardized aquatic habitat restoration best management practices (BMPs) in projects, including use in requests for proposals, restoration and management activities, and project evaluation criteria.

The following actions will be ***undertaken by the SARP Science and Data Committee*** to implement **ICS3:**

ICS Action 3K. Encourage and facilitate integration of relevant data from state and federal water quality agencies, NGOs and grassroots watershed organizations in the Southeast to address the problematic water quality issues affecting watersheds in the Southeast.

ICS Action 3L. Encourage and facilitate integration of relevant data from state, regional and federal groups concerning identification, introduction, and control of invasive species in the region.

Integrated Conservation Strategy 4: *Law and policy*

Although laws and policy to protect aquatic habitats in the Southeast exist on federal, state and local levels, they are neither universally compatible nor universally applied. Some are enforced throughout the region; others are enforced only in certain areas or under certain conditions. These differences can reduce the effectiveness of landscape-level habitat conservation and restoration throughout a watershed or the region.

Sometimes interjurisdictional overlaps or differences are not noticed until attention is brought when initiating a project or through litigation. Through education on law and policy, such differences could be accommodated early on, prior to implementation of a joint venture. For example, a universal understanding of land use and zoning ordinances throughout a watershed or the region would be an appropriate step in coordinating projects located in several different areas addressing the same problem or focusing on the same watershed. Likewise, support for coordination of instream-flow policies would ensure watershed or regional conservation outcomes and facilitate monitoring activities.

When necessary, tools such as cooperative agreements can be developed to integrate state and local policies, facilitating acceptance and perhaps even universal standards. In addition, policy-related procedures or new legislation can maximize aquatic habitat restoration outcomes. For example, land acquisition may be a necessary part of certain conservation or restoration projects. A streamlined, regionally agreed-upon process for aquatic habitat-related land acquisition or easement acquisition would be an important step in securing broad support and cooperation in a watershed or the region.

SARP's role under the law and policy integrated conservation strategy is to gather and make available relevant data, tools and protocols that can be used by appropriate government bodies to enact or change legislation and policy. SARP does not advocate specific changes in law and policy. It coordinates and shares information about existing laws and policies (and gaps in them) so that appropriate government bodies can enable aquatic habitat protection, conservation and restoration to meet the Plan's objectives.

The following actions will be ***undertaken by the SARP Steering Committee*** to implement **ICS 4**:

> **ICS Action 4A.** In the first three years, work with the Instream Flow Council, state water agencies, state legislators and conservation NGOs to develop adequately staffed instream flow programs in each of the southeastern states and a network to integrate stream flow and mitigation standards in the region. This process will create a procedural template for additional law and policy actions to meet the Plan's objectives.
>
> **ICS Action 4B.** Opportunistically, develop tools, guidelines and protocols to facilitate law and policy focusing on uniform regional water quality standards, TMDLs for sediment and stormwater issues, and the habitat needs of at-risk aquatic species.
>
> **ICS Action 4C.** Using the procedural template from action item 4A, identify and convene as needed networks of experts to assist in developing region- or watershed-wide policies or legislation to facilitate coordinated projects to achieve the Plan's objectives.

The following action will be ***undertaken by the SARP Education and Outreach Committee*** to implement **ICS 4:**

> **ICS Action 4D.** Support workshops for user groups such as city and county planners, describing laws, policies, potential conflicts, jurisdictional overlaps and information gaps relevant to aquatic resources and habitats.

How can SARP and project partners measure success?

Monitoring Habitat Conservation and Recovery

This Plan suggests the pathway to conserve and restore the inland, coastal and estuarine habitats of the 14 member states of the Southeast Aquatic Resources Partnership (SARP). As SARP facilitates and manages the implementation of the Plan, it is vital to understand and document the Plan's conservation and restoration performance and, in view of that performance, adapt the Plan's program and project approaches to improve future conservation and restoration practices and projects.

