FINAL
AMENDMENT 10 TO THE FISHERY MANAGEMENT PLAN FOR SPINY LOBSTER IN THE GULF OF MEXICO AND SOUTH ATLANTIC
Including Final Environmental Impact Statement, Regulatory Impact Review, and Regulatory Flexibility Act Analysis

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ABBREVIATIONS USED IN THIS DOCUMENT

ABC	acceptable biological catch
ACL	annual catch limit
ACT	annual catch target
AM	accountability measure
APA	Administrative Procedure Act
B	Biomass
B_{MSY}	Biomass at MSY
CEA	Cumulative Effects Analysis
CEQ	Council on Environmental Quality
CFMC	Caribbean Fishery Management Council
CFR	Code of Federal Regulations
Councils	Gulf of Mexico Fishery and South Atlantic Management Councils
CPUE	catch per unit effort
CWA	Clean Water Act
CZMA	Coastal Zone Management Act
DQA	Data Quality Act
EEZ	Exclusive Economic Zone
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
EJ	Environmental Justice
EO	Executive Order
EPA	Environmental Protection Agency
ESA	Endangered Species Act
F	instantaneous fishing mortality rate
FAC	Florida Administrative Code
FAO	Food and Agriculture Organization (United Nations)
FIS	Fishery Impact Statement
FKNMS	Florida Keys National Marine Sanctuary
FMP	fishery management plan
F_{MSY}	Fishing Mortality Rate Yielding MSY
FMU	fishery management unit
FWC	Florida Fish and Wildlife Conservation Commission
FWRI	Fish and Wildlife Research Institute
FWS	United States Fish and Wildlife Service
GC	general counsel
GMFMC	Gulf of Mexico Fishery Management Council
Gulf	Gulf of Mexico
IRFA	initial regulatory flexibility analysis
M	instantaneous natural mortality rate
Magnuson-Stevens Act	Magnuson-Stevens Fishery Conservation and Management Act
MBTA	Migratory Bird Treaty Act
MFMT	Maximum Fishing Mortality Threshold
MMPA	Marine Mammal Protection Act
mp	million pounds
MPA	Marine Protected Area
MRFSS	Marine Recreational Fishery Statistics Survey

MRIP	Marine Recreational Information Program
MSST	Minimum Stock Size Threshold
MSY	maximum sustainable yield
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOAA Fisheries	Same as NMFS
OFL	overfishing limit
OMB	Office of Management and Budget
OY	optimum yield
PRA	Paperwork Reduction Act
RA	Regional Administrator of NMFS
RFA	Regulatory Flexibility Act
RIR	regulatory impact review
RSE	restricted species endorsement
SAFMC	South Atlantic Fishery Management Council
SBA	Small Business Administration
Secretary	Secretary of Commerce
SEDAR	Southeast Data Assessment Review (stock assessment
SEFSC	Southeast Fisheries Science Center of NMFS
SFA	Sustainable Fisheries Act
SoVI	Social Vulnerability Index
SPL	saltwater products license (FL)
SPR	spawning potential ratio
SRCL	Special Recreational Crawfish License
SSB	spawning stock biomass
SSBR	spawning stock biomass per recruit
SSC	Scientific and Statistical Committee
TED	turtle excluder device
TCP	trap certification program
USCG	United States Coast Guard
VEC	valued environmental component
ww	whole weight

AMENDMENT 10 TO THE FISHERY MANAGEMENT PLAN FOR SPINY LOBSTER IN THE GULF OF MEXICO AND SOUTH ATLANTIC REGIONS

INCLUDING A FINAL ENVIRONMENTAL IMPACT STATEMENT (FEIS), REGULATORY IMPACT REVIEW (RIR), REGULATORY FLEXIBILITY ACT ANALYSIS (RFA)

Proposed actions:	Establish annual catch limits and accountability measures for Caribbean spiny lobster; remove several other species of lobster from the FMP; redefine biological reference points; update the framework process; and establish or modify other management measures.
Lead agency:	FMP Amendment – Gulf of Mexico and South Atlantic Fishery Management Councils EIS - NOAA Fisheries Service
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NOI for Amendment 10:	1/28/09 (74 FR 4943) – SAFMC 9/1/09 (74 FR 45182) – GMFMC

Scoping meetings held:	SAFMC as part of Comp. ACL Amendment (1/26/09 in Charleston, SC; 1/27/09 in New Bern, NC; 2/3/09 in Key Largo, FL; 2/4/09 in Cape Canaveral, FL and 2/5/09 in Pooler, GA) GMFMC (9/21/09 in Key West, FL and 9/22/09 in Marathon, FL)
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Abstract

Revisions to the Magnuson-Stevens Fishery Management and Conservation Act in 2006 require that fishery management plans contain annual catch limits and accountability measures for all managed species to prevent overfishing. Annual catch limits must be set at levels that prevent overfishing and do not exceed the recommendations of the respective Councils' Scientific and Statistical Committees for acceptable biological catch. Species in a fishery management plan not subject to overfishing should have annual catch limits and accountability measures effective in 2011. No species in the spiny lobster fishery management unit are known to be undergoing overfishing. Amendment 10 to the Fishery Management Plan for Spiny Lobster in the Gulf of Mexico and South Atlantic contains the following actions by the Gulf of Mexico Fishery Management Council and the South Atlantic Fishery Management Council: Removing species from the fishery management plan (i.e., smoothtail spiny lobster, spotted spiny lobster, Spanish slipper lobster, and ridged slipper lobster); defining or modifying biological reference points (i.e., maximum sustainable yield, overfishing, and overfished thresholds); considering sector allocations; specifying an acceptable biological catch control rule; setting annual catch limits and annual catch targets; establishing accountability measures; updating the framework procedure and protocol for enhanced cooperative management; modifying or removing the allowance of undersized lobsters as bait in commercial traps; modifying or removing tailing permit regulations; and determining authority to remove derelict or abandoned spiny lobster traps from federal waters off Florida. This amendment also explored two additional actions pertaining to protected resources: one was limiting fishing areas to protect threatened staghorn and elkhorn corals (*Acropora* spp.) and the other was trap line marking requirements for the commercial sector. The Councils decided to take no action in this amendment, and will address them in a separate amendment to allow more time for stakeholder input.

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Action 2: Modify the Current Definitions of Maximum Sustainable Yield, Overfishing Threshold, and Overfished Threshold for Caribbean Spiny Lobster

Action 2-1: Maximum Sustainable Yield (MSY)

Alternative 4: The MSY proxy will be the overfishing limit (OFL) recommended by the Gulf SSC at 7.90 million pounds.

Action 2-2: Overfishing Threshold (Maximum Fishing Mortality Threshold)

Alternative 3: Specify the MFMT as the OFL defined by the Gulf SSC at 7.90 million pounds.

Action 2-3: Overfished Threshold (Minimum Stock Size Threshold)

Alternative 3: MSST = (1-M) x B_{MSY}. Definitions: M = instantaneous natural mortality and B_{MSY} = biomass at maximum sustainable yield or the appropriate proxy.

Action 3: Establish Sector Allocations for Caribbean Spiny Lobster in State and Federal Waters from North Carolina through Texas

Alternative 1: No action – Do not establish sector allocations.

Action 4: Acceptable Biological Catch (ABC) Control Rule, ABC Level(s), Annual Catch Limits, and Annual Catch Targets for Caribbean Spiny Lobster

Action 4-1: Acceptable Biological Catch (ABC) Control Rule

Alternative 2: Adopt the following ABC Control rule: **Option b**: the Gulf Council's ABC control rule.

Action 4-2: Set Annual Catch Limits (ACLs) for Caribbean Spiny Lobster

Alternative 2: Set an ACL for the entire stock based on the ABC: **Option a:** ACL = ABC = (7.32 million pounds).

Action 4-3: Set Annual Catch Targets (ACTs) for Caribbean Spiny Lobster

Alternative 2: Set an ACT for the entire stock. **Option a:** ACT = OY = 90% of ACL (6.59 million pounds).

Action 5: Accountability Measures (AMs) by Sector

Alternative 4: Establish the ACT as the accountability measure for Caribbean spiny lobster (ACT = 6.59 million pounds).

Action 6: Develop or Update a Framework Procedure and Protocol for Enhanced Cooperative Management for Spiny Lobster

Alternative 2: Update the current Protocol for Enhanced Cooperative Management.

Alternative 4: Revise the current Regulatory Amendment Procedures to create an expanded Framework Procedure: **Option a:** Adopt the base Framework Procedure

Action 7: Modify Regulations Regarding Possession and Handling of Short Caribbean Spiny Lobsters as "Undersized Attractants"

Alternative 4: Allow undersized spiny lobster not exceeding 50 per boat and 1 per trap aboard each boat if used exclusively for luring, decoying or otherwise attracting non-captive spiny lobsters into the trap

Action 8: Modify Tailing Requirements for Caribbean Spiny Lobster for Vessels that Obtain a Tailing Permit

Alternative 3: Revise the current regulations to clearly state that all vessels must have either 1) a valid federal spiny lobster permit or 2) a valid Florida Restricted Species Endorsement and a valid Crawfish Endorsement associated with a valid Florida Saltwater Products License to obtain a tailing permit.

Alternative 4: All Caribbean spiny lobster landed must either be landed all “whole” or all “tailed”.

Action 9: Limit Spiny Lobster Fishing in Certain Areas in the EEZ off Florida to Protect Threatened Staghorn and Elkhorn Corals (*Acropora* spp.)

Alternative 1: No Action – Do not limit spiny lobster fishing in certain areas in the EEZ off Florida to address ESA concerns for *Acropora* spp.

Action 10: Require Gear Markings so all Spiny Lobster Trap Lines in the EEZ off Florida are Identifiable

Alternative 1: No Action – Do not require gear marking measures for spiny lobster trap lines.

Action 11: Authority to Remove Derelict or Abandoned Spiny Lobster Traps Found in the EEZ off Florida

Alternative 6: Delegate authority to regulate the removal of derelict or abandoned spiny lobster traps occurring in the EEZ off Florida to FWC.

EXECUTIVE SUMMARY of SPINY LOBSTER AMENDMENT 10

EXECUTIVE SUMMARY

The Gulf of Mexico and South Atlantic Fishery Management Councils (Councils) are developing regulations to bring the spiny lobster fishery management plan into compliance with new requirements of the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act) and to meet requirements of the Endangered Species Act. The Spiny Lobster fishery management plan is jointly managed by the Councils. The regulations are expected to be implemented in 2012.

This document is intended to serve as a SUMMARY for all the actions and alternatives in Spiny Lobster Amendment 10/Environmental Impact Statement. It outlines the alternatives with a focus on the preferred alternatives. It also provides background information and includes a summary of the expected biological and socio-economic effects from the management measures.

Table of Contents for the Summary

BACKGROUND

What Actions Are Being Proposed?

The Councils are specifying, where applicable, the following for many managed species:

- changes to the species composition of the fishery management plan;
- control rules for acceptable biological catch;
- annual catch limits;
- annual catch targets;
- allocations; and,
- accountability measures

Who is Proposing the Action?

Councils are proposing the actions. The Councils develop the amendments and submit them to NOAA Fisheries Service who ultimately approves, disapproves, or partially approves the actions in the amendment on behalf of the Secretary of Commerce (Secretary). NOAA Fisheries Service is an agency in the National Oceanic and Atmospheric Administration.

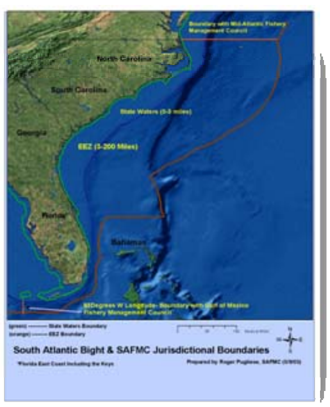
Gulf of Mexico & South Atlantic Fishery Management Councils

- Responsible for conservation and management of fish stocks
- Consist of 13-17 voting members who are appointed by the Secretary of Commerce
- Management area is from 3 to 200 miles off the coasts of North Carolina through Texas; 9-200 miles off Florida West Coast & Texas.
- Responsible for developing fishery management plans and recommends regulations to NOAA Fisheries Service for implementation

Where is the Project Located?

Management of the federal spiny lobster fishery located in the South Atlantic and Gulf of Mexico in the 3-200 nautical mile (nm) (9-200 nm off Florida West Coast & Texas) U.S. Exclusive Economic Zone (EEZ) is conducted under the Fishery Management Plan (FMP) for the Spiny Lobster Fishery in the Gulf of Mexico and South Atlantic Regions (GMFMC/SAFMC 1982) (**Figure 1-1**).

Figure 1-1. Jurisdictional boundary of the South Atlantic Fishery Management Council.



Why are the Councils Considering Action?

The Magnuson-Stevens Act requires the Regional Fishery Management Councils and NOAA Fisheries Service to prevent overfishing while achieving optimum yield from each fishery. When it is determined a stock is undergoing overfishing, measures must be implemented to end overfishing. In cases where stocks are overfished, the Councils and NOAA Fisheries Service must implement rebuilding plans. Revisions to the Magnuson-Stevens Act in 2006 require that in 2010, FMPs for fisheries determined by the Secretary to be subject to overfishing establish a mechanism for specifying annual catch limits (ACLs) at a level that prevents overfishing and does not exceed the recommendations of the respective Council's Scientific and Statistical Committee (SSC) or other established peer review processes. These FMPs must also establish, within this timeframe, measures to ensure accountability. ACLs and measures to ensure accountability must be implemented in 2011 for most other fisheries. The Councils are addressing the lobster species in this amendment.

Which Species Will Be Affected ?

These actions would apply to the following species:

- Caribbean spiny lobster, *Panulirus argus*
- smoothtail spiny lobster**,** *Panulirus laevicauda*
- spotted spiny lobster, *Panulirus guttatus*
- Spanish slipper lobster, *Scyllarides aequinoctialis*
- ridged slipper lobster, *Scyllarides nodifer*

CATEGORIES OF ACTIONS

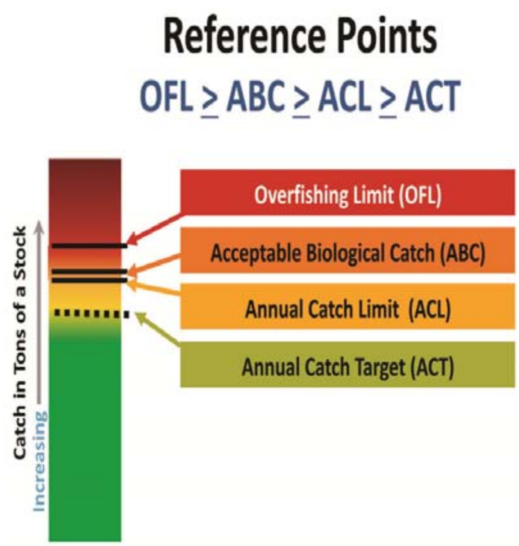
There are six categories of actions in Spiny Lobster Amendment 10.

Changes to the Species Composition of the Fishery Management Plan

The Council is considering removing species from the Spiny Lobster Fishery Management Plan.

Control Rules for Acceptable Biological Catch

Acceptable Biological Catch (ABC) is the range of estimated allowable catch for a species of species group. *ABC Control Rule* is a policy for establishing a limit or target fishing level that is based on the best available scientific information and is established by fishery managers in consultation with fisheries scientists. Control rules should be designed so that management actions become more conservative as biomass estimates, or other proxies, for a stock or stock complex decline, and as science and management uncertainty increases.



Annual Catch Limits

Annual catch limit (ACL) is the level of catch that triggers accountability measures. It is expressed either in pounds or numbers of fish. The level may not exceed the ABC.

Annual Catch Targets

Annual catch target (ACT) is an amount of annual catch of a stock or stock complex that is the management target of the fishery, and accounts for management uncertainty in controlling the actual catch at or below the ACL. Annual catch targets are recommended in the system of accountability measures so that ACL is not exceeded.

Sector Allocations

Allocation is distribution of the opportunity to fish among user groups or individuals. The share a user group gets is sometimes based on historic harvest amounts.

Accountability Measures

Accountability measure (AM) is an action taken to keep catch below or to avoid exceeding an identified catch level (usually the ACL). The following are four AMs: specification of an ACT, in-season regulations changes, post-season regulation changes, and specification of management measures (e.g., bag limits).

Purpose and need of the proposed action

The *purpose* of Amendment 10 is to:

- bring the Spiny Lobster FMP into compliance with Magnuson-Stevens Act requirements for ACLs and AMs to prevent overfishing;
- update biological reference points, policies, and procedures; and
- consider adjustment of management measures to aid law enforcement and comply with measures to protect endangered species.

The *need* for the action is to keep the Caribbean spiny lobster stock at a level that will produce optimum yield. Optimum yield, the ultimate goal of any fishery, is the level of harvest that provides the greatest economic, social, and ecological benefit to the nation.

List of Management Actions

There are 11 *actions* in Amendment 10 that will address the purpose and need.

Action 1: Other species in the Spiny Lobster FMP
Action 2: Modify the current definitions of Maximum Sustainable Yield, Overfishing Threshold, and Overfished Threshold for Caribbean Spiny Lobster
  Action 2-1: Maximum Sustainable Yield (MSY)
  Action 2-2: Overfishing Threshold (MFMT)
  Action 2-3: Overfished Threshold (MSST)
Action 3: Establish sector allocations for Caribbean Spiny Lobster in State & Federal waters from North Carolina through Texas
Action 4: Acceptable Biological Catch Control Rule, ABC Level(s), Annual Catch Limits, and Annual Catch Targets for Caribbean Spiny Lobster
  Action 4-1: Acceptable Biological Catch (ABC) Control Rule
  Action 4-2: Set Annual Catch Limits (ACLs) for Caribbean Spiny Lobster
  Action 4-3: Set Annual Catch Targets (ACTs) for Caribbean Spiny Lobster
Action 5: Accountability Measures (AMs) by Sector
Action 6: Develop or Update a Framework Procedure and Protocol for enhanced cooperative management for Spiny Lobster
Action 7: Modify regulations regarding possession and handling of short Caribbean Spiny Lobsters as "Undersized Attractants"
Action 8: Modify tailing requirements for Caribbean Spiny Lobster for vessels that obtain a tailing permit

The following Actions address Endangered Species Act considerations:

Action 9: Limit Spiny Lobster fishing in certain areas in the EEZ off Florida to protect threatened Staghorn and Elkhorn corals (*Acropora* spp.)
Action 10: Require gear markings so all spiny lobster trap lines in the EEZ off Florida are identifiable
Action 11: Authority to remove derelict or abandoned spiny lobster traps found in the EEZ off Florida

Spiny Lobster Distribution

From left to right: Caribbean spiny lobster, smoothtail spiny lobster, and spotted spiny lobster.

The Caribbean spiny lobster is widely distributed throughout the western Atlantic Ocean as far north as North Carolina to as far south as Brazil including Bermuda, the Bahamas, Caribbean, and Central America. DNA analyses indicate a single stock throughout its range. This species inhabits shallow waters, occasionally as deep as 295 ft (90 m), possibly even deeper. They live among rocks, on reefs, in grass beds or in any habitat that provides protection. The species is gregarious and migratory. Maximum total body length recorded is 18 inches, but the average total body length is 8 inches. Distribution and dispersal is determined by the long free-floating larval phase (up to 9 months) until they settle to the bottom.

ACTIONS IN THE SPINY LOBSTER FISHERY MANAGEMENT PLAN

1. Removing Species from FMP

Action 1 (Species in Unit) Alternatives
Alternative 1: No Action – Retain the following species: smoothtail spiny lobster**,** *Panulirus laevicauda,* spotted spiny lobster, *Panulirus guttatus,* Spanish slipper lobster, *Scyllarides aequinoctialis,* in the Fishery Management Plan for data collection purposes only, but do not add them to the Fishery Management Unit. **Alternative 2:** Set annual catch limits and accountability measures using historical landings for Spanish slipper lobster *Scyllarides aequinoctialis,* after adding them to the Fishery Management Unit and for ridged slipper lobster, *Scyllarides nodifer*, currently in the Fishery Management Unit. **Alternative 3:** List species as ecosystem component species: **Option a:** smoothtail spiny lobster**,** *Panulirus laevicauda* **Option b:** spotted spiny lobster, *Panulirus guttatus* **Option c:** Spanish slipper lobster, *Scyllarides aequinoctialis* **Option d:** ridged slipper lobster, *Scyllarides nodifer* **Preferred Alternative 4:** Remove the following species from the Joint Spiny Lobster FMP: **Preferred Option a:** smoothtail spiny lobster**,** *Panulirus laevicauda* **Preferred Option b:** spotted spiny lobster, *Panulirus guttatus* **Preferred Option c:** Spanish slipper lobster, *Scyllarides aequinoctialis* **Preferred Option d:** ridged slipper lobster, *Scyllarides nodifer*

The preferred alternative would remove species based on the following criteria:

(1) Low landings
(2) Not heavily targeted; some landed as bycatch in shrimp fishery
(3) Under State of Florida Regulations – more conservative than federal

Five species are in the Spiny Lobster FMP, but only two species (Caribbean spiny lobster and ridged slipper lobster) currently have regulations and are within the fishery management unit. After many discussions the Councils determined that federal management of these four lobster species was no longer necessary. The Councils felt that the State of Florida could provide adequate if not better protection for these species compared to the current federal management plan. The Councils are also concerned that the requirement for ACLs and AMs for some species will create a significant administrative burden to science and the administrative environment as landings are minimial and variable over time. In addition, little biological or landings data are available for many of these species causing problems specifying ACLs.

Removal

Common Name	Scientific Name
Caribbean spiny lobster	*Panulirus argus*
Smoothtail spiny lobster	*Panulirus laevicauda*
Spotted spiny lobster	*Panulirus guttatus*
Spanish slipper lobster	*Scyllarides aequinoctialis*
Ridged slipper lobster	*Scyllarides nodifer*

Impacts from Action 1 (Species in the FMP)

Biological

Alternative 1 would not meet the National Standard 1 guidelines and would have the same impacts to the physical or biological environments as currently exist. **Alternative 2** would be expected to have positive impacts on the physical and biological environments if catch is constrained below current levels. **Alternative 3** impacts would be the same as currently exist, unless new data collection programs are developed. **Preferred Alternative 4** would remove all of the lobster species other than Caribbean spiny lobster from the FMP. If other agencies, such as the individual states, took over management, positive physical and biological impacts could occur. In particular, Florida regulations concerning the taking of egg-bearing females, or stripping or removing eggs, are more conservative than federal regulations for most of these species.

Economic

Under **Alternative 1,** all status quo management conditions and related operation of the fishery, and associated economic benefits, would remain unchanged. The economic benefit for **Alternative 2** is estimated by the ex-vessel value of $24,232 which could be reduced to zero under **Alternatives 1, 3** or **4.** Among the options for **Alternative 3**, the ex-vessel value of landings of Scyllarid lobsters could decline by as much as $24,232 per year. This amount represents the estimated economic impact of **Alternative 3, Option c** and **Option d** together, when compared with **Alternative 1**. The economic impact of **Alternative 3, Option a,** or **Alternative 3, Option b**, is not known, but assumed to be less. It assumed that the economic impacts of **Alternatives 3-4** are essentially the same.

Social

Alternative 1 would have little impact on the social environment but likely require ACLs and AMs for all species in the plan. Setting ACLs and AMs in **Alternative 2** would likely have an impact on the social environment depending upon the thresholds selected and the measures that were implemented to account for any overages for little used species. Listing species as ecosystem components as in **Alternative 3** or removing species from the FMP as in **Preferred Alternative 4** would likely have few social impacts unless one or more of the **Preferred Options a-d** were not selected. Leaving any species in the FMP would require ACLs and AMs be set. Because landing information on these species is imprecise, setting an ACL and subsequent AMs would be problematic and could cause some social disruption and changes in fishing behavior if thresholds were set at such a level that would affect current harvesting patterns or linked to harvest of other species.

Administrative

Alternative 1 would not meet the requirements of the Magnuson-Stevens Act, and could leave NOAA Fisheries Service and the Councils subject to litigation, which would result in a significant administrative burden. Specifying an ACL alone (**Alternative 2**) would not increase the administrative burden over the status-quo. However, the monitoring and documentation needed to track the ACL could result in a need for additional cost and personnel resources because a monitoring mechanism is not already in place. After the ACL is specified, the administrative burden associated with monitoring and enforcement, implementing management measures, and accountability measures would increase. **Alternative 3** would eliminate the administrative burden associated with establishing ACLs and AMs for those species. **Preferred Alternative 4** would remove species from the FMP, resulting in less administrative burden with regards to establishing ACLs and AMs.

2. Modify Maximum Sustainable Yield, Overfishing, and Overfished

The Councils are considering separate alternatives for these 3 actions.

Action 2-1 (Maximum Sustainable Yield) Alternatives

Alternative 1: No Action- Use the current definitions of MSY as a proxy. The Gulf of Mexico approved definition**:** MSY is estimated as 12.7 million pounds annually for the maximum yield per recruit size of 3.5 inch carapace length. The South Atlantic approved definition: MSY is defined as a harvest strategy that results in at least a 20% static SPR (spawning potential ratio).

Alternative 2: Modify the Gulf of Mexico definition to mirror the South Atlantic definition of MSY proxy, defined as 20% static SPR.

Alternative 3: the MSY equals the yield produced by fishing mortality at maximum sustainable yield (F_{MSY}) or proxy for F_{MSY}. Maximum sustainable yield will be defined by the most recent SEDAR and joint Scientific and Statistical Committee processes.

Preferred Alternative 4: the MSY proxy will be the Overfishing Limit (OFL) recommended by the Gulf of Mexico Scientific and Statistical Committee at 7.90 million pounds.

Action 2-2 (Overfishing Threshold) Alternatives

Alternative 1: No Action - Use the current definitions of overfishing thresholds. The Gulf and South Atlantic approved definition: overfishing level as a fishing mortality rate (F) in excess of the fishing mortality rate at 20% static SPR ($F_{20\%}$ static SPR).

Alternative 2: Specify the Maximum Fishing Mortality Threshold (MFMT) as F_{MSY} or F_{MSY} proxy. The most recent SEDAR and joint Scientific and Statistical Committees will define F_{MSY} or F_{MSY} proxy. This should equal the Overfishing Limit (OFL) provided by the Scientific and Statistical Committees (SSCs). The Councils will compare the most recent value for the current fishing mortality rate (F) from the SEDAR/SSC process to the level of fishing mortality that would result in overfishing (MFMT) and if the current F is greater than the MFMT, overfishing is occurring. Comparing these two numbers:

- $F_{CURRENT}$/MFMT = X.XXX

*This comparison is referred to as the **overfishing ratio**. If the ratio is greater than 1, then overfishing is occurring.

Preferred Alternative 3: Specify the Maximum Fishing Mortality Threshold (MFMT**)** as the Overfishing Limit (OFL) defined by the Gulf of Mexico Scientific and Statistical Committee at 7.90 million pounds.

Action 2-3 (Overfished Threshold) Alternatives

Alternative 1: No Action – Do not establish an overfished threshold. The Gulf Council does not have an approved definition of the overfished threshold. The South Atlantic Council approved definition is a framework procedure to add a biomass based component to the overfished definition, due to no biomass levels and/or proxies being available.

Alternative 2: The MSST is defined by the most recent SEDAR and joint Scientific and Statistical Committees process. The Councils will compare the current spawning stock biomass (SSB) from the SEDAR and Scientific and Statistical Committees process to the level of spawning stock biomass that could be rebuilt to the level to produce the MSY in 10 years. Comparing these two numbers:

- $SSB_{CURRENT}$/MSST = Y.YYY

This comparison is referred to as the **overfished ratio**. If the ratio is less than 1, then the stock is overfished.

Preferred Alternative 3: The MSST = (1-M) x B_{MSY}.

Maximum Sustainable Yield (MSY)

Largest long-term average catch or yield that can be taken from a stock or stock complex under prevailing ecological and environmental conditions.

- The Councils must specify MSY or MSY proxy.
- MSY for Caribbean spiny lobster cannot be calculated until a Caribbean-wide assessment is conducted. Therefore, a proxy must be used.
- A proxy is a placeholder until sufficient data become available to estimate MSY.
- Preferred MSY proxy = 7.90 million pounds

Overfishing

- None now
- Overfishing is occurring if landings exceed 7.90 million pounds

Impacts from Action 2 (Modify Maximum Sustainble Yield, Overfishing, and Overfished)

Biological

Alternative 1 under all actions could have negative impacts to the physical and biological/ecological environment, due to the biological reference points being inconsistent between the two Councils. Due to the Caribbean spiny lobster fishery being a jointly managed species, now may be the best time for the Councils to adopt the same biological reference points in this full amendment. The Councils currently have an approved definition for the overfishing threshold (**Action 2-2**). Consistency between Councils when establishing biological reference points would be more beneficial for the physical and biological environments. **Alternative 3** under Action 2-1 (MSY) and **Alternatives 2** under Action 2-2 (Overfishing Threshold) and Action 2-3 (Overfished Threshold) would modify all biological determination criteria from the current definitions to those from the most recent SEDAR and SSC processes. However, because the most recent stock assessment was not accepted due to external recruitment from other Caribbean populations, these alternatives may not provide the best protection to the resource. **Preferred Alternative 4** (Action 2-1) provides the best protection of the resource because the 2010 update assessment was rejected. **Preferred Alternative 3** under Action 2-2 (MFMT) is based on Caribbean spiny lobster landings and may provide the best protection of the resource and thereby the biological and ecological environments. However, without a clear estimate of Caribbean spiny lobster biomass, it is unknown if **Alternatives 2** or **3** under Action 2-3 (Overfished Threshold) would provide the best protection for the resource and various subsequent negative and positive impacts to the biological and ecological environments.

Economic

Defining the MSY, MFMT, and MSST of a species does not alter the current harvest or use of the resource. Since there would be no direct effects on resource harvest or use, there would be no direct effects on fishery participants, associated industries, or communities.

Social

The setting of MSY for Caribbean spiny lobster is primarily a biological threshold that may impact the social environment depending upon where the threshold is set. **Alternative 1** would likely have few impacts as it uses the present definition. **Alternative 2** and **Alternative 3** could have impacts if the threshold is well below current landing levels, although it is likely that **Alternative 2** would not change that threshold substantially. The **Preferred Alternative 4**, which uses the MSY proxy recommended by the SSC, may have few negative social effects if the threshold is above the mean landings and not substantially reduced by other management action.

Administrative

There could be additional administrative burdens, if the biological reference points are not modified for consistency. Changing these biological reference points is required under the Magnuson-Stevens Act, and if not done, could leave NOAA Fisheries Service and the Councils subject to litigation, which would result in a significant administrative burden.

3. Sector Allocations

The Councils are evaluating allocating the Annual Catch Limit (ACL) by recreational and commercial sectors. This can be helpful in preventing the total ACL from being exceeded.

Action 3 (Sector Allocation) Alternatives
Preferred Alternative 1: No action – Do not establish sector allocations.
Alternative 2: Allocate the spiny lobster ACL by the following sector allocations: 80% commercial and 20% recreational.
Alternative 3: Allocate the spiny lobster ACL by the following sector allocations: 74% commercial and 26% recreational.
Alternative 4: Allocate the spiny lobster ACL by the following sector allocations: 78% commercial and 22% recreational.
Alternative 5: Allocate the spiny lobster ACL by the following sector allocations: 77% commercial and 23% recreational.
Alternative 6: Allocate the spiny lobster ACL by the following sector allocations: 76% commercial and 24% recreational.

Impacts from Action 3 (Sector Allocations)

Biological

Allocating the ACL between the recreational and commercial sectors would have no direct effect on the physical and biological/ecological environments.

Economic

The sector allocations under Action 3 have no application in Amendment 10 apart from ACL and ACT alternatives under Action 4 and that is where they are analyzed.

Social

By establishing sector allocations there would likely be some changes in fishing behavior and impacts to the social environment. The mere act of separating the ACL into two sector ACLs has the perception of creating scarcity in that limits have been imposed on each individual sector. **Preferred Alternative 1** provides an overall ACL which would allow for harvest to freely flow between the commercial and recreational sectors as it has in the past so would have few if any negative social effects. **Alternatives 2** and **4** would provide an increase in allocation to the commercial sector and subsequent reduction to the recreational, while **Alternative 3** would provide an increase to the recreational sector. **Alternatives 5** and **Alternative 6** both provide increases to the recreational sector, although smaller than previous alternatives. So, in all cases, it would be expected that there may be negative social effects to whichever sector receives less than their current allocation and those effects would correspond to the amount of reduction.

Administrative

Sector allocations (**Alternatives 2-6)** would increase the burden on the administrative environment because two ACLs or ACTs would need to be monitored rather than one, as in **Preferred Alternative 1**. There are no administrative impacts from allocating among the commercial and recreational sectors other than preparation of the amendment document and notices.

Why the preferred alternative would not establish sector ACLs:

1) ACL expected to be below recent landings
2) No data system for recreational sector
3) Commercial landings are not tracked in timely fashion for in–season quota monitoring

4. ABC Control Rule/ABC, ACLs, & ACTs

The Councils are considering separate alternatives for these requirements.

Action 4-1 (Allowable Biological Catch Control Rule) Alternatives

Alternative 1: No Action – Do not establish an ABC Control Rule for spiny lobster.

Preferred Alternative 2: Adopt the following ABC Control rule:
- **Option a**: the South Atlantic Council's ABC control rule.
- **Preferred Option b**: the Gulf Council's ABC control rule (7.32 million pounds).

Alternative 3: Establish an ABC Control Rule where ABC equals OFL.

Alternative 4: Specify ABC as equal to the mean of the last 10 years landings.

Alternative 5: Specify ABC as equal to the high of the last 10 years landings.

Alternative 6: Specify ABC as equal to the low of the last 10 years landings.

Action 4-2 (Annual Catch Limits) Alternatives

Alternative 1: No Action – Do not set Annual Catch Limits.

Preferred Alternative 2: Set an Annual Catch Limit for the entire stock based on the Acceptable Biological Catch:
- **Preferred Option a:** Annual Catch Limit = Acceptable Biological Catch (7.32 mp).
- **Option b:** Annual Catch Limit = 90% of Acceptable Biological Catch (6.59 mp).
- **Option c:** Annual Catch Limit = 80% of Acceptable Biological Catch (5.86 mp).

Alternative 3: Set Annual Catch Limits for each sector based on allocations determined in Action 3:
- **Option a:** Annual Catch Limit = (sector allocation x Acceptable Biological Catch).
- **Option b:** Annual Catch Limit = 80% or 90% of (sector allocation x Acceptable Biological Catch).
- **Option c:** Annual Catch Limit = sector allocation x (80% or 90% x% of Acceptable Biological Catch).

Action 4-3 (Annual Catch Target) Alternatives

Alternative 1: No Action – Do not set Annual Catch Targets.

Preferred Alternative 2: Set an Annual Catch Target for the entire stock.
- **Preferred Option a:** Annual Catch Target = OY = 90% of ACL (6.59 mp).
- **Option b:** Annual Catch Target = OY = ACL (7.32 mp).
- **Option c**: Annual Catch Target = 6.0 million pounds.

Alternative 3: Set Annual Catch Targets for each sector based on allocations from Action 3.
- **Option a:** Annual Catch Target = OY = (sector allocation x Annual Catch Limit).
- **Option b:** Annual Catch Target = OY = 90% of (sector allocation x Annual Catch Limit).
- **Option c:** Annual Catch Target = OY = sector allocation x (90% of Annual Catch Limit).

Preferred Alternatives

Allowable Biological Catch (ABC) Control Rule & ABC

- OFL = 10-year mean + 2 standard deviations = 7.90 million pounds
- ABC = 10-year mean + 1.5 standard deviations = 7.32 million pounds

Annual Catch Limit (ACL)

- ACL = ABC = 7.32 million pounds

Annual Catch Target (ACT)

- ACT = 90% ACL = 6.59 million pounds

Impacts from Action 4 (ABC Control Rule/ABC, ACLs, and ACTs)

Biological

Setting an ABC control rule, ACL, or ACT could affect the physical environment if harvest changes from current levels. An ACL equal to the ABC would allow a higher level of landings than an ACL lower than the ABC. Likewise, not setting an ACT would allow a higher level of landings than setting an ACT. If the ACL is separated by sectors, accountability measures would be triggered as each sector reaches its limit. This level of control would be expected to result in greater positive impacts on the biological environment because catch would be more restricted. The preferred alternatives set an ACL and ACT higher than the recent 10-year average; therefore, no biological impacts would be expected.

Economic

Under **Alternative 1**, status quo management conditions and related operation of the fishery, and associated economic benefits, would remain unchanged, with some caveats. Given the alternatives specified in Amendment 10, however, the more traditional output-control regulations for the commercial sector (to limit landings, impose trips limits and shorten seasons) of Actions 4 and 5 may be seen as having differing, if not conflicting objectives, in that they would introduce a move away from a private market mechanism for allocating harvesting rights. The regulations for recreational fishing of Actions 4 and 5 as well as state regulations are more harmonious, if not market oriented. Regardless, the impact on economic activity associated recreational fishing of lower bag limits, early season closures, and/or shorter seasons are more difficult to quantify than are counterparts for commercial fishing.

Social

Setting an ABC Control rule, ACL or ACT can have indirect effects on the social environment, although it is difficult to know what those effects will be until a definitive number has been assigned which translates into harvest levels. Certainly, setting thresholds that adequately assess biological risk through harvest levels on stocks that are vulnerable can help stabilize landings and thereby provide long-term benefits to the fishery which should translate into positive social benefits over time. It is the short-term costs involved that often drive perceptions of negative impacts. These impacts can translate into real costs that have significant impacts to both the commercial and recreational sectors. The ABC and ACLs that have been selected through preferred alternatives in this amendment should not impose negative short term social effects and provide positive benefits over the long term as a sustainable stock should result.

Administrative

With establishment of an ACL or ACT, commercial landings may need to be included in the Southeast Fisheries Science Center's Quota Monitoring System. This system requires dealers to report landings, usually on a biweekly basis. If ACLs or ACTs are set by sector or gear, separate entries would be needed in the system.

5. Accountability Measures (AMs)

More than one alternative, option, sub-option, or combinations may be chosen as preferred.

Action 5 (Accountability Measures) Alternatives

Alternative 1: No Action – Do not set accountability measures. Currently there are no management measures in place that could be considered AMs.

Alternative 2: Establish commercial in-season accountability measures**:**

- **Option a**: close the commercial fishery when the ACL is projected to be met.
- **Option b**: implement a commercial trip limit when 75% of the commercial ACL is projected to be met.

Alternative 3: Establish post-season accountability measures:

- **Option a**: Commercial
  - **Sub-option i**: ACL payback in the fishing season following a previous years ACL overage.
  - **Sub-option ii**: Adjust the length of the fishing season following an ACL overage.
  - **Sub-option iii**: Implement a trip limit.
- **Option b**: Recreational
  - **Sub-option i**: ACL payback in the fishing season following an ACL overage. To estimate the overage, compare the recreational ACL with recreational landings over a range of years. For 2011, use only 2011 landings. For 2012, use the average landings of 2011 and 2012. For 2013 and beyond, use the most recent three-year running average.
  - **Sub-option ii**: Adjust the length of the fishing season following an ACL overage. To estimate the overage, compare recreational ACL with recreational landings over a range of years. For 2011, use only 2011 landings. For 2012, use the average landings of 2011 and 2012. For 2013 and beyond, use the most recent three-year running average.
  - **Sub-option iii**: Adjust bag limit for the fishing season following a previous seasons ACL overage.
- **Option c**: Recreational and commercial combined accountability measures
  - **Sub-option i**: Adjust season length for both recreational and commercial harvest of spiny lobster in the fishing season following an ACL overage
  - **Sub-option ii**: Recreational and commercial ACL payback in the fishing season following a previous years ACL overage (if a combined ACL is chosen).

Preferred Alternative 4: Establish the ACT as the accountability measure for Caribbean spiny lobster (6.59 million pounds).

If the ACT is exceeded the Councils will convene a review panel to determine if corrective action is necessary to prevent the ACL from being exceeded. Furthermore, if the catch exceeds the ACL more than once in the last four consecutive years, the entire system of ACLs and AMs would be re-evaluated as required by the National Standard 1 guidelines.

Prefered Alternative

Accountability Measures (AMs)

- AM = ACT = 6.59 million pounds
- If landings > 6.59 million pounds, Councils will convene a scientific review panel to determine if regulations need to change
- Framework will be used to implement changes
- NOAA Fisheries Service will work with Florida on any regulatory changes

ACT compared to Landings

- Last 10 years only exceeded in 2000/01 (7.5 mp) and 2002/03 (6.9 mp)
- Last 5 years below 6.59 mp (Table 2.4.1)
- Effort controls in place to limit catch
- Commercial = trap reduction program
- Recreational = season & bag limits
- No further regulations needed at this time
- Fishery seems to be in a period of lower landings as compared to earlier years
- If fishery productivity returns to earlier levels, and no overfishing is evident, the Councils would re-evaluate the ACT

Impacts from Action 5 (Accountability Measures)

Biological

Alternative 1 is not considered a viable option because it would specify no AM and therefore, would not limit harvest to the ACL or correct for an ACL overage if one were to occur. The Magnuson-Stevens Act requires that mechanisms of accountability be established for all federally managed species. **Alternative 2** would attempt to limit commercial harvest to levels at or below the ACL or ACT by reducing and/or closing harvest once a particular landings threshold is met for the commercial sector. The most biologically beneficial in-season AM would be a combination of **Option a** and **Option b**. **Alternative 3** includes a large suite of possible sector-specific post-season AMs that would be triggered in the event of an ACL overage. A combination of recreational and commercial AMs (**Options a** and **b**), would yield similar biological benefits when compared to **Option c**, which builds in a combination sector AMs. **Option b** alone would be the least biologically beneficial post-season AM because it does not compensate for any overages created by the commercial fishery. The biological impacts of **Preferred Alternative 4** would likely be similar to the status quo unless landings increase over recent years.

Economic

Under **Preferred Alternative 4**, the ACT of 6.59 mp exceeds the recent average landings of 5.039 mp, and would not be expected to have any economic impact, providing that sporadic instances of landings exceeding the ACL do not result in a fishery closure. This specification for the AM appears to minimize the potential for economic impact on small entities within the context of alternatives considered by the Councils for specifying sector allocations, ABC, ACL, ACT, and AM.

Social

The setting of AMs can have significant direct and indirect effects on the social environment as they usually impose some restriction on harvest. The long term effects should be beneficial as they provide protection from further negative impacts on the stock. While the negative effects are usually short term, they may at times induce other indirect effects through changes in fishing behavior.

Administrative

Alternative 1 would not produce near-term administrative impacts. However, this alternative would not comply with Magnuson-Stevens Act requirements and therefore, may trigger some type of legal action for not doing so. **Alternative 2** would result in some additional administrative cost and time burdens associated with tracking commercial landings in-season. **Alternative 3** could potentially produce a significant negative impact on the administrative environment regardless of the choice of options and sub-options. Under each of the sub-options spiny lobster would need to be added to the list of species tracked via MRFSS/MRIP, and through the quota management system. Implementing these ACL/AM tracking mechanisms is not a trivial undertaking and could result in significant administrative cost and time in the near-term and long-term. **Preferred Alternative 4** could result in moderate administrative impacts in the form of evaluations of actual harvest compared the ACT and ACL. If the ACT is exceeded or if the ACL is exceeded more than once within a four year time period, the burden on the administrative environment would likely increase if a regulatory amendment is needed to modify management measures or harvest limits for Caribbean spiny lobster.

6. Framework Procedure & Protocol

More than one alternative may be chosen as preferred.

Action 6 (Framework Procedure & Protocol) Alternatives

Alternative 1: No Action – Do not update the Protocol for Enhanced Cooperative Management or the Regulatory Amendment Procedure.

Preferred Alternative 2: Update the current Protocol for Enhanced Cooperative Management.

Alternative 3: Update the current Regulatory Amendment Procedures to develop a Framework Procedure to modify ACLs and AMs.

Preferred Alternative 4: Revise the current Regulatory Amendment Procedures to create an expanded Framework Procedure:

- **Preferred Option a:** Adopt the base Framework Procedure
- **Option b:** Adopt the more broad Framework Procedure
- **Option c:** Adopt the more narrow Framework Procedure

Allows managers to respond more quickly to changes in the fishery and outlines how Florida, Councils, and NOAA Fisheries Service work cooperatively to manage the Caribbean Spiny Lobster fishery.

Framework

- Allows more rapid change in regulations
- Needs to be updated to add new requirements (adjustments to ABC, ACL, and ACT)
- Needs to be updated with new terminology

Cooperative Management

- Protocol outlines how federal and state managers work together
- Much of management is governed by Florida
- Needs to be update to add new names of organizations and update the steps

Impacts from Action 6 (Framework Procedure & Protocol)

Biological

Alternative 1 would maintain the Regional Administrator's current ability to adjust total allowable catch, quotas, trip limits, bag limits, size limits, seasonal closures, and area closures; however, no means would exist to make needed adjustments to the National Standard 1 harvest parameters in a timely manner. Such a scenario could be biologically detrimental because excessive levels of fishing mortality, or even overfishing, could persist until the appropriate harvest limitations could be put in place through amendment action. The impacts on the physical environment would not change under this alternative. **Preferred Alternative 2** would have no impact on the physical or biological environment because its only purpose is to update the protocol. **Alternatives 3** and **4** would likely be biologically beneficial for spiny lobster.

Economic

Action 6 is primarily administrative in intent. Implementation of Amendment 10 depends on cooperative management. There may be differences of opinion about economic impacts among respective legislative bodies, regulatory bodies and courts. Any differences in regulation between Florida and the Councils would have the most economic impact. This is because practically all of the landings of Caribbean spiny lobster occur in Florida, which has its own regulations for this species. Furthermore, Florida landings occur largely in Monroe County (approximately 90% for commercial landings and 67% for recreational landings. Hence, economic impacts under Amendment 10 would occur primarily in Florida and largely in Monroe County.

Social

The development of a framework procedure would have beneficial impacts on the social environment as management can react to changes in the stock status or fishery in a timelier manner. **Alternative 1** would not allow for these types of changes and could, over time, have negative indirect effects. However, framework actions that are done rapidly do not always provide for as much public input and comment on the actions as other regulatory processes. The benefits of timely action often outweigh the diminished timeframe for comment though. **Preferred Alternative 2** would provide consistency in language with regulatory changes and have few effects on the social environment. **Alternatives 3** and **4** provide options for implementing a framework procedure that becomes less restrictive in terms of timing and public input going from **Preferred Alternative 4, Option a** to **Option c**. As mentioned earlier, timing and public input become the parameters that are constrained by these options. While public input and participation by advisory panels can be beneficial, it is time consuming and can slow the process. Yet, that participation can provide a more acceptable regulation which may lead to better compliance.

Administrative

Alternative 1 would be the most administratively burdensome of the alternatives being considered, because all modifications to ACLs, ACTs, and AMs would need to be implemented through an FMP amendment, which is a more laborious and time consuming process than a framework action. **Preferred Alternative 2** would have no impact on the administrative environment. **Alternatives 3** would incur less of an administrative burden than **Alternative 1** because several steps in the lengthy amendment process would be eliminated. **Preferred Alternative 4** would incur even less of an administrative burden because other management measures could also be adjusted through framework actions. **Alternative 4, Option b** would be the least burdensome because it would allow the widest range of actions to take place under the framework procedure.

7. Use of Shorts as "Attractants"

Action 7 (Use of Shorts as "Attractants") Alternatives
Alternative 1: No Action – Allow the possession of no more than 50 undersized Caribbean spiny lobsters, or one per trap aboard the vessel, whichever is greater, for use as attractants. **Alternative 2:** Prohibit the possession and use of undersized Caribbean spiny lobsters as attractants. **Alternative 3:** Allow undersized Caribbean spiny lobsters, but modify the number of allowable undersized lobsters, regardless of the number of traps fished: **Option a:** allow 50 undersized lobsters **Option b:** allow 35 undersized lobsters **Preferred Alternative 4:** Allow undersized spiny lobster not exceeding 50 per boat and 1 per trap aboard each boat if used exclusively for luring, decoying or otherwise attracting non-captive spiny lobsters into the trap.

Preferred Alternative 4 tracks Florida regulations and would make law enforcement more effective.

Shorts as Attractants

- Traps are more efficient with attractants
- Mortality is estimated at 10% which is less than the release mortality in many other fisheries
- Live wells are required to reduce mortality
- If traps are less efficient, bycatch of other species could increase

Impacts from Action 7 (Use of Shorts as "Attractants")

Biological

Alternative 1 would produce the second highest rate of spiny lobster mortality associated with use as attractants relative to **Alternatives 2**, **3b,** and **Preferred Alternative 4**. **Alternative 2** would be the most biologically conservative alternative under this action since, theoretically, all mortality associated with using undersized lobsters as attractants would cease. **Alternative 3** could help to reduce fishing mortality attributable to use of undersized lobsters for baiting purposes. **Alternative 3** is not as precautionary as **Alternative 2**, and depending upon the option chosen, may only yield negligible biological benefits over the status quo. **Preferred Alternative 4** is the least biologically conservative for spiny lobster of all the alternatives considered because it would increase the number of undersized lobsters able to be maintained onboard a vessel for use as attractants. However, bycatch of other species may be reduced because traps will be left in the water a shorter period of time due to increased efficiency.

Economic

Alternative 1 would not result in any change in the use of undersized spiny lobsters in lobster traps as attractants. As a result, all status quo operation of the fishery, and associated economic benefits, would remain unchanged. **Alternative 2** would in practice require the use of more purchased bait, hence increase trip costs on average for commercial fishing for spiny lobster as a whole. This would reduce producer surplus for this activity. **Alternative 3** should reduce the fishing mortality associated with the use undersized Caribbean spiny lobster as attractants, more so for **Option b** than for **Option a,** when compared with **Alternative 1.** The economic impact of **Alternative 3** would be less than that of **Alternative 2,** and require the use of less purchased bait, hence less increase in trip costs for commercial fishing for spiny lobster as a whole. It would reduce producer surplus less than **Alternative 2,** when both are compared with **Alternative 1. Preferred Alternative 4** would not have an economic impact, is consistent with Florida regulations, and could bolster fishing in federal waters relative to fishing in state waters.

Social

The use of undersized lobster as attractants has been acceptable practice in the spiny lobster fishery for some time. **Alternative 1** would continue the difficulty that law enforcement faces with prosecuting undersized lobster violations because of inconsistency with state regulations. **Alternative 2** could solve the law enforcement issue, but may impose a hardship on lobster fishermen who utilize "shorts" as attractants, if their harvest is reduced as a result. The two options under **Alternative 3** would reduce the number allowed on board; however the difficulty for law enforcement would remain. With **Preferred Alternative 4** there is consistency with state regulation which would benefit law enforcement.

Administrative

Alternative 2 would create the lowest impact on the administrative environment since it would remove the need for enforcement personnel to check vessels for specific numbers of undersized lobsters. **Options a** and **b** under **Alternative 3** would not increase the administrative burden over the status quo since numbers of undersized lobsters would still need to be documented, just at a lower number. However, **Alternative 1, Alternative 3,** and **Preferred Alternative 4,** would not address the current enforcement concerns regarding the use of undersized lobster, and difficulty in prosecuting related violations would persist. Because **Preferred Alternative 4** is consistent with current state regulations in Florida, it would ease the burden on enforcement to track compliance across the state/federal jurisdictional boundary.

8. Modify "Tailing" Permits

More than one alternative may be chosen as preferred.

Action 8 (Modify "Tailing" Permit) Alternatives
Alternative 1: No Action – Possession of a separated Caribbean spiny lobster tail in or from the EEZ is allowed only when the possession is incidental to fishing exclusively in the EEZ on a trip of 48 hours or more, and a federal tailing permit is issued to and on board the vessel. **Alternative 2:** Eliminate the Tail-Separation Permit for all vessels fishing for Caribbean spiny lobster in Gulf and South Atlantic waters of the EEZ. **Preferred Alternative 3:** Revise the current regulations to clearly state that all vessels must have either 1) a valid federal spiny lobster permit or 2) a valid Florida Restricted Species Endorsements and a valid Crawfish Endorsement associated with a VALID Florida Saltwater Products License to obtain a tailing permit. **Preferred Alternative 4:** All Caribbean spiny lobster landed must either be landed all "whole" or all "tailed".

Modify "Tailing" Permits

- On long trips, product quality is better if tails are separated and iced or frozen
- Original intent for only commercial fishery
- Improves enforcement

Preferred Alternative 4 tracks recommendations by the commercial industry and will assist law enforcement.

Impacts from Action 8 (Modify "Tailing" Permits)

Biological

No biological benefit would be realized under **Alternative 1**. **Alternative 2** would be the most biologically conservative of all the alternatives being considered under this action. Removing the ability for fishermen to land any Caribbean spiny lobster tailed would increase the probability that most lobster landed would be of legal size since they could easily be measured. **Preferred Alternative 3** would result in negligible biological impacts because it is thought that there are very few recreational fishermen who have in their possession a Tail-Separation Permit. If **Preferred Alternative 3** were implemented in combination with **Preferred Alternative 4**, the issue of recreational fishermen obtaining Tail-Separation Permits would be addressed, and could; therefore, result in greater biological benefit than if **Preferred Alternative 4** were chosen alone.

Economic

Alternative 2 would reverse the long-standing Councils decision that provided an economic incentive to engage in multi-day, deep-water fishing for spiny lobster in the EEZ. **Alternative 2** would have an economic impact exclusively on the commercial sector when compared with **Alternative 1.** **Preferred Alternative 3** may affect some for-hire vessels by specifying that all vessels wanting federal tail-separation for the EEZ must have requisite permits for commercial fishing. Among the 1,330 vessels licensed to engage in for-hire fishing for spiny lobster in Florida in state and federal waters, none are reported to have permits for commercial fishing, although some may have heretofore acquired federal tail-separation permits. These for-hire vessels could continue to engage in for-hire fishing for lobster in the EEZ, but they could not possess or land lobster tails, and they might have to add ice-chest capacity to keep the more cumbersome whole lobsters fresh for paying customers. **Preferred Alternative 4** could have an economic impact on vessels engaged in deep-water, multi-day commercial fishing for spiny lobster. These vessels have landed whole and tailed lobsters on the same trip.

Social

Alternative 1 would provide no solution as no action would be taken. While **Alternative 2** would solve most of the law enforcement issues, it would not provide the benefits of the original intent which allows for fishermen who take longer fishing trips to accommodate space issues with whole lobsters. By requiring recreational fishermen to obtain state commercial permits to obtain a tailing permit under **Preferred Alternative 3** would remove some of the uncertainty for law enforcement, yet still impose some ambiguity in the regulations making it difficult to regulate harvest of undersized lobster. **Preferred Alternative 4** would remove some of the difficulty in prosecuting the harvest of undersized lobster and in conjunction with **Preferred Alternative 3** may be the best solution to a difficult problem while continuing to provide for fishermen's concerns of space on long trips.

Administrative

Under **Alternative 1**, the current level of administrative time and cost burdens would be maintained. Enforcement concerns related to the harvest of undersized lobsters would persist and recreational fishermen may continue to acquire Tail Separation Permits, which was an unintended consequence of previously implemented regulations. **Alternative 2** would have a positive impact on the administrative and law enforcement environments since the Tail-Separation Permit would no longer exist and the practice of tailing lobsters would be prohibited. **Preferred Alternative 3** would create a very small administrative burden when compared to the status quo because some updates to the current regulatory text would be necessary. **Preferred Alternative 4** would also require a modification to the regulations; however, the administrative burden would be very low.

9. Limit Fishing Areas to Protect Threatened Staghorn and Elkhorn Corals

Action 9 (Limit Fishing Area) Alternatives
Preferred Alternative 1: No Action – Do not limit spiny lobster fishing in certain areas in the EEZ off Florida to address ESA concerns for *Acropora* spp.
Alternative 2: Prohibit spiny lobster trapping on all known hardbottom in the EEZ off Florida in water depths less than 30 meters.
Alternative 3: Expand existing and/or create new closed areas to prohibit spiny lobster trapping in the EEZ off Florida. **Option a:** Create 24 —large closed areas to protect threatened *Acropora* spp. corals. **Option b:** Create 37 —medium closed areas to protect threatened *Acropora* spp. corals. **Option c:** Create 52 —small closed areas to protect threatened *Acropora* spp. corals.
Alternative 4: Expand existing and/or create new closed areas to prohibit all spiny lobster fishing in the EEZ off Florida. **Option a:** Create 24 —large closed areas to protect threatened *Acropora* spp. corals. **Option b:** Create 37 —medium closed areas to protect threatened *Acropora* spp. corals. **Option c:** Create 52 —small closed areas to protect threatened *Acropora* spp. corals.

The Endangered Species Act (ESA) requires analyses to determine whether or not fishing operations impact threatened species including threatened and endangered staghorn and elkhorn corals (*Acropora* spp.). The ESA Biological Opinion specifies certain actions that must be taken to

Limit Fishing Areas

- NMFS Protected Resources staff is working with the commercial fishing industry to develop closed areas
- This action will be revisited in Amendment 11 to the FMP after further input from stakeholders
- Traps are generally not set on coral or hardbottom
- Traps are set on seagrass, rubble, or sandy habitats because these areas are less likely to damage traps
- The movement of traps during storms poses the greatest threat
- Areas were chosen to protect colonies with high conservation value and areas of high coral density

Impacts from Action 9 (Limit Fishing Areas)

Biological

Preferred Alternative 1 would have the least biological benefit to *Acropora* spp. and would perpetuate the existing level of risk of interaction between these species and the fishery. Although this alternative would not meet the requirement established under the Biological Opinion, the Councils chose it as their preferred alternative to allow more time for stakeholder input on areas of important habitat to protect *Acropora* spp. coral. The Councils intend to quickly develop the new amendment and put measures into place that would provide protection for *Acropora* spp.. **Alternative 2** would provide the greatest biological benefit to *Acropora* spp. and other hardbottom/coral resources. **Alternative 3, Options a-c** would reduce the risk of trap damage to *Acropora* spp. by prohibiting the use of traps near areas of high *Acropora* spp. density or near colonies with high conservation value. **Alternative 3, Option a** would likely provide the greatest biological benefit and **Alternative 3, Option b** and **c** would likely have decreasing biological benefits. **Alternative 4** and the associated options would provide slightly more biological benefit to *Acropora* spp. colonies than **Alternative 3** and the associated options because it would prohibit all fishing for spiny lobster in the proposed closed areas.

Economic

Compared with **Preferred Alternative 1**, **Alternative 2** could preclude 1,441 trips per year in the EEZ off the Keys for 195 vessels, referring to trips with reported depths of less than 100 ft. **Alternative 2** would have the greatest economic impact. Under **Alternative 3**, 25 large areas, 32 medium areas, or 52 small areas would be closed, gross revenue would be 18.6%, 11.2% and 5.6% of $2.9 million, respectively. **Alternative 4** differs from **Alternative 3** in that it covers all fishing for spiny lobster, not just trap fishing.

Social

Preferred Alternative 1 would not meet the requirement in the Biological Opinion, although with the Councils' intent to address this issue in another amendment there should be positive social benefits. The most restrictive, **Alternative 2,** would have direct negative impacts on the social environment through harvest restrictions. **Alternatives 3** and **4** offer a broad array of options which provide less negative social impacts than **Alterative 2**, but may introduce other inefficiencies with regard to enforcement and compliance. Choosing smaller closed areas, as in **Alternative 3 Option b** and **c** may provide more flexibility for trap fishermen, but may make it more difficult to monitor and enforce compliance. **Alternative 4, Options b** and **c** would have similar social effects but for both commercial and recreational fishermen. Larger closed areas, like those in **Alternative 3, Option a** and **Alternative 4, Option a** may enhance enforcement, but could have more negative social effects on fishermen as they find less area to fish which could reduce harvests and force them to increase travel time to fishing grounds. Closed areas to traps could also create crowding as fishermen move more traps into areas where others are already placing traps or as recreational divers are also forced into areas that become congested.

Administrative

Preferred Alternative 1 would not meet the requirements of the Biological Opinion and requires the Councils to develop a new amendment that will address this requirement. Alternatives that create new closed areas will increase the administrative burden over the current level due to changes in maps, outreach and education, and greater enforcement needs. **Alternative 2** would require enforcement over the largest area. **Alternatives 3** and **4** are similar except **Alternative 3** applies to trap fishing only, and **Alternative 4** applies to all lobster fishing. **Alternative 4** would be easier to enforce because any boat in a closed area with lobster on board would be in violation of regulations. **Option a** would create less administrative and enforcement burden than **Option b** or **c**.

10. Require Gear Markings on Trap Lines

Action 10 (Gear Markings on Trap Line) Alternatives
Preferred Alternative 1: No Action – Do not require gear marking measures for spiny lobster trap lines.
Alternative 2: Require all spiny lobster trap lines in the EEZ off Florida to be COLOR, or have a COLOR marking along its entire length. All gear must comply with marking requirements no later than August 2014.
Alternative 3: Require all spiny lobster trap lines in the EEZ off Florida to have a permanently affixed 4-inch COLOR marking every 15 ft along the buoy line or at the midpoint if less than 15 ft. All gear must comply with marking requirements no later than August 2014.

Gear Markings on Trap Lines

- This action will be revisited in Amendment 11 to the FMP after further input from stakeholders
- Delayed implementation would minimize economic impacts from new line requirement
- Councils want public input to determine color that should be used
- Need to be able to identify endangered species interactions to a specific fishery

The Endangered Species Act (ESA) requires analyses to determine whether or not fishing operations impact threatened species including threatened staghorn and elkhorn corals (*Acropora* spp.). The ESA Biological Opinion specifies certain actions that must be taken to minimize the impacts from the federal spiny lobster fishery.

Impacts from Action 10 (Gear Markings on Trap Lines)

Biological

Preferred Alternative 1 would have no biological benefit for protected species. The Councils selected this alternative so that this action could be addressed in separate amendment after further input from stakeholders. **Alternative 2** would likely have slightly more biological benefit than **Alternative 3.** Requiring gear markings along the entire length of trap lines would minimize the likelihood that a portion of a spiny lobster trap line is recovered without an identifiable mark. **Alternative 3** would provide greater biological benefit than **Preferred Alternative 1** but the benefits would likely be less than **Alternative 2** for the reason described above. The trap marking requirements under **Alternatives 2** and **Alternative 3** would provide indirect benefits to sea turtles and smalltooth sawfish. Trap marking requirements would provide better understanding of the frequency of interactions between these species and the fishery. These requirements could also help rule out the spiny lobster fishery as a potential source of entanglement with protected species.

Economic

Lobster trap line replacement outside of the normal schedule and at a quicker pace implies an economic impact for **Alternatives 2 and 3**. Including all commercial vessels in the sector, the economic impact is less than it would have been in the past, because the number of traps fished in Florida has declined, along with the number of vessels, trips, and hours fished.

Social

Marking trap lines could have significant effects on the social environment as it may impose substantial costs to modify the gear according to testimony during public hearings. The **Preferred Alternative 1** would allow the Councils more time to address this issue and develop other alternatives in another amendment to the FMP that may assist in alleviating any of the hardships imposed by this requirement and still address concerns over interactions with protected species. **Alternatives 2** and **3** would require some type of marking on trap lines which are required in other fisheries and could resolve any future problems with identification of trap lines being associated with interactions with protected species yet may impose substantial costs to the industry. **Alternative 2** may allow for more efficient marking of lines as fishermen would not have measure each line marking pattern and therefore save time and money.

Administrative

Preferred Alternative 1 would not meet the requirements of the Biological Opinion and requires the Councils to develop a new amendment that will address this requirement. **Alternatives 2-4** would increase the need for enforcement to check if trap lines are properly colored or marked. On the other hand, the ability to identify lines entangled with endangered species would reduce the difficulty in determining assignment of incidental take to a particular fishery by NOAA Fisheries Service Protected Resources Division. In general, none of these alternatives would be more or less burdensome than any other.

11. Authority to Remove Derelict or Abandoned Spiny Lobster Traps in the EEZ off Florida

Action 11 (Removal of Derelict or Abandoned Trap) Alternatives
Alternative 1: No Action – Do not allow the public to remove any derelict or abandoned spiny lobster trap found in the EEZ off Florida.
Alternative 2: Allow the public to completely remove from the water any derelict or abandoned spiny lobster trap found in the EEZ off Florida from the end of lobster season trap removal period (usually April 5) until the beginning of the next season's trap deployment period (August 1).
Alternative 3: Allow the public to completely remove from the water any derelict or abandoned spiny lobster trap found in the EEZ off Florida during the closed seasons for both spiny lobster and stone crab (May 20-July 31).
Alternative 4: Allow the public to remove spiny lobster trap lines, buoys, and/or throats, but otherwise leave in place, any trap found in the EEZ off Florida from the end of season trap removal period (usually April 5) until the beginning of the next season's trap deployment period (August 1).
Alternative 5: Allow the public to remove spiny lobster trap lines, buoys, and/or throats, but otherwise leave in place, any trap found in the EEZ off Florida during the closed seasons for both spiny lobster and stone crab (May 20-July 31).
Preferred Alternative 6: Delegate authority to regulate the removal of derelict or abandoned spiny lobster traps occurring in the EEZ off Florida to FWC.

Removal of Derelict or Abandoned Spiny Lobster Traps in the EEZ off Florida

- Florida has a program to remove traps in state waters
- Industry has concerns about the public removing traps
- Under the Florida program, the public could participate in trap removal after an approval of the plan by FWC.

The Endangered Species Act (ESA) requires analyses to determine whether or not fishing operations impact threatened species including Threatened staghorn and elkhorn Corals (*Acropora* spp.). The ESA Biological Opinion specifies certain actions that must be taken to minimize the impacts from the federal spiny lobster fishery.

Impacts from Action 11 (Authority to Remove Derelict or Abandoned Spiny Lobster Traps in the EEZ off Florida)

Biological

Alternative 1 would have no biological benefit for protected species or benthic habitat and would perpetuate the existing level of risk for interactions between these protected species and lost trap gear. **Alternative 2** would likely have the greatest biological benefits. **Alternative 3** would also allow for the complete removal of derelict or abandoned trap gear, but for a shorter period. As a result, the biological benefit of **Alternative 3** may be less than **Alternative 2**. **Alternatives 4** and **5** would likely have less biological benefit than **Alternatives 2** and **3**. Allowing the public to remove trap line, buoys, and throats, would help reduce the potential impacts from ghost fishing and entanglement. However, traps remaining in the environment still have the potential to cause damage to benthic habitat. **Alternative 4** would allow more time for the public to remove trap line, buoys, and throats from derelict or abandoned traps, potentially increasing the biological benefit. Compared to **Alternatives 2-4**, **Alternative 5** would likely have the least biological benefit. It is currently unclear what type of biological impact **Preferred Alternative 6** would have.

Economic

Although none of these five alternatives would affect ongoing commercial fishing activity during the open season, fishermen's perception about any trap removal can impact their economic activity, wellbeing, and willingness to support regulations. Thus, **Preferred Alternative 6** may have the least economic impact. Federal and/or state outreach programs could change fishermen's perceptions over time, but change in attitudes may be a long time in coming.

Social

Alternative 1 may be the most desirable for some trap fishermen. Trap molestation is always a concern for trap fishermen and if the public is provided with an opportunity to clear derelict traps during the closed season, there may be a perception that their duty extends to other times and areas. **Alternative 2** would allow for a more lengthy time period for the public to participate than **Alternative 3** which is limited to the closed season for spiny lobster and stone crab. The negative effects of allowing the public to participate are that there is no guarantee that legal traps might be removed by someone unfamiliar with the regulations. **Alternatives 4** and **5** would remedy some of the above concerns by allowing for removal of only parts of the trap, but there are still concerns about the public's knowledge and familiarity with the regulations. **Preferred Alternative 6** would allow the FWC to develop a program for trap removal that might address the concerns mentioned with previous alternatives and would likely have the fewest negative social effects.

Administrative

Alternative 1 would have no impacts on the administrative environment. **Alternatives 2** and **3** may create enforcement problems because someone with a trap aboard their vessel may have been removing it from the water because they found it abandoned or because they were illegal fishing. **Alternatives 4** and **5** would only allow the public to disable traps and would not allow them to retain the traps on board; thus enforcement would be easier. **Preferred Alternative 6** would have no impacts on the administrative environment for the federal government, but would increase the burden on the state government.

1.0 INTRODUCTION

This Final Environmental Impact Statement (FEIS) for Amendment 10 to the Fishery Management Plan for Spiny Lobster in the Gulf of Mexico and South Atlantic (Spiny Lobster FMP) will bring the FMP into compliance with Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act) requirements. The Spiny Lobster FMP is jointly managed by the Gulf of Mexico and South Atlantic Fishery Management Councils (Councils).

1.1 Background

In 2006, the Magnuson-Stevens Act was re-authorized and included a number of changes to improve conservation of managed fishery resources. The goals require that conservation and management measures “shall prevent overfishing while achieving, on a continuing basis, the optimum yield from each fishery for the United States fishing industry.” Included in these changes are requirements that the Regional Councils must establish both a mechanism for specifying annual catch limits (ACLs) at a level such that overfishing does not occur in the fishery, and accountability measures (AMs) to ensure the ACLs are not exceeded and to correct if overages occur. Accountability measures are management controls to prevent the ACLs from being exceeded and to correct by either in-season or post-season measures if they do occur.

The ACL is set by the Councils, but begins with specifying an overfishing limit (OFL), which is the yield above which overfishing occurs. After an OFL is specified, an acceptable biological catch (ABC) is recommended by the Councils’ Scientific and Statistical Committees. The ABC is based on the OFL and takes into consideration scientific uncertainty. An annual catch target (ACT) can also be set. An ACT is not required, but if used should be set at a level that takes into account management uncertainty and provides a low probability of the ACL being exceeded. These measures must be implemented in 2010 for all stocks experiencing overfishing, and 2011 for all other stocks.

There are some exceptions for the development of ACLs; for example, when a species can be considered an ecosystem component species or has an annual life cycle. Stocks listed in the fishery management unit are classified as either ‘‘in the fishery’’ or as an ‘‘ecosystem component.’’ By default, stocks are considered to be “in the fishery” unless declared ecosystem component species. Ecosystem component species are exempt from the requirement for ACLs. In addition, ecosystem component species may, but are not required to be, included in a FMP for any of the following reasons: data collection purposes, ecosystem considerations related to specification of optimum yield for the associated fishery, as considerations in the development of conservation and management measures for the associated fishery, and/or to address other ecosystem issues.

The original Spiny Lobster FMP included the Caribbean spiny lobster, *Panulirus argus*, and other incidental species of lobster (spotted spiny lobster, *Panulirus guttatus*; smoothtail spiny lobster, *Panulirus laevicauda*; Spanish slipper lobster, *Scyllarides aequinoctialis*, and ridged slipper lobster, *Scyllarides nodifer*) which inhabit or migrate through coastal waters and the fishery conservation zone now named the exclusive economic zone (EEZ) of the Gulf of Mexico and the South Atlantic (GMFMC and SAFMC 1982). All five species of lobster are in the fishery, but only two species, the Caribbean spiny lobster and ridged slipper lobster, are listed under the fishery management unit (GMFMC and SAFMC 1986).

Of the four species other than the Caribbean spiny lobster in the Spiny Lobster FMP, only the ridged slipper lobster is specified in the regulations; the other species are in the FMP for data collection purposes only. Official landings information is not available on the smoothtail and spotted spiny lobsters. Low numbers of these species may be landed and recorded as Caribbean spiny lobster in either the commercial or recreational sector, but no records are available at this time. Spanish and ridged slipper lobsters occur in federal waters along the west coast of Florida and are primarily landed as bycatch in shrimp trawls. Because landings information is scarce and incomplete, setting ACLs would be very difficult for these species. The Councils could list these four species as ecosystem components or remove them from the FMP; in either case, ACLs and AMs would not be required. If these species are left in the FMP and considered to be in the fishery, ACLs and AMs must be set.

An ACL for a given stock or stock complex can be established in several ways: either a single ACL for the entire fishery divided into sector ACLs (i.e., recreational and commercial sectors) or divided into sector and gear types (i.e., recreational, commercial diving, bully netting, and commercial trapping). In any of these cases, the sum of the ACLs cannot exceed the ABC. Under the reauthorized Magnuson-Stevens Act and the 2008 amended guidelines for National Standard 1 (74 FR 3178, January 16, 2009), ACLs and, if selected by the Council, ACTs should be adjusted in the future by framework action. Revision of the current framework procedure would allow such adjustments.

Current regulations on the Caribbean spiny lobster off the Gulf of Mexico and South Atlantic are summarized in Table 1.1.1 and defined in 50 CFR part 640. *Scyllarides nodifer* is the other species currently in the Fishery Management Unit and managed by the regulations. The common name Slipper (Spanish) lobster as *Scyllarides nodifer* in the regulations (i.e., 50 CFR 640.2) is not the correct common name according to American Fisheries Society book of Common and Scientific Names of Aquatic Invertebrates (2005) and FAO Fisheries Synopsis (1991) authorities on the correct common names of invertebrate species; the correct common name is ridged slipper lobster. For the purposes of this document, the ridged slipper lobster will be used throughout the rest of the document. The regulations specified for ridged slipper lobster discuss conservation and management [50 CFR 640.1(b)], define slipper lobster by genus and species [50 CFR 640.2], prohibit harvest of a berried (egg-bearing) lobsters [50 CFR 640.21(a)], and prohibit the use of poisons and explosives to take slipper lobster in the exclusive economic zone [50 CFR 640.22(a)(3)].

Table 1.1.1. Current commercial and recreational Caribbean spiny lobster regulations for federal waters of the South Atlantic and the Gulf of Mexico.

	Permits required	Size Limits	Bag/Possession Limits	Closed areas	Closed Season	Gear Restrictions	Other Prohibitions
Commercial	Federal spiny lobster vessel permit except if fishing in federal waters off FL. FL commercial harvester permit required in EEZ off FL. Tailing permit if tailing lobster.	Carapace must be greater than 3”, separated tails must be at least 5.5”	Off of NC, SC, and GA: 2 per person. Off FL and other Gulf states: 6 per person per day.*	None	FL and other Gulf states: April 1 through August 5. NC, SC, or GA: No closed season.	No spear, hooks, piercing devices, explosives, or poisons. Degradable panel required on non-wooden traps.	No trap tending at night. No taking of spiny lobster with eggs.
Recreational	State endorsement to the fishing license required.	Carapace must be more than 3” (measured in the water).	Off of NC, SC, and GA: 2 per person. Off FL and other Gulf states: 6 per person per day.	None	FL and other Gulf states: April 1 through August 5. Exception off FL: 2-day non-trap mini-season last Wed and Thurs in July** Off other Gulf states: 2-day non-trap mini-season last Sat and Sun in July	No spear, hooks, piercing devices, or explosives. Degradable panel required on non-wooden traps.	No taking of spiny lobster with eggs.

* A person is exempt from the bag/possession limits off Florida if the harvest of Caribbean spiny lobster is by diving or by use of bully net, hoop net, or spiny lobster trap; and the vessel has on board the required commercial Florida state licenses.
**During the two-day mini-season off Florida, the bag limit is 12 Caribbean spiny lobsters per person per day, in or from the EEZ, other than off Monroe County. Off Monroe County the bag limit is six Caribbean spiny lobsters per person per day.

Two current federal regulations may be causing detrimental impacts to the resource as well as creating enforcement problems. First, under certain situations and with a federal tailing permit, Caribbean spiny lobster tails may be separated from the body onboard a fishing vessel. This allowance creates difficulties for law enforcement in determining if hooks and spears were used to harvest the resource. Second, up to 50 Caribbean spiny lobsters under the minimum size limit or one per trap, whichever is greater, may be retained aboard a vessel provided they are held in a live well. When in a trap, such juveniles or “short” lobsters are used to attract other lobsters for harvest. Federal regulations are not consistent with Florida regulations, which allow retention of up to 50 Caribbean spiny lobsters under the minimum size limit and one per trap. The Councils considered modifying or repealing these two regulations.

Consultation under the Endangered Species Act

The Endangered Species Act (ESA) of 1973 (16 U.S.C. Section 1531 et seq.) requires that federal agencies ensure actions they authorize, fund, or carry out are not likely to jeopardize the continued existence of threatened or endangered species or the habitat designated as critical to their survival and recovery. The ESA requires NOAA Fisheries Service to consult with the appropriate administrative agency (itself for most marine species and the U.S. Fish and Wildlife Service for all remaining species) when proposing an action that may affect threatened or endangered species or adversely modify critical habitat. Consultations are necessary to determine the potential impacts of the proposed action. Formal consultations, resulting in a Biological Opinion, are required when proposed actions may affect and are "likely to adversely affect" threatened or endangered species or adversely modify designated critical habitat.

To satisfy the ESA consultation requirements, NOAA Fisheries Service completed a formal consultation, and resulting Biological Opinion, on the continued authorization of the Gulf of Mexico and South Atlantic spiny lobster fishery in 2009. When making determinations on FMP actions, not only are the effects of the specific proposed actions analyzed, but also the effects of all discretionary fishing activity under the affected FMPs. Thus, the Biological Opinion analyzed the potential impacts to ESA-listed species from the continued authorization of the federal spiny lobster fishery. The opinion stated the fishery was not likely to adversely affect ESA-listed marine mammals, Gulf sturgeon, or designated critical habitat for elkhorn and staghorn corals. However, the opinion determined that the spiny lobster fishery would adversely affect sea turtles, smalltooth sawfish, and elkhorn and staghorn corals, but would not jeopardize their continued existence. An incidental take statement was issued for green, hawksbill, Kemp's ridley, leatherback, and loggerhead sea turtles, smalltooth sawfish, and both species of coral. Reasonable and prudent measures to minimize the impact of these incidental takes were specified, along with terms and conditions to implement them. Specific terms and conditions required to implement the prescribed reasonable and prudent measures include, but are not limited to: creating new or expanding existing closed areas to protect coral, implementing trap line-marking requirements, and consideration of allowing the public to remove trap-related marine debris. The Councils considered alternatives to meet these requirements; however, they chose to take no action on the actions to require area closures and gear markings to allow for additional stakeholder input. The Councils intend to quickly develop Amendment 11 to put these measures into place as required by the Biological Opinion. Because the decision to address these issues in Amendment 11 was made late in the development process for Amendment 10 and the analysis of the suite of alternatives was completed, the Council felt the actions and associated impacts analysis should remain in this document in addition to being incorporated in Amendment 11.