Monitoring will contribute to an understanding of the complex ecological systems within which the Plan's conservation and restoration projects are implemented, and result in identifying habitat improvement. It can warn of environmental decline, establish a record of conditions or trends, and identify gaps in existing scientific knowledge. It will also provide the basis for a rigorous review of habitat project planning and implementation to determine whether project results are being achieved and if mid-course corrections are necessary. This will allow for design improvements in future projects, provide tools for planning additional habitat management strategies, and provide essential information on whether project results are good measures for anticipating progress on Plan objectives.

The Plan's monitoring approach has a two-tier structure that corresponds to program-level performance measurement of the Plan's objectives at ecosystem and regional scales and, at local scales, project-level monitoring of the performance of specific projects against their purposes and objectives.

Tier 1 – Monitoring the Plan's performance

Because the resource targets in the current version of the Plan rely on existing databases and analyses as described under each objective, program-level monitoring under Tier 1 will use those databases and analyses as further developed in future years. Certain limitations will be inherent in this monitoring approach because these databases and analyses are managed independent of SARP. Where possible, SARP will attempt to secure and use the underlying data from these sources to independently develop assessments of progress in cases where analysis or assessment may not be completed by the source organization.

SARP has begun development of GIS-referenced analysis tools that will allow it to conduct regional aquatic habitat condition assessments using methodology described by the NFHAP Science and Data report. The first phase of this project, focused on the Tennessee-Cumberland watershed, will yield a GIS-referenced database that can eventually be developed for Tier 1 analysis. SARP's long-term plan, as funds can be secured, is to collect and analyze data and conduct habitat condition assessments for all major watersheds in the region in a manner compatible with the NFHAP. GIS analysis of various combinations of these data can provide graphic description to better assess achievement of the objectives' targets as well as assist in future habitat restoration project planning and prioritization. The tool(s) will be compatible with the NFHAP National Habitat Condition Assessments.

When fully developed, such tools can be used for effectively monitoring and evaluating aquatic habitat health in the Southeast. Once sufficient data have been developed, compatible data set formats identified and NFHAP National Habitat Condition Assessments are available, the status and trends of the aquatic habitats in the region will be assessed at the Tier 1 level every five years. A variety of data can be used, based upon the targets identified for the objectives. For NFHI projects, these evaluations will be guided by the NFHAP condition assessment processes and protocols. Conditions in SARP's priority watersheds will be examined in particular detail, and compared to Plan targets and conditions generally throughout the SARP states as an indicator of the effectiveness of the Plan's efforts at ecosystem and regional scales.

Tier 2 – Monitoring project performance

Through the Plan, large-scale habitat conservation and restoration in the SARP states will be achieved by managing aquatic habitat projects implemented through new and existing partnerships, and facilitating project funding. However, many, if not all, of these projects will be completed at local, project level (i.e., watershed, sub-watershed and municipal) scales. While monitoring at the input and output levels for project management purposes is expected, monitoring those Plan objectives associated with the project is also necessary. The former provides SARP and project managers with information on whether the project is doing what it promised to do; and the latter gives information on whether or not the project is contributing to achievement of the Plan's objectives.

To ensure that data is accumulated on these scales, every project proposal will be required to include a monitoring plan. An example will be provided in the request for proposals. The data gathered in this process can then be in forms that can be analyzed on several levels, such as written reports, photographic documentation, information on survival rates or anticipated life spans of physical and biological changes, and hydrologic data. It is expected that monitoring efforts will be periodic in the first year and annually thereafter. This type of monitoring plan can improve the project's success by including contingency measures specifying remediation procedures to be followed if success criteria or scheduled performance criteria are not fully satisfied. Adaptive management activities can then be used to adjust to unforeseen or changing circumstances.

Sharing monitoring data and analyses

To be useful, monitoring findings, conclusions and "lessons learned" have to be shared. Information resulting from a well-designed and conducted monitoring program supports the timely and successful management of on-going habitat conservation and restoration projects, and the success of the Plan itself. Project and Plan managers can use results in adaptive management to make mid-course corrections in specific project features. Additionally, monitoring information regarding the performance of both a project overall and its constituent features is highly useful to individuals designing current and future projects with similar features and goals or in similar habitats. Monitoring data, results analysis, and a discussion of lessons learned will be made available by SARP in many ways, especially on the SARP web site.