1.2 Purpose Statement

The purpose of this amendment is to bring the Spiny Lobster FMP into compliance with Magnuson-Stevens Act requirements for ACLs and AMs to prevent overfishing; update biological reference points, policies, and procedures; and consider adjustment of management measures to aid law enforcement and comply with measures to protect endangered species established under a Biological Opinion.[1]

1.3 Need for the Proposed Action

Revisions to the Magnuson-Stevens Act in 2006 require FMPs contain ACLs for all managed species. Annual catch limits must be set at a level that prevents overfishing and does not exceed the recommendations of the respective Councils' Scientific and Statistical Committees for ABC. Fisheries Management Plans are also required to establish AMs, which are management controls that ensure ACLs are not exceeded or provide corrective measures if overages occur. For stocks determined by the Secretary of Commerce to be subject to overfishing, ACLs and AMs must be effective in 2010; for all other stocks managed under an FMP, except species with annual life cycles and ecosystem component species, ACLs and AMs must be effective in 2011. No species in the Spiny Lobster FMP is known to be undergoing overfishing. The Councils intend to meet the 2011 deadline through Amendment 10 to the Spiny Lobster FMP.

Current definitions of maximum sustainable yield, overfishing, and overfished were set for Caribbean spiny lobster in Amendment 6. Currently, the Councils have different definitions for some criterion. The Councils may modify these definitions based on recommendations of the Scientific and Statistical Committees. A single definition for each biological reference point would simplify management.

The implementation process for a plan amendment can take over a year from initial scoping to final implementation. Framework procedures provide a mechanism for timelier implementation of routine actions such as setting ACLs, and a guideline for implementing such actions in a consistent manner. The framework procedure in the Spiny Lobster FMP was set in Amendment 2 and allows changes to be made to gear and harvest restrictions (GMFMC and SAFMC 1989). Revisions would allow additional actions to be implemented through the framework procedure. Amendment 2 also contains a process for the Florida to propose modifications to regulations. This process is now outdated and needs to be updated.

The Councils are considering modifying or repealing two current federal regulations regarding tailing permits and use of undersized lobsters as attractants may be causing detrimental impacts to the resource as well as creating enforcement problems. In addition, the Councils are considering alternatives to meet the requirements of the 2009 Biological Opinion.

[1] Note that the Councils determined some of the measures to protect endangered species as required by the Biological Opinion are now being addressed in a subsequent amendment to allow more time for stakeholder input.

1.4 Management History

Fishery Management Plan for Spiny Lobster in the Gulf of Mexico and the South Atlantic (1982)
The Spiny Lobster FMP largely extended Florida's rules regulating the fishery to the EEZ throughout the range of the fishery, i.e., North Carolina to Texas. The FMP regulations were effective on July 2, 1982 (47 FR 29203). Major items are as follows:

- Maximum sustainable yield is estimated as 12.7 million pounds (mp) annually for the maximum yield per recruit size of 3.5 in carapace length.
- Optimum yield is specified to be all lobster more than 3 in carapace length or not less than 5.5 in tail length that can be harvested by commercial and recreational fishermen given existing technology and prevailing economic conditions.
- A minimum harvestable size limit of more than 3 in carapace length or not less than 5.5 in tail length shall be established.
- A closed season from April 1 through July 25 shall be established. During this closed season there shall be a five-day "soak period" from July 21-25 and a five-day grace period for removal of traps from April 1-5.
- All spiny lobster traps shall have a degradable surface of sufficient size so as to allow escapement of lobsters from lost traps.
- All spiny lobster taken below the legal size limit shall be immediately returned to the water unharmed except undersized or "short" lobsters which may be carried on the boat/vessel provided they are: for use as lures or attractants in traps and kept in a shaded "bait" box while being transported between traps. No more than three live "shorts" per trap (traps carried on the boat) or 200 live "shorts", whichever is greater, may be carried at any one time.
- A special two-day recreational non-trap season shall be established.
- The retention on boat boats or vessels or possession on land of "berried" female spiny lobsters shall be prohibited. Stripping or otherwise molesting female lobsters to remove the eggs shall be prohibited. "Berried" female lobsters taken in traps or with other gear must be immediately returned to the water alive and unharmed.

Table 1.4.1. GMFMC/SAFMC FMP Amendments affecting spiny lobster.

Description of Action	FMP/Amendment	Effective Date
Updated the FMP rules to be more compatible with that of FL. Management measures: limited attractants to 100 per vessel, required live wells, required a commercial vessel permit, provided for a recreational permit, limited recreational fishermen to possession of 6 lobsters per day, modified the special 2-day recreational season, modified the duration of the closed commercial season (April 1-August 5, preseason soak period beginning August 1), provided a 10-day trap retrieval period, prohibited possession of egg-bearing lobster, specified the minimum size limit for tails, provided for a tail separation permit, and prohibited possession of egg-bearing slipper lobster.	Amendment 1 (1987)	July 15, 1987 (52 FR 22659) with certain rules deferred and implemented on May 16, 1988 (53 FR 17 196) and on July 30, 1990 (55 FR 26448).
Modified the problems/issues and objectives of the fishery management plan; modified the statement of optimum yield (specified to be all spiny lobster more than 3" carapace length or not less than 5.5" tail length that can be legally harvested by commercial and recreational fishermen given existing technology and prevailing economic conditions); established a protocol and procedure for an enhanced cooperative state/council management system for instituting future compatible state and federal rules without amending the FMP; and added to the vessel safety and habitat sections of the FMP.	Amendment 2 (1989)	October 27, 1989 (54 FR 48059)
Contained provisions for adding a scientifically measurable definition of overfishing (overfishing exists when the eggs per recruit ratio of the exploited population to the unexploited population is reduced below 5% and recruitment of small lobsters into the fishery has declined for 3 consecutive fishing years. Overfishing will be avoided when the eggs per recruit ratio of exploited to unexploited populations is maintained above 5%), an action plan to prevent overfishing, should it occur, and the requirement for collection of fees for the administrative cost of issuing permits.	Amendment 3 (1990)	March 25, 1991 (5 6 FR 12357)

Table 1.4.1. GMFMC/SAFMC FMP Amendments affecting spiny lobster. (continued)

Description of Action	FMP/Amendment	Effective Date
Included extension of the Florida spiny lobster trap certificate system for reducing the number of traps in the commercial fishery to the EEZ off FL; revision of the FMP commercial permitting requirements; limitation of the number of live undersized lobster used as attractants; specification of gear allowed for commercial fishing in the EEZ off FL, specification of the possession limit of spiny lobsters by persons diving at night; requirement of lobsters harvested by divers be measured without removing from the water; and specification of uniform trap and buoy numbers for the EEZ off FL.	Regulatory Amendment 1 (1992)	
Included a change in the days for the special recreational season in the EEZ off Florida; a prohibition on night-time harvest off Monroe County during that season; specification of allowable gear during that season; and different bag limits during that season off the Florida Keys and the EEZ off other areas of Florida.	Regulatory Amendment 2 (1993)	
Allowed the harvest of 2 lobsters per person per day for all fishermen all year long but only north of the FL/GA border. This measure was added to the framework procedure so that future potential changes to the limit do not require a plan amendment. [Developed by the SAFMC]	Amendment 4 (1994)	September 15, 1995 (60 FR 41 828)
Identified Essential Fish Habitat (EFH) and EFH-Habitat Areas of Particular Concern for spiny lobster. [Developed by the SAFMC]	Amendment 5 (1998)	July 14, 2000
The Council reviewed alternatives and concluded the best available data supports using 20% static SPR as a proxy for MSY. OY for the spiny lobster fishery is the amount of harvest that can be taken by U.S. fishermen while maintaining the SPR at or above 30% Static SPR. Overfishing for species in the Spiny Lobster FMP can only be defined in terms of the fishing mortality component given the data-poor status of these species. Based on the written guidance from NMFS, the Council is setting the overfishing level as a fishing mortality rate (F) in excess of the fishing mortality rate at 20% Static SPR (F20% Static SPR). [Developed by the SAFMC]	Amendment 6 (1998)	December 2, 1999

Table 1.4.1. GMFMC/SAFMC FMP Amendments affecting spiny lobster. (continued)

Description of Action	FMP/Amendment	Effective Date
Identified EFH, described the distribution and relative abundance of juvenile and adult spiny lobster for offshore, near-shore, and estuarine habitats of the Gulf. [Developed by the GMFMC]	Generic Amendment (1998) (no Spiny Lobster amendment number)	Partially approved February 8, 1999 64 FR 13363
Proposed revision to biological thresholds. MSY, OY, and MSST were disapproved because they were based on transitional spawning stock biomass per recruit. Updated the description of the spiny lobster fisheries and provided fishing community assessment information for Monroe County. [Developed by the GMFMC]	Generic SFA Amendment (1999) (no Spiny Lobster amendment number)	Partially approved December 2, 1999 64 FR 59126
Created two no-use marine reserves. Tortugas South in the GMFMC EEZ to encompass a spawning aggregation site for mutton snapper. Tortugas North included part of the fishery jurisdiction of the FKNMS, Dry Tortugas National Monument, GMFMC, and Florida, and was cooperatively implemented by these agencies. [Developed by the GMFMC]	Generic Tortugas Marine Amendment/ Spiny Lobster Amendment 7	August 19,2002 67 FR 47467
Specified that the holder of a valid crawfish license or trap number, lobster trap certificate and state saltwater products license issued by Florida may harvest and possess, while in the EEZ off Florida, undersized lobster not exceeding 50 per boat and 1 per trap aboard each boat, if used exclusively for luring, decoying or otherwise attracting non-captive lobster into traps.	Regulatory Amendment 3 (2002)	
Set minimum size limit for importation of spiny lobster; and disallowed importation of spiny lobster tail meat which is not in whole tail form with the exoskeleton attached and the importation of spiny lobster with eggs attached or importation of spiny lobster where the eggs, swimmerets, or pleopods have been removed or stripped.	Amendment 8 (2008)	February 11, 2009 (74 FR 1148)
Provides spatial information for EFH and EFH-Habitat Areas of Particular Concern designations for species in the Spiny Lobster FMP.	Amendment 9 (2009)	July 22, 2010 (75 FR 35330)

2.0 MANAGEMENT ALTERNATIVES

2.1 Action 1: Other species in the Spiny Lobster Fishery Management Plan (FMP)

*Note: More than one alternative may be chosen as a preferred.

Alternative 1: No Action – Retain the following species: smoothtail spiny lobster**,** *Panulirus laevicauda,* spotted spiny lobster, *Panulirus guttatus,* Spanish slipper lobster, *Scyllarides aequinoctialis,* in the FMP for data collection purposes only, but do not add them to the Fishery Management Unit.

Alternative 2: Set annual catch limits and accountability measures using historical landings for Spanish slipper lobster *Scyllarides aequinoctialis,* after adding them to the Fishery Management Unit and for ridged slipper lobster, *Scyllarides nodifer*, currently in the Fishery Management Unit.

Alternative 3: List species as ecosystem component species:
- **Option a:** smoothtail spiny lobster**,** *Panulirus laevicauda*
- **Option b:** spotted spiny lobster, *Panulirus guttatus*
- **Option c:** Spanish slipper lobster, *Scyllarides aequinoctialis*
- **Option d:** ridged slipper lobster, *Scyllarides nodifer*

Preferred Alternative 4: Remove the following species from the FMP:
- **Preferred Option a:** smoothtail spiny lobster**,** *Panulirus laevicauda*
- **Preferred Option b:** spotted spiny lobster, *Panulirus guttatus*
- **Preferred Option c:** Spanish slipper lobster, *Scyllarides aequinoctialis*
- **Preferred Option d:** ridged slipper lobster, *Scyllarides nodifer*

Comparison of Alternatives: Landings and regulations are established for two species of lobster within the fishery management unit, the Caribbean spiny lobster and the ridged slipper lobster (GMFMC and SAFMC 1982). In order to establish regulations for the other species (i.e., smoothtail spiny lobster, spotted spiny lobster, and Spanish slipper lobster) they would also need to be placed within the fishery management unit. The Gulf of Mexico and South Atlantic Councils (Councils) would have to complete this type of action through a full plan amendment. The species other than Caribbean spiny lobster were placed into the fishery management plan for data collection purposes.

Landings of lobster species by the recreational sector are not documented by the Marine Recreational Fisheries Statistics Survey (MRFSS); only finfish data are collected. The Florida Fish and Wildlife Conservation Commission (FWC) documents recreational catch of Caribbean spiny lobster landings through a survey. FWC documents commercial landings of Caribbean spiny lobster and slipper lobsters by family, meaning the landings could be either Spanish or ridged slipper lobster.

No landings or bycatch information have been documented for smoothtail or spotted spiny lobster species. Because these species are found mostly inshore and are relatively small, neither commercial nor recreational fishers in the Florida Keys generally target these species in U.S. federal waters (W. Kelly, Florida Keys Commercial Fishermen's Association, pers. comm.). Outside of Brazil, the smoothtail spiny lobster is considered to be of minor importance (FAO 2007). In the commercial Caribbean spiny lobster fishery, spotted spiny lobsters are only captured in traps set directly on the reef (Sharp et al. 1997). Spotted spiny lobsters rarely occupy the same dens as Caribbean spiny lobsters (Sharp et al. 1997), so they are unlikely to be taken incidentally by divers.

Even though slipper lobster are not always identified to species level when documented, the slipper lobster catch is believed to be primarily composed of ridged slipper lobster, because it is the only species commonly occurring along the west coast of Florida north of the Florida Keys that attains a size sufficient to be exploited for the industry (Sharp et al. 2007). Table 2.1.1 shows a decrease in slipper lobster landings, number of vessels, and trips. However, catch per unit effort (CPUE, pounds per trip) may have actually increased in recent years. The change in landings seems to be the result of a change in commercial shrimp effort. Major declines in commercial shrimp effort when slipper lobsters were caught occurred 1998/1999-1999/2000 and 2003/2004-2004/2005 (Table 2.1.1).

Table 2.1.1. Number of trips when slipper lobster were caught by vessels with a shrimp permit, plus landings and value of those slipper lobsters in the Gulf and South Atlantic.

Fishing year	Trips	Pounds	CPUE (lbs per trip)	2008$
97/98	335	30,900	92	$131,100
98/99	225	13,100	58	$56,900
99/00	146	7,200	49	$33,500
00/01	145	8,800	60	$49,200
01/02	179	8,600	48	$51,100
02/03	130	10,000	77	$58,200
03/04	132	17,000	129	$98,800
04/05	72	5,000	69	$23,500
05/06	63	4,300	68	$22,100
06/07	56	6,100	108	$30,900
07/08	23	6,400	280	$36,900
08/09	22	1,900	86	$7,700

Source: SEFSC, FTT (Mar. 19, 2010) data

Sharp et al. (2007) suggested decreased landings of slipper lobsters are related to the decreased number of commercial shrimping trips, because much of the slipper lobster landings are incidental catch in shrimp trawls. Gulf commercial shrimping effort was down 77% for 2009 from the base years of 2001-2003 (J. Nance, Southeast Fisheries Science Center, unpublished data). Effort (trips) of slipper lobster for 2009 was down 85% from the base-years average. Over the most recent three years (2006-2009), average slipper lobster landings were down 77%. So, decreases in landings for slipper lobster could be the result of decreased shrimp effort. We have also seen decreased effort in other fisheries due to economic issues such as increased fuel prices. The possibility still exists that effort has decreased because of decreases in the resource, but the stable-to-increasing CPUEs indicate otherwise.

In contrast to the total average commercial trap Caribbean spiny lobsters landings, slipper lobster landings are low and constitute less than 1% of the total average landings in both federal and state waters of the South Atlantic and Gulf of Mexico (Gulf; Table 2.1.2). One commercial fisherman stated of 2,200 traps fished each year he averages about three slipper lobsters per year (K. Lassard, commercial fisherman, pers. comm.).

Table 2.1.2. Average commercial trap landings, number of trips, and value of slipper lobsters (Slipper) versus Caribbean spiny lobster (Spiny) from 1999 through 2008 for Gulf federal waters, South Atlantic federal waters, and state of Florida landings (combined for both coasts). Average pounds landed are live whole animal weight.

Average	Gulf federal		Atlantic federal		Florida state waters	
	Slipper	Spiny	Slipper	Spiny	Slipper	Spiny
Pounds	6,527	164,912	996	998,218	1,594	3,419,293
# Trips	69	413	26	2,976	21	17,805
$ Value	$26,580	$828,149	$4,080	$4,878,155	$6,074	$17,655,979

Source: FWC, Marine Fisheries Information System, 2009. Note: Only one space is available on trip tickets for waters fished. Fishers could fish in both state and federal waters within one day, based on the season and other fishing behaviors. This table should be viewed with some caution, because additional unaccounted variability could exist due to the way the data is recorded and analyzed.

In addition to commercial trap landings data on the ridged and Spanish slipper lobsters, bycatch information is also available from observer coverage of the Gulf and South Atlantic shrimp fishery (Scott-Denton 2004). During these studies, observers did not always specify whether the species was a ridged or Spanish slipper lobster, so often only the family was recorded. An additional species from this family was recorded as bycatch, the Chace slipper lobster (*Scyllarus chacei*). This species is not currently in the Spiny Lobster FMP and bycatch of this species was the lowest of all three species characterized to the species level.

Observer bycatch of all the slipper lobster species was low for both the Gulf and South Atlantic waters (Table 2.1.3). Catch during the 2001-2002 time period was 0.22 slipper lobster (all species) per characterized tow in the Gulf and 0.07 slipper lobster per characterized tow in the South Atlantic. A majority of the observer data from the family Scyllaridae was documented off the west coast of Florida and some off the Louisiana/Texas coast (Figure 2.1.1). Ridged slipper lobster was documented more often than Spanish slipper lobster in the Gulf, similar to Alabama and Florida documented landings. Low bycatch of the family Scyllaridae was also documented off the east coast of Florida (Figure 2.1.1).

Table 2.1.3. Current and historical bycatch of lobster species documented by observer coverage of the Gulf and South Atlantic shrimp fishery.

Lobster species	Gulf (2001-2002)	Atlantic (2001-2007)	Gulf (1992-1996)	Atlantic (1992-1995)
Caribbean spiny lobster (*Panulirus argus)*	19	0	6	0
Ridged slipper Lobster (*Scyllarides nodifer*)	101	1	103	0
Spanish slipper lobster (*Scyllarides aequinoctialis*)	16	1	41	0
Family Scyllaridae (slipper lobsters: ridged, Spanish or Chace)	68	45	0	0
Characterized Tows (Sum)	839	649	1,438	301

Source: E. Scott-Denton, NMFS Galveston Laboratory.

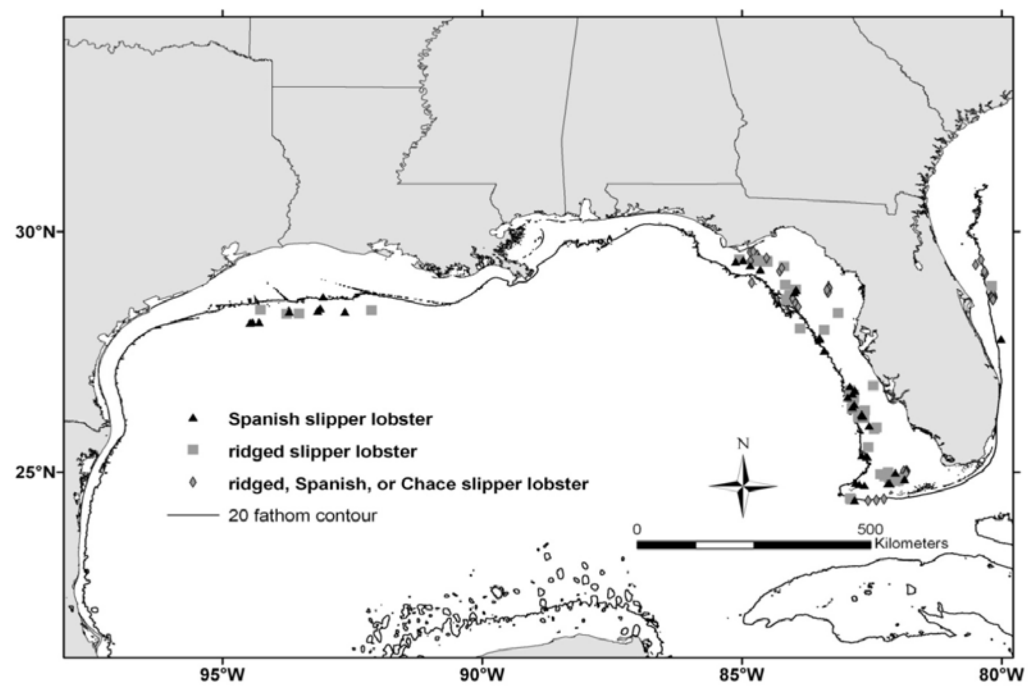


Figure 2.1.1. Location of bycatch documented from the observer shrimp trawl coverage of the Gulf and South Atlantic coast.
Source: E. Scott-Denton, NMFS Galveston Laboratory. Map created by J. Froeschke, Gulf Council Staff

Recreational landings for slipper lobsters are not recorded by the FWC survey, only Caribbean spiny lobster landings. However, due to the intense recreational fishery for Caribbean spiny lobster, some fishers may harvest slipper lobster species if observed (Sharp et al. 2007). Some recreational fishing tournaments may target slipper lobsters, as noted by a Panama City, Florida fishing website (http://www.schooners.com/events/lobsterfestival.htm#results). However, examination of intensive creel surveys of the recreational spiny lobster fishery in the Florida Keys, which were conducted during the special two-day sport season and the first two weeks of the regular season, indicated slipper lobsters are not as targeted by recreational fishers in the Keys. There is evidence that they are targeted to some degree by recreational divers in the northern Gulf (W. Sharp, pers. comm.); however, because of their cryptic nature, it is unlikely a substantial recreational fishery will develop (Sharp et al. 2007). Also, due to the lack of data on slipper lobster species life history, growth rates, and reproductive biology, conducting an effective stock assessment would be difficult (Sharp et al. 2007).

Alternative 1 would retain all species currently in the FMP for data collection purposes only, without adding them to the fishery management unit (FMU). After 28 years, the Councils have not seen the need to add these stocks to the FMU to manage them. However, the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act) requires annual catch limits (ACLs) and accountability measures (AMs) for all species in the FMP except ecosystem component species, so this alternative would not comply with legal requirements.

Alternative 2 would set ACLs and AMs using historical commercial landings for Spanish slipper lobster after adding them to the FMU, and for ridged slipper lobster, currently in the FMU. The ACLs and AMs would need to be set for both species combined because commercial landings are recorded by family, meaning catch could be composed of Spanish slipper lobster, ridged slipper lobster, or both. Positive biological benefits may be expected from setting ACLs and AMs; however, landings of these two species combined are low so the effect may be small. Due to a lack of monitoring and data collection sources for these two species, ACLs may be very difficult to track and AMs may need to be less restrictive to account for limited landings information and potential large fluctuations. The status of this stock is completely unknown, and further life history information is needed before an effective assessment can be undertaken, especially regarding recruitment dynamics, growth rates, behavior, and reproductive biology. Setting ACLs and AMs for the two slipper lobsters combined may not provide the desired positive benefits to the ecological and biological environment because little is known about these two species and currently there are not adequate monitoring programs in place.

Alternative 3 would place any of the four species in the FMU and list them as ecosystem component species (**Options a-d**). The option to use ecosystem component status is intended to encourage the incorporation of ecosystem considerations into FMPs (see Figure 2.1.2 as a guide). Species can be defined as ecosystem component species for reasons such as for ecosystem considerations related to specification of optimum yield for the associated fishery, as considerations in the development of conservation and management measures for the associated fishery, or to address other ecosystem issues.

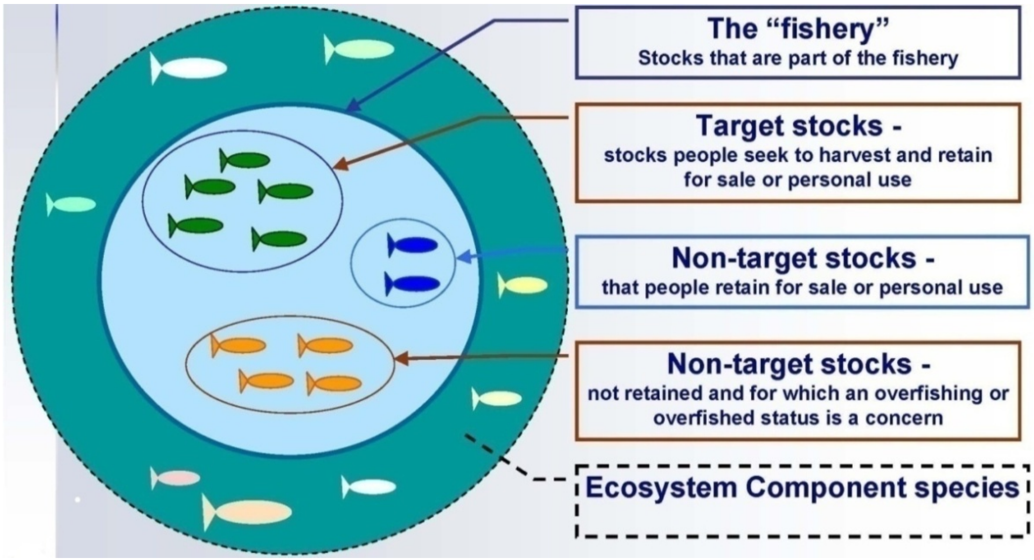


Figure 2.1.2. A conceptual model of stocks in the fishery and ecosystem component stocks.
Source: National Standard 1 guidelines.

Alternative 3, Options a and **b,** would place smoothtail and spotted spiny lobsters in the FMU and list them as ecosystem component species. The smoothtail and spotted spiny lobsters meet all of the ecosystem component criteria, because they are non-targeted, not subject to overfishing or overfished, nor likely to become subject to overfishing or overfished (Table 2.1.4). The National Standard 1 final guidelines add new language in 50 CFR 600.310(d)(5)(i)(D) —''not generally retained for sale or personal use''— in lieu of ''*de minimis* levels of catch'' and clarify that occasional retention of a species would not, in itself, preclude consideration of a species in the ecosystem component classification.

Table 2.1.4. Ecosystem component criteria for stocks in the Gulf and South Atlantic. Average landings were calculated by combining Gulf and South Atlantic commercial landings.

			National Standard 1 Guidelines Criteria			
Species	**Average shrimp trawl landings (pounds) 1997-2009**	**Average trap landings (pounds) 1999-2008**	**Non-target**	**Not overfished or overfishing?**	**Not likely to become overfished or overfishing**	**Not generally retained for sale or personal use**
smoothtail spiny lobster	0	0	X	Unknown	Unknown	X
spotted spiny lobster	0	0	X	Unknown	Unknown	X
Spanish slipper lobster	9,942	11,120	X	Unknown	Unknown	
ridged slipper lobster				Unknown	Unknown	

Source: FWC, Marine Fisheries Information System, 2009 and SEFSC, FTT (19Mar10) data. Note: An "X" indicates the National Standard 1 criteria apply to that species.

Commercial trap landings of the Spanish and ridged slipper lobsters (**Options c** and **d**) are low and averaged 11,120 lbs whole animal weight per year during 1999-2008. The average landings from commercial vessels with a shrimp permit are also low and average 9,942 lbs whole animal weight per year during 1997-2009. The commercial shrimp trawl fishery appeared to target slipper lobsters in the 1980s; landings peaked in 1985, and then decreased greatly until the 1990s (Sharp et al. 2007). This drop in slipper lobster landings by the commercial shrimp fleet might be related to regulatory changes implemented during 1987 that prohibited both the possession of egg-bearing females of the ridged slipper lobster and the removal of eggs by clipping their pleopods. Additionally, commercial shrimp trawls were required to have turtle-excluding devices (TEDS) in the early 1990s which may have also reduced the efficiency with which the gear captured slipper lobsters (Sharp et al. 2007).

Both Spanish and ridged slipper lobster may be targeted at times and are generally retained for sale or personal use; therefore, these species may not meet all the National Standard 1 guidelines for ecosystem component species. Placing species in the ecosystem component classification would allow them to remain in the FMP for data collection, but not require setting ACLs. There are other benefits to designating species as ecosystem component species, other than not establishing management measures. One of the benefits is that those species could be used for ecosystem-based management if the Councils chose to do so. There are also disadvantages for designating them as ecosystem component species and leaving them in the FMP for data collection purposes alone. The primary disadvantage is that designation in itself would not improve the current data collection system. Instead, the current data collection system would have to be modified considerably, because the federal recreational data collection system does not include invertebrates only finfish. There could be positive biological and ecological benefits for these species if regulatory action was needed at a later date because these species would already be in the FMP. However, in order to establish regulations species have to be within the FMU which requires the Councils to take this action through a full plan amendment. Therefore, maintaining species in the FMP and designating them as ecosystem component species with the current monitoring programs may negate any potential positive benefits to the resource.

Preferred Alternative 4 would remove all four species from the Spiny Lobster FMP. If species are removed from federal management, states can manage harvest of the species within federal waters adjacent to state waters for vessels registered to the state or landing catch in the state. Currently, Florida regulations prohibit possession or harvest of egg-bearing females of any spiny or slipper lobster species; thus some of these species would receive greater protection under state management than under current federal management. Representatives of FWC have indicated the state would likely extend their regulations into federal waters if these species are removed from the federal FMP.

Preferred Options a and **b** for smoothtail and spotted spiny lobsters, respectively would remove these species from the FMP. Smoothtail and spotted spiny lobsters have no landings information available. Based on the current data collection programs if these species were removed from the FMP, but landed and sold to a federal dealer, landings data would still be recorded for these species. This would negate any reason to designate them as ecosystem component species for data collection purposes alone. Further if the Councils chose to establish regulations for these species then they would have to be listed within the FMU which requires a full plan amendment to do so. If any of the species are removed from the FMP without another agency taking over management, the potential for negative impacts to the physical and biological environments may occur if fishing effort for these species increased. However, as stated above, these species would be afforded greater protection under Florida regulations than if they were retained in the FMP.

Preferred Options c and **d** for Spanish and ridged slipper lobsters, respectively would remove these species from the FMP. Currently, ridged slipper lobster is within the FMU and because of this, federal regulations have been established for this species. Based on the current data collection programs if these species were removed from the FMP, but landed and sold to a federal dealer, landings data would still be recorded for these species. This would negate any reason to designate them as ecosystem component species for data collection purposes alone. If these species were removed from the FMP, the federal regulations for ridged slipper lobster would no longer apply. However, the state of Florida could manage the fishery in the exclusive economic zone (EEZ) off state waters, and Florida state regulations are more conservative than federal regulations in that they prohibit the harvest of egg-bearing females for all species of slipper lobster. As stated above, commercial landings of slipper lobster are low and have been decreasing over the years. Most data indicate these species are only incidentally caught, primarily by the commercial shrimp fishery and incidentally in Caribbean spiny lobster traps. Slipper lobster landings have decreased concurrent with decreased effort in the commercial shrimp fishery. No recreational landings data are available, but creel surveys of the recreational spiny lobster fishery in the Florida Keys conducted during the special two-day sport season and the first two weeks of the regular season indicated slipper lobsters are not targeted by recreational fishers in the Keys. Although there is some evidence slipper lobsters are targeted to some degree by recreational divers in the northern Gulf, because of their cryptic nature, behavior, and size, they are unlikely to support a substantial recreational fishery.

2.2 Action 2: Modify the Current Definitions of Maximum Sustainable Yield, Overfishing Threshold, and Overfished Threshold for Caribbean Spiny Lobster

2.2.1 Action 2-1: Maximum Sustainable Yield (MSY)

Alternative 1: No Action- Use the current definitions of MSY as a proxy. The Gulf approved definition**:** MSY is estimated as 12.7 million pounds annually for the maximum yield per recruit size of 3.5 inch carapace length. The South Atlantic approved definition: MSY is defined as a harvest strategy that results in at least a 20% static SPR (spawning potential ratio).

Alternative 2: Modify the Gulf definition to mirror the South Atlantic definition of MSY proxy, defined as 20% static SPR.

Alternative 3: The MSY equals the yield produced by fishing mortality at maximum sustainable yield (F_{MSY}) or proxy for F_{MSY}. Maximum sustainable yield will be defined by the most recent
Southeast Data Assessment and Review (SEDAR) and joint Scientific and Statistical Committee (SSC) processes.

<u>Preferred Alternative 4</u>: The MSY proxy will be the overfishing limit (OFL) recommended by the Gulf SSC at 7.90 million pounds.

2.2.2 Action 2-2: Overfishing Threshold (Maximum Fishing Mortality Threshold)

Alternative 1: No Action - Use the current definitions of overfishing thresholds. The Gulf and South Atlantic approved definition: overfishing level as a fishing mortality rate (F) in excess of the fishing mortality rate at 20% static SPR ($F_{20\%}$ static SPR).

Alternative 2: Specify the Maximum Fishing Mortality Threshold (MFMT) as F_{MSY} or F_{MSY} proxy. The most recent SEDAR and SSCs will define F_{MSY} or F_{MSY} proxy. This should equal the OFL provided by the SSCs. The Councils will compare the most recent value for the current fishing mortality rate (F) from the SEDAR/SSC process to the level of fishing mortality that would result in MFMT and if the current F is greater than the MFMT, overfishing is occurring. Comparing these two numbers:

- $F_{CURRENT}$/MFMT = X.XXX

*This comparison is referred to as the **overfishing ratio**. If the ratio is greater than 1, then overfishing is occurring.

<u>Preferred Alternative 3</u>: Specify the MFMT as the OFL defined by the Gulf SSC at 7.90 million pounds.

2.2.3 Action 2-3: Overfished Threshold (Minimum Stock Size Threshold)

Alternative 1: No Action – Do not establish an overfished threshold. The Gulf Council does not have an approved definition of the overfished threshold. The South Atlantic Council approved definition is a framework procedure to add a biomass based component to the overfished definition, due to no biomass levels and/or proxies being available.

Alternative 2: The Minimum Stock Size Threshold (MSST) is defined by the most recent SEDAR and SSC process. The Councils will compare the current spawning stock biomass (SSB) from the SEDAR and SSC process to the level of spawning stock biomass that could be rebuilt to the level to produce the MSY in 10 years. Comparing these two numbers:

- $SSB_{CURRENT}/MSST = Y.YYY$

This comparison is referred to as the **overfished ratio**. If the ratio is less than 1, then the stock is overfished.

Preferred Alternative 3: $MSST = (1-M) \times B_{MSY}$. Definitions: M = instantaneous natural mortality and B_{MSY} = biomass at maximum sustainable yield or the appropriate proxy.

Comparison of Alternatives: There are three sub-actions for modification of the current definition for each of the following biological reference points: MSY, MFMT, and MSST. The optimum yield (OY) definition is addressed under Action 4-2.

Currently the Councils have different approved definitions for two of three biological reference points (Actions 2-1 and 2-3). The Gulf Council does not currently have an approved MSST definition and the South Atlantic Council's approved definition is a framework procedure (GMFMC and SAFMC 1982; GMFMC and SAFMC 1990; GMFMC 1999; SAFMC 1998; SEDAR 8 2005). The Gulf Council definitions submitted to NOAA Fisheries Service in their Generic Sustainable Fisheries Act (SFA) Amendment were partially approved (NOAA Fisheries Service letter to the Gulf Council received November 17, 1999; log file number 5153). The letter states that SPR is not biomass-based and is not an acceptable proxy for MSY or MSST. In addition, the letter goes on to state that transitional SPR is not an appropriate proxy for the MFMT for spiny lobster, because it is affected by past fishing mortality. However, static SPR is the appropriate proxy for MFMT. After modification the Gulf Council's definition was approved.

Transitional SPR versus static SPR was used for the unapproved definitions of MSY and MSST by the Gulf Council. As the name suggests, SPR ratio expresses spawning per recruit as a ratio in a fished condition relative to the maximum theoretical amount of spawning per recruit that occurs when there is no fishing (Slipke and Maceina 2000; MRAG Americas 2001). Due to increased fishing effort reducing the potential reproductive output, the denominator in the spawning potential ratio is always greater than or equal to the numerator, so the resulting values will range between 0 and 1 (MRAG Americas 2001).

The benchmark assessment for Caribbean spiny lobster (SEDAR 8 2005) found that the biomass of the stock could not be estimated. Therefore MSY, biomass at MSY, and MSST were not estimated (Table 2.2.3.1). An updated assessment on Caribbean spiny lobster was completed in 2010. The Review Panel was made up of members of both Councils' SSCs. After careful consideration, the Review Panel concluded there is sufficient concern with the performance of the two assessment models to reject the results, and that the stock status of Caribbean spiny lobster in the southeastern U.S. was unknown. This was primarily based on new genetic evidence presented by Mike Tringali from FWC indicating the southeastern U.S. Caribbean spiny lobster stock largely depends on external recruitment from upstream Caribbean populations (Hunt and Tringali 2011). Due to this new genetic information, the Review Panel concluded that the U.S. Caribbean spiny lobster stock cannot be assessed in isolation and the assessment was not conducted on the appropriate geographical and biological scale needed to capture population-wide dynamics. The Gulf SSC went on to request in a motion that monitoring and research be supported to produce a pan-Caribbean population-wide assessment. The South Atlantic SSC reviewed the update assessment for spiny lobster at their meeting in April 2011. The South Atlantic SSC agreed with the SEDAR Review Panel recommendations and the Gulf SSC that stock status could not be determined due to strong evidence of external recruitment and no indication of a separate U.S. stock.

Alternative 1 under Actions 2-1 and 2-3 would use the current approved definitions of MSY and MSST, separately for each Council. Due to the Caribbean spiny lobster fishery being a jointly managed species, now may be the best time for the Councils to adopt the same biological reference points in this full amendment. However, under Action 2-2, the Councils have the same approved definitions for the overfishing threshold, but may select a different alternative based on new scientific information from the 2010 update stock assessment and SSC Review Processes.

The MSY is currently unknown for the U.S. stock of Caribbean spiny lobster because biomass estimates are unreliable due to outside recruitment from the pan-Caribbean population. Therefore, the biomass estimates were not accepted from the 2010 Update Assessment. **Alternative 2** under Action 2-1 would modify the definition of MSY to mirror the South Atlantic Council's definition, which is a harvest strategy resulting in 20% static SPR, versus using landings estimates which is currently the approved Gulf Council definition (**Alternative 1**). A non-landings based definition of MSY (i.e., 20% transitional SPR) was developed by the Gulf Council in 1998 in their Generic Sustainble Fisheries Act Amendment, but was disapproved because it was not biomass-based and was not considered an acceptable proxy for MSY (log file number 5153). Although the South Atlantic Council's definition was not biomass based, it was approved in Amendment 6, 1998 and became effective December 2, 1999 (i.e., 20% static SPR).

Justification for using static SPR is based on projected yield streams at equilibrium, versus the current dynamic measure (transitional SPR), which may change in future years from the current estimate. This could make the projections less reliable than using equilibrium recruitment and mortality conditions (static SPR). Since stock assessments are not usually completed on an annual basis, static SPR may be a better index to use for yield projections. Further, static SPR does not require constant recruitment, because it is expressed on a "per recruit" basis and is useful as a measure of overfishing (MRAG Americas 2001).

Alternative 3 under Action 2-1 and **Alternatives 2** under Action 2-2 and Action 2-3 would modify all biological determination criteria from the current definitions to those established under the most recent SEDAR and SSC process. This alternative would provide the best available science in the update assessment and modify the separate Council definitions into one biological reference point for MSY, overfishing, and overfished threshold. However, the 2010 update assessment for spiny lobster was not accepted by the Review Panel or by the Gulf SSC, based on new evidence indicating the southeastern U.S. stock largely depends on external recruitment from upstream Caribbean populations. It was determined that this finding precluded reliable estimation of management reference points.

Due to the MSY being currently unknown, the Gulf Council proposed using the Gulf SSC recommendations for the overfishing limit (OFL). The MSY proxy also designed as the OFL recommended by the Gulf SSC was derived in the following manner: Using Tier 3a of the Gulf ABC Control Rule, the Gulf SSC recommended an OFL be set as the mean of the most recent landings in the last 10 years (i.e., fishing years 2000/2001-2009/2010; Table 2.4.1) plus two standard deviations from the mean. The Gulf ABC Control Rule is discussed in greater detail under Action 4-1. The Councils' SSCs used the data set from the 2010 Update Assessment that excluded attractants, which is consistent with finfish assessment excluding dead discards. (Note: an attractant is an "undersized lobster" used in a trap to draw other legal sized lobsters into the traps due to their gregarious behavior, 2010 Update Assessment Report. Section 2.7 addresses the use of "undersized lobsters" as attractants).

Because biomass estimates are unreliable for Caribbean spiny lobster and the 2010 update stock assessment was rejected, the Councils selected **Preferred Alternative 4** for Action 2-1. This alternative will establish the MSY proxy as the OFL recommended by the Gulf SSC at 7.90 million pounds (mp). The unaccepted MSY estimate calculated in the 2010 update assessment for Caribbean spiny lobster was the yield at $F_{20\%SPR}$ = 7.95 mp (Update Assessment Review Workshop Report 2010). This unaccepted value is nearly the same value as the current **Preferred Alternative 4** for Action 2-1 calculated by the Gulf Council SSC from the ABC Control Rule. It is fortunate that these numbers worked out to be so close because Tier 3a of the ABC Control Rule is based on landings and the stock assessment is based on the best available science estimate of an OFL based on the MSY proxy of $F_{20\%SPR}$.

In addition to the MSY level being unknown, the MFMT is also unknown due to biomass estimates for Caribbean spiny lobster being unreliable. Therefore the Gulf Council requested that the MFMT be defined by the Gulf SSC OFL at 7.90 mp, as reflected in the current Action 2-2 **Preferred Alternative 3**.

The proxy of $F_{20\%SPR}$ for F_{MSY} was used to estimate this value in both the update and benchmark assessments (Table 2.2.3.1). The value estimated from the update assessment for MFMT was 0.45 per year which is very close to the estimate calculated from the benchmark assessment at 0.49 per year. These estimates are based on a fishing mortality rate at MSY or in the case of Caribbean spiny lobster a proxy for F_{MSY} defined as $F_{20\%SPR}$. The Councils felt using the landings-based estimate was more appropriate for the MFMT rather than using the fishing mortality proxy. Since the MSY proxy was the OFL=7.90 mp (**Preferred Alternative 4**), specifying the overfishing threshold at a rate that exceeds 7.90 mp is appropriate (**Preferred Alternative 3** under **Action 2-2**).

Based on the unestimated biomass of Caribbean spiny lobster in the southeastern U.S. due to external recruitment from pan-Caribbean populations, the MSST is also unknown. Under the current **Preferred Alternative 3** for Action 2-3**,** the MSST will be equal to (1-M) x B_{MSY}. (Definitions: M = instantaneous natural mortality and B_{MSY} = biomass at maximum sustainable yield or the appropriate proxy.) The instantaneous natural mortality number used for both the SEDAR 8 benchmark assessment and 2010 update assessment was M = 0.34 per year. However, due to the biomass of the southeastern U.S. Caribbean spiny lobster stock remaining unknown, MSST cannot be calculated. Nevertheless, it was estimated in the 2010 update assessment at 1.150 x 10^{12} eggs (Table 2.2.3.1).

Table 2.2.3.1. Management benchmarks for Caribbean spiny lobster in the southeastern United States.

Criterion	Description	Definition	Unaccepted Values 2010 Update Assessment	Accepted Values from SEDAR 8 2005
MSY	Maximum Sustainable Yield	Yield@$F_{20\%SPR}$	7.95 mp	Not estimated
MFMT	Maximum Fishing Mortality Threshold	F_{MSY} =$F_{20\%SPR}$	0.45 per year	0.49 per year
B_{MSY}	Biomass at MSY	Biomass@$F_{20\%SPR}$	1.743 x 10^{12} eggs	Not estimated
MSST	Minimum Spawning Stock Threshold	B_{MSY} x (1-M)	1.150 x 10^{12} eggs	Not estimated

Source: Update Assessment Review Workshop Report 2010 (unaccepted assessment values) and SEDAR 8 Benchmark Assessment 2005.

The values in the SEDAR-based alternatives for MSY (Action 2-1, **Alternative 3**), Overfishing Threshold (Action 2-2, **Alternative 2**), and Overfished Threshold (Action 2-3, **Alternative 2**) were not accepted by the Review Panel or the Gulf SSC. Therefore as currently written, **Actions 2-1**, **Alternatives 2** and **3** are the same. However, the Councils felt it was necessary to leave these alternatives in the document because a more reliable Caribbean-wide estimate of biomass may be produced. At that time these alternatives may provide the best protection for the resource. Until another benchmark assessment can be completed for Caribbean spiny lobster with additional information on the pan-Caribbean stock Action 2-1, **Alternative 4** and Action 2-2, **Alternative 3** provide the best protection for the resource. The overfished threshold **(**Action 2-3, **Alternative 3)** is currently unknown but would provide the same biological reference point for both Councils. Therefore, when the biomass is able to be estimated for Caribbean spiny lobster, Action 2-3, **Alternative 3** would provide adequate protection for the resource. However, without a clear estimate of Caribbean spiny lobster biomass, it is unknown if **Alternatives 2** or **3** under Action 2-3 would provide the best protection for the resource.

2.3 Action 3: Establish Sector Allocations for Caribbean Spiny Lobster in State and Federal Waters from North Carolina through Texas

Preferred Alternative 1: No action – Do not establish sector allocations.

Alternative 2: Allocate the spiny lobster ACL by the following sector allocations: 80% commercial and 20% recreational.

Alternative 3: Allocate the spiny lobster ACL by the following sector allocations: 74% commercial and 26% recreational.

Alternative 4: Allocate the spiny lobster ACL by the following sector allocations: 78% commercial and 22% recreational.

Alternative 5: Allocate the spiny lobster ACL by the following sector allocations: 77% commercial and 23% recreational.

Alternative 6: Allocate the spiny lobster ACL by the following sector allocations: 76% commercial and 24% recreational.

Comparison of Alternatives: **Preferred Alternative 1** would not establish sector ACLs. Allocations would be necessary if sector ACLs or ACTs were set. However, the Councils chose to set a single stock ACL and ACT. The Councils recognize the competition between commercial diving and commercial trapping but the existing quota monitoring programs do not provide the ability to track these separate commercial quotas. The Councils chose to not designate sector allocations to minimize the administrative burden, and also because the ACL will likely not be exceeded under the current fishery conditions. The Councils will review the decision for sector allocations if landings increase in the future.

For all alternatives, the Councils are including all gear types for the commercial sector into one allocation. **Alternative 2** is based on the "better year" defined by the Florida Spiny Lobster Advisory Board (Advisory Board), which was the 1998/99 fishing season when the trap fishery had the highest proportion of total landings. This alternative was supported by 10 of the 14 members of the Advisory Board present at the May 23-24, 2006 meeting. **Alternative 3** is based on using 1993/1994 landings for allocations and was supported by 3 of the 14 members of the Advisory Board. **Alternative 4** is the average of **Alternatives 2** and old Alternative 3 (see Appendix A) and was supported by 11 of the 14 members of the Advisory Board present. This is the consensus recommendation of the Advisory Board for spiny lobster allocations. **Alternative 5** uses catches from fishing years/seasons 1991/1992 through 2009/2010 (Table 2.4.1.2). **Alternative 6** bases 50% of the allocation on the most recent 10 years (2000/2001-2009/2010) and 50% on the most recent three years (2007/2008-2009/2010).

By way of comparison with recent landings, the recreational sector harvested 21% in 2009/2010. **Alternative 2** would represent a reduction of 1% to the recreational sector, **Alternative 3** would represent an increase of 5%, **Alternative 4** would represent an increase of 1%, **Alternative 5** would represent an increase of 2%, and **Alternative 6** would represent an increase of 3%. Using the same base year (2009/2010), the commercial sector would see an increase of 1% under **Alternative 2**, a decrease of 5% under **Alternative 3**, a decrease of 1% under **Alternative 4**, a decrease of 2% under **Alternative 5**, and a decrease of 3% under **Alternative 6**. **Preferred Alternative 1** would allow both sectors to operate as they have in the past, and the Councils will monitor the level of harvest and take action if necessary through the framework procedure.

2.4 Action 4: Acceptable Biological Catch (ABC) Control Rule, ABC Level(s), Annual Catch Limits, and Annual Catch Targets for Caribbean Spiny Lobster

2.4.1 Action 4-1: Acceptable Biological Catch (ABC) Control Rule

Alternative 1: No Action – Do not establish an ABC Control Rule for spiny lobster.

Preferred Alternative 2: Adopt the following ABC Control rule:
- **Option a**: the South Atlantic Council's ABC control rule.
- **Preferred Option b**: the Gulf Council's ABC control rule.

Alternative 3: Establish an ABC Control Rule where ABC equals OFL.

Alternative 4: Specify ABC as equal to the mean of the last 10 years landings.

Alternative 5: Specify ABC as equal to the high of the last 10 years landings.

Alternative 6: Specify ABC as equal to the low of the last 10 years landings.

Comparison of Alternatives: Alternative 1 does not specify an ABC control rule. The SSC would set ABC for each stock using their best judgment. The National Standard 1 guidelines require that fishery management plans contain an ABC control rule, defined as "a specified approach to setting the ABC for a stock or stock complex as a function of the scientific uncertainty in the estimate of OFL and any other scientific uncertainty" (600.310(f)(2)(iii)). Because this alternative does not provide a specified approach, it is not viable under the guidelines.

Alternative 2, Option a would use the South Atlantic Council's ABC control rule, which is still under development. The rule provides a hierarchy of dimensions and tiers within dimensions used to characterize uncertainty associated with stock assessments in the South Atlantic. Dimension one for assessed stocks is complete; an interim approach is available for unassessed stocks. However, at their April 2011 meeting, the South Atlantic Council's SSC chose not to use this method for Caribbean spiny lobster.

Preferred Alternative 2, Option b uses the ABC control rule developed by the Gulf Council's SSC (Table 2.4.1.1) to set ABC for Caribbean spiny lobster. In January, the Gulf SSC met and reviewed the spiny lobster stock assessment update. They agreed with the review panel's decision to reject the update, and proceeded to set ABC using Tier 3a of the control rule. At the December 2010 South Atlantic Council meeting, the South Atlantic Council directed their SSC to consider the Gulf Council ABC control rule. The South Atlantic Council's SSC met in April 2011 and accepted the Gulf Council's ABC control rule for Caribbean spiny lobster.

The Gulf Council ABC control rule determines the appropriate level of risk and/or buffer to set between the OFL and ABC. The ABC control rule offers three tiers of guidance for setting ABC based on the amount of information for a given stock. Stocks with less information have greater scientific uncertainty, and therefore, the buffer between the OFL and ABC should be greater.

Table 2.4.1.1. Gulf Council Acceptable Biological Catch Control Rule (March 2011).

Tier 1 Acceptable Biological Catch Control Rule	
Condition for Use	A quantitative assessment provides both an estimate of overfishing limit based on MSY or its proxy and a probability density function of overfishing limit that reflects scientific uncertainty. Specific components of scientific uncertainty can be evaluated through a risk determination table.
OFL	OFL = yield resulting from applying F_{MSY} or its proxy to estimated biomass.
ABC	The Council with advice from the SSC will set an appropriate level of risk (P*) using a risk determination table that calculates a P* based on the level of information and uncertainty in the stock assessment. ABC = yield at P*.
Tier 2 Acceptable Biological Catch Control Rule	
Condition for Use*	An assessment exists but does not provide an estimate of MSY or its proxy. Instead, the assessment provides a measure of overfishing limit based on alternative methodology. Additionally, a probability density function can be calculated to estimate scientific uncertainty in the model-derived overfishing limit measure. This density function can be used to approximate the probability of exceeding the overfishing limit, thus providing a buffer between the overfishing limit and acceptable biological catch.
OFL	An overfishing limit measure is available from alternative methodology.
ABC	Calculate a probability density function around the overfishing limit measure that accounts for scientific uncertainty. The buffer between the overfishing limit and acceptable biological catch will be based on that probability density function and the level of risk of exceeding the overfishing limit selected by the Council. a. Risk of exceeding OFL = 50% b. Risk of exceeding OFL = 40% c. Risk of exceeding OFL = 30% (default) d. Set ABC = OFL – buffer at risk of exceeding OFL
Tier 3a Acceptable Biological Catch Control Rule	
Condition for Use*	No assessment is available, but landings data exist. The probability of exceeding the overfishing limit in a given year can be approximated from the variance about the mean of recent landings to produce a buffer between the overfishing limit and acceptable biological catch. Based on expert evaluation of the best scientific information available, recent historical landings are without trend, landings are small relative to stock biomass, or the stock is unlikely to undergo overfishing if future landings are equal to or moderately higher than the mean of recent landings. For stock complexes, the determination of whether a stock complex is in Tier 3a or 3b will be made using all the information available, including stock specific catch trends.
OFL	Set the overfishing limit equal to the mean of recent landings plus two standard deviations. A time series of at least ten years is recommended to compute the mean of recent landings, but a different number of years may be used to attain a representative level of variance in the landings.
ABC	Set acceptable biological catch using a buffer from the overfishing limit that represents an acceptable level of risk due to scientific uncertainty. The buffer will be predetermined for each stock or stock complex by the Council with advice from the SSC as:

	a. ABC = mean of the landings plus 1.5 * standard deviation (risk of exceeding OFL = 31%) b. ABC = mean of the landings plus 1.0 * standard deviation (default)(risk of exceeding OFL = 16%) c. ABC = mean of the landings plus 0.5 * standard deviation (risk of exceeding OFL = 7%) d. ABC = mean of the landings (risk of exceeding OFL = 2.3%)
Tier 3b Acceptable Biological Catch Control Rule	
Condition for Use*	No assessment is available, but landings data exist. Based on expert evaluation of the best scientific information available, recent landings may be unsustainable.
OFL	Set the overfishing limit equal to the mean of landings. A time series of at least ten years is recommended to compute the mean of recent landings, but a different number of years may be used to attain a representative level of variance in the landings.
ABC	Set acceptable biological catch using a buffer from the overfishing limit that represents an acceptable level of risk due to scientific uncertainty. The buffer will be predetermined for each stock or stock complex by the Council with advice from its SSC as: e. ABC = 100% of OFL f. ABC = 85% of OFL g. ABC = 75% of OFL (default) h. ABC = 65% of OFL

Note 1: Changes in the trend of a stock's landings or a stock complex's landings in three consecutive years shall trigger a reevaluation of their acceptable biological catch control rule determination under Tiers 2, 3a, or 3b.
Note 2: There may be situations in which reliable landings estimates do not exist for a given data-poor stock. The approach and methodology for setting OFL and ABC will be determined on a case-by-case basis, based on expert opinion and the best scientific information available.

Tier 1 is for stocks that have undergone a quantitative assessment that has produced an estimate of MSY and a probability distribution around the estimate (See the Gulf Councils Generic ACL/AM Control Rule for the P-star table). Tier 2 is for stocks that have not had a quantitative assessment that produces an estimate of MSY or MSY proxy. Tier 3a is for stocks that have not been assessed, but are stable over time or, in the judgment of the SSC, the stock or stock complex is unlikely to undergo overfishing at current average levels or at levels moderately higher than current average levels. Tier 3b is for stocks that do not meet the requirements of either Tier 1 or Tier 2 and, in the judgment of the SSC the current fishing levels may not be sustainable over time.

Tier 3a was determined to be appropriate for Caribbean spiny lobster because the Review Panel rejected the SEDAR update assessment, but landings data are available. Further, because of the almost complete recruitment from outside the U.S., the stock is not at risk of undergoing overfishing. Under this tier, OFL was set at mean landings (recent 10 years) plus two standard deviations (7.9 mp). The ABC was set using a buffer from OFL that represents an acceptable level of risk due to scientific uncertainty. The Gulf Council's SSC recommended using mean landings plus 1.5 standard deviations (7.32 mp) because, based on population genetics and physical transport data presented, juvenile spiny lobster that settle in south Florida have a high probability of recruiting from several spawning populations throughout the greater Caribbean and are not locally self-recruited. Therefore, landings in south Florida are unlikely to have a substantial effect on future recruitment there.

Table 2.4.1.2 shows values for each alternative using the recent 10-year average landings. **Alternative 3** would set ABC equal to OFL; however, some method would be needed for setting the OFL if the current control rules are not used. **Alternatives 4-6** cover the range of values under consideration by the Councils.

Table 2.4.1.2. Caribbean spiny lobster landings.

Fishing Season	Com. Total	%Com	Rec. Total	%Rec	Com. & Rec. Total
91/92	6,836,015	79%	1,815,791	21%	8,651,806
92/93	5,368,188	80%	1,352,443	20%	6,720,631
93/94	5,309,790	74%	1,883,114	26%	7,192,904
94/95	7,181,641	79%	1,905,995	21%	9,087,636
95/96	7,017,134	78%	1,930,718	22%	8,947,852
96/97	7,744,104	80%	1,922,596	20%	9,666,700
97/98	7,640,177	77%	2,304,186	23%	9,944,363
98/99	5,447,533	81%	1,302,677	19%	6,750,210
99/00	7,669,207	76%	2,461,981	24%	10,131,188
00/01	5,568,707	74%	1,949,033	26%	7,517,740
01/02	3,079,263	71%	1,251,081	29%	4,330,343
02/03	4,577,392	76%	1,455,298	24%	6,032,690
03/04	4,161,589	75%	1,411,509	25%	5,573,097
04/05	5,472,994	76%	1,657,535	24%	6,906,397
05/06	2,963,160	72%	1,131,014	28%	4,094,174
06/07	4,799,493	79%	1,304,511	21%	6,104,004
07/08	3,778,037	76%	1,215,069	24%	4,993,105
08/09	3,269,397	72%	1,263,509	28%	4,532,906
09/10	4,343,305	79%	1,126,714	21%	5,470,019
All years	5,380,375	77%	1,601,086	23%	6,981,461
Recent 10-year values					
Mean					5,584,939
Median					5,521,558
Minimum					4,094,174
Maximum					7,517,740
Mean + 1.5Std.					7,323,117
Mean + 2.0Std.					7,902,510

Source: Landings from FWC as of June 24, 2010. Recreational landings are estimated landings through Labor Day of each season only. The recreational landings from 2000 onward reflect the retrospective analysis done to include additional recreational permit holders that were not incorporated into the original landings models. Total landings for the 02004/2005 season were not provided because the recreational surveys were not conducted that season due to storms; previous estimates only included the 2-day season landings and substantially underestimated total recreational landings for the combined 2-day season and the first month of the regular season. Recreational 2004/2005 landings were estimated based on the average percent of recreational landings in the preceding years.

2.4.2 Action 4-2: Set Annual Catch Limits (ACLs) for Caribbean Spiny Lobster

Alternative 1: No Action – Do not set ACLs.

<u>Preferred Alternative 2</u>: Set an ACL for the entire stock based on the ABC:

- **<u>Preferred Option a</u>:** ACL = ABC = (7.32 million pounds).
- **Option b:** ACL = 90% of ABC (6.59 million pounds).
- **Option c:** ACL = 80% of ABC (5.86 million pounds).

Alternative 3: Set ACLs for each sector based on allocations determined in Action 3:

- **Option a:** ACL = (sector allocation x ABC).
- **Option b:** ACL = 80% or 90% of (sector allocation x ABC).
- **Option c:** ACL = sector allocation x (80% or 90% of ABC).

<u>Comparison of Alternatives</u>: ACLs are set by the Councils and should take into account management uncertainty. Management uncertainty may occur because sufficient catch information is lacking, and may include late catch reporting, misreporting, and underreporting of catches. Management uncertainty is affected by the ability to control actual catch in the fishery. For example, a fishery with in-season catch data and in-season closure authority has better management control than a fishery without these features. Annual catch limits, in coordination with AMs, must prevent overfishing.

The Caribbean spiny lobster stock was previously assessed in 2005 (SEDAR 8). This assessment determined the stock was not undergoing overfishing based on a static spawning potential ratio of 20% ($F_{20\%}$) as set in Amendment 6. However, because the spawning stock includes the entire Caribbean region, spawning biomass at MSY (B_{MSY}) or the MSST could not be determined; therefore, the assessment could not determine if the stock is overfished. A stock assessment update was completed in November 2010. The base run of the model determined the stock is not overfished or undergoing overfishing. The Review Panel reviewed the SEDAR 8 Update and suggested using values based on the assumed maturity schedule. The new values still indicated no overfishing ($F_{current}/F_{20\%SPR}$ = 0.47) and not overfished ($SSB_{current}/SSB\ F_{20\%SPR}$ = 1.29). However, the Review Panel rejected the assessment update and stated they had no confidence in the reference points.

Alternative 1 would not specify an ACL for spiny lobster. Currently, there are no quotas in place that could serve as ACLs for either the commercial or recreational sector. Therefore, **Alternative 1** would not meet the requirements specified in the Magnuson-Stevens Act.

An ACL for a given stock can be established as either a single ACL for the entire fishery, or separate ACLs for various sectors. One ACL for the entire stock (**Preferred Alternative 2**) may be appropriate if sector allocations are not set (Action 3). The ACL cannot exceed the ABC. If a Council recommends an ACL which equals ABC (**Preferred Alternative 2, Option a**), and the ABC is equal to the OFL, the Council must provide sufficient analysis and justification for the approach or the Secretary of Commerce may presume overfishing will not be prevented. However, the Gulf Council's SSC set OFL at 7.9 mp which is higher than the recommended ABC of 7.32 mp. The ACL can also be reduced from the ABC to account for management uncertainty. Under the Gulf Council's ABC control rule, **Alternative 2, Options b** and **c** would equal 6.59 mp and 5.86 mp, respectively.

Sector ACLs (**Alternative 3**) may be appropriate if allocations are set, or if based on landings data. Recreational landings data in Florida are slightly less complete than commercial landings for the same time period. If more than one ACL is set, the sum of the ACLs can equal (**Alternative 3, Option a**), but not exceed, the ABC. The ABC could be separated using the sector allocations chosen in Action 3, in which case each ACL could be reduced for management uncertainty particular to that sector (**Alternative 3, Option b**). Alternately, the ABC could be reduced for overall management uncertainty first, then the resulting amount divided into separate sector ACLs (**Alternative 3, Option c**). The actual pounds for each option would depend on the allocation set in Action 3 (see Table 4.4.2.2 for the full range of allocations associated with each option).

2.4.3 Action 4-3: Set Annual Catch Targets (ACTs) for Caribbean Spiny Lobster

Alternative 1: No Action – Do not set ACTs.

Preferred Alternative 2: Set an ACT for the entire stock.
- **Preferred Option a:** ACT = OY = 90% of ACL (6.59 million pounds).
- **Option b:** ACT = OY = ACL (7.32 million pounds).
- **Option c:** ACT = OY = 6.0 million pounds.

Alternative 3: Set ACTs for each sector based on allocations from Action 3.
- **Option a:** ACT = OY = (sector allocation x ACL).
- **Option b:** ACT = OY = 90% of (sector allocation x ACL).
- **Option c:** ACT = OY = sector allocation x (90% of ACL).

Comparison of Alternatives: The ACT is the amount of annual catch of a stock that is the management target of the fishery, and accounts for further management uncertainty in controlling the actual catch at or below the ACL. An ACT set less than the ACL provides a buffer so the risk of exceeding the ACL is reduced and, therefore, the likelihood of triggering AMs is reduced. An ACT lowers the allowed catch below the ACL, but provides stability for fisheries that are apt to fluctuate around a target catch rate. The ACT equals OY, because the ACT is the management target and the stock should be managed to achieve OY.

Alternative 1 would not set an ACT for Caribbean spiny lobster. The National Standard 1 Guidelines do not require ACTs be established, but provide that ACTs may be used as part of a system of AMs. Accountability measures are required regardless of whether ACTs are established. If no ACT is set, the AMs would be based on the ACL.

One ACT could be set for the entire Caribbean spiny lobster stock (**Preferred Alternative 2**) if a single ACL is set for the stock (Action 4-2 Preferred Alternative 2). A single ACT would apply to all sectors and any AMs would be triggered simultaneously. Currently, no quotas constrain harvest of Caribbean spiny lobster. If the Councils were to set the ACT equal to the ACL (**Alternative 2, Option b**), no buffer would be in place. An ACT less than the ACL (**Preferred Option a** and **Option c**) creates a buffer which would be an AM to alert the Councils and NOAA Fisheries Service that landings are nearing the ACL (see Action 5).

A recent genetic study indicates the majority of Caribbean spiny lobster recruits come from outside the management area (Hunt and Tringali 2011). Therefore, any biological benefits to the population within the subject management area as a result of reducing the ACT below the ACL are likely to be negligible. A 10% buffer (**Preferred Alternative 2, Option a**) would set the ACT at 6.59 mp. The level set in **Option c** is slightly lower than the highest landings in the recent five years (2005/2006-2009/2010).

Sector ACTs **(Alternative 3)** could be set if separate sector ACLs are set **(**Action 4-2, Alternative 4**)** or if a single ACL is set for the stock **(**Action 4-2, Alternative 2**)**. In the second case, the AMs could be based on the stock ACL allowing one or more of the separate ACTs to be exceeded without severe consequences. This separation might be useful if one group consistently has landings below their allocation and can "absorb" any overage from another group. If separate ACTs are set, the sum of the ACTs can equal the ACL (**Alternative 3, Option a**). The ACL could be separated using the sector allocations chosen in Action 3, then each ACT could be reduced for management uncertainty particular to that sector (**Alternative 3, Option b**). Alternately, the ACL could be reduced for overall management uncertainty first, then the resulting amount divided into separate sector ACTs (**Alternative 3, Option c**). Again, a 10% buffer may be adequate for **Options b** and **c** because overfishing is unlikely. However, the Councils' preferred alternative for Action 3 is to not set sector allocations.

2.5 Action 5: Accountability Measures (AMs) by Sector

*Note: More than one alternative, option, sub-option, or combinations thereof, may be chosen as preferred.

Alternative 1: No Action – Do not set AMs. Currently there are no management measures in place that could be considered AMs.

Alternative 2: Establish commercial in-season AMs**:**

> **Option a**: Close the commercial fishery when the ACL is projected to be met.
> **Option b**: Implement a commercial trip limit when 75% of the commercial ACL is projected to be met.

Alternative 3: Establish post-season AMs:

- **Option a**: Commercial
  - **Sub-option i**: ACL payback in the fishing season following a previous years ACL overage.
  - **Sub-option ii**: Adjust the length of the fishing season following an ACL overage.
  - **Sub-option iii**: Implement a trip limit.
- **Option b**: Recreational
  - **Sub-option i**: ACL payback in the fishing season following an ACL overage. To estimate the overage, compare the recreational ACL with recreational landings over a range of years. For 2011, use only 2011 landings. For 2012, use the average landings of 2011 and 2012. For 2013 and beyond, use the most recent three-year running average.
  - **Sub-option ii**: Adjust the length of the fishing season following an ACL overage. To estimate the overage, compare recreational ACL with recreational landings over a range of years. For 2011, use only 2011 landings. For 2012, use the average landings of 2011 and 2012. For 2013 and beyond, use the most recent three-year running average.
  - **Sub-option iii**: Adjust bag limit for the fishing season following a previous season's ACL overage.
- **Option c**: Recreational and commercial combined accountability measures
  - **Sub-option i**: Adjust season length for both recreational and commercial harvest of spiny lobster in the fishing season following an ACL overage.
  - **Sub-option ii**: Recreational and commercial ACL payback in the fishing season following a previous season's ACL overage (if a combined ACL is chosen).

<u>Preferred Alternative 4</u>: Establish the ACT as the accountability measure for Caribbean spiny lobster (ACT = 6.59 million pounds).

<u>Comparison of Alternatives</u>: Accountability measures are designed to provoke an action once either the ACL or ACT is reached during the course of a fishing season to reduce the risk overfishing will occur. However, depending on how timely the data are, it might not be realized that either the ACL and/or ACT has been reached until after a season has ended.

There are several types of AMs that may be applied in the Caribbean spiny lobster fishery. In-season AMs are those that are triggered during the fishing season and are typically implemented before an ACL is exceeded. Some examples of in-season AMs include quota closures, trip or bag limit reductions, gear restrictions, or catch shares. Post-season AMs would be triggered if the ACL is exceeded and would typically be implemented the following fishing season. Post-season AMs could include seasonal closures, reduced trip limits, bag limits, and quotas, or shortening of the fishing season.

Alternative 1 would not establish AMs for the spiny lobster fishery. The Magnuson-Stevens Act requires that ACLs and AMs be established in 2011 for all managed species; therefore, if **Alternative 1** were chosen as a preferred alternative, the FMP would not be in compliance with those requirements.

Under **Alternative 2,** commercial in-season AMs would be triggered in order to prevent the ACL from being exceeded. Once the ACL is projected to be met, the Regional Administrator (RA) would publish a notice notifying the fishery of the closing date for the season. After that date all harvest and possession, and purchase and sale, of spiny lobster would be prohibited for those holding commercial spiny lobster permits. If the commercial ACL or ACT is caught quickly, there is a chance the ACL could be met or exceeded before the fishery could be notified of a quota closure. If the ACL is exceeded more than once within a four-year period the entire system of ACLs and AMs must be re-examined for effectiveness.

Under **Alternative 3,** post-season AMs would be implemented in the fishing season following the season when an ACL is exceeded. Post-season AMs would allow all landings for a particular season to be reported before any additional harvest restricting measures would take effect, and is thus associated with less uncertainty than in-season monitoring. This method of accountability alone may correct for one year’s or several years’ overages. Implementing post-season AMs for the recreational sector may be more pragmatic than in-season AMs because MRFSS and MRIP do not collect landings information on crustaceans, and Florida’s data survey method would be the primary means of tracking recreational landings, unless some other method of recreational data collection is implemented. The Councils may choose a combination of in-season and post-season AMs. This would be the most administratively burdensome scenario; however, if an ACL overage were to occur after an in-season AM has been implemented, the Regional Administrator could use a post-season AM as a means to correct an overage and prevent overfishing.

Preferred Alternative 4 would use the ACT of 6.59 mp as the AM. At their June joint meeting, the Councils changed their preferred alternative from 6.0 mp to a value that is 90% of the ACL or 6.59 mp. The ACL is 7.32 mp and is equal to the ABC, which is derived using the ABC control rule adopted by the Gulf Council. The Councils felt an ACT that is 10% lower than the ACL would provide an adequate buffer between the target level of harvest and the annual limit on harvest. An exceedence of the ACT would automatically trigger an AM whereby the Councils would convene a review panel to assess whether or not corrective action is needed to prevent the ACL from being exceeded. It is unlikely the ACL would be exceeded under the current ACL preferred alternative based on landings history; however, the updated framework procedure contained within this amendment would facilitate timely adjustments to the National Standard 1 harvest parameters and management measures if needed in the future. The ability to expeditiously implement modifications to the ACL, ACT, AMs, and management measures for Caribbean spiny lobster would limit any negative biological impact that could result from continued ACT or ACL overages.

The biological impacts of **Preferred Alternative 4** would likely be similar to that of status quo since the combined recreational/commercial average landings for the last 10 fishing seasons do not exceed the preferred ACT. Additionally, a recent study using microsatellite DNA analysis to identify sources of recruitment among Caribbean spiny lobsters indicates the majority of recruits come from areas outside the management area (Hunt and Tringali 2011). Therefore, any true biological benefits that may accrue in the Caribbean spiny lobster population found within the subject management area, as a result of implementing any one of the AMs considered, are likely to be negligible. Under **Preferred Alternative 4**, variations in year-to-year harvest would be accounted for by evaluating what percentage of the ACT is caught over several years, rather than on a single season basis. It is unlikely the ACL would be exceeded repeatedly under the current ACL preferred alternative based on landings history; however, the updated framework procedure contained within this amendment would facilitate timely adjustments to the National Standard 1 harvest parameters if needed in the future. The ability to expeditiously implement modifications to the ACL, ACT, and AMs for Caribbean spiny lobster would limit any negative biological impact that could result from continued ACT or ACL overages.

2.6 Action 6: Develop or Update a Framework Procedure and Protocol for Enhanced Cooperative Management for Spiny Lobster

*Note: more than one alternative may be chosen as a preferred.

Alternative 1: No Action – Do not update the Protocol for Enhanced Cooperative Management or the Regulatory Amendment Procedure.

Preferred Alternative 2: Update the current Protocol for Enhanced Cooperative Management.

Alternative 3: Update the current Regulatory Amendment Procedures to develop a Framework Procedure to modify ACLs and AMs.

Preferred Alternative 4: Revise the current Regulatory Amendment Procedures to create an expanded Framework Procedure:

Preferred Option a: Adopt the base Framework Procedure
Option b: Adopt the more broad Framework Procedure
Option c: Adopt the more narrow Framework Procedure

Comparison of Alternatives: The current Protocol for Enhanced Cooperative Management in the FMP outlines the roles of federal and Florida agencies in managing Caribbean spiny lobster. The current Regulatory Amendment Procedure outlines the actions that can be implemented through framework actions, such as gear and harvest restrictions. The current protocol and procedure were developed through Amendment 2 (GMFMC and SAFMC 1989). This action proposes to modify and update the *protocol* to include relevant agency names and authorities. The framework *procedure* would also be updated to include relevant terms and adjustments to ACLs, ACTs, and AMs. (Note: The Regulatory Amendment Procedure and the Framework Procedure are the same thing, and the Councils will now refer to this procedure in the FMP as the Framework Procedure.)

Alternative 1 would not modify the current protocols or procedures to include modern terminology and adjustments to ACLs, ACTs, and AMs. The RA would maintain his/her current ability to adjust trip limits, bag limits, size limits, seasonal closures, and gear restrictions, but no means would exist of making needed adjustments to the National Standard 1 harvest parameters or management measures in a timely manner.

Preferred Alternative 2 would retain the current agreement with Florida, but update the language to be consistent with changes in agency names and terminology since 1989. This alternative could be chosen in conjunction with either **Alternative 3** or **4**.

Proposed Language for the Updated Protocol

Protocol for Roles of Federal and State of Florida Agencies for the Management of Gulf and South Atlantic Spiny Lobster

1. The Gulf of Mexico and South Atlantic Fishery Management Councils (Councils) and NOAA Fisheries Service acknowledge that the fishery is largely a State of Florida (State) fishery, which extends into the exclusive economic zone (EEZ), in terms of current participants in the directed fishery, major nursery, fishing, landing areas, and historical regulation of the fishery. As such, this fishery requires cooperative state/federal efforts for effective management through the Fishery Management Plan for the Spiny Lobster Fishery of the Gulf of Mexico and South Atlantic (Spiny Lobster FMP).

2. The Councils and NOAA Fisheries Service acknowledge that the State is managing and will continue to manage the resource to protect and increase the long-term yields and prevent depletion of lobster stocks and that the State Administrative Procedure Act and rule implementation procedures, including final approval of the rules by Governor and Cabinet, provide ample and fair opportunity for all persons to participate in the rulemaking procedure.

3. The Florida Fish and Wildlife Conservation Commission (FWC) acknowledges that rules proposed for implementation under any fishery management plan amendment, regulatory or otherwise, must be consistent with the management objectives of the Spiny Lobster FMP, the National Standards, the Magnuson-Stevens Fishery Conservation and Management Act, and other applicable law. Federal rules will be implemented in accordance with the Administrative Procedure Act.

4. The Councils and NOAA Fisheries Service agree that, for any rules defined within an amendment to the Spiny Lobster FMP, the State may propose the rule directly to NOAA Fisheries Service, concurrently informing the Councils of the nature of the rule, and that NOAA Fisheries Service will implement the rule within the EEZ provided it is consistent under paragraph three. If either of the Councils informs NOAA Fisheries Service of their concern over the rule's inconsistency with paragraph three, NOAA Fisheries Service will not implement the rule until the Councils, FWC, and NOAA Fisheries Service resolve the issue.

5. The State will have the responsibility for collecting and developing the information upon which to base the fishing rules, with assistance as needed by NOAA Fisheries Service, and cooperatively share the responsibility for enforcement with federal agencies.

6. Florida FWC will provide to NOAA Fisheries Service and the Councils written explanations of its decisions related to each of the rules; summaries of public comments; biological, economic and social analysis of the impacts of the proposed rule and alternatives; and such other relevant information.

7. The rules will apply to the EEZ for the management area of North Carolina through Texas, unless the Regional Administrator (RA) determines those rules may adversely impact other state and federal fisheries. In that event, the RA may limit the application of the rule, as necessary, to address the problem.

8. NOAA Fisheries Service and the Councils agree that their staffs will prepare the proposed and final rules and the associated National Environmental Policy Act documentation and other documents required to support the rule.

Under **Alternatives 3** and **4**, adjustments to ACLs, ACTs, AMs, and other management measures could be made relatively quickly as new fishery and stock abundance information becomes available. The alternatives that would update or revise the current procedure would likely be biologically beneficial for spiny lobster because they would allow periodic adjustments to National Standard 1 guideline harvest parameters, and management measures could be altered in a timely manner in response to stock assessment or survey results. Framework actions are initiated by the Councils and implemented by the RA, and require less time when compared to the lengthy amendment process. The majority of public participation and comment on framework issues typically takes place when the framework procedure is initially drafted during the regular amendment process, as in this action. **Alternative 3** and **4** would be expected to increase the efficiency and effectiveness of management change, potentially allowing less severe corrective action when necessary, or the quicker receipt of social and economic benefits associated with less restrictive management. In the long term, positive social and economic effects, relative to the status quo, would be expected from more timely management adjustments.

Alternative 3 would update language and formatting, as well as allow adjustments to ACLs, ACTs, and accountability measures. When the procedure was originally developed, these parameters were not in use. The updates would streamline the process for making these changes if a new stock assessment indicates their necessity. However, the procedure remains fairly restrictive both substantively and procedurally. The potential changes are summarized in Table 2.6.1. The full text of the updated framework procedure follows.

Table 2.6.1. Proposed framework modifications under Alternative 3.

Items retained from current framework	Items modified from current framework	Items added to current framework
Adjustments to or implementation of trip limits, bag limits (including zero bag limits), minimum sizes, gear restrictions, and seasonal/area closures	Change the term "Regional Director" to "Regional Administrator"	Use of SEDAR reports or other documentation the Councils or FWC deem appropriate to provide biological analyses
Adjustment to or implementation of time frames for recovery of an overfished species	Change the term "FMFC" to "Florida Fish and Wildlife Conservation Commission (FWC)"	The SSC prepares a written report to the Councils and FWC specifying OFL and a range of ABCs for species in need of catch reductions to achieve OY
Initial specification and subsequent adjustments of biomass levels and age structured analysis		The SEDAR report or SSC will recommend rebuilding periods
Inclusion of public input in the framework adjustment process		Adjustments to ABCs, ACLs, and/or sector ACLs
		Adjustment to or implementation of ACTs and AMs
		Adjustments to or establishment of MSY
		Adjustments to or implementation of quotas, including closing any commercial fishery when the quota is filled

Proposed Language for Updated Framework Procedure

Joint Fishery Management Plan for the Spiny Lobster Fishery of the Gulf of Mexico (Gulf) and South Atlantic Framework Procedure for Specification of Annual Catch Limits, Annual Catch Targets, Overfishing Limits, Acceptable Biological Catch, Accountability Measures, and annual adjustments:

1. At times determined by NOAA Fisheries Service Southeast Regional Office and Florida Fish and Wildlife Conservation Commission (FWC), the Gulf of Mexico and South Atlantic Councils (Councils), and the Southeast Data, Assessment, and Review (SEDAR) steering committee, stock assessments or assessment updates for spiny lobster in the Gulf and South Atlantic will be conducted under the SEDAR process. Each SEDAR stock assessment or assessment update will: 1) assess, to the extent possible, the current biomass (B), biomass proxy, or spawning potential ratio (SPR) levels for each stock; 2) estimate fishing mortality (F) in relation to F_{MSY} (maximum fishing mortality threshold [MFMT]) and F_{OY}); 3) determine the overfishing limit (OFL); 4) estimate other population parameters deemed appropriate; 5) summarize statistics on the fishery; 6) specify the geographical variations in stock abundance, mortality, recruitment, and age of entry into the fishery for each stock or stock complex; and 7) develop estimates of B_{MSY}.

2. The Councils and the FWC will consider SEDAR stock assessments, or other documentation deemed appropriate, to provide the biological analysis and data listed above in paragraph 1. Either the Southeast Fisheries Science Center or the stock assessment branch of a State agency may serve as the lead in conducting the analysis, as determined by the SEDAR Steering Committee. The joint Gulf and South Atlantic Scientific and Statistical Committees (SSCs) or some subgroup thereof, will prepare a written report specifying an OFL to the Councils and FWC and may recommend a range of acceptable biological catch (ABC) for attaining or maintaining optimum yield (OY). The OFL is the annual harvest level corresponding to fishing at MFMT (F_{MSY}). The ABC range is intended to provide ABC range. In addition, the joint SSC sub-group will examine information provided by the social scientists and economists from the Councils' staffs and from the Southeast Regional Office analyzing social and economic impacts of any specification demanding adjustments of allocations, annual catch limits (ACLs), annual catch targets (ACTs), accountability measures (AMs), quotas, bag limits, or other fishing restrictions. The joint SSC sub-group will use the ABC control rule to set ABC at or below the OFL, taking in account scientific uncertainty. If the joint SSC sub-group set ABC equal to OFL, they will provide rational why they believe that level of fishing will not exceed MFMT.

4. The Councils and FWC may conduct a public hearing on the reports and the joint SSCs' ABC recommendation at, or prior to, the time it is considered by the Councils for action. Other public hearings also may be held. The Councils and FWC may convene their Spiny Lobster Advisory Panels, and optionally their socioeconomic panels, to review the report before taking action.

5. If necessary, the Councils and FWC will utilize the following criteria in selecting an ACL, ACT, AM, and a stock restoration time period, in addition to taking into consideration the recommendations and information provided in paragraphs 1-4:

> **a.** Set ACL at or below the ABC specified by the joint SSC sub-group or set a series of annual ACLs at or below the projected ABCs to account for management uncertainty. If the Councils and FWC set the ACL equal to ABC, and ABC has been set equal to OFL, the Councils and FWC will provide rationale why they believe that level of fishing will not exceed MFMT.
>
> **b.** Optionally, subdivide the ACLs into commercial, for-hire, and private recreational sector ACLs or gear specific ACLs that maximize the net benefits of the fishery to the nation. The sector ACLs will be based on allocations determined by criteria established by the Councils and FWC, and specified by the Councils through a plan amendment. If spiny lobster is overfished, and harvest in any year exceeds the ACL or sector ACL, management measure and catch levels for that sector will be adjusted in accordance with the AMs established for that stock.
>
> **c.** Optionally, set ACTs or sector ACTs at or below ACLs and in accordance with the provision of the AMs for spiny lobster. The ACT is the management target that accounts for management uncertainty in controlling the actual catch at or below the ACL. If an ACL is exceeded repeatedly, the Councils and FWC have the option to establish an ACT if one does not already exist for a particular stock, and to adjust or establish AMs for that stock as well.

6. The Councils will provide to the RA: 1) the joint SSC sub-group specification of OFL and recommendation of ABCs, ACLs, sector ACLs, ACTs, sector ACTs, AMs, sector AMs; 2) stock restoration target dates for each stock or stock complex; 3) estimates of B_{MSY} and MSST; 4) estimates of MFMT, and; 5) the quotas, bag limits, trip limits, size limits, closed seasons, and gear restrictions necessary to avoid exceeding the ACL or sector ACLs. The Councils will also provide the joint SSC subgroup reports, a regulatory impact review, proper National Environmental Policy Act documentation, and the proposed regulations within a predetermined time as agreed upon by the Councils, FWC and RA. The Councils and FWC may also recommend new levels or statements for MSY (or proxy) and OY.

7. The RA will review the Councils' recommendations and supporting information; if he/she concurs the recommendations are consistent with the objectives of the Spiny Lobster FMP, the National Standards, and other applicable law, he/she shall prepare a framework action and forward notice of proposed rules to the Assistant Administrator for publication (providing appropriate time for additional public comment). The RA will consider all public comment and information received and will forward a final rule for publication in the Federal Register within 30 days of the close of the public comment period, or such other time as agreed upon by the Councils and RA.

8. Appropriate regulatory changes that may be implemented by final rule in the Federal Register include:

a. ACLs or sector ACLs, or a series of annual ACLs or sector ACLs.
b. ACTs or sector ACTs, or a series of annual ACTs or sector ACTs, and establishment of ACTs for stocks which do not have an ACT.
c. AMs, or sector AMs.
d. Bag limits, size limits, vessel trip limits, closed seasons or areas, gear restrictions, and quotas designed to achieve OY and keep harvest levels from exceeding the ACL or sector ACL.
e. New levels or statements of MSY (or proxy) and OY for any stock.
f. Fishing season/year adjustments.

9. The RA is authorized, through notice action, to conduct the following activities.

a. Close the commercial fishery for spiny lobster at such time as projected to be necessary to prevent the commercial sector from exceeding the commercial sector ACL or ACT for the remainder of the fishing year or sub-quota season.
b. Close the recreational fishery for spiny lobster at such time as projected to be necessary to prevent recreational sector ACLs or ACTs from being exceeded.
c. Reopen a commercial or recreational season that had been prematurely closed if needed to assure that a sector ACL or ACT can be reached.

10. If NOAA Fisheries Service decides not to publish the proposed rule of the recommended management measures, or to otherwise hold the measures in abeyance, then the RA must notify the Councils and FWC with the reasons for concern along with suggested changes to the proposed management measures that would alleviate the concerns. Such notice shall specify: 1) The applicable law with which the amendment is inconsistent; 2) the nature of such inconsistencies; and 3) recommendations concerning the action that could be taken by the Councils to conform the amendment to the requirements of applicable law.

The options in **Preferred Alternative 4** would increase the flexibility of the Councils and NOAA Fisheries Service by identifying additional measures that could be changed under the procedure. In addition, these framework options would clarify the appropriate process needed for each type of change. The major differences among the options are highlighted in Table 2.6.2. The full text of the revised framework procedure for each option follows.

Table 2.6.2. Comparison of Alternative 4 options for a framework procedure.

	Preferred Option a (Base)	Option b (Broad)	Option c (Narrow)
Types of framework processes	Open abbreviated Open standard Closed	Open Closed	Open Closed
When open framework can be used	New stock assessment New information or circumstances Changes are required to comply with applicable law or a court order	In response to any new information or changed circumstances	Only when there is a new stock assessment
Actions that can be taken	Abbreviated Open framework can be used for actions that are considered minor and insignificant Standard Open framework used for all others *Lists of actions that can be taken under Abbreviated and Standard Open framework are given.* Closed framework can be used for a specific list of actions	Open framework can be used for a representative list of actions, plus other measures deemed appropriate by the Councils Closed framework can be used for a specific list of actions, plus any other immediate action specified in the regulations	Open framework can only be used for specific listed actions Closed framework can only be used for a specific list of actions
Public input	Requires public discussion at one meeting for each Council	Requires public discussion at one meeting for each Council	Requires public discussion during at least three meetings for each Council, and discussion at separate public hearings within the areas most affected by the proposed measures.
AP/SSC participation	Each Council may convene their SSC, SEP, or AP, as appropriate	Convening the SSC, SEP, or AP, prior to final action is not required	Each Council shall convene their SSC, SEP, and AP
How a request of action is made	Abbreviated requires a letter or memo from the Councils with supporting analyses Standard requires a completed framework document with supporting analyses	Via letter, memo, or the completed framework document with supporting analyses.	Via letter, memo, or completed framework document with supporting analyses.

Option a (Base)
This framework procedure provides standardized procedures for implementing management changes pursuant to the provisions of the Spiny Lobster Fishery Management Plan (FMP) managed jointly between the Gulf of Mexico and South Atlantic Fishery Management Councils (Councils). Two basic processes are included: the open framework process and the closed framework process. The open framework addresses issues where more policy discretion exists in selecting among various management options developed to address an identified management issue, such as changing a size limit to reduce harvest. The closed framework addresses much more specific factual circumstances, where the FMP and implementing regulations identify specific action to be taken in the event of specific facts occurring, such as closing a sector of a fishery when the quota is or is projected to be harvested.

Open Framework:

1. Situations under which the open framework procedure may be used to implement management changes include the following:
    a. A new stock assessment results in changes to the overfishing limit, acceptable biological catch, or other associated management parameters.
       In such instances the Councils may, as part of a proposed framework action, propose an annual catch limit (ACL) or series of ACLs and optionally an annual catch target (ACT) or series of ACTs, as well as any corresponding adjustments to maximum sustainable yield (MSY), optimum yield (OY), and related management parameters.
    b. New information becomes available or circumstances change.
       The Councils will, as part of a proposed framework action, identify the new information and provide rationale why this new information indicates management measures should be changed.
    c. Changes are required to comply with applicable law such as the Magnuson-Stevens Act, Endangered Species Act, Marine Mammal Protection Act, or are required as a result of a court order.
       In such instances the Regional Administrator (RA) will notify the Councils in writing of the issue and that action is required. If there is a legal deadline for taking action, the deadline will be included in the notification.
2. Open framework actions may be implemented in either of two ways: abbreviated documentation or standard documentation process.
    a. Abbreviated documentation process. Regulatory changes that may be categorized as routine or insignificant may be proposed in the form of a letter or memo from the Councils to the RA containing the proposed action, and the relevant biological, social, and economic information to support the action. Either Council may initiate the letter or memo, but both Councils must approve it. If multiple actions are proposed, a finding that the actions are also routine or insignificant must also be included. If the RA concurs with the determination and approves the proposed action, the action will be implemented through publication of appropriate notification in the Federal Register. Changes that may be viewed as routine or insignificant include, among others:

        i. Reporting and monitoring requirements,
        ii. Permitting requirements,
        iii. Gear marking requirements,

iv. Vessel marking requirements,
v. Restrictions relating to the use of undersized attractants,
vi. Restrictions relating to tailing,
vii. Bag and possession limit changes of not more than one lobster,
viii. Size limit changes of not more than 10% of the prior size limit,
ix. Vessel trip limit changes of not more than 10% of the prior trip limit,
x. Closed seasons of not more than 10% of the overall open fishing season,
xi. Restricted areas (seasonal or year-round) affecting no more than a total of 100 nautical square miles,
xii. Respecification of ACL, ACT, or quotas that were previously approved as part of a series of ACLs, ACTs or quotas,
xiii. Specification of MSY proxy, OY, and associated management parameters (such as overfished and overfishing definitions) where new values are calculated based on previously approved specifications,
xiv. Gear restrictions, except those that result in significant changes in the fishery, such as complete prohibitions on gear types,
xv. Quota changes of not more than 10%, or retention of portion of an annual quota in anticipation of future regulatory changes during the same fishing year.

b. Standard documentation process. Regulatory changes that do not qualify as routine or insignificant may be proposed in the form of a framework document with supporting analyses. Non-routine or significant changes that may be implemented under a framework action include:
   i. Specification of ACTs or sector ACTs,
   ii. Specification of ABC and ABC control rule,
   iii. Creation of rebuilding plans and revisions to approved rebuilding plans,
   iv. Changes specified in section 2(a) that exceed the established thresholds.

3. Either Council may initiate the open framework process to inform the public of the issues and develop potential alternatives to address the issues. The framework process will include the development of documentation and public discussion during at least one meeting for each Council.
4. Prior to taking final action on the proposed framework action, each Council may convene their SSC, SEP, or AP, as appropriate, to provide recommendations on the proposed actions.
5. For all framework actions, the initiating Council will provide the letter, memo, or the completed framework document along with proposed regulations to the RA in a timely manner following final action by both Councils.
6. For all framework action requests, the RA will review the Councils' recommendations and supporting information and notify the Councils of the determinations, in accordance with the Magnuson-Stevens Act (Section 304) and other applicable law.

Closed Framework:

Consistent with existing requirements in the FMP and implementing regulations, the RA is authorized to conduct the following framework actions through appropriate notification in the Federal Register:

a. Close or adjust harvest in any sector of the fishery for a species, sub-species, or species group that has a quota or sub-quota at such time as projected to be necessary to prevent the sector from exceeding its sector-quota for the remainder of the fishing year or sub-quota season,
b. Reopen any sector of the fishery that had been prematurely closed,
c. Implement an in-season accountability measure for a sector that has reached or is projected to reach, or is approaching or is projected to approach its ACL, or implement a post-season accountability measure for a sector that exceeded its ACL in the current year.

Option b (Broad)
This framework procedure provides standardized procedures for implementing management changes pursuant to the provisions of the Spiny Lobster Fishery Management Plan (FMP) managed jointly between the Gulf of Mexico and South Atlantic Fishery Management Councils (Councils). Two basic processes are included: the open framework process and the closed framework process. The open framework addresses issues where more policy discretion exists in selecting among various management options developed to address an identified management issue, such as changing a size limit to reduce harvest. The closed framework addresses much more specific factual circumstances, where the FMP and implementing regulations identify specific action to be taken in the event of specific facts occurring, such as closing a sector of a fishery when the quota is or is projected to be harvested.

Open Framework:

1. The Councils may utilize this framework procedure to implement management changes in response to any additional information or changed circumstances. The Councils will, as part of a proposed framework action, identify the new information and provide rationale why this new information requires management measures be adjusted.
2. Open framework actions may be implemented at any time based on information supporting the need for adjustment of management measures or management parameters:
   Changes that may be implemented via the open framework procedure include:
   a. Reporting and monitoring requirements,
   b. Permitting requirements,
   c. Gear marking requirements,
   d. Vessel marking requirements,
   e. Restrictions relating to the use of undersized attractants,
   f. Restrictions relating to tailing,
   g. Bag and possession limits,
   h. Size limits,
   i. Vessel trip limits,
   j. Closed seasons,
   k. Restricted areas (seasonal or year-round),
   l. Re-specification of annual catch limits (ACLs), annual catch targets (ACTs), or quotas that were previously approved as part of a series of ACLs, ACTs or quotas,
   m. Specification of maximum sustainable yield (MSY) proxy, optimum yield (OY), and associated management parameters (such as overfished and overfishing definitions) where new values are calculated based on previously approved specifications,

n. Gear restrictions, except those that result in significant changes in the fishery, such as complete prohibitions on gear types,
o. Quota,
p. Specification of ACTs or sector ACTs,
q. Creation of rebuilding plans and revisions to approved rebuilding plans,
r. Any other measures deemed appropriate by the Council.

3. Either Council may initiate the open framework process to inform the public of the issue and develop potential alternatives to address the issue. The framework process will include the development of documentation and public discussion during one meeting for each Council.
4. For all framework actions, the initiating Council will provide the letter, memo, or the completed framework document along with proposed regulations to the Regional Administrator (RA) following final action by both Councils.
5. For all framework action requests, the RA will review the Councils' recommendations and supporting information and notify the Councils of the determinations, in accordance with the Magnuson-Stevens Act (Section 304) and other applicable law.

Closed Framework:

Consistent with existing requirements in the FMP and implementing regulations, the RA is authorized to conduct the following framework actions through appropriate notification in the Federal Register:

a. Close or adjust harvest in any sector of the fishery for a species, sub-species, or species group that has a quota or sub-quota at such time as projected to be necessary to prevent the sector from exceeding its sector-quota for the remainder of the fishing year or sub-quota season,
b. Reopen any sector of the fishery that was prematurely closed,
c. Implement an in-season accountability measure for a sector that has reached or is projected to reach, or is approaching or is projected to approach its ACL, or implement a post-season accountability measure for a sector that exceeded its ACL in the current year,
d. Take any other immediate action specified in the regulations.

Option c (Narrow)

This framework procedure provides standardized procedures for implementing management changes pursuant to the provisions of the Spiny Lobster Fishery Management Plan (FMP) managed jointly between the Gulf of Mexico and South Atlantic Fishery Management Councils (Councils). Two basic processes are included: the open framework process and the closed framework process. The open framework addresses issues where more policy discretion exists in selecting among various management options developed to address an identified management issue, such as changing a size limit to reduce harvest. The closed framework addresses much more specific factual circumstances, where the FMP and implementing regulations identify specific action to be taken in the event of specific facts occurring, such as closing a sector of a fishery when the quota is or is projected to be harvested.

Open Framework:

1. The open framework procedure may be used to implement management changes only when a new stock assessment results in changes to the overfishing limit, acceptable biological catch, or other associated management parameters. In such instances the

Councils may, as part of a proposed framework action, propose an annual catch limit (ACL) or series of ACLs and optionally an annual catch target (ACT) or series of ACTs, as well as any corresponding adjustments to maximum sustainable yield (MSY), optimum yield (OY), and related management parameters.

2. Actions that may be implemented via the framework procedure include:
   a. Reporting and monitoring requirements,
   b. Bag and possession limits,
   c. Size limits,
   d. Closed seasons,
   e. Restricted areas (seasonal or year-round),
   f. Quotas.
3. Either Council may initiate the open framework process to inform the public of the issue and develop potential alternatives to address the issue. The framework process will include the development of documentation and public discussion during at least three meetings for each Council, and shall be discussed at separate public hearings within the areas most affected by the proposed measures.
4. Prior to taking final action on the proposed framework action, each Council shall convene its SSC, SEP, and AP to provide recommendations on the proposed actions.
5. For all framework actions, the initiating Council will provide the letter, memo, or the completed framework document, and all supporting analyses, along with proposed regulations to the RA in a timely manner following final action by both Councils.
6. For all framework action requests, the RA will review the Councils' recommendations and supporting information and notify the Councils of the determinations, in accordance with the Magnuson-Stevens Act (Section 304) and other applicable law. The RA will provide the Councils weekly updates on the status of the proposed measures.

Closed Framework:

Consistent with existing requirements in the FMP and implementing regulations, the RA is authorized to conduct the following framework actions through appropriate notification in the Federal Register:

a. Close or adjust harvest in any sector of the fishery for a species, sub-species, or species group that has a quota or sub-quota at such time as projected to be necessary to prevent the sector from exceeding its sector-quota for the remainder of the fishing year or sub-quota season,
b. Reopen any sector of the fishery that was prematurely closed,
c. Implement an in-season accountability measure for a sector that has reached or is projected to reach, or is approaching or is projected to approach its ACL, or implement a post-season accountability measure for a sector that exceeded its ACL in the current year.

2.7 Action 7: Modify Regulations Regarding Possession and Handling of Short Caribbean Spiny Lobsters as "Undersized Attractants"

Alternative 1: No Action – Allow the possession of no more than 50 undersized Caribbean spiny lobsters, or one per trap aboard the vessel, whichever is greater, for use as attractants.

Alternative 2: Prohibit the possession and use of undersized Caribbean spiny lobsters as attractants.

Alternative 3: Allow undersized Caribbean spiny lobsters, but modify the number of allowable undersized lobsters, regardless of the number of traps fished:

Option a: Allow 50 undersized lobsters
Option b: Allow 35 undersized lobsters

Preferred Alternative 4: Allow undersized spiny lobster not exceeding 50 per boat and 1 per trap aboard each boat if used exclusively for luring, decoying or otherwise attracting non-captive spiny lobsters into the trap.

Comparison of Alternatives: Alternative 1 would not change the regulations concerning the use of undersized lobsters as attractants. Currently, federal regulations at 50 CFR 640.21(c) state the following:

> *A live spiny lobster under the minimum size limit specified in paragraph (b)(1) of this section that is harvested in the EEZ by a trap may be retained aboard the harvesting vessel for future use as an attractant in a trap provided it is held in a live well aboard the vessel. No more than fifty undersized spiny lobsters, or one per trap aboard the vessel, whichever is greater, may be retained aboard for use as attractants. The live well must provide a minimum of ¾ gallons (1.7 liters) of seawater per spiny lobster. An undersized spiny lobster so retained must be released alive and unharmed immediately upon leaving the trap lines and prior to one hour after official sunset each day.*

Florida allows not only 50 undersized lobsters to be maintained onboard licensed vessels, but also one undersized lobster per trap, which is not consistent with current federal regulations. **Alternative 1** would perpetuate this discrepancy and continue the resulting difficulty for law enforcement officials.

Alternative 2 would eliminate the difficulties law enforcement officials currently experience in prosecuting undersized spiny lobster cases, and any negative biological impacts attributable to undersized lobster as attractants. Prohibiting the use of undersized spiny lobster as attractants may, therefore, lead to a reduced risk of exceeding the ACL in any given year and hedge against future overfishing. The enforcement and biological benefits under **Alternative 2** are likely to be negligible given recent data that suggests the majority of Caribbean spiny lobster recruits come from outside management area (Hunt and Tringali 2011), and confinement mortality of undersized Caribbean spiny lobsters is estimated to be low (10%)(SEDAR 8, 2005). However, the socioeconomic impacts of prohibiting the use of undersized spiny lobster as attractants could be significant given a large portion of commercial fishermen fishing for spiny lobster use undersized lobsters as attractants. Subsequent to the allowance for the use of undersized spiny lobsters as attractants in state regulations in 1977, Amendment 1 to the Spiny Lobster FMP (1987) stated as a major issue:

> *The illegal market in undersize lobsters, on board handling and exposure of undersize lobsters and their confinement in traps as attractants are significant sources of undersize lobster mortality that are preventing the fishery from harvesting optimum yield. Although undersize lobsters are an effective attractant, the mortality associated with their use as attractants, in combination with increasing number of traps being fished, are contributing to the fishery's inability to achieve optimum yield….*

Enforcement issues still exist today despite the implementation of the "50 Short" rule and the requirement to use live wells to maintain undersized spiny lobsters onboard fishing vessels. The most recent SEDAR assessment for spiny lobster assumed a 10% mortality rate of undersized spiny lobsters used as attractants. Though this mortality rate is relatively low, eliminating the use of undersized lobsters may increase the number of juveniles that are allowed to fully mature and reach harvestable sizes. **Alternative 3** would not improve law enforcement efforts in the fishery; however, it could potentially increase the number of Caribbean spiny lobsters allowed to grow to harvestable sizes without incurring the same magnitude of socioeconomic impacts that would accrue under **Alternative 2**. The options under **Alternative 3** are intended to limit the number of undersized spiny lobsters used as attractants to a level lower than the status quo without prohibiting the practice altogether.

Preferred Alternative 4 is very similar to **Alternative 1** in that it would allow spiny lobsters to be kept onboard for use as attractants; however, it would change the provision to allow 50 spiny lobsters *plus* one per trap, rather than 50 spiny lobsters *or* one per trap, and it would remove the "whichever is greater" portion of the provision. As Section 4.7.2 of this document states, the number of traps fished on a trip can be estimated for **Alternative 1**, when this number is interpreted to mean the number of traps hauled to remove lobsters. This is not necessarily an indication of the number traps on a vessel, which may be 30-35 at any one time during fishing operations. Allowing 50 undersized lobsters to be used as attractants plus one per trap ensures that fishermen have an adequate supply of bait lobsters on board as the traps are hauled and re-deployed. Furthermore, biological impacts of the use of attractants likely decreases as the fishing season progresses since the total number of traps fished on all trips declines by month on average as the season goes on, along with total pounds landed, and the median number of traps fished per trip.

Preferred Alternative 4 would mirror Florida's state regulations, and ease some enforcement concerns related to inconsistent regulations across the state /federal jurisdictional boundary. **Preferred Alternative 4** would provide the least opportunity for juvenile Caribbean spiny lobsters to grow to harvestable size of all the alternatives considered because it would increase the number of spiny lobsters able to be maintained onboard a vessel, and could thus result in increased confinement mortalities. However, under other alternatives total bycatch may actually increase because traps with alternate types of bait would need to soak longer to achieve the same catch as traps with undersized attractants. Although mortality of shorts may result in some foregone yield, a prohibition on the use of shorts could result in increased bycatch of other species and decreased economic benefits. Additionally, a recent study conducted by Hunt and Tringali (2011), used DNA analysis to identify sources of recruitment for Caribbean spiny lobster. The study found the majority of recruits do not come from within the management area, suggesting that the use of undersized Caribbean spiny lobsters and other management measures for the Caribbean spiny lobster fishery would have negligible biological impacts on the population within the management area. Based on the findings of this study, it is unlikely that the continued use of undersized Caribbean spiny lobsters as attractants would have significant adverse effects on the biological environment.

2.8 Action 8: Modify Tailing Requirements for Caribbean Spiny Lobster for Vessels that Obtain a Tailing Permit

*Note: more than one alternative may be chosen as a preferred alternative.

Alternative 1: No Action – Possession of a separated Caribbean spiny lobster tail in or from the EEZ is allowed only when the possession is incidental to fishing exclusively in the EEZ on a trip of 48 hours or more, and a federal tailing permit is issued to and on board the vessel.

Alternative 2: Eliminate the Tail-Separation Permit for all vessels fishing for Caribbean spiny lobster in Gulf and South Atlantic waters of the EEZ.

Preferred Alternative 3: Revise the current regulations to clearly state that all vessels must have either 1) a valid federal spiny lobster permit or 2) a valid Florida Restricted Species Endorsement and a valid Crawfish Endorsement associated with a valid Florida Saltwater Products License to obtain a tailing permit.

Preferred Alternative 4: All Caribbean spiny lobster landed must either be landed all "whole" or all "tailed".

Comparison of Alternatives: Alternative 1 would not modify the current Tail-Separation Permit regulations for Caribbean spiny lobster. A Tail-Separation Permit would still be required to possess spiny lobsters that have been tailed, and the trips would still be required to be 48 hours or longer in duration. The ability to tail spiny lobsters is important to fishermen who do not have the storage capacity to hold large amounts of whole spiny lobster onboard over long trip durations. Tailing allows such fishermen to safely store more products in coolers without compromising quality, thus maximizing the profitability of each trip. However, anecdotal information indicates some fishermen (commercial and recreational) may be tailing lobsters in an effort to conceal the fact that they may be undersized. For this reason fishery participants requested that the Councils address the issue in an FMP amendment.

Alternative 2 would be the most biologically beneficial of the alternatives because it would slow the speed of harvest. Removing the ability for fishermen to tail any Caribbean spiny lobster before landing would increase the probability that most lobsters landed would be of legal size because they could easily be measured. Also, **Alternative 2** would be consistent with Florida state regulations, and therefore, beneficial for law enforcement efforts.

Preferred Alternative 3 alone would address the issue of recreational fishermen obtaining Tail-Separation Permits, which was not the original intent of the Councils, but it would not address the issue of commercial fishermen landing undersized lobster by tailing them. **Preferred Alternative 3** would provide minimal biological benefits since it is thought that there are very few recreational fishermen who have in their possession a Tail-Separation Permit. It would, however, prevent any more recreational fishermen from obtaining the permit.

One major challenge reported by NOAA Fisheries Service law enforcement officials is commercially permitted lobster divers who spear and tail spiny lobster, which removes evidence of the illegal act of spearing a spiny lobster. If tailing were to continue, this type of illegal activity could persist. **Preferred Alternative 4** would address the issue of some fishermen landing part of their catch whole and part tailed a practice that has been reported anecdotally. It has also been reported that some fishery participants may engage in this practice in order to land sub-legal spiny lobsters for profit. If under **Preferred Alternative 4** most fishermen choose to land the majority of their Caribbean spiny lobster harvest whole, the rate at which Caribbean spiny lobsters are commercially harvested would likely decrease due to storage capacity issues of whole lobster on participating vessels.

2.9 Action 9: Limit Spiny Lobster Fishing in Certain Areas in the EEZ off Florida to Protect Threatened Staghorn and Elkhorn Corals (*Acropora* spp.)

<u>Preferred Alternative 1</u>: No Action – Do not limit spiny lobster fishing in certain areas in the EEZ off Florida to address ESA concerns for *Acropora* spp.

Alternative 2: Prohibit spiny lobster trapping on all known hardbottom in the EEZ off Florida in water depths less than 30 meters.

Alternative 3: Expand existing and/or create new closed areas to prohibit spiny lobster trapping in the EEZ off Florida.

Option a: Create 24 ―large closed areas to protect threatened *Acropora* spp. corals.
Option b: Create 37 ―medium closed areas to protect threatened *Acropora* spp. corals.
Option c: Create 52 ―small closed areas to protect threatened *Acropora* spp. corals.

Alternative 4: Expand existing and/or create new closed areas to prohibit all spiny lobster fishing in the EEZ off Florida.

Option a: Create 24 ―large closed areas to protect threatened *Acropora* spp. corals.
Option b: Create 37 ―medium closed areas to protect threatened *Acropora* spp. corals.
Option c: Create 52 ―small closed areas to protect threatened *Acropora* spp. corals.

<u>Comparison of Alternatives</u>: The Biological Opinion on the spiny lobster fishery (August 27, 2009, Appendix I) requires NOAA Fisheries Service and the Councils to work together to protect areas of staghorn and elkhorn coral (*Acropora* spp.) by expanding existing or creating new closed areas for lobster fishing where *Acropora* spp. are present. See Appendix H for the locations of proposed and existing areas closed to trapping from west to east.

The Florida Keys National Marine Sanctuary (FKNMS) has designated 15 special use or sanctuary preservation areas in federal waters where trap fishing is prohibited [15 CFR 922.164(d)(iii)]. *Acropora* spp. occur at relatively high densities in many of these areas. However, colonies of high conservation value and additional areas of high *Acropora* spp. density exist outside these closed areas. Creating new closed areas or expanding existing closed areas to include these areas of high *Acropora* spp. density would help reduce the likelihood of interactions between spiny lobster traps and coral colonies.

The current alternatives propose closed areas of varying sizes. The primary challenge with selecting closed areas is balancing impacts to the fishery and benefits to the environment. Larger areas are more easily enforced, fewer in number, and more likely to provide protection to corals. Larger areas encompass multiple reefs/hardbottom areas where *Acropora* spp.colonies are found. However, they also include (and would prohibit trapping on) sand/rubble habitats where fishers prefer to set traps. As the closed areas get smaller, the amount of sand/rubble habitat that would be closed to fishing also decreases. However, as areas get smaller their overall number increases and problems with enforcement also increase.

The proposed closed areas were selected for several reasons. Colonial size data were used to identify *Acropora* spp. colonies of varying sizes and maturities. The largest "super colonies" have been designated as the highest conservation priority because of their importance to sexual reproduction. *Acropora* spp. are generally considered sexually mature when the surface area of live tissue exceeds 100 cm^2. Elkhorn corals with a living tissue surface area of 1,000 cm^2 could be considered “super colonies.” A similar distinction could be made for staghorn corals with a living tissue surface area of 500 cm^2. Colonies of this size have exponentially higher reproductive potential compared to other sexually mature colonies, and represent essential sources of gamete production. Colonies of this size are also exceedingly rare. Sampling at over 1,000 locations throughout the Florida Keys and the Dry Tortugas identified only 17 super colonies (6 staghorn colonies and 9 elkhorn colonies). The same level of sampling has also identified 62 sexually mature colonies (32 staghorn colonies and 30 elkhorn colonies) and 61 non-sexually mature colonies (58 staghorn colonies and 3 elkhorn colonies).

Additional data indicating the location of *Acropora* spp. colonies were also used to develop the proposed areas. These data points simply reflect whether *Acropora* spp. colonies were present at the time of sampling and do not include colonial size information. Since no size information is available for these colonies, conservation priorities could not be assigned. It is important to remember that locations without assigned conservation priorities are not of low conservation value; rather they are areas with minimal data. In all likelihood, areas of high *Acropora* spp. occurrence provide significant conservation benefits and should be viewed as areas requiring special attention and protection.

The boundaries of all the closed areas run along lines of latitude and longitude, and only form right angles. No angled boundaries are proposed to improve compliance and support enforcement. In general, the “large” areas span whole minutes of lat./long. (e.g., 24°34’0” to 24°33’0”), and the “medium” areas span 30 second intervals of lat./long. (e.g., 24°33’30” to 24°33’0”). “Small” areas do not follow any particular sizing pattern.

Preferred Alternative 1 would have the least biological benefit to *Acropora* spp., and would perpetuate the existing level of risk of interaction between these species and the fishery because it would provide no additional protections. Existing closed areas would remain in place (see maps in Appendix H). **Preferred Alternative 1** would not meet the requirement established under the Biological Opinion. However, the Councils chose it as their preferred alternative to allow more time for members of the public, along with NOAA Fisheries Service and Marine Sanctuary representatives to work together to define areas of important habitat to protect *Acropora* spp. This action will be included in Amendment 11 to the Spiny Lobster FMP. The Councils intend to quickly develop the new amendment and put measures into place that would provide protection for *Acropora* spp. as required by the Biological Opinion.

Alternative 2 would provide the greatest biological benefit to *Acropora* spp. and other hardbottom/coral resources. **Alternative 2** would prohibit trapping on all hardbottom in the Florida EEZ, which support *Acropora* spp. This would reduce the likelihood of interactions between spiny lobster trap gear in the EEZ and *Acropora* spp. to almost zero. The vast majority of *Acropora* spp. colonies in the Florida EEZ occur in waters under the South Atlantic Council’s jurisdiction. While areas of hardbottom habitat in the Florida EEZ fall under the jurisdiction of the Gulf Council, the water quality in these areas is generally too poor to sustain *Acropora* spp. colonies. However, if water quality improves these areas would likely support *Acropora* spp. Prohibiting trapping on all hardbottom areas would close approximately 73 mi^2 of the EEZ off Florida to trapping. The negative social and economic impacts of **Alternative 2** are likely to be significant. Closing all hardbottom areas to trapping would significantly reduce the area available to trapping and may make trapping all together impractical.

Relative to **Alternative 2**, **Alternatives 3** and **4** would be less biologically beneficial to *Acropora* spp. colonies located outside the closed areas. **Alternative 3, Options a-c** would reduce the risk of trap damage to *Acropora* spp. by prohibiting the use of traps near areas of high *Acropora* spp. density or near colonies with high conservation value. **Alternative 3, Option a** would likely provide the greatest biological benefit because it closes approximately 14 mi^2 of hardbottom habitat to trapping. **Alternative 3, Option b** and **c** would likely have decreasing biological benefits, closing approximately 8 mi^2 and 4 mi^2 of hardbottom habitat to trapping, respectively. As proposed closed areas get smaller, traps are more likely to be accidentally dropped upon colonies. Larger closed areas also provide larger buffers between their boundaries and colonies. Non-tropical storm systems can move traps 100 ft from their original locations. However, stronger storms (i.e., tropical systems) can move traps many times further. **Alternative 3, Option a** would provide the largest buffer providing additional protection to colonies in the event a stronger storm moves traps longer distances. As the proposed areas get smaller, (i.e., **Alternative 3, Option b** and **c**) the additional protection against trap movement during stronger storms would be reduced. Likewise, as closed areas get smaller the potential for interactions between trap gear and corals increase. If one of **Alternative 3, Options a-c** were chosen, the negative social and economic impacts would likely be reduced as the size of the closed areas gets smaller. However, the burden of enforcing closed areas would increase as closed areas get smaller.

Alternative 4 and the associated options would provide slightly more biological benefit to *Acropora* colonies than **Alternative 3** and the associated options because it would prohibit all fishing for spiny lobster in the proposed closed areas. Although the impacts to *Acropora* spp. from diving for spiny lobster are unknown, other types of diving and the associated anchoring are known to adversely affect *Acropora* spp. **Alternative 4** would provide additional benefits because it would reduce the likelihood that adverse effects known from diving and anchoring could occur. The overall size of the proposed closed areas is less relevant when discussing the impacts from diving because divers must be in very close proximity to colonies to impact them. Thus, simply prohibiting the practice of diving for spiny lobster inside the proposed closed areas would likely help minimize any potential threat. Thus, **Alternative 4**, **Option a** would likely have the greatest biological benefit because it would create the largest buffer against trap impacts, while also reducing potential impacts from diving. **Alternative 4**, **Option b** and **c** are likely to have diminished biological benefits relative **Alternative 4**, **Option a** with respect to reduce trap impacts; however, the alternatives are likely to have same biological benefit as **Alternative 4**, **Option a** relative to diving and anchoring impacts. **Alternative 4, Options a-c** would likely have additional social and economic impacts than **Alternative 3** since it would apply to both the commercial and recreational sectors. However, requirements for both sectors may be viewed as more equitable.

2.10 Action 10: Require Gear Markings so all Spiny Lobster Trap Lines in the EEZ off Florida are Identifiable

<u>Preferred Alternative 1</u>: No Action – Do not require gear marking measures for spiny lobster trap lines.

Alternative 2: Require all spiny lobster trap lines in the EEZ off Florida to be COLOR, or have a COLOR marking along its entire length. All gear must comply with marking requirements no later than August 2014.

Alternative 3: Require all spiny lobster trap lines in the EEZ off Florida to have a permanently affixed 4-inch COLOR marking every 15 ft along the buoy line or at the midpoint if less than 15 ft. All gear must comply with marking requirements no later than August 2014.

<u>Comparison of Alternatives</u>: The biological opinion on the spiny lobster fishery (Appendix I) mandates the establishment of trap line marking requirements no later than August 2014 to improve the monitoring of incidentally taken protected species. The federal spiny lobster fishery has three management areas: the EEZ off Gulf states other than Florida, the EEZ off Florida, and the EEZ off southern Atlantic states other than Florida. Because there is essentially no spiny lobster trap fishing outside Florida, the biological opinion did not considered trap impacts to protected species anywhere else. Therefore, all measures required under the biological opinion only apply to spiny lobster trap fishing occurring in the Florida EEZ.

Currently, all spiny lobster traps fished in the EEZ off Florida must follow the gear marking requirements established by the State of Florida at 68B-24 in the Florida Administrative Code (FAC). Those regulations require a buoy or a time-release buoy to be attached to each spiny lobster trap or at each end of a weighted trap trotline. Each buoy must be a minimum of six inches in diameter and constructed of Styrofoam, cork, molded polyvinyl chloride, or molded polystyrene [FAC 68B-24.006(3)]. Additionally, each trap and buoy used must have the fishers' current lobster license or trap number permanently affixed in legible figures. On each buoy, the affixed lobster license or trap number shall be at least two inches high [FAC 68B-24.006(4)].

Lines are consistently found as marine debris and most frequently recovered without the buoys or traps still attached. Miller et al. (2008) reported lost pot/trap gear was the second most prevalent type of marine debris in the Florida Keys and the most damaging to benthic habitat. In all cases, lines were without buoys. While current gear marking regulations require buoys and traps to be marked, buoys are frequently dislodged from lines and the lines used in the spiny lobster fishery are also used in other fisheries and for other purposes. These conditions make it extremely difficult to determine if line found in the environment, or entangling protected species, originated from the spiny lobster fishery. A lack of uniquely identifiable markings also makes monitoring incidental take in the fishery difficult. Trap line marking requirements would allow for greater accuracy in identifying fishery interaction impacts to benthic habitats and protected species leading to more targeted measures to reduce the level and severity of those impacts.

Trap line marking requirements are currently in place for other fisheries in other regions. Under the Atlantic Large Whale Take Reduction Plan trap/pot fisheries in the Northeast and Mid-

Atlantic regions must use red, orange, or black markings on their gear depending on the fishery. When the line in use is the same color as the required gear marking color scheme, those lines are marked with a white line.

Preferred Alternative 1 would have no biological benefit for protected species and would not satisfy the trap line marking requirements of the Biological Opinion. This alternative is unlikely to have any social or economic impact. The Councils chose **Preferred Alternative 1** to allow more time for input from stakeholders on the most appropriate and cost-effective ways to mark lines. This action will be included in Amendment 11, which is under development. NOAA Fisheries Service is considering modifying the terms and conditions from the biological opinion to allow more time for implementation of this measure.

Because color marking schemes using red, orange, and black are currently in use, those colors were not considered here. Spiny lobster industry members requested that only colors that were not likely to attract sea turtle be considered for gear marking requirements. Most sea turtles appear to have at least some color vision and most are able to see a color spectrum similar to what humans observe (Liebman and Granda 1971; Granda and O'Shea 1972; Liebman and Granda 1975; Levenson et al. 2004; Mäthger et al. 2007). Limited research has not yet identified any particular color that would be less likely to attract sea turtles. However, anecdotal evidence from sea turtle rehabilitation suggests that bright colors such as pinks, yellows, and bright greens can capture their attention (S. Schaf, FWC, pers. comm.). Given this information, the color will be selected for the gear marking requirement in **Alternative 2** because it is not currently in use elsewhere and less likely to attract sea turtles. Requiring a specific color trap line or a color tracer in the line (Figure 2.10.1) as under **Alternative 2** would meet the requirements of the biological opinion.

Figure 2.10.1. Example of a color tracer line (orange) woven along the entire length of a black trap line. In the image, the trap line is coiled.

Three methods for marking gear were tested and found to work satisfactorily in the Northeast Region under normal conditions. At the top of Figure 2.10.2, colored twine is seized around the line and woven between the strands. In the center, the line was spray-painted; this method requires that the line be dry. At the bottom, colored electrical tape was wrapped in one direction and then back over itself to form two layers. Similar marking techniques would likely be sufficient for the spiny lobster fishery under **Alternative 3**.

Figure 2.10.2. Examples of satisfactory gear markings for trap lines in the Northeast Region.

Marine debris surveys conducted in the Florida Keys documented that 21% of trap lines found were less than 15 ft long and approximately 53% were between 15 and 45 ft in length with the remainder being longer than 50 ft (Miller et al. 2008). The average length of line encountered was approximately 35 ft (Miller et al. 2008). Requiring gear marks along the entire length of the line or at least every 15 ft (**Alternative 3**) improves the likelihood that line found in the environment can be identified properly.

Florida could greatly improve the efficacy of gear marking requirements for spiny lobster gear fished in the EEZ off Florida by creating compatible gear marking requirements for spiny lobster trap gear in state waters. The selection of a gear marking scheme does not preclude non-spiny lobster fishers from using the same color. Florida could further improve the efficacy of gear marking requirements proposed under this action by instituting gear marking requirements for other state water trap fisheries (blue crab and stone crab).

Alternative 2 would likely have slightly more biological benefits than **Alternative 3.** Requiring gear markings along the entire length of trap lines would minimize the likelihood that a portion of a spiny lobster trap line is recovered without an identifiable mark. **Alternative 3** would provide greater biological benefit than **Preferred Alternative 1** but the benefits would likely be less than **Alternative 2** for the reason described above. The social and economic impacts from **Alternatives 2** and **3** would likely be similar. Additional costs would be incurred to replace existing trap lines with trap lines of specific color (**Alternative 2**). However, trap lines are generally replaced after several years due to wear and the phase-in provision of this action should allow fishers to begin using lines that meet the gear marking requirements as they replace old lines. The materials needed to meet the requirements of **Alternative 3** would likely cost less than those required in **Alternative 2.** However, the time commitment needed to properly mark all lines as proposed in **Alternative 3** may be greater than the time required to switch out old lines.

2.11 Action 11: Authority to Remove Derelict or Abandoned Spiny Lobster Traps Found in the EEZ off Florida

Alternative 1: No Action – Do not allow the public to remove any derelict or abandoned spiny lobster trap found in the EEZ off Florida.

Alternative 2: Allow the public to completely remove from the water any derelict or abandoned spiny lobster trap found in the EEZ off Florida from the end of lobster season trap removal period (usually April 5) until the beginning of the next season's trap deployment period (August 1).

Alternative 3: Allow the public to completely remove from the water any derelict or abandoned spiny lobster trap found in the EEZ off Florida during the closed seasons for both spiny lobster and stone crab (May 20-July 31).

Alternative 4: Allow the public to remove spiny lobster trap lines, buoys, and/or throats, but otherwise leave in place, any trap found in the EEZ off Florida from the end of season trap removal period (usually April 5) until the beginning of the next season's trap deployment period (August 1).

Alternative 5: Allow the public to remove spiny lobster trap lines, buoys, and/or throats, but otherwise leave in place, any trap found in the EEZ off Florida during the closed seasons for both spiny lobster and stone crab (May 20-July 31).

Preferred Alternative 6: Delegate authority to regulate the removal of derelict or abandoned spiny lobster traps occurring in the EEZ off Florida to FWC.

Comparison of Alternatives: The biological opinion (Appendix I) on the spiny lobster fishery requires NOAA Fisheries Service and the Councils explore allowing the public to remove derelict trap gear from the EEZ off Florida. The federal spiny lobster fishery has three management areas: the EEZ off Gulf states other than Florida, the EEZ off Florida, and the EEZ off southern Atlantic states other than Florida. Because there is essentially no spiny lobster trap fishing outside Florida the biological opinion did not considered trap impacts to protected species anywhere else. Therefore, all measures required under the biological opinion only apply to spiny lobster trap fishing occurring in the Florida EEZ.

Current federal regulations state that any trap, buoy, or rope found in the EEZ of Florida and any other Gulf state outside of this authorized period is considered unclaimed or abandoned property and may be disposed of in any manner considered appropriate by the Assistant Administrator or authorized officer [50 CFR 640.20(b)(3)(iii)]. Those regulations also state that pulling or tending another person's spiny lobster trap, without prior authorization is prohibited.

Florida regulations allow spiny lobster traps to be deployed beginning August 1 of each year and require all traps be removed from the water by April 5 (with the opportunity for an extension under certain circumstances). Florida considers traps remaining in the environment outside of the authorized fishing season to be derelict [FAC 68B-55.004]. At any time, local, state, or federal government personnel may remove trap debris and derelict traps from areas of state waters permanently closed to trapping without prior authorization from FWC [FAC 68B-55.002 and 68B-55.004]. During the spiny lobster season, FWC employees, local, state, or federal personnel may retrieve derelict traps at any time deemed appropriate by FWC. Members of a fishery participant organization may also remove derelict traps from state waters at any time deemed appropriate by FWC during the season, if they have a FWC-approved trap retrieval plan. During the closed season for spiny lobster, and after any authorized trap retrieval period together with any extensions, nonprofit nongovernmental organizations, fishery participant organizations, or other community or citizens groups may retrieve derelict traps as part of coastal cleanup events authorized by FWC [FAC 68B-55.004].

Trap debris may be removed at any time from shoreline areas shoreward of mean low water, and from mangroves or other shoreline vegetation by nonprofit nongovernmental organizations, fishery participant organizations, or other community or citizen groups when they organize, promote, and participate in coastal cleanup events for the purpose of removing marine debris. Prior authorization from FWC is required for any coastal clean-up events that remove trap debris occurring in state waters seaward of mean low water [FAC 68B-55.002].

Lost traps pose multiple threats to the environment and protected species. Lost traps can "ghost" fish for a year or more (FWC unpublished data; Lewis et al. 2009), and trailing trap lines can become entangled on the reef, damaging corals and sponges (Chiappone et al. 2005). Marine mammals and ESA-listed sea turtles and marine fish can also become entangled in trailing ropes (Guillory et al. 2001; Seitz and Poulakis 2006; Lewis et al. 2009). Wooden traps eventually degrade after many months, but plastic trap throats and polystyrene buoys persist indefinitely in the marine environment. Seagrass meadows can be damaged when traps are lost or left for periods longer than six weeks (Uhrin et al. 2005). Thousands of lost and abandoned traps can have a significant effect on the reef environment and benthic habitats.

Unlike nearshore areas where traps can be located during aerial surveys or by boats during low tides, traps lost in federal waters are more difficult to identify. Traps identified in the nearshore environment are also more conducive to trap clean-up events because of their proximity to boat ramps and areas where recovered traps can be off loaded. Organized clean ups for the sole purpose of removing derelict trap gear in federal waters is generally expensive and difficult to conduct. Allowing the public to remove derelict trap gear (**Alternatives 2** and **3**) would promote many individual contributions, which could have a large cumulative effect.

Arguments against allowing the public to remove derelict or abandoned traps cite concerns that legally fishing traps may be removed by someone other than the traps' owners, either intentionally or by accident. However, some industry members did recognize the potential environmental impacts of lost traps and suggested their own alternative that would allow the public to make traps unfishable (**Alternatives 4** and **5**). Specifically, they recommended authorizing the removal of buoys, trap lines, and throats from derelict spiny lobster traps in the EEZ. They stated that these actions would render the trap unlikely to ghost fish, and would reduce a traps' likelihood of moving during storm events. This proposal also ensures that only the owner of the trap would be authorized to remove the trap from the water.

Another argument against allowing the public to pull derelict traps is a concern over confusion between similar looking traps. For example, some industry members voiced concerns that legally fishing stone crab traps would be confused for derelict spiny lobster traps by the public and pulled. **Alternatives 3** and **5** would only allow the public to remove derelict traps during the closed seasons for both spiny lobster and stone crabs. Limiting the removal of traps to the closed seasons for both species ensures that only truly derelict traps are removed.

Alternative 1 would have no biological benefit for protected species or benthic habitat and would perpetuate the existing level of risk for interactions between these protected species and lost trap gear. No negative social or economic impacts are anticipated under this alternative. **Alternative 2** would likely have the greatest biological benefits. This alternative would allow for the complete removal of all derelict or abandoned traps and authorize that removal for the longest period of time, likely increasing the number of derelict or abandoned traps removed. **Alternative 3** would also allow for the complete removal of derelict or abandoned trap gear, but for a shorter period. As a result, the biological benefit of **Alternative 3** may be less than **Alternative 2**. The potential social and economic impacts from **Alternative 2** include the accidental or intentional removal of legally fishing traps. Well meaning members of the public may accidentally remove a legally fishing lobster trap from the water. Likewise, well meaning members of the public may accidentally remove similar looking traps (i.e., stone crab traps). The potential social and economic impacts from **Alternative 3** would likely be similar those expected from **Alternative 2**; however, the likelihood of the accidental removal of legally fished, similar looking traps may be reduced. Since fines may be levied for derelict traps recovered by law enforcement or during FWC-contracted trap removal programs, allowing the public to remove traps may have positive economic impacts in the form of avoided fines. **Alternatives 4** and **5** would likely have less biological benefit than **Alternatives 2** and **3**. Allowing the public to remove trap line, buoys, and throats would help reduce the potential impacts from ghost fishing and entanglement. However, traps remaining in the environment still have the potential to cause damage to benthic habitat. **Alternative 4** would allow more time for the public to remove trap line, buoys, and throats from derelict or abandoned traps, potentially increasing the biological benefit. Compared to **Alternatives 2-4**, **Alternative 5** would likely have the least biological benefit. The social and economic impacts of **Alternatives 4** and **5** would likely be similar to **Alternatives 2** and **3**. Removal of lines and throats from a legally fishing trap would likely result in the same economic impacts to fishers as the complete removal of a trap from the water. It is unclear if the owner of a recovered derelict trap that had previously had its trap lines, buoys, and/or throats removed would still be subject to fines or civil penalties. If so, the potential economic benefits from **Alternatives 2** and **3** may not be realized with **Alternatives 4** and **5**. It is currently unclear what type of biological impact **Preferred Alternative 6** would have. If the delegation of authority to the FWC leads to the removal of more derelicts traps and trap debris, the biological benefits from the alternative would likely be within the range anticipated from **Alternatives 2-5**. If **Preferred Alternative 6** ultimately results in no change or fewer derelict traps and trap debris being removed, then its biological benefit would likely be similar to the effect anticipated under **Alternative 1**. The social and economic impacts of **Preferred Alternative 6** are unclear.

3.0 AFFECTED ENVIRONMENT

3.1 Description of the Fishery

3.1.1 Caribbean Spiny Lobster – Commercial Fishery

Introduction

Florida landings of Caribbean spiny lobster began to increase in the late 1940s to levels ranging 4.0-7.0 million pounds (mp) whole weight (ww) in the 1970s-1990s, and then fell to 3.5-5.0 mp in 2001 onward (Figure 3.1.1.1). This excludes landings from international waters, an estimated 1.0-5.7 mp in 1964-1975 (Vondruska 2010b). Landings occur predominantly in the Florida Keys (Monroe County) and elsewhere in south Florida. Relatively small amounts have been reported for other states since 1977.

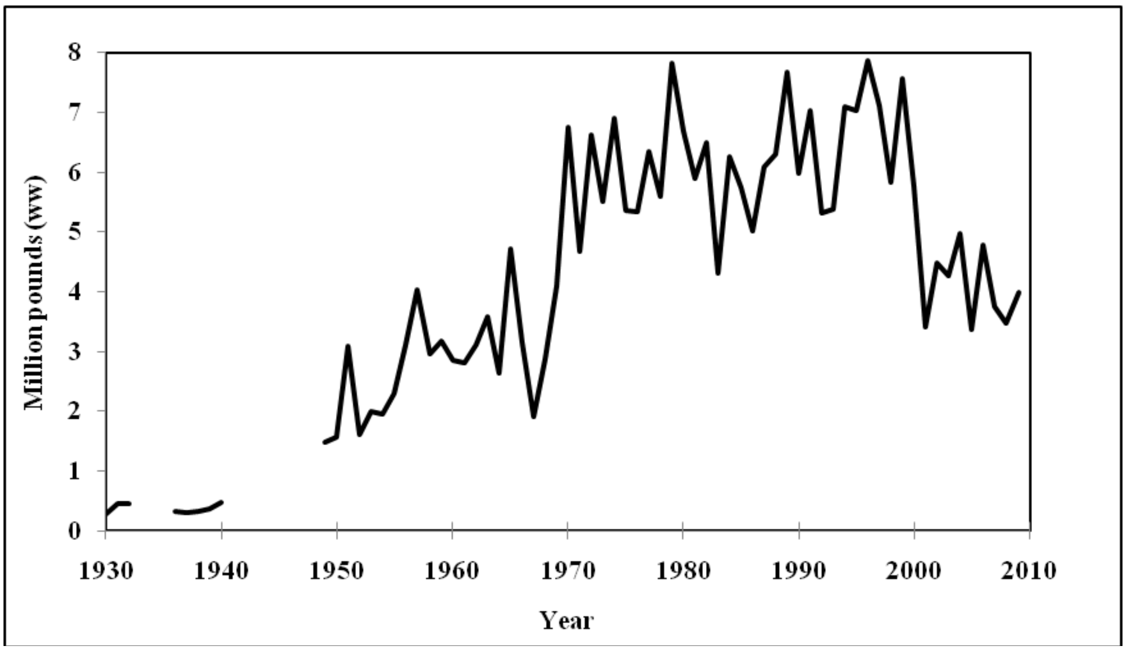


Figure 3.1.1.1. Florida commercial landings of Caribbean spiny lobster, 1930-2009.
Note: Excludes estimated landings from international waters in 64-76 (Vondruska 2010b).

The Caribbean spiny lobster in the U.S. Exclusive Economic Zone (EEZ) of the Atlantic Ocean and Gulf of Mexico (Gulf) is jointly managed by the South Atlantic and Gulf of Mexico Fishery Management Councils (Councils) through the Fishery Management Plan for Spiny Lobster (FMP) in the Gulf 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 through a separate 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. To streamline a management process that involves both state and federal jurisdictions, the FMP basically extends the Florida Fish and Wildlife Conservation Commission (FWC) rules regulating the state fishery to the southeastern U.S. EEZ from North Carolina to Texas.

Currently, harvest or possession of Caribbean spiny lobsters in the U.S. Gulf and South Atlantic EEZ is regulated in the Code of Federal Regulations (CFR). According to 50 CFR 640.4, anyone who sells, trades, or barters or attempts to sell, trade, or barter Caribbean spiny lobster 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 the Florida Administrative Code (FAC). Similarly, any person who sells, trades, or barters or attempts to sell, trade, or barter a Caribbean spiny lobster harvested in the 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)]. In 2010, the state of Florida issued 1,286 commercial spiny lobster permits and 293 commercial dive permits. As of March 25, 2011, NOAA Fisheries Service listed 199 valid federal spiny lobster permits.

The commercial and recreational fishing season for spiny lobster in the EEZ off Florida and the Gulf States other than Florida, begins on August 6 and ends March 31 [50 CFR 640.20(b)]. Lobster traps may be worked during daylight hours only and no Caribbean spiny lobster can be harvested in excess of the bag limit by diving at night. Specifications for traps and buoys, identification requirements, and prohibited gear are detailed in FAC 68B-24.006.

No person may possess a Caribbean spiny lobster in or from the Gulf or South Atlantic EEZ with a carapace length of 3.0 in (7.62 cm) or less or a separated tail with a length less than 5.5 in (13.97 cm) [50 CFR 640.21(b)], except under particular circumstances. The holder of a valid crawfish license, lobster trap certificates, and a valid Saltwater Products License (SPL) may harvest and possess, while on the water, undersized spiny lobsters to use as attractants. Florida regulations allow for 50 such undersized attractants plus one per trap aboard each vessel, but Federal regulations allow for 50 or one per trap. Both sets of regulations require the use of live wells for undersized lobsters that follow specific guidelines. The possession aboard a fishing vessel of a separated Caribbean spiny lobster tail is allowed only during trips of 48 hours or more if a federal tail-separation permit has been issued to that vessel. As of March 25, 2011, NOAA Fisheries Service listed 355 valid federal tailing permits.

Current regulations prohibit the possession of a Caribbean 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 egg-bearing Caribbean spiny lobster to be returned immediately to the water [50 CFR 640.7(g)].

3.1.2 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.

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).[2] The FKNMS is comprised of 9,660 km^2 (about 2,900 nm^2) of coastal waters off the Florida Keys. It extends approximately 220 mi 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% is in federal waters. Both NOAA and Florida manage the Sanctuary. The waters of the FKNMS are within the jurisdiction of both Councils.

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 mi long. The park extends from shore about 14 mi to the 60-ft 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 no take of Caribbean spiny lobster in those areas.

Dry Tortugas National Park
The Dry Tortugas National Park was established by Congress in 1992. 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.

State Spiny Lobster Laws and Fisheries Histories
Descriptions and discussions of the development of the spiny lobster fishery in Florida are provided in Labisky et al. (1980), Moe (1991), Florida Marine Fisheries Commission (1991), Prochaska and Baarda (1975), and Williams (1976). Significant events or facts about the development of the fishery include the fishery being primarily a bait fishery up until the twentieth century (Labisky et al. 1980); construction of the Overseas Railroad in 1912 and a large ice-making and cold-storage facility in Key West by the 1920s, allowing shipment to distant markets; the implementation of size limits in 1929 (Prochaska and Baarda 1975); the development of freeze processing, enabling the expansion of the retail market in the 1940s; the development of SCUBA, hydraulic systems to haul traps, and the use of shorts (Moe 1991); the first gear restrictions imposed in 1965 (trap regulations; Prochaska and Baarda 1975; Williams 1976); the enactment of the special two-day sport season in 1975; the development of the state fishery management plan in 1987; the creation in 1991 of the recreational spiny lobster license

[2] 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.

and initiation of annual surveys to estimate recreational harvests and a commercial trap certificate program.

The estimated number of traps used for commercial fishing for Caribbean spiny lobster in Florida approximately doubled every 10 years during 1950-1990, reached nearly a million traps in the early 1990s, and was reduced to less than a half million traps by the late 2000s (Shivlani 2009). The state first issued commercial lobster permits in 1954/1955; imposed a fee of $50 per permit starting in 1971; and in 1987/1988 limited the numbers of traps per permit holder to 2,000 and initiated a permit moratorium, among other things, all with the expectation of reducing landings (Milon et al. 1998; 1999). In 1991, the Florida Legislature passed a law creating the Trap Certificate Reduction Program (TCP) to "stabilize the lobster fishery by reducing the total number of traps" (Florida Statutes 370.142(1), as quoted in Shivlani 2009). "It is the goal of the Commission [which administers the program] to substantially reduce mortality of undersized spiny lobster in the fishery, by reducing the number of traps used in the fishery to the lowest number which will maintain or increase overall catch levels, promote economic efficiency in the fishery, and conserve natural resources" [FAC 68B-24.001]. Quoting Larkin and Milon (2000):

> The state of Florida has managed the commercial spiny lobster trap fishery using a tradable effort permit program since 1992. Under this input control program, individuals own shares of a restricted input, but output is unregulated. This type of program can be contrasted with an output control program, such as individual transferable quotas (ITQs) where individuals own shares of a restricted output. The commonality between these programs is that they both allow shares to be bought or sold. The transfer of shares essentially generates a private market for effort or harvest rights, which can allow for efficiency and profitability gains in the fishery (Squires et al. 1995).

While many studies focused on the fishery as a whole, Shivlani et al. (2004) analyzed the impact of the TCP on fishing communities and economic viability of individual fishermen. Based on survey responses for the 2001/2002 fishing season, it appears that 1,232 is the minimum average number of trap certificates needed for economic viability at the vessel (fishing business) level (Shivlani et al. 2004; Shivlani 2009). According to this study, the initial allocation of certificates among fishermen under the TCP had created two groups of fishermen. Apparently, those initially awarded more than 1,500 certificates viewed the TCP as a means of reducing the size of their operations, and those initially awarded fewer than 1,500 certificates were forced for the most part to purchase certificates from other fishermen to remain competitive (Shivlani 2009). As part of their analysis of the TCP, Milon et al. (1999) include a summary of initial eligibility rules and certificate allocations under the TCP, along with data on certificate purchases and sales, leasing, prices and other matters. When landings were at their peak in the mid-1990s, the purchase prices for certificates were upward of $60 and a leasing system developed (Shivlani 2009).

Given the financial barriers to entry into trap fishing, commercial dive fishing for Caribbean spiny lobster emerged and expanded in the wake of the TCP. Commercial divers were not subject to controls on effort and entry until 2004, and this weakened the effectiveness of the TCP as a limited access program for the fishery as a whole (Shivlani 2009).[3] Compared with traps, landings from diving increased rapidly in the first decade of the TCP, from 0.098 mp in 1991/1992 to a peak of 0.582 mp in 1999/2000, and then declined to 0.152 mp by2009/2010 (Table 3.1.2.1). In south Florida, there is a daily diving-vessel trip limit of 250 lobsters [FAC 68B-24.0055]. Owners of trap certificates cannot own a commercial diving permit [FAC 68B-24.0055(1)]. There is a moratorium on issuing new licenses (permits) for commercial dive fishing; they had declined from 405 in 2004/2005 to 293 in 2009/2010 (Table 3.1.2.1).

The Special Recreational Crawfish License (SRCL) allows the harvest, but not the sale of a special daily bag limit of lobsters. The SRCLs were first issued for the 1994/1995 lobster fishing season. The SRCLs were implemented for persons who held SPLs and spiny lobster/crawfish endorsements in 1993/1994, but did not meet the income requirements for a Restricted Species Endorsement (RSE) that allows the sale of spiny lobster. The SRCL special bag limit was 50 lobsters in 2003/2004 and it will have been reduced to 10 lobsters by 2011/2012 [FAC 68B-24.004]. The number of SRCLs declined from 515 in 1994/1995 (with landings of 74,980 lbs for 22,267 person days of effort) to 168 by 2008/2009 (with landings of 10,727 lbs for 3,594 person days of effort) (Table 3.1.2.1 and SEDAR 8, 2010 update, Table 2.1.2). To maintain an SRLC, a recreational lobster permit is required and a RSE for Caribbean spiny lobster is prohibited. The SRCLs will not be issued or renewed after 2012/2013 [FAC 68B-24.0035].

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[3]With some exceptions related to age or other factors, commercial vessel operators, vessels (fishing firms), and crew members must sell $5,000 of products or have earned income of $2,500 per year from sales to licensed Florida dealers to qualify for a restricted species endorsement (FAC 68B-24.0035; FS 379.355(5); FS 379.361 (2) on SPLs; FWC, Restricted Species Endorsement Application).

Table 3.1.2.1. Number of licenses (permits) and landings (thousands of pounds, ww).

Fishing year	Crawfish/lobster trap permits		Commercial dive permits		Special recreational crawfish		Restricted species licenses	Stone crab trap permits
	Permits	Landings	Permits	Landings	Permits	Landings		
90/91	4,245	5,899		98			7,092	4,719
91/92	3,869	6,602		192			7,891	4,914
92/93	3,498	5,125		223			7,921	5,044
93/94	3,199	5,109		176			8,329	5,515
94/95	2,283	6,895		253	515	75	9,361	6,066
95/96	2,312	6,682		308	430	67	9,813	4,954
96/97	2,513	7,363		334	398	55	9,904	4,347
97/98	2,415	7,185		394	365	50	9,874	3,851
98/99	2,424	5,003		351	363	49	9,531	3,491
99/00	2,298	7,024		582	318	61	9,207	3,216
00/01	2,282	4,934		569	301	38	9,881	2,863
01/02	1,965	2,606		442	273	32	9,916	1,492
02/03	1,853	3,988		547	291	44	9,969	1,658
03/04	1,801	3,727		392	280	39	9,739	1,533
04/05	1,601	5,096	405	305	9	34	9,488	1,433
05/06	1,444	2,644	380	259	23	26	8,912	1,348
06/07	1,346	4,495	352	243	14	27	8,537	1,273
07/08	1,302	3,449	334	286	81	21	8,470	1,251
08/09	1,268	2,988	322	241	168	17	8,210	1,202
09/10	1,286	4,084	293	152				

Permits: FWC website data for annual summaries of licenses and/ or permits. Data for 09/10 obtained separately. Landings: SEDAR 8 Update 2010. Recreational landings are estimated for 85/86-91/92, using regression analysis and commercial landings by region in August, and they are estimated for 04/05 based on averages 03/04 and 05/06 (SEDAR 8; J. Munyandorero and R. Muller, FWC, pers. comm.). SRLC landings are reported quarterly by the license/permit holders [FAC 68B-24.0035].

Currently, Florida law requires anyone who commercially harvests or sells spiny lobster to have a SPL. An SPL may be issued in the name of an individual or a valid vessel registration number issued in the name of the licensed applicant. Florida also requires anyone who sells spiny lobster to have an RSE and Crawfish Endorsement.

Caribbean 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 [FAC 68B-24.003(4)]. Possession of Caribbean spiny lobster tails that have been separated on or below state waters is prohibited unless the Caribbean spiny lobster is being imported pursuant to FAC 68B-24.0045, 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 in length, otherwise, if whole, the carapace must be greater than 3 in long [FAC 68B-24.003(1)].

In Florida, the harvest or possession of egg-bearing Caribbean spiny lobster is prohibited and any egg-bearing lobster found in traps must be immediately returned to the water free, alive and unharmed [FAC 68B-24.007]. The practice of stripping or otherwise molesting egg-bearing Caribbean spiny lobster to remove the eggs is prohibited and the possession of Caribbean spiny lobster or spiny lobster tails from which the eggs, swimmerets or pleopods have been removed or stripped is prohibited [FAC 68B-24.007].

Possession of undersized Caribbean spiny lobster is prohibited, except in the lobster trap fishery, where fishermen use undersized lobsters to attract legal-sized ones. Allowable gear types are traps, hand-held net, hoop net (diameter no larger than 10 ft), bully net (diameter no larger than 3 ft), 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 lobster trap fishery, trap certificates and tags are required for all traps. A tag must be securely attached to each trap; Caribbean spiny lobster trap specifications and trap, buoy, and vessel marking requirements apply; and traps, buoys, and vessels must display the Crawfish Endorsement number. Traps must be constructed of wood or plastic and be no larger than 3 ft by 2 ft or the volumetric equivalent (12 ft^3) with the entrance located on top of the trap. Each plastic trap must have a degradable panel. Traps may 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 ft of the Intracoastal 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. 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.

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 own trap certificates. After January 1, 2005, no diver permits were issued, renewed or replaced except those that were active in 2004/2005. 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.

The commercial and regular recreational Caribbean spiny lobster seasons start August 6 and end March 31 [FAC 68B-24.005(1)]. No person can harvest, attempt to harvest, or have in his possession, regardless of where taken, any spiny lobster during the closed season of April 1 through August 5 of each year, except during the two-day sport season, for storage and distribution of lawfully possessed inventory stocks or by special permit issued by the FWC [FAC 68B-24.005(1)]. During the two-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.

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 and Orbach 1990).[4] Prior to the zoning change, fishers could store and work on traps on 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 six months or one 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.

3.1.3 Caribbean Spiny Lobster – Recreational Fishery

The Florida recreational Caribbean spiny lobster fishing season has two parts: a two-day sport season that occurs before commercial spiny lobster fishers place their traps in the water and a regular season that coincides with the commercial fishing season. The two-day sport season has been and remains popular as illustrated by a July 28, 1991, article in the *St. Petersburg Times* that concerns "lobstermania" and a July 30, 2009, *Miami Herald* article with the title, "Lobster hunters turn out in droves for Florida mini-season." Recreational spiny lobster fishers individually spend hundreds of dollars for fuel, ramp fees, food, beverages, scuba, snorkeling and hooking equipment and licenses annually. At the same time, however, there have been and continue to be residents and business and commercial interests in the Keys who favor abolishing the sport season. Processors are among those who are critical of the sport season. Shivlani et al. (2004) reported that 11% of the processors that they interviewed blamed the sport season for declining commercial landings.

Florida has a variety of permits that will allow recreational fishers to take spiny lobster. In 2010, the state issued 129,865 annual or five-year crawfish permits; in addition, they issued 36,030 other permits, such as Sportsman Gold or Saltwater Lifetime permit, that also allow holders to take spiny lobster. NOAA Fisheries Service does not require a permit for recreational fishing in the EEZ.

Beginning with a pilot study in 1991 and continuing through 2007, the FWC has surveyed these permit holders regarding their lobster fishing activities using mail surveys to estimate landings and fishing effort. In 2007, the FWC conducted its first e-mail survey of these permit holders, and since 2008 has used e-mail surveys exclusively to conduct the surveys. These surveys provide an estimate of recreational landings and fishing effort during two specific time periods during the recreational fishing season – the special two-day sport season and the first month of the regular lobster fishing season (August 6 through Labor Day). Although the regular lobster fishing season in Florida does not close until April 1, the FWC surveys have only incorporated those two time periods because anecdotal observations, which were subsequently confirmed by

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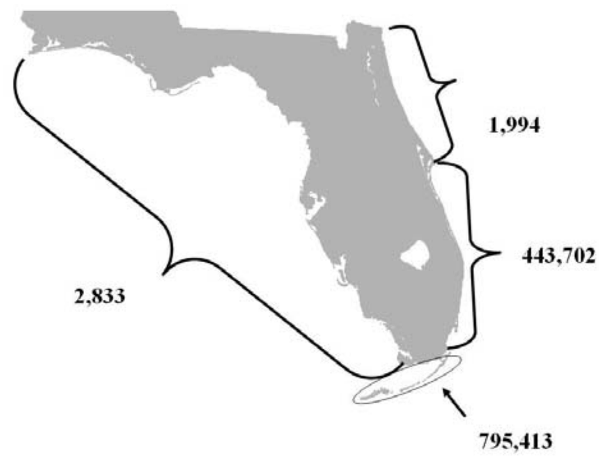
[4] Traps used to be dipped in recycled oil to protect them from the marine environment. However, that practice was prohibited beginning in 1995. Now fishermen soak traps in a brine solution to extend the life of their traps.

these surveys and an additional small season-ending survey, indicated that the largest proportion of recreational lobster fishing effort occurs during those two periods and consequently provided the best opportunity to accurately monitor long-term trends in the fishery using mail surveys. Additional mail surveys throughout the fishing season would have been cost and labor prohibitive. However, the recently developed e-mail survey now makes it more feasible to survey permit holders about their late season fishing activities. The FWC is developing surveys designed to provide estimates of recreational landings from Labor Day to the end of the fishing season.

Like the commercial fishery, the recreational fishery is concentrated along the Florida Keys. The survey conducted in 2008, for example, estimated that approximately 64% of the 1,247,000 lbs of lobsters that were harvested during the two-day sport season and first month of the regular season were harvested in the Keys, and approximately 36% (443,702) were harvested in the southeast coast of the state (Figure 3.1.3.1). Less than 1% as harvested elsewhere in the state. Typically, approximately 60% of the statewide fishing effort occurs in the Florida Keys (Sharp et al. 2005).

Figure 3.1.3.1. Estimated recreational lobster landings (lbs) during the 2008 Special Two-Day Sport Season and first month of the regular lobster fishing season.
Source: FWC.



The large majority of recreational landings are taken by divers who tend to target Caribbean spiny lobster in similar areas as commercial divers. Little fishing effort occurs north of Monroe County on the Gulf side. The recreational fishery is largely conducted from docks, boats, residential properties, and numerous other places along the Florida Keys and southernmost counties where a diver can get into the water from shore or from boats or platforms where an individual can use a bully or hoop net. The geographic variability has made the inclusion of spiny lobster in the Marine Recreational Fisheries Statistics Survey (MRFSS) cost prohibitive. There has been and continues to be no evidence of subsistence fishing for Caribbean spiny lobster (GMFMC and SAFMC 1982).

Recreational Landings and Catch per Unit Effort (CPUE)
Estimated recreational landings, fishing effort, and CPUE for Caribbean spiny lobster in Florida during the two-day sport season and the first month of the regular lobster fishing season were mostly lower from 2001/2002 onward than in the 1990s (Figures 3.1.3.2 and 3.1.3.3). In the last five years, they averaged 1.208 mp (ww), 406,166 person days, and 2.70 lobsters per person day. Compared with the respective totals, 30% of the landings and 24% of the effort occurred in the special two-day season (last five-year averages of 94,574 person days for 0.342 mp for the special season; 298,065 person days for the first month of the regular season for 0.846 mp; and 392,638 person days overall for 1.208 mp; W. Sharp, FWC, pers. comm.).

The effects of weakened national economic conditions in the last two to three years may largely explain reduced landings, effort, and a fall off in the number of recreational licensed purchased (Table 3.4.2.1). Previously, in the mid-2000s, at least three hurricanes had occurred when recreational fishing would otherwise be expected to be seasonally high, including Charley (2004), Dennis (2005) and Katrina (2005). By virtue of their timing during the season, some hurricanes affected commercial fishing primarily, including most recently, George in 1998, and Katrina, Rita and Wilma in 2005, both years involving the damage or destruction of large proportions of the traps (Shivlani 2009).

Weakened economic conditions in the last two-to three years, hurricanes in 2004-2005, and other factors may help explain the lower recreational landings, effort and catch per unit effort in 2001/2002 onward compared with 1990s (Figures 3.1.3.2 and 3.1.3.3). In contrast with declining effort and increased productivity for commercial fishing (Figures 3.4.1.2 and 3.4.1.3), however, recreational fishing effort has remained relatively flat during the last twenty years, along with productivity (lobsters landed per person day in Figure 3.1.3.3). Effort has been reduced and productivity has increased for commercial fishing under the TCP, thereby achieving purposes of that program, but the state’s recreational fishing permit program imposes no limit on the number of permits issued.

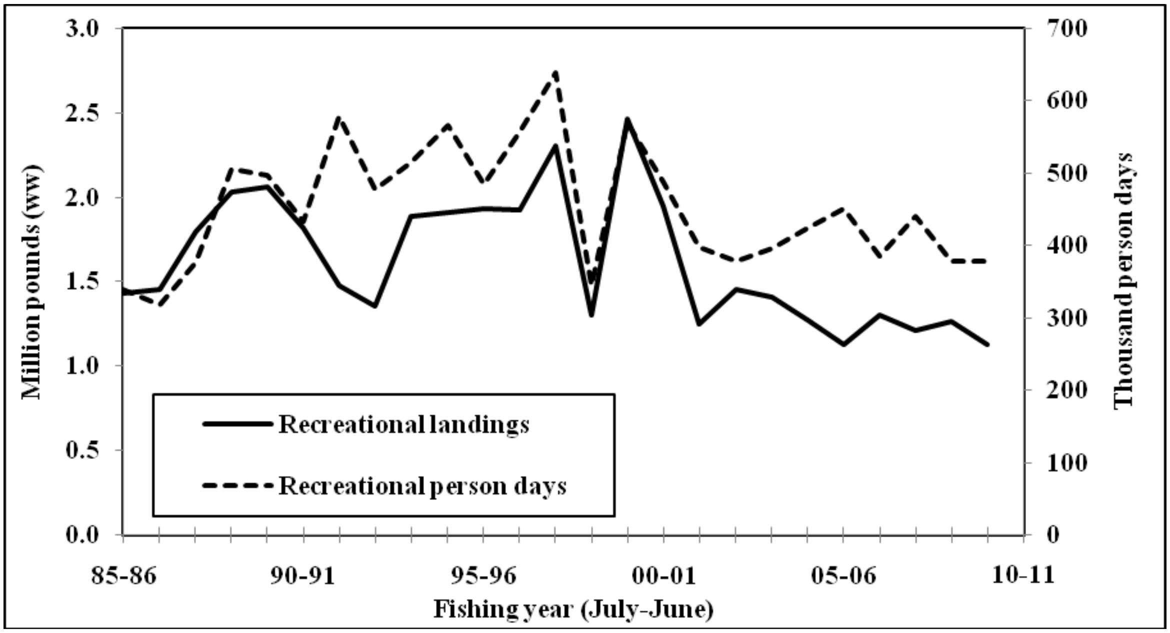


Figure 3.1.3.2. Florida recreational landings and fishing effort.
Source: SEDAR-8, 2010 update.