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Algae – A variety of single-celled to complex multicellular plants that are common in aquatic ecosystems.

Amphibian – A class of cold-blooded vertebrate, such as a frog or salamander, with gilled aquatic larvae (e.g. tadpole) that develop air-breathing lungs as an adult (e.g. frog).

Anadromous – A type of migration in which adult fish spend their lives at sea and return to freshwater to spawn.

Anthropogenic – Effects, processes, objects, or materials derived from human activities.

Aquatic – Growing, living in, or frequenting water. Taking place in or on water.

Aquatic habitats – All bodies of flowing and standing water such as streams, rivers, reservoirs, lakes and ponds; estuarine, palustrine, lacustrine and forested wetlands; riparian areas along streams, rivers, lakes and reservoirs; karsts; coastal freshwater dune swales; coral reefs, oyster reefs, sand and algal flats.

Aquifer – An underground layer of water-bearing permeable rock or unconsolidated materials such as gravel, sand, silt or clay from which water can be usefully extracted.

Armored Shoreline – Areas along a waterbody where the land has been structurally reinforced.

At risk – A description of populations that are likely to become severely reduced or extinct due to imminent threats.

Backwater – A waterbody created by a flood or tide or by being held or forced back by a dam.

Benthic; benthonic – On the bottom, under a body of water.

Benthos – Organisms and habitats under a body of water, on the floor of fresh and salt waterbodies.

Biocide – a chemical substance capable of killing living organisms.

Biodiversity – The variety of life and its processes, including the variety of living organisms, the genetic differences among them, and the communities and ecosystems in which they occur.

Biotic integrity – A healthy balance of biota in a habitat. It is measured by one of a number of multi-metric indices (IBI) that have been developed by study of aquatic ecology. The metrics reflect the richness and composition of biota in a habitat as well as the trophic organization and function, reproductive behavior and condition of all individual species.

Bog – A palustrine wetland with poorly drained, wet spongy soil full of plant residue, frequently surrounding open water.

Buffer – Land located immediately adjacent to a waterbody that has sufficient size and vegetative composition to perform the function of filtering surface and soil water as it finds its way to the stream channel.

Canopy – A layer or multiple layers of branches and foliage at the top or crown of a forest's trees.

Channel – The natural or man-made bed in which a stream of water runs; the area between two stream banks at bank-full elevation.

Channelization – The process of reconstructing the natural course of a stream in order to make it flow into a restricted path.

Clear cut – A harvesting and regeneration method that removes all trees within a given area. Clear-cutting is most commonly used in pine and hardwood forests, which require full sunlight to regenerate and grow efficiently.

Community – A group of species that share an ecosystem.

Connectivity – The ability of water, nutrients and organisms to move unobstructed along water courses to include movement upstream and downstream, lateral movement to floodplains, and vertical movement to recharge aquifers.

Conservation – Planned management of the use of the biosphere to benefit the present generation in a way that ensures continuing availability for future generations; careful use of natural resources for sustainability. Also, the
use of methods and procedures necessary to bring any endangered or threatened species to a point at which the measures provided under the Endangered Species Act are no longer necessary.

Contaminants – substances that are harmful or toxic to aquatic life.

Cubic feet per second (cfs) – Measurement unit to describe how much water is flowing in a stream or river. Flow (or discharge) is measured as the volume (cubic feet) of water that passes a given point each second.

Culvert – A conduit used to enclose a flowing body of water. Culverts can be made of many different materials such as steel, polyvinyl chloride, and concrete.

Dam – A barrier across flowing water that obstructs, directs or retards the flow, often creating a reservoir, lake or impoundment.

Denitrification – The process of reducing nitrate and nitrite, highly oxidized forms of nitrogen available for consumption by many groups of organisms, into gaseous nitrogen, which is far less accessible to life forms.