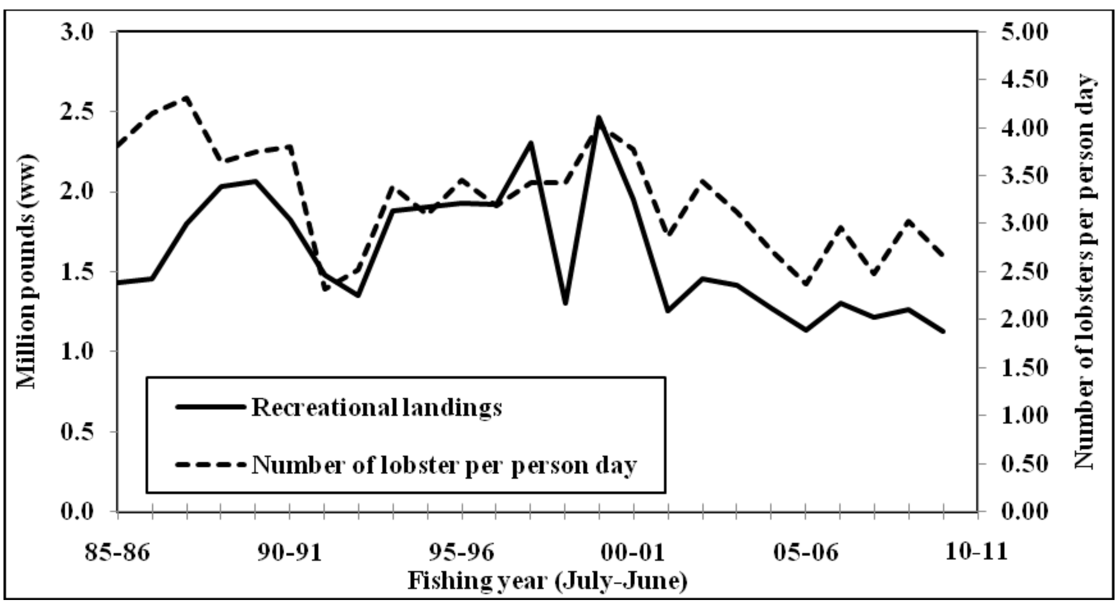


Figure 3.1.3.3. Florida recreational landings and catch per person.
Source: SEDAR-8, 2010 update

Gear Types Used

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. 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 such liquid is prohibited. Most recreational diving occurs in the Florida Keys and in moderately shallow waters.

A survey of recreational divers in the mid-1970s found that 95% of the free divers dove no deeper than 30 ft, while 81% of those who used SCUBA gear dove no deeper than 40 ft. None of the sampled divers reported diving deeper than 80 ft (GMFMC and SAFMC 1982). Some Caribbean spiny lobsters were caught on shallow flats by recreational fishers using bully nets, but they represented only a small portion of the recreational catch.

Hookah fishing involves diving from a boat for lobster using an air compressor that supplies air for the diver through a long hose. Multiple divers can be connected to the same compressor. The use of a hookah system has become increasingly popular because one can use it without becoming certified in scuba diving. Anyone can purchase a hookah system, although hookah diving shares many of the same risks as scuba diving such as decompression sickness and air embolism. Novice divers can stay under for longer periods of time than scuba divers, although there is always the risk of the hose breaking or dislodging from the compressor.

According to the FWC (2006a), the large proportion of recreational divers is highly active only at the start of the fishing season when the lobsters are most abundant. As the recreational lobster fishing season continues, the number of dive trips and number of lobsters recreational divers land declines rapidly. Also, there are many divers with a license are not active during the lobster fishing season.

Some divers, generally those from outside southern Florida, will use charter or party boats. Charter boats typically are hired by diving clubs while party boats operate out of dive shops along the Florida Keys (GMFMC and SAFMC 1982). These boats can hold from 30 to 50 divers and have commercial lobster licenses. In Florida, patrons aboard a fishing charter are not required to possess a recreational saltwater fishing permit because they are covered under the fishing license of the charter boat.

Those who use bully nets perch on bows of boats at night, shine bright lights into the shallows and use a long-handled net to bag spiny lobsters that move out into the open (Cocking 2009). Spears, wire snares, hooks or any gear/device that could penetrate, puncture or crush the shell of a lobster is prohibited. Divers typically use a “tickle stick” to coerce lobsters from their dens into a hand-held net.

3.1.4 Other spiny lobster species

The spotted spiny lobster and smoothtail spiny lobster are found generally in 15-20 ft of water and are considered obligate reef dwellers (Sharp et al. 1997). Further, individuals are relatively small compared to Caribbean spiny lobsters. For these reasons, commercial fishers in the Florida Keys generally do not target these species in U.S. federal waters (W. Kelley pers. comm.). A “luxury” fishery exists in Bermuda and parts of the Caribbean for the spotted spiny lobster (Evans and Lockwood 1995). The smoothtail spiny lobster supports a fishery in Brazil concurrent with a Caribbean spiny lobster fishery; this species is considered to be of minor importance elsewhere (FAO 2007).

Federal regulations prohibit the possession of egg-bearing Caribbean spiny lobster and the removal of eggs, swimmerettes or pleopods; Florida regulations prohibit the same for any species of Family Palinuridae (spiny lobsters). No commercial or recreational landings data are available for either of these species, although some may be reported as Caribbean spiny lobster.

3.1.5 Slipper lobster species

The commercial fishery for slipper lobsters is mainly for the ridged slipper lobster, but landings data are recorded by family only and not by species (Table 3.1.5.1). The following information is taken from Sharp et al. (2007) and Spanier and Lavalli (2006). The slipper lobster fishery is basically a trawl fishery by shrimpers, who harvest slipper lobsters as bycatch. In the Florida Keys, they are harvested by divers for the aquarium trade and are also bycatch in spiny lobster traps. The vast majority of landings are along the Florida west coast. A targeted fishery developed during the 1980's by trawlers during the off-season for shrimp (spring and summer). This is also the spawning season for slipper lobsters, and their migration into shallower water at this time likely contributed to their catchability. In 1987, Florida implemented regulations prohibiting the harvest of egg-bearing female or the removal of eggs by stripping or clipping the pleopods. Around this time, landings declined dramatically. Landings increased somewhat during the 1990s, then declined again and remained low since 1999. The number of shrimp trips also declined beginning in 1999 (Sharp et al. 2007).

Table 3.1.5.1. Commercial effort, landings, and CPUE (pounds/trip) of slipper lobsters in the Gulf and South Atlantic.

Year	Trips	Pounds (x1000)	Lbs/trip
86/87	535	28,097	53
87/88	487	19,952	41
88/89	558	40,736	73
89/90	334	14,793	44
90/91	465	27,282	59
91/92	653	48,728	75
92/93	584	48,708	83
93/94	655	60,230	92
94/95	411	33,531	82
95/96	362	26,843	74
96/97	437	43,565	100
97/98	335	30,872	92
98/99	225	13,139	58
99/00	146	7,196	49
00/01	145	8,766	60
01/02	179	8,582	48
02/03	130	9,951	77
03/04	132	17,012	129
04/05	72	5,000	69
05/06	63	4,291	68
06/07	56	6,060	108
07/08	23	6,443	280
08/09	22	1,889	86
04/05-08/09 Average	47	5.0	24
99/00-08/09 Average	97	7.5	41.2

Source: SEFSC, FTT (Mar 19, 2010) data

The majority of the commercial landings for both the Spanish and ridged slipper lobsters, occur in federal waters off the Gulf coast (Figure 3.1.5.1). The gear types used to harvest these species by trips were 56% by trawl, 23% by diving, and 19% by traps, which was fairly consistent over the 10-year period. Low landings of slipper lobsters were also documented in federal South Atlantic waters and Florida state waters for the combined coasts. In the Florida Keys, slipper lobster species are bycatch in traps for Caribbean spiny lobster (Sharp et al. 2007).

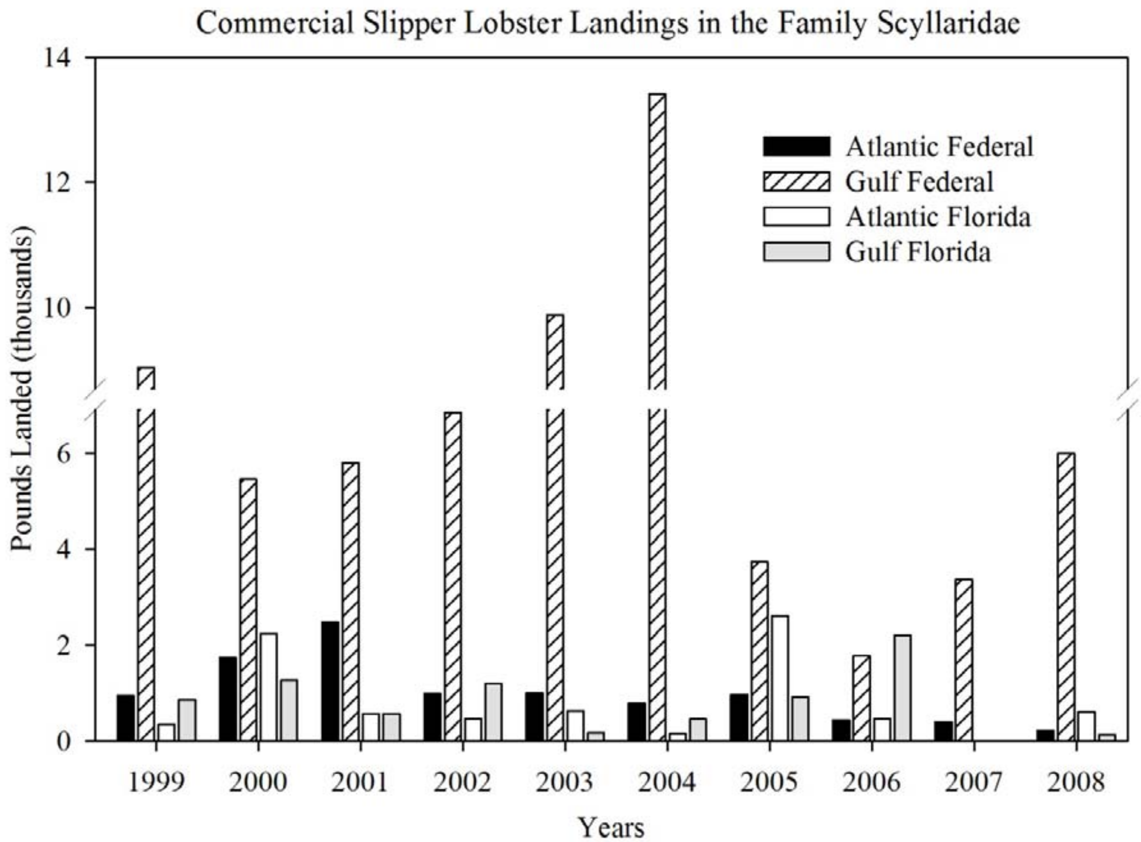


Figure 3.1.5.1. Commercial landings for the family Scyllaridae from 1999 through 2008. by coast. in federal and Florida waters.
Source: FWC, Marine Fisheries Information System 2009. Note: These data are based on the trip ticket program. There is only one space available for waters fished. Fishers could fish in both state and federal waters within one day, based on the season and other fishing behaviors. This figure should be viewed with some caution, because there could be additional unaccounted variability, due to the way the data is recorded and analyzed.

Other Gulf States also had some information on slipper lobster landings. Alabama reported total commercial landings of 10,000 lbs or less whole animal weight of slipper lobsters during 1999-2008. Landings records indicate that these species were incidentally caught from shrimp trawls fishing in federal waters off the west coast of Florida (C. Denson, Alabama Marine Resources Division, Alabama Department of Conservation and Natural Resources, pers. comm.). There were no reported landings for Mississippi, Louisiana, and Texas for slipper lobster species (Source: http://www.st.nmfs.noaa.gov/st1/commercial/landings/annual_landings.html).

From the South Atlantic states, Georgia had no reported commercial landings of slipper lobster species in either state or federal waters for 1999-2008 (J. Califf, Commercial Fisheries Statistics Coordinator, Coastal Resources Division, Georgia Department of Natural Resources, pers. comm.). In South Carolina, there were no recorded landings of slipper lobster species in state or federal waters (G. Steele, Biological Statistician, South Carolina Department of Natural Resources, pers. comm.). In the state waters of North Carolina there were no recorded landings of slipper lobsters; however, during the years 1999, 2000, 2002, and 2005 commercial landings for slipper or spiny lobster were not recorded by the North Carolina Division of Marine Fisheries

(A. Bianchi, Trip Ticket Coordinator, North Carolina Division of Marine Fisheries, pers. comm.).

Little information exists on harvest of slipper lobsters by the recreational sector. MRFSS does not survey lobster, and the Florida recreational survey does not collect information on any species except the Caribbean spiny lobster. A creel survey of Caribbean spiny lobster fishermen conducted in the Florida Keys during the special two-day sport season and the first two weeks of the regular season indicated slipper lobsters are not targeted by these fishers in the Keys. There is some evidence that they may be targeted to some degree by divers in the northern Gulf. However, these species are both cryptic and nocturnal, rendering them difficult to find by recreational divers. For this reason, they are unlikely to support a large recreational fishery (Sharp et al 2007).

Federal regulations prohibit the possession of a slipper lobster, defined as *Scyllarides nodifer* only, with eggs or from which the eggs, swimmerettes, or pleopods have been removed; Florida regulations prohibit the same for all species of Family Scyllaridae (slipper lobsters). Poisons and explosives may not be used to take slipper lobster in the EEZ.

3.2 Physical Environment

Detailed descriptions of the physical environments related to the spiny lobster fishery are provided in the Final EIS for the Gulf Council's Generic Essential Fish Habitat Amendment (GMFMC 2004) and in the South Atlantic Council's Fishery Ecosystem Plan (SAFMC 2009), and are incorporated by reference herein.

The Gulf has a total area of approximately 600,000 mi^2 (1.5 million km^2), including state waters (Gore 1992). It is a semi-enclosed, oceanic basin connected to the Atlantic Ocean by the Straits of Florida and to the Caribbean Sea by the Yucatan Channel. Oceanic conditions are primarily affected by the Loop Current, the discharge of freshwater into the Northern Gulf, and a semi-permanent, anticyclonic gyre in the western Gulf. Gulf surface water temperatures range 12-29º C (54-84º F) depending on time of year and depth of water.

The Deepwater Horizon MC252 oil spill in 2010 affected more than one-third of the Gulf area from western Louisiana east to the panhandle of Florida and south to the Campeche Bank in Mexico. The impacts of the oil spill on the physical environment are expected to be significant and may be long-term. However, the oil remained outside most of the area where this species is abundant. Oil was dispersed on the surface, and because of the heavy use of dispersants, oil was also documented as being suspended within the water column, some even deeper than the location of the broken well head. Floating and suspended oil washed onto shore in several areas of the Gulf as well as non-floating tar balls. Whereas suspended and floating oil degrades over time, tar balls are persistent in the environment and can be transported hundreds of miles. Oil on the surface of the water could restrict the normal process of atmospheric oxygen mixing into and replenishing oxygen concentrations in the water column. In addition, microbes in the water that break down oil and dispersant also consume oxygen; this could lead to further oxygen depletion. It is also possible that zooplankton that feed on algae could be negatively impacted, thus allowing more of the hypoxia-fueling algae to grow.

The South Atlantic 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 approximately 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. 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. 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.

Given the large to near total dependence on larval recruitment from the Caribbean, it is appropriate to include the Caribbean area in the description of the physical environment. A detailed description of the physical environment in the Caribbean related to the spiny lobster fishery is provided in Amendment 8 to the FMP (CFMS, GMFMC, and SAFMC 2008) and is incorporated by reference herein.

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 nm 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). As a seismic and volcanic region, the Caribbean has a 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 nm wide at 100 m depth. 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 4,700 m deep. At its western extremity it communicates freely at depth of more than 5,000 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 7,680 m deep.

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.

3.3 Biological Environment

3.3.1 Lobster species

Family Palinuridae (Figure 3.3.1.1)

Figure 3.3.1.1. Photograph of the following lobster species from left to right: Caribbean spiny lobster, smoothtail spiny lobster, spotted spiny lobster.
Source: Photograph from FWC website.

Caribbean spiny lobster
This species is widely distributed throughout the western Atlantic Ocean as far north as North Carolina to as far south as Brazil including Bermuda, the Bahamas, Caribbean, and Central America (Herrnkind 1980; Figure 3.3.1.2). Analyses of DNA indicate a single stock structure for the Caribbean spiny lobster throughout its range (Lipcius and Cobb 1994; Silberman and Walsh 1994; Hunt et al. 2009). This species inhabits shallow waters, occasionally as deep as 295 ft (90 m), possibly even deeper. Caribbean spiny lobster can be found among rocks, on reefs, in grass beds or in any habitat that provides protection. The species is gregarious and migratory. Maximum total body length recorded is 18 in (45 cm), but the average total body length for this species is 8 in (20 cm; FAO Fisheries Synopsis 1991).

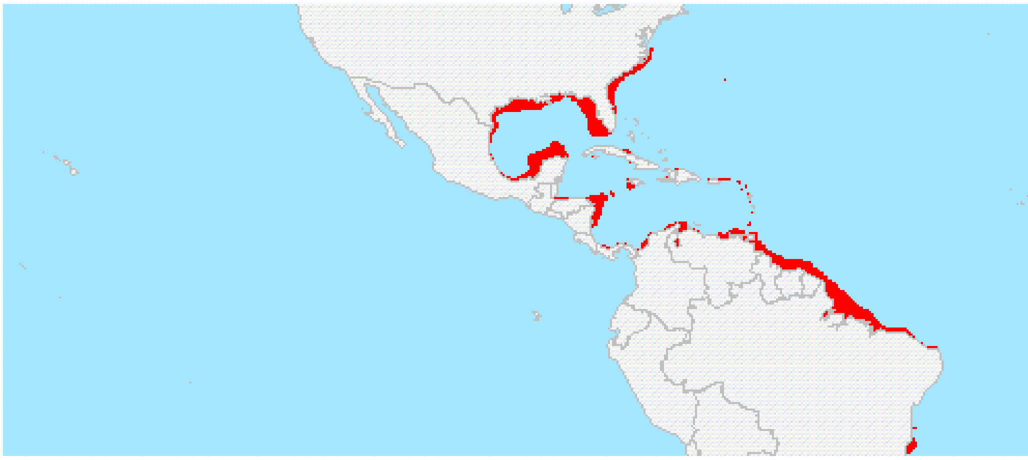


Figure 3.3.1.2. Distribution of Caribbean spiny lobster.
Source: FAO Fisheries Synopsis 1991; Joint CFMC-GMFMC-SAFMC Amendment 8 2008.

Distribution and dispersal of Caribbean spiny lobster 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, nearshore environments to grow and develop.

Young benthic stages of Caribbean spiny lobster 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 show 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 Hernkind 1985).

Individuals two to four years of age show 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).

Given the wide distribution of this species from Bermuda 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 their range. The long duration that lobsters spend in the larval stage, traveling by the currents leads scientists to expect recruits in the U.S. come from many other areas (Hunt et al. 2009).

Silberman et al. (1994) and Hunt et al. (2009) concluded Caribbean spiny lobster is a single stock from Brazil to Bermuda, and throughout the Caribbean. More recent genetic studies have shown almost all recruits in U.S. waters are from elsewhere in the Caribbean. However, studies have 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 Caribbean spiny lobster conforms to the typical decapod body plan consisting of five cephalic and eight thoracic segments fused together to form the cephalothorax (Figure 3.3.1.3). 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 et al. 1980). There are five pairs of walking legs called pereiopods (walking legs) 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).

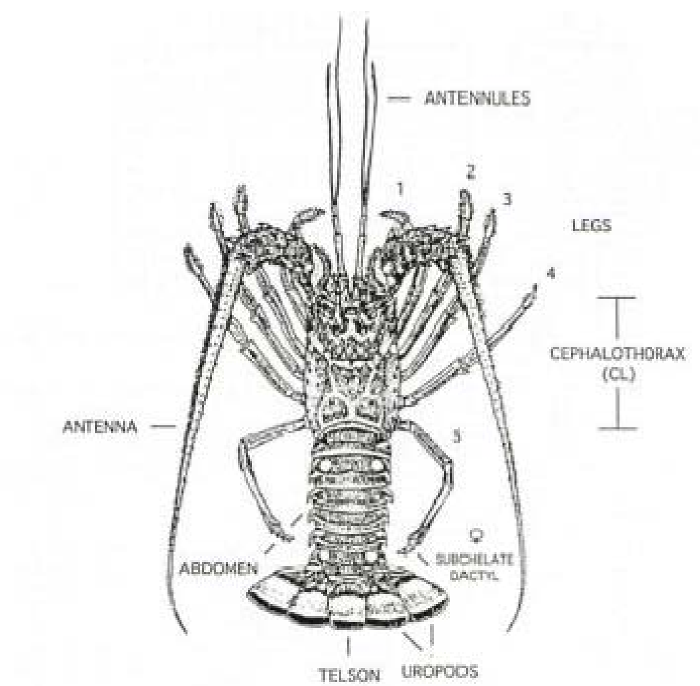


Figure 3.3.1.3. Morphology of Caribbean spiny lobsters.
Source: Lipcius and Cobb (1994).

Gills are the main organs used by lobsters for respiration. The rate of oxygen consumption 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 et al. 1980).

Food Habits
After Caribbean spiny lobster settle from the planktonic phase to the benthic habitat they enter 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.

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). Studies have found that the initiation of spawning is related to water temperature with an optimal water temperature for mating of 24^{o}C (Lyons et al. 1981). The gestation period for eggs is about a month.

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 (Maxwell et al. 2009).

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 (Figure 3.3.1.4). 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 1.4 in (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 2.4-2.8 in (60-70 mm) within about two years (Hernkind 1980). Once they reach about 2.8 in (70 mm) and begin to sexually mature, the young Caribbean spiny lobsters emigrate from the nursery to deeper offshore reef environments.

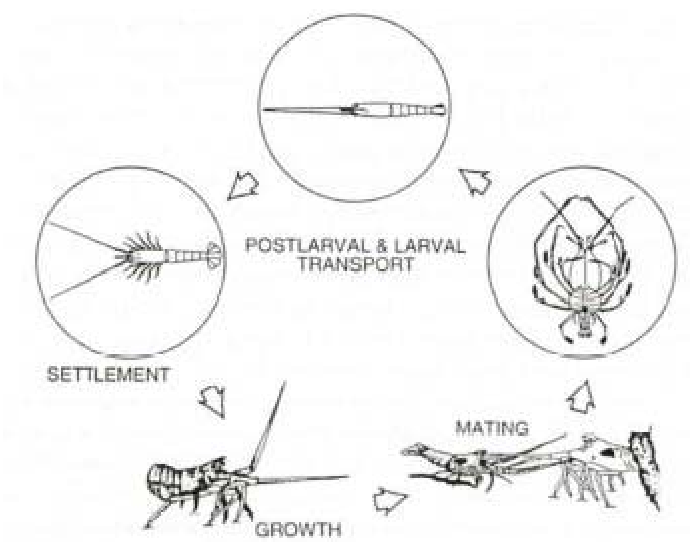


Figure 3.3.1.4. The life cycle of the Caribbean spiny lobster.
Source: Lipcius and Cobb (1994).

Physical growth of lobsters is achieved through molting (Figure 3.3.1.4). 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 inter-molt 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 Hernkind 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. Once molted, the lobster seeks immediate shelter, as they are especially vulnerable until their new cuticle becomes hardened (Lipcius and Hernkind 1982). Adult lobsters molt on 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 28th 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 Caribbean spiny lobster will display maximal feeding, foraging and locomotor activity rates to accommodate for the active tissue growth that occurs (Lipcius and Hernkind 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 catchability of spiny lobster is expected before molting when foraging decreases and the lobster becomes less mobile (Lipcius and Hernkind 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. However, the 2010 Update Assessment for Spiny Lobster SEDAR 8, estimated growth from two sources: tag returns and rate of accumulation of eye stalk lipofuscin (Maxwell et al. 2007). The lipofuscin technique has potential to provide ages, but in this case the aging was based on 51 laboratory-raised spiny lobsters that spanned only four years. In addition the sources of variability in lipofuscin concentrations may differ based on sex and habitat type of spiny lobsters. For example, female lobsters had lower lipofuscin concentrations than did males of the same age, and animals from the Dry Tortugas had lower concentrations than did lobsters from the Florida Keys. Natural mortality rates for Caribbean spiny lobster populations have been difficult to isolate from fished rates of mortality. In the 2010 Update Assessment, natural morality was modeled at 0.34 per year, which was between the Data Workshop and Assessment Workshop conclusions ranging between 0.3 and 0.4 per year. There currently is no information available on natural mortality on post-larvae (2010 Update Assessment).

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). Caribbean spiny lobster patterns of movement fall into the following categories: homing, nomadism, and migration. Throughout most of their life, Caribbean spiny lobster is a shelter-dweller during the day and forager at night. Evening movements within the home range are directed; lobsters are aware of their location 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 are inactive during the migration in the fall, and don't begin to mature until the late winter (Herrnkind 1985).

The first autumn storm in the tropics usually brings a drop in water temperature of about 5°C, 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 54-57 ºF (12-14 ºC); molting individuals usually perish under these conditions. According to Herrnkind (1985), the behavioral changes observed in Caribbean spiny lobster 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. 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 19-31 statute miles (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 to avoid overcrowding of shelters at their final destination (Kanciruk and Herrnkind 1978). After individuals reach sheltered habitats located in deeper water, such as a deep reef site, the migratory queuing behavior ends and the lobsters disperse.

<u>Other Species in the Family Palinuridae</u>

The spotted spiny lobster range includes the western Atlantic, Bermuda, Bahamas, South Florida, Belize, Panama, and Venezuela, as well as the Caribbean from Cuba to Trinidad, Curacao, and Bonaire (Figure 3.3.1.5). This species prefers shallow water and inhabits rocky areas, mainly in crevices. Maximum total body length recorded is 8 in (20 cm), but the average total body length for this species is 6 in (15 cm; FAO Fisheries Synopsis 1991). This species is occasionally caught in traps typically set for other species, such as the Caribbean spiny lobster (FAO Fisheries Synopsis 1991).

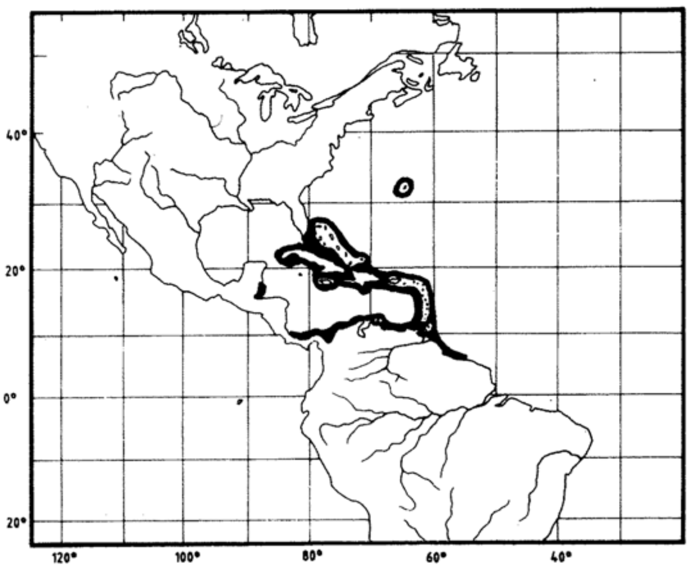


Figure 3.3.1.5. Distribution of spotted spiny lobster.
Source: FAO Fisheries Synopsis (1991).

The smoothtail spiny lobster range includes the western Atlantic, Bermuda, South Florida, down into Brazil, as well as Central America, and the Caribbean (Figure 3.3.1.6). This species is found in coastal waters, as deep as 164 ft (50 m) and prefers rock or coral reef substrate as habitat. Maximum total body length recorded is 12 in (31 cm), but the average total body length for this species is 8 in (20 cm). Sometimes smoothtail spiny lobsters are taken together with Caribbean spiny lobster. The largest yield for this species is in Brazil (FAO Fisheries Synopsis 1991).

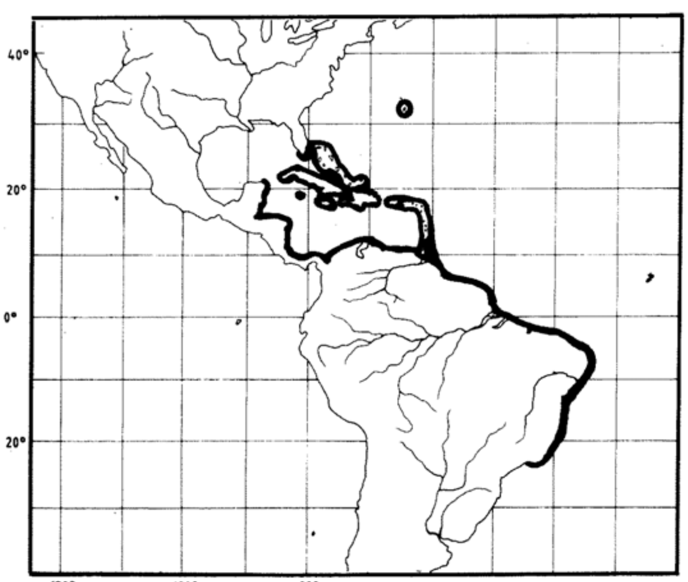


Figure 3.3.1.6. Distribution of smoothtail spiny lobster.
Source: FAO Fisheries Synopsis (1991).

Family Scyllaridae

Spanish slipper lobsters are distributed in the western Atlantic Ocean, as far north as South Carolina down to Brazil including Bermuda, the Gulf of Mexico, and the Caribbean (Figure 3.3.1.7). This species depth distribution ranges from 2 to 591 ft (0.6 to 180 m), usually between 2 to 210 ft (0.6 and 64 m). This species preferred habitat is sand or rocks, often on high-relief coral reefs in crevices (FAO Fisheries Synopsis 1991; Sharp et al. 2007). The animals are sluggish and nocturnal and feed on algae and detritus. They bury themselves in the sand. Maximum total body length recorded is 12 in (31 cm), but average carapace length is 5 in (12 cm; FAO Fisheries Synopsis 1991; Sharp et al. 2007).

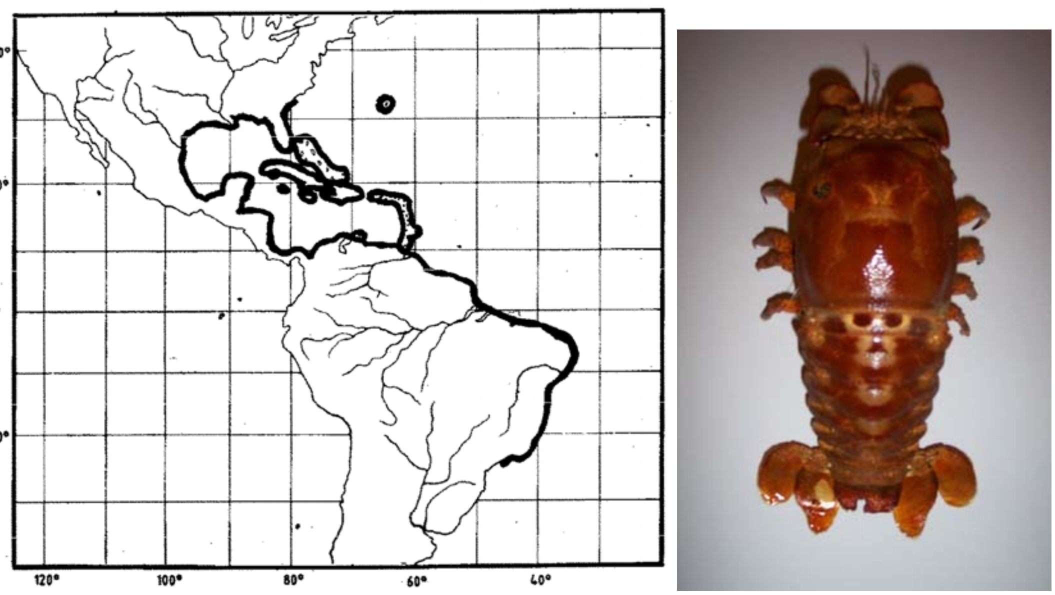


Figure 3.3.1.7. Distribution and photograph of Spanish slipper lobsters.
Source: FAO Fisheries Synopsis (1991); Photograph by J. Hunt (2009).

Ridged slipper lobsters are distributed throughout the western Atlantic Ocean, south of Cape Lookout, North Carolina, Bermuda, and the entire Gulf of Mexico (Figure 3.3.1.8). This species is typically found in the Florida Keys and Dry Tortugas (FAO Fisheries Synopsis 1991). Ridged slipper lobster depth distribution ranges between 6.5 to 299 ft (2 and 91 m) and they prefer sandy substrate, sometimes mixed with mud, shell, or corals. They are often found on low-relief coral reefs and bury themselves in sediments during daylight hours (Sharp et al. 2007). Maximum total body length recorded is 14 in (35 cm), but average carapace length is 4.3 in (11 cm; FAO Fisheries Synopsis 1991; Sharp et al. 2007).

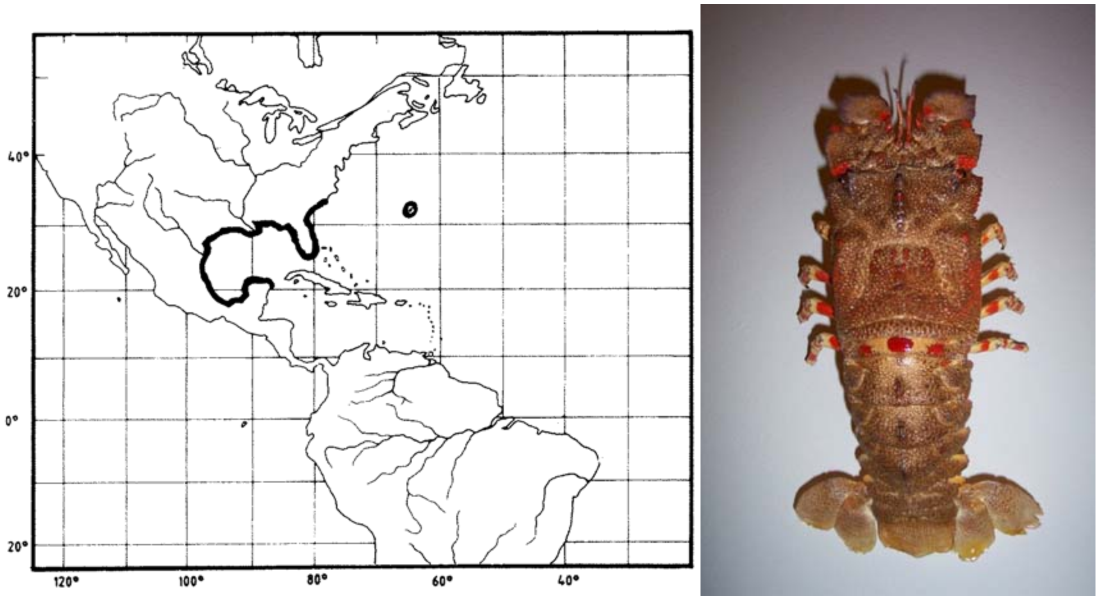


Figure 3.3.1.8. Distribution and photograph of ridged slipper lobster.
Source: FAO Fisheries Synopsis (1991); Photograph by J. Hunt (2009).

3.3.2 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 Marine Mammals Protection Act (MMPA) and six are also listed as endangered under the Endangered Species Act (ESA) (i.e., sperm, sei, fin, blue, humpback and North Atlantic right whales). From 2002-2009, two bottlenose dolphins were entangled in what was likely Caribbean spiny lobster trap gear. During that period, an additional eight bottlenose dolphins in Florida were discovered with entangling trap/pot. The type of gear could not be definitively linked to a target species or specific fishery. No direct interactions between ESA-listed marine mammals and the Caribbean spiny lobster fishery have ever been documented.

Other species protected under the ESA occurring in the Gulf, 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.

ESA-Listed Sea Turtles

The following sections are a brief overview of the general life history characteristics of the sea turtles found in the Gulf and South Atlantic region. Several volumes exist that cover more thoroughly the biology and ecology of these species (i.e., Lutz and Musick 1997; Lutz et al. 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 (Bjorndal 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 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 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, 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 692-764 ft (211 to 233 m; 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).

ESA-Listed Marine Fish

The historical range of the smalltooth sawfish in the U.S. was 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. 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 m (Simpfendorfer pers. comm.). 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 1938; Bigelow and Schroeder 1953).

ESA-Listed Marine Invertebrates

Acropora spp. (Figure 3.3.2.1) 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.

A B

Figure 3.3.2.1 *Acropora* species. A. Elkhorn Coral (*Acropora palmata*). B. Staghorn Coral (*A. cervicornis*).
Photo Credit: W. Jaap

Elkhorn and staghorn corals are two of the major reef-building corals in the wider Caribbean. In the Gulf, 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. The depth range for these species is from less than 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* spp. 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 25-29°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* spp. are much more susceptible to increases in water turbidity than some other coral species.

Fertilization and development of *Acropora* spp. 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, *Acropora* spp. 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 *Acropora* spp. indicated that larger colonies of both species[5] had higher fertility rates than smaller colonies (Soong and Lang 1992).

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[5] As measured by surface area of the live colony

3.4 Economic Environment

3.4.1 Commercial Fishery

Commercial fishing for Caribbean spiny lobster in Florida has been affected by sharply lower prices in the last two years and by landings that have been the lowest since the early 1960's (Figure 3.4.1.1, Table 3.4.1.1; Vondruska 2010a). Decreased landings are likely due to the increased cost of fuel and decreased prices are likely due to the depressed economy in recent years. Ex-vessel prices decreased sharply to $3.30/lb (ww) in 2009/2010, compared with the 22-year high of $7.94/lb for two years earlier. Based on five-year averages for 1987/1988-1991/1992 and 2005/2006-2009/2010, fishing effort is now much lower than it was (Table 3.4.1.1; Figure 3.4.2.2; Vondruska 2010a):

1) The number of vessels declined from 2,175 to 781 per year.
2) The number of trips declined from 39,086 to 15,568 per year.
3) The number of hours fished declined from 493,211 to 234,292 per year.
4) The number of traps fished on all trips declined from 8.65 to 4.24 million (including duplication, because individual traps are usually fished on more than one trip, unless lost or damaged).
5) Vessel-based estimates for the number of "traps that could be fished" declined from 704,580 to 368,106 traps (excluding duplication attributable to the use of individual traps on multiple trips). The number of traps that could be fished is a proxy for the number of traps licensed to fish for spiny lobster. The number peaked in 1991/1992 at 814,864 traps.

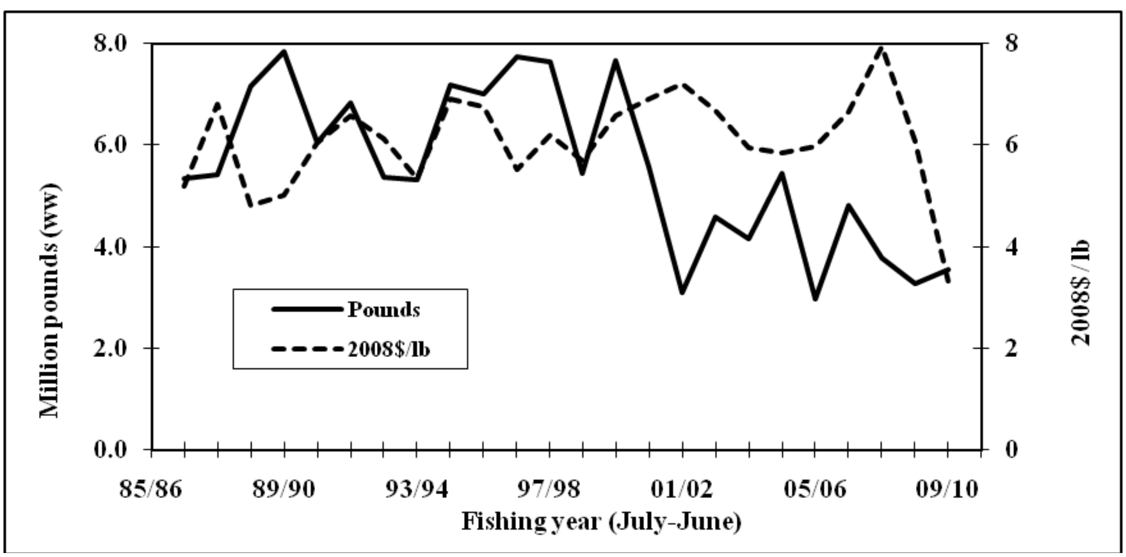

Figure 3.4.1.1 Commercial Florida landings and ex-vessel prices for Caribbean spiny lobster.
Source: FTT data as of Mar 19, 2010 (Vondruska 2010a).

Economic conditions would have been worse without long-term reductions in fishing effort and consequent increases in vessel and trip productivity. Average vessel and trip landings have exhibited flat to upward trends since the early-1990s (Figure 3.4.1.3; Table 3.4.1.1).

Initially, the number of trap certificates was reduced in steps, from 944,000 in 1992 to 543,000 by 1999. Given a decade or so of fisher experience with the program, Shivlani et al. (2004) conducted a survey of fishers and analyzed the economic and social conditions at the fisher level and fisher attitudes about the program. Today, reductions in the total number of certificates occur routinely if certificates are transferred and/or revert to the state because the owner does not pay requisite annual fees for three years. Besides the TCP, other factors have affected commercial fishing for spiny lobster in Florida, such as gentrification, state and local regulations on the storage of traps, and availability and access to docks and dealers.

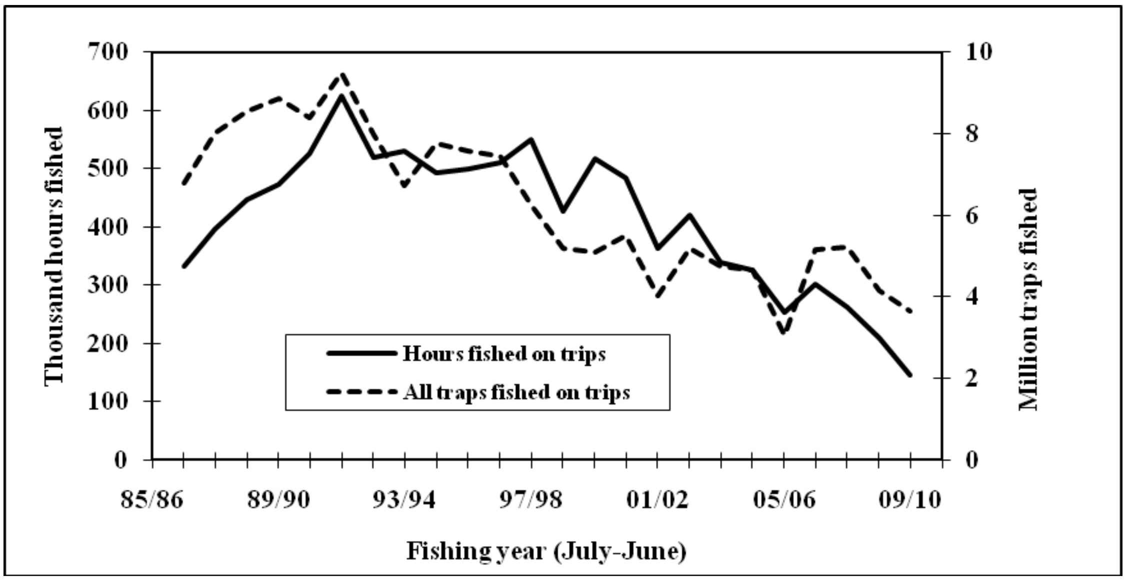

Figure 3.4.1.2 Commercial fishing for Caribbean spiny lobster in Florida, hours and traps fished.
Source: FTT data as of Mar 19, 2010 (Vondruska 2010a).

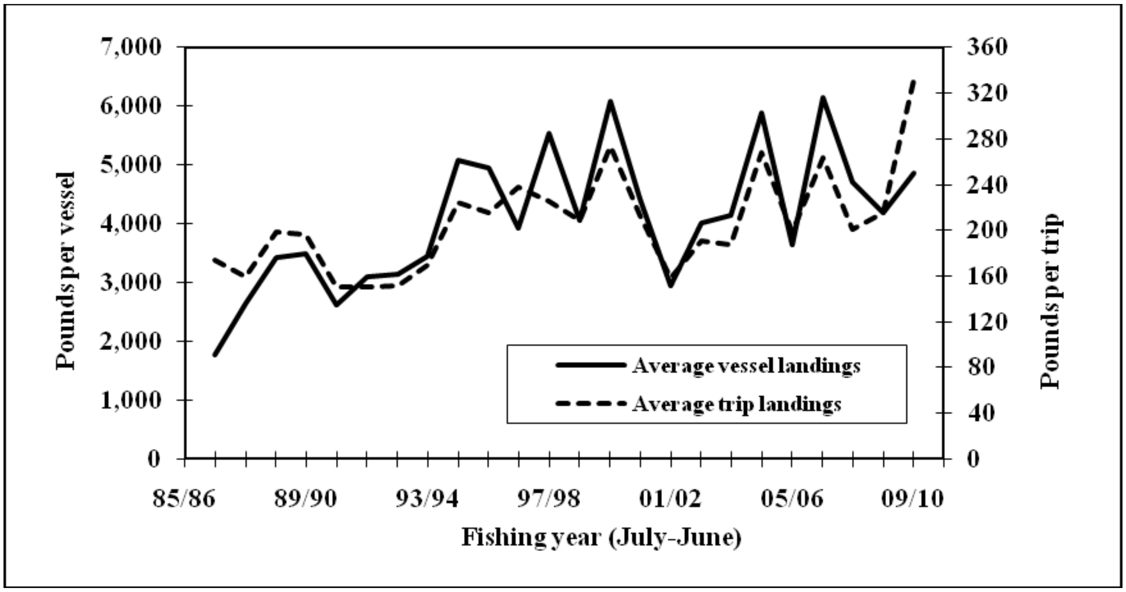

Figure 3.4.1.3 Commercial fishing for Caribbean spiny lobster in Florida, vessel and trip landings.

Source: FTT data as of Mar 19, 2010 (Vondruska 2010a).

Table 3.4.1.1. Florida commercial fishing statistics for Caribbean spiny lobster.

Fishing year (July-June)	Landings (ww), Caribbean spiny lobster						
	Thousand pounds	Thousand 2008$	2008$ /lb	Vessels	Lbs / vessel	Trips	Lbs / trip
86/87	5,351	$27,786	$5.19		1,762	30,696	174
87/88	5,417	$36,833	$6.80	2,045	2,649	34,005	159
88/89	7,154	$34,327	$4.80	2,086	3,430	36,021	199
89/90	7,830	$39,229	$5.01	2,244	3,489	39,935	196
90/91	6,044	$36,523	$6.04	2,300	2,628	40,194	150
91/92	6,834	$45,018	$6.59	2,200	3,106	45,276	151
92/93	5,367	$32,804	$6.11	1,702	3,153	35,387	152
93/94	5,309	$28,362	$5.34	1,536	3,457	31,283	170
94/95	7,181	$49,553	$6.90	1,411	5,090	32,093	224
95/96	7,017	$47,295	$6.74	1,419	4,945	32,546	216
96/97	7,748	$42,675	$5.51	1,968	3,937	32,591	238
97/98	7,641	$47,373	$6.20	1,382	5,529	33,906	225
98/99	5,448	$30,980	$5.69	1,342	4,060	26,012	209
99/00	7,669	$50,402	$6.57	1,260	6,086	27,947	274
00/01	5,570	$38,391	$6.89	1,259	4,424	26,111	213
01/02	3,081	$22,186	$7.20	1,047	2,943	19,528	158
02/03	4,574	$30,529	$6.68	1,140	4,012	23,960	191
03/04	4,161	$24,773	$5.95	1,003	4,149	22,088	188
04/05	5,445	$31,799	$5.84	926	5,880	20,295	268
05/06	2,964	$17,666	$5.96	814	3,642	14,901	199
06/07	4,799	$31,913	$6.65	780	6,152	18,184	264
07/08	3,782	$30,025	$7.94	803	4,710	18,858	201
08/09	3,271	$19,836	$6.06	780	4,194	15,238	215
09/10	3,541	$11,695	$3.30	727	4,870	10,660	332
5-yr aver							
87/88-91/92	6,656	$38,386	$5.85	2,175	3,060	39,086	171
05/06-09/10	3,671	$22,227	$5.98	781	4,714	15,568	242

Source: FTT data as of Mar 19, 2010 (Vondruska 2010a).

Economic Impacts

Descriptions of the commercial fishery for Caribbean spiny lobster are contained in Vondruska (2010a), Vondruska (2010b), and CFMC (2008) and are incorporated herein by reference. Select summary statistics for the commercial fishery are provided in Table 3.4.1.2, and estimates of economic impacts (economic activity) are provided in Table 3.4.1.3.

Estimates of the average annual economic activity associated with the commercial Caribbean spiny lobster fishery were derived using the model developed for and applied in NMFS (2009) and are provided in Table 3.4.1.3. Business activity for the commercial sector is characterized in the form of full-time equivalent (FTE) jobs, income impacts (wages, salaries, and self-employed income), and output (sales) impacts (gross business sales). Income impacts should not be added to output (sales) impacts because this would result in double counting.

Table 3.4.1.2. Five-year average performance statistics for the commercial sector of the Caribbean spiny lobster fishery.

	Vessels	Total Lobster Ex-vessel Value[2] (millions)	Total All Species Ex-vessel Value[2] (millions)	Average Ex-vessel Value per Vessel
2005-2010 Average[1]	781	$22,227	$23,399	$29,960

[1]Fishing-year (2005/2006, 2006/2007, 2009/2010).
[2]2008 dollars.
Source: Florida Trip Ticket System and NMFS SEFSC Accumulated Landings System.

Table 3.4.1.3. Average annual economic activity associated with the Caribbean spiny lobster fishery.

Species	Average Ex-vessel Value[1] (millions)	Total Jobs	Harvester Jobs	Output (Sales) Impacts (millions)	Income Impacts (millions)
Spiny Lobster	$22.23	4,223	580	$293,188	$125,382
- All Species[2]	$23.40	4,445	611	$308,647	$131,993

[1]2008 dollars.
[2]Ex-vessel revenues and economic activity associated with the harvests of all species harvested by vessels that harvested spiny lobster.

As noted in Table 3.4.1.3, the annual period refers to the fishing year, as appropriate to the management of the species. The estimates of economic activity include the direct effects (effects in the sector where an expenditure is actually made), indirect effects (effects in sectors providing goods and services to directly affected sectors), and induced effects (effects induced by the personal consumption expenditures of employees in the direct and indirectly affected sectors). Estimates are provided for the economic activity associated with the ex-vessel revenues from Caribbean spiny lobster as well as the revenues from all species harvested by these same vessels.

Permits

There are two kinds of federal commercial permits for fishing for spiny lobster in the EEZ, one of which allows possessing and landing whole lobster, while the other allows possessing and landing tails. The number of vessels with federal spiny lobster permits averaged 200 in the last five calendar years, while the number of vessels with federal tailing permits averaged 454, with most having home ports in Florida. The distribution of permitted vessels by "home-port" state in Table 3.4.1.4 differs from what might be expected based on commercial landings and effort data.

Table 3.4.1.4 Number of federal permits for fishing for Caribbean spiny lobster in the EEZ.
LC=federal lobster permits, LT=federal lobster tailing permits.

State	Spiny lobster (LC permits)						Spiny lobster tailing (LT permits)					
	2005	2006	2007	2008	2009	Total	2005	2006	2007	2008	2009	Total
AL	1	2	7	9	10	29	8	7	11	12	12	50
FL	153	139	151	179	195	817	407	390	385	381	376	1,939
GA	2	2	5	6	6	21	5	5	7	7	9	33
LA	3	1		1	1	6	2	1	1	2	1	7
MA	5	5	3	3	3	19	3	3	3	4	4	17
MS					1	1			1	1	2	4
NC	6	6	9	17	29	67	10	16	24	31	39	120
NJ	1	2	2	3	3	11	3	4	4	4	4	19
NY			1	1	1	3	1	1	1	1	2	6
PA							1	1	1	1	1	5
SC				1	2	3	4	4	1	5	13	27
TX		1	1	1	2	5	11	11	3	2	2	29
VA	1	1	5	5	5	17	1	1	5	4	5	16
Total	172	159	184	226	258	999	456	444	447	455	470	2,272

Source: NMFS, SERO, Permits Office, Feb, 3, 2011. State refers to a vessel's home port state, which is not necessarily the state in which its landings may occur.

Virtually all commercial landings of Caribbean spiny lobster occur in Florida, with landings in other states being relatively low since 1977 (see Section 3.1). During the last five fishing years, an average of 781 vessels commercially landed 3.671 mp (ww) per year in Florida, including 3.282 mp in Monroe County, and 0.670 mp from the EEZ (Tables 3.4.1.1 and 4.9.2.1). It is estimated that an annual average of 34.8 vessels in the last five years landed 0.025 mp (ww) of Carribean spiny lobster tails in Florida, with landings of 0.057 mp (ww) for whole lobster and tails for the same trips (Table 4.8.2.1, see footnote on methodology).

The estimated number of vessels with landings of tails, 34.8 vessels, is much lower than the number with permits to do so, 454 vessels (388 vessels in Florida) (Tables 4.8.2.1 and 3.1.3.3). The reasons are not known. Perhaps commercial fishing vessel operators obtain tailing permits along with other federal permits as a low-cost precaution, should the happen to need to retain tails onboard. Perhaps, a loophole in federal and state regulations may have allowed an unknown number of tailing permits be held by for-hire fishing vessels, other for-hire vessels, and/or private recreational vessels. This loophole would be removed under Action 8, Preferred Alternative 3. Current FWC methods for collecting data on recreational landings of spiny lobster do not provide data on the effort, catch, and landings of tailed spiny lobsters (R. Muller, FWC, pers. comm.). It is noted that for Monroe County, the number of recreational vessels registered increased from 4,000 in 1971 to 23,340 in 2000, and to 25,370 in 2007 and that the number of commercial fishing vessels declined by 17.3% to 2,653 between 2007 and 2008 (Shivlani 2009). Not all for-hire fishing vessels, other for-hire vessels, and private recreational vessels engage in fishing, but those that do could account for some federal spiny lobster tailing permits for fishing in the EEZ.

3.4.2 Recreational Fishery

Number and Description of Recreational Fishers

From the 1990/1991 to 1994/1995 seasons, an average of 110,000 persons purchased a Florida crawfish permit. Sharp et al. (2005) estimated that the number of permit holders that fished during the special two-day sport season from 1993 through 2002 ranged from approximately 32,500 to approximately 57,000 and that the number permit holders that fished at some time during the first month of the regular season ranged from approximately 49,000 to 78,000 over those same years.

The FWC included a socioeconomic component in its 1992 recreational lobster survey. Recreational fishers were asked how much they would be willing to pay to avoid a decrease in the bag limits and how much they would be willing to pay to have an increase in the bag limits. The least they were willing to pay to avoid the bag limits was $0.94 per lobster (in 1992 dollars) and to increase the bag limits was $0.37 per lobster (in 1992 dollars).

Because fewer people actually fish than have saltwater fishing licenses and permits to do so, the numbers of permits in Table 3.4.2.1 provide upper-end approximations for the potential number of recreational fishers for spiny lobster from 1995/1996 through 2009/2010. The number of permits may suggest an upward trend in recreational fishing activity, at least through 2007/2008, but landings and effort have been mostly lower in 2001/2002 onward than in the 1990s (landings, effort and CPUE in Figures 3.1.3.3 and 3.13.4; numbers of permits in Table 3.4.2.1). These indicators reflect weakened national economic conditions in the last two to three years. The status, numbers, and landings for SRCLs are discussed in Section 3.1.2 and Table 3.1.2.1.

Presently, the cost of a resident Florida saltwater fishing license is $17.00, which is valid for one year but does not include lobster fishing privileges ($79 for a five-year permit), and the cost of a resident lobster (crawfish) permit is $5.00 ($25.00 for a five-year permit; see http://myfwc.com/license/licpermit_swfishing.htm). The recreational lobster permit is required of all fishers 16 years and older, but not Florida residents who are 65 years or older. A permit is not required for recreational fishing in the EEZ.

Table 3.4.2.1. Number of valid Florida recreational fishing licenses/permits by fishing year.

Fishing year	Annual & 5-year Crawfish Permits	Sportsman Gold (Annual)	Military Gold (Annual)	Lifetime Sportsman	Lifetime Saltwater
95/96	112,627			1,772	654
96/97	120,651			1,838	824
97/98	139,553			939	1,012
98/99	130,812			1,096	1,237
99/00	135,146			1,253	1,493
00/01	137,219			1,417	1,735
01-02	128,256			1,597	2,000
02/03	123,003	8,370		1,826	2,319
03/04	136,163	15,007		2,097	2,626
04/05	130,358	17,874		2,352	2,962
05/06	136,888	20,075	6,556	2,708	3,320
06/07	143,362	21,643	7,425	3,049	3,784
07/08	146,988	20,597	8,849	3,158	4,258
08/09	141,876	19,384	10,996	3,530	5,010
09/10	129,865	15,283	10,805	3,941	6,001

*Data for 09/10, as of July 2010. Note: Annual data for those licenses that give the owner recreational lobster fishing privileges under lifetime and five-year permits are cumulative. The Lifetime Sportsman and Lifetime Saltwater Permit values do not include those older than 64 or younger than 16 years of age.
Source: W. Sharp, FWC, pers. comm.

Charter-fishing vessels may take 25-30 divers per trip, with perhaps three trips per day (R. Muller, FWC, pers. comm.). Charter-fishing vessel fulfill Florida requirements for paying passengers who fish for lobster, but without their own licenses and permits.

Economic Impacts

The recreational spiny lobster fishery is very important to Monroe County. In 2001, additional socio-economic questions were added on to the annual survey. Almost 230 thousand (229,395) person-days of recreational lobster fishing occurred that year in Monroe County. Of those person-days, approximately 75% (171,127) were during the regular season, and the remaining 58,268 person-days (25%) were during the two-day sport season. Approximately 79% of those person-days (180,123) were attributed to visitors of Monroe County and the remaining 21% (49,272 person-days) to residents (Table 3.4.2.2).

Table 3.4.2.2. Average Expenditures per Person-Day in 2001.

Season	Person Days		Ave. Exp. Per Person-Day		Total Expenditures (2001 Dollars)		
	Resident	Visitor	Resident	Visitor	Resident	Visitor	Total
Two-Day	12,306	45,962	$33.99	$129.41	418,281	5,947,942	6,366,223
Regular	36,966	134,161	$42.83	$122.35	1,583,254	16,414,598	17,997,852
Total	49,272	180,123	$40.61	$124.15	2,000,936	22,362,270	24,363,206

Source: Sharp et al. 2005.

Visitors spend substantially more per person-day than residents of Monroe County, and visitors spend slightly more during the two-day sport season than regular season (Table 3.4.2.2). 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%) of the total monies spent on recreational lobster fishing in the Keys.

3.5 Social Environment

The demographic description of the social environment is presented primarily at the county level for south Florida counties and will include a brief discussion of the communities within in those counties that are most reliant upon spiny lobster, both commercially and recreationally. The focus on south Florida is due to the nature of the fishery which is prosecuted primarily in Miami-Dade and Monroe Counties. Communities chosen for more detailed description were chosen based upon their ranking within what is called their "regional quota" (rq) the proportion of landings and value of community landings out of total landings for the region. Those communities where their "rq" was very low were not considered for further description. This excluded communities from other states as their landings were well below the top fifteen communities which is further evidence of a highly localized fishery.

Utilizing demographic data at the county level will allow for updated statistics from the Census Bureau, which produces estimates for geographies (counties; minor civil divisions; census designated places, etc.) that are larger than 20,000 prior to the decennial census.[6] Estimates for smaller geographies were not available at this time. Because employment opportunities often occur within a wider geographic boundary than just the community level, a discussion of various demographics within the county is appropriate and will be used to address environmental justice concerns. A more detailed description of environmental justice concerns will be at the end of this section. The county descriptions will correspond with recent research that was also conducted at the county level concerning social vulnerability and is described below.

The county-level description will focus primarily on the demographic character while fishing activity at the community level will be described where needed. A brief discussion of coastal growth and development that seems to affect many coastal communities, especially those with

[6] American Community Survey estimates are based on data collected over a three year time period. The estimates represent the average characteristics of population and housing between January 2006 and December 2008 and do not represent a single point in time. Because these data are collected over three years, they include estimates for geographic areas with populations of 20,000 or more.

either or both commercial and recreational working waterfronts that might be reflected in those demographic statistics is also included. This is especially true for Monroe County which has very limited land area and has seen a steady rise in land values. Recent research on the Key's communities (Shivalani 2010) has described the problem of increasing land values and disappearance of working waterfronts, especially for communities like Key West. The rapid disappearance of these types of waterfronts has important implications as the disruption of various types of fishing-related businesses and employment affect fisheries overall. The process of "gentrification," which tends to push those of a lower socio-economic class out of traditional communities as property values and taxes rise, has become common along coastal areas of the U.S. and around the world. Working waterfronts tend to be displaced with development that is often stated as the "highest and best" use of waterfront property, but often is not associated with water-dependent occupations. However, with the continued removal of these types of businesses over time, the local economy becomes less diverse and more reliant on the service sector and recreational tourism. As home values increase, people within lower socio-economic strata find it difficult to live within these communities and eventually must move. Consequently they spend more time and expense commuting to work, if jobs continue to be available. Newer residents often have no association with the water-dependent employment and may see that type of work and its associated infrastructure as unappealing. They often do not see the linkage between those occupations and the aesthetics of the community that produced the initial appeal for many migrants. The demographic trends within counties can provide some indication as to whether these types of coastal change may be occurring if an unusually high rate of growth or change in the demographic character of the population is present. A rise in education levels, property values, fewer owner occupied properties and an increase in the median age can at times indicate a growing process of gentrification.

Although the most recent estimates of census data have been used here, many of the statistics related to the economic condition of counties or communities do not capture the recent downturn in the economy which may have significant impacts on current employment opportunities and business operations. Therefore, in the descriptions of both counties and communities, it should be understood that in terms of unemployment, the current conditions could be worse than indicated by the estimates used here. To be consistent, census data are used for the various demographic characteristics and as noted earlier are limited to the most recent estimates which are an average for 2006-2008. Other aspects of trade and market forces as a result of the economic downturn could also affect the business operations of vessels, dealers, wholesalers and retail seafood businesses for the commercial sector and charter services and other support services for the recreational fishery. These may not be reflected in the demographic profile provided here.

Marine Related Employment

Other county level tables provide summaries of marine related employment within the coastal counties of South Florida. These estimates provide the number of sole proprietors (# Prop) and the number of employed persons (# Emp) for various sectors associated with employment in the marine environment. These categories were chosen because the occupations that are represented within each sector often include fishing related activities or fishing related support activities. For instance, the sector entitled Scenic Water includes charter fishermen within the estimate. The sector Shipping includes various shipping containers that would be used by fish houses and others to handle seafood. While these estimates do not encompass all employment related to fishing and its support activities, it does provide some estimate of the amount of activity associated with employment related to both recreational and commercial fishing.

Social Vulnerability

In the map below, the counties in South Florida are shown with fishing communities identified in each. Each county has also been geocoded with regard to social vulnerability as measured by Social Vulnerability Index (SoVI). Those counties most vulnerable are shaded with light and darker red tones while those least vulnerable are shaded in lighter and darker blue tones. The yellow shading represents medium vulnerability. The Index was created by the Hazards Research Lab at the University of South Carolina (Cutter et al. 2003) to understand how places that are susceptible to coastal hazards might also exhibit vulnerabilities to social change or disruptions. These vulnerabilities may come in the form of high unemployment, high poverty rates, low education and other demographic characteristics. In fact, the SoVI is an index that consists of 32 different variables combined into one comprehensive index to measure social vulnerability. Although the SoVI was created to understand social vulnerability to coastal environmental hazards, it can also be interpreted as a general measure of vulnerability to other social disruptions, such as adverse regulatory change or manmade hazards. This does not mean that there will be adverse effects, only that there may be a potential for adverse effects under the right circumstances. Fishing communities in these vulnerable counties may have more difficulty adjusting to regulatory changes if those impacts affect employment or other critical social capital. At present, a social vulnerability index is being created for fishing communities in the Southeast region with more timely data (the SoVI uses 2000 census data). Until that index is completed, the SoVI will substitute at the county level for a measure of vulnerability for those communities that are within the boundaries of a particular coastal county. This concept is closely tied to environmental justice and the thresholds associated with that are addressed below.

Fishing Communities

The communities displayed in Figure 3.5.1 below represent a categorization of communities based upon their overall value of local commercial landings divided by the overall value of commercial landings. These data were assembled from the accumulated landings system which includes all species from both state and federal waters landed in 2008. All communities were ranked on this “regional quotient” and divided by those who were above the mean and those below. Those above the mean were then divided into thirds with the top tier classified as Primarily Involved in fishing; the second tier classified as Secondarily Involved; and the third classified as being Tangentially Involved. The communities included within the map were only those communities that were categorized as primarily or secondarily involved. This breakdown of fisheries involvement is similar to the how communities were categorized in the community profiling of South Atlantic fishing communities (Jepson et al. 2005). However, the categorization within the community profiles included other aspects associated with fishing such as infrastructure and other measures to determine a community’s status with regard to reliance upon fishing. While these communities represent all fishing, communities those that are more involved in the spiny lobster fishery are represented in more depth within their respective county description.

A further breakdown of community landings is provided for those communities which have substantial landings of spiny lobster as evidenced by their local quotient (lq) which is the amount of landings and value out of the total landings for the community. This provides an indication of how reliant a community may be on a particular species.

Although it is difficult to place recreational landings within a community, a table is provided below with recreational fishing communities that have been identified by their ranking on a number of criteria including number of charter permits per thousand population and recreational fishing infrastructure as listed under the Marine Recreational Information Program (MRIP) survey identified within each community. Because the recreational lobster fishery is such an important part of the Florida Keys economy, most every Keys community might be considered a recreational fishing community. This list of recreational fishing communities is not exhaustive and should be considered a guide to where substantial recreational fishing activity may take place.

Southern Florida Counties

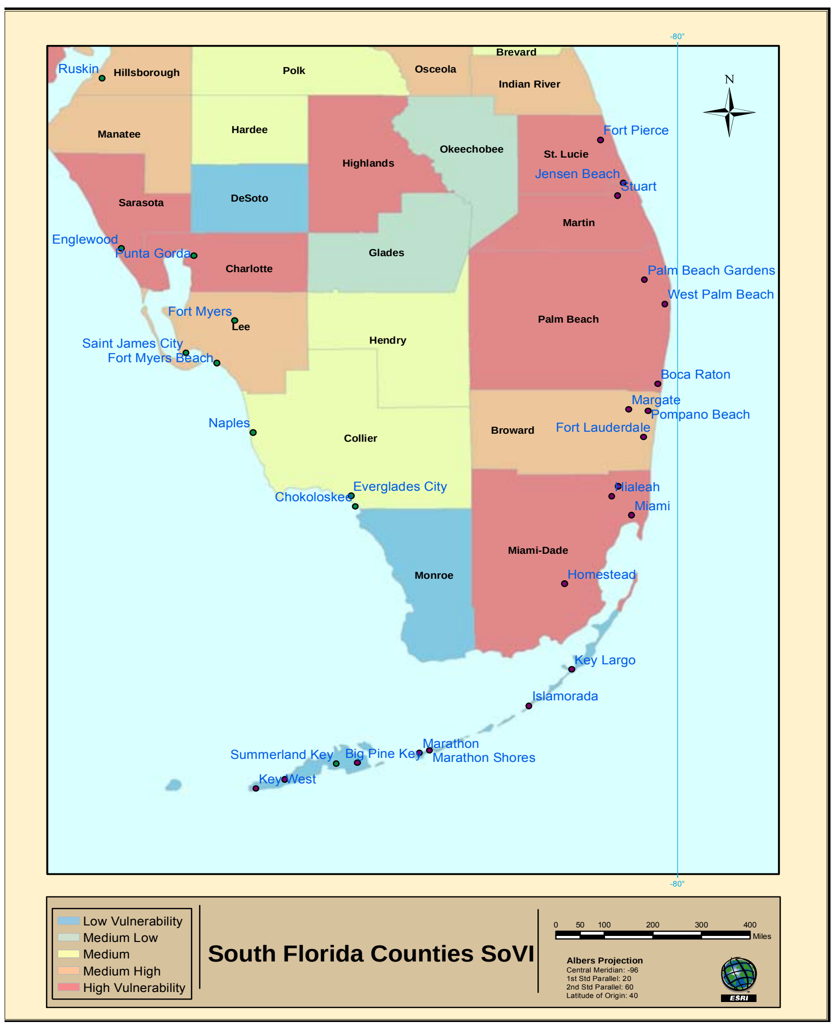

Figure 3.5.1. The Social Vulnerability Index applied to South Florida Counties.
Source: http://webra.cas.sc.edu/hvri/products/sovi.aspx#.

Table 3.5.1. Marine Related Employment for 2007 in South Florida Coastal Counties.

Florida County	Broward		Miami-Dade		Monroe		Palm Beach		Collier	
Sector	# Prop	# Emp	# Prop	# Emp	# Prop	# Emp	# Prop	# Emp	# Prop	# Emp
Boat Dealers	253	.	108	.	23	.	108	.	26	
Seafood Dealers	.	406	.	.	.	112	.	46		38
Seafood Harvesters	228	.	396	.	934	.	287	.	176	
Seafood Retail	28	291	79	.	7	7	18	57		14
Marinas	.	707	34	.	.	191	10	887		204
Processors	0	142	.	.	0	.	.	176		
Scenic Water	.	313	.	.	.	315	.	94		97
Ship Boat Builders	.	776	.	.	.	17	.	100		
Shipping Support	.	1557	.	.	.	67	.	756		7
Shipping		995	.	.	.	35		69		5

Source: Census Bureau 2010

Gulf Counties

Of those commuities in the Gulf with landings of Caribbean spiny lobster, Key West leads with over 50% of the pounds and close to 50% of the value of total Gulf landings or regional quota (rq) (Figure 3.5.2). Marathon is second with over 30% of both landings and value in the Gulf.

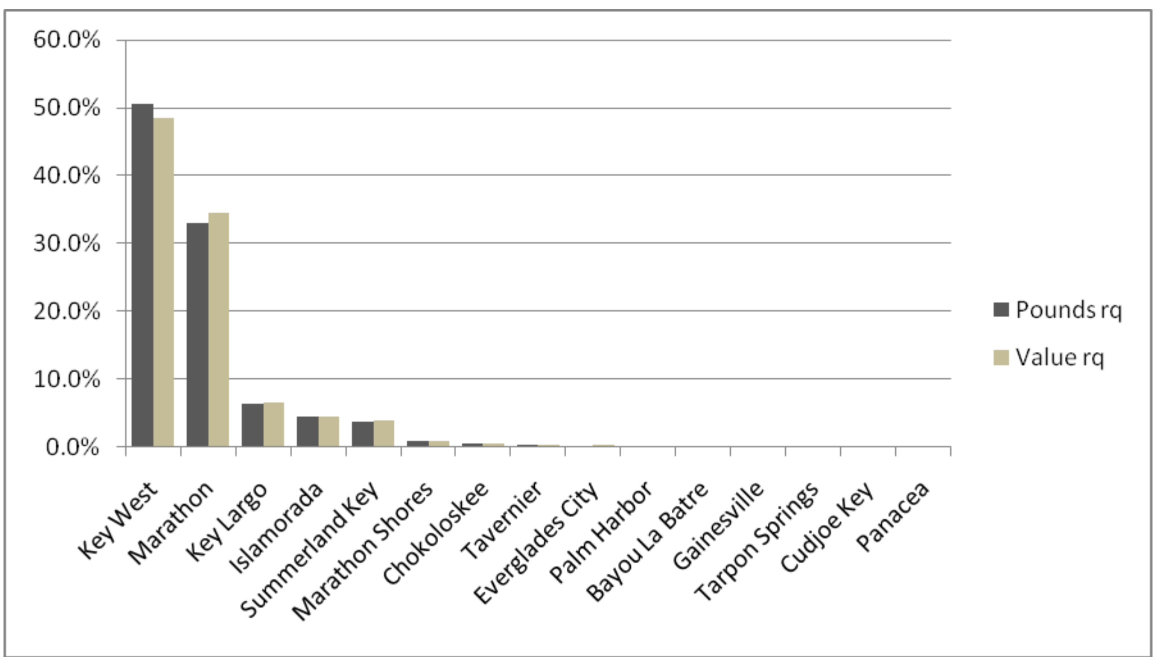

Figure 3.5.2. Proportion of spiny lobster commercial landings and value by total spiny lobster landings and value for Gulf Coast Communities.

Source: ALS 2008.

The next four communities have less than 10% each and are: Key Largo, Islamorada, Summerland Key and Marathon Shores. Chokoloskee and Everglades City in Collier County are the two highest landing communities on the mainland, both with less than 1% of the Gulf total. These communities are featured under their respective county descriptions.

Monroe County

Monroe County had a total population of 79,589 in 2000 that is estimated to have fallen to 74,397 by 2007. The majority of residents was identified as White (92.0%) in 2000 and was estimated to have dropped slightly to 90.4% in 2007. The Hispanic population has grown from 16.0 % in 2000 to 18.0% in 2007. Florida as a state had an estimated 77.8% White population and Hispanics made up 20.5% of its total population. The White alone population for the state was estimated to be 60.7% in 2007. The median age for residents of Monroe County was estimated to have been 47.2, which is slightly higher than it was in 2000 when it was 43.0. The median age for Florida was 38.7 in 2000 and was estimated to have increased to 40.1 by 2007 so Monroe County's median age is considerably older than the state as a whole. There was an estimated 2.8% of the population in the civilian force that was estimated to be unemployed in Monroe County, which was quite a bit lower than the state's unemployment rate of 6.4%. The percentage of persons below the poverty level was estimated at 10.1% which was below the 12.6% for the state as a whole during 2007. Monroe County had a slightly higher owner-occupied housing rate than the state with slightly over 71.2% of owner occupied housing to the state's 70.3% estimated for 2007 (U.S. Census Bureau).

Of the Monroe County communities, Key West is by far the leader in Caribbean spiny lobster landings as shown in Figure 3.5.2. Caribbean spiny lobster landings have by far more value than any other fishery or component fishery making up over 50% of total landings value for the community (Figure 3.5.3). Pink shrimp is second in value, but first in terms of pounds landed within the community.

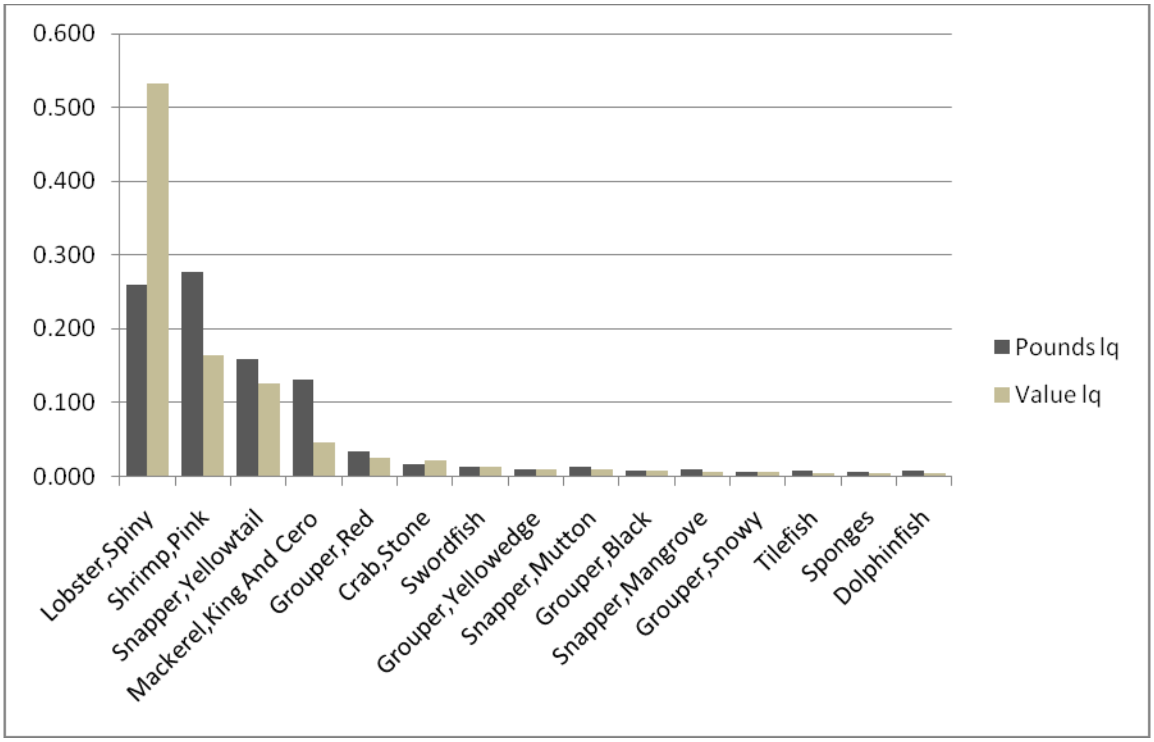

Figure 3.5.3. Proportion (lq) of landings and value for top fifteen species out of total landings and value for Key West, Florida.
Source: ALS 2008.

The community of Marathon has a significant amount of local quotient value derived from spiny lobster with over 60% of total landings value coming from Caribbean spiny lobster and 40% of landings in 2008 (Figure 3.5.4). Stone crab landing are almost equal to lobster, but value is far greater for spiny lobster.

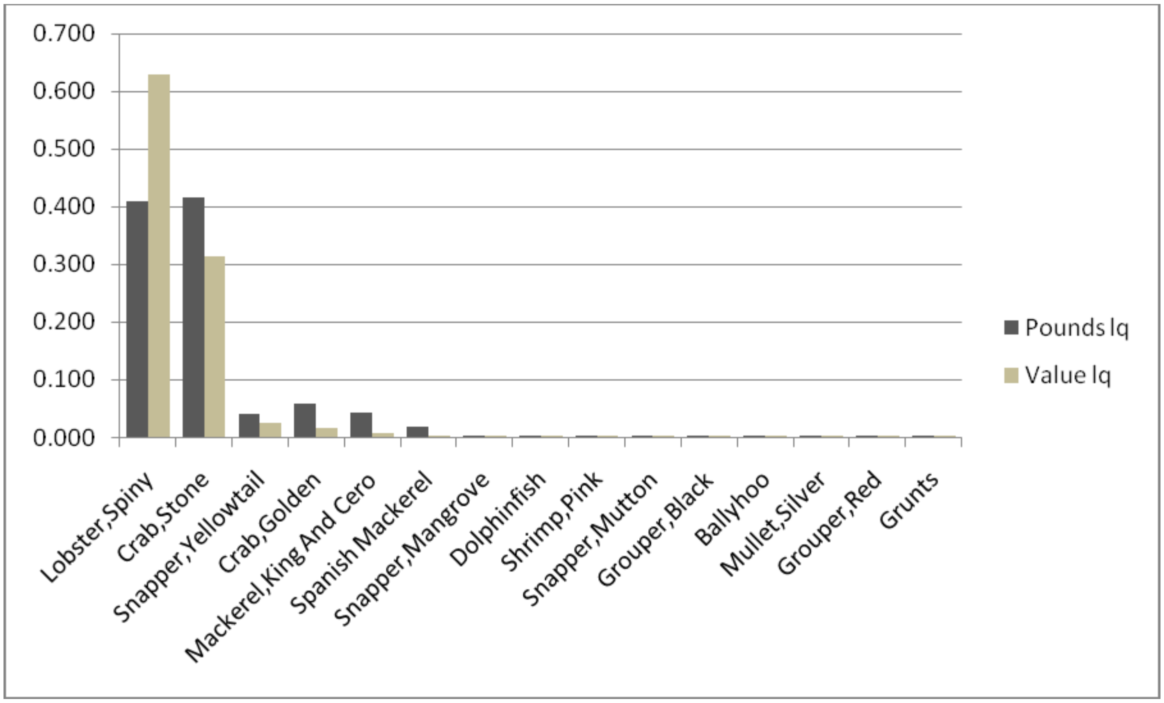

Figure 3.5.4. Proportion (lq) of landings and value for top fifteen species out of total landings and value for Marathon, Florida.
Source: ALS 2008.

The community of Key Largo also recieves considerable value from Caribbean spiny lobster with over 50% of the value from all landings coming from that species which comprises less than 20% of all landings (Figure 3.5.5).

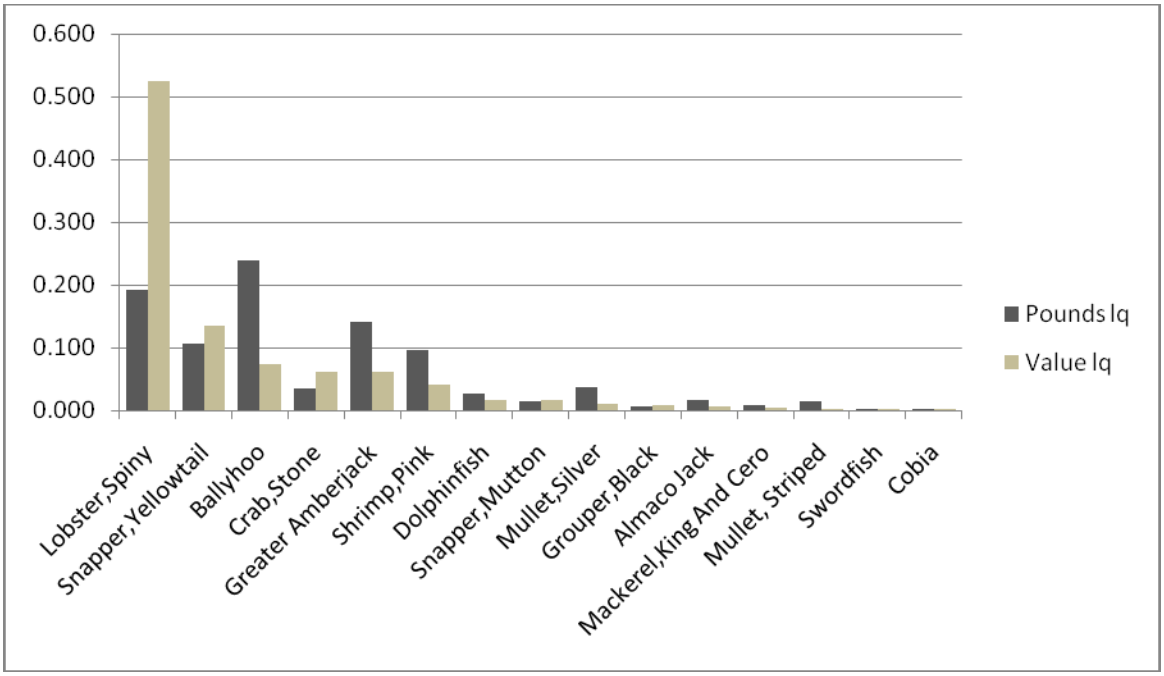

Figure 3.5.5. Proportion (lq) of landings and value for top fifteen species out of total landings and value for Key Largo, Florida.
Source: ALS 2008.

Islamorada also derives over 50% of all value from Caribbean spiny lobster landings while constituting only 20% of total landings for the community (Figure 3.5.6).

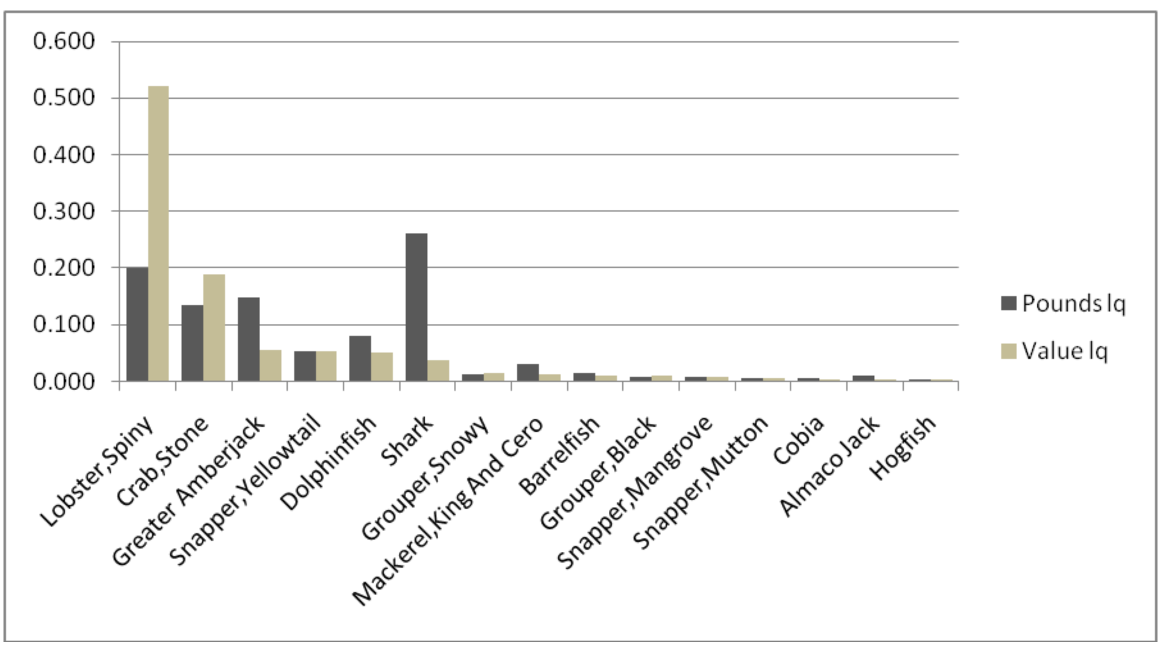

Figure 3.5.6. Proportion (lq) of landings and value for top fifteen species out of total landings and value for Islamorada, Florida.
Source: ALS 2008.

Summerland Key, also in Monroe County, has substantial landings and value from Caribbean spiny lobster. As depicted in Figure 3.5.7, spiny lobster accounts for over 60% of all landed value for the community and 40% of all landings. The next closest species is yellowtail snapper with just 10% of value and just under 20% of landings.

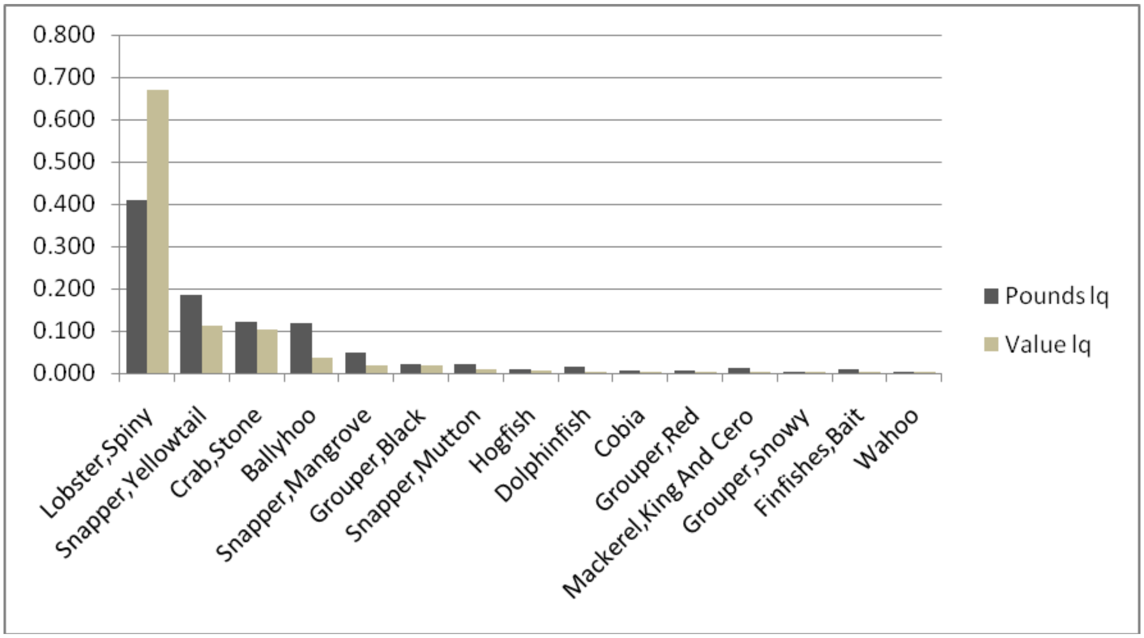

Figure 3.5.7. Proportion (lq) of landings and value for top fifteen species out of total landings and value for Summerland Key, Florida.
Source: ALS 2008.

<u>Collier County</u>
Collier County had a total population of 251,377 in 2000 that is estimated to have grown to 315,839 by 2007. The majority of residents (87.2%) were identified as White in 2007 and the Hispanic population was 25.1% in 2007, while Florida as a state had an estimated 77.8% White population and Hispanics made up 20.5% of its total population. The median age for residents of Collier County was estimated to have been 44.3 while the median age for Florida was 40.1 by 2007 so Collier County's median age is higher than the state as a whole. There was an estimated 5.3% of the population in the civilian force that was estimated to be unemployed in Collier County, which was slightly below the state's unemployment rate of 6.4%. The percentage of persons below the poverty level was estimated at 10.2% which was below the 12.6% for the state as a whole during 2007. Collier County had a higher owner occupied housing rate than the state with over 76.3% of owner occupied housing to the state's 70.3% estimated for 2007 (U.S. Census Bureau)

Of the communities in Collier County that have Caribbean spiny lobster landings, the two most active are Chokoloskee and Everglades City (Figures 3.5.8 and 3.5.9). Neither community derives substantial landings or value from spiny lobster, yet it is third in value for both communities. Landings and value in both communities is dominated by stone crab.

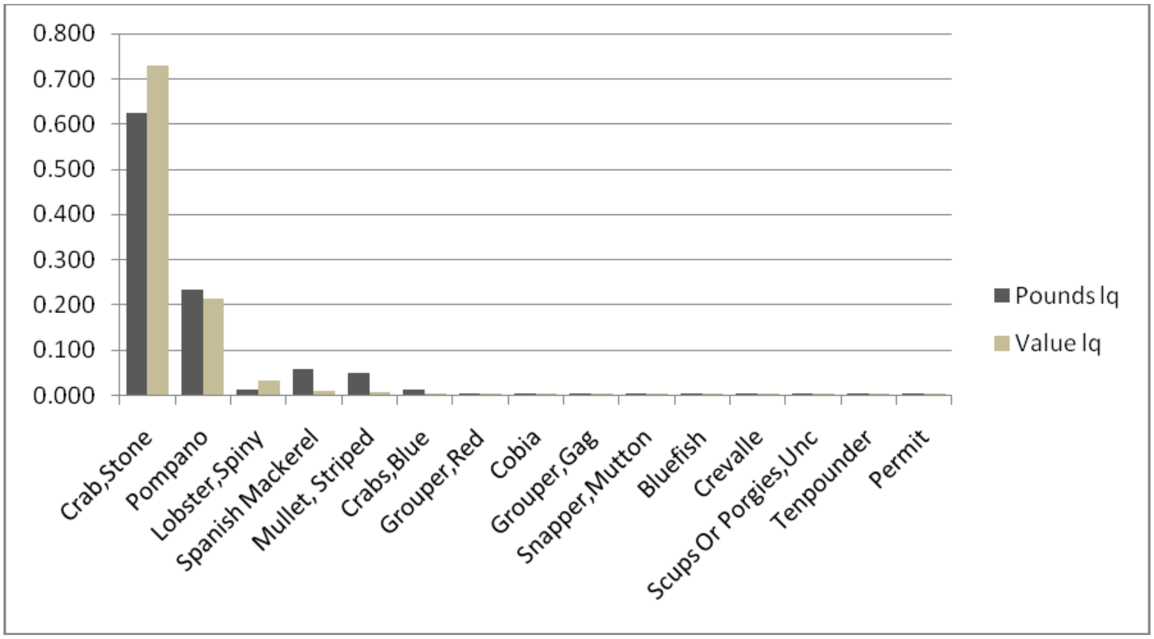

Figure 3.5.8. Proportion (lq) of landings and value for top fifteen species out of total landings and value for Everglades City, Florida.
Source: ALS 2008.

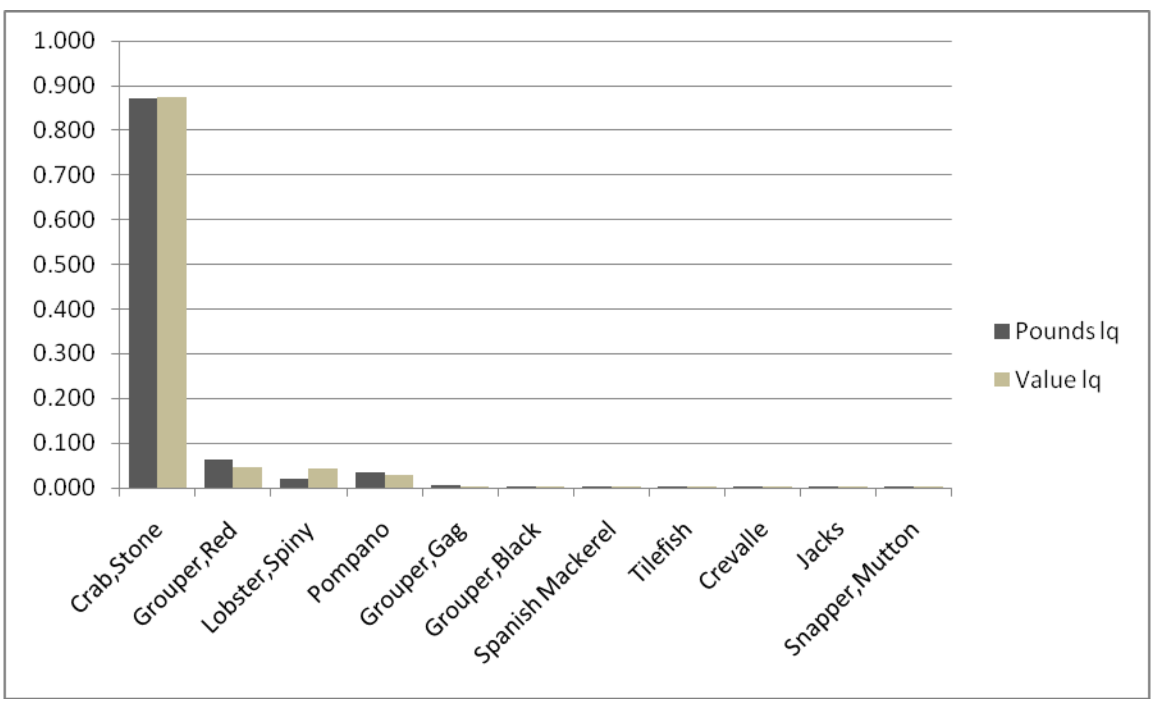

Figure 3.5.9. Proportion (lq) of landings and value for top fifteen species out of total landings and value for Chokoloskee, Florida.
Source: ALS 2008.

South Atlantic Counties

Of those commuities in the South Atlantic with landings of Caribbean spiny lobster, Miami has by far the most with over 75% of the pounds and value of total South Alantic landings (the Keys communities were included in the Gulf landings) (Figure 3.5.10). The next four communities have less than 10% each and are: Fort Lauderdale, North Miami, Palm Beach Gardens and Hialeah. These five communities are featured under their respective county descriptions.

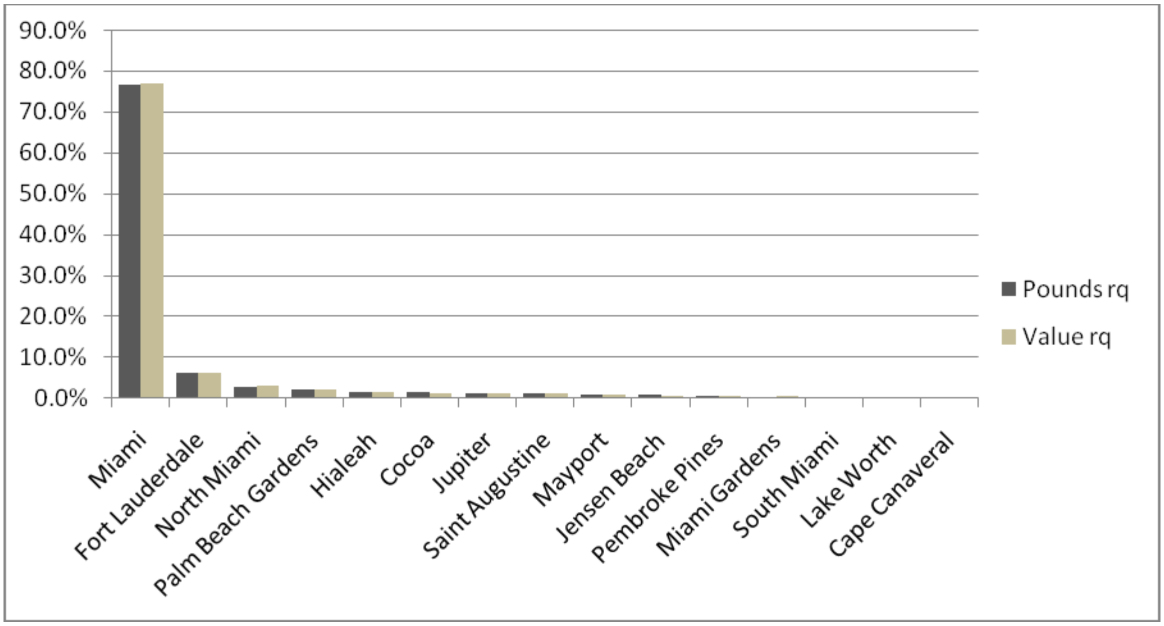

Figure 3.5.10. Proportion (rq) of spiny lobster commercial landings and value by total spiny lobster landings and value for South Atlantic communities.
Source: ALS 2008.

Palm Beach County

Palm Beach County had a total population of 1,131,191 in 2000 that is estimated to have grown to 1,754,846 by 2007. The majority of residents (75.6%) were identified as White in 2007 and the Hispanic population was 17.3% in 2007, while Florida as a state had an estimated 77.8% White population and Hispanics made up 20.5% of its total population. The median age for residents of Palm Beach County was estimated to have been 43.0 while the median age for Florida was 40.1 by 2007 so Palm Beach County's median age is higher than the state as a whole. There was an estimated 6.3% of the population in the civilian force that was estimated to be unemployed in Palm Beach County, which was almost the same as the state's unemployment rate of 6.4%. The percentage of persons below the poverty level was estimated at 11.5% which was below the 12.6% for the state as a whole during 2007. Palm Beach County had a higher owner occupied housing rate than the state with over 74.3% of owner occupied housing to the state's 70.3% estimated for 2007 (U.S. Census Bureau).

Value of Caribbean spiny lobster for Palm Beach Gardens is just below 5% of total landings and around 2% of landings overall. Five other species rank ahead of spiny lobster in terms of value, with swordfish by far the most valuable for the community (Figure 3.5.11).

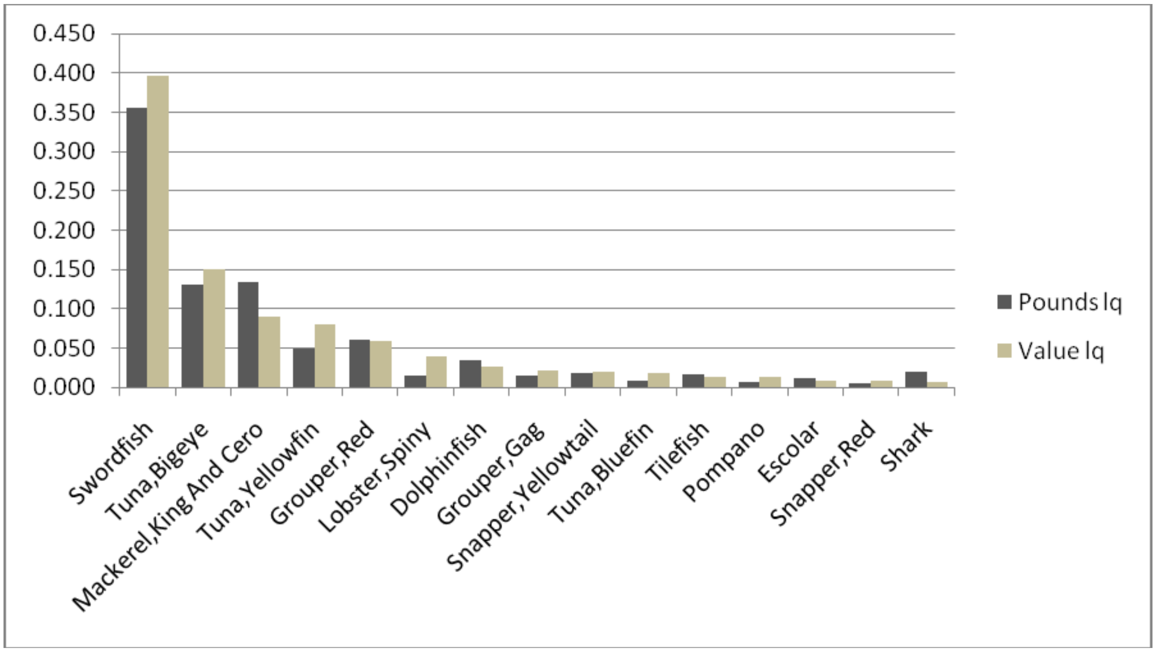

Figure 3.5.11. Proportion (lq) of landings and value for top fifteen species out of total landings and value for Palm Beach Gardens, Florida.
Source: ALS 2008.

Miami-Dade County

Miami-Dade County had a total population of 2,253,779 in 2000 that is estimated to have grown to 2,387,170 by 2007. The majority of residents were identified as White (74.4%) in 2007 and the Hispanic population was 61.7%, the largest in the state. Florida as a state had an estimated 77.8% White population and Hispanics made up 20.5% of its total population. The median age for residents of Miami-Dade County was estimated to have been 38.7 while the median age for Florida was 40.1.7 by 2007 so Miami-Dade County's median age is slightly younger than the state as a whole. There was an estimated 5.9% of the population in the civilian force that was estimated to be unemployed in Miami-Dade County, which was somewhat lower than the state's unemployment rate of 6.4%. The percentage of persons below the poverty level was estimated at 16.1% which was above the 12.6% for the state as a whole during 2007. Miami-Dade County had a lower owner occupied housing rate than the state with over 60.1% of owner occupied housing to the state's 70.3% estimated for 2007 (U.S. Census Bureau).

Caribbean spiny lobster is by far the most valuable species landed in Miami with over 60% of the value of total landings and just over 30% of landings (Figure 3.5.12).

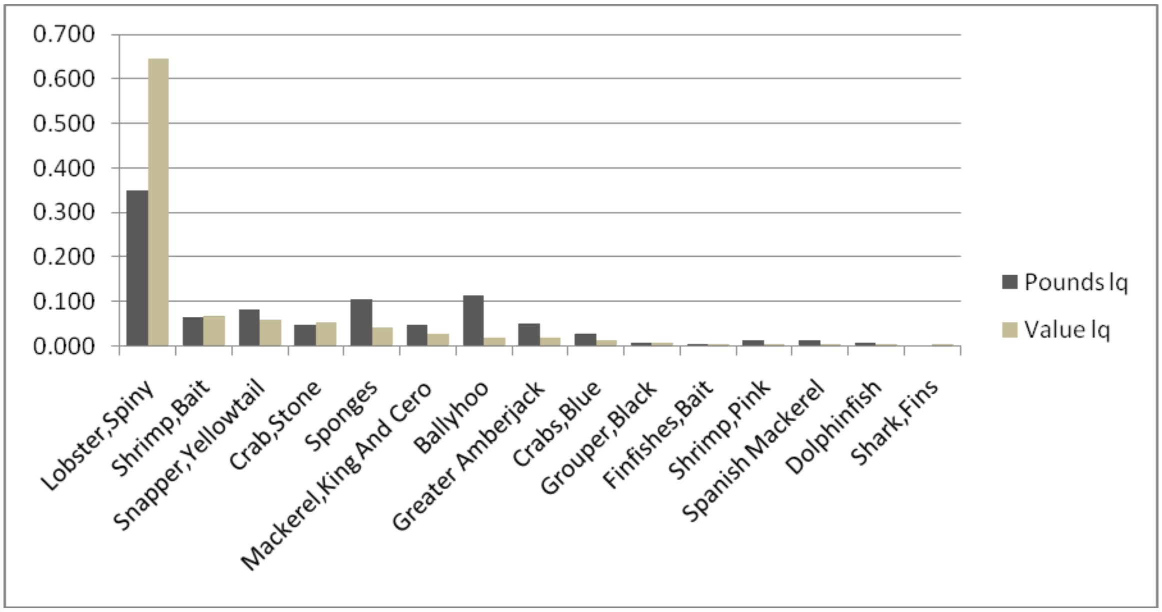

Figure 3.5.12. Proportion (lq) of landings and value for top fifteen species out of total landings and value for Miami, Florida.
Source: ALS 2008.

North Miami landings and value are completely dominated by Caribbean spiny lobster with over 90% of the value and 80% of total landings attributed to that species (Figure 3.5.13). All other species make up less than 3% each.

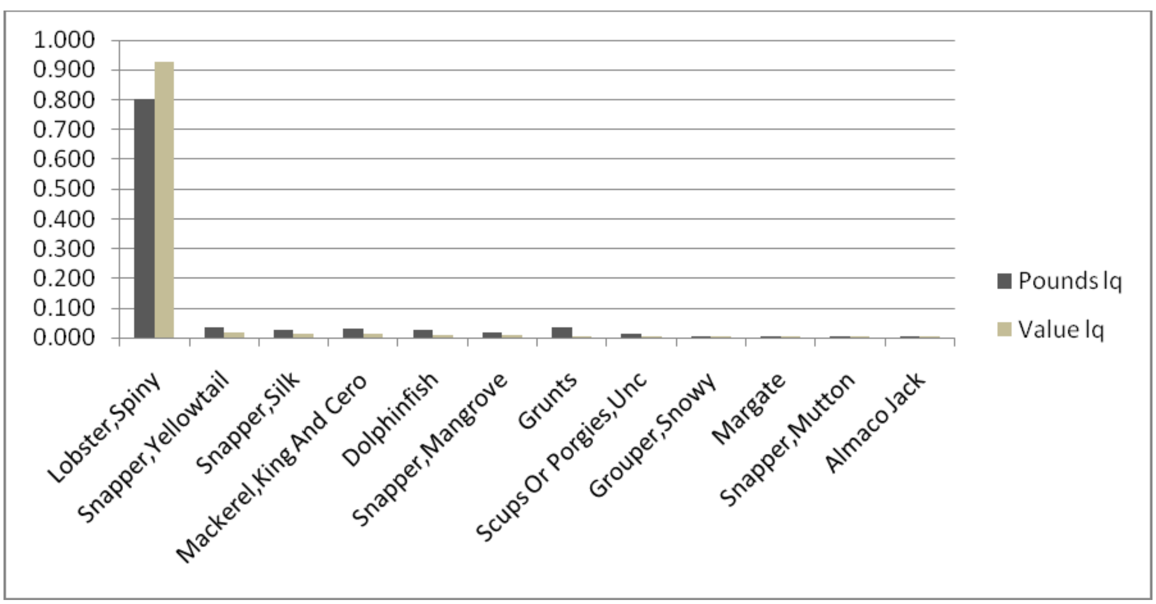

Figure 3.5.13. Proportion (lq) of landings and value for top fifteen species out of total landings and value for North Miami, Florida.
Source: ALS 2008.

Hialeah derives almost 40% of value from all landings in Caribbean spiny lobster while it represents only 15% of landings (Figure 3.5.14). In contrast, king mackerel represents over 50% of landings and only slightly less than 40% of value.

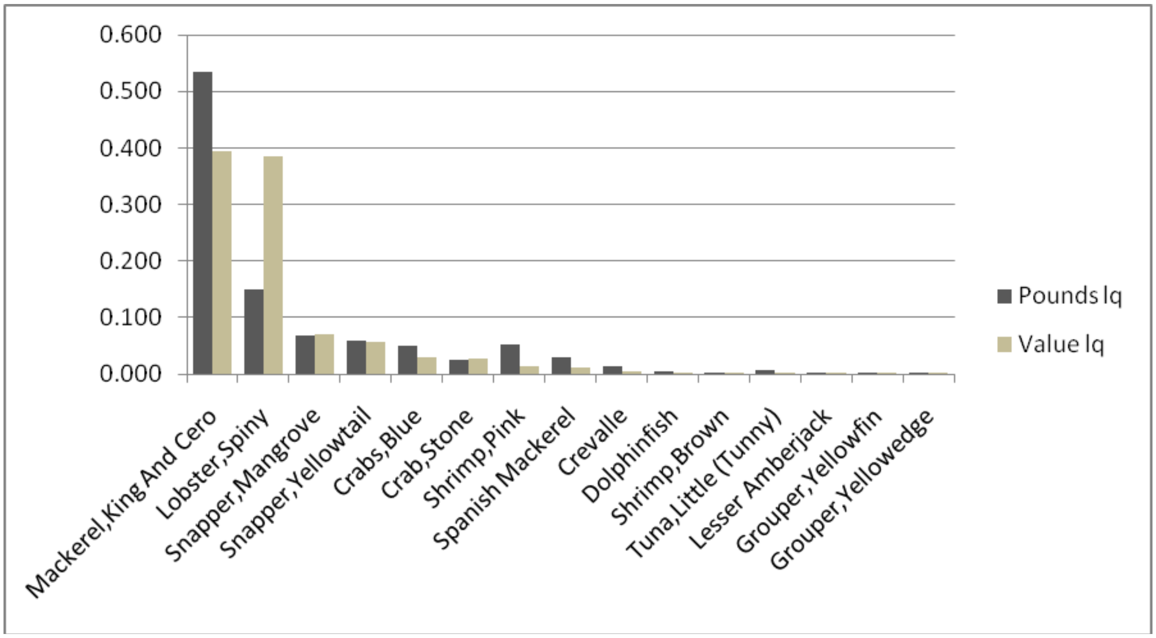

Figure 3.5.14. Proportion (lq) of landings and value for top fifteen species out of total landings and value for Hialeah, Florida.
Source: ALS 2008.

Recreational Fishing
As mentioned earlier, recreational fishing for Caribbean spiny lobster is an important fishery for the Keys and surrounding counties. Table 3.5.2 lists recreational fishing communities along Florida's Atlantic coast, including the Keys.

Table 3.5.2. Recreational Fishing Commuinties along Florida's East Coast.

Rank	Community
1	Islamorada
2	Cudjoe Key
3	Key West
4	Tavernier
5	Little Torch Key
6	Ponce Inlet
7	Marathon
8	Sugarloaf Key
9	Palm Beach Shores
10	Big Pine Key
11	Saint Augustine
12	Key Largo
13	Summerland Key
14	Sebastian
15	Cape Canaveral

The ranking is based upon serveral criteria as mentioned earlier which include the number of charter permits per thousand population and the number of recreational fishing infratstructure attributed to the community as listed under the MRIP survey. As seen in Table 3.5.2, the Keys communities rank high in terms of reliance upon recreational fishing.

In Figure 3.5.15, the distribution of recreational spiny lobster permits is presented by community and suggests a wide dispersion around the state. By far the largest concentration of permits are in the lower east coast communities and the Keys, with Miami having the largest concentration of permits overall. Sharp et al. (2005) found that many recreational lobster fishermen travel to the Keys, especially during the two day season. The influx of so many people in such a short time period has caused concern among many Key's residents as there is considerable overcrowding during the event. Unfortunately, management alternatives have been ineffecitve in alleviating the problem. While recreational lobster fishing brings an important economic boost to the Keys economy, there are externalities for which costs are not always apparent, but evident through social impacts.

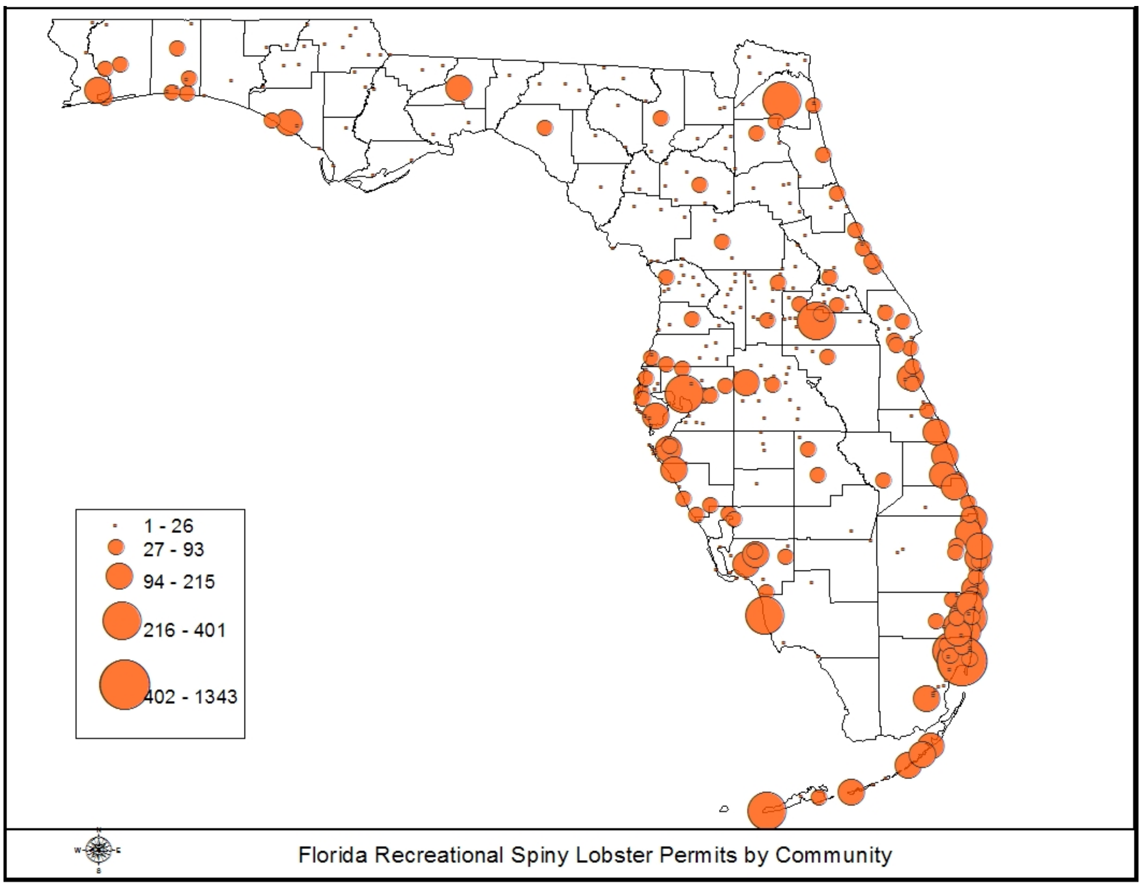

Figure 3.5.15 Florida recreational spiny lobster permits for 2010 by community of permit holder
Source: FWC 2010.

3.5.1 Environmental Justice (EJ)

Executive Order 12898 requires federal agencies to identify and address, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations. As mentioned, EJ is related to the idea of social vulnerability; however, there are no thresholds with regard to social vulnerability as there are with EJ. Thresholds for poverty and number of minorities have been established for EJ and those areas that exceed such thresholds are identified.

Although it is anticipated that the impacts of this amendment may affect communities with EJ concerns, because the impacts should not discriminate against any group, this action should not trigger any EJ concerns. In reviewing the thresholds for minorities among the coastal counties involved, Miami-Dade and Broward in Florida exceed the threshold for minorities, while only Miami-Dade County exceeds the poverty threshold. Again, as illustrated by the SoVI, EJ is closely tied to social vulnerability as most of the counties that do not meet these thresholds are also considered medium high or highly vulnerable. It is anticipated that the impacts from the following management actions may impact minorities and the poor, but not through discriminatory application of these regulations. However, it is also noted that while Monroe County does not exceed any of the EJ thresholds, nor is it classified as being vulnerable in terms of social vulnerability, there are processes that affect working waterfronts and therefore commercial and charter fishermen through the process of gentrification. While the regulatory actions within this amendment in and of themselves may not precipitate social change or disruptions, in combination with these and other outside factors, working waterfronts may be negatively affected.

3.6 Administrative Environment

3.6.1 Federal Fishery Management

Federal fishery management is conducted under the authority of the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act), originally enacted in 1976. 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 of Commerce (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 NOAA Fisheries Service.

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 and Texas, and the three-mile seaward boundary of the Atlantic side of Florida and the states of Alabama, Georgia, Louisiana, Mississippi, North Carolina, and South Carolina.

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 NOAA Fisheries Service. 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 for Law Enforcement, the U.S. Coast Guard, and various state authorities. To better coordinate enforcement activities, federal and state enforcement agencies have developed cooperative agreements to enforce the Magnuson-Stevens Act.

3.6.2 State Fishery Management

The purpose of state representation at the council level is to ensure state participation in federal fishery management decision-making and to promote the development of compatible regulations in state and federal waters. The state governments have the authority to manage their respective state fisheries. Each of the states exercises legislative and regulatory authority over their state's natural resources through discrete administrative units. Although each agency is the primary administrative body with respect to the state's natural resources, all states cooperate with numerous state and federal regulatory agencies when managing marine resources.

4.0 ENVIRONMENTAL CONSEQUENCES

4.1 Action 1: Other species in the Spiny Lobster Fishery Management Plan (FMP)

*Note: More than one alternative may be chosen as a preferred.

Alternative 1: No Action – Retain the following species: smoothtail spiny lobster**,** *Panulirus laevicauda,* spotted spiny lobster, *Panulirus guttatus,* Spanish slipper lobster, *Scyllarides aequinoctialis,* in the FMP for data collection purposes only, but do not add them to the Fishery Management Unit.

Alternative 2: Set annual catch limits and accountability measures using historical landings for Spanish slipper lobster *Scyllarides aequinoctialis,* after adding them to the Fishery Management Unit and for ridged slipper lobster, *Scyllarides nodifer*, currently in the Fishery Management Unit.

Alternative 3: List species as ecosystem component species:
- **Option a:** smoothtail spiny lobster**,** *Panulirus laevicauda*
- **Option b:** spotted spiny lobster, *Panulirus guttatus*
- **Option c:** Spanish slipper lobster, *Scyllarides aequinoctialis*
- **Option d:** ridged slipper lobster, *Scyllarides nodifer*

Preferred Alternative 4: Remove the following species from the FMP:
- **Preferred Option a:** smoothtail spiny lobster**,** *Panulirus laevicauda*
- **Preferred Option b:** spotted spiny lobster, *Panulirus guttatus*
- **Preferred Option c:** Spanish slipper lobster, *Scyllarides aequinoctialis*
- **Preferred Option d:** ridged slipper lobster, *Scyllarides nodifer*

4.1.1 Direct and Indirect Effect on the Physical and Biological/Ecological Environments

Alternative 1 would not meet the National Standard 1 guidelines and would have the same impacts to the physical or biological environments as currently exist.

Alternative 2 would set annual catch limits (ACLs) and accountability measures (AMs) for slipper lobsters. This alternative would be expected to have positive impacts on the physical and biological environments if catch is constrained below current levels. However, setting an appropriate ACL would be difficult, because no data on life history, growth rates, and reproductive biology are available to conduct an effective stock assessment. The two species of slipper lobsters, Spanish and ridged, have some commercial landings information, but are considered species landed as bycatch in the commercial shrimp trawl and Caribbean lobster trap fisheries. In the early 1980s vessels with state commercial shrimp trawl permits targeted slipper lobsters in the western Gulf of Mexico (Gulf) (Sharp et al. 2007). However, average landings of slipper lobster are low and constitute less than 1% of the total average landings in both federal and state waters of the South Atlantic and Gulf (Table 2.1.2). Positive physical, ecological, and biological impacts may result from better monitoring and record keeping of the resource, and implementing AMs, when and if the ACLs are exceeded. However, monitoring systems would need to be established for both species of slipper lobsters to obtain these projected positive benefits.

Alternative 3 would designate all four species as ecosystem component species. Impacts would be the same as currently exist, unless new data collection programs are developed. Leaving the species in the FMP may offer the benefit of collecting data in the future that could be used in the development of conservation and management measures, and positive impacts to the physical and biological environments would be expected at a later date. However, no data collection programs are currently in place for any of these species. Ridged slipper lobsters do not meet all the ecosystem component criteria outlined in the National Standard 1 guidelines, because they are sometimes targeted and are generally retained for sale or personal use.

Preferred Alternative 4 would remove all four species from the FMP. If these species were removed from the FMP, but landed and sold to a federal dealer, landings data could still be recorded for these species. If other agencies, such as the individual states, took over management after they are removed from the FMP, then positive physical and biological impacts could occur. In particular, Florida regulations concerning the taking of egg-bearing females, or stripping or removing eggs, are more conservative than federal regulations for most of these species. If another agency did not take over management of other lobster species, and overfishing occurred negative physical and biological impacts would be expected. Because of the lack of landings and data on life history, growth rates, and reproductive biology, completing a stock assessment would probably not be possible, even for the ridged slipper lobster (Sharp et al. 2007).

Preferred Options a and **b** have no landings information available, so management by any agency would be difficult. These species are not targeted by either commercial or recreational fishermen, and may not be in need of federal management.

Florida Fish and Wildlife Conservation Commission (FWC) estimated that in the last nine years, 23% of the landings of slipper lobsters (**Preferred Options c** and **d**) have been by commercial divers. If the FWC trap limitation program proceeds and the commercial dive fishery increases, more of these species may be landed. However, little data exist to suggest commercial divers are targeting them. Instead, commercial divers are landing them coincidently with Caribbean spiny lobsters. Further, FWC intensive creel surveys, which were conducted for Caribbean spiny lobster in the Florida Keys during the special two-day sport season and the first two weeks of the regular season, indicated slipper lobsters are not targeted by recreational fishers in the Keys. Due to their cryptic nature, slipper lobsters are unlikely to support a substantial recreational fishery (Sharp et al. 2007). The commercial shrimp trawl fishery currently lands slipper lobster species as incidental catch. In the 1980s, commercial shrimpers are believed to have targeted slipper lobsters in the northeastern Gulf; however, after implementation of various regulations such as the prohibition of egg-bearing females and the turtle-excluder devices (TEDs) slipper lobster landings have been greatly reduced. As commercial shrimp trawl effort in the Gulf declined so have slipper lobster landings (Sharp et al. 2007; see Section 2.1 and 4.1.2).

4.1.2 Direct and Indirect Effect on the Economic Environment

Data on commercial fishing for slipper lobsters (ridged and Spanish) are collected and managed inseparably, and the data are summarized for Florida in Section 2.1 and Tables 4.1.2.1 - 4.1.2.2. Today, the landings and effort are well below what they were previously. Landings in Florida averaged 4,737 pounds per year in the last five years, compared with 39,948 lbs per year in 1989/1990–1993/1994 (Table 4.1.2.1). The number of vessels with landings fell from 192 to 23 and the number of trips fell from 538 to 47. In the last five years, the ex-vessel value (paid to fishermen by first buyers) averaged $24,232 per year in 2008$ and this is a small part of the total for trip gross, $304,989, approximately two-thirds of which is for shrimp (Table 4.1.2.1). Although landing of slipper lobsters declined markedly in the last two decades, annual average trip landings were relatively stable at 100 lbs per trip for the last five years, 70 lbs per trip in the preceding five years, and 55 lbs per trip from 1986/1987 – 1990/1991 (Table 4.1.2.2).

Table 4.1.2.1. Florida commercial fishing statistics for slipper lobsters.

Period	Vessels	Trips	Landings, lbs	2008$	2008 $ /lb	Trip gross, 2008$	Shrimp in trip gross, 2008$	Vessel gross, 2008$
Trips for which landings of slipper lobster >= 1 lb								
89/90-93/94	192	538	39,948	152,479	3.82	2,503,041	2,095,000	2,503,041
04/05-08/09	23	47	4,737	24,232	5.12	304,989	216,000	304,989
Trips for which landings of slipper lobster >= 1 lb and slipper lobster is the top species in trip value.								
89/90-93/94	78	137	27,173	106,037	3.90	120,604		120,604
04/05-08/09	8.6	15.8	3,476	18,546	5.34	19,606		19,606

Source: NMFS, SEFSC, FTT (19Mar10), methods as for spiny lobster in Vondruska (2010). In ranking species (or groups of species) by dollar value on individual trips, all shrimp are counted as one species, and the same is true for groupers, snappers other than yellowtail snapper, tuna, and stone crab.

During the past 20 years or so, slipper lobsters landed in Florida have been caught at greater depths, approximately 80-110 ft, compared with 30-45 ft for Caribbean spiny lobster, and 40-70 ft for shrimp. The median monthly time in hours away from port for trips for slipper lobsters was more variable than for shrimp (shrimp, approximately 8 hours), more seasonal, and typically, much longer, often 70 hours to 200 hours or more per trip. These data on depth of capture and time away from port for trips are consistent with results of a two-year study of populations of several species of lobster, including the ridged slipper lobster (Sharp et al. 2007). Slipper lobsters reside in dens during the day and may feed on unconsolidated bottoms at night. Sharp et al. (2007) indicate that in the early 1980s, shrimp fishermen had directed fishing effort toward the ridged slipper lobster on the west coast of Florida in the spring and summer, and that such effort declined from the late 1980s onward. Indeed, for most, but not all vessels with landings, slipper lobsters accounted for a relatively small part of vessel gross revenue, with shrimp accounting for perhaps two-thirds (Table 4.1.2.1, top part; data for 1986/1987-2008/2009 in Table 4.1.2.2).

However, slipper lobsters cannot be viewed strictly as an incidental or bycatch species when fishing for shrimp, because a relatively small number of vessels account for well over half of the landings. In the last five years, slipper lobsters were the top species in dollar value for an annual average of 16 trips (8.6 vessels) out of 47 trips (23 vessels) with slipper lobster landings, and these 16 trips accounted for much of the total landings (3,476 lbs out of 4,737 lbs landed (Table 4.1.2.1). In 1989/1990 – 1993/1994, an annual average of 137 trips (78 vessels) accounted for 27,173 lbs out of the total of 39,948 lbs landed (on 538 trips and 192 vessels).

Table 4.1.2.2. Florida commercial fishing statistics for slipper lobsters.

Fishing year	Slipper (Scyllaridae family) lobster				Trip gross, all species landed	Value of shrimp in trip gross	Slipper lobster
	Vessels	Trips	Lbs	2008$	2008$	2008$	Lbs / trip
86/87	145	535	28,097	$139,737	$3,164,506	$2,847,000	53
87/88	131	487	19,952	$77,776	$3,368,151	$3,094,000	41
88/89	198	558	40,736	$127,040	$3,462,936	$3,145,000	73
89/90	149	334	14,793	$46,590	$1,911,348	$1,699,000	44
90/91	187	465	27,282	$100,244	$2,005,785	$1,757,000	59
91/92	213	653	48,728	$190,484	$2,041,960	$1,586,000	75
92/93	193	584	48,708	$201,406	$2,909,027	$2,326,000	83
93/94	220	655	60,230	$223,671	$3,647,087	$3,107,000	92
94/95	130	411	33,531	$117,551	$2,425,114	$1,789,000	82
95/96	148	362	26,843	$109,467	$1,741,169	$1,258,000	74
96/97	193	437	43,565	$194,740	$2,755,427	$2,467,000	100
97/98	122	335	30,872	$131,100	$2,589,996	$2,287,000	92
98/99	101	225	13,139	$56,937	$967,323	$662,000	58
99/00	71	146	7,196	$33,469	$1,300,163	$839,000	49
00/01	88	145	8,766	$49,169	$1,321,361	$983,000	60
01/02	81	179	8,582	$51,109	$1,767,823	$1,245,000	48
02/03	59	130	9,951	$58,195	$857,261	$637,000	77
03/04	58	132	17,012	$98,764	$671,789	$429,000	129
04/05	36	72	5,000	$23,537	$532,271	$430,000	69
05/06	30	63	4,291	$22,078	$496,995	$411,000	68
06/07	26	56	6,060	$30,933	$185,422	$26,000	108
07/08	10	23	6,443	$36,865	$159,716	$116,000	280
08/09	14	22	1,889	$7,747	$150,541	$97,000	86
Averages for rows above, excepting last column (see footnote)							
86/87-90/91	162	476	26,172	$98,277	$2,782,545	$2,508,400	55
99/00-03/04	71	146	10,301	$58,141	$1,183,679	$826,600	70
04/05-08/09	23	47	4,737	$24,232	$304,989	$216,000	100

Source: NMFS, SEFSC, FTT (Mar 19, 2010). All shrimp are counted as one species. Data are for trips with landings of at least one pound of slipper lobsters for July-June fishing years. Multi-year averages for pounds per trip were obtained from data in this table as pounds/trips, e.g., for 04/05-08/09 (100 lbs/trip=4,737 lb/47 trips).

Slipper lobsters have been landed in states from South Carolina through Mississippi according to data for 1977-2010, notably Florida and Alabama (NMFS, SEFSC). However, the landings for some years, states and gear, including landings in Alabama and Florida by coast, may be relatively small and/or confidential because of reporting by fewer than three dealers. On a calendar year basis, landings in the southeast (SC-MS only) peaked in 1985 at 113,440 lbs, and they were 1,283 lbs in 2009, and 1,921 lbs in 2010 (data for 2010 is preliminary and may not cover 12 months). During 1997-2009, shrimp trawls accounted for 85.2% of the landings by gear for the southeast (SC-MS only), followed by spiny lobster traps at 9.2%, and diving at 5.0%, with smaller amounts for other gear. Florida's east coast accounted for most of the landings by diving, where diving was the leading gear (approximately, 9,000 out of 14,000 lbs, 1997-2010 all-year totals).

The long-term decline in landings of slipper lobsters depicted in Table 4.1.2.2 may be partly explained by several factors: requiring the use of TEDs in shrimp trawls in waters off Florida (1990); prohibiting the molestation and possession of berried female lobsters in Florida (1987); and a decline in effort in the shrimp fishery (Sharp et al. 2007). Given the significance of fuel in trip costs, fuel prices could have been a factor in 2004-2008.[7]

Alternative 1 would not result in any change in the species contained in the fishery management unit (FMU), species retained for data collection, or species listed as ecosystem components. As a result, all status quo management conditions and related operation of the fishery, and associated economic benefits, would remain unchanged. If any or all of the species considered by this action require more detailed management and protection, they would need to be placed within the FMU. The Gulf of Mexico and South Atlantic Councils (Councils) would have to complete this type of action through a full plan amendment.

Alternative 2 would set ACLs and AMs using historical landings for Spanish slipper lobster, after adding to the FMU, and for ridged slipper lobster, currently in the FMU. If current or future resource decline were to occur under **Alternatives 1, 3** or **4,** but not under **Alternative 2**, the economic benefit for **Alternative 2** is represented by the ex-vessel value of $24,232 in 2008$ for Scyllarid lobsters, which could be reduced to zero under **Alternatives 1, 3** or **4.** There are some caveats. If current or future resource declines were to occur under **Alternatives 1, 3,** or **4,** but not under **Alternative 2**, the loss under **Alternatives 1, 3,** or **4** refers to slipper lobster only. This assumes that the vessel owners (operators) could pursue other fishing opportunities and not be driven out of commercial fishing.

Among the options for **Alternative 3**, data on commercial fishing are not available for any of the four species separately. Sharp et al. (2007) describe the ecology for some of these species, and describe commercial fishing for Scyllaridae family lobsters as a whole, meaning the two slipper

[7]Diesel fuel rose sharply in 2007-2008, peaked in July 2008, and declined by half in late 2008 to levels of late 2006. Note: An index of producer-level prices for diesel fuel averaged 100.5 in 2003, peaked at 431.9 in July 2008 and fell to 168.0 in December 2008 (U.S. Bureau of Labor Statistics, 1982 base of 100).

lobster species combined. Data on commercial fishing in Florida for slipper lobsters are summarized in Section 2.1, with additional information in Tables 4.1.2.1 - 4.1.2.2.

Should such resource decline occur under **Alternative 3**, **Option c** and **Option d** together, it is estimated that the ex-vessel value of landings of slipper lobsters could decline by as much as $24,232 per year (Table 4.1.2.1). That is, this amount represents the estimated economic impact of **Alternative 3, Option c** and **Option d** together, when compared with **Alternative 1**. The economic impact of **Alternative 3, Option a,** or **Alternative 3, Option b**, is not known, but is assumed to be less. It is assumed that the economic impacts of **Alternatives 3-4** are essentially the same.

4.1.3 Direct and Indirect Effect on the Social Environment

The effects on the social environment from removing or not removing other species from the FMP would likely accrue from the implementation of new ACLs and AMs on those species. **Alternative 1** would have little impact on the social environment, yet may not be feasible if these species remain in the FMP as National Standard 1 will not be met. Setting ACLs and AMs in **Alternative 2** would likely have an impact on the social environment depending upon the thresholds selected and the measures that were implemented to account for any overages. Listing species as ecosystem components as in **Alternative 3** or removing species from the FMP as in **Preferred Alternative 4** would likely have few social impacts unless one or more of the **Options a-d** were not selected. Leaving any species in the FMP would require ACLs and AMs be set. Because landing information on these species is imprecise, setting an ACL and subsequent AMs would be problematic and could cause some social disruption and changes in fishing behavior if thresholds were set too low. These species tend to be bycatch in other fisheries which makes monitoring difficult. While removing them from the FMP may preclude any federal monitoring of status of these species, continuing to manage them with ACLs and AMs may be costly and impractical.

4.1.4 Direct and Indirect Effect on the Administrative Environment

Alternative 1 would not meet the requirements of the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act), and could leave NOAA Fisheries Service subject to litigation, which would result in a significant administrative burden. Specifying an ACL alone (**Alternative 2**) would not increase the administrative burden over the status-quo. However, the monitoring and documentation needed to track the ACL could result in a need for additional cost and personnel resources because a monitoring mechanism is not already in place. After the ACL is specified, the administrative burden associated with monitoring and enforcement, implementing management measures, and AMs would increase. **Alternative 3** would designate species as ecosystem component species which would eliminate the administrative burden associated with establishing ACLs and AMs for those species. **Preferred Alternative 4** would remove species from the FMP, resulting in less administrative burden with regards to establishing ACLs and AMs.

4.1.5 Council Conclusions

After many discussions, the Councils determined that federal management of these four lobster species was no longer necessary. Therefore they selected **Preferred Alternative 4** (**Options a-d**) to remove all four species from the FMP. The Councils felt that Florida could provide adequate if not better protection for these four species compared to current federal management which only protects ridged slipper lobster, *Scyllarides nodifer*. Ridged slipper lobster is the only species within the FMU and at the time the original Spiny Lobster FMP was implemented in 1982 which needed federal regulations. The other species were placed into the FMP for data collection purposes. The Councils also discussed designating these species as ecosystem component species with the idea that data collection may improve for these species if left in the FMP; however, the current federal data collection programs would need to be modified to include invertebrates. Currently, MRFSS only collects information on finfish so the federal data collection system relies primarily on the states and in particular Florida to collect information on invertebrates. By designating these species as ecosystem component species it was thought if regulations were needed they could be established at a later date for these species. However, only one lobster species is currently within the FMU and a full plan amendment would be needed to move the other species into the FMU and create the new regulations, which is timely and would not necessarily improve data collection or protection of these resources.

4.2 Action 2: Modify the Current Definitions of Maximum Sustainable Yield, Overfishing Threshold, and Overfished Threshold for Caribbean Spiny Lobster

Action 2-1: Maximum Sustainable Yield (MSY)

Alternative 1: No Action- Use the current definitions of MSY as a proxy. The Gulf approved definition**:** MSY is estimated as 12.7 million pounds annually for the maximum yield per recruit size of 3.5 inch carapace length. The South Atlantic approved definition: MSY is defined as a harvest strategy that results in at least a 20% static SPR (spawning potential ratio).

Alternative 2: Modify the Gulf definition to mirror the South Atlantic definition of MSY proxy, defined as 20% static SPR.

Alternative 3: The MSY equals the yield produced by fishing mortality at maximum sustainable yield (F_{MSY}) or proxy for F_{MSY}. Maximum sustainable yield will be defined by the most recent SEDAR and joint Scientific and Statistical Committee (SSC) processes.

Preferred Alternative 4: The MSY proxy will be the overfishing limit (OFL) recommended by the Gulf SSC at 7.90 million pounds.

Action 2-2: Overfishing Threshold (Maximum Fishing Mortality Threshold)

Alternative 1: No Action - Use the current definitions of overfishing thresholds. The Gulf and South Atlantic approved definition: overfishing level as a fishing mortality rate (F) in excess of the fishing mortality rate at 20% static SPR ($F_{20\%}$ static SPR).

Alternative 2: Specify the Maximum Fishing Mortality Threshold (MFMT) as F_{MSY} or F_{MSY} proxy. The most recent SEDAR and SSCs will define F_{MSY} or F_{MSY} proxy. This should equal the OFL provided by the SSCs. The Councils will compare the most recent value for the current fishing mortality rate (F) from the SEDAR/SSC process to the level of fishing mortality that would result in MFMT and if the current F is greater than the MFMT, overfishing is occurring. Comparing these two numbers:

- $F_{CURRENT}$/MFMT = X.XXX

*This comparison is referred to as the **overfishing ratio**. If the ratio is greater than 1, then overfishing is occurring.

<u>Preferred Alternative 3</u>: Specify the MFMT as the OFL defined by the Gulf SSC at 7.90 million pounds.

Action 2-3: Overfished Threshold (Minimum Stock Size Threshold)

Alternative 1: No Action – Do not establish an overfished threshold. The Gulf Council does not have an approved definition of the overfished threshold. The South Atlantic Council approved definition is a framework procedure to add a biomass based component to the overfished definition, due to no biomass levels and/or proxies being available.

Alternative 2: The Minimum Stock Size Threshold (MSST) is defined by the most recent SEDAR and SSC process. The Councils will compare the current spawning stock biomass (SSB) from the SEDAR and SSC process to the level of spawning stock biomass that could be rebuilt to the level to produce the MSY in 10 years. Comparing these two numbers:

- $SSB_{CURRENT}$/MSST = Y.YYY

This comparison is referred to as the **overfished ratio**. If the ratio is less than 1, then the stock is overfished.

<u>Preferred Alternative 3</u>: MSST = (1-M) x B_{MSY}. Definitions: M = instantaneous natural mortality and B_{MSY} = biomass at maximum sustainable yield or the appropriate proxy.

4.2.1 Direct and Indirect Effect on the Physical and Biological/Ecological Environments

There are three sub-actions for modification of the current definition of each of the following biological reference points: MSY, MFMT, and MSST. **Alternative 1,** under all actions could have negative impacts to the physical and biological/ecological environment, due to the biological reference points for MSY and MSST being inconsistent between the two Councils. In addition, the South Atlantic Council's approved definition of MSY is a proxy based on spawning potential ratio and is not a biomass-based proxy. The Gulf Council has an approved MSY definition that is based on Caribbean spiny lobster landings. However, in 1998 during the same time period the South Atlantic Council was developing their Generic Sustainable Fisheries Act Amendment the Gulf Council was also developing theirs with an updated definition of MSY (i.e., 20% transitional SPR). The Gulf Council's definition was not approved meaning the MSY definition for the Gulf then reverted back their previous definition based on landings (i.e., 12.7 mp).

The South Atlantic Council currently uses static SPR as a proxy and **Alternative 2**, under **Actions 2-1** would modify the Gulf Council's definition to static SPR. This would make the overfished definitions consistent between the Councils and static SPR is a better proxy for yield projections, because it uses equilibrium changes in recruitment and mortality. Consistency between Councils when establishing biological reference points would be more beneficial for the physical and biological environments. Using the same proxies reduces confusion for assessments and provides guidance for analysts. Further, based on the information available on Caribbean spiny lobster, static SPR is a more appropriate proxy to use. Transitional SPR proxies should be estimated on an annual basis and are not beneficial for long term yield projections (MRAG Americas 2001). Caribbean spiny lobster were not undergoing overfishing based on the MFMT proxy definition of $F_{20\%}$ static SPR in either the benchmark or update assessments, and the overfished status could not be evaluated without a pan-Caribbean wide stock assessment (SEDAR 8 2005; 2010 Update Assessment).

Alternative 3 under Action 2-1 and **Alternatives 2** under Action 2-2 and Action 2-3 would modify the current definitions to the biological reference points established during the Southeast Data Assessment and Review (SEDAR) and Scientific and Statistical Committee (SSC) processes. These would be based on the best available science and reviewed by experts; therefore, this alternative if selected as preferred could provide the most benefits to the physical and biological environments. The biological reference points would be consistent between Councils and based on the most recent data. However, because the most recent results from the SEDAR and SSC processes for Caribbean spiny lobster in the southeastern U.S. were not accepted due to external recruitment from other Caribbean populations, these alternatives may not provide the best protection to the resource.

Preferred Alternative 4 (Action 2-1) would set the MSY proxy as the OFL = 7.90 million pounds (mp) recommended by the Gulf Council's SSC using landings data and Tier 3a of the Gulf Acceptable Biological Catch (ABC) Control Rule. Currently this preferred alternative provides the best protection of the resource because the 2010 update assessment was rejected. This alternative would also establish the MSY proxy 4.8 mp lower than **Alternative 1** (MSY=12.7 mp, annually). Similarly, **Preferred Alternative 3** under Action 2-2 is based on Caribbean spiny lobster landings and may provide the best protection of the resource and thereby the biological and ecological environments. However, without a clear estimate of Caribbean spiny lobster biomass it is unknown if **Alternatives 2** or **3** under Action 2-3 would provide the best protection for the resource and various subsequent negative and positive impacts to the biological and ecological environments.

4.2.2 Direct and Indirect Effect on the Economic Environment

Defining the MSY, MFMT, and MSST of a species does not alter the current harvest or use of the resource. Specification of these measures merely establishes benchmarks for fishery and resource evaluation from which additional management actions for the species would be based, should comparison of the fishery and resource with the benchmarks indicate that management adjustments are necessary. The impacts of these management adjustments will be evaluated at the time they are proposed. As benchmarks, these parameters would not limit how, when, where, or with what frequency participants in the fishery engage the resource. This includes participants who directly utilize the resource (principally, commercial vessels, for-hire operations, and recreational anglers), as well as participants associated with peripheral and support industries. All entities could continue normal and customary activities under any of the alternative specifications. Participation rates and harvest levels could continue unchanged.

Because there would be no direct effects on resource harvest or use, there would be no direct effects on fishery participants, associated industries or communities. Direct effects only accrue to actions that alter harvest or other use of the resource. Specifying MSY, MFMT, and MSST, however, establishes the platform for future management, specifically from the perspective of bounding allowable harvest levels. The relationship between and implications of the harvests levels implied by the MSY and OY alternatives relative to the status quo are discussed in Section 4.4.2.2.

Administrative costs of fishery management accrue to the time and labor involved in developing new regulations, permitting systems, or other management actions. To the extent that each of the MSY and OY alternatives provides fishery scientists and managers with specific objective and measurable criteria to use in assessing the status and performance of the fishery, the impacts of the various alternatives on administrative costs are indistinguishable. However, the more conservative (lower) the equivalent allowable harvest level, the greater the potential for harvest overages, necessitating additional management action, with associated administrative costs.

In addition to the trigger to subsequent management that MSY and OY may provide, the MSST identifies the stock level below which a resource is determined overfished. Should the evaluation of the resource relative to the benchmark result in said designation, harvest and/or effort controls are mandated as part of a recovery plan. These harvest and effort controls would directly impact the individuals, social networks, and associated industries associated with the resource or fishery, inducing short-term adverse economic impacts until the resource is rebuilt and less restrictive management is allowable.

4.2.3 Direct and Indirect Effect on the Social Environment

The setting of MSY in Action 2-1 for Caribbean spiny lobster is primarily a biological threshold that may impact the social environment depending upon where the threshold is set. These thresholds are determined through the assessments by several scientific panels and are entirely determined on the biology of the spiny lobster. Therefore, any indirect effect on the social environment would depend upon the level determined for each threshold and how it relates to current landings by both commercial and recreational sectors. The setting of this threshold becomes even more critical if sector allocation is chosen and at what level each sector allocation is set. Certainly if this threshold is set below current landing levels, there will be changes to the social environment and setting sector allocation will become controversial. **Alternative 1** would likely have few impacts as it uses the present definitions and would not change current thresholds. **Alternative 2** and **Alternative 3** could have impacts if the threshold is well below current landing levels, although it is likely that **Alternative 2** would not change that threshold substantially. The **Preferred Alternative 4**, which uses the MSY proxy recommended by the SSC, may have few negative social effects since the threshold is above the mean landings and if not substantially reduced by other management action.

The setting of the overfishing and overfished threshold in Actions 2-2 and 2-3, for Caribbean spiny lobster are also primarily biological thresholds that may impact the social environment depending upon where the threshold is set and when that threshold is reached. With all thresholds it is assumed that the long-term effect will ensure a stable stock and should have positive social benefits. But as mentioned earlier, there can be short term negative social effects if the thresholds impose levels that reduce the current levels of harvest. These thresholds are determined through the assessments by several scientific panels and are entirely determined on the biology of the spiny lobster. Therefore, the effect on the social environment would depend upon the level determined for the overfishing and overfished threshold and how they relate to current landings by both commercial and recreational sectors. Like the other alternatives, the setting of these thresholds becomes important if sector allocation is chosen and at what level each sector allocation is set. Certainly if these thresholds are set below current landing levels, there will be changes to the social environment and setting sector allocation will become controversial. For Action 2-2, **Alternative 1** would likely have few impacts as it uses the present definition, although if this threshold is too high then long term problems with stock viability could accrue. **Alternative 2** could have impacts if the threshold is well below current landing levels. **Preferred Alternative 3** should not impose short term negative social impacts as the level should allow for current harvesting levels to continue. The same is true for Action 2-3 and it is anticipated with its **Preferred Alternative 3** that any social effects will accrue once the threshold is exceeded as management action will need to impose restrictions to harvest.

4.2.4 Direct and Indirect Effect on the Administrative Environment

There could be additional administrative burdens, if these biological reference points are not modified for consistency. Changing these biological reference points is required under the requirements of the Magnuson-Stevens Act, and if not done, could leave NOAA Fisheries Service subject to litigation, which would result in a significant administrative burden.

4.2.5 Council Conclusions

For Action 2-1 the Councils selected **Preferred Alternative 4** to establish the MSY proxy as the OFL recommended by the Gulf SSC at 7.90 mp. The Councils selected this alternative as preferred because the 2010 Update Assessment for Caribbean Spiny Lobster was not accepted. Instead the assessment and review panel concluded that a pan-Caribbean assessment was necessary to estimate Caribbean spiny lobster biomass, which genetic studies determined to be largely reliant on recruitment from Caribbean Countries. Until a pan-Caribbean assessment can be completed landings history was used to estimate MSY. The Gulf Council SSC used their ABC Control Rule and the last 10 years of Caribbean spiny lobster landings plus two standard deviations from the mean to estimate the OFL at 7.90 mp. The Councils selected this alternative as their MSY proxy until the biomass of the U.S. Caribbean spiny lobster stock can be better estimated.

For Action 2-2 the Councils selected **Preferred Alternative 3** which was to specify the MFMT as the OFL defined by the Gulf SSC at 7.90 mp. The Councils selected this alternative as preferred because the biomass of the U.S. Caribbean spiny lobster stock is unknown and largely reliant on outside recruitment from other Caribbean countries; therefore the MFMT is also unknown for Caribbean spiny lobster. The Councils decided to use the OFL estimate from landings until the biomass of the U.S. Caribbean spiny lobster stock can be estimated.

For Action 2-3 the Councils selected **Preferred Alternative 3** MSST = (1-M) x $B_{MSY.}$ The Councils selected this alternative as preferred with the understanding that MSST cannot be estimated currently. However, as stock assessments improve to include information on parent stocks throughout the Caribbean and therefore better estimates of the southeastern U.S. Caribbean spiny lobster biomass then the MSST will be estimated using this equation.

4.3 Action 3: Establish Sector Allocations for Caribbean Spiny Lobster in State and Federal Waters from North Carolina through Texas

Preferred Alternative 1: No action – Do not establish sector allocations.

Alternative 2: Allocate the spiny lobster ACL by the following sector allocations: 80% commercial and 20% recreational.

Alternative 3: Allocate the spiny lobster ACL by the following sector allocations: 74% commercial and 26% recreational.

Alternative 4: Allocate the spiny lobster ACL by the following sector allocations: 78% commercial and 22% recreational.

Alternative 5: Allocate the spiny lobster ACL by the following sector allocations: 77% commercial and 23% recreational.

Alternative 6: Allocate the spiny lobster ACL by the following sector allocations: 76% commercial and 24% recreational.

4.3.1 Direct and Indirect Effect on the Physical and Biological/Ecological Environments

The FWC invited representatives of stakeholder groups participating in Florida's lobster fishery to serve as members of the Spiny Lobster Ad Hoc Advisory Board (Advisory Board). The Advisory Board was made up of five commercial trappers, three commercial divers, three recreational fishers, two wholesale dealers, two environmental groups, and one FWC representative. The Advisory Board was designed to bring together a group of stakeholder representatives from around the state who represent the diversity of the lobster fishery community. The goal was to provide constructive comments and guidance to the FWC in the form of proposed refinements to the management of Florida's spiny lobster fishery. Over a period of sixteen months the Advisory Board met approximately eight times for approximately two days each to focus on reviewing and discussing lobster fishery issues and proposals for refinements to Florida's spiny lobster fishery.

The Advisory Board examined landings records for all sectors of the spiny lobster fishery from 1993/1994 through 2003/2004. These data have been updated and are included in detail in Table 4.3.1.1. The Advisory Board ignored landings from unknown and other gear categories. The Advisory Board alternatives were developed by splitting the landings into four sectors (commercial trap, commercial diving, commercial bully nets, and recreational). During that time, the allocation of the lobster harvest among the different sectors changed. During the initial years of trap reductions, annual landings were generally higher than they had been in a decade. Landings by commercial divers increased, but because landings were so high, the progressive shift in the landings allocation toward that group appeared subtle. However, a period of lower landings beginning with the 2000/2001 season underscored this shift toward the commercial dive fishery and the recreational fishery as well. Regulations limiting harvest of commercial divers were enacted beginning with the 2003/2004 season. The effects of these rules can be seen by comparing allocations in the 2002/2003 and 2003/2004 seasons. Landings were essentially the same for both seasons, but the harvest share of commercial divers was reduced because of trip limits and the prohibition of harvest from artificial habitat. It appears that in high landing years, trappers have a larger harvest share because lobsters are available to be captured later in the season when there is little diving activity. Harvest from casitas is most effective early in the season. (Note: Harvest by casitas was prohibited in 2003). In low landings years, these early landings make up a larger harvest share than in high landing years. There is a need to understand current allocations in the spiny lobster fishery, how those allocations have shifted over time, and how rule changes have likely impacted allocation. The Councils have collapsed the commercial sub-allocations by gear into one commercial allocation for the alternatives being considered.

Table 4.3.1.1. Florida landings of spiny lobster, by sector (thousand pounds, ww).

Fishing year	Directed commercial					Bait	Recreational		Total
	Traps	Diving	Other	Total	% of total		Pounds	% of total	
91/92	6,602	192	43	6,836	79%	427	1,816	21%	8,652
92/93	5,125	223	20	5,368	80%	352	1,352	20%	6,721
93/94	5,109	176	24	5,310	74%	237	1,883	26%	7,193
94/95	6,808	254	119	7,182	79%	310	1,906	21%	9,088
95/96	6,638	308	72	7,017	78%	306	1,931	22%	8,948
96/97	7,319	338	88	7,744	80%	360	1,923	20%	9,667
97/98	7,148	397	96	7,640	77%	405	2,304	23%	9,944
98/99	5,037	352	58	5,448	81%	188	1,303	19%	6,750
99/00	6,996	588	85	7,669	76%	368	2,462	24%	10,131
00/01	4,856	635	77	5,569	74%	288	1,949	26%	7,518
01/02	2,610	447	22	3,079	71%	234	1,251	29%	4,330
02/03	3,992	560	25	4,577	76%	259	1,455	24%	6,033
03/04	3,727	392	42	4,162	75%	231	1,412	25%	5,573
04/05	5,126	312	35	5,473	76%	244	1,658	23%	7,201
05/06	2,680	267	17	2,963	72%	147	1,131	28%	4,094
06/07	4,517	252	31	4,799	79%	160	1,305	21%	6,104
07/08	3,468	289	21	3,778	76%	185	1,215	24%	4,993
08/09	3,006	244	20	3,269	72%	98	1,264	28%	4,533
09/10	4,149	152	42	4,343	79%	139	1,127	21%	5,470
10 yr ave	3,813	355	33	4,201	75%	198	1,377	25%	5,585
5 yr ave	3,564	241	26	3,831	76%	146	1,208	24%	5,039

Sources: The Gulf Council's Standing and Special Spiny Lobster SSC estimated the recreational landings for 04/05. Otherwise, the data source for 91/92-09/10 sector totals, grand total, and commercial sector breakouts for traps and diving for 94/95-09/10 is from FWC (W. Sharp, pers. comm., Nov. 7, 2010, including updates as of June 24, 2010). Data source for commercial sector breakouts for traps and diving, 86/8-93/94 and estimated fishing mortality associated with the use of under-sized lobsters as bait (attractants) in traps for all years is SEDAR 8 update 2010 (01Dec10). Landings for "other" commercial gear estimated from unrounded data used in this table. Recreational landings from 92/93 are estimated using surveys of recreational lobster permit holders and represent combined landings during the special 2-day sport season and from opening day of the regular season (Aug. 6) through Labor Day. Grand total excludes estimated fishing mortality for bait. Underlying data may differ among sources.

So, why does increasing harvest from one sector have the effect of reducing the harvest of another sector? It is because the total lobster harvest each year is largely dependent upon the number of lobster available to be harvested that year and not by the amount of fishing effort expended to catch those lobsters, except in those unusual circumstances where effort is curtailed by extraordinary events such as hurricanes. Across the range of effort in the fishery since approximately 1975, landings and effort have not been related. Good fishing years have occurred with high and low effort, as have poor fishing years. For example, the best year on record for the commercial fishery was 1979 when nearly 7.9 mp were landed using about 600,000 traps. In contrast, 1983 was a poor fishing season with a harvest of 4.5 mp, again from about 600,000 traps. Similar observations can be made in recent years when landings estimates for all fishing groups were available. During 1999, the fishery (recreational and commercial) harvested 10.1 mp from 534,000 traps, 4,377 commercial fishing dive days, and 555,000 recreational fishing days. In contrast, the 2001 harvest of 4.3 mp was caught from the same number of traps, 4,538 commercial dive days, and 366,000 recreational fishing days. Furthermore, the size-structure of the lobsters landed by the fishery has remained constant since 1987, as has the average size. The average size has consistently been 3 ¼-in carapace length, just barely above the minimum legal size. This indicates that the fishery is heavily reliant on a single year class of lobsters each season – those that have just grown to legal size. Fluctuations in harvest are related to fluctuations in the numbers of new recruits to the fishery and not the number of traps, diver-days or recreational fishing days. Put another way, the size of the 'lobster pie' each year is determined by the number of lobsters attaining legal size. A change in fishing effort by any one sector simply alters that sector's piece of the pie.

The Councils used the alternatives and the administrative record developed by the FWC as the basis for developing allocation alternatives given that the majority of the harvest occurs off Florida and given that the Councils have delegated much of the management to Florida through a protocol established in Spiny Lobster Amendment 2 in 1989. The consensus recommendations of the Advisory Board, including all options evaluated, are presented in a document dated May 2007. The alternatives and rational are taken from the Facilitator's Summary Report of the May 23-24, 2006 Meeting. These documents and other materials related to the Spiny Lobster Advisory Committee are available at: http://consensus.fsu.edu/FWC/LAB.html

Allocating the ACL between the recreational and commercial sectors will have no direct effect on the physical and biological/ecological environments. The range of commercial allocations (74-80%) is not sufficient to affect the number of lobster traps used so there would be no change in the impacts from lobster traps. A discussion of the impacts of each sector on target and non-target species can be found in the Bycatch Practicability Analysis (Appendix D).

4.3.2 Direct and Indirect Effect on the Economic Environment

The sector allocations under Action 3 have no application in Amendment 10 apart from ACL and ACT alternatives under Action 4 wherein they are incorporated. In this context, their effects are discussed in Section 4.4.2. Sector allocations and ACTs are not mandated under the Magnuson-Stevens Act, whereas ACLs and AMs are. Any economic impacts of Amendment 10 would occur largely in Monroe County. That is, even though the FMP applies to all southeastern coastal states (North Carolina through Texas), practically all of the landings of Caribbean spiny lobster occur in Florida, largely in Monroe County, which accounts for 90% for Florida's commercial landings and 67% of Florida's recreational landings (averages for 2005/06-2009/10).[8]

Recreational and commercial landings and fishing effort for Caribbean spiny lobster in Florida have been volatile, and mostly lower from 2001/2002 onward than in the 1990s (Figures 4.3.2.1 and 4.3.2.2).

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[8] Relatively small amounts have been reported for other states since 1977, in most instances for fewer than three dealers, in which case the data are confidential (unpublished analysis of NMFS, SEFSC, ALS data as of Aug. 31, 2010). The percentages of landings for Monroe County are based on 04/05-09/10 averages for data from J. Munyandorero and R. Muller (FWC, pers. comm.).