Detritus – Non-living particulate organic material, such a decaying plant and animal matter.

Development – New construction projects that convert land from green space to buildings and impermeable surfaces.

Discharge – The amount of water that is flowing in a stream channel. Measured as volume per unit of time such as cubic feet per second (cfs).

Dissolved oxygen – The amount of gaseous oxygen molecules (O_2) found in water. Water molecules also contain oxygen, but only this gaseous form is readily available for respiration by aquatic plants and animals.

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Dredging – The removal of material from the bottom of a waterbody, typically done to make the area deeper for navigation, or to harvest gravel or sand for building materials.

Easement – A contractual agreement between a landowner and another party, or government agency on behalf of the public, that allows specific uses of the property for a specified time period, but does not release the ownership of the land.

Ecology – Science concerned with the interrelationships of organisms and their environments.

Ecosystem – Any dynamic and interrelated community of living things interacting with nonliving chemical and physical components that form and function as a natural environmental unit.

Emergent wetlands – Marshes dominated by grass-like plants, rooted in bottom sediments, and emerging or appearing above the surface of the water.

Endangered species – An animal or plant species in danger of extinction throughout all or a significant portion of its range.

Endemic – Restricted in distribution to a particular geographic area or drainage. Term used with reference to any plant or animal taxon.

Ephemeral – Living or lasting for only one or a few days.

Erosion – Process of weathering or wearing away stream banks and adjacent land slopes by water, ice, wind, or other factors. Removal of rock and soil from the land surface by a variety of processes including gravitational stress, mass wasting, or movement in a medium.

Estuary – A semi-enclosed coastal body of water which has a free connection with the open sea and within which sea water is measurably diluted or mixed with fresh water from land drainage.

Estuarine – Of, relating to, or formed in an estuary.

Fauna – Collectively, the animal life of a particular area region, or special environment. A list of animal species and descriptions for a particular area or time period.

Fecundity – Reproductive fruitfulness. Relative number of eggs, sperm, or young produced by an animal.

Fen – Bog with alkaline, mineral rich water.

Floodplain – Palustrine wetland adjacent to a river. When a river's water exceeds its banks, it enters the floodplain and is forced to spread out, losing most if its velocity and capacity to rise.

Flora – The plant life of a particular area, region, or special environment. A list of plant species characteristic of a specific place or time period.

Flow – To move or movement in a continual change of place.

Forested wetland – Wetland dominated by trees, similar to a true swamp but lacking continuously standing water, although repeated flooding is common.

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Freshwater – Water that contains less than 1,000 milligrams per liter (mg/L) of dissolved solids. Water that is not salty.

Freshwater marsh – A wet meadow with saturated soil and dominated by grasses and sedges adjacent to a bog or marsh with persistent emergent plants and open water.

Functional guild – A group of organisms that are considered influential in providing particular ecosystems services. For instance, freshwater mussel species as well as net-spinning caddis flies may improve water quality by filtering a wide array of suspended particles and nutrients such as ammonia and nitrates from the water column, and converting it to animal biomass.

GIS – Acronym for Geographic Information System. An integrated collection of computer software and data used to view and manage information about geographic places, analyze spatial relationships, and model spatial processes. Provides a framework for gathering and organizing spatial data and related information for display and analysis.

Groundwater – Water located beneath the ground surface in soil pore spaces and in the fractures of geologic formations.

Guild – An association of animals with similar food and reproductive habits, and habitat use.

Habitat – Area in which natural functions provide the necessary food, water, shelter and space for a system of plants, animals, and other organisms to live.

Habitat enhancement – Manipulation of the physical, chemical, or biological characteristics of a site to heighten, intensify, or improve specific functions.

Habitat establishment – Manipulation of the physical, chemical, or biological characteristics present to create and maintain habitat that did not previously exist on the site.