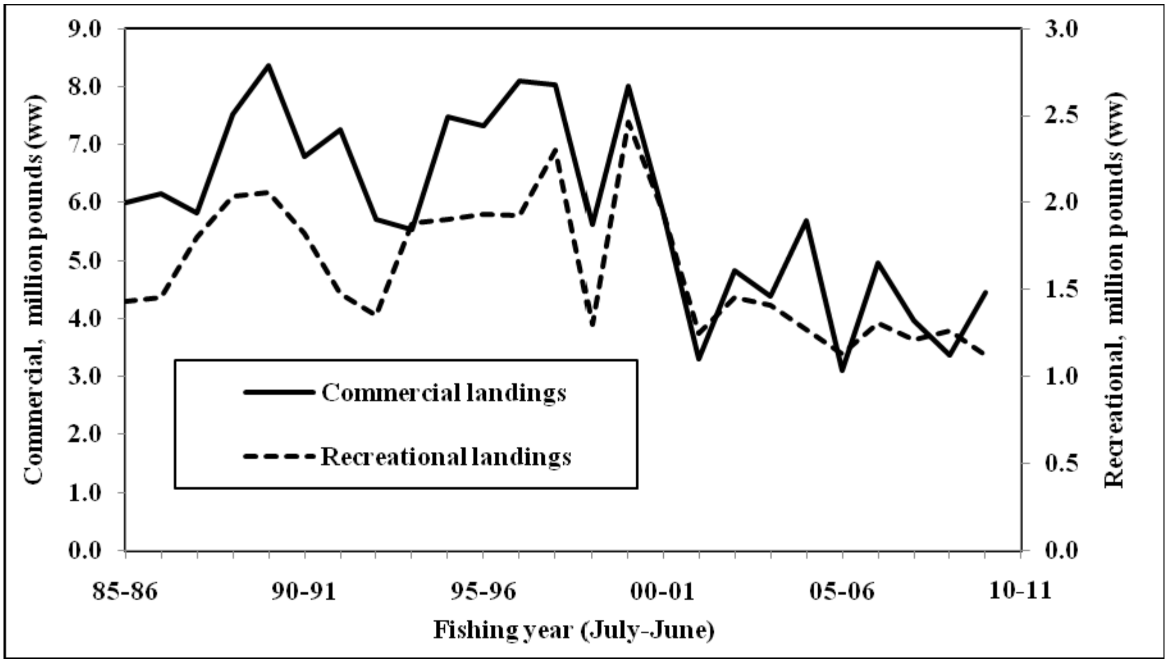

Figure 4.3.2.1. Florida commercial and recreational landings.
Source: SEDAR-8, 2010 update.

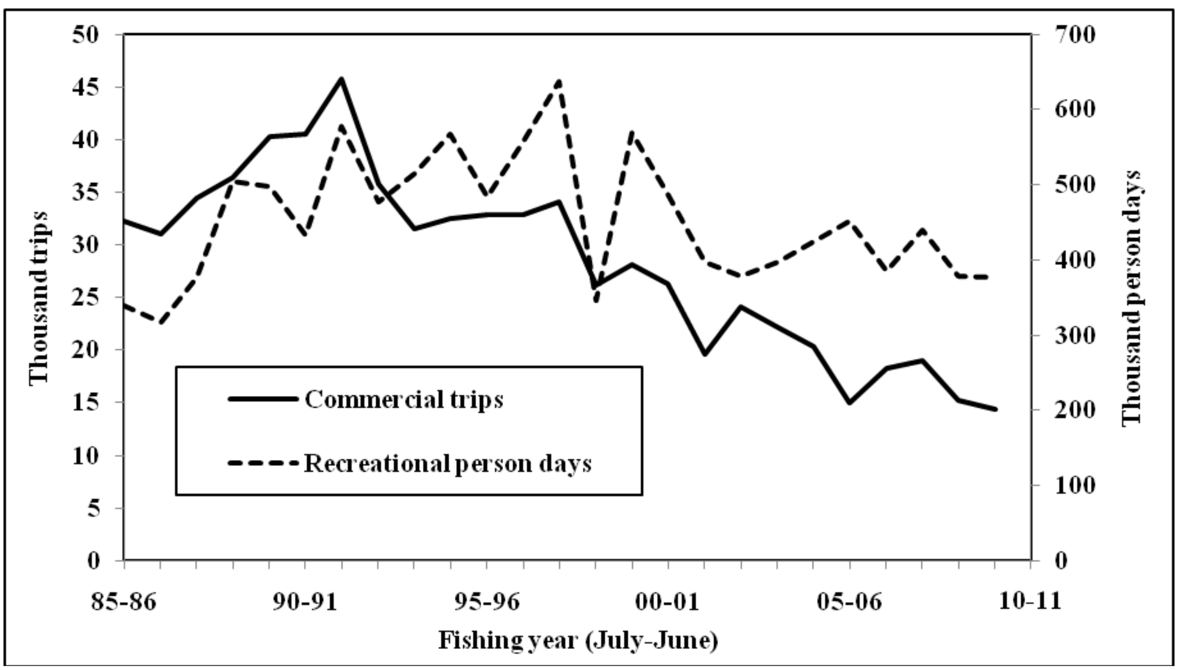

Figure 4.3.2.2. Florida commercial and recreational fishing effort.
Source: SEDAR-8, 2010 update.

Since 1991, regulation of recreational landings of Caribbean spiny lobster in Florida has been achieved through a system of state and federal bag limits, which vary by area fished and time of year. In addition, there are mandatory licenses and permits, as described in Sections 3.1.3 and

3.4.2. In contrast with commercial fishing for spiny lobster, however, participation and entry to the recreational sector are not limited (Shivlani 2009). Data on recreational landings, effort, and numbers of permits, and lower ex-vessel prices in the commercial sector all reflect weakened national economic conditions in the last few years (see figures in Sections 3.1.3 and 3.1.4).

Commercial fishing effort for Caribbean spiny lobster in Florida has been reduced substantially under the State's Trap Certificate Program. The number of vessel and trips with landings are far less than what they were in the early 1990s, along with the number of hours fished and the estimated number of traps fished (Vondruska 2010a). Despite lower landings in the 2000s (Figure 4.3.2.1), trends in productivity continued to increase in terms of landings per trip and landings per vessel, albeit at a slower pace than in the past (Section 3.4.1). Recreational landings were also lower in the 2000s, but fishing effort appears to be relatively flat compared with commercial fishing effort (Figures 4.3.2.1 and 4.3.2.2), and recreational CPUE has remained relatively flat compared with commercial fishing CPUE (Figures 3.4.1.3 and 3.1.3.4).

4.3.3 Direct and Indirect Effect on the Social Environment

By establishing sector allocations there would likely be some changes in fishing behavior and impacts to the social environment. The mere act of separating the ACL into two sector ACLs has the perception of creating scarcity in that limits have been imposed on each individual sector. The setting of an ACL has the same impact but on the overall fishery. Each subsequent division will drive perceptions of scarcity and likely change the fishing behavior of those within a particular sector. The commercial lobster fishery has been under a trap reduction program since the early 1990s and has seen a gradual reduction in the number of traps being fished. This was the goal of the trap reduction program. However, recently the active trap reduction portion of the program has stopped and only passive trap reduction continues. This was requested by the industry which did not seem to believe the trap reduction program was producing the economic efficiency that was one of the goals of the program. Over the past decade, there has been a gradual increase in the portion of overall landings being taken by the recreational sector. As mentioned above, the Caribbean spiny lobster stock is dependent upon annual recruitment, so harvest is highly dependent upon the effort with either sector. Whether the trap reduction program is partly responsible for this shift is unknown. While traps have been reduced there has not been a parallel reduction in commercial landings. Recreational trips have declined also, so it may not be merely an increase in recreational effort either. It is likely that a complex set of factors are contributing to the shift in landings. Changes in regulation both to commercial diving and recreational diving and the use of casitas along with illegal activity have all likely had an impact on the shifting effort and harvest.

By not establishing separate sector allocations, the **Preferred Alternative 1** would allow for harvest to freely flow between the commercial and recreational sectors as it has in the past; although, if harvest exceeds the overall ACL then both sectors could be closed. This would likely become more an issue for the commercial sector than the recreational, because commercial fishermen continue to fish later in the year when lobsters become scarcer. **Alternatives 2** and **4** would provide an increase in allocation to the commercial sector and subsequent reduction to the recreational; while **Alternative 3** would provide an increase to the recreational sector. Of all the different scenarios, **Alternative 4** seems to have some support as it was selected by the Advisory

Board as the most favorable of the options. **Alternatives 5** and **6** both provide increases to the recreational sector, although smaller than previous alternatives. So, in all cases where sector allocations are imposed, it would be expected that there may be negative social effects to whichever sector receives less than their current allocation and those effects would correspond to the amount of reduction.

4.3.4 Direct and Indirect Effect on the Administrative Environment

Sector allocations (**Alternatives 2-6)** would increase the burden on the administrative environment because two ACLs or ACTs would need to be monitored rather than one, as in **Preferred Alternative 1**. There are no other administrative impacts from allocating among the commercial and recreational sectors other than preparation of the amendment document and notices.

4.3.5 Council Conclusions

The Councils moved the options that would have allocated the ACL by gear within the commercial sectors to Appendix A: Alternatives Considered but Eliminated from Detailed Consideration because some of the quotas were too small to track given the existing quota monitoring programs (e.g., 1% to the commercial bully net fishery). The Councils recognize the competition between commercial diving and commercial trapping but the existing quota monitoring programs do not provide the ability to track these separate commercial quotas. After the Councils chose to combine all gear types when determining allocations for each sector, alternatives were moved to Appendix A that were identical or very similar to alternatives retained under the action. The Councils chose to not designate sector allocations to minimize the administrative burden, and also because the ACL will likely not be exceeded under the current fishery conditions. The Councils will review the decision for sector allocations if landings increase in the future.

4.4 Action 4: Acceptable Biological Catch (ABC) Control Rule, ABC Level(s), Annual Catch Limits, and Annual Catch Targets for Caribbean Spiny Lobster

Action 4-1: Acceptable Biological Catch (ABC) Control Rule

Alternative 1: No Action – Do not establish an ABC Control Rule for spiny lobster.

Preferred Alternative 2: Adopt the following ABC Control rule:
- **Option a**: the South Atlantic Council's ABC control rule.
- **Preferred Option b**: the Gulf Council's ABC control rule.

Alternative 3: Establish an ABC Control Rule where ABC equals OFL.

Alternative 4: Specify ABC as equal to the mean of the last 10 years landings.

Alternative 5: Specify ABC as equal to the high of the last 10 years landings.

Alternative 6: Specify ABC as equal to the low of the last 10 years landings.

Action 4-2: Set Annual Catch Limits (ACLs) for Caribbean Spiny Lobster

Alternative 1: No Action – Do not set ACLs.

Preferred Alternative 2: Set an ACL for the entire stock based on the ABC:
- **Preferred Option a:** ACL = ABC = (7.32 million pounds).
- **Option b:** ACL = 90% of ABC (6.59 million pounds).
- **Option c:** ACL = 80% of ABC (5.86 million pounds).

Alternative 3: Set ACLs for each sector based on allocations determined in Action 3:
- **Option a:** ACL = (sector allocation x ABC).
- **Option b:** ACL = 80% or 90% of (sector allocation x ABC).
- **Option c:** ACL = sector allocation x (80% or 90% of ABC).

Action 4-3: Set Annual Catch Targets (ACTs) for Caribbean Spiny Lobster

Alternative 1: No Action – Do not set ACTs.

Preferred Alternative 2: Set an ACT for the entire stock.
- **Preferred Option a:** ACT = OY = 90% of ACL (6.59 million pounds).
- **Option b:** ACT = OY = ACL (7.32 million pounds).
- **Option c:** ACT = OY = 6.0 million pounds.

Alternative 3: Set ACTs for each sector based on allocations from Action 3.

Option a: ACT = OY = (sector allocation x ACL).

Option b: ACT = OY = 90% of (sector allocation x ACL).

Option c: ACT = OY = sector allocation x (90% of ACL).

4.4.1 Direct and Indirect Effects on the Physical and Biological/Ecological Environments

Setting an ABC control rule (Action 4-1) would not affect the physical or biological environments. Setting an ACL or ACT (Actions 4-2 and 4-3) could affect the physical environment if harvest changes from current levels. Lobster fishing, particularly when traps are used, can have negative impacts on the bottom as described in Section 4.9.1. Commercial trap fishing for Caribbean spiny lobster is not managed by landings but by restricting the number of trap tags issued by Florida. Therefore, unless the state increases the number of trap tags it distributes, the number of traps could not increase even if more landings were allowed. If harvest is restricted under an ACL or ACT, fishing effort could be reduced through AMs such as a shortened season, and negative impacts to the resource might be decreased.

Setting an ACL or ACT (Action 4-2 and 4-3) potentially will have an impact on the biological environment if harvest changes from current levels, and AMs are triggered when the ACL or ACT are met or exceeded. An ACL equal to the ABC would allow a higher level of landings than an ACL lower than the ABC. Likewise, not setting an ACT may allow a higher level of landings than setting an ACT below the ACL. **Preferred Alternative 2, Option a** for Action 4-3 sets an ACT higher than the recent 10-year average and has only been exceeded once in the past 10 years. Even the most restrictive ACT (**Option c**) is higher than the recent 10-year average. Therefore, no biological impacts would be expected from setting ACL and ABC.

Traps impact species other than lobsters. Fish, crabs, and other invertebrates may be captured as bycatch. Marine mammals and sea turtles can become entangled in trap line. These negative biological impacts could increase or decrease if effort changes; however, effort is not expected to increase. Current effort is limited by the number of trap tags issued by Florida, commercial and recreational bag limits, and the length of the fishing season. Although fishers could fish more often and fish during a longer part of the season to increase effort, they presumably are already fishing at the level they desire because regulations do not prohibit such increased effort.

The more divided the ACL or ACT is, the more accountability each division will have. With a single ACL or ACT for the stock (**Preferred Alternative 2,** Actions 4-3 and 4-3), one sector could exceed its allocation without triggering AMs, as long as the stock ACL is not exceeded. If the ACL or ACT is separated by sectors (**Preferred Alternative 3,** Actions 4-3 and 4-3), AMs would be triggered as each sector reaches its limit, provided adequate monitoring could be in place. This level of control would be expected to result in greater positive impacts on the biological environment because catch would be more restricted. Further, with separate ACLs or ACTs, different types of AMs could be triggered that are more suited to the particular sector, and therefore, be more effective in constraining harvest within the ACL.

4.4.2 Direct and Indirect Effect on the Economic Environment

The ABCs for **Alternatives 2-6** of Action 4-1 are shown in Table 4.4.2.1. These ABCs are transferred to Table 4.4.2.2, which provides a basis for comparing the effects of sector allocations, ABCs, and ACLs. There are 108 single or paired-set ACLs possible. For example, consider the ACL in the upper left corner of Table 4.4.2.2, 5.522 mp, which is for **Preferred Alternative 2, Option a** of Action 4-2 (ACL = 100% of ABC) and **Alternative 2, Option a** of Action 4-1 (ABC = 10-year median landings). For purposes of comparison, it is assumed that landings under **Alternative 1** are as shown in Table 4.4.2.1.

Table 4.4.2.1 Caribbean spiny lobster off Florida status quo landings & ABCs in million pounds (ww)

ABC alternative	5-yr means	ABC control rule	ABC
Alt. 1 (status quo), total landings	5.039		
Commercial landings	3.831		
Recreational landings	1.208		
Alt. 2a: SAFMC ABC control rule		10-year median	5.522
Alt. 2b: GMFMC ABC control rule		10-year mean + 1.5 sd	7.320
Alt. 3: GMFMC OFL (ABC = OFL)		10-year mean + 2.0 sd	7.900
Alt. 4		10-year mean	5.585
Alt. 5		10-year high	7.518
Alt. 6		10-year low	4.094

Landings for Alternative 1 and the ABC values for Alternatives 2-6 are based on data in Table 2.4.1. The Gulf Council's Standing and Special Spiny Lobster SSC recommended spiny lobster be considered as a special case fishery for purposes of setting OFL and ABC in accord with Tier 3a (draft committee-report summary for the SSC meeting in Tampa, Florida, Jan. 18-21, 2011). They estimated recreational landings for 04/05, which were not available. Data source: FWC (W. Sharp, pers. comm.).

Table 4.4.2.2 Caribbean spiny lobster off Florida. ABC control rules and ACLs in million pounds (ww)

Action 3, sector allocation alternatives	ACL: % of ABC	Sector %	Action 4.1 ABC Alternatives based on 00/01-09/10 data					
			2a: 10-yr median	2b: 10-yr mean + 1.5 sd	3: 10-yr mean + 2.0 sd	4: 10-yr mean	5: 10-yr high	6: 10-yr low
Action 4-2, Alternative 2, specify overall ACL and OY based on a percentage of ABC								
Alt 2a: ACL = % of ABC	100	na	5.522	7.320	7.900	5.585	7.518	**4.094**
Alt 2b: ACL = % of ABC	90	na	**4.969**	6.588	7.110	5.026	6.766	**3.685**
Alt 2c: ACL = % of ABC	80	na	**4.417**	5.856	6.320	4.468	6.014	**3.275**
Action 4-2, Alternative 3a: Sector ACL = Sector OY = (Sector Allocation % * 100% of ABC)								
Com ACL, Act 3, Alt 2	100	80	4.417	5.856	6.320	4.468	6.014	**3.275**
Rec ACL, Act 3, Alt 2	100	20	**1.104**	1.464	1.580	**1.117**	1.504	**0.819**
Com ACL, Act 3, Alt 3	100	74	4.086	5.417	5.846	4.133	5.563	**3.030**
Rec ACL, Act 3, Alt 3	100	26	1.436	1.903	2.054	1.452	1.955	**1.064**
Com ACL, Act 3, Alt 4	100	78	4.307	5.710	6.162	4.356	5.864	**3.193**
Rec ACL, Act 3, Alt 4	100	22	1.215	1.610	1.738	1.229	1.654	**0.901**
Com ACL, Act 3, Alt 5	100	77	4.252	5.636	6.083	4.300	5.789	**3.153**
Rec ACL, Act 3, Alt 5	100	23	1.684	1.684	1.817	1.285	1.729	**0.942**
Com ACL, Act 3, Alt 6	100	76	4.196	5.563	6.004	4.245	5.713	**3.112**
Rec ACL, Act 3, Alt 6	100	24	1.325	1.757	1.896	1.340	1.804	**0.983**
Action 4-2, Alternative 3b: Sector ACL = Sector OY = (Sector Allocation % * 90% of ABC)								
Com ACL, Act 3, Alt 2	90	80	3.976	5.270	5.688	4.021	5.413	**2.948**
Rec ACL, Act 3, Alt 2	90	20	**0.994**	1.318	1.422	**1.005**	1.353	**0.737**
Com ACL, Act 3, Alt 3	90	74	**3.677**	4.875	5.261	**3.720**	5.007	**2.727**
Rec ACL, Act 3, Alt 3	90	26	1.292	1.713	1.849	1.307	1.759	**0.958**
Com ACL, Act 3, Alt 4	90	78	3.876	5.139	5.546	3.921	5.277	**2.874**
Rec ACL, Act 3, Alt 4	90	22	**1.093**	1.449	1.564	**1.106**	1.489	**0.811**
Com ACL, Act 3, Alt 5	90	77	**3.826**	5.073	5.475	**3.870**	5.210	**2.837**
Rec ACL, Act 3, Alt 5	90	23	**1.143**	1.515	1.635	**1.156**	1.556	**0.847**
Com ACL, Act 3, Alt 6	90	76	**3.777**	5.007	5.404	**3.820**	5.142	**2.800**
Rec ACL, Act 3, Alt 6	90	24	**1.193**	1.581	1.706	**1.206**	1.624	**0.884**
Action 4-2, Alternative 3c: Sector ACL = Sector OY = (Sector Allocation % * 80% of ABC)								
Com ACL, Act 3, Alt 2	80	80	**3.534**	4.685	5.056	**3.574**	4.811	**2.620**
Rec ACL, Act 3, Alt 2	80	20	**0.883**	**1.171**	1.264	**0.894**	**1.203**	**0.655**
Com ACL, Act 3, Alt 3	80	74	**3.269**	4.333	4.677	**3.306**	4.451	**2.424**
Rec ACL, Act 3, Alt 3	80	26	**1.148**	1.523	1.643	**1.162**	1.564	**0.852**
Com ACL, Act 3, Alt 4	80	78	**3.445**	4.568	4.930	**3.485**	4.691	**2.555**
Rec ACL, Act 3, Alt 4	80	22	**0.972**	1.288	1.390	**0.983**	1.323	**0.721**
Com ACL, Act 3, Alt 5	80	77	**3.401**	4.509	4.866	**3.440**	4.631	**2.522**
Rec ACL, Act 3, Alt 5	80	23	**1.016**	1.347	1.454	**1.028**	1.383	**0.753**
Com ACL, Act 3, Alt 6	80	76	**3.357**	4.451	4.803	**3.396**	4.571	**2.489**
Rec ACL, Act 3, Alt 6	80	24	**1.060**	1.405	1.517	**1.072**	1.443	**0.786**

Source: ABCs in Table 4.4.2.1

Sector allocations may be perceived as a conservation measure, but they could restrict total catch well below ABC if activity in one sector is curtailed because that sector's ACL is reached and the ACL for the other sector is not reached. This could result in triggering AMs for one sector while the other sector would not be affected, and total landings would remain below the overall limit.

Under **Alternative 1**, management conditions and related operation of the fishery, and associated economic benefits, would remain unchanged, with some caveats. The choice of **Alternative 1** for Actions 4-1 and 4-2 would lead a decision by the Secretary of Commerce to not approve Amendment 10, and involve the additional work and cost of redoing and resubmitting the amendment, either by NOAA Fisheries Service or the Councils. This could affect constituent perceptions about the ability of fishery managers to comply with the requirements of the Magnuson-Stevens Act to specify ACLs and AMs, thereby introducing elements of uncertainty about future business conditions and fishery regulations. While the extent of any change in economic behavior of fishery participants is not known, uncertainty about business conditions and regulations may be seen as adversely affecting various sectors of the economy, including commercial and recreational fishing. If increased protection were needed, such as might occur with a lower ACLs, then **Alternative 1** could preclude such protection from occurring, thereby increasing the likelihood of current or future resource decline, with associated reduction in economic benefits.

On the other hand, some of the 108 single or paired-set ACLs in Table 4.4.2.2 could require substantial reductions in landings. The ACLs with commercial, recreational, or total landings below those for Action 4-2 **Alternative 1** are shown in bold type, referring to **Alternative 1** commercial landings of 3.831 mp, recreational landings of 1.208 mp, and total landings of 5.039 mp**.** Arguably, economic activity could have been reduced under the more traditional output-control AMs of Action 5, and/or via further adjustments to Florida market-oriented input-control regulations for the commercial sector.[9] Given the alternatives specified in Amendment 10, however, the more traditional output-control regulations for the commercial sector (to limit landings, impose trips limits and shorten seasons) of Actions 4 and 5 may be seen as having differing, if not conflicting objectives, in that they would introduce a move away from a private market mechanism for allocating harvesting rights (Larkin and Milon 2000, quoted in Section 3.1.2).

The regulations for recreational fishing of Actions 4 and 5 and state regulations are more harmonious, if not market oriented. Florida has used area-specific bag limits and seasons to regulate recreational fishing and has not limited or reduced the relatively large number of recreational licenses and permits that may be issued (Table 3.4.2.1; Sections 3.1.3 and 3.4.2). The prospects for implementing market mechanisms under state or federal auspices to allocate

[9]Since the early 1990s, the State's Trap Certificate Program has been quite successful in meeting the objectives of substantially reducing commercial fishing effort, thereby improving productivity and economic conditions for remaining fishermen (Table 3.1.2.1; Sections 3.1.2 and 3.4.1). Much smaller landings, numbers of permits, and effort have been reduced by the State for commercial divers, as well as for recreational divers with Special Recreational Crawfish Licenses (Table 3.1.2.1).

recreational harvesting rights for spiny lobster would seem remote at best, though such mechanisms have been employed in recreational hunting and fishing.

Regardless, the impact on economic activity associated recreational fishing of lower bag limits, early season closures, and/or shorter seasons are more difficult to quantify than are counterparts for commercial fishing. This is because the demand for recreational fishing activity relates in part to other dimensions of trips than the amount of fish or shellfish caught. It is possible that bag limit analyses could be conducted using data collected by the FWC. One might expect a considerable range in the number of lobsters per person per trip, ranging from zero to beyond the bag limit. If so, one would expect that a reduced bag limit would affect some trips, but not all. Still, the dollar amount per lobster in terms of willingness to pay is much higher for decreases in bag limits than for increases in bag limits (FWC survey of recreational lobster fishing of 1992; see Section 3.4.2).

Data on participants in recreational fishing in Florida has been collected annually via two mail-in surveys sent to persons with lobster licenses/permits (Section 3.4.2). The mail-in surveys would not include data for spiny lobster caught by passengers aboard for-hire fishing vessels when individual participants do not have Florida licenses and permits (see Section 3.4.2, last paragraph under "Number and Description of Recreational Fishers"). Furthermore, data on economic activity specifically for for-hire vessels engaged in trips for spiny lobster does not appear to be available.

4.4.3 Direct and Indirect Effect on the Social Environment

That ABC can have important social effects as it is in many ways the determination of stock status and all decisions of allowable harvest level are derived from that threshold. For Action 4-1, **Alternative 1** seems to be untenable, since some level needs to be set, unless as in **Alternative 3** the threshold is equal to the OFL which would likely impose few negative social effects, but could risk a volatile stock status. **Preferred Alternative 2** offers **Option a** and **Preferred Option b** corresponding to each Council's SSC control rule which would vary depending upon the threshold levels that are calculated. The Gulf Council SSC's ABC calculations are above the most recent landing levels. With **Alternative 4** using the mean of the last 10 years, there would be a reduction from the most recent years landings and certainly **Alternative 6,** which uses the lowest landing level of the past 10 years, would have negative social effects as it would reduce harvest from current levels. **Alternative 5** would have few negative social effects in the short term as there would be no reduction in harvest, but may have long term effects if the catch limits are too high and jeopardize stock status.

Setting thresholds that adequately assess biological risk through harvest levels on stocks that are vulnerable can help stabilize landings and thereby provide long-term benefits to the fishery which should translate into positive social benefits over time. It is the short-term costs involved that often drive perceptions of negative impacts. These impacts can translate into real costs that have significant impacts to both the commercial and recreational sectors. For Action 4-2, **Alternative 1** would not set ACLs and in that case harvest levels would likely revert to some other threshold, like ABC. This would likely have fewer negative social effects than a more restrictive ACL like those in **Alternative 2, Options b** and **c**. **Preferred Alternative 2, Option**

a would not impose a more restrictive catch limit. **Alternative 3, Option a** would be similar except that it incorporates sector allocations as do **Alternative 3, Options b and c**.

It is the setting of ACTs where social and economic considerations might enter the equation as management uncertainty is evaluated. Setting of ACTs is utilized in fisheries where there may be management uncertainty that adds risk to reaching target harvest levels beyond the biological risks. It usually entails a further reduction in harvest levels to ensure catch remains at or below the ACL and does not wildly fluctuate. For fisheries where information is scarce and management is uncertain, it becomes a real possibility that there can be negative short-term impacts that may not have been necessary if thresholds are too restrictive. In other fisheries which have more certainty in management and monitoring of catch, a more precise harvest level can be set with certainty and reduce volatility in the fishery. The spiny lobster fishery does not seem to be overfished and has not experienced large fluctuations in landings, although, there are many avenues for changes in stock status that are attributed to factors outside of manager's purview, i.e. disease, hurricanes, or habitat degradation. Management has imposed restrictions on catch that over the years has imposed some certainty, yet the recreational fishery does not have the timely monitoring that can be imposed on the commercial fishery. The spiny lobster fishery seems to be stable and would not require an ACT if managers felt a level of certainty in the present management regime. Therefore for Action 4-3, **Alternative 1** would not impose further negative social effects. **Alternatives 2** and **3** could impose further reductions in harvest and could have short-term negative effects depending upon the reduction of harvest from present levels. It is assumed that if alternatives were chosen that do reduce current harvest levels it would be for the long-term benefits of increasing stock status which may have positive social benefits in the long term, but is entirely dependent upon the severity of the short-term negative social effects. **Preferred Alternative 2, Option a** would be above the most recent landing levels, although in the past landings have exceeded that threshold. Because it does have a buffer from the ACL, exceeding the ACT should not jeopardize the stock.

4.4.4 Direct and Indirect Effects on the Administrative Environment

Alternative 1 for Actions 4-1 and 4-2 would not meet the requirements in the Magnuson-Stevens Act and the Code of Federal Regulations, and could be subject to litigation, which would result in a significant administrative burden on the agency. Specifying an ABC control rule would not increase the administrative burden over the status-quo. With establishment of an ACL or ACT (Actions 4-2 and 4-3, **Preferred Alternative 2** and **Alternative 3**), commercial landings would need to be included in the Southeast Fisheries Science Center's Quota Monitoring System. This system requires dealers to report landings, usually on a biweekly basis. Currently, commercial fishermen report their catch through state trip tickets, which are compiled over several months before totals are available for federal management. Recreational catch is estimated based on telephone, email, and dockside surveys. Recreational landings are not collected by the Marine Recreational Information Program (MRIP).

For Actions 4-2 and 4-3, **Alternative 3** provides options related to the allocation of the quota between the commercial and recreational sectors. Options to track the ACL or ACT by sector would have a greater administrative impact than single stock ACL or ACT (**Preferred**

Alternative 2) because landings would need to be monitored in relation to the commercial and recreational separately.

4.4.5 Council Conclusions

For Action 4-1, the Councils chose **Preferred Alternative 2, Option b** to be consistent with decisions made for other species and to provide a statistically based way of setting ABC, even if a new stock assessment changed the status of the stock. In that case, the same control rule could be used, but the SSC could choose a different tier, based on the best scientific information. **Alternative 1** would not meet the Magnuson-Stevens Act requirements and **Alternatives 3-6** would not allow for changes to the ABC based on subsequent stock assessments.

For Action 4-2, the Councils chose to set an ACL equal to the ABC (**Preferred Alternative 2, Option a**) because total landings of Caribbean spiny lobster have been below that level for many years. The stock is not believed to be overfished or undergoing overfishing, so further reductions in catch (**Options b-c**) are not necessary. The Council did not choose **Alternative 3** because no sector allocations currently exist and implementing AMs separately would impose an unnecessary burden. **Alternative 1** would not meet the Magnuson-Stevens Act requirements.

For Action 4-3, the Councils chose **Preferred Alternative 2** because an ACT would provide a reference point if landings increased over recent average levels. **Preferred Option a** sets a buffer from the ACL, which means if the ACT is exceeded due to increasing landings, new measures could be implemented before the ACL is reached. **Option b** would not establish a buffer, and **Option c** would not allow the ACT to change if the ACL changed. The Councils did not choose sector ACTs (**Alternative 3**) for the same reasons they did not choose sector ACLs.

4.5 Action 5: Accountability Measures (AMs) by Sector

*Note: More than one alternative, option, sub-option, or combinations thereof, may be chosen as preferred.

Alternative 1: No Action – Do not set AMs. Currently there are no management measures in place that could be considered AMs.

Alternative 2: Establish commercial in-season AMs**:**

- **Option a**: Close the commercial fishery when the ACL is projected to be met.
- **Option b**: Implement a commercial trip limit when 75% of the commercial ACL is projected to be met.

Alternative 3: Establish post-season AMs:

- **Option a**: Commercial
  - **Sub-option i**: ACL payback in the fishing season following a previous years ACL overage.
  - **Sub-option ii**: Adjust the length of the fishing season following an ACL overage.

Sub-option iii: Implement a trip limit.

Option b: Recreational

Sub-option i: ACL payback in the fishing season following an ACL overage. To estimate the overage, compare the recreational ACL with recreational landings over a range of years. For 2011, use only 2011 landings. For 2012, use the average landings of 2011 and 2012. For 2013 and beyond, use the most recent three-year running average.

Sub-option ii: Adjust the length of the fishing season following an ACL overage. To estimate the overage, compare recreational ACL with recreational landings over a range of years. For 2011, use only 2011 landings. For 2012, use the average landings of 2011 and 2012. For 2013 and beyond, use the most recent three-year running average.

Sub-option iii: Adjust bag limit for the fishing season following a previous season's ACL overage.

Option c: Recreational and commercial combined accountability measures

Sub-option i: Adjust season length for both recreational and commercial harvest of spiny lobster in the fishing season following an ACL overage.

Sub-option ii: Recreational and commercial ACL payback in the fishing season following a previous season's ACL overage (if a combined ACL is chosen).

Preferred Alternative 4: Establish the ACT as the accountability measure for Caribbean spiny lobster (ACT = 6.59 million pounds).

4.5.1 Direct and Indirect Effect on the Physical and Biological/Ecological Environments

Alternative 1 is not considered a viable option since it would specify no AMs and therefore, would not limit harvest to the ACL or correct for an ACL overage if one were to occur. The Magnuson-Stevens Act requires that mechanisms of accountability be established for all federally managed species, with exceptions for ecosystem component species and species with annual life cycles. **Alternative 1** would not comply with this mandate, and would provide no biological benefit to the species.

Before proceeding with the discussion of AMs it is important to note that a recent study using microsatellite DNA analysis to identify sources of recruitment among Caribbean spiny lobsters indicates the majority of recruits come from areas outside the management area (Hunt and Tringali 2011). Therefore, any true biological benefits that may accrue in the Caribbean spiny lobster population found within the subject management area, as a result of implementing any one of the AMs considered, are likely to be negligible. What is more likely to significantly impact the local population of spiny lobster is an environmental event on a more regional scale that could potentially disrupt current larval dispersion patterns into and out of the management area, or alter the habitat in such a way as to prevent the settling post-larvae Caribbean spiny lobster in southeastern U.S. waters.

The Councils considered in-season AMs for the recreational sector of the spiny lobster fishery; however, difficulties in accurately tracking recreational harvest of spiny lobster in-season precluded further consideration of those alternatives (See Appendix A for Considered but Rejected Alternatives). The newly implemented MRIP does not collect landings information on crustaceans, so in-season tracking of spiny lobster landings in the recreational fishery would depend on Florida's limited recreational data survey program. Therefore, the implementation of in-season AMs is not practical for the recreational sector of the spiny lobster fishery.

Alternative 2 would attempt to limit commercial harvest to levels at or below the ACL by reducing and/or prohibiting harvest once the ACL or a portion of the ACL is projected to be met. Tracking recreational landings of spiny lobster in-season would be very difficult because spiny lobster landings are not currently collected under MRIP. Thus, **Alternative 2** would be considered a sector AM for the commercial sector only. However, the current preferred alternatives for the actions to establish ACL and ACT use a single ACL equal to OY which is equal to the ABC, and a single ACT for the commercial and recreational sectors equal to 6.59 mp. In this case, there may be no need to establish separate commercial and recreational AMs for the spiny lobster fishery.

The most biologically beneficial in-season commercial sector AM would be a combination of **Alternative 2, Option a** and **Option b**. The combination of these options would help to hedge against an ACL overage by reducing the trip limit when 75% of the commercial ACL is projected to be met, and then close the commercial sector when the quota is projected to be met. Closing the commercial fishery once the ACL is projected to be met would remove the incentive to harvest spiny lobster because purchase and sale would also be prohibited.

Alternative 3 includes a large suite of possible sector-specific post-season AMs that would be triggered in the event of an ACL overage. As noted previously, the current single ACL and ACT preferred alternatives eliminate the need for separate post-season AMs for the commercial and recreational sectors.

The post-season AM options are designed to compensate or correct for the magnitude of an overage during the following fishing year. In doing so, harvest levels would return to their baseline ACL over the course of two fishing years, the year of the overage and the year of the overage correction. Biologically, the ideal scenario is not to allow the ACL to be exceeded, then no post-season AM would be required and the stock would realize the biological benefits of sustainable harvest conditions into perpetuity. Unfortunately, management and scientific uncertainty, and numerous other variables including economic and unforeseen biologic and weather events, play a major role in annual spiny lobster landings, which may fall above or below any number of harvest parameters. The advantage of implementing post-season AMs is that the landings data for any given year can be examined in totality before the AM is actually triggered, as opposed to in-season AMs that would rely largely on projections of harvest that may or may not have a high degree of uncertainty. Using actual landings data to calculate the precise magnitude of an overage is typically biologically beneficial in that it ensures an adequate level of payback is implemented.

A combination of recreational and commercial AMs (**Alternative 3, Options a** and **b**), would yield similar biological benefits when compared to **Option c**, which combines sector AMs. **Option b** alone would be the least biologically beneficial post-season AM because it does not compensate for any overages created by the commercial fishery. The variability in recreational landings data should be taken into account when considering **Option b** under **Alternative 3**.

Currently, the Florida, where the majority of recreational fishing for spiny lobster takes place, tracks recreational landings through two separate annual surveys sent to fishermen holding recreational lobster permits. The surveys are distributed via e-mail to collect landings information on harvest during the Special Two-Day Season, and from the opening day of the regular season through the first Monday in September (when the majority of spiny lobster fishing effort occurs) (Sharp et al. 2005). Because Florida is the only state to track recreational landings of spiny lobster and no recreational landings data are collected by NOAA Fisheries Service, a new recreational ACL monitoring program would need to be developed that would incorporate a mechanism to collect recreational and commercial landings information to track ACLs. A commercial ACL monitoring program for spiny lobster could potentially be dealer-based through the establishment of a dealer permit and reporting program specifically designed for spiny lobster. However, a federal dealer permit for spiny lobster does not currently exist. Additionally, spiny lobster could be added to the list of species for which recreational landings data is captured through MRIP, though doing so may not address the issue of time lags between the time of harvest and the time when the data are available to fisheries managers. Any supplemental or improved data collection efforts for spiny lobster could improve our understanding of the stock's population dynamics and harvest trends through time.

Because recreational landings data are known to be highly variable and MRIP does not currently collect information on spiny lobster harvest, using a three-year running average of estimated recreational landings compared to the recreational ACL could reduce, to some extent, variability caused by anomalous spikes or declines in landings. Sudden spikes or reductions in harvest could greatly influence post-season AMs in the recreational sector if they are only considered on a year-by-year basis. Averaging recreational spiny lobster harvest over several years would minimize the influence any one exceptionally poor or exceptionally good year could have on the magnitude of the pay-back or season length reduction. **Alternative 3, Option a** is a more biologically conservative alternative than **Option b** because the commercial component of the fishery is larger than the recreational component; however, it does not account for any overages in the recreational sector. The most precautionary post-season AM is **Option c**, which includes AMs for the commercial and recreational sectors, and would therefore be expected to adequately compensate for overages in one or both sectors. Reducing the length of the fishing season by the amount needed to pay back the overage in addition to shortening the season length to prevent a future overage would provide an additional safeguard when compared to only reducing the length of the fishing season.

Preferred Alternative 4 would use the ACT (6.59 mp) as the AM, which is based on 90% of the specified ACL value (7.32 mp). The ACL is equal to the ABC, which is derived using the ABC control rule adopted by the Gulf Council. The Councils felt an ACT that is 10% lower than the ACL would provide an adequate buffer between the target level of harvest and the annual limit on harvest. The level of harvest would be compared to the ACT and evaluated on an ongoing basis. An exceedence of the ACT would automatically trigger an AM whereby the Councils will convene a review panel to assess whether or not corrective action is needed to prevent the ACL from being exceeded. If the review panel determines corrective action is needed the Council's may request an emergency rule or framework amendment to implement management measures intended to limit harvest below the ACL such as bag limits, seasonal closures, and trip limits.

As part of the performance standard, if the catch exceeds the ACL more than once in the last four consecutive years, the entire system of ACLs and AMs would be re-evaluated as required by the National Standard 1 guidelines. If the subject evaluation reveals that some modification to the current National Standard 1 harvest parameters for Caribbean spiny lobster is needed in order to prevent ACL overages, such changes could be made expeditiously through a framework action based on the updated framework procedure for Caribbean spiny lobster. Regulatory amendments require less time to prepare; therefore, they are often the regulatory instrument of choice when a management measure or harvest level requires an adjustment.

The final rule implementing National Standard 1 guidelines states: "For fisheries without in-season management control to prevent the ACL from being exceeded, AMs should utilize ACTs that are set below ACLs so that catches do not exceed the ACL" (74 FR 3178). The current preferred alternative for ACL is to set the ACL equal to the ABC which would be 7.32 mp according to the Gulf Council's preferred ABC. Therefore, using an ACT of 6.59 mp as the AM for Caribbean spiny lobster is consistent with the National Standard 1 guidelines. Additionally, in-season tracking of landings of Caribbean spiny lobster may be associated with a high degree of uncertainty, especially for landings made by the recreational sector. The difficulty associated with tracking in-season landings of Caribbean spiny lobster, the Council's specification of an ACT below the preferred ACL value, and the ability to readily adjust management measures through framework amendments, makes the use of an ACT a reasonable AM alternative for Caribbean spiny lobster.

The biological impacts of **Preferred Alternative 4** would likely be similar to the status quo since the combined recreational/commercial average landings for the last 10 fishing seasons does not exceed the proposed ACT, and the maximum landings over the past three years falls slightly below the proposed ACT. Variations in year-to-year harvest would be accounted for by evaluating what percentage of the ACT is caught over several years, rather than on a single season basis. It is unlikely the ACL would be exceeded under the current ACL preferred alternative based on landings history; however, the updated framework procedure contained within this amendment would facilitate timely adjustments to the National Standard 1 harvest parameters and management measures if needed in the future. The ability to expeditiously implement modifications to the ACL, ACT, AMs, and management measures for Caribbean spiny lobster would limit any negative biological impact that could result from continued ACT or ACL overages.

Alternative 1 would perpetuate the existing level of risk for interactions between Endangered Species Act (ESA)-listed species and the fishery. Establishing AMs is unlikely to alter fishing behavior in a way that would cause new adverse effects to *Acropora* corals. The potential impacts of **Alternatives 2- 4,** and the associated options, on sea turtles and smalltooth sawfish are unclear. If they perpetuate the existing amount of fishing effort, but cause effort redistribution, any potential effort shift is unlikely to change the level of interaction between sea turtles and smalltooth sawfish and the fishery as a whole. If these alternatives reduce the overall amount of fishing effort in the fishery, the risk of interaction between sea turtles and smalltooth sawfish will likely decrease.

4.5.2 Direct and Indirect Effect on the Economic Environment

Some alternatives and options under Action 5 could have differential economic impacts by sector, adding to those that have accrued over time in part under existing Florida regulations. Under Florida regulations, participation and entry are not limited for recreational fishing, but they are clearly limited for commercial fishing (Shivlani 2009). Some options under Action 5 may have a negative economic impact on commercial fishing via limits on landings, trips, and season length, but have no impact on recreation fishing. Other alternatives and options under Action 5 could impact both sectors, or they could impact recreational fishing, but not commercial fishing.

In retrospect, economic activity associated with commercial fishing for spiny lobster in Florida could have been reduced, if necessary, via further adjustments to Florida market-oriented input-control regulations for the commercial sector.[10] It is noted that the guidelines for NS1 of the Magnuson-Stevens Act do allow “reductions in effort,” or other measures besides output controls [50 CFR § 610.310 (g) accountability measures]. However, the alternatives specified under Action 5 may be seen as having differing, if not conflicting objectives, in that they bring a move away from an innovative private market mechanism for allocating harvesting rights (Larkin and Milon 2000, quoted in Section 3.1.2). Commercial fishing effort for Caribbean spiny lobster in Florida has been reduced substantially under the state’s trap certificate reduction program, and it continues to be reduced, albeit at a slower rate (see Section 4.3.3). In other words, the number of commercial vessels and trips with landings are far below what they were in the early 1990s, along with the number of hours fished and the number of traps fished (Vondruska 2010a). Without these reductions, economic conditions amidst the lower landings of 2001 onward would have been much worse.

Under Action 5, **Preferred Alternative 4** establishes the ACT as the accountability measure for Caribbean spiny lobster, wherein ACT = 6.59 mp, which is less than the ACL of 7.32 mp. The AM is specified as being less than the ACL in accord NS1 of the Magnuson-Stevens Act. The ACT of 6.59 mp exceeds the recent average landings of 5.039 mp, and would not be expected to have any economic impact, assuming that catch in excess of ACT is allowed occasionally.

4.5.3 Direct and Indirect Effect on the Social Environment

The setting of AMs can have significant direct and indirect effects on the social environment as they usually impose some restriction on harvest. The long-term effects should be beneficial as they provide protection from further negative impacts on the stock. While the negative effects

[10]Since the early 1990s, the State’s Trap Certificate Program has been quite successful in meeting the objectives of substantially reducing commercial fishing effort, thereby improving productivity and economic conditions for remaining fishermen (Table 3.1.2.1; Sections 3.1.2 and 3.4.1). Much smaller landings, numbers of permits, and effort have been reduced by the State for commercial divers, as well as for recreational divers with Special Recreational Crawfish Licenses (Table 3.1.2.1).

are usually short term, they may at times induce other indirect effects through changes in fishing behavior.

Alternative 1 would put no AMs in place and would risk damage to the stock if the ACL were exceeded. This would avoid short-term negative social impacts, but may incur longer term impacts if stock status were jeopardized.

The implementation of in-season AMs in **Alternative 2** would require projection of the harvest in the commercial fishery to ensure no overages. This type of quota monitoring is not as precise as post-season and cannot be accomplished with the recreational fishery as in-season monitoring is not feasible. In-season monitoring might contain the overage and lessen the chance of exceeding the ACL if monitoring precision is adequate. **Alternative 2, Option a** would provide immediate protection for the stock by closing the commercial fishery when the ACL is met and depending upon AMs chosen, could provide for accountability if payback is provided. **Alternative 2, Option b** could exceed the ACL by season's end depending upon the trip limit chosen.

The many options under **Alternative 3**, post-season monitoring and accountability can be more precise in both determining the size of the overage, but also the payback necessary. It does however, increase the risk of exceeding an ACL. **Alternative 3, Option a** and its suboptions offer several alternatives for payback for the commercial fishery. **Suboption i** would impose a reduction in next year's ACL to correspond to the overage, while **Suboptions ii** and **iii** offer other avenues for payback to constrain harvest the next year which may be preferable to a straight reduction in harvest levels. **Alternative 3, Option b** offers various suboptions for the AMs for the recreational sector that are similar to the commercial alternatives although the calculations for the harvest level are different. As with the commercial options, **Alternative 3, Option b, Suboption i** would impose an immediate reduction on the next year's harvest, whereas **Suboptions ii** and **iii** offer alternatives that may have fewer negative social impacts that accrue to the recreational sector. **Alternative 3, Option c, Suboptions i** and **ii** offer similar AMs for both sectors combined.

Preferred Alternative 4 would establish the ACT as an AM and would likely have few negative social effects. What impacts are derived from either in-season or post-season AMs would depend upon the volatility of the fishery and the perceived risks of exceeding the ACL. In spiny lobster, it would seem there would be few risks as the fishery seems to be fairly stable and post-season AMs may be adequate. However, as discussed earlier, fishing behaviors can change depending upon management measures chosen and the perception of scarcity. If ACLs begin to be exceeded and AMs are implemented which close the fishery, effort may be directed elsewhere. The ability to redirect fishing effort is becoming more difficult as limited entry management is becoming more common. Therefore, if there are fewer choices for redirecting effort, whether it is changing fisheries or choosing temporary work outside the fishery, the indirect effects on the social environment may extend beyond the lobster fishery. As mentioned in the discussion of Section 3.5, there are outside factors that are affecting fishermen in South Florida. Continued social disruption may be confounded by these other factors that have gradually pushed fishermen and their associated businesses from the waterfront. On the other hand, if AMs are adopted that keep stock status viable and productive, the effects on the social environment may have negative short term effects, but longer term benefits.

4.5.4 Direct and Indirect Effect on the Administrative Environment

Alternative 1 would not produce near-term administrative impacts. However, this alternative would not comply with Magnuson-Stevens Act requirements and therefore, may trigger some type of legal action for not doing so. If this scenario were to occur, the burden on the administrative environment would be great in the future. **Alternative 2** would result in some additional administrative cost and time burdens associated with tracking commercial landings in-season. Florida already has a mechanism in place to track commercial landings of spiny lobster; however, a tracking mechanism would need to be developed to account for spiny lobster landings off other states. **Alternative 3** could potentially produce a significant negative impact on the administrative environment regardless of the choice of options and sub-options. Under each of the sub-options spiny lobster would need to be added to the list of species tracked via MRIP, and through the quota management system. Implementing these ACL tracking mechanisms is not a trivial undertaking and could result in significant administrative cost and time in the near-term and long-term. Additionally, each of the sub-options would require a notice to be drafted and disseminated to fishery participants notifying them of the previous year's overages, and how much the next year's catch limit and/or bag limit would be reduced, or season shortened. **Preferred Alternative 4** could result in moderate administrative impacts in the form of multi-year evaluations of actual harvest compared the ACT and ACL. If the ACT is exceeded the Councils' review panel would need to be convened to determine whether or not corrective action is needed to prevent the ACL from being exceeded. Because corrective actions are not built into this AM, implementation of additional harvest restrictions would require an emergency rule or framework amendments, which can significantly burden the administrative environment. Additionally, if the ACL is exceeded more than once within a four year time period, the burden on the administrative environment would likely increase if a regulatory amendment is needed to modify management measures or harvest limits for Caribbean spiny lobster.

4.5.5 Council Conclusions

The reauthorized Magnuson-Stevens Act requires that AMs be established for all species not subject to overfishing in 2011. Therefore, the Councils must approve some type of AM for the Caribbean spiny lobster fishery. If the Councils failed to chose an AM for implementation, the Spiny Lobster FMP would not be in compliance with the Magnuson-Stevens Act mandate. After considering the suite of AM alternatives presented and analyzed, the Councils chose to use the ACT of 6.59 mp as the harvest level that would trigger an AM. The ACT is based on 90% of the ACL, which is 7.32 mp. The ACL is equal to the ABC, which is derived using the ABC control rule adopted by the Gulf Council. The Councils felt an ACT that is 10% lower than the ACL would provide an adequate buffer between the target level of harvest and the annual limit on harvest. Additionally, the Councils considered new scientific information that indicates the majority of recruits come from areas outside the management area (Hunt and Tringali 2011), meaning any true biological benefits that may accrue in the Caribbean spiny lobster population found within the subject management area, as a result of implementing any one of the AMs considered, are likely to be negligible. The preferred alternative would result in the least socioeconomic impacts on the fishing community, while establishing the system of accountability required under the Magnuson-Stevens Act to ensure that overfishing does not occur. Under the preferred alternative, the level of harvest would be compared to the ACT and evaluated on an ongoing basis. An exceedence of the ACT would automatically trigger an AM whereby the Councils will convene a review panel to assess whether or not corrective action is needed to prevent the ACL from being exceeded. If corrective action is needed management measures could be modified expeditiously via framework action or emergency rule.

4.6 Action 6: Develop or Update a Framework Procedure and Protocol for Enhanced Cooperative Management for Spiny Lobster

*Note: more than one alternative may be chosen as a preferred.

Alternative 1: No Action – Do not update the Protocol for Enhanced Cooperative Management or the Regulatory Amendment Procedure.

Preferred Alternative 2: Update the current Protocol for Enhanced Cooperative Management.

Alternative 3: Update the current Regulatory Amendment Procedures to develop a Framework Procedure to modify ACLs and AMs.

Preferred Alternative 4: Revise the current Regulatory Amendment Procedures to create an expanded Framework Procedure:

- **Preferred Option a:** Adopt the base Framework Procedure
- **Option b:** Adopt the more broad Framework Procedure
- **Option c:** Adopt the more narrow Framework Procedure

4.6.1 Direct and Indirect Effect on the Physical and Biological/Ecological Environments

Alternative 1 would maintain the Regional Administrator's current ability to adjust total allowable catch, quotas, trip limits, bag limits, size limits, seasonal closures, and area closures; however, no means would exist to make needed adjustments to the National Standard 1 harvest parameters in a timely manner. Often, when a harvest reduction is needed, corrective action is required quickly. Not allowing ACLs, ACTs, and AMs to be adjusted through a framework procedure would most likely lead to extended delays in implementing harvest reductions and/or associated AMs. Such a scenario could be biologically detrimental because excessive levels of fishing mortality, or even overfishing, could persist until the appropriate harvest limitations could be put in place through amendment action. Alternately, if new data shows a stock is doing better than previous assessments indicated, unnecessary restrictions could prevent the fishery from harvesting its optimum yield. The impacts on the physical environment would not change under this alternative.

Preferred Alternative 2 would have no impact on the physical or biological environment because its only purpose is to update the protocol, which defines the roles of federal and Florida agencies in managing spiny lobster. The updates would include relevant agency names and authorities. Regardless of how the current framework procedures or protocols are modified, those changes will have no immediate effect because those changes will not cause immediate changes in harvest objectives.

Alternatives 3 and **4** would likely be biologically beneficial for spiny lobster. Under **Alternative 3,** adjustments to ACLs, ACTs, and AMs could be made relatively quickly as new fishery and stock abundance information becomes available. Under **Preferred Alternative 4**, adjustments to other management measures would also be simplified. By changing the current framework procedure to allow for periodic adjustments to National Standard 1 harvest parameters, management measures could be altered in a timely manner to implement harvest level changes or AMs in response to stock assessment or survey results. Allowing ACL and other adjustments to be made through framework actions could eliminate the need to prepare and analyze individual amendments or amendment actions for each adjustment needed. Eliminating these time-consuming factors would enable harvest modifications to be expedited when they are most needed. The physical environment would be indirectly impacted because changes in harvest levels would change effort levels, either increasing or decreasing the impact of traps on the bottom. A quicker change to the regulations would result in a quicker change in the physical impacts of the fishery.

4.6.2 Direct and Indirect Effect on the Economic Environment

Action 6 is primarily administrative in intent. Implementation of Amendment 10 depends on cooperative management. However, Amendment 10 is complicated, with large numbers of possible combinations for alternatives and options. There may be differences of opinion about economic impacts among respective legislative bodies, regulatory bodies and courts. Any differences in regulation between Florida and the Councils would have the most economic impact. This is because practically all of the landings of Caribbean spiny lobster occur in Florida, which has its own regulations for this species. Furthermore, Florida landings occur largely in Monroe County (approximately 90% for commercial landings and 67% for recreational landings, see Table 4.3.1.1). Hence, economic impacts under this action would occur primarily in Florida and largely in Monroe County.

4.6.3 Direct and Indirect Effect on the Social Environment

The development of a framework procedure would have beneficial impacts on the social environment as management can react to changes in the stock status or fishery in a more timely manner. **Alternative 1** would not allow for these types of changes and could, over time, have negative indirect effects. However, framework actions that are done rapidly do not always provide for as much public input and comment on the actions as other regulatory processes. In these situations, the benefits of timely action should outweigh the diminished time frame for comment though. **Preferred Alternative 2** would provide consistency in language with regulatory changes and have few effects on the social environment. **Alternatives 3** would simply update the current the framework to allow for setting of ACLs and AMs and likely have few social effects. **Alternative 4** provide options for implementing a framework procedure that becomes less restrictive in terms of timing and public input going from **Preferred Alternative 4,**

Preferred Option a to **Option c**. As mentioned earlier, timing and public input become the parameters that are constrained by these options. While public input and participation by advisory panels can be beneficial, it is time consuming and can slow the process. Yet, that participation can provide a more acceptable regulation which may lead to better compliance.

4.6.4 Direct and Indirect Effect on the Administrative Environment

Alternative 1 would be the most administratively burdensome of the alternatives being considered, because all modifications to ACLs, ACTs, and AMs would need to be implemented through an FMP amendment, which is a more laborious and time consuming process than a framework action. **Preferred Alternative 2** would have no impact on the administrative environment. **Alternatives 3** would incur less of an administrative burden than **Alternative 1** because several steps in the lengthy amendment process would be eliminated if the Regional Administrator were given the latitude to adjust ACLs, ACTs, and AMs through framework actions. **Preferred Alternative 4** would incur even less of an administrative burden because other management measures could also be adjusted through framework actions. **Alternative 4, Option b** would be the least burdensome because it would allow the widest range of actions to take place under the framework procedure.

The Gulf Council is considering alternatives to the framework procedures of all Gulf FMPs that are similar to the options in **Alternative 4**. If the Councils choose the same basic framework for the Spiny Lobster FMP as for other Gulf FMPs, the process of implementing framework actions may be more streamlined in the Gulf region.

4.6.5 Council Conclusions

The Councils chose **Preferred Alternative 2** to be consistent with Florida terminology and **Preferred Alternative 4, Option a** to have flexibility in making management change while providing both substantive and procedural guidelines. The protocol and framework procedure under **Alternative 1** are out of date and not consistent with current assessment and management methods. The framework under **Alternative 3** would be up-to-date, but would remain restrictive in the items that could be changed and unspecific about procedure. **Options b** and **c** for **Alternative 4** give the Councils and NOAA Fisheries Service too much and too little authority, respectively, to change management outside of the plan amendment process.

4.7 Action 7: Modify Regulations Regarding Possession and Handling of Short Caribbean Spiny Lobsters as "Undersized Attractants"

Alternative 1: No Action – Allow the possession of no more than 50 undersized Caribbean spiny lobsters, or one per trap aboard the vessel, whichever is greater, for use as attractants.

Alternative 2: Prohibit the possession and use of undersized Caribbean spiny lobsters as attractants.

Alternative 3: Allow undersized Caribbean spiny lobsters, but modify the number of allowable undersized lobsters, regardless of the number of traps fished:

> **Option a:** Allow 50 undersized lobsters
> **Option b:** Allow 35 undersized lobsters

Preferred Alternative 4: Allow undersized spiny lobster not exceeding 50 per boat and 1 per trap aboard each boat if used exclusively for luring, decoying or otherwise attracting non-captive spiny lobsters into the trap.

4.7.1 Direct and Indirect Effect on the Physical and Biological/Ecological Environments

This action is being considered to address law enforcement concerns related to allowing vessels to maintain undersized spiny lobsters onboard fishing vessels. The number and storage requirements for undersized spiny lobsters allowed to be retained have been modified several times since the original Spiny Lobster FMP was implemented. In 1982, the Spiny Lobster FMP included the first provisions for keeping undersized spiny lobsters for use as attractants. At that time, no more than three live undersized lobsters could be placed in each trap or no more than 200 undersized lobsters could be maintained on board a vessel, whichever was greater. The July 1987 final rule implementing Amendment 1 changed the number of undersized lobsters that could be kept on board to 100. In May 1988, a second final rule implementing Amendment 1 was published and included a requirement that all undersized lobsters are to be maintained in a live well. A regulatory amendment was developed in 1992, which further revised the provisions regarding keeping undersized spiny lobsters for use as attractants. The final rule for this regulatory amendment was published in November 1992, and reduced the number of undersized lobsters allowed to be kept from 100 to 50, and maintained the live well requirement. The 1992 regulations are still in place today.

Currently, regulations at 50 CFR 640.21(c) state the following:

> *A live spiny lobster under the minimum size limit specified in paragraph (b)(1) of this section that is harvested in the EEZ by a trap may be retained aboard the harvesting vessel for future use as an attractant in a trap provided it is held in a live well aboard the vessel. No more than fifty undersized spiny lobsters, or one per trap aboard the vessel, whichever is greater, may be retained aboard for use as attractants. The live well must provide a minimum of ¾ gallons (1.7 liters) of seawater per spiny lobster.*

An undersized spiny lobster so retained must be released alive and unharmed immediately upon leaving the trap lines and prior to one hour after official sunset each day.

Therefore, each vessel is not necessarily limited to only 50 undersized lobsters, but one lobster per trap. In the commercial spiny lobster fishery, it is common for a vessel to fish more than 100 traps on any one trip (Vondruska 2010a), but only 30-35 traps are on board the vessel at any one time. Traditionally, fishermen have realized great success using live lobster as bait in lobster traps. Experiments have shown that traps baited with short lobsters catch approximately three times more lobster than traps baited with any other method (Heatwole et al. 1988; Moe 1991).

Allowing possession of undersized lobsters on board any permitted spiny lobster vessel within the EEZ makes it difficult for law enforcement officials to discern whether those undersized lobsters are truly being maintained for use as attractants, or for illegal purposes. If a vessel is stopped by a law enforcement official with undersized lobsters onboard in transit toward port with the intention to sell or keep those lobsters, prosecution is made more difficult by the fact that regulations allow undersized spiny lobsters to be kept under certain conditions. Furthermore, Florida has implemented their own requirements for the number of undersized lobsters allowed to be kept onboard for use as attractants, which are slightly different from current implemented federal regulations. Florida regulations state:

The holder of a valid crawfish license or trap number, lobster trap certificates, and a valid saltwater products license issued by the FWC may harvest and possess, while on the water, undersized spiny lobster not exceeding 50 per boat and one per trap aboard each boat if used exclusively for luring, decoying, or otherwise attracting noncaptive spiny lobster into traps.

Florida allows not only 50 undersized lobsters to be maintained onboard licensed vessels, but also one undersized lobster per trap, which is not consistent with current federal regulations.

In addition to law enforcement concerns, there may be negative biological impacts of allowing 50 or more undersized spiny lobsters to be maintained in a live well. If undersized spiny lobsters continue to be sold illegally, and transported under the guise of being used as attractants, those lobsters are not returned to the water and thus are not able to contribute reproductively to the overall biomass. Secondly, trauma incurred during holding in live wells, caused by crowding, duration of confinement during transport, relocation to a different environment, or exposure to the PaV1 virus, may also contribute to undersized spiny lobsters mortality, and ultimately reduce the number of adults available for harvest. It should be noted that about one percent of undersized lobsters escape per night from traps (J. Hunt and W. Sharp, pers. comm.). Hunt et al. (1986) indicated an exposure and confinement mortality rate of 26.3% for lobsters exposed to air and confined in traps for four weeks. Lobsters that were then held in live wells and confined for the same amount of time showed a mortality rate of 10.1%. A study conducted by Matthews (2001) indicated similar reductions in the mortality rates of spiny lobster kept for use as attractants based on observation of commercial lobster traps, due to the implementation of the live well requirement. Additionally, the Matthews study showed commercial and recreational harvest of spiny lobster increased notably as a result of decreased mortality of undersized lobsters maintained in live wells (Matthews 2001). These mortality rates were reviewed and utilized in SEDAR 8 (2005). Although live wells reduce the risk of mortality due to air exposure, some lobsters may perish as a result of predation or starvation when confined to a trap. Furthermore, the continued practice of using sub-legal size lobsters as bait has been shown to increase injuries caused by handling and to reduce the growth rate, causing females to mature at smaller sizes (Maxwell et al. 2009). Smaller females carry fewer eggs then larger females, and thus are considered less fecund than females that reach sexual maturity at larger sizes (Maxwell et al. 2009).

If undersized spiny lobsters continue to be sold illegally, and transported under the guise of being used as attractants, those lobsters are not returned to the water, and therefore, would not have the opportunity to grow to harvestable sizes. Secondly, trauma incurred during holding in live wells, caused by crowding, duration of confinement during transport or relocation to a different environment may also contribute to undersized spiny lobster mortality, which may negatively impact the population.

Through time, the Caribbean spiny lobster population has fluctuated substantially (Figure 4.7.1.1). The total biomass ranged from 15,000 mt in 1985-86 to 20,200 mt in 1995-96 and was 19,200 mt at the beginning of 2003-04. Spawning biomass increased from 3,300 mt in 1985-86 to 5,700 mt in 2003-04 (SEDAR 8 2005) indicating undersized spiny lobsters benefit from use of live wells in the form of decreased mortality rates. The SEDAR 8 (2005) used an estimated 10% confinement mortality rate for undersized Caribbean spiny lobsters kept for use as attractants; however, the time of the season and soak times can cause confinement mortality rates to fluctuate. It is difficult to know the precise number of undersized Caribbean spiny lobsters used as attractants in any given year; however, it is understood to be a very common practice in the commercial sector and SEDAR 8 (2005) indicates the total fishing mortality rate in 2003-2004 fishing year was 0.85 per year with the bait mortality portion of that fishing mortality rate being 0.05 per year. Figure 4.7.1.1 illustrates fishing related mortality attributable to each sector and use of undersized lobsters as attractants through history.

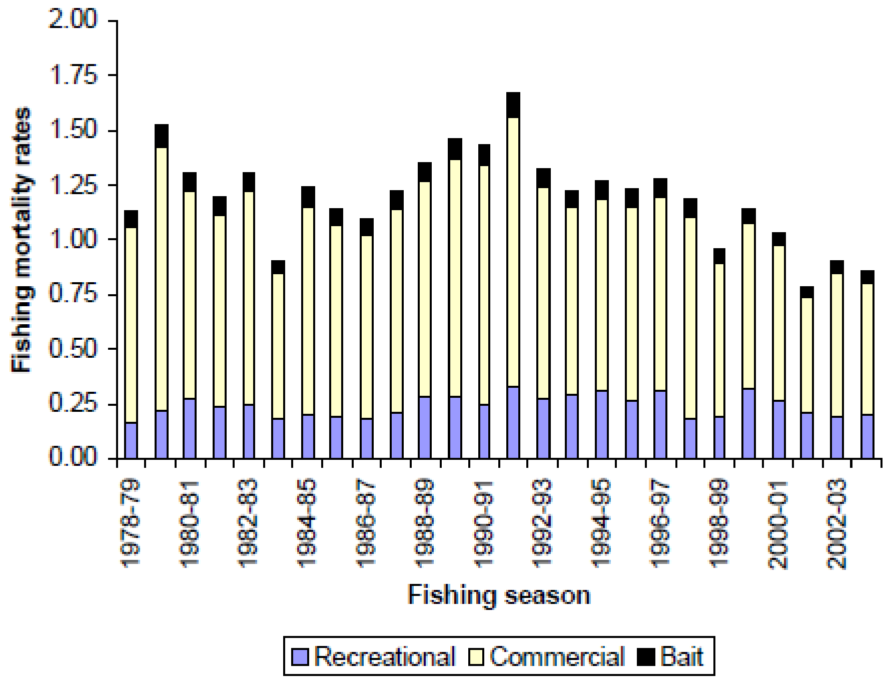

Figure 4.7.1.1. Fishing mortality per year by fishing year for the recreational fishery (purple bars), commercial fishery (yellow bars), and bait fishery (black bars).
Source: SEDAR 8, 2005

Alternative 1 is the second least biologically conservative of the three alternatives under consideration. **Alternative 1** produces the second highest rate of spiny lobster mortality associated with use as attractants relative to **Alternative 2**, **Alternative 3, Option b,** and **Preferred Alternative 4**. Additionally, **Alternative 1** does not address the previously referenced enforcement concerns.

Alternative 2 would be the most biologically conservative alternative under this action since, theoretically, all mortality associated with using undersized lobsters as attractants would cease. Under **Alternative 2** there would be an approximate decrease in confinement mortality of 10% (SEDAR8 2005). Prohibiting the use of undersized Caribbean spiny lobsters as attractants may also reduce the risk of potential ACL overages and hedge against future overfishing. Additionally, **Alternative 2** would address enforcement issues related to undersized Caribbean spiny lobster since there would no longer be a legal reason for any vessel to have undersized Caribbean spiny lobsters onboard. Alternately, prohibiting the use of undersized lobsters for use as attractants may not be a practicable management measure for the fishery since it would likely result in a substantial decrease in harvest (Moe 1991; Heatwole et al. 1988), could reduce opportunities for the fishery to achieve optimum yield, and increase bycatch of other species.

Alternative 3 would not address the issues raised by the Office for Law Enforcement; however, it could help to reduce fishing mortality attributable to use of undersized lobsters for baiting purposes. **Alternative 3** is not as precautionary as **Alternative 2**, and depending upon the option chosen, may only yield negligible biological benefits over the status quo. Limiting the number of undersized lobsters that could be used as attractants to 35 (**Option b**) could potentially reduce the current level of confinement mortality by about half, which would likely increase the number of Caribbean spiny lobsters that have the opportunity to grow to harvestable sizes. Additionally, allowing only 35 undersized lobsters to be used as bait, and removing the provision that allows one undersized lobster per trap (whichever is greater), could hedge against overfishing, but not to the same degree as **Alternative 2**. **Alternative 3, Option a** is less precautionary than **Option b** because it deviates less from the status quo. **Option a** would retain the allowance for 50 undersized Caribbean spiny lobsters, but would remove the one lobster per trap provision. In doing so, vessels would be limited to 50 undersized lobsters regardless of the number of traps they are carrying onboard. **Alternative 3** is intended to limit the biological impacts of using undersized spiny lobsters as attractants by limiting their use to a level below the status quo without prohibiting the practice altogether. There may be some biological benefit in terms of increasing the number of lobsters allowed to grow to harvestable sizes under this option; however, the degree to which those benefits would impact the environment would depend on the number of fishermen who traditionally carry more than 50 traps and keep more than 50 undersized lobsters for use as attractants.

Preferred Alternative 4 is very similar to **Alternative 1** in that it would allow spiny lobsters to be kept onboard for use as attractants; however, it would change the provision to allow 50 spiny lobsters *plus* one per trap, rather than 50 spiny lobster *or* one per trap, and it would remove the "whichever is greater" portion of the provision. This alternative is the least biologically conservative for spiny lobster of all the alternatives considered because it would increase the number of undersized lobsters able to be maintained onboard a vessel for use as attractants. Changing the current use of "shorts" provision under **Preferred Alternative 4** would make the federal regulations compatible with Florida's state regulations, which may aid enforcement efforts at the state/federal water boundary. The purpose of keeping 50 spiny lobsters onboard is to ensure there is an adequate supply of attractants during the baiting process for each trap, i.e., some traps will be onboard being baited while others would be in the water needing new bait. As Section 4.7.2 of this document states, the number of traps fished on a trip can be estimated for **Alternative 1**, when this number is interpreted to mean the number of traps hauled to remove lobsters. This is not necessarily an indication of the number traps on a vessel, which may be 30-35 at any one time during fishing operations. Allowing 50 undersized lobsters to be used as attractants plus one per trap ensures that fishermen have an adequate supply of bait lobsters on board as the traps are hauled and re-deployed. Furthermore, biological impacts of the use of attractants likely decreases as the fishing season progresses since the total number of traps fished on all trips declines by month on average as the season goes on, along with total pounds landed, and the median number of traps fished per trip.

Most commercial spiny lobster fishermen do not consider keeping undersized lobsters for use as attractants a form of bycatch because in their view, they are "borrowing" from the resource with the intent to release the lobsters back into the environment alive. A small percentage (10%) of lobsters kept to be used as attractants die as a result of such use (SEDAR 8 2005). A recent study conducted by Hunt and Tringali (2011), used DNA analysis to identify sources of recruitment for Caribbean spiny lobster. The study found the majority of recruits do not come from within the management area, suggesting that the use of undersized Caribbean spiny lobsters and other management measures for the Caribbean spiny lobster fishery would have negligible biological impacts on the population within the management area. Based on the findings of this study, it is unlikely that the continued use of undersized Caribbean spiny lobsters as attractants would adversely affect the biological environment.

Although undersized attractants are technically bycatch under the Magnuson-Stevens Act, their use may actually decrease the total level of bycatch by the lobster fishery. Experiments have shown that traps baited with shorts caught approximately three times more lobster than traps baited with any other method (Heatwole et al. 1988). Further, traps using non-lobster bait caught fewer lobsters than unbaited traps, probably because the bait attracted stone crabs, which lobsters avoid. Traps using non-lobster bait or no bait would thus take two to three times longer to harvest the same amount of lobsters as traps using lobster bait. Increased soak times of traps would increase bycatch of other species, such as juvenile and adult fish, crabs, and mollusks.

There is concern that allowing spiny lobsters to be kept onboard, even at the status-quo level, could perpetuate the spread of the PaV1 virus, which typically affects juvenile spiny lobsters and causes general lethargy. The virus can be transmitted via prolonged contact and ingestion. Spiny lobsters infected with the PaV1 virus are typically avoided by healthy, normally social, conspecifics (Behringer et al. 2008). A study conducted by Behringer and Butle (2010), found that healthy spiny lobsters were less likely to cohabitate with lobsters infected with PaV1, which could leave them vulnerable to predation if they were to choose a less safe shelter to avoid contact with the infected lobster. Therefore, the higher the number of spiny lobsters allowed to be maintained in live wells, the higher the risk of perpetuating the spread of the PaV1 virus, especially amongst young spiny lobsters that are more susceptible to acquiring the virus.

Alternative 1 would perpetuate the existing level of risk for interactions between ESA-listed species and the fishery. Modifying or removing the 50-shorts rule is unlikely to alter fishing behavior in a way that would cause new adverse effects to *Acropora* spp. The impacts from **Alternative 2**, **Alternative 3, Option b,** and **Preferred Alternative 4,** and the associated options, on sea turtles and smalltooth sawfish are unclear. If they perpetuate the existing amount of fishing effort, but cause effort redistribution, any potential effort shift is unlikely to change the level of interaction between sea turtles and smalltooth sawfish and the fishery as a whole. If these alternatives reduce the overall amount of fishing effort in the fishery, the risk of interaction between sea turtles and smalltooth sawfish will likely decrease.

4.7.2 Direct and Indirect Effect on the Economic Environment

The estimated mortality associated with the use of undersized lobsters as bait is shown along with commercial landings and recreational landings in Figure 4.7.2.1. It has been declining and averaged 189,091 pounds per year in 2004/2005-2009/2010 compared with 541,000 lbs in 1985/1986-1989/1990.

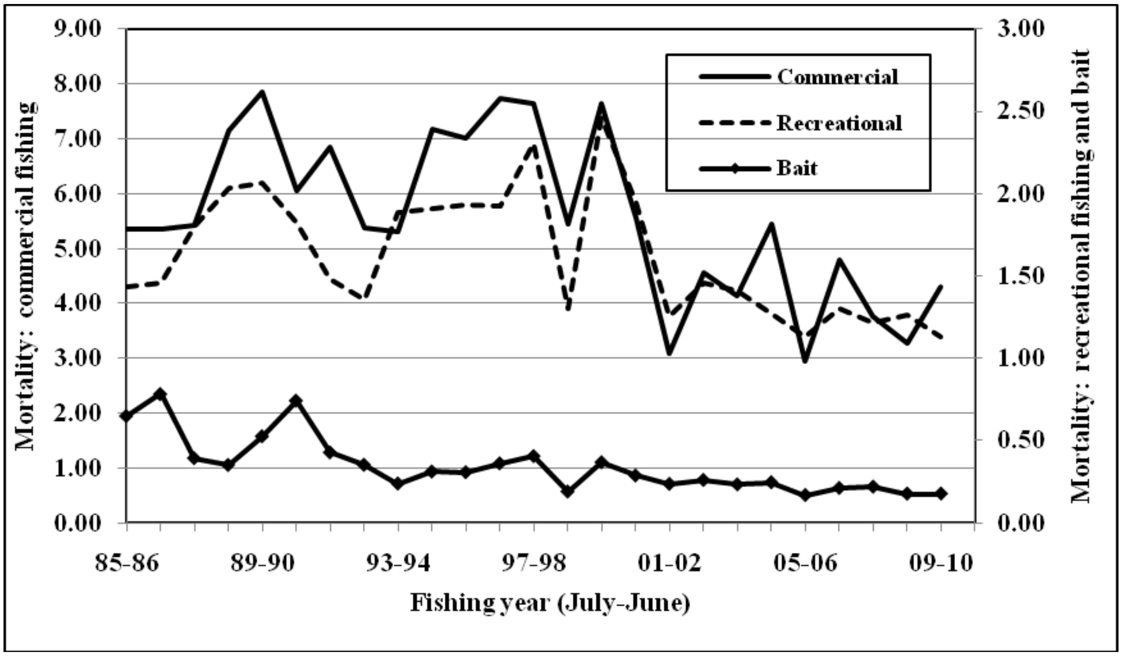

Figure 4.7.2.1 Fishing mortality: commercial and recreational fishing, and bait
Source: SEDAR 8, 2010 update, Table 2.1.1

Many commercial trap fishermen may already purchase bait, based on fishermen's perceptions on how to best attract lobsters (Shivlani et al. 2004). Those who reported more use of undersized lobsters as attractants had much lower average trip costs for bait compared with those who used purchased bait (such as cowhide), and they had shorter trips, and lower average trip costs for other major items as well. Average trips costs for bait were in the range of $12.72 (Middle Keys) to $133.24 (Key West), with the average trip costs for bait costs of $60.90 for the whole sample (data in current dollars for 2001/2002, not adjusted to 2008 dollars).

Alternative 1 would not result in any change in the use of undersized spiny lobsters in lobster traps as attractants. As a result, all status quo operation of the fishery, and associated economic benefits, would remain unchanged. However, if **Alternative 2** would reduce the risk of exceeding the ACL when compared with **Alternative 1**, then **Alternative 1** would increase the likelihood of shortened fishing seasons, trip limits, bag limits, or whatever the Councils choose as a means to regulate fishing when landings exceed or are expected to exceed the ACL.

Compared with **Alternative 1**, **Alternative 2** could reduce the likelihood of incurring shortened fishing seasons, trip limits, bag limits, or whatever the Councils choose as a means to regulate fishing when landings exceed or are expected to exceed the ACL. It is assumed here that what is counted as "bait" for stock assessment purposes represents the estimated fishing mortality associated with the use of undersized Caribbean spiny lobster as attractants, as shown in Figure 4.7.2.1. Under **Alternative 2**, fishing mortality would be reduced by 189,091 lbs, the estimated bait-associated mortality under **Alternative 1**. At least some, if not most the undersized Caribbean spiny lobster used as attractants are kept alive on board a vessel and returned to the water alive, as required. **Alternative 2** would in practice require the use of more purchased bait, hence increase trip costs on average for commercial fishing for spiny lobster as a whole. This would reduce producer surplus for this activity.

Alternative 3 should reduce the fishing mortality associated with the use undersized Caribbean spiny lobster as attractants, more so for **Option b** than for **Option a,** when compared with **Alternative 1**, for which the assumed bait mortality is 189,000 lbs per year (Table 4.3.1.1). The economic impact of **Alternative 3** would be less than that of **Alternative 2,** and require the use of less purchased bait, hence less increase in trip costs for commercial fishing for spiny lobster as a whole. It would reduce producer surplus less than **Alternative 2**, when both are compared with **Alternative 1**. Compared with **Alternative 1**, **Alternative 3** would require the use of more purchased bait, hence an increase in trip costs for commercial fishing for spiny lobster as a whole. It would reduce producer surplus from that for **Alternative 1**.

Preferred Alternative 4 would reduce fishing mortality associated with the use undersized Caribbean spiny lobster as attractants far less than **Alternative 2,** and require the use of less purchased bait, hence less increase in trip costs for commercial fishing for spiny lobster as a whole. It would reduce producer surplus less than **Alternative 2**, when both are compared with **Alternative 1**.

It is estimated that **Preferred Alternative 4** could allow perhaps 50-80 attractants on board vessel during fishing operations (50 per vessel plus 1 per trap on board, perhaps 30-35 on average) when estimated as described below. This compares with having a maximum 50 on board under **Alternative 1**, assuming the averages estimated below are indicative (a maximum of either 50 per vessel or 30-35 per vessel based on the average number of traps on board during fishing operations).

The number of traps fished on a trip can be estimated for **Alternative 1**, when this number is interpreted to mean the number of traps hauled to remove lobsters. This is not necessarily an indication of the number traps on a vessel, which may be 30-35 at any one time during fishing operations. In the last five years, the average number of traps hauled per trip was mostly in the range of 200-280 traps on trips of 14-17 hours (hours away from port), with 7-8 sets per trip, which is interpreted to mean trap lines hauled and returned to the water per trip) (underlying data as used in Vondruska 2010a). The total number of traps fished on all trips declines by month on average as the season goes on, along with total pounds landed, and the median number of traps fished per trip.

4.7.3 Direct and Indirect Effect on the Social Environment

The use of undersized lobster as attractants has been acceptable practice in the spiny lobster fishery for some time. It complicates law enforcement as the size limits on harvested lobster can make determination of the lobster's disposition as bait or product questionable. **Alternative 1** would continue the difficulty that law enforcement faces with prosecuting undersized lobster violations. **Alternative 2** could solve the law enforcement issue, but may impose a hardship on lobster fishermen who utilize "shorts" as attractants, if their harvest is reduced as a result. The two options under **Alternative 3** would continue to allow undersized lobster for attractants, but would reduce the number allowed on board and not resolve the inconsistencies with current state regulations. In either case, the difficulty for law enforcement would remain. With **Preferred Alternative 4** there is consistency with state regulation which would benefit law enforcement but still does not address the difficulty with the ability to determine undersize harvest. There does not seem to be an alternative that solves all the issues involved with the use of "shorts" as an attractant in the spiny lobster fishery.

4.7.4 Direct and Indirect Effect on the Administrative Environment

Alternative 2 would create the lowest impact on the administrative environment since it would remove the need for enforcement personnel to check vessels for specific numbers of undersized Caribbean spiny lobsters. Enforcement officers would simply check for the absence or presence of undersized lobsters. Additionally, the task of gathering prosecutorial evidence to prove a violation would be made simpler because the vessel operator would not be able to circumvent the undersized lobster prohibition by claiming they were in transit, or had several more traps in the water. **Options a** and **b** under **Alternative 3** would not increase the administrative burden over the status quo since numbers of undersized lobsters would still need to be documented, just at a lower number. However, **Alternative 1, Alternative 3,** and **Preferred Alternative 4,** would not address the current enforcement concerns regarding the retention of undersized Caribbean spiny lobster, and difficulty in prosecuting related violations would persist. **Preferred Alternative 4** is consistent with current state regulations in Florida, and therefore, would ease the burden on enforcement to track compliance across the state/federal jurisdictional boundary.

4.7.5 Council Conclusions

The original intent of this action was to address concerns raised by the law enforcement community, which felt that prohibiting the use of undersized Caribbean spiny lobsters as attractants would mitigate difficulties associated prosecuting undersized spiny lobster cases. The preferred alternative would not rectify this issue; however, it would bring federal regulations for the use of undersized Caribbean spiny lobsters as attractants into line with state regulations, which will ease enforcement of the provision along the state/federal jurisdictional boundary. Additionally, the use of undersized spiny lobsters as attractants is an extremely important practice of fishery participants in terms of overall yield. Therefore, the Councils felt that prohibiting the use of undersized lobsters was not practicable and would incur unnecessary negative socioeconomic impacts with negligible biological benefits based on new scientific evidence showing that the most spiny lobster recruits come from outside the management area (Hunt and Tringali 2011). The purpose of allowing 50 spiny lobsters plus one per trap onboard is to ensure there is an adequate supply of attractants during the baiting process for each trap, i.e., some traps will be onboard being baited while others would be in the water needing new bait. Furthermore, allowing the use of undersized lobsters as attractants could indirectly decrease bycatch in the fishery since using non-lobster bait or no bait would require soak times to at least double in order to harvest the same amount of lobsters as traps using lobster bait. Subsequently, increased soak times of traps would increase bycatch of other species, such as juvenile and adult fish, crabs, and molluscs. Although the preferred alternative would not directly benefit the biological environment, biological impacts of the use of attractants are likely to decrease as the fishing season progresses since the total number of traps fished on all trips declines by month on average as the season goes on. For these reasons the Councils chose **Alternative 4** as their preferred alternative under Action 7.

4.8 Action 8: Modify Tailing Requirements for Caribbean Spiny Lobster for Vessels that Obtain a Tailing Permit

*Note: more than one alternative may be chosen as a preferred alternative.

Alternative 1: No Action – Possession of a separated Caribbean spiny lobster tail in or from the EEZ is allowed only when the possession is incidental to fishing exclusively in the EEZ on a trip of 48 hours or more, and a federal tailing permit is issued to and on board the vessel.

Alternative 2: Eliminate the Tail-Separation Permit for all vessels fishing for Caribbean spiny lobster in Gulf and South Atlantic waters of the EEZ.

Preferred Alternative 3: Revise the current regulations to clearly state that all vessels must have either 1) a valid federal spiny lobster permit or 2) a valid Florida Restricted Species Endorsement and a valid Crawfish Endorsement associated with a valid Florida Saltwater Products License to obtain a tailing permit.

Preferred Alternative 4: All Caribbean spiny lobster landed must either be landed all "whole" or all "tailed".

4.8.1 Direct and Indirect Effect on the Physical and Biological/Ecological Environments

Currently, a valid Tail-Separation Permit is required for any vessel that wishes to land spiny lobster with tails detached for storage purposes on trips longer than 48 hours in duration. As of March 18, 2011, 353 vessels have active Tail-Separation Permits. Regulations at 50 CFR 640.21(d) do not require that a vessel fishing for spiny lobster in the EEZ first have a federal or state permit/license/endorsement before they may obtain a federal Tail-Separation Permit. However, any vessel owner wishing to legally sell Caribbean spiny lobster must have the requisite permit/license/endorsement.

Florida state regulations require that a valid Crawfish Endorsement must be obtained to sell or harvest Caribbean spiny lobster in excess of the bag limits. Crawfish Endorsements can only be issued to a person, firm, or corporation that possesses a valid Saltwater Products License (SPL) with a Restricted Species Endorsement [FAC 68B-24.0055]. Furthermore, in the 2004/2005 fishing season, a Commercial Diver Permit was required to harvest Caribbean spiny lobster in excess of the bag limit if harvested by diving. Commercial diver permits could be obtained by applicants who did not already possess one or more lobster trap certificates. However, from January 2005 – July 1, 2015, no new Commercial Diver Permits will be issued or renewed, except for those that were active during the 2004/2005 fishing season.

Current regulations do not explicitly state that a vessel must be associated with a valid SPL and also possess a valid Florida Restricted Species Endorsement and a valid Crawfish Endorsement, or possess a valid federal Spiny Lobster Permit to obtain a Tail-Separation Permit. This leaves open the possibility for a non-commercially permitted vessel to obtain a tailing permit, which may affect enforcement of the minimum size requirements, the spear fishing prohibition, and illegal sales. Action 11 of Amendment 1 to the Spiny Lobster FMP (1987) clearly states the Council's initial intent for issuance of tailing permits:

> *The separation of lobster carapace and tail at sea shall be prohibited except by species permit. To be eligible for a tail separation permit, the fishing craft must have been assigned a commercial lobster permit, and must be operated for lobster fishing in the EEZ for two or more days from port. Furthermore, a signed statement that his fishing activity necessitates a tail separation permit.*

However, regulations regarding tailing permit requirements have changed several times since the inception of the permit. In 1990, a final rule implementing Amendment 1 prohibited tailing of spiny lobster harvested from the EEZ except by special permit, and required that a vessel must be associated with a valid federal commercial spiny lobster permit to obtain a Tail-Separation Permit. In 1992, the Council opted to make the Tail-Separation Permit an endorsement to the federal Spiny Lobster Permit through a regulatory amendment. At that time, it was also determined that federal Spiny Lobster Permit issuance would discontinue when Florida's trap certificate and identification program was implemented and when Florida designated spiny lobster as a restricted species, thus limiting the sellers of Caribbean spiny lobster to individuals who have valid Restricted Species Endorsements on their SPL. The Florida trap certificate and identification program was implemented through a final rule published in 1993. Therefore, as stated in the 1992 regulatory amendment, a federal Spiny Lobster Permit was no longer required for vessels fishing for spiny lobster in state or federal waters off Florida. However, the regulations stated that only vessels with federal Spiny Lobster Permits could obtain a Tail-Separation Endorsement. To allow vessels participating in Florida's trap certificate program without a federal Spiny Lobster Permit, to obtain a Tail-Separation Endorsement, the regulations were modified to change the "Tail-Separation Endorsement" to a "Tail-Separation Permit", and removed the requirement for a federal Spiny Lobster Permit, as outlined in the 1992 regulatory amendment. The regulations currently state:

> *The possession aboard a fishing vessel of a separated spiny lobster tail in or from the EEZ is authorized only when the possession is incidental to fishing exclusively in the EEZ on a trip of 48 hours or more and a federal Tail-Separation Permit specified in 50 CFR 640.4(a)(2).*

50 CFR 640.4(a)(2) states:

> *For a person to possess aboard a fishing vessel a separated spiny lobster tail in or from the EEZ, a Tail-Separation Permit must be issued to the vessel and must be on board.*

The intent of allowing fishermen to tail Caribbean spiny lobster was to promote ease of storage and transport of harvested lobster on long commercial trips. Tail-Separation Permits were not intended for use by non-commercially permitted vessels. However, because the regulations do not explicitly state that a valid federal Spiny Lobster Permit or a valid SPL with a Restricted Species Endorsement are required in order to obtain a Tail-Separation Permit, some recreational fishermen have obtained Tail-Separation Permits for their own purposes. Tail-Separation Permits enable commercial vessels (and unintentionally some recreational vessels) to fish more efficiently for spiny lobster than those vessels without the permit. Whole lobsters tend to maintain their quality better than tailed lobsters; however, they also utilize more storage space than tails. Vessels that are associated with a Tail-Separation Permit are able to store much more product than vessels required to store the lobster whole. Space limitations such as cooler capacity onboard fishing vessels can also affect product quality. Therefore, fishermen that are allowed to tail their harvested lobster may not only store more product onboard during long trips, they may do so without having to compromise its quality. Greater efficiency means those vessels with Tail-Separation Permits are able to take longer trips without returning to port to offload their catch. Therefore, eliminating the Tail-Separation Permit and prohibiting all tailing of Caribbean spiny lobsters could potentially reduce the probability that the commercial ACL would be met or exceeded in any given season as well as aid law enforcement efforts, which is the original intent of this action. At the very least, a prohibition on tailing would slow the pace at which Caribbean spiny lobsters are harvested due to storage capacity issues onboard participating vessels.

Several fishery participants who attended the scoping meetings were in favor of requiring all Caribbean spiny lobster be either landed all whole or landed all tailed. The rationale for proposing this alternative is that requiring spiny lobster to be landed all whole or all tailed would prevent the anecdotally reported practice of tailing select lobsters in order to conceal their undersized status. Not all fishery participants and dealers noted this as a significant problem, and some did support maintaining the current tailing provisions. The magnitude of illegal tailing is not known, and it is important to note that the ability to tail Caribbean spiny lobsters is a very important contributor to the viability of fishing operations conducted on board vessels with limited storage capacity on long trips. However, requiring that all Caribbean spiny lobsters be landed tailed or whole would close the regulatory loophole for those who attempt to circumvent the three-inch carapace length minimum size requirement, while not prohibiting the practice all together for those who rely on the tailing provision to make profitable trips. Additionally, a major challenge that NOAA Fisheries Service law enforcement officials are presented with is commercially permitted lobster divers who spear and tail spiny lobster, which removes evidence of the illegal act of spearing a spiny lobster. To continue to allow tailing will continue to facilitate this type of illegal activity.

Under **Alternative 1** the problem of some recreational fishermen obtaining Tail-Separation Permits, and some commercial and recreational fishermen tailing only undersized lobsters and keeping the legal sized lobsters whole for landing would persist. There would be no biological benefit realized under **Alternative 1**. The average Caribbean spiny lobster fishing trip is eight hours (Vondruska 2010a), so the number of individuals utilizing this provision is unknown.

Alternative 2 would be the most biologically conservative of all the alternatives being considered under this action. Removing the ability for fishermen to land any tailed Caribbean spiny lobster would increase the probability that most lobster landed would be of legal size since they could easily be measured. According to Witham et al. (1968), spiny lobsters reach sexual maturity at lengths of approximately 2.8-3.2 inches. Legal-sized lobsters are likely to have reached their reproductive potential and are able to contribute to the overall stock abundance. Therefore, ensuring that spiny lobsters are able to mature enough to reproductively contribute to the population by making it more difficult for fishermen to profit off an undersized harvest would remove the incentive for the practice to continue.

Preferred Alternative 3 alone would address the issue of recreational fishermen obtaining Tail-Separation Permits, but it would not address the issue of commercial fishermen landing undersized lobster by tailing them. Clarifying the regulations now would prevent even more recreational fishermen from trying to obtain the Tail-Separation Permit in the future, which would reduce the risk that undersized lobster could be kept onboard in a tailed condition.

Preferred Alternative 4 would address the issues associated with some fishermen landing part of their catch whole and part of it tailed. Presuming anecdotal information is correct, several of those engaging in the practice do so in order to land sub-legal spiny lobsters for profit or to hide evidence of spearing. If vessels were to consistently land all Caribbean spiny lobster tailed rather than whole, the chance that a portion of that harvest is sub-legal is higher than if fishermen chose to land their entire harvest whole. However, whole lobster may be more desirable in the market, and therefore, this measure may reduce the incentive to land all spiny lobster tailed even though it may result in storage issues on long trips. If under **Preferred Alternative 4** most fishermen choose to land all of their Caribbean spiny lobster harvest whole, the action would be expected to benefit the biological environment by slowing the rate of harvest and potentially reducing the probability of ACL overages. If the majority of fishermen choose to land their harvest tailed, there is an increased risk that more undersized lobsters would be taken. Additionally, **Preferred Alternative 4** alone does not address the issue of recreational fishermen obtaining Tail-Separation Permits. However, if **Preferred Alternative 3** were implemented in combination with **Preferred Alternative 4**, the issue of recreational fishermen obtaining Tail-Separation Permits would be addressed and could therefore result in greater biological benefit than if **Preferred Alternative 4** were chosen alone.

Alternative 1 would perpetuate the existing level of risk for interactions between ESA-listed species and the fishery. Requiring that all Caribbean spiny lobster be landed whole or all spiny lobster be landed tailed is unlikely to alter fishing behavior in a way that would cause new adverse effects to *Acropora* spp. The impacts from **Alternatives 2-4,** on sea turtles and smalltooth sawfish are unclear. If they perpetuate the existing amount of fishing effort, but cause effort redistribution, any potential effort shift or increase in fishing effort is unlikely to change the level of interaction between sea turtles and smalltooth sawfish and the fishery as a whole. If these alternatives reduce the overall amount of fishing effort in the fishery, the risk of interaction between sea turtles and smalltooth sawfish will likely decrease.

4.8.2 Direct and Indirect Effect on the Economic Environment

Preferred Alternative 3 would close an unintended loophole in regulations. Compared with **Alternative 1**, **Preferred Alternative 3** would disallow an unknown number of instances wherein individual recreational fishers and/or charter-boat operators reportedly obtained federal tailing permits and could thereby legally possess and land, but not sell, recreationally-caught lobster tails.

Alternative 2 would reverse the long-standing Councils decision that provided an economic incentive to engage in multi-day, deep-water fishing for spiny lobster in the EEZ. **Alternative 2** would have an economic impact exclusively on the commercial sector when compared with **Alternative 1**, because lobster tails could not be held onboard fishing vessels in the EEZ, thereby ending what is now a much reduced economic activity (Figure 4.8.2.1).

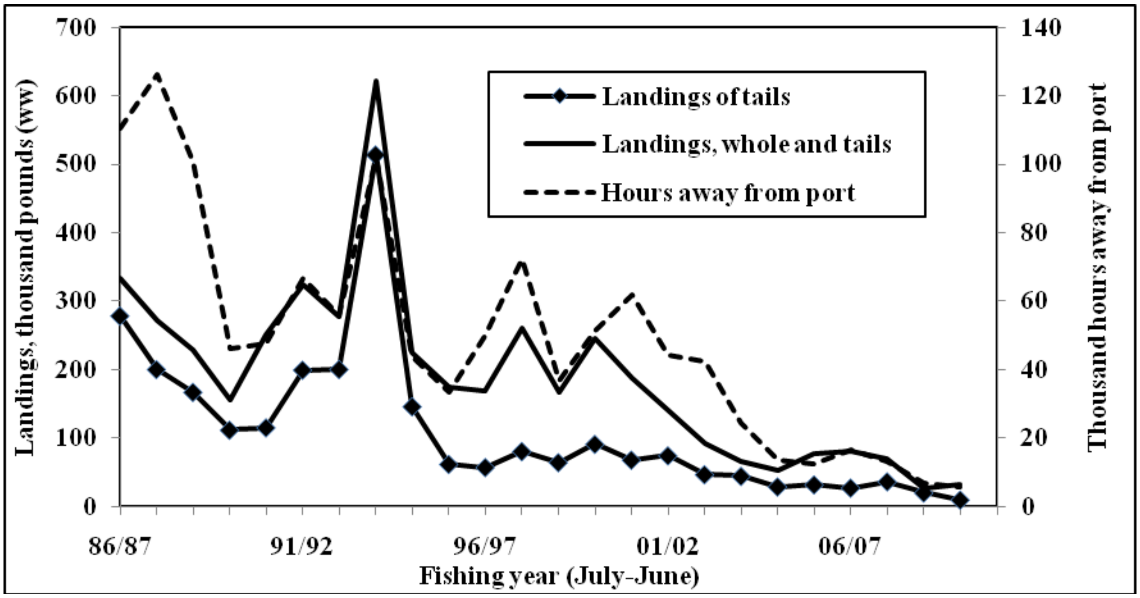

Figure 4.8.2.1. Spiny lobster tail trips, landings and fishing effort in Florida
Source: NMFS, SEFSC, FTT (Mar. 19, 2010), data and methods as in Vondruska 2010a.

The long-term decline in multi-day, deep-water fishing for spiny lobster may be attributed to several factors, many of which have increased the cost of fishing.[11] Comparisons of gross revenue and costs using available data suggest that fishermen are even less likely to cover their costs for multi-day, deep-water fishing for spiny lobster than for other fishing for spiny lobster (see last paragraph under "Survey Data" in this section).

[11]The long-term decline in multi-day, deep-water fishing for spiny lobster may be attributed to such factors as the expansion of no-take areas, "gentrification" of the Florida Keys, land-use regulations (such as respecting trap storage), reduced access to waterfront land and higher docking fees, a decline in the number of dealers (who provide docking and other services to fishermen), the cost of living in the Florida Keys, especially in Key West, and high vessel-operating and trip costs (Shivlani et al. 2004; Shivlani 2009).

Table 4.8.2.1. Florida spiny lobster, landings and effort indicators

Data shown represent annual averages for fishing years 2005/06 - 2009/10	Florida, all trips	Florida, trips landing whole lobster	Florida, trips landing lobster tails	
			Landings of tails	All lobster landings
	1	2	3	4
Total landings of spiny lobster, pounds (ww)	3,671,381	3,646,331	25,050	57,210
Total ex-vessel value of lobster, 2008$	$22,226,899	$22,081,439	$145,458	$333,682
Vessel gross, all FTT-reported landings, 2008$	$23,532,683			$542,636
Trips	15,568	15,470	129.8	na
Spiny lobster, pounds (ww) / trip	242.2	241.8	189.4	433.2
Spiny lobster, 2008$ / trip	$1,386	$1,386	$1,073	$2,386
Trip gross, all species landed, 2008$ / trip	$1,468	$1,457	na	$4,098
Vessels	780.8	769.4	34.8	na
Trips per year	19.94	20.11	3.73	na
Spiny lobster, pounds (ww) / vessel	4713.6	4752.4	711.2	1593.8
2008$ / vessel for spiny lobster	$28,305	$28,564	$4,063	$8,921
Vessel gross, 2008$ / vessel	$29,960	$30,027	na	$15,384
Traps hauled / trip	275.6	276.0	na	421.4
Time away from port, average hours / trip	15.2	14.4	na	82.4
Median--50th percentile--hours / trip	8.0	8.0	na	57.6
90th percentile, hours / trip	22.0	21.6	na	192.0
Gear soaktime, hours / trip	241.4	241.2	na	496.8
Trap lines set per trip	8.0	8.0	na	34.8
Depth fished in feet, average for trips	33.4	33.4	na	84.8
90th percentile, depth fished	148.0	139.0	na	150.0

Source: NMFS, SEFSC, FTT (Mar. 19, 2010), data and methods as in Vondruska 2010a. Data for landings and ex-vessel value of lobster tails and whole lobster are separated into two data sets based on FTT data record fields for whole weight, landed weight and conversion factors (columns 2 and 3). Categorical variables in the data set for lobster tails (column 3; month, year, vessel id and trip ticket number) are used to select data records (from data set for column 1) so as to create another data set with landings of both lobster tails and whole lobster (column 4). There are some caveats; e.g., vessel and trip totals in columns 2 and 3 are not mutually exclusive, i.e., their sums exceed the respective totals in column 1 because some vessels and trips land whole lobsters and tails.

Preferred Alternative 4 may seem at first glance to have a less onerous economic impact on commercial fishing than **Alternative 2,** but either could affect the economic viability of remnant multi-day, deep-water fishing for spiny lobster tails in the EEZ, notably fishing in Monroe County (Figure 4.8.2.1, Table 4.8.2.1). **Alternative 2** and **Preferred Alternative 4** would, respectively, disallow or restrict fishermen's choices in vessel-based, market-oriented production of spiny lobsters in accord with changing economic and global-market conditions. Shore-based production of tails from whole lobsters would occur, and this would transfer the associated economic value added (net income) away from fishermen. It is estimated that a significant proportion of Florida's spiny lobsters are exported (Vondruska 2010b). U.S. exports include frozen, shell-on tails, as for the U.S. market, but market preferences mean that relatively more live, fresh whole, and frozen whole spiny lobsters are imported by other countries. U.S. exports of spiny lobster go to Canada, France, Japan, China and many other countries in Asia, Europe and the Western Hemisphere.

Estimated commercial landings of spiny lobster tails and the associated fishing effort in Florida have declined substantially since the late 1980s and early 1990s (Figure 4.8.2.1). Landings of tails are relatively low, an estimated 0.025 mp (ww) on average in the last five years compared with 3.646 mp for whole lobsters (Table 4.8.2.1, columns 2 and 3). Strictly speaking, the associated fishing effort is not for lobster tails alone. More whole lobsters were landed on the trips with landings of lobster tails in the last five years, though the proportions have varied over time (Figure 4.8.2.1; see methodological note in Table 4.8.2.1).

According to several indicators, average effort on trips with landings of spiny lobster tails is higher (compare column 4 with columns 1 and 2, Table 4.8.2.1). For example, hours away from port are greater (82 hours per trip versus 14-15 hours); depth fished is greater (85 ft versus 33 ft); more traps are hauled (421 traps per versus 275-276 traps); gear soaktime is greater (497 hours versus 241 hours); and the number of trap lines set is higher (34.8 versus 8.0). Also, trip landings, the ex-vessel value of spiny lobster landed, and trip gross are higher, along with the share of other species in trip gross. If FTT-reported data represents all of their fishing activity, then vessel gross is lower (i.e., assuming no landings are reported in other states).

The characteristics of multi-day, deep-water fishing trips in the EEZ depicted in Table 4.8.2.1 and the implied trip costs most closely fit sample data for Key West and the Lower Keys, two of five sampling areas for a cost-and-returns survey covering the 2001/2002 season (Shivlani et al. 2004). According to the survey, the average number of traps hauled per trip is highest for Key West (410 traps), and this is close to what is shown in Table 4.8.2.1 (421 traps). For two of the five areas, Key West and Lower Keys, trip costs are higher, notably because of purchases of fuel/oil, ice, bait, and food. The Key West fishermen's trip costs averaged $459, compared with $242 per trip for all fishermen in the survey (data include crew shares; data are not adjusted to 2008$). Most of the higher trip costs for Key West relate to trip length. Higher costs for purchased bait for Key West relate to fishermen's perceptions about the efficacy of different bait. Bait costs were much lower elsewhere, because "shorts" tended to be used more in the Middle Keys, Upper Keys and Miami River (Shivlani et al. 2004).

Other survey results for the 2001/2002 season (Shivlani et al. 2004) indicate that commercial fishermen operating in the Keys tended to have long tenure (mostly more than 20 years), to be full-time operators, to derive 83% of their personal income from commercial fishing, and to have considerable investment in vessels and traps. For example, the average cost of vessels exceeded $107,000 ($131,000 for Key West) and an average of 1,142 traps was worth more than $29,000 (vessel operating costs).[12] Vessels were slightly longer in Key West and tended to have more powerful engines. Docking costs were highest for Key West, $5,951 versus a survey average of $3,316, as were the number of traps built each year, 492 traps versus a survey average of 434 traps, given the differences in trap life span (4.11 years versus a survey average of 3.31 years). Trip length affected how crew members were paid, and vessels that engaged in multi-day trips

[12]Shivlani et al. (2004) state: "Key West, from where most multiple-day trips are taken and which is closest to the fishing grounds of the Dry Tortugas and eastern Gulf of Mexico, requires a longer distance fleet, and the higher average vessel value may reflect that."

were more likely to use shareholder arrangements, wherein crew members take on more responsibilities and risks, and they are paid accordingly.

Cost and revenue comparisons suggest that fishermen on average are more likely to cover trip costs than they are to cover vessel-operating costs for multi-day, deep-water fishing for spiny lobster in the EEZ. Significant statistical variability among observations in the 2001/2002 survey implies that some fishermen are more likely to cover trip and vessel-operating costs than others. Fishermen are not likely to make a trip if they expect trip revenue to fall short of trip costs. If they cannot also cover annual vessel-operating costs with what remains of gross revenue after covering trip costs, there is an economic disincentive to continue fishing. A few may be able to cover fishing costs with income from other sources, but this seems unlikely for most, because surveyed vessel owners derived 83% of their personal income from commercial fishing, and 86.5% claimed to be full-time fishery participants (Shivlani et al. 2004).

Comparing annual average trip costs ($459) and trip gross ($4,049) suggests an economic incentive to make trips with landings of lobster tails in Florida (Table 4.8.2.1, column 4, data in 2008$; Shivlani et al. 2004, Key West sample, data in 2001/2002 dollars). The same is not true for vessels, because the vessel gross ($15,384 in 2008$) falls well short of estimated vessel-operating costs (approximately $38,000 per year in 2001/2002 dollars, not counting trip costs for a vessel, perhaps $1,700 per year) (Table 4.8.2.1, column 4; Shivlani et al. 2004, Key West sample). On average, trip gross for all trips with landings of spiny lobster in Florida ($1,468) exceeds estimated trip costs ($242), but vessel gross ($29,960) falls short of vessel-operating costs (approximately $42,000, not counting trip costs for a vessel, perhaps $4,800; Table 4.8.2.1, column 1; Shivlani et al. 2004, data for whole sample).

Any excess of fish costs over gross revenue would help explain the decline in the number of vessels engaged in landing lobster tails in Florida (Figure 4.8.2.2). An average of 315 vessels per year engaged in this activity 1986/1987–1990/1991 and 35 did so in 2005/2006–2009/2010. Over the same period of time, the average number trips per year declined from 931trips to 130. Among the factors affecting trip costs since the 2001/2002 survey was completed by Shivlani et al. (2004), it is noted that fuel prices increased sharply in the mid to late 2000s and then declined. However, it now appears that they may reach new highs as the 2011/2012 commercial lobster season gets underway in August 2011. Fuel costs could have contributed to the decline in effort since the mid to late 2000s (Figures 4.8.2.1 and 4.8.2.2).

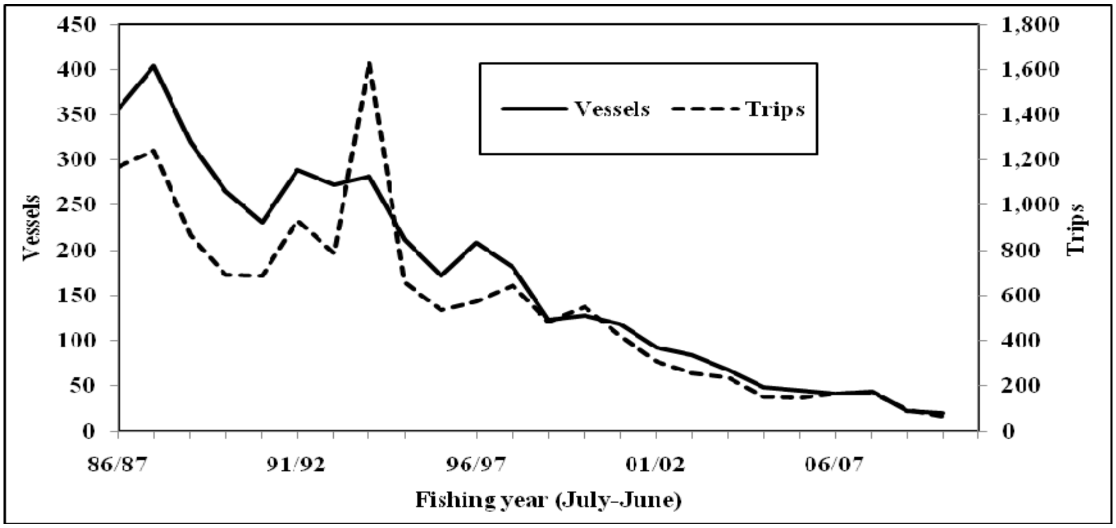

Figure 4.8.2.2. Spiny lobster tail trips and vessels.

Alternative 2 or **Preferred Alternative 4** would reverse a long-standing Council decision that provided an economic incentive to engage in commercial multi-day, deep-water fishing for spiny lobster in the EEZ. Even with the Councils approved incentive, other factors have greatly reduced the number of vessels landing lobster tails commercially to an average of 35 per year in 2005/2006–2009/2010 (Table 4.8.2.1 and Figure 4.8.2.2). There are more vessels with landings of spiny lobster in Florida, 2,175 on average in 1987/1988–1991/1992 and 781 vessels in 2005/2006–2009/2010 (Table 3.4.1.1).

4.8.3 Direct and Indirect Effect on the Social Environment

Modifying the tailing requirements can certainly benefit the social environment; yet, the alternatives do not provide a complete solution to the problem. **Alternative 1** would provide no solution as no action would be taken. While **Alternative 2** would solve most of the law enforcement issues, it would not provide the benefits of the original intent which allows for fishermen who take longer fishing trips to accommodate space issues with whole lobsters. By requiring all fishermen to obtain state commercial permits to obtain a tailing permit under **Preferred Alternative 3** would remove some of the uncertainty for law enforcement, yet still impose some ambiguity in the regulations making it difficult to regulate harvest of undersized lobster. By requiring fishermen to either land all tailed or whole product, **Preferred Alternative 4** would remove some of the difficulty in prosecuting the harvest of undersized lobster, and in conjunction with **Preferred Alternative 3,** may be the best solution to a difficult problem while continuing to provide for fishermen's concerns of space on long trips.

4.8.4 Direct and Indirect Effect on the Administrative Environment

Under **Alternative 1**, the current level of administrative time and cost burdens would be maintained. Enforcement concerns related to the harvest of undersized Caribbean spiny lobsters would persist and recreational fishermen may continue to acquire Tail Separation Permits, which was an unintended consequence of previously implemented regulations. **Alternative 2** would have a positive impact on the administrative and law enforcement environments since the Tail-Separation Permit would no longer exist and the practice of tailing Caribbean spiny lobsters would be prohibited. **Preferred Alternative 3** would create a very small administrative burden when compared to the status quo because some updates to the current regulatory text would be necessary. **Preferred Alternative 4** would also require a modification to the regulations; however, the administrative burden would be very low. If the majority of fishermen chose to land their harvest whole the burden on law enforcement officers would be reduced for those trips. Law enforcement issues may still exist for those fishermen who may choose to land their entire harvest tailed under **Preferred Alternative 4**.

4.8.5 Council Conclusions

Preferred Alternative 3 addresses the issue of recreational fishermen obtaining Tail-Separation Permits, which was not the intended use of the Tail Separation Permit. Clarifying the regulations now would prevent even more recreational fishermen from trying to obtain the Tail-Separation Permit in the future. Based on anecdotal information from fishery participants indicating that some spiny lobster fishermen land part of their catch tailed in order to conceal harvest of undersized spiny lobsters, the Councils determined some action to prevent the practices was necessary to ease enforcement burdens and protect the stock. Therefore, in addition to choosing **Alternative 3** as a preferred alternative, the Councils also chose **Alternative 4** as a preferred alternative. It is likely that requiring harvested spiny lobsters to be landed either all whole or all tailed will curtail the practice of concealing illegally harvested undersized spiny lobsters without incurring significant socioeconomic impacts.

4.9 Action 9: Limit Spiny Lobster Fishing in Certain Areas in the EEZ off Florida to Protect Threatened Staghorn and Elkhorn Corals (*Acropora* spp.)

Preferred Alternative 1: No Action – Do not limit spiny lobster fishing in certain areas in the EEZ off Florida to address ESA concerns for *Acropora* spp.

Alternative 2: Prohibit spiny lobster trapping on all known hardbottom in the EEZ off Florida in water depths less than 30 meters.

Alternative 3: Expand existing and/or create new closed areas to prohibit spiny lobster trapping in the EEZ off Florida.

- **Option a:** Create 24 —large closed areas to protect threatened *Acropora* spp. corals.
- **Option b:** Create 37 —medium closed areas to protect threatened *Acropora* spp. corals.
- **Option c:** Create 52 —small closed areas to protect threatened *Acropora* spp. corals.

Alternative 4: Expand existing and/or create new closed areas to prohibit all spiny lobster fishing in the EEZ off Florida.

- **Option a:** Create 24 —large closed areas to protect threatened *Acropora* spp. corals.
- **Option b:** Create 37 —medium closed areas to protect threatened *Acropora* spp. corals.
- **Option c:** Create 52 —small closed areas to protect threatened *Acropora* spp. corals.

4.9.1 Direct and Indirect Effect on the Physical and Biological/Ecological Environments

Spiny lobster traps are generally not deployed on coral or hardbottom (Lewis et al. 2009), and most fishers appear to drop traps on seagrass, rubble, or sandy habitats because these areas are less likely to damage traps (Hill et al. 2003). Traps also appear to move less on these substrates (Uhrin et al. 2005). However, the relatively poor water quality in the Lower and Middle Keys may cause fishers to accidentally deploy traps on habitats that could support elkhorn and staghorn corals (*Acropora* spp.). The biological opinion determined that the deployment and retrieval of traps during normal fishing operations had little impact to *Acropora* spp. relative to traps moved from their original locations during storms.

Lewis et al. (2009) analyzed the impacts to benthic habitat in the Florida Keys of trap movement during storms. The study documented the distance traps moved during non-tropical storm events. Buoyed traps moved an average of 15 ft during each storm and as much as 98 ft from their original location (Lewis et al. 2009). The movement of buoyed spiny lobster traps following a tropical storm or hurricane has never been measured during a trap impact study, largely because those traps move so far from their original locations that they are rarely, if ever, recovered. However, anecdotal evidence indicates that fishermen have found traps several miles from their original location after tropical storms or hurricanes (FWC unpublished data).

The movement of traps during storms poses the greatest threat to *Acropora* spp. Because of *Acropora* spp. branching morphology, colonies of any size are susceptible to fragmentation/breakage and abrasion from traps and trap lines. Even traps initially placed by fishermen in locations devoid of *Acropora* spp. colonies can be moved by storms into reef habitats and cause damage. Creating closed areas would reduce the likelihood of traps contacting colonies even if they are moved by storms by creating buffers between the closest traps and *Acropora* spp. colonies. Closed areas approximately 200 ft or more across would likely be sufficient to protect *Acropora* spp. colonies from trap movements occurring during typical non-tropical storm conditions.

Alternatives 2, 3, and **4** were developed primarily to protect colonies with high conservation value and areas of high *Acropora* spp. density. The largest "super colonies" were designated as the highest conservation priority because of their importance to sexual reproduction. *Acropora* spp. corals are generally considered sexually mature when the surface area of live tissue exceeds 100 cm^2. Elkhorn corals with a living tissue surface area of 1,000 cm^2 could be considered "super colonies." A similar distinction could be made for staghorn corals with a living tissue surface area of 500 cm^2. Colonies of this size have exponentially higher reproductive potential compared to other sexually mature colonies, and represent essential sources of gamete production. Colonies of this size are also exceedingly rare. Sampling at over 1,000 locations throughout the Florida Keys and the Dry Tortugas identified only 17 super colonies (6 staghorn colonies and 9 elkhorn colonies). The same level of sampling has also identified 62 sexually mature colonies (32 staghorn colonies and 30 elkhorn colonies) and 61 non-sexually mature colonies (58 staghorn colonies and 3 elkhorn colonies).

Preferred Alternative 1 would have the least biological benefit to *Acropora* spp., and would perpetuate the existing level of risk of interaction between these species and the fishery. **Preferred Alternative 1** would not meet the requirement established under the biological opinion; however, the Councils have initiated Amendment 11 to the Spiny Lobster FMP to address this requirement after allowing more time for stakeholder input. The Councils intend to quickly develop the new amendment and put measures into place that would provide protection for *Acropora* spp. as required by the biological opinion.

Alternative 2 would provide the greatest biological benefit to *Acropora* spp. and other hardbottom/coral resources. **Alternative 2** would prohibit trapping on all hardbottom in the Florida EEZ, which support *Acropora* spp. This would reduce the likelihood of interactions between spiny lobster trap gear in the EEZ and *Acropora* spp. to almost zero. The vast majority of *Acropora* spp. colonies in the Florida EEZ occur in waters under the South Atlantic Council's jurisdiction. While areas of hardbottom habitat in the Florida EEZ fall under the jurisdiction of the Gulf Council, the water quality in these areas is generally too poor to sustain *Acropora* spp. colonies. However, if water quality improves these areas would likely support *Acropora* spp.

Relative to **Alternative 2**, **Alternatives 3** and **4** would be less biologically beneficial to *Acropora* spp. colonies located outside the closed areas. **Alternative 3, Options a-c** would reduce the risk of trap damage to *Acropora* spp. by prohibiting the use of traps near areas of high *Acropora* spp. density or near colonies with high conservation value. **Alternative 3, Option a** would likely provide the greatest biological benefit because it closes approximately 14 mi^2 of hardbottom habitat to trapping. **Alternative 3, Option b and c** would likely have decreasing biological benefits, closing approximately 8 and 4 mi^2 of hardbottom habitat to trapping, respectively. As proposed closed areas get smaller, traps are more likely to be accidentally dropped upon colonies. Larger closed areas also provide larger buffers between their boundaries and colonies. Non-tropical storm systems can move traps 100 ft from their original locations. However, stronger storms (i.e., tropical systems) can move traps many times further. **Alternative 3, Option a** would provide the largest buffer providing additional protection to colonies in the event a stronger storm moves traps longer distances. As the proposed areas get smaller, (i.e., **Alternative 3, Option b** and **c**) the additional protection against trap movement during stronger storms would be reduced. Likewise, as closed areas get smaller the potential for interactions between trap gear and corals increase.

Alternative 4 and the associated options would provide slightly more biological benefit to *Acropora* spp. colonies than **Alternative 3** and the associated options because it would prohibit all fishing for spiny lobster in the proposed closed areas. Although the effects to *Acropora* spp. from diving for spiny lobster are unknown, other types of diving and the associated anchoring are known to adversely affect *Acropora* spp.. **Alternative 4** would provide additional benefits because it would reduce the likelihood that adverse effects known from diving and anchoring could occur. The overall size of the proposed closed areas is less relevant when discussing the impacts from diving since divers must be in very close proximity to colonies to impact them. Thus, simply prohibiting the practice of diving for spiny lobster inside the proposed closed areas would likely help minimize any potential threat. Thus, **Alternative 4**, **Option a** would likely have the greatest biological benefit because it would create the largest buffer against trap impacts, while also reducing potential impacts from diving. **Alternative 4**, **Option b** and **c** are likely to have diminished biological benefits relative **Alternative 4**, **Option a** with respect to reduce trap impacts; however, the alternatives are likely to have same biological benefit as **Alternative 4**, **Option a** relative to diving and anchoring impacts. Maps of the proposed closed areas are in Appendix H.

Preferred Alternative 1 would perpetuate the existing level of risk for interactions between other ESA-listed species and the fishery. The impacts from **Alternatives 2-4** and their associated options on sea turtles and smalltooth sawfish are unclear. If these closed areas perpetuate the existing amount of fishing effort, but cause effort redistribution, any potential effort shift is unlikely to change the level of interaction between sea turtles and smalltooth sawfish and the fishery as a whole. If these alternatives reduce the overall amount of fishing effort in the fishery, the risk of interaction between sea turtles and smalltooth sawfish would likely decrease.

4.9.2 Direct and Indirect Effect on the Economic Environment

In terms of assessing economic impacts, the extent of lobster fishing in the proposed closed areas must be estimated. Survey-based studies by Murray (2005) and (Shivlani et al. 2004) suggest similar economic characteristics of the fishermen and experience-based knowledge of the areas they fish. Fishermen have provided information used to assess the alternatives.

Compared with **Preferred Alternative 1**, it is estimated that **Alternative 2** could preclude 1,441 trips per year in the EEZ in the Keys area for 195 vessels, referring to trips with reported depths of less than 100 ft (Table 4.9.2.1, last row and footnote). These trips have relatively high average landings, and if they do not occur, the landings of Caribbean spiny lobster would be reduced by 0.486 mp ($2.7 million in 2008$) (Table 4.9.2.1). Assuming the trips do not occur, the total for trip and vessel gross revenue for all species landed would be reduced by $2.9 million, 12% of the total for Florida and 14% of the total for Monroe County, and 75% of the total for the Keys EEZ.

Table 4.9.2.1. Caribbean spiny lobster landings, Florida and Keys, all and EEZ

Area	Caribbean spiny lobster					Trip gross		
	Trips	Thousand pounds	Lbs / trip	Thousand 2008$	2008$ / trip	Thousand 2008$	%, Florida	%, Monroe
Florida	15,568	3,671	236	$22,227	$1,428	$23,533	100%	
Florida, *EEZ*	1,977	670	339	$3,795	$1,919	$4,351	18%	
Monroe	13,237	3,282	248	$19,761	$1,493	$20,724	88%	100%
Keys, EEZ	1,664	630	379	$3,556	$2,137	$3,830	16%	18%
Keys, EEZ, <100 ft	1,441	486	337	$2,723	$1,889	$2,908	12%	14%

Source: NMFS, SEFSC, FTT (Mar. 19, 2010), data and methods as in Vondruska 2010a, annual averages for fishing years 04/05-09/10. The trip averages may differ from those in other tables. A depth of 30 m is approximately 100 ft (98 feet = 30 meters * 39.37 inches / 12 inches per foot; 16.39 fathoms = 30 meters / 1.83). Selected vessel averages for gross revenue are as follows: $29,532 (781 vessels, Florida), and $18,056 (212 vessels, landings from the Keys EEZ), and $14,829, (195 vessels, landings from the Keys EEZ in depths less than 100 feet).

There would be 25 large closed areas in the EEZ off Florida under **Alternative 3, Option a**. This includes a small part of the federal waters in the EEZ to about Key Biscayne which total 1,134 sq miles out to a depth of 200 ft, referring to waters under South Atlantic Council's jurisdiction (A. Herndon, personal communication). Most fishermen appear to deploy traps out to a depth of about 100 ft, and close to, but not intentionally on, hard-bottom areas. This includes an estimated 73 mi^2 of hard-bottom, of which 13.6 mi^2 (or 18.6%) are in the 25 large closed areas. Reportedly, lobsters reside in hard-bottom areas (primarily reef and reef-like habit), but traps that fall unintentionally on hard-bottom areas can get caught and then be damaged when fishermen attempt to retrieve them.

If 25 large areas of hard-bottom were closed to trap fishing under **Alternative 3, Option a** (18.6% of the specified hard-bottom area of 73 mi^2 that is less that 100 ft deep), then an estimated 18.6% of the landings of 0.486 lbs ($0.506 million in 2008$) of spiny lobster for 1,441 trips and 195 vessels would be precluded (Table 4.9.2.1). Including the value of other species landed by the trips and vessels, and assuming the trips do not occur, the associated dollar loss in vessel and trip would be nearly $0.55 million (approximately 18.6% of trip and vessel gross of $2.908 million).

If 37 medium areas were to be closed to trap fishing under **Alternative 3, Option b**, then 11.2% of the specified hard-bottom area (of 73 mi^2 that is less that 100 ft deep) could not be used for lobster traps. This would affect an estimated 11.2% of the landings and ex-vessel value of spiny lobster, and assuming the trips do not occur, it would result in a loss in trip and vessel gross of nearly $0.33 million (Table 4.9.2.1; 11.2% of 0.486 lbs; and approximately 11.2% of trip and vessel gross of $2.908 million).

If 52 small areas were to be closed to trap fishing via **Alternative 3, Option c**, then 5.6% of the specified hard-bottom area (of 73 mi^2 that is less that 100 ft deep) could not be used for lobster traps. This would affect an estimated 5.6% of the landings of spiny lobster, and assuming the trips do not occur, it would result in a loss of nearly $0.16 million in associated trip and vessel gross (Table 4.9.2.1; 5.6% of 0.486 lbs, and approximately 5.6% of trip and vessel gross of $2.908 million, or a reduction of $0.16 million).

4.9.3 Direct and Indirect Effect on the Social Environment

Closure of fishing areas is always a controversial management strategy and can have numerous direct and indirect effects to the social environment. Yet, to meet the mandates of the biological opinion, closed areas may be the most viable solution. The proposed options for closed areas attest to the difficulty in balancing the impact to the fishery and impacts to the endangered species. **Preferred Alternative 1** would not meet the requirement established under the biological opinion; however, the Councils have initiated Amendment 11 to the Spiny Lobster FMP to address this requirement after allowing more time for stakeholder input. The Councils intend to quickly develop the new amendment and put measures into place that would provide protection for *Acropora* spp. as required by the Biological Opinion.

The most restrictive alternative, **Alternative 2,** would prohibit traps on all hard bottom in the EEZ and likely have the most direct impacts on the social environment. **Alternatives 3** and **4** offer a broad array of options which provide less negative social impacts than **Alterative 2**, but may introduce other inefficiencies with regard to enforcement and compliance. Choosing smaller closed areas, as in **Alternative 3 Options b** and **c** may provide more flexibility for trap fishermen, but may make it more difficult to monitor and enforce compliance. **Alternative 4, Options b** and **c** would have similar social effects but for both commercial and recreational fishermen. Larger closed areas, like those in **Alternative 3, Option a** and **Alternative 4, Option a** may enhance enforcement, but could have more negative social effects on fishermen as they find less area to fish which could reduce harvests. Closed areas to fish could also create crowding as fishermen move more traps into areas closer to where others are already placing traps or as recreational divers are also forced into areas that become congested. At this time there are no data on trap placement with sufficient detail to analyze such effects. The impacts will be better known once fishermen have had an opportunity to examine the proposed closures and how they may be affected.

4.9.4 Direct and Indirect Effect on the Administrative Environment

Preferred Alternative 1 would not meet the requirements of the Biological Opinion and requires the Councils to develop a new amendment that will address this requirement. The

Councils intend to quickly develop the new amendment and put measures into place that would provide protection for *Acropora* spp. as required by the Biological Opinion.

Any alternative that creates new closed areas would increase the administrative burden over the current level due to changes in maps, outreach, and education of the public, and greater enforcement needs. **Alternative 2** would be the most inclusive and require enforcement over the largest area. **Alternatives 3** and **4** are similar except **Alternative 3** applies to trap fishing only, and **Alternative 4** applies to all lobster fishing. **Alternative 4** would be easier to enforce because any boat in a closed area with lobster on board would be in violation of regulations. Larger areas could incorporate multiple colonies and thereby reduce the actual number of closed areas. Thus, the expectation is **Option a** would result in fewer, larger closed areas; **Option c** would result in more, small areas; and **Option b** would be between the two. Therefore, **Option a** would create less administrative and enforcement burden than **Option b** or **c**.

4.9.5 Council Conclusions

The Councils chose **Preferred Alternative 1** to allow more time for industry representatives, along with NMFS/NOAA and Marine Sanctuary representatives to work together to define areas of important habitat to protect *Acropora* spp. coral. This action will be included in Amendment 11. The Councils did not choose any of the other alternatives because they wanted to be sure the areas closed were the most appropriate for protecting *Acropora* spp.

4.10 Action 10: Require Gear Markings so All Spiny Lobster Trap Lines in the EEZ off Florida are Identifiable

<u>Preferred Alternative 1</u>: No Action – Do not require gear marking measures for spiny lobster trap lines.

Alternative 2: Require all spiny lobster trap lines in the EEZ off Florida to be COLOR, or have a COLOR marking along its entire length. All gear must comply with marking requirements no later than August 2014.

Alternative 3: Require all spiny lobster trap lines in the EEZ off Florida to have a permanently affixed 4-inch COLOR marking every 15 ft along the buoy line or at the midpoint if less than 15 ft. All gear must comply with marking requirements no later than August 2014.

4.10.1 Direct and Indirect Effect on the Physical and Biological/Ecological Environments

Trap lines are consistently found as marine debris and most frequently without buoys or traps still attached. These conditions make it extremely difficult to determine if line found in the environment, or entangling protected species, originated from the spiny lobster fishery. A lack of uniquely identifiable markings also makes monitoring incidental take by the fishery difficult. Trap line marking requirements would allow for greater accuracy in identifying fishery interactions with protected species, leading to more targeted measures to reduce the level and severity of those impacts. Trap line marking requirements would allow for greater accuracy in determining, or ruling out, fishery-based sources of marine debris.

Preferred Alternative 1 would not meet the requirement established under the biological opinion; however, the Councils have initiated Amendment 11 to the Spiny Lobster FMP to address this requirement after allowing more time for stakeholder input. The Councils intend to quickly develop the new amendment and put measures into place that would provide protection for *Acropora* spp. as required by the biological opinion.

Alternative 2 would likely have slightly more biological benefit than **Alternative 3.** Requiring gear markings along the entire length of trap lines would minimize the likelihood that a portion of a spiny lobster trap line is recovered without an identifiable mark. **Alternative 3** would provide greater biological benefit than **Preferred Alternative 1,** but the benefits would likely be less than **Alternative 2** for the reason described above. **Alternatives 2** and **3** would fulfill the requirements of the biological opinion. The trap marking requirements under **Alternatives 2** and **3** would provide indirect benefits to sea turtles and smalltooth sawfish. Trap marking requirements would provide better understanding of the frequency of interactions between these species and the fishery. These requirements could also help rule out the spiny lobster fishery as a potential source of entanglement with protected species. By better understanding which fisheries are interacting with sea turtles and smalltooth sawfish, ways to reduce those interactions can be developed.

4.10.2 Direct and Indirect Effect on the Economic Environment

Lobster trap line replacement outside of the normal schedule and at a quicker pace implies an economic impact for **Alternatives 2** and **3**. Recognizing that the number of traps, trap line length, wear and replacement schedule, and other factors may vary, an industry source estimated the cost of replacing trap lines at $20,000 per vessel,[13] and this exceeds the average annual gross revenue (for all landings, $15,866) for the 274 vessels with landings of spiny lobster in Florida from the EEZ, though it is less than the average gross for the 781 vessels with landings of spiny lobster in Florida ($29,960, data from Table 4.9.2.1, footnote; also, see Table 3.4.1.1). There are far fewer traps than in the past, and the number fished declines as the season progresses.[14]

4.10.3 Direct and Indirect Effect on the Social Environment

Marking trap lines could have significant effects on the social environment as it may impose substantial costs to modify the gear, according to testimony during public hearings. **Preferred Alternative 1** would allow the Councils more time to address this issue and develop other alternatives in another amendment to the FMP that may assist in alleviating any of the hardships imposed by this requirement and still address concerns over interactions with protected species. **Alternatives 2** and **3** would require some type of marking on trap lines which are required in other fisheries and could resolve any future problems with identification of trap lines being associated with interactions with protected species, yet may impose substantial costs to the industry. **Alternative 2** may allow for more efficient marking of lines as fishermen would not have measure each line marking pattern and therefore save time and money, although it is unclear as to what the costs would be to industry. Having more time to consider other options will allow for both protection of protected species and take into consideration industry concerns over increased costs that could have negative social effects if profit margins in this fishery are small.

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[13]According to personal communication, 09Feb 11, Florida Keys Commercial Fishermen's Association, P.O. Box 501404, Marathon, FL 33050, the cost per trap for a line of 90 ft in the Florida Keys would be $26.10 (90 ft @ $0.29 / ft for 3/8" standard black polypropylene line); i.e., approximately $20,000 per vessel (750 traps more or less @ $26.10 per trap), or $12.685 million (for 485,000 traps). The estimate excludes labor to remove and replace lines, the cost of disposal of the old lines, the cost of purchasing lines with color, shorter replacement schedules for lines that are not black, and the use of heavier and longer lines by some fishermen.

[14]The number of traps used to fish for spiny lobster in Florida has declined, along with the number of vessels, trips, and hours fished (Section 3.4.1, with the number of traps "that could be fished" fell from an estimated 704,580 in 1987/88 – 1991/92 to 368,106 in 2005/06 – 2009/10; Vondruska 2010a). The number of traps fished declines seasonally, mostly it appears because of the seasonal decline in number of trips; i.e., the median number of traps fished per trip remains relatively stable through December and then declines more sharply (Vondruska 2010a). The cost of replacement per vessel depends on the number owned, which would be expected to exceed the number hauled on most trips. Based on statistical analysis of FTT data (1986-2009, as of 19Mar10, as used in Vondruska 2010a) and the last 5 years of data for June-July fishing years, the "maximum" number of traps hauled per vessel (based on each vessel's high-trap trip) averaged 400-500 traps per year per vessel (400-500 traps at the 75th percentile, and 600-1200 traps per vessel at the 90th percentile). For the Florida EEZ, approximately 10% of the trips have reported depths of more 112 ft, and for the trips with landings of tails, approximately 25% of the trips have reported depths of more than 136 feet.

4.10.4 Direct and Indirect Effect on the Administrative Environment

Preferred Alternative 1 would not meet the requirements of the biological opinion; however, the Councils and NOAA Fisheries Service have already initiated Amendment 11 to the Spiny Lobster FMP to set trap line requirements. The Councils took this action to allow more time for stakeholder input on the methods for marking trap lines. **Alternatives 2-4** would increase the need for enforcement to check if trap lines are properly colored or marked. On the other hand, the ability to identify lines entangled with endangered species would reduce the difficulty in determining assignment of incidental take to a particular fishery by NOAA Fisheries Service Protected Resources Division. In general, none of the alternatives to mark lines would be more or less burdensome than the other.

4.10.5 Council Conclusions

The Councils chose **Preferred Alternative 1** to allow more time for industry representatives, along with NMFS/NOAA and Marine Sanctuary representatives to work together to determine appropriate and cost-effective ways to mark lines. This action will be included in Amendment 11. The Councils did not choose any of the other alternatives because they wanted to be sure the line marking requirements were not overly burdensome on fishermen.

4.11 Action 11: Authority to Remove Derelict or Abandoned Spiny Lobster Traps Found in the EEZ off Florida

Alternative 1: No Action – Do not allow the public to remove any derelict or abandoned spiny lobster trap found in the EEZ off Florida.

Alternative 2: Allow the public to completely remove from the water any derelict or abandoned spiny lobster trap found in the EEZ off Florida from the end of lobster season trap removal period (usually April 5) until the beginning of the next season‘s trap deployment period (August 1).

Alternative 3: Allow the public to completely remove from the water any derelict or abandoned spiny lobster trap found in the EEZ off Florida during the closed seasons for both spiny lobster and stone crab (May 20-July 31).

Alternative 4: Allow the public to remove spiny lobster trap lines, buoys, and/or throats, but otherwise leave in place, any trap found in the EEZ off Florida from the end of season trap removal period (usually April 5) until the beginning of the next season‘s trap deployment period (August 1).

Alternative 5: Allow the public to remove spiny lobster trap lines, buoys, and/or throats, but otherwise leave in place, any trap found in the EEZ off Florida during the closed seasons for both spiny lobster and stone crab (May 20-July 31).

Preferred Alternative 6: Delegate authority to regulate the removal of derelict or abandoned spiny lobster traps occurring in the EEZ off Florida to the Florida FWC.

4.11.1 Direct and Indirect Effect on the Physical and Biological/Ecological Environments

The biological opinion on the spiny lobster fishery requires NOAA Fisheries Service to explore allowing the public to remove derelict trap gear from the EEZ off Florida. Lost traps pose multiple threats to the environment and protected species. Lost traps can “ghost” fish for a year or more (FWC unpublished data; Lewis et al. 2009). Trailing trap lines can become entangled in the reef, damaging corals and sponges (Chiappone et al. 2005). Marine mammals and ESA-listed sea turtles and marine fish can become entangled in trailing ropes (Guillory et al. 2001; Seitz and Poulakis 2006; Lewis et al. 2009). Derelict traps and trap lines can also cause fragmentation/breakage and abrasion of *Acropora* spp. colonies, particularly when derelict traps are moved during storms. Wooden traps eventually degrade after many months, but plastic trap throats and polystyrene buoys persist indefinitely in the marine environment. Seagrass meadows can be damaged when traps are lost or left for periods longer than six weeks (Uhrin et al. 2005). Thousands of lost and abandoned traps can have a significant effect on the reef environment and benthic habitats.

Alternative 1 would have no biological benefit for protected species or benthic habitat and would perpetuate the existing level of risk for interactions between these protected species and lost trap gear. **Alternative 2** would likely have the greatest biological benefits. This alternative would allow for the complete removal of all derelict or abandoned traps for the longest period of time, potentially increasing the number of derelict or abandoned traps removed. **Alternative 3** would also allow for the complete removal of derelict or abandoned trap gear, but for a shorter period. As a result, the biological benefit of **Alternative 3** may be less than **Alternative 2**. **Alternatives 4** and **5** would likely have less biological benefit than **Alternatives 2** and **3**. Allowing the public to remove trap line, buoys, and throats, would help reduce the potential impacts from ghost fishing and entanglement. However, traps remaining in the environment still have the potential to cause damage to benthic habitat. **Alternative 4** would allow more time for the public to remove trap line, buoys, and throats from derelict or abandoned traps, potentially increasing the biological benefit. Compared to **Alternatives 2-4**, **Alternative 5** would likely have the least biological benefit.

It is currently unclear what type of biological impact **Preferred Alternative 6** would have. Florida currently removes a limited number of derelict traps in the EEZ under certain situations. Given the difficulty of identifying derelict traps in the deeper waters of the EEZ, as well as the additional costs and time associated with transporting recovered derelict traps from the EEZ to disposal sites on shore, it is unlikely that the number of traps removed under this alternative will substantially increase. Thus, the biological benefit of **Preferred Alternative 6** is likely to be similar to the benefit anticipated under **Alternative 1**.

4.11.2 Direct and Indirect Effect on the Economic Environment

High proportions of the licensed traps were lost during the 2005/2006 season because of hurricanes, far more than normally lost. Apparently only a small proportion the traps lost, 10-20%, is ever recovered, meaning that the rest, 80-90%, become derelict. Retrieval of derelict traps by FWC employees and other government employees is allowed at times specified by the FWC.

Alternatives 2-5 would allow the public to remove derelict traps during different portions of the closed season for commercial fishing. **Preferred Alternative 6** would delegate authority for removal the EEZ to the FWC, as now occurs in waters under state jurisdiction.

Though none of these alternatives would affect ongoing commercial fishing activity during the open season, fishermen's perception about any trap removal can impact their economic activity, wellbeing, and willingness to support regulations. Thus, **Preferred Alternative 6** may have the least economic impact. Federal and/or state outreach programs could change fishermen's perceptions over time, but change in attitudes may be a long time in coming and not as supportive as fishery managers may hope, as for the Florida Trap Certificate Program (Shivlani et al. 2004).

4.11.3 Direct and Indirect Effect on the Social Environment

Allowing the public to remove spiny lobster traps, lines or buoys could have indirect effects on the social environment. Trap fishermen are often very protective of their traps. Indeed, there are federal regulations involving the disturbance and molestation of traps while in season. Yet, the number of derelict traps does pose problems of both biological impacts and public perception. Because derelict traps degrade the habitat and can continue to ghost fish, the removal of derelict traps can have positive social benefits. Fishermen are supportive of trap removal programs but are often suspect of having the general public involved. **Alternative 1** may be the most desirable for some trap fishermen. Trap molestation is always a concern for trap fishermen and if the public is provided with an opportunity to clear derelict traps during the closed season, there may be a perception that they may conclude that their duty extends to other times and areas. Yet, public involvement in trap cleanup can be very effective as it increases the number of individuals who can remove traps. **Alternative 2** would allow for a more lengthy time period for the public to participate than **Alternative 3** which is limited to the closed season for spiny lobster and stone crab. The negative effects of allowing the public to participate are that there is no guarantee that legal traps might be removed by someone unfamiliar with the regulations. **Alternatives 4** and **5** would remedy some of the above concerns by allowing for removal of only parts of the trap, but there are still concerns about the public's knowledge and familiarity with the regulations. **Preferred Alternative 6** would allow the FWC to develop a program for trap removal that might address the concerns mentioned with previous alternatives and would likely have the fewest negative social effects.

4.11.4 Direct and Indirect Effect on the Administrative Environment

Alternative 1 would have no impacts on the administrative environment. **Alternatives 2** and **3** would allow members of the public to remove derelict traps from the water. These alternatives may create enforcement problems because someone with a trap aboard their vessel may have been removing it from the water because they found it abandoned or because they were illegal fishing. **Alternatives 4** and **5** would only allow the public to disable traps and would not allow them to retain the traps on board; thus enforcement would be easier. **Alternatives 2** and **4** would allow removal or disabling of traps during the closed season for lobster. Enforcement would need to be vigilant during this time to ensure the public did not unintentionally remove other traps, such as stone crab traps, which may be legally fishing. **Alternatives 3** and **5** would allow removal or disabling of traps only when both lobster and stone crab seasons are closed. These alternatives would create a much lower burden on enforcement because all similar traps would be prohibited during this time and could be considered derelict if in the water. **Preferred Alternative 6** would allow Florida to administer the clean-up of derelict traps in the EEZ off Florida. Florida currently has a program to remove abandoned traps in state waters. This alternative would have no impacts on the administrative environment for the federal government, but would increase the burden on the state government.

4.11.5 Council Conclusions

The Councils chose **Preferred Alternative 6** because Florida has a trap retrieval program in place that could be extended to include federal waters. This program is funded by $25 from every trap tag sold. In addition, nonprofit nongovernmental organizations, fishery participant organizations, or other community or citizens groups may retrieve derelict traps as part of coastal cleanup events authorized by FWC. The Councils did not choose **Alternative 1** because lost traps pose multiple threats to the environment and protected species, such as ghost fishing and entanglement of lines on reefs. **Alternatives 2-5** were not chosen because trap fishermen are protective of their traps and state regulations prohibit the disturbance and molestation of traps while in season. Well meaning members of the public might remove a legally fishing lobster trap from the water if they are not familiar with the regulations. Likewise, well meaning members of the public might remove similar looking traps, such as stone crab traps. Under the preferred alternative, the public would still be able to participate in cleanup activities.

4.12 Cumulative Effects Analysis (CEA)

As directed by the National Environmental Policy Act (NEPA), federal agencies are mandated to assess not only the indirect and direct impacts, but cumulative impacts of actions as well. The 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 CFR 1508.7). Cumulative effects can either be additive or synergistic. A synergistic effect occurs when the combined effects are greater than the sum of the individual effects.

This section uses an approach for assessing cumulative effects 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.

Cumulative effects on the biophysical environment, socio-economic environment, and administrative environments are analyzed below.

1. Identify the significant cumulative effects issues associated with the proposed action and define the assessment goals.

The CEQ cumulative effects guidance states this step is accomplished through three activities as follows:

I. The direct and indirect effects of the proposed actions (Section 4.1-4.11);
II. Which resources, ecosystems, and human communities are affected (Section 3); and

III. Which effects are important from a cumulative effects perspective (information revealed in this CEA)

Valued ecosystem components (VECs) are "any part of the environment that is considered important by the proponent, public, scientists and government involved in the assessment process. Importance may be determined on the basis of cultural values or scientific concern" (CEAA 1999). The important VECs for this analysis are as follows:

1. Managed Resource
2. Habitat
3. Protected Resources
4. Human Communities

2. Establish the geographic scope of the analysis.

The immediate areas affected by this action and analyzed in this CEA are the federal waters of the Gulf and South Atlantic. These waters extend from the seaward side of the state waters of Texas, Louisiana, Mississippi, Alabama, Florida, Georgia, South Carolina, and North Carolina to 200 miles. In practice, the waters off south Florida are the primary area where this species is fished in the U.S. and that will be affected by actions in this amendment. Other affected VECs including non-target species, habitat, and protected species are also within this geographic scope. The human community includes the fishing community which coincides with the managed species' geographic range, as well as the areas where processing, importing, and shipping of lobster tails takes place.

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). The most recent spiny lobster stock benchmark assessment was SEDAR 8 (2005). An update to that assessment was conducted in 2010; however, the Review Panel rejected that assessment. The update included data for analysis of stock status from the 1985/1986 season to the 2009/2010 season for commercial and recreational landings. The next SEDAR benchmark assessment is scheduled for 2014.

Council action was deferred on two actions from this amendment until Amendment 11 to the Spiny Lobster FMP to allow more time for stakeholder input. This amendment is expected to be completed before the beginning of the 2012 fishing season.

4. Identify the other actions affecting the resources, ecosystems, and human communities of concern.

a. Past federal actions affecting the spiny lobster fishery are summarized in Section 1.4. The following list identifies more recent actions.

- The Tortugas South marine reserve (60 square nautical miles) was sited in the Gulf EEZ to encompass a spawning aggregation site for mutton snapper. The Tortugas North marine reserve (120 square nautical miles) included part of the fishery jurisdiction of the

FKNMS, Dry Tortugas National Monument, Gulf EEZ, and Florida, and was cooperatively implemented by these agencies. Both of these marine reserves encompass spiny lobster habitat.

- Regulatory amendment 3 specified that the holder of a valid crawfish license or trap number, lobster trap certificate, and state saltwater products license issued by the FWC may harvest and possess, while in the EEZ off Florida, undersized lobster not exceeding 50 per boat or1 per trap aboard each boat, if used exclusively for luring, decoying or otherwise attracting non-captive lobster into traps. This action is being reconsidered in this amendment.
- Amendment 8 set a minimum size limit for importation of spiny lobster, disallowed importation of spiny lobster tail meat which is not in whole tail form with the exoskeleton attached, and disallowed the importation of spiny lobster with eggs attached or importation of spiny lobster where the eggs, swimmerets, or pleopods have been removed or stripped.
- Amendment 9 (CEBA-1) provided a presentation of spatial information for EFH and EFH-Habitat Areas of Particular Concern designations for species in the Spiny Lobster FMP.

b. The following are recent Florida actions important to the spiny lobster fishery.

- In 2001, the FWC set the target number of spiny lobster traps at 400,000 and implemented a 4% annual reduction in traps. The FWC suspended the annual trap reduction in 2003; nonetheless, the program resulted in a significant reduction in the annual numbers of traps set. In 2010, new regulations became effective that reduce the number of certificates by 10% if sold to a non-family member. This reduction will continue until the number of certificates is reduced to 400,000.
- As of January 1, 2005, and until July 1, 2015, 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 2004/2005 fishing season.
- In 2010, new regulations were enacted to remove latent trap certificates. Prior to the 2010/2011 season, any certificate for which the fee was not paid for three years shall be considered abandoned, revert to the state, and become permanently unavailable. Beginning with the 2010/2011 season, reversion will occur if the fee is not paid for two consecutive years.

c. The following are non-FMP actions which can influence the spiny lobster fishery.

- A naturally occurring, pathogenic virus, PaV1, infects juvenile Caribbean spiny lobsters. This virus is lethal to lobsters. Infection is highest in smaller juveniles; mortality occurs after larval settlement but before recruitment to the fishery. PaV1 was first detected in the U.S. spiny lobster population around 1996. No evidence shows PaV1 has increased in prevalence or virulence since around 2000, so mortality from PaV1 may explain why landings declined beginning about that time while the post-larval recruitment index remained steady.
- The Deepwater Horizon MC252 oil spill has affected more than one-third of the Gulf from western Louisiana east to the panhandle of Florida and south to the Campeche

Bank in Mexico. The impacts of the oil spill on the physical and biological environment are expected to be significant and may be long-term. However, the oil remained outside most of the area where spiny lobsters are abundant. Oil on the surface has largely evaporated or been removed. Heavy use of dispersants resulted in oil suspended within the water column, in some cases even deeper than the location of the broken well head. Floating and suspended oil has washed onto shore in several areas of the Gulf as non-floating tar balls. Whereas suspended and floating oil degrade over time relatively quickly, tar balls are more persistent in the environment and can be transported hundreds of miles. Information on the effects of the oil on the spiny lobster fishery is incomplete and unavailable at this time.

- The hurricane season is from June 1 to November 30, and accounts for 97% of all tropical activity affecting the Atlantic Basin (NOAA 2007). These storms, although unpredictable in their annual occurrence, can devastate areas when they occur. Direct losses to the fishing industry and businesses supporting fishing activities included: loss of vessels, loss of revenue due to cancelled fishing trips, and destruction of marinas and other fishery infrastructure (Walker et al. 2006). However, while these effects may be temporary, those fishing-related businesses whose profitability is marginal may go out of business if a hurricane strikes.
- Because of the continuing rise in the cost of fishing, including increases in the cost of fuel and insurance, along with other increases in operating costs, more fishermen are having difficulty making a living fishing. For example, fuel prices have increased more than 2.2 times since January 2000 according to the U.S. Department of Energy. Communities that are dependent on jobs that support the spiny lobster fishery could also be negatively impacted. If an ACL is set below current catch levels, accountability measures may curtail the fishery. This in turn may impact businesses dependent on commercial and recreational spiny lobster fishing because of fewer days to sell charter services, ice, fuel, tackle, hotel rooms, and other services to people participating in the fishery.
- How global climate changes will affect Gulf and South Atlantic fisheries is unclear. Climate change can impact marine ecosystems through ocean warming by increased thermal stratification, reduced upwelling, sea level rise; and through increases in wave height and frequency, loss of sea ice, and increased risk of diseases in marine biota. Decreases in surface ocean pH due to absorption of anthropogenic CO2 emissions may impact a wide range of organisms and ecosystems, particularly organism that absorb calcium from surface waters, such as corals and crustaceans (IPCC 2007, and references therein).

5. Characterize the resources, ecosystems, and human communities identified in scoping in terms of their response to change and capacity to withstand stress.

This step should identify the trends, existing conditions, and the ability to withstand stresses of the environmental components. According to the CEQ guidance describing stress factors, two types of information are needed: the socioeconomic driving variables identifying the types, distribution, and intensity of key social and economic activities within the region; and the indicators of stress on specific resources, ecosystems, and communities.

Caribbean Spiny Lobster
Trends in landings and the status of Caribbean spiny lobster are summarized in Section 3.1 and 3.3. Caribbean spiny lobster is not considered to be undergoing overfishing and the overfished status is unknown. This amendment would redefine the overfished and overfishing thresholds, so both Councils would use the same definition. Under any of the proposed definitions, including that under the preferred alternative, the stock likely would not be considered in an overfished condition. SEDAR 8 (2005) and the rejected 2010 update defined the overfishing level as fishing mortality (F) at 20% SPR. For SEDAR 8, that level was 0.49 per year and for the update was 0.45 per year. Only once since 2005/2006 season did the full F exceed either level. The mean F for 2007-2009 is 0.21 per year. However, the assessment analysts for the update cautioned that F may be underestimated for recent years.

Ecosystem
Changes in the spiny lobster fishery are not likely to create additional stress on the environment. Traps and trap lines can damage habitat through snagging or entanglement; however, these impacts are generally minimal. Changes in the population size structure as a result of shifting spiny lobster fishing selectivity and changes in stock abundance could lead to changes in the abundance of other species that compete with spiny lobster for shelter and food. Predators of spiny lobster could increase if spiny lobster abundance increased, and species competing for similar resources as spiny lobster could potentially decrease in abundance if less food and/or shelter are available. If spiny lobster abundance decreased, the opposite effects would take place. Efforts to model these interactions are still in their development stages, and so predicting possible stresses on the ecosystem in a meaningful way is not possible at this time.

Spiny Lobster Fishery
Florida trip ticket data used to monitor commercial spiny lobster effort include the number of vessels with landings, the number of trips taken, and trip duration. Trends are described in Sections 3.1, 3.4, and briefly summarized here.

Florida commercial landings of Caribbean spiny lobster increased from the late 1940s then fell from 2001 onward (Figure 3.1.1.1). The estimated number of traps used for commercial fishing for Caribbean spiny lobster in Florida approximately doubled every 10 years during 1950-1990, reached nearly a million traps in the early 1990s, and was reduced to less than a half million traps by the late 2000s. These declines can largely be credited to the trap limitation program which began in 1993. Commercial diving landings increased rapidly in the first decade of the trap limitation program and then declined thereafter (see landings by gear in Table 4.3.1.1). Estimated recreational landings of Caribbean spiny lobster and fishing effort in Florida (based on surveys of recreational permit holders) were more consistently low from 2001/2002 onward than in the 1990s (Figure 3.1.3.3).

Other reasons for the decline in effort include increases in fishing costs, increases in harvesting efficiency, and even improvements in the stock status. However, data currently are inadequate to determine which of these factors may have contributed to the decline in fishing effort.

6. Characterize the stresses affecting these resources, ecosystems, and human communities and their relation to regulatory thresholds.

This section examines whether resources, ecosystems, and human communities are approaching conditions where additional stresses could have an important cumulative effect beyond any current plan, regulatory, or sustainability threshold (CEQ 1997). Sustainability thresholds, which are levels of impact beyond which the resources cannot be sustained in a stable state, can be identified for some resources. Other thresholds are established through numerical standards, qualitative standards, or management goals. The CEA should address whether thresholds could be exceeded because of the contribution of the proposed action to other cumulative activities affecting resources.

<u>Caribbean Spiny Lobster</u>
Currently, the Councils have different definitions for biological reference points, and the South Atlantic Council does not have an overfished threshold definition (GMFMC 1999; SAFMC 1998; SEDAR 8 2005). Transitional SPR is used for the definitions of MSY, OY, overfishing, and overfished threshold by the Gulf Council. Generally, static SPR is more frequently used than transitional SPR. The SEDAR 8 (2005) benchmark assessment terms of reference suggest static SPR was used as in the South Atlantic Fishery Management Council's Spiny Lobster Amendment 6 (SAFMC 1998).

MSY is unknown but the landings data from 1991/1992 through 2009/2010 fishing years (Table 2.4.1.1) can be used to provide an indication of the productivity of the portion of the stock within the area of the Spiny Lobster FMP. Total landings provide an index of MSY and have ranged from a high of 10.1 mp in 1999/2000 to a low of 4.1 mp in 2005/2006, with an average of 7.0 mp.

Caribbean spiny lobster was not undergoing overfishing based on the SEDAR 8 (2005) benchmark assessment. The 2010 assessment update reached the same conclusion; however, the assessment update was rejected by the Review Panel. Because of the long planktonic larval stage for this species and hydrodynamic characteristics of the Gulf, South Atlantic, and Caribbean basins, Caribbean spiny lobsters in the U.S. fishery are believed to originate from spawning stocks outside of the U.S. Thus stressors on the population include fishing and other human activities outside the jurisdiction of the U.S. If the majority of recruitment is from areas outside of NOAA Fisheries Service authority, then fishing levels in this country may have no effect on stock biomass.

<u>Ecosystems</u>
In the biological opinion, NOAA Fisheries Service determined the spiny lobster trap fishery as it currently operates (e.g., number of traps, fishing techniques, gear types, etc.) may adversely affect the green, hawksbill, Kemp's ridley, leatherback, or loggerhead sea turtles, *Acropora* spp., or smalltooth sawfish, but is not likely to jeopardize their continued existence. The current cap on the number of traps available to the fishery is extremely unlikely to increase over the next three years [FAC. 68B-24.009(1)]. Additionally, an action to increase the number of traps available in the fishery would represent a modification to the fishery regulations and an ESA

section 7 consultation may need to be reinitiated to evaluate any new risks to protected species not previously considered.

The biological opinion stated it is reasonable to assume the level of take estimated to have occurred over the last three years (2004/2005-2006/2007 fishing seasons) is likely to continue into the future. Therefore, the biological opinion anticipated that over any consecutive three-year period, spiny lobster trap fishing would incidentally take up to three loggerhead, three green sea turtles, and one hawksbill, Kemp's ridley, or leatherback sea turtle; two smalltooth sawfish (non-lethal); and 482.09 m^2 of *A. cervicornis* and 7.41 m^2 of *A. palmata*.

7. Define a baseline condition for the resources, ecosystems, and human communities.

The purpose of defining a baseline condition for the resource and ecosystems in the area of the proposed action is to establish a point of reference for evaluating the extent and significance of expected cumulative effects.

Although the 2010 stock assessment update was rejected by the Review Panel, the assessment report shows trends in biomass and fishing mortality dating to the 1985/1986 fishing season. Within this timeframe, spiny lobster has not been considered to have been undergoing overfishing. Because spawning stock biomass cannot be determined without a Caribbean-wide assessment, the overfished condition could not be determined. These results are consistent with SEDAR 8 (2005).

The spiny lobster fishery was primarily a bait fishery (Labisky et al. 1980), until the development of freeze processing enabled the expansion of the retail market in the 1940's. The development of SCUBA further expanded the commercial fishery as well as the recreational fishery in the 1960's. Baseline information is lacking on the social environment of these fisheries, although some economic data are available. Ex-vessel revenues and numbers of traps in the water are available dating to the early 1960s. For further details on the history of the spiny lobster fishery, please see Section 3.0.

8. Identify the important cause-and-effect relationships between human activities and resources, ecosystems, and human communities.

Cause-and–effect relationships are presented in Table 4.12.1.

Table 4.12.1. The cause and effect relationship of fishing and regulatory actions for Caribbean spiny lobster within the time period of the CEA.

Time period	Cause	Observed and/or expected effects
1975	Florida enacted legislation creating the Special Two-Day Sport Season	Increased/concentrated recreational effort; "lobstermania"
1970's-80's	Increased number of traps in the water	Increased user conflicts on the water, excessive mortality of shorts, declining yield per trap
1988	Requirement and specification of live wells for holding undersized attractants	Reduced mortality of undersized attractants from 26% to 10%
1993	Florida implemented the spiny lobster Trap Certificate Program	Reduction from 750,326 traps in 1993 to 492,253 traps in 2010
1993	Florida implemented the restricted species endorsement	Reduced the adverse impacts caused by the two-day sport season by restricting recreational fishers to the bag limit

9. Determine the magnitude and significance of cumulative effects.

The objectives of this amendment and associated EIS are to: bring the Spiny Lobster FMP into compliance with Magnuson-Stevens Act requirements for ACLs and AMs to prevent overfishing (Actions 1, 3-5); update biological reference points (Action 2), and policies and procedures (Action 6); consider adjustment of management measures to aid law enforcement (Actions 7-8); and consider measures to protect threatened and endangered species established under a Biological Opinion (Action 9-11). The short- and long-term direct and indirect effects of each these actions are provided in Section 4.