Habitat improvement – On-the-ground restoration, enhancement, establishment or protective action to restore or artificially provide physiographic, hydrological, or disturbance conditions necessary to establish or maintain native plant and animal communities.

Habitat maintenance – Manipulation of the physical, chemical, or biological characteristics of an existing, functioning habitat to preserve or continue the efficacy of specific functions.

Habitat restoration – Manipulation of the physical, chemical, or biological characteristics of a site to return some or all of its natural and historic functions.

Horticulture – The science and art of growing fruits, vegetables, flowers, or other plants.

Hydrologic – Having to do with the properties, distribution, and circulation of water on the surface of the land, in soil and underlying rocks, and in the atmosphere.

Hydrology – The science of dealing with the properties, distribution, and circulation of water on the surface of land, in soil and underlying rocks, and in the atmosphere.

Hypoxic – State of having too little oxygen in the tissues or water for normal metabolism or a healthy ecosystem.

Impaired – Made worse or diminished in some respect. Relative to aquatic systems, a particular waterbody has been negatively impacted so that it does not meet its designated use of fishable, swimmable, or some other criterion.

Imperiled species – Species of concern, species of greatest conservation need, a population of a species that is in danger of disappearing due to a variety of circumstances.

Impervious – Refers to material through which water cannot pass or passes with great difficulty.

Impoundment – A natural or artificial body of water that is confined by a structure such as a dam to retain water, sediment or wastes.

Integrated – Incorporated or melding various parts into a cohesive, larger unit. Unified.

Integrity – The unimpaired condition of a habitat or environment.

Interim – An intervening period of time, not final.

Interjurisdictional – Between political jurisdictions. A species, area, or responsibility shared among various state, federal or other public entities.

Intertidal flats – That portion of the sea bottom between high and low tide lines with a very slight gradient. Depending on tidal amplitude and slope of the bottom, intertidal flats may be narrow or wide.

Invasive species – Any nonindigenous species, including its seeds, eggs, spores, or other biological material, propagating or able to propagate in a specific ecosystem, whose introduction does or is likely to cause economic or environmental harm or harm to human health.

Karst –Terrain usually formed on carbonate rock where groundwater has made openings to form a subsurface drainage system. Caves with standing or moving water.

Lacustrine habitat – All habitats situated in a lake, depression or dammed channel, lacking trees, shrubs, persistent emergent plants, emergent mosses or lichens with greater than 30% aerial coverage. Total area usually exceeds 20 acres. Waters may be tidal or nontidal, but always less than .05% salinity.

Lentic – An aquatic system with standing or slow flowing water such as a lake, pond, reservoir or wetland, with a nondirectional net flow of water.

Levee – A natural or artificial embankment or earthen dike, which parallels the course of a river.

Lotic – An aquatic system with flowing water such as a brook, stream or river, with unidirectional net flow of water from headwater to mouth.

Marine – Of or relating to the sea and saltwater.

Marsh – A wetland with emergent vegetation, and located in zones progressing from terrestrial habitat to open water. May be dominated by either salt or freshwater.

Metrics – Standard units of measure for certain characteristics of habitat, biota, organization or function.

Morphology – Physical attributes of a waterbody.

Native – Plant or animal species that occur naturally in aquatic or terrestrial habitats.

Niche – Ecological position of an organism within its community or ecosystem that results from the organism's structural adaptations, physiological responses, and specific behavior.

Nitrification – The process of binding gaseous atmospheric nitrogen to soil or water, usually by conversion into ammonia or nitrate. Nitrification is an important step in the nitrogen cycle.

Nonindigenous – An organisms that is not native to a particular waterbody, basin, or region. Non-native.

Nutrient – Element or compound essential for growth, development, and life for living organisms.

Organic – Of biological origin.

Palustrine habitat –Any inland wetland which lacks flowing water and contains ocean-derived salts in concentrations of less than .05%. Inland marsh, swamp, bog, fen, tundra or floodplain.

Parasites – An animal or plant that lives in or on a host (another animal or plant) and obtains nourishment from the host without benefiting or killing it.

Partner – Any entity that voluntarily participates with another on a project.

Parts per million (ppm) – A unit of concentration equal to a number of parts of one substance in one million parts of the solution. One ppm equals 0.283 gallons/cubic foot, 0.0038 grams/gallon, 2.72 pounds/acre foot, and one milligram/liter.

Pathogens – An organism that causes disease in another organism.

Pesticide – any chemical used to control populations or organisms that are undesirable to humans.

Pollutant – a chemical or waste product contaminating the air, soil, or water.

Preservation – Protection of ecologically important aquatic resources in perpetuity through the implementation of appropriate legal and physical mechanisms.

Priorities – Most critical geographic and or habitat areas, sometimes described in species-related terms.

Productivity – (1) Capacity or ability of an environmental unit to produce organic materials. (2) Rate of formation of new tissue or energy use by one or more organisms.

Reservoir – Anything used to store water with easy access for addition or removal. Most often, it is an artificial lake, created by a dam.

Resource – (1) A living or non-living substance of value to humans. Often classified as renewable (fish, forest, water, etc.) or nonrenewable (minerals, fossil fuels, etc., that cannot sustain a rate of formation relative to human use).

Riparian – Pertaining to, situated or dwelling on the margin of a river or other waterbody.

Riparian corridor – Area between the topographic floodplain banks of a flowing waterbody, excluding the stream channel.

Runoff – surface water from rain, snow melt and other sources that flows overland and into waterbodies.

Saltwater – Water containing dissolved salts, especially salts of alkali metals or magnesium.

Saline – Consisting of or containing salt, especially relating to the salts of alkali metals or magnesium.

Sediment – Particulate matter, especially loose pieces of mineral and rock that may be carried by flowing water, settled in benthic areas, or suspended in a water column.

Siltation – Settling of fine, suspended sediments in water where water velocity is reduced.

Species – A classification of individual organisms with common attributes, which actually or potentially interbreed.

Species of concern –A species that might be in need of conservation action.

Sprawl – Growth of an urban area that is unplanned and uncontrolled.

Stakeholder – A person or group of people having direct interest, involvement, or investment in an issue or resource.

Subsidence – Lowering of surface elevations caused by loss of support and subsequent settling or caving of subsurface materials.

Substrate – Mineral and organic material forming the bottom of a waterway or waterbody.

Sustainability – The continuity of economic, social, institutional and environmental aspects of human society to meet their needs and express their greatest potential in the present, while preserving biodiversity and natural ecosystems, and planning and acting for their maintenance in the long term.

Swamp – A wetland dominated by woody plants.

Target – Desired quantitative and/or qualitative result of restoration, conservation, or maintenance actions.

Terrestrial – Belonging to, or living on, land, the ground or earth.

Threatened species – Any animal or plant species likely to become endangered within the foreseeable future throughout all or a significant portion of its range.

Toxicity – Quality, state, or degree of a harmful effect in organisms that results from alteration of natural environmental conditions.

Urbanization – Increase over time of the population and extent of cities and towns.

Water – A binary compound that occurs at room temperature as a clear, colorless, odorless, tasteless liquid, freezing into ice below 0 degrees C. and boiling above 100 degrees C.

Water quality – Description of the chemical, physical and biological characteristics of water in an aquatic area or waterbody, usually in relation to its uses or suitability for a particular purpose.

Waterbody – Any area with water flowing or standing above ground to the extent that evidence of an ordinary high water mark is established in any normal year. It can be a stream, river, lake, spring, backwater, bayou, creek, ocean, bay, pond, or wetland.

Watershed –The catchment basin bounded by ridges, from which the waters of a stream, marsh, river, lake or groundwater system are drawn.

Watershed connectivity – Spatial and temporal connections for aquatic and riparian species within and between watersheds that provide physically, chemically and biologically unobstructed movement for their survival, migration and reproduction.

Wetland – Land areas containing much soil moisture, usually poorly drained, and characterized by hydrophytic vegetation, and hydric soils. The land area may have permanent or periodic inundation by water or prolonged soil saturation generally resulting in anaerobic soil conditions.

FISHERY ECOSYSTEM PLAN
OF THE SOUTH ATLANTIC REGION

VOLUME VI: REFERENCES

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ABBREVIATIONS AND ACRONYMS

ABC	Acceptable Biological Catch
ACCSP	Atlantic Coastal Cooperative Statistics Program
APA	Administrative Procedures Act
AUV	Autonomous Underwater Vehicle
B	A measure of stock biomass either in weight or other appropriate unit
B_{MSY}	The stock biomass expected to exist under equilibrium conditions when fishing at F_{MSY}
B_{OY}	The stock biomass expected to exist under equilibrium conditions when fishing at F_{OY}
B_{CURR}	The current stock biomass
CEA	Cumulative Effects Analysis
CEQ	Council on Environmental Quality
CFMC	Caribbean Fishery Management Council
CPUE	Catch per unit effort
CRP	Cooperative Research Program
CZMA	Coastal Zone Management Act
DEIS	Draft Environmental Impact Statement
EA	Environmental Assessment
EBM	Ecosystem-Based Management
EEZ	Exclusive Economic Zone
EFH	Essential Fish Habitat
EFH-HAPC	Essential Fish Habitat - Habitat Area of Particular Concern
EIS	Environmental Impact Statement
EPAP	Ecosystem Principles Advisory Panel
ESA	Endangered Species Act of 1973
F	A measure of the instantaneous rate of fishing mortality
$F_{30\%SPR}$	Fishing mortality that will produce a static SPR = 30%.
$F_{45\%SPR}$	Fishing mortality that will produce a static SPR = 45%.
F_{CURR}	The current instantaneous rate of fishing mortality
FMP	Fishery management plan
F_{MSY}	The rate of fishing mortality expected to achieve MSY under equilibrium conditions and a corresponding biomass of B_{MSY}
F_{OY}	The rate of fishing mortality expected to achieve OY under equilibrium conditions and a corresponding biomass of B_{OY}
FEIS	Final Environmental Impact Statement
FMU	Fishery Management Unit
FONSI	Finding Of No Significant Impact
GOOS	Global Ocean Observing System
GFMC	Gulf of Mexico Fishery Management Council
IFQ	Individual fishing quota
IMS	Internet Mapping Server
IOOS	Integrated Ocean Observing System
M	Natural mortality rate

MARMAP	Marine Resources Monitoring Assessment and Prediction Program
MARFIN	Marine Fisheries Initiative
MBTA	Migratory Bird Treaty Act
MFMT	Maximum Fishing Mortality Threshold
MMPA	Marine Mammal Protection Act of 1973
MRFSS	Marine Recreational Fisheries Statistics Survey
MSA	Magnuson-Stevens Act
MSST	Minimum Stock Size Threshold
MSY	Maximum Sustainable Yield
NEPA	National Environmental Policy Act of 1969
NMFS	National Marine Fisheries Service
NMSA	National Marine Sanctuary Act
NOAA	National Oceanic and Atmospheric Administration
NRC	National Research Council
OY	Optimum Yield
POC	Pew Oceans Commission
R	Recruitment
RFA	Regulatory Flexibility Act
RIR	Regulatory Impact Review
SAFE	Stock Assessment and Fishery Evaluation Report
SAFMC	South Atlantic Fishery Management Council
SEDAR	Southeast Data, Assessment, and Review
SEFSC	Southeast Fisheries Science Center
SERO	Southeast Regional Office
SDDP	Supplementary Discard Data Program
SFA	Sustainable Fisheries Act
SIA	Social Impact Assessment
SSC	Scientific and Statistical Committee
TAC	Total allowable catch
T_{MIN}	The length of time in which a stock could rebuild to B_{MSY} in the absence of fishing mortality
USCG	U.S. Coast Guard
USCOP	U.S. Commission on Ocean Policy
VMS	Vessel Monitoring System

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