To examine the magnitude and significance of the cumulative effects, important VECs were identified for the overall action to be taken with this amendment. For purposes of this analysis, four categories of VECs were identified (Table 4.12.2), and the consequences of each alternative proposed in this amendment on each VEC were evaluated. Some of these VECs were combined because the impacts of many of the past and current actions were similar.

Table 4.12.2. Evaluated VECs considered for further analysis and VECs consolidated for analysis.

VECs considered for further evaluation	VECs consolidated for further evaluation
Managed resource Adult Caribbean spiny lobsters Sub-legal Caribbean spiny lobsters	
Habitat	Hard bottom EFH
Protected resources *Acropora* spp. Endangered/threatened species	Marine mammals Sea turtles Sawfish
Human communities	Commercial harvesters Recreational harvesters Dealers Fishing communities

The following discussion refers to the effects of past and present actions on the various VECs.

<u>Managed Resources</u>

Adult Caribbean Spiny Lobsters

SEDAR 8 (2005) found the Caribbean spiny lobster stock was not undergoing overfishing, but the overfished status could not be determined. However, much evidence exists that recruitment is almost entirely from outside of the U.S. To obtain a true estimate of spawning stock biomass, a Caribbean-wide assessment is needed. Further, management and harvest practices in other countries may have a substantial impact on recruitment to the U.S. fishery. The import size restrictions may increase the size of the spawning stock in countries that previously harvested lobsters at or below reproductive size.

Non-fishing activities are likely to adversely affect spiny lobster stocks. Products from the Deepwater Horizon MC252 oil spill could potentially make their way into spiny lobster habitat in the Florida Keys. Effects could be minimal because of weathering, or effects could be more detrimental, especially impacting reproductive output and larval survival. These impacts may or may not influence the Caribbean spiny lobster stock, as most of the larvae produced in the Keys are believed to be lost to the population. Global warming could also have a detrimental effect on spiny lobsters; however, those effects cannot be quantified at this time.

Sub-legal Caribbean Spiny Lobsters

The practice of using undersized attractants in traps may facilitate the spread of PaV1 by moving infected juveniles into new areas. In addition, although lobsters are generally gregarious, they avoid infected lobsters (Behringer et al. 2008). By putting potentially infected lobsters in traps as bait, fishermen may artificially create a condition that increases the infection rate of PaV1.

<u>Habitat</u>

EFH is defined in the Gulf Council's Generic Essential Fish Habitat Amendment (GMFMC 2004) and in the South Atlantic Council's Fishery Ecosystem Plan (SAFMC 2009). Sections 3.2

and 3.3 of this amendment describe the physical environment inhabited by Caribbean spiny lobsters. In general, Caribbean spiny lobster can be found among rocks, on reefs, in grass beds or in any habitat that provides protection. A planktonic larval stage lives in the water column for six to seven months and feeds on zooplankton and phytoplankton. Young benthic stages of Caribbean spiny lobster 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. Individuals two to four years show nomadic behavior, emigrating out of the shallows and moving to deeper, offshore reef environments.

From fishing, the most detrimental effects to the environment are caused by traps. Deployment of traps and movement of traps can damage both soft and hard bottom habitats. The development of marine reserves around the Dry Tortugas and the Florida Keys National Marine Sanctuary has helped protect some critical habitat. Florida's trap limitation program reduced the number of traps by about 50% during the 10 years of implementation. Derelict traps may also impact habitat. Florida has a trap clean-up program in state waters that would be extended to federal waters in this amendment through Action 11. Hurricanes are not uncommon in the Florida Keys where most of the lobster population lives. Storms can move both active and derelict traps over sensitive habitat even more than under normal conditions.

Although impacts to habitat are less for fishermen using gears other than traps, damage can still be done. Boats carrying recreational or commercial divers may drive through sea grass beds creating the ubiquitous prop scars visible in the Keys. Boats are sometimes anchored over hard bottom, and inexperienced divers sometimes stand on or grab bottom structures with living organisms. The illegal use by commercial divers of casitas, artificial dens to attract lobsters, can damage or alter bottom structure.

Damage caused by spiny lobster fishing is associated with the level of fishing effort. Therefore, actions reducing levels of effort would result in greater benefits to the physical environment because fishing related interactions with habitat would be reduced. Thus, if actions in this amendment to set ACLs and AMs result in decreased effort, the impacts on habitat would be beneficial. However, the Council chose an ACL and an ACT that are higher than average recent landings, so effort would not be expected to change.

The 2009 Biological Opinion determined the spiny lobster fishery is not likely to adversely affect *Acropora* spp. critical habitat. The physical feature essential to the conservation of *Acropora* spp. critical habitat (typically referred to as the essential feature(s)) is substrate of suitable quality and availability to support larval settlement and recruitment, as well as reattachment and recruitment of asexual fragments. Effects to the essential feature identified for *Acropora* spp. critical habitat from bully netting and diving for spiny lobster either do not occur or occur so rarely that any affect on the essential feature is discountable. Commercial trapping may affect *Acropora* spp. critical habitat, but any affects will be temporary and insignificant. Traps do not cause consolidated hardbottom to become unconsolidated, nor do they cause growth of macroalgae or increased sedimentation.

EFH, particularly coral reefs, sea grasses, and algae, are susceptible to non-fishing activities. Anything that suspends sediments, such as tropical storms, can block sunlight and decrease photosynthesis. Dramatic climate change in the future could alter temperatures to an extent to exceed the viable range for the organisms that make up these habitats.

Protected Resources

Acropora spp.

Commercial and recreational bully net use is not likely to adversely affect *Acropora* spp., based on the low likelihood of interactions between these species and this gear type. The reliance upon visual contact with a target species reduces the potential for fragmentation or abrasion of *Acropora* spp. caused by bully nets. *Acropora* spp. are extremely unlikely to occur on the seagrass and mud flats where the vast majority of bully nets are used.

Commercial and recreational diving for spiny lobster is not likely to adversely affect *Acropora* spp. *Acropora* spp. occur only rarely and in discrete locations within the Gulf and South Atlantic regions, and is not found in the Gulf portion of the Florida Keys. Where they do occur, fisheries could cause fragmentation or abrasion resulting from: 1) fishing gear/marine debris, 2) damaging fishing practices, 3) vessel groundings, 4) anchoring, and 5) diver/snorkeler interactions (*Acropora* BRT 2005).

Traps may affect *Acropora* spp. via fragmentation and abrasion if they become mobilized during storm events and collide with colonies. The deployment of spiny lobster traps may adversely affect *Acropora* spp. as traps drop toward the sea floor or when traps are retrieved and pulled to the surface. Abrasion may occur when traps or trap lines contact *Acropora* spp. during storm events or normal fishing activities. However, *Acropora* spp. are only rarely, if ever, observed in the Gulf off south Florida where the majority of trap fishing occurs because of relatively poor water quality. For this reason, any adverse affects from abrasion/fragmentation due to interactions with commercial spiny lobster trap gear are only likely to occur in the South Atlantic waters off south Florida. The Florida trap limitation program, although suspended at this time, reduced the number of traps by Florida fishermen by about 34%. Fewer traps in the water reduce the likelihood of *Acropora* spp. suffering adverse impacts.

Localized adverse affects on *Acropora* spp. in the action area have resulted from many of the same stressors affecting *Acropora* spp. throughout its range, namely anthropogenic breakage, disease, and intense weather events (i.e., hurricanes and extreme cold-water disturbances). These stressors have led to declines of *Acropora* spp. in the action area commensurate with declines seen elsewhere in the species' range (*Acropora* BRT 2005). Stresses associated with climate change have been documented worldwide and are expected to increase. For example, increased temperatures can lead to bleaching (loss of algal symbionts). Researchers predict bleaching threshold temperatures will be exceeded at least once per year on the majority of the world's coral reefs by 2030-2050 (IPCC 2007).

Increases in atmospheric carbon dioxide leading to ocean acidification are also of concern for *Acropora*. As atmospheric CO_2 is dissolved in surface seawater, seawater becomes more acidic shifting the balance of inorganic carbon away from CO_2 and carbonate (CO_3^{-2}) toward bicarbonate (HCO_3^{-1}). This shift decreases the ability of corals to calcify because corals are believed to use CO_3^{-2} as the source of carbonate to build their aragonite ($CaCO_3$) skeletons (*Acropora* BRT 2005).

Sea Turtles and Smalltooth Sawfish
Commercial and recreational bully net use is not likely to adversely affect sea turtles or smalltooth sawfish based on the low likelihood of interactions between these species and this gear type. Bully nets require an active fishing technique that is only effective when target prey can be seen and the net is tended constantly. Thus, sea turtles or smalltooth sawfish are extremely unlikely to become entangled in these gears.

The distribution of spiny lobster diving effort overlaps spatially with areas known to be inhabited by sea turtles and smalltooth sawfish. However, divers only occasionally encounter sea turtles and rarely encounter smalltooth sawfish, if at all.

Sub-adult and adult loggerhead sea turtles are primarily coastal dwelling and typically prey on benthic invertebrates such as mollusks and decapod crustaceans in hardbottom habitats. As such, loggerhead sea turtles may be attracted to spiny lobster traps when lobsters are inside. They are also known to feed on epibionts growing on traps, trap lines, and floats and may be attracted to spiny lobster traps for this reason as well (NMFS and USFWS 1991). Commercial lobster traps may adversely affect sea turtles via entanglement and forced submergence. Sea turtles released alive may later succumb to injuries sustained at the time of capture. Of the entangled sea turtles that do not die from their wounds, some may suffer impaired swimming or foraging abilities, altered migratory behavior, or altered breeding or reproductive patterns. Smalltooth sawfish feed primarily on fish, such as mullet, jacks, and ladyfish (Simpfendorfer 2001). There is currently no data available on the attraction of smalltooth sawfish to spiny lobster trap gear.

The biological opinion requires NOAA Fisheries Service to work with the Councils to minimize impacts of spiny lobster traps on *Acropora* spp. and other protected species. Actions 9-11 address the reasonable and prudent measures outlined in the opinion. However, Actions 9 and 10 were deferred to Amendment 11, which should be completed before the beginning of the 2012 fishing year.

Human Communities
Adverse or beneficial effects of actions to vessel owners, captains, crew, and associated shoreside businesses are tied to the ability of individuals to earn income and pursue traditional and culturally significant livelihoods. In commercial fisheries, income benefits are usually derived in terms of shares awarded after fishing expenses are accounted for. The greater the difference between expenses and payment for caught fish, the more revenue is generated by the fishing vessel. For the for-hire sector, revenues are generated by the number of trips sold for charter businesses, and by the number of paying passengers for headboat businesses.

Fishing communities include the infrastructure, which refers to fishing-related businesses and includes marinas, rentals, snorkel and dive shops, boat dockage and repair facilities, tackle and bait shops, fish houses, and lodgings related to recreational fisheries industry. This infrastructure is tied to the commercial and recreational fisheries and can be affected by adverse and beneficial economic conditions in those fisheries. Therefore, the effects of past and present actions on communities should reflect responses by the fisheries to these actions.

Current management measures have had a negative, short-term impact on the commercial fishery. The trap limitation program and the moratorium on commercial dive permits both restricted access to this fishery. On the other hand, Amendment 8 establishes a minimum size limit for imported spiny lobster that should, in the long run, improve the status of the domestic and foreign stocks and the associated economic benefits. The restrictions are expected to affect people who had been damaged economically by the illegal importation of Caribbean spiny lobster, particularly in Florida, Puerto Rico, and the U.S. Virgin Islands.

Non-management stressors can have large effects on fishing communities. Although the Deepwater Horizon MC252 oil spill did not directly impact south Florida, fishermen and dealers may have experienced hardship from reduced consumer confidence in seafood from the region. Because of the continuing rise in the cost of fishing, including increases in the cost of fuel and insurance, many fishermen are having a more difficult time making a living fishing.

Tropical storms can have both positive and negative economic impacts on spiny lobster fishermen, especially those that use traps. The beneficial impact is that a storm can cause lobsters to move and enter traps, 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. 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. In the Florida Keys, one-fourth to one-half of all commercial spiny lobster traps were estimated as tangled or destroyed by the passage of Katrina alone (Buck 2005). According to an 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).

10. Modify or add alternatives to avoid, minimize, or mitigate significant cumulative effects.

The cumulative effects of the actions in this amendment on the biological/ecological, physical, social, and economic environments are positive because they will ultimately maintain the stocks at a level that will protect the resource and allow the maximum benefits in yield and fishing opportunities to be achieved. However, short-term negative impacts on the social and economic environment may occur to the fishery if accountability measures are triggered. The chance of triggering these measures is minimized by the size limits, season closures, and effort control programs that are already in use. Further, modification of the framework procedure (Action 6) will allow more timely response if those management measures need to be changed. If significant effects are identified after this document is completed, an additional amendment could be developed under this framework procedure 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 alternatives and modify management as necessary.

The effects of the proposed actions are, and will continue to be, monitored through stock assessments and stock assessment updates, life history studies, economic and social analyses, and other scientific observations.

NOAA Fisheries Service will need to develop programs to monitor recreational and commercial landings of spiny lobster to determine if landings are approaching, meeting, or exceeding the specified ACT and ACL. Currently, commercial landings are monitored through state trip tickets, which may take up to six months to be complete and available. Recreational landings are estimated through a Florida survey that does not include the entire fishing year; currently MRIP does not collect data on crustacean species. All other species managed under a federal FMP also require ACLs by the end of 2011. For the Southeast region, the number of ACLs is still to be determined based on actions from the Councils; current amendments addressing ACLs contain 38 ACLs for the Gulf Council, 42 ACLs for the South Atlantic Council, and 17 ACLs for the Caribbean Council. Some of these species may additionally have separate ACLs for the commercial and recreational sectors. The immense burden of monitoring all these ACLs will be borne by NOAA Fisheries Service. Although a monitoring plan is being planned while the associated FMP amendments are being developed, limited resources could strain NOAA Fisheries Service's ability to implement the program.

Monitoring and tracking the level of take of protected species by the spiny lobster fishery is imperative. NOAA Fisheries Service must ensure that measures to monitor and report any sea turtle or smalltooth sawfish encounters, or any *Acropora* spp. interactions: 1) detect any adverse effects resulting from the spiny lobster fishery; 2) assess the actual level of incidental take in comparison with the anticipated incidental take; and 3) detect when the level of anticipated take is exceeded.

4.13 Other Effects

4.13.1 Unavoidable Adverse Effects

Setting an ACL and ACT for the spiny lobster fishery may result in negative short-term effects on the social and economic environments if those limits constrain catch below recent levels. This fishery has never been controlled by limits on landings; rather, the commercial fishery has been managed for effort through trap limitation programs. These potential effects are unavoidable because the Magnuson-Stevens Act requires setting ACLs and AMs for all federally managed species.

The continued prosecution of the Caribbean spiny lobster fishery is not likely to jeopardize the continued existence of any protected species. The three-year anticipated take of protected species is as follows: sea turtles (9), small-tooth sawfish (2), and *Acropora* spp. (489.5 m^2).

Undersized lobsters ("shorts") are used widely throughout the trapping component of the fishery as attractants for legal-sized lobster because Caribbean spiny lobsters are gregarious by nature. About 10% of shorts die despite requirements for live wells to keep them healthy. Thus the larger the number of shorts allowed per vessel, the higher the mortality would be. Conversely, disallowing the use of shorts would create a hardship for commercial fishermen because other baits are more costly and less effective.

Merely refining the requirements for tailing permits would not impact commercial fishermen who are fishing legally. However, eliminating the federal tailing permit may have negative impacts for some commercial fishermen. The ability to tail spiny lobsters is important to fishermen who do not have the storage capacity to hold large amounts of whole spiny lobster onboard over long trip durations. Tailing allows such fishermen to safely store more product without compromising quality, thus maximizing the profitability of each trip.

Limiting spiny lobster fishing in area to protect *Acropora* spp. corals would necessarily reduce the open fishing area. Large closed areas may better protect corals but would close more area to fishing. The requirement to mark trap lines would incur costs to fishermen, although NOAA Fisheries Service staff have worked closely with industry representatives to choose methods that would be less expensive. Fishermen would have until August 2014 to comply, before which time many trap lines would need to be replaced anyway. Both of these actions are required by the biological opinion and are therefore unavoidable. Although the Council deferred action on these two requirements, Amendment 11 is expected to implement them before the beginning of the 2012 fishing year.

Actions considered in this amendment should not adversely affect public health or safety because these measures should not alter fishing practices in a substantial way. Unique characteristics of the geographic area are highlighted in Section 3.2. Adverse effects of fishing activities on the physical environment are described in detail in Sections 4.1-4.13. These sections conclude little adverse impact on the physical environment should occur from actions proposed in this document. Uncertainty and risk associated with the measures, as assumptions underlying the analyses, are described in detail in the same sections as well.

4.13.2 Relationship Between Short-Term Uses and Long-Term Productivity

The objectives of this amendment are to bring the Spiny Lobster FMP into compliance with Magnuson-Stevens Act requirements for ACLs and AMs to prevent overfishing; update biological reference points, policies, and procedures; and consider adjustment of management measures to aid law enforcement and consider measures to protect endangered species established under a biological opinion. In achieving these objectives, the fishery may encounter short-term economic impacts, such as reduced catch or increased equipment costs, but experience long-term economic productivity due to protection of the resources, as discussed in previous sections.

The process of managing the spiny lobster stock is expected to have a negative short-term effect on the social and economic environment, and will create a burden on the administrative environment. No alternatives are being considered that would avoid these negative effects because they are a necessary cost associated with managing this stock. The ranges of alternatives have varying degrees of economic costs and administrative burdens. Some alternatives have relatively small short-term economic costs and administrative burdens, but would also provide smaller and more delayed long-term benefits. Other alternatives have greater short-term costs, but provide larger and more immediate long-term benefits. Therefore, mitigating these measures would be difficult, and managers must balance the costs and benefits when choosing management alternatives for the fishery.

4.13.3 Mitigation, Monitoring, and Enforcement Measures

Available data do not allow the determination if the characteristics of affected fishery participants trigger environmental justice considerations and the need for special mitigation measures to respond to environmental justice concerns. Nevertheless, the proposed actions would apply equally to all fishery participants regardless of minority or income status, and no information has been identified that would indicate differential costs on or benefits to minority or low income persons distinct from those expected to accrue to other constituencies involved in the fishery. Therefore, no environmental justice issues have been identified and no mitigation measures in response to environmental justice issues have been considered.

If the ACT is exceeded, the Councils will convene a review panel to evaluate the ACL, ACT, and AMs. National Standard 1 guidelines state that if catch exceeds the ACL for a given stock or stock complex more than once in the last four years, the system of ACLs and AMs should be re-evaluated, and modified if necessary, to improve its performance and effectiveness. Additionally, NOAA Fisheries Service annually reports on the status of stocks in its Report to Congress.

To ensure the spiny lobster stock is managed for OY, periodic reviews of stock status are needed. These reviews are designed to incorporate new information and to address unanticipated developments in the respective fisheries, and would be used to make appropriate adjustments in regulations should harvest not achieve OY objectives. Reviews would be based on periodic stock assessments. These assessments would be requested as needed by the SEDAR Steering Committee. A SEDAR assessment update conducted in 2010 was rejected by the Review Panel. No baseline assessment is scheduled for spiny lobster; however, the both the assessment panel and the Review Panel for the update recommended a baseline assessment for this species in the near future. This assessment would benefit from use of a more appropriate model and updated landings information through state and federal fishery monitoring programs. Depending on the outcome of assessments, the Councils may determine further management action should be taken. Actions the Councils could employ to further restrict harvest include, but would not be limited to, changes in size limits, bag limits, seasonal closures, or area closures.

The Councils have four options for implementing these measures. The first is to amend the Spiny Lobster FMP to include new information and management actions. Recent plan amendments put forth by the Councils have taken between two and three years from conception to implementation. The second method is a regulatory amendment based on the framework established in Action 6 of this amendment. Recent regulatory amendments have taken between nine months and two years from conception to implementation. NOAA Fisheries Service may take management actions through emergency or an interim measures. Emergency actions and interim measures only remain in effect for 180 days after the date of publication of the rule and may be extended by publication in the Federal Register for not more than 186 days provided the public has had an opportunity to comment on the measures. The Magnuson-Stevens Act further states when a Council requests that an emergency action and interim measure, the Councils should be actively preparing plan amendments or regulations that address the emergency on a permanent basis.

The type of rule making vehicle NOAA Fisheries Service or the Councils determine is needed is difficult to predict. Actions would be dictated by the severity of overages in harvest and by the time frame needed to implement a regulatory change. If the overage is severe, the Councils could ask for an emergency action or interim rule that would severely restrict or halt the harvest of spiny lobster while the Councils explore management measures to bring the harvest to levels consistent with the management objectives of the FMP.

The jeopardy analyses for sea turtles, smalltooth sawfish, and *Acropora* spp. are based on the assumption that the frequency and magnitude of adverse effects that occurred in the past will continue into the future. If estimates regarding the frequency and magnitude of incidental take prove to be underestimates, the potential adverse effects to the sea turtles, smalltooth sawfish, and *Acropora* spp. may be greater than previously thought. Thus, monitoring and tracking the level of take specific to the spiny lobster trap fishery is imperative. NOAA Fisheries Service developed Reasonable and Prudent Measures (RPMs), and implementing Terms and Conditions (T/Cs), to not only help monitor future incidental takes, but help minimize the impacts of those takes. The RPMs and T/Cs ensure NOAA Fisheries can: 1) detect any adverse effects resulting from the spiny lobster fishery; 2) assess the actual level of incidental take in comparison with the anticipated incidental take documented in the opinion; and 3) detect when the level of anticipated take is exceeded. See Sections 9.3 and 9.4 of Appendix I for the specific RPMs and T/Cs. NOAA Fisheries Service and other government agencies also support research on this species by federal, state, academic, and private research entities.

Current spiny lobster regulations can be labor intensive for law enforcement officials. NOAA Fisheries Service law enforcement officials work cooperatively with other federal and state agencies to keep illegal activity to a minimum. Violators are penalized, and for commercial operators, permits required to operate in their respective fisheries can be sanctioned.

4.13.4 Irreversible and Irretrievable Commitments of Resources

No irreversible or irretrievable commitments of agency resources are proposed herein. The actions to set ACLs, AMs, and other management measures in the spiny lobster fishery 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 potential limitation of harvest due to accountability measures. No irreversible or irretrievable commitment of natural resources is anticipated.

4.14 Any Other Disclosures

CEQ guidance on environmental consequences [40 CFR 1502.16] indicates the following elements should be considered for the scientific and analytic basis for comparisons of alternatives. These are:

a) Direct effects and their significance.
b) Indirect effects and their significance.

c) Possible conflicts between the proposed action and the objectives of federal, regional, state, and local (and in the case of a reservation, Indian tribe) land use plans, policies and controls for the area concerned.
d) The environmental effects of alternatives including the proposed action.
e) Energy requirements and conservation potential of various alternatives and mitigation measures.
f) Natural or depletable resource requirements and conservation potential of various alternatives and mitigation measures.
g) Urban quality, historic and cultural resources, and the design of the built environment, including the reuse and conservation potential of various alternatives and mitigation measures.
h) Means to mitigate adverse environmental impacts.

Items a, b, d, e, f, and h are addressed in Sections 2, 3, and 4. Items a, b, and d are directly discussed in Sections 2 and 4. Item e is discussed in the economic analyses. Alternatives that encourage fewer fishing trips would result in energy conservation. Item f is discussed throughout the document as spiny lobster stocks are a natural and depletable resource. A goal of this amendment is to make these stocks sustainable resources for the nation. Mitigations measures are discussed in Section 4.13.3. Because this amendment concerns the management of spiny lobster stocks, it is not in conflict with the objectives of federal, regional, state, or local land use plans, policies, and controls (Item c).

Urban quality and the design of the built environment, including the reuse and conservation potential of various alternatives and mitigation measures (Item g), are not a factor in this amendment. The actions taken in this amendment will affect a marine stock and its fishery, and should not affect land-based, urban environments. The proposed actions are not expected to result in substantial impacts to unique or ecologically critical areas.

In the South Atlantic, several notable shipwrecks can be found along the southeast coast in federal and state waters including Lofthus (eastern Florida), SS Copenhagen (southeast Florida), Half Moon (southeast Florida), Hebe (Myrtle Beach), Georgiana (Charleston), Monitor (Cape Hatteras), Huron (Nags Head), and Metropolis (Carolla). In the Gulf, the U.S.S. Hatteras isolated in federal waters off Texas and is listed in the National Register of Historic Places. Shipwrecks in the Florida Keys and Dry Tortugas include USCG Cutter Duane, USS Alligator, San Pedro, Windjammer, and Bird Key. Fishing activity already occurs in the vicinity of these sites; but actions within this amendment would have no additional impacts on the above listed historic resources, nor would they alter any regulations intended to protect them.

With respect to the ESA, fishing activities pursuant to the spiny lobster fishery should not affect endangered and threatened species or critical habitat in any manner not considered in prior consultations on this fishery. The most recent biological opinion on the spiny lobster fishery was completed on August 27, 2009. The opinion stated the fishery was not likely to adversely affect ESA-listed marine mammals, Gulf sturgeon, or designated critical habitat for elkhorn and staghorn corals. However, the opinion determined the spiny lobster fishery would adversely affect sea turtles, smalltooth sawfish, and elkhorn and staghorn corals, but would not jeopardize their continued existence. An incidental take statement was issued for green, hawksbill, Kemp's ridley, leatherback, and loggerhead sea turtles, smalltooth sawfish, and both species of coral. Reasonable and prudent measures to minimize the impact of these incidental takes were specified, along with terms and conditions to implement them.

With respect to the Marine Mammal Protection Act (MMPA), fishing activities conducted under the Spiny Lobster FMP should have no adverse impact on marine mammals. The 2011 List of Fisheries (75 FR 68468; November 8, 2010) lists the Florida Spiny Lobster Trap/Pot fishery as a Category III Fishery under the MMPA. This classification indicates the annual mortality and serious injury of a marine mammal stock resulting from any fishery is less than or equal to 1 percent 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. The proposed actions are not expected to alter existing fishing practices in such a way as to alter the interactions with marine mammals.

Because the proposed actions are directed towards the management of naturally occurring species, the introduction or spread of nonindigenous species should not occur.

5.0 FISHERY IMPACT STATEMENT (FIS)

The Magnuson-Stevens Act requires a FIS be prepared for all amendments to Fishery Management Plans (FMPs). The FIS contains an assessment of the likely biological and socioeconomic effects of the conservation and management measures on: 1) fishery participants and their communities; 2) participants in the fisheries conducted in adjacent areas under the authority of another Council; and 3) the safety of human life at sea.

5.1 Actions Contained in Amendment 10 to the Spiny Lobster FMP

Amendment 10 to the Spiny Lobster FMP would bring the Spiny Lobster FMP into compliance with Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act) requirements for Annual Catch Limits (ACLs) and Accountability Measures (AMs); update biological reference points, policies, and procedures for managing spiny lobster; modify management measures, and consider requirements from the biological opinion. Specifically, Amendment 10 would:

- Remove smoothtail spiny lobster, spotted spiny lobster, Spanish slipper lobster, and ridged slipper lobster from the Spiny Lobster FMP.
- Specify the overfishing limit (OFL) as the proxy for maximum sustainable yield (MSY), which is 7.90 million pounds.
- Specify the overfishing threshold (MFMT) as the OFL recommended by the Gulf of Mexico Fishery Management Council's (Gulf Council) Scientific and Statistical Committee.
- Specify the overfished threshold (MSST) as (1-M) x $B_{MSY.}$
- Adopt the Gulf Council's acceptable biological catch (ABC) control rule.
- Specify the ACL as equal to the optimum yield (OY) and the ABC, currently 7.32 million pounds (mp).
- Specify an annual catch target (ACT) equal to 90% of ACL., currently 6.59 mp.
- Establish the ACT as the AM.
- Revise the framework procedure and protocol for managing spiny lobster to include the National Standard 1 harvest parameters.
- Allow use of undersized spiny lobster as attractants in numbers not exceeding 50 per boat and 1 per trap.
- Revise tailing permit regulations to state that all vessels must have either a federal spiny lobster permit or a Florida Restricted Species Endorsement and a Crawfish Endorsement associated with a Florida Saltwater Products License to obtain a tailing permit, and require all spiny lobster to be landed all tailed or all whole.
- Delegate authority to regulate the removal of derelict or abandoned spiny lobster traps occurring in the EEZ off Florida to the Florida Fish and Wildlife Conservation Commission (FWC).

Two actions were considered by the Councils but deferred to another amendment to allow more time for stakeholder input:

- Require all spiny lobster trap lines in the EEZ off Florida to be color, or have a color marking, all gear must comply with marking requirements by August 2014.
- Delegate authority to regulate the removal of derelict or abandoned spiny lobster traps occurring in the EEZ off Florida to the Florida Fish and Wildlife Conservation Commission.

5.2 Assessment of Biological Effects

Removal of any of the lobster species from the Spiny Lobster FMP is expected to have little impact on the biological environment. Very little information is available about life history attributes of these species and landings data are only available for two species in the FMP (ridged slipper lobster and Spanish slipper lobster). If other agencies, such as FWC assume management then these lesser landed species may have better management protection than what is currently listed under the federal fishery management plan (e.g., prohibition of egg–bearing females, stripping, or removing eggs). If another agency does not take over management of the other lobster species and overfishing occurs then negative biological impacts would be expected.

The three sub-actions for modifying MSY, MFMT, and MSST for Caribbean spiny lobster are expected to have positive biological impacts to the environment. The Councils currently have different reference points for MSY and MSST, so modifying these definitions would provide consistency between the two Councils. The definitions selected by the Councils are based on the most recent stock assessment and the best available scientific information reviewed by both Councils' Scientific and Statistical Committees, thereby suggesting the best protection for the resource.

The ABC, ACL, and ACT levels set are above recent landings and are likely to have biological impacts only if harvest changes from current levels. Additionally, the biological impacts of using the ACT as the AM would likely be similar to the status quo since the combined recreational/commercial average landings for the last 10 fishing seasons do not exceed the preferred ACT. A recent study using microsatellite DNA analysis to identify sources of recruitment among Caribbean spiny lobsters indicates the majority of recruits come from areas outside the management area (Hunt and Tringali 2011). Therefore, any true biological benefits that may accrue in the Caribbean spiny lobster population found within the joint Council's management area are likely to be negligible.

Updating the protocol, which defines the roles of federal and Florida agencies in managing spiny lobster, and the framework, which outlines the actions that can be implemented through framework actions, would have no impact on the biological environment except to enable harvest modifications to be expedited when they are most needed.

Using undersized lobster as attractants reduces the opportunity for juvenile spiny lobsters to grow to harvestable size due to confinement mortality. However, total bycatch may actually increase undersized spiny lobsters are not used because traps with other baits would need to soak longer to achieve the same catch as traps with undersized attractants. Revising the tailing permit regulations would provide a minimal biological benefit since it is thought that there are very few recreational fishermen who have in their possession a Tail-Separation Permit. Requiring that all spiny lobster must be landed all whole or all tailed would address the issue of some fishermen landing part of their catch whole and part tailed a practice that may be an attempt to land sub-legal spiny lobsters for profit, as has been reported anecdotally. If most fishermen choose to land the majority of their Caribbean spiny lobster harvest whole, the rate at which Caribbean spiny lobsters are harvested would likely decrease due to storage capacity issues of whole lobster tails on participating vessels.

The biological opinion requires NOAA Fisheries Service and the Councils to explore allowing the public to remove derelict trap gear from the EEZ off Florida. Commercial fishermen's primary concerns about allowing the public to remove derelict or abandoned traps are that legally fishing traps may be removed by someone other than the fishermen, either intentionally or by accident, due to confusion between similar looking traps. If the delegation of trap removal authority to the FWC leads to the elimination of more derelict traps and trap debris, positive biological benefits would be realized.

Prohibiting the use of traps in identified areas would reduce the risk of trap damage to *Acropora* spp. in areas of high density or near colonies with high conservation value. Movement of traps during storms poses the greatest threat to *Acropora* spp. because the branching morphology makes them susceptible to fragmentation/breakage and abrasion from traps and trap lines. Trap line markings are required by the biological opinion because each fishery has an incidental take statement estimating the number of protected species taken by that fishery. Requiring markings along the entire length of trap lines would allow managers to identify takes attributable to the spiny lobster fishery. In addition, by better understanding which fisheries are interacting with sea turtles and smalltooth sawfish, better ways to reduce those interactions can be developed. These actions will be considered in Amendment 11 to the Spiny Lobster FMP.

5.3 Assessment of Economic Effects

The AM and ACT are specified as being less than the ACL and would not be expected to have any economic effects, assuming that catch in excess of ACT is allowed occasionally, as discussed in Section 4.5.1.

The requirement that all spiny lobster from the EEZ must be landed all whole or all tails on a trip is expected to have a direct economic impact on a small number of commercial fishing vessels (35 vessels) that engaged in deep-water, multi-day fishing trips for spiny lobster in the EEZ. They land both whole and tailed lobsters on the same trips. This deep-water fishing activity has declined relatively more than all fishing for lobsters in Florida. There is an expected economic impact for the closure of some areas of the EEZ to protect corals, but it affects a larger proportion of the vessels (274 vessels, including the 35 vessels above) that operate mostly in waters less than 100 ft deep.

Under the proposed rule, regulations are to be re-written to more clearly state that vessels using tailing permits must have requisite Florida permits/licenses for commercial fishing for lobster in the Florida EEZ, or must have federal permits for lobster fishing in the EEZ for states other than Florida. This is not likely to have any economic impact on commercial and for-hire fishing for spiny lobster. Available data and methods allow only approximations of the number of affected vessels in different categories. In the last 5 years, there were perhaps 275-388 vessels with tailing permits in Florida and they could encompass the 274 vessels with documented commercial landings of lobster from the Florida EEZ. Approximately 50-80 vessels of the 388 vessels possess at least one federal for-hire permit for finfish fishing in the EEZ, and something between 50-80 vessels and 388 vessels falls short of the number, 1,330 vessels, with Florida permits/licenses for for-hire fishing for lobster in state and federal waters off Florida. In turn, the 1,330 for-hire vessels appear to account for only a fraction of the 140,000 permits for recreational fishing for lobster in Florida, recognizing that some customers may have their own permits onboard. In Monroe County (the Florida Keys) alone, there may be some 25,000 registered recreational vessels. Perhaps some of the 1,330 for-hire vessels and an unknown number of "private," recreational vessels ("private" vessels refers to vessels without earned income from fishing) could have acquired tailing permits. Finally, an unknown number of commercial and for-hire fishing vessels may have purchased "open-access" lobster tail-separation permits as a low-cost ($10) precaution, should incidental catch of lobster tails occur under bag-limit rules. Any such incidental catch of lobster tails represents non-monetary compensation to captains and crews, and, loosely speaking, it may be called "recreational catch" of lobster because it is governed by bag-limit rules.

Closing hardbottom areas in the EEZ off Florida to protect corals would have an economic impact on the commercial trap fishery. The Councils will revisit this action in Amendment 11 after additional input from stakeholders on the appropriate areas to close to provide the greatest protection to *Acropora* spp..

The time between implementation of Amendment 10 and the date for compliance, August 2014 is growing shorter and is already less than the normal, 5-7 year replacement schedule for trap lines. NOAA Fisheries Service is reviewing the biological opinion to determine if more time can be allowed for compliance with this requirement. The Councils will address this action in Amendment 11 after additional input from stakeholders on the best way to mark trap lines.

Although no alternative to allow the removal of abandoned or derelict lobster traps found in the EEZ purportedly during the closed season would affect commercial fishing activity during the open season, fishermen's perception about any trap removal can impact their economic activity, wellbeing, and willingness to support regulations (Shivlani et al. 2004). The proposed action may have the least perceived economic impact among fishermen.

5.4 Assessment of the Social Effects

The combined impacts of the amendment are from a number actions and alternatives affecting harvest levels, sector allocation, closed areas and gear modifications. The effects are described below in summary fashion for all alternatives.

Removing species from the management unit would likely have positive social effects as it would streamline management. Requiring federal agencies to maintain ACLs and AMs on species that are landed infrequently may pose some difficulty in monitoring because landings data are sparse or non-existent. Furthermore, it could impose further regulatory burdens on fishermen if harvest levels are reduced because of uncertainty and their incidental harvest is somehow tied to fishing for other species. The preferred alternative, which removes most species that are often a bycatch species, should have positive social effects for both the administration of fishery and for fishermen who may encounter these species on occasion.

Overfishing limits and other biological thresholds are determined through stock assessment and deliberation of the SSC from which ACLs and ACTs are derived. The ACT is the final threshold from which the Councils choose to manage harvest levels through a series of decisions about uncertainty with stock status and management. The preferred option at this time sets an ACT threshold that is slightly above recent landings, however, it has been exceeded in the past. It is likely that there would be few negative social effects from an ACT set at a level of 6.59 million pounds. By setting the ACT as the AM, any overages will be reviewed over time to consider whether changes need to be made. Overall, these actions should have positive social effects as there are no severe reductions to harvest and timely monitoring should allow for accountability over time which should maintain some stability within the fishery. These positive social effects would also be reflected in the action to establish a framework procedure that would allow for timely management of this species to address not only biological changes, but socioeconomic issues.

The action which allows for short or undersized lobster to be used for bait would establish federal regulations compatible with current state regulations which should have positive social effects as it removes the possibility of conflicting regulations regarding this practice. This places fewer burdens on law enforcement and provides consistent management for fishermen. The allowance for the landing of lobster tails should have positive social effects for those fishermen who make longer trips and need extra hold space for their catch, but may continue to make law enforcement difficult. By requiring a federal permit or state restricted species endorsement to land tails separated from the body would be more consistent for all harvester requirements, although it may still be difficult for law enforcement to determine whether the lobster are of legal size.

The selection of no action with regard to creating and expand closed harvest areas should have positive social effects. By choosing no action, the Councils can consider the impacts of such a closure with more refined information once the public and other agencies have had more time to consider this action. With some alternatives, lobster fishermen may see substantial fishing bottom closed to trapping. If smaller closed areas are sufficient to reduce damage and satisfy the biological opinion requirements, there may be fewer negative social effects and still address the issue of damaged coral. By requiring the marking of all lobster trap lines to comply with federal regulation of protected species, enforcement will be better able to identify any interactions of the lobster fishery with protected species. However, fishermen could incur substantial costs to replace trap lines depending upon their operation and labor costs. By choosing the no action alternative again, the Councils can allow for a more substantial analysis of the effects that were described during public comment. Finally, by delegating the FWC to regulate trap removal in the EEZ and state waters, management is somewhat more streamlined and ensures that trap removal is scrutinized by a regulatory authority alleviating some fears by commercial fishermen that a possibly uniformed public may be entrusted with removal privileges. Because Florida has a trap removal program already in place, there should be few if any negative social effects from this action.

The overall social effects from actions within this amendment should be beneficial considering the mandate to impose these biological and management thresholds. Other actions included should enhance both the stock status and fishermen's ability to harvest a sustainable stock.

5.5 Assessment of Effects on Safety at Sea

Expanding and/or creating new closed areas within which use of spiny lobster traps would be prohibited could result in increased safety at sea concerns for vessels having to traverse around a closed area if they have traps and spiny lobster onboard. However, a transit provision could allow vessels with legally harvested spiny lobster and spiny lobster traps onboard to transit directly through a closed area in order to reach shore in as little time as possible when foul weather situations arise. This transit allowance would mitigate any safety at sea issues that would otherwise be present for vessels required to travel around a closed area and will be considered in Amendment 11.

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GC = General Counsel, SERO=Southeast Regional Office, NEPA=National Environmental Policy Act, HC = Habitat Conservation, SEFSC=Southeast Fisheries Science Center, FWC=Florida Fish and Wildlife Conservation Commission, OLE=NOAA Fisheries Service Office for Law Enforcement

7.0 LIST OF AGENCIES, ORGANIZATIONS AND PERSONS TO WHOM COPIES OF THE STATEMENT ARE SENT

Department of Commerce Office of General Counsel
Environmental Defense
Texas Parks and Wildlife Department
Alabama Department of Conservation and Natural Resources/Marine Resources Division
Louisiana Department of Wildlife and Fisheries
Mississippi Department of Marine Resources
Florida Fish and Wildlife Conservation Commission
Georgia Department of Natural Resources/Coastal Resources Division
South Carolina Department of Natural Resources/Marine Resources Division
North Carolina Division of Marine Fisheries
Florida Keys Commercial Fishermen's Association
Monroe County Commercial Fishermen's Association
National Fisheries Institute
National Marine Fisheries Service Office of General Counsel
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
United States Coast Guard
United States Fish and Wildlife Services

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9.0 INDEX

Appendix A. Alternatives Considered but Rejected

Action: Delegate management of the Spiny Lobster FMP to Florida FWC

Alternative 1: No Action – Continue the current state and federal management system

Alternative 2: Delegate all management to Florida FWC, except establishment of an annual catch limit (ACL)

Alternative 3: Delegate certain management criteria to Florida FWC, except establishment of an ACL

Management criteria to delegate include:
Options a: Numerical specification of ACL and breakdown into sector-specific ACLs based on the definitions later in document
Options b: Commercial quotas and recreational allocations based on the allocations specified later in this document
Options c: Size limits
Options d: Recreational bag limits
Options e: Commercial trip limits
Options f: Permit endorsements
Options g: Fishing seasons
Options h: Application of the accountability measures, including closing the fishery when a sector reaches its quota and/or allocation
Options i: Rules and regulations for traps, including gear marking, tagging, etc.
Options j: Data collection and reporting requirements
Options k: Closed areas

<u>Comparison of Alternatives</u>: The Fishery Management Plan for Spiny Lobster in the Gulf of Mexico and South Atlantic (Spiny Lobster FMP) has been jointly managed by the Gulf of Mexico and South Atlantic Fishery Management Councils (Councils) since 1982. In 1989, the Spiny Lobster FMP was amended to establish compatible regulations between the federal and state fisheries. Thereafter, the Florida Fish and Wildlife Conservation Commission (FWC) has taken the lead in Caribbean spiny lobster fishery management, with NOAA Fisheries Service establishing compatible regulations when applicable. The commercial fishery is currently managed with a trap limitation and permitting program, minimum size limits, closed fishing seasons, gear restrictions, and other prohibitions. The recreational fishery is currently managed with minimum size limits, bag limits, closed fishing seasons, gear restrictions, and other prohibitions (Table 2.1.1).

The joint jurisdiction of the two Councils extends from the North Carolina/Virginia border in the South Atlantic to the Texas/Mexico border in the Gulf of Mexico. A majority of the commercial and recreational landings for Caribbean spiny lobster occurs in the waters off Florida (Table 2.1.1). Caribbean spiny lobster are also found in waters off other states within the Councils' jurisdiction, but in these areas, low abundance results in low levels of harvest. For example in the Gulf of Mexico, Alabama reported no commercial landings of spiny lobster species (C. Denson, Alabama Marine Resources Division, Alabama Department of Conservation and Natural Resources, pers. comm.). There were no reported commercial landings for spiny lobster in Mississippi, Louisiana, and Texas and no program currently in place to document recreational landings in any of the states but Florida (Source: http://www.st.nmfs.noaa.gov/st1/commercial/landings/annual_landings.html).

Off Georgia there were no commercial landings of Caribbean spiny lobster species from state or federal waters for the years 1999-2008 (J. Califf, Commercial Fisheries Statistics Coordinator, Coastal Resources Division, Georgia Department of Natural Resources, pers. comm.). Similarly, in the state waters off South Carolina there were no recorded landings of spiny lobster species. In federal waters off South Carolina, commercial landings by divers between 1991 and 2003 included 6 lbs landed one year, and between 2004 and 2008, 15 lbs was landed in one year (G. Steele, Biological Statistician, South Carolina Department of Natural Resources, pers. comm.).

In state waters off North Carolina, there were no recorded landings of Caribbean spiny lobster. However, in federal waters off North Carolina there were low landings for Caribbean spiny lobster in 2001, 2003, 2004, 2006, 2007, and 2008. The average landings were 100 lbs or less live whole animal weight by commercial divers. The ex-vessel value for Caribbean spiny lobster species during this time period (1999-2008) ranged from $50 to $3,500 (A. Bianchi, Trip Ticket Coordinator, North Carolina Division of Marine Fisheries, pers. comm.). In 1999, 2000, 2002, and 2005 commercial landings for those species were not recorded by the North Carolina Division of Marine Fisheries.

Because of the low landings from states other than Florida, the federal fishery is currently managed through regulations affecting the EEZ off states in three areas: the South Atlantic states not including Florida (North Carolina, South Carolina, and Georgia), the State of Florida, and the Gulf of Mexico states not including Florida (Texas, Louisiana, Mississippi, and Alabama). This division of regulations reflects differences in Caribbean spiny lobster abundance and fishing effort in these regions (Table 2.1.2).

Table 2.1.2. Average commercial landings of Caribbean spiny lobsters 1999-2008 for Gulf federal waters, South Atlantic federal waters, and state of Florida waters (both coasts). Average pounds landed are live whole animal weight.

Caribbean Spiny Lobster	Gulf federal	Atlantic federal	Florida state waters
Average Pounds	164,912	998,218	1,709,646
Average # Trips	413	2,976	8,903
Average $ Value	$828,149	$4,878,155	$8,827,990

Source: Florida FWC, Marine Fisheries Information System 2009.
Note: This data is based on the trip ticket program. There is only one space available for waters fished. Fishers could fish in both state and federal waters within one day, based on the season and other fishing behaviors. This table should be viewed with some caution, because there could be additional unaccounted variability, due to the way the data is recorded and analyzed.

Alternative 1, no action, would continue the current state and federal management system and set an ACL and accountability measures as determined in actions later in this amendment for Caribbean spiny lobster. If this alternative was selected as the preferred alternative, the National Standard 1 guideline would still need to be met in 2011. Alternative 2 or 3 would set an ACL and accountability measures (AMs), but delegate all or certain management measures, respectively. Delegation to Florida would require agreement from Florida FWC to accept the responsibility of Caribbean spiny lobster management. Alternative 2, would delegate all management of Caribbean spiny lobster to Florida FWC, but still set an ACL (see Action 4). If Alternative 2 was selected as a preferred alternative, Florida FWC could use various management criteria to maintain the ACL. This method of management is similar to what is occurring presently; Florida FWC has taken the lead in Caribbean spiny lobster fishery management, with NOAA Fisheries Service establishing compatible regulations when applicable through the Council's processes. One modification from the current management process in addition to setting an ACL is establishing AMs. If the ACL was exceeded Florida FWC would need to apply AMs, compatible in federal waters to account for these overages, under the National Standard 1 guidelines.

Alternative 3 would also set an ACL, but delegate certain management criteria to Florida FWC, such as size limits, bag limits, fishing seasons, and trip limits. This alternative could be become more complicated; if and when the ACL was exceeded NOAA Fisheries Service would need to implement the previously established AMs. If Florida FWC only has certain management criteria or vice versa, then the appropriate criteria for management may be split between the Councils and NOAA Fisheries Service and Florida FWC, making it more difficult to prevent the ACL from being exceeded or by initiating AMs, if and when they were exceeded. The public could also become confused, by management changes coming from NOAA Fisheries Service instead of Florida FWC and compatibility with these regulations. The benefit of delegating all or certain management criteria to Florida FWC is that the state can move faster than the federal system when and if, accountability measures need to be implemented. Alternatives 2 and 3 would still allow the Councils to maintain their joint Amendment 4 and 8 with the Caribbean Council (73 FR 1148). This newly implemented amendment prohibits importation of undersized Caribbean spiny lobsters into the U.S.

This action is primarily administrative and alternatives in this action are expected to have little impact on the biological or physical environments. Alternative 2 may be more streamlined than Alternative 3 or Alternative 1 simply due to all management criteria being delegated to Florida FWC. This may create more of an administrative burden for Florida FWC working jointly with NOAA Fisheries Service and the Councils, but be less burdensome to the public keeping up with regulatory changes. If Alternative 3 is selected as preferred, there may be more of an administrative burden for all parties involved, Florida FWC, NOAA Fisheries Service, and the Councils. In addition, by delegating only certain management criteria the process, meant to be streamlined, may become more burdensome for all parties involved. Further, members of the public following regulations for Caribbean spiny lobster may become confused if various management criteria are implemented from different agencies.

Action 1: Other species in the Spiny Lobster FMP

Alternative 2: Set ACLs and AMs for each species using historical landings
Option a: smoothtail spiny lobster, *Panulirus laevicauda*
Option b: spotted spiny lobster, *Panulirus guttatus*

Discussion: Alternative 2 would set ACLs and AMs for each species, which would be very difficult for smoothtail and spotted spiny lobster (Option a and b), because there are no historical landings available for these species. However, the other two species of slipper lobsters, Spanish and ridged (Option c and d) have commercial landings information, but are not targeted species. Positive biological and physical benefits are expected from setting ACLs and AMs; however, if no historical landings information is available, the rationale for setting biological determination criteria may have limited positive impacts on the physical or biological environment.

Action 2: Modify the current definitions of Maximum Sustainable Yield, Optimum Yield, Overfishing Threshold, and Overfished Threshold for Caribbean spiny lobster

2-3 Overfished Threshold

Alternative 2**:** Adopt the Gulf Council overfished threshold definition for the South Atlantic. The Gulf of Mexico definition: proxy for MSST of 15% transitional SPR, with the additional modification to static SPR.

Discussion: This action explores various alternatives for establishing biological reference points: MSY, OY, overfishing threshold, and overfished threshold. Currently the Gulf of Mexico and the South Atlantic Councils have different definitions for these biological reference points and the South Atlantic Council does not currently have an overfished threshold definition (GMFMC 1999, SAFMC 1998, SEDAR 8 2005).

Transitional SPR versus static SPR is used for the definitions of MSY, OY, overfishing, and overfished threshold by the Gulf Council. As the name suggests SPR ratio expresses spawning per recruit as a ratio in a fished condition, relative to the maximum theoretical amount of spawning per recruit that occurs when there is no fishing (Slipke and Maceina 2000; MRAG Americas 2001). Due to increased fishing effort reducing the potential reproductive output, the denominator in the spawning potential ratio is always greater than or equal to the numerator, so the resulting values will range between 0 and 1 (MRAG Americas 2001).

Generally, static SPR is more frequently used than transitional SPR. Static SPR requires minimal data inputs, whereas transitional SPR requires data from a full age-based stock assessment (Parkes 2001). Static SPR is calculated on a per-recruit basis assuming equilibrium conditions of recruitment and mortality throughout their life span. Transitional SPR is computed on a yearly basis and uses actual annual variation in population structure and mortality rates therefore it is considered a dynamic measure (MRAG Americas 2001, Slipke and Maceina 2001). The SEDAR 8 (2005) benchmark assessment terms of reference, suggest that static SPR was used is the assessment based on the South Atlantic Fishery Management Council's Spiny Lobster Amendment 6 (SAFMC 1998).

Alternative 2 under Action 2.3.4 would adopt the Gulf Council's current definition at 15% transitional SPR, with modification for consistency to static SPR. Again, static SPR is generally used when the stock is not overfished and stock assessments are not completed on an annual basis.

Action 3: Establish sector allocations for Caribbean spiny lobster in state and federal waters from North Carolina through Texas

Alternative 2: Allocate the spiny lobster ACL by the following sector and or gear allocations:
Option a: 75% to the commercial trap fishery, 4% to the commercial dive fishery, 1% to the commercial bully net fishery, and 20% to the recreational fishery

Alternative 3: Allocate the spiny lobster ACL by the following sector and or gear allocations:
Option a: 70% to the commercial trap fishery, 6% to the commercial dive fishery, 1% to the commercial bully net fishery, and 23% to the recreational fishery.

Alternative 4: Allocate the spiny lobster ACL by the following sector and or gear allocations:
Option a: 70% to the commercial trap fishery, 3% to the commercial dive fishery, 1% to the commercial bully net fishery, and 26% to the recreational fishery.

Alternative 5: Allocate the spiny lobster ACL by the following sector and or gear allocations:
Option a: 72% to the commercial trap fishery, 5% to the commercial dive fishery, 1% to the commercial bully net fishery, and 22% to the recreational fishery.

Alternative 6: Allocate the spiny lobster ACL by the following sector and or gear allocations:
Option a**:** 72% to the commercial trap fishery, 4% to the commercial dive fishery, 1% to the commercial bully net fishery, and 23% to the recreational fishery.

Discussion: The Florida Fish and Wildlife Conservation Commission (FWC) invited representatives of stakeholder groups participating in Florida's Lobster Fishery to serve as members of the Spiny Lobster Ad Hoc Advisory Board (Advisory Board). The Advisory Board was made up of five commercial trappers, three commercial divers, three recreational fishers, two wholesale dealers, two environmental groups, and one FWC representative on the board.

The Advisory Board was designed to bring together a group of stakeholder representatives from around the state who represent the diversity of the lobster fishery community and included commercial lobster trappers, commercial lobster divers, recreational lobster fishers, a special recreational license holder, wholesale lobster dealers, an environmental group, and a representative from the FWC. The goal was to provide constructive comments and guidance to the FWC in the form of proposed refinements to the management of Florida's spiny lobster fishery. Over a period of sixteen months the Advisory Board met approximately eight times for approximately two days each to focus on reviewing and discussing lobster fishery issues and proposals for refinements to Florida's spiny lobster fishery.

The Councils chose to combine all gear types when determining allocations for each sector. After this was accomplished for each of the alternatives, the alternatives moved to considered but rejected were identical or very similar to alternatives retained under the action.

Action 4-2: Set annual catch limits (ACLs) for Caribbean Spiny Lobster

Alternative 3: Set separate state and federal ACLs based on landings.
Option a: sum of ACLs = ABC
Option b: sum of ACLs = x% of ABC

Discussion: The Caribbean spiny lobster fishery occurs mainly off the state of Florida. Commercial landings data are available from 1984; starting in this year, commercial fishermen were required to sell their catch to licensed dealers who were required to submit trip tickets. Separate state and federal ACLs (Alternative 3) may be appropriate because a large amount of harvest is in state waters. However, distinguishing between landings from these areas is difficult. In addition, federal management would be limited to the portion of the fishery under federal authority. The sum of the state and federal ACLs could equal ABC (Option a) or be reduced from the ABC for management uncertainty (Option b).

Action 4-3: Set Annual Catch Targets for Caribbean Spiny Lobster

Alternative 3: Set separate state and federal ACTs (If Action 4.2, Alternative 2 or 3 chosen).

Discussion: Separate federal/state ACTs (Alternative 3) would be appropriate if separate ACLs are set (Action 4.2, Alternative 3), or if a single ACL is set (Action 4.2, Alternative 2). However, the federal government does not have authority to manage harvest of Caribbean spiny lobster in state waters. Unless the states adopt the ACTs as quotas, and institute accountability measures, any ACT set by the Councils could be exceeded without consequence. In an extreme case, landings in state waters could exceed the ABC under these circumstances.

Action 5: Accountability Measures (AMS) by Sector

Alternative 2: Establish in-season AMs.
Option b: Recreational
Sub-option i: quota closure
Sub-option ii: reduce the bag limit when 75% of the recreational ACL or ACT is projected to be met.
Option c: Recreational and commercial combined AM
Sub-option i: prohibit both recreational and commercial harvest when the commercial ACL or ACT, or combined ACL or ACT is projected to be met.
Sub-option ii: reduce the recreational and commercial bag/trip limits when 75% of the commercial ACL or ACT is projected to be met.

Discussion: Under Alternative 2, in-season AMs would be triggered to prevent the ACL from being exceeded. The efficacy of in-season AMs is largely reliant upon in-season monitoring of landings, which may be especially difficult for the recreational sector. The Marine Recreational

Fishing Statistics Survey and the newly implemented Marine Recreational Information Program does not collect landings information on crustaceans. Therefore, in-season tracking of Caribbean spiny lobster landings in the recreational sector would be based on the Marine Recreational Fishing Statistics Survey program and state landings reports. An additional obstacle to tracking recreational harvest in-season is that there is a lag time between when the Caribbean spiny lobsters are landed and when those landings are reported in the landings database. This lag time means that projections of when the ACL is expected to be met would need to be employed. Landings projections are not always 100% accurate, thus using such estimates could lead to an in-season AM being triggered prematurely, or not soon enough causing an ACL overage.

Action 8: Modify Tailing Requirements for Caribbean Spiny Lobster for Vessels that Obtain a Tailing Permit

Alternative 4: Modify the requirements for obtaining a Tail-Separation Permit.

<u>Discussion</u>: Alternative 4 would modify the prerequisites needed for obtaining a Tail-Separation Permit in a way that would make them more restrictive and specific. The regulations could be modified in such a way that would address the issue of recreational fishermen obtaining Tail-Separation Permits, as well as the issue of some fishermen landing undersized lobster tailed and legal sized lobster whole. However, Alternative 4, unless the modification includes the complete removal of the Tail-Separation Permit, would not be as biologically beneficial as Alternative 2.

Appendix B. Regulatory Impact Review

NOAA Fisheries Service requires a Regulatory Impact Review (RIR) for all regulatory actions that are of public interest pursuant to Executive Order (E.O.) 12866, as amended. The RIR: 1) provides a comprehensive review of the level and incidence of impacts associated with a proposed or final regulatory action; 2) provides a review of the problems and policy objectives prompting the regulatory proposals and an evaluation of the major alternatives that could be used to solve the problem; and 3) 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 provides the information needed to determine whether the proposed regulations constitute a "significant regulatory action" under the criteria provided in E.O. 12866 and serves as the basis for determining if the actions will have a significant economic impact on a substantial number of small entities as per the requirements of the Regulatory Flexibility Act (RFA). This RIR analyzes the expected impacts of these actions on the spiny lobster fishery. Additional details on the expected economic effects of the various alternatives under each action are included in Section 4.

Problems and Objectives

The purpose and need, issues, problems, and objectives of the proposed amendment are presented in Section 1.0 and are incorporated herein by reference. The stated purpose for this amendment is to bring the Fishery Management Plan for Spiny Lobster in the Gulf of Mexico and South Atlantic (FMP) into compliance with Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act) regarding annual catch limits (ACLs) and accountability measures (AMs) to prevent overfishing; update biological reference points, policies, and procedures; and consider adjustment of management measures to aid law enforcement and consider measures to protect endangered species established under a biological opinion.

Methodology and Framework for Analysis

This RIR assesses management measures from the standpoint of determining the resulting changes in costs and benefits to society. To the extent practicable, the net effects of proposed measures should be stated in terms of producer and consumer surplus, changes in profits, and employment in the direct and support industries. However, given the competitive nature of the market for spiny lobster and the fact that prices are determined largely under global market conditions in which U.S. production is relatively small, potential changes in domestic production due to changing regulations are not expected to affect prices and thus consumer surplus. Further, given the lack of production cost data, estimates of producer surplus and profits are not currently available for vessels operating in the spiny lobster fishery. Therefore, benefits are stated in terms of gains in production and gross revenue. Since, by definition, gross revenue does not account for production costs, they are an overestimate of the actual net economic benefits to society. In addition, the public and private costs associated with the process of developing and enforcing regulations on fishing for spiny lobster in waters of the U.S. South Atlantic and Gulf of Mexico are provided.

Description of the Fishery
A description of the spiny lobster fishery is contained in Section 3.4.

Impacts of Management Measures

Details on the economic impacts of all alternatives are included in Section 4.0. The following discussion includes only the expected impacts of the preferred alternatives.

Other species in the Spiny Lobster Fishery Management Plan (FMP) (Action 1)

The FMP includes Caribbean spiny lobster, along with two other species of spiny lobster and two species of slipper lobster. **Preferred Alternative 4** would remove the other four species from the FMP. It would not affect fishing; hence, it would not have an economic impact. Commercial fishing is analyzed using inseparable data for the two species of slipper lobster taken together for Florida as a whole for reasons of confidentiality of data for most years, states, and gear, though it may be noted that landings in southeast coastal states (SC–MS only) peaked in 1985 at 133,440 lbs (ww). The long-term decline in landings of slipper lobsters may be partly explained by several factors, including required use of TEDs in shrimp trawls in waters off Florida (1990); a prohibition of the molestation and possession of berried female lobsters in Florida (1987); a decline in effort in the shrimp fishery; and the effort-related cost of trips for slipper lobster. Slipper lobsters cannot be viewed strictly as an incidental or bycatch species, because they were the top-value species on trips for the 8.6 vessels which landed 3,476 lbs out of the total of 4,737 lbs for the 23 vessels with landings (averages for 2004/2005 – 2008/2009).

Modify the Current Definitions of Maximum Sustainable Yield (MSY), Overfishing Threshold (MFMT), and Overfished Threshold (MSST) for Caribbean Spiny Lobster (Action 2)

Defining the MSY, MFMT, and MSST of a species does not alter the current harvest or use of the resource. Because there would be no direct effects on resource harvest or use, there would be no direct effects on fishery participants, associated industries or communities. Direct effects only accrue to actions that alter harvest or other use of the resource. Specifying MSY, MFMT, and MSST, however, establishes the platform for management, specifically from the perspective of bounding allowable harvest levels.

Establish Sector Allocations for Caribbean Spiny Lobster in State and Federal Waters from North Carolina through Texas (Action 3)

No sector allocations would be applied under **Preferred Alternative 1**; hence, it would not have an economic impact. Among the alternatives, it is most compatible with Florida's existing allocation system. Commercial fishing effort for Caribbean spiny lobster in Florida has been reduced substantially under the State's Trap Certificate Program, one of the nation's longest running market-based limited-access systems. In contrast with commercial fishing for spiny lobster, however, participation and entry into the recreational sector are neither limited nor managed under a market-based allocation system.

Acceptable Biological Catch (ABC) Control Rule, ABC Level(s), Annual Catch Limits (ACL), and Annual Catch Targets (ACT) for Caribbean Spiny Lobster (Action 4)

Under Action 4, the preferred alternatives/options for three biological parameters do the following: 1) specify the Gulf Council's ABC Control Rule, resulting in ABC = 7.32 mp (ww) (10-year mean of landings plus 1.5 standard deviation units); 2) specify that ACL = ABC; and 3) specify that ACT = OY= 6.59 mp.

Accountability Measures (AMs) by Sector (Action 5)

Under Action 5, **Preferred Alternative 4** establishes the ACT as the accountability measure for Caribbean spiny lobster, wherein ACT = 6.59 mp, which is less than the ACL of 7.32 mp. The AM is specified as being less than the ACL in accord with SF1 guidelines for the Magnuson-Stevens Act. The ACT of 6.59 mp exceeds the status-quo landings of 5.039 mp, and would not be expected to have any economic impact, assuming that catch in excess of ACT is allowed occasionally. It is noted that a sporadic instance of landings exceeding the ACT may or may not result in a fishery closure.

Develop or Update a Framework Procedure and Protocol for Enhanced Cooperative Management for Spiny Lobster (Action 6)

Preferred Alternative 2 would update the current protocol, while **Preferred Alternative 4, Option a** would revise the current framework procedures and adopt the base Framework Procedure. This would facilitate implementation of changes in management measures, such as changes in ACL, ACT, and AM. For small entities, such changes could be beneficial, or they could have an economic impact. While the proposed action is administrative in intent, the proposed rule as a whole is complicated. To the extent that any unresolved differences result in an economic impact, it would most affect Florida, especially Monroe County. This is because practically all of the southeast landings of spiny lobster occur in Florida. Furthermore, Florida landings occur largely in Monroe County (90% for commercial landings and 67% for recreational landings).

Modify Regulations Regarding Possession and Handling of Short Caribbean Spiny Lobsters as "Undersized Attractants" (Action 7)

Preferred Alternative 4 would allow undersized spiny lobster not exceeding 50 per boat plus 1 per trap aboard each boat if used in federal waters exclusively for luring, decoying or otherwise attracting non-captive spiny lobsters into the trap. This would allow more attractants on board a vessel than **Alternative 1**. Therefore, **Preferred Alternative 4** would not have an economic impact, it is consistent with Florida regulations, and it could bolster fishing in federal waters relative to fishing in state waters. The numbers of vessels, trips, and traps with landings of spiny lobster in Florida have declined substantially since the implementation of the State's Trap Certificate Program in the early 1990s, a stated goal of which was "to substantially reduce the mortality of undersize lobster" (FAC 68B-24.001). The associated fishing mortality is an estimated 189,091 lbs per year in 2004/2005 – 2009/2010 compared with 541,000 lbs per year in 1985/1986 – 1989/1990 (Table 4.3.3.1).

Modify Tailing Requirements for Caribbean Spiny Lobster for Vessels that Obtain a Tailing Permit (Action 8)

To facilitate the presentation of data, **Preferred Alternative 4** is discussed first. It would require that all Caribbean spiny lobster from the EEZ must be landed "whole" or "tailed" on a single trip. It could have an economic impact, and expedite the decline of deep-water, multi-day fishing in the EEZ. Total commercial landings in Florida of spiny lobster averaged 3.671 mp (ww) for 781 vessels in the last five years. This includes 0.670 mp landed from the EEZ by 274 vessels, which in turn includes 0.025 mp (ww) of tails landed by 35 vessels from the EEZ (total landings came to 0.057 mp (ww) for the same trips, including tails and whole lobster). These trips involve multi-day, deep-water fishing in the EEZ off Florida. Several factors have affected costs and revenues for deep-water, EEZ fishing for spiny lobster, including higher fuel prices, thereby helping to explain the steeper, long-term decline in this economic activity than for all fishing for spiny lobster in Florida.

Preferred Alternative 3, Action 8 would continue the long-standing policy intent under the FMP to allow possession and landing of tails on long commercial fishing trips (at least 48 hours) in the EEZ to make better use of onboard space to store catch. To accomplish this, **Preferred Alternative 3** would revise the current regulations to clearly state that vessels using tailing permits must have requisite Florida permits/licenses for commercial fishing for lobster in the Florida EEZ, or must have federal permits for lobster fishing in the EEZ for states other than Florida. Florida has income and other requirements for commercial and for-hire fishing vessels, and they apply whether a vessel lands spiny lobster in Florida from federal or state waters. In the last five years, approximately 275 vessels held federal lobster tail-separation permits in Florida.[15] There were 274 vessels with reported commercial landings of lobster from the EEZ off Florida, but only 35 of them landed lobster tails. While the number of for-hire vessels that fish for spiny lobster in the EEZ off Florida is not known, it is likely less than the 1,330 vessels with Florida permits/licenses to do so in state and federal waters. Perhaps some of the 1,330 vessels may have acquired federal lobster tail-separation permits. Under **Preferred Alternative 3**, for-hire vessels could continue to engage in for-hire fishing for lobster in the EEZ, they could not possess or land lobster tails, and they might have to add ice-chest capacity to keep the more cumbersome whole lobsters fresh for paying customers. However, bag limits and the demand for for-hire fishing services would not be affected.

Limit Spiny Lobster Fishing in Certain Areas in the EEZ off Florida to Protect Threatened Staghorn and Elkhorn Corals (*Acropora* spp.) (Action 9).

The no action alternative became the proposed action following the Council meetings of June 2011. The action and it alternatives are to become part of what will be Amendment 11 to the FMP. The alternatives are assessed in Section 4.9.2.

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[15]Sources of data: analysis of NMFS, SERO permits data, mid-1990s through 2011 (RBASE, 30Oct06; PIMS, 24Jun11); Florida recreational permits for spiny lobster, Table 3.4.2.1; 35 vessels with FTT-reported landings, as in Table 4.9.2.1; 38 vessels with landings of lobster in Florida, unpublished summaries of NMFS, SEFSC, Coastal Fisheries Logbook data as of 09Mar11; and Aron Podey (Florida, FMC, Division of Fisheries Management), personal communication, 28Apr11.

Require Gear Markings so All Spiny Lobster Trap Lines in the EEZ off Florida are Identifiable (Action 10).

The no action alternative became the proposed action following the Council meetings of June 2011. The action and it alternatives are to become part of what will be Amendment 11 to the FMP. The alternatives are assessed in Section 4.10.2.

Allow the Public to Remove Derelict or Abandoned Spiny Lobster Traps Found in the EEZ off Florida (Action 11).

Preferred Alternative 6 would delegate authority for removal in the EEZ to the FWC, as now occurs in waters under state jurisdiction. Though none of the alternatives would affect ongoing commercial fishing activity during the open season, fishermen's perception about any trap removal can impact their economic activity, wellbeing, and willingness to support regulations (Shivlani et al., 2004). Thus, **Preferred Alternative 6** may have the least perceived economic impact.

Summary of Economic Impacts

Among the eleven actions, further consideration by the Councils of Actions 9 and 10 is deferred, pending Amendment 11. Of the remaining nine actions, two could have beneficial economic effects (the opposite of economic impacts). **Preferred Alternative 4,** Action 5, would not be expected to have any economic impact, providing that sporadic instances of landings exceeding the ACL may be allowed and not result in fishery closure. **Preferred Alternative 4,** Action 7 could bolster commercial fishing for lobster in the EEZ off Florida, which appears to have declined relatively more than fishing for lobsters in state waters. **Preferred Alternative 4,** Action 8, could have an economic impact on a long-declining and now relatively small number of vessels (35 vessels) that engage in deep-water, multi-day fishing for lobster in the EEZ off Florida.

Appendix C. Regulatory Flexibility Analysis (RFA, economic impacts of proposed regulatory actions)

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 of 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 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 various alternatives contained in the FMP or amendment (including framework management measures and other regulatory actions) and to ensure 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 an initial regulatory flexibility analysis (IRFA) for each proposed rule. The IRFA 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. An IRFA is conducted to primarily determine whether the proposed action would have a "significant economic impact on a substantial number of small entities." In addition to analyses conducted for the RIR, the IRFA 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) a description and, where feasible, an estimate of the number of small entities to which the proposed rule will apply; 4) a 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 requirements of the report or record; and, 5) an identification, to the extent practicable, of all relevant federal rules, which may duplicate, overlap, or conflict with the proposed rule.

2. Statement of the need for, objectives of, and legal basis for the rule

A discussion of the need for and objectives of this action is provided in Section 1.2 of this document. The Magnuson-Stevens Act provides the statutory basis for this proposed rule.

3. Description and estimate of the number of small entities to which the proposed action would apply

This proposed action would apply to all fishing that is managed under the Fishery Management Plan for Spiny Lobster in the Gulf and South Atlantic. However, landings of spiny lobster occur predominantly in the Florida Keys (Monroe County) and elsewhere in south Florida. Relatively small (mostly confidential) amounts have been reported for other states since 1977. Excluding Florida, where the federal permit for spiny lobster fishing is not required, there were on average 66 vessels in other states with such permits in the last 5 years. Fishing for spiny lobster in Florida is managed cooperatively by the Councils and the State of Florida, which collects the data used to analyze the activity. Commercial and for-hire fishing vessels that fish for spiny lobster in state and federal waters off Florida must have Florida permits/licenses. On average in the last 5 years, 781 vessels landed spiny lobster commercially in Florida, and they averaged $29,960 per vessel in gross revenue for all species landed. Among the 781 vessels, 274 landed spiny lobster from the EEZ, and averaged $15,889 in gross revenue. Another 23 vessels landed slipper lobster, and averaged $13,260 in gross revenue.

While the number of for-hire vessels that fish for spiny lobster in the EEZ off Florida is not known, it is likely less than 1,330 vessels that have the necessary Florida permits/licenses to engage in for-hire fishing for spiny lobster in state and federal waters. These vessels target other species as well, because recreational landings of spiny lobster occur predominantly in late July through the first week of September. The for-hire fleet is comprised mostly of charter boats, which charge a fee on a vessel basis, and a much smaller number of head boats, which charge a fee on an individual angler (head) basis. The charter boat annual average gross revenue is estimated to range from approximately $62,000-$84,000 in Florida. For head boats, the corresponding estimates are $170,000-$362,000 in Florida.

The Small Business Administration has established size criteria for all major industry sectors in the U.S. including fish harvesters. A business involved in commercial shellfish harvesting is classified as a small business if it is independently owned and operated, is not dominant in its field of operation (including its affiliates), and has combined annual receipts not in excess of $4.0 million (NAICS code 114112, shellfish fishing) for all its affiliated operations worldwide. A for-hire business involved in fish harvesting is classified as a small business if it is independently owned and operated, is not dominant in its field of operation (including its affiliates), and has combined annual receipts not in excess of $7.0 million (NAICS code 713990, recreational industries). Based on the average revenue estimates provided above, all commercial and for-hire fishing vessels expected to be directly affected by this proposed rule are determined for the purpose of this analysis to be small business entities.

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

This proposed rule would not establish any new reporting, record keeping, or other compliance requirements.

5. Identification of all relevant federal rules, which may duplicate, overlap or conflict with the proposed rule

No duplicative, overlapping, or conflicting federal rules have been identified.

6. Significance of economic impacts on small entities

<u>Substantial number criterion</u>

This proposed rule, if implemented, would be expected to affect all vessels that engage in commercial and recreational fishing in the EEZ that is managed under the Fishery Management Plan for Spiny Lobster in the Gulf and South Atlantic.

Significant economic impacts

The outcome of "significant economic impact" can be ascertained by examining two factors: Disproportionality and profitability.

> Disproportionality: Do the regulations place a substantial number of small entities at a significant competitive disadvantage to large entities?

All entities expected to be directly affected by the measures in this proposed rule are determined for the purpose of this analysis to be small business entities, so the issue of disproportionality does not arise in the present case.

> Profitability: Do the regulations significantly reduce profits for a substantial number of small entities?

The majority of the actions in this proposed regulation are either administrative in nature or would be expected to accommodate status quo harvests or fishing behavior. The possible exception to this determination is the proposed action to relating to the possession and landing of tailed lobsters from the EEZ. Available data does not support the determination of the number of vessels that may be affected by this proposed action. Approximately 35 vessels with commercial landings from the EEZ landed both tails and whole lobsters on the same trips. The effect on these vessels of the requirement to land either tails or whole lobsters on one trip is not known. This requirement may, however, be a problem for for-hire vessels with limited holding capacity. The solution for these vessels may simply be the purchase of additional ice chests to store customer harvests. However, while this proposed requirement may be limiting for some for-hire vessels, this would not be expected to be a problem, on average, for the for-hire fleet because the majority of vessels would not be expected to engage in the practice of landing tailed lobsters, or depend on this type of business for a significant portion of their revenues. As a result, the actions in this proposed regulation would not be expected to significantly reduce profits for a substantial number of small entities. Public comment, however, is requested on this determination, specifically with respect to the effects of the proposed modifications to the tailing requirements.

7. Description of significant alternatives to the proposed action and discussion of how the alternatives attempt to minimize economic impacts on small entities

Although none of the proposed actions would be expected to result in significant economic impacts on small entities, this section discusses all of the alternatives considered in this proposed amendment.

Other Species in the Spiny Lobster FMP

Including options, 10 alternatives were considered respecting species other than spiny lobster in the FMP, and the proposed action (which includes four alternatives, one for each of the four species) would remove all four species from the FMP. None of the alternatives would be expected have an economic impact on small entities because the alternatives are administrative in nature and the species addresses are not significantly harvested. One alternative, the status-quo no-action alternative, would not meet the requirements of the Magnuson-Stevens Act. A second alternative to the proposed action would have added one species to the FMP, and establish ACLs and AMs for two species, and another four other alternatives (one for each of four species) would have listed four species as ecosystem components under the FMP. These alternatives were not adopted because the Councils concluded these species no longer required federal management. The Councils concluded that the proposed action best meets the purpose and need to bring the Spiny Lobster FMP into compliance with Magnuson-Stevens Act requirements for ACLs and AMs to prevent overfishing.

Modify the definition of maximum sustainable yield, overfishing threshold, and the overfished threshold for Caribbean spiny lobster

Defining the MSY, MSST and other biological parameters for a species does not alter the current harvest or use of the resource. Therefore, no economic impact on small entities would be expected to result from the specification of these management parameters. The Councils concluded that the proposed actions for defining these parameters best meet the purpose and need to bring the Spiny Lobster FMP into compliance with Magnuson-Stevens Act requirements for ACLs and AMs to prevent overfishing.

Four alternatives, including the no-action alternative (status quo), were considered for the definition of MSY, and the proposed action specifies an MSY proxy; i.e., MSY = OFL = 7.90 mp, in accordance with the recommendations of the Gulf SSC for the Overfishing Limit (OFL). The no-action alternative was not adopted as the proposed action because it would not comply with the Magnuson Stevens Act. The remaining two alternatives to the proposed action were not adopted because they would require an updated stock assessment approved by the two SSCs, which is not available at this time.

Three alternatives, including the no-action alternative (status quo), were considered for the definition of the Overfishing Limit (OFL), and the proposed action specifies that OFL = 7.90 mp, in accordance with the recommendations of the Gulf SSC. The no-action alternative was not adopted because it would not comply with the Magnuson Stevens Act. The remaining alternative was not adopted because it would require an updated stock assessment approved by the two SSCs, which is not available at this time.

Three alternatives, including the no-action alternative (status quo), were considered for the definition of the Overfished Threshold (Minimum Stock Size Threshold, MSST), and the proposed action specifies a proxy value. The no-action alternative was not adopted because it would not comply with the Magnuson Stevens Act. The Councils recognize that the proposed action and the second alternative would both require an updated stock assessment approved by the two SSCs, which is not available at this time. However, despite the absence of an updated stock assessment, the proposed action was adopted instead of the second alternative because the proposed action would be best capable of incorporating best available science.

Establish Sector Allocations for Caribbean Spiny Lobster in State and Federal Waters from North Carolina through Texas

Six alternatives, including the no-action alternative (status quo), to establish sector allocations were considered by the Councils. Among the six alternatives, the no-action alternative was adopted as the proposed action by the Councils. The five alternatives to the proposed action that would specify allocations would have varying effects determined by their combination with the selection of accommodating alternatives used to specify the ABC, ACL, OY, and ACT. Combining all the alternative combinations for sector allocations, ABC, ACL, OY, and ACT results in 108 single (stock) or paired-set (sector) ACLs, some of which were greater than or less than the respective status-quo landings. Any scenario where allowable landings would be reduced would be expected to result in a reduction in economic benefits to the respective affected sector. The Councils concluded that it was best to manage the spiny lobster fishery without allocations between the recreational and commercial sectors because no mechanism currently exists to track recreational landings and the commercial trip ticket data are not compiled with sufficient speed to support in-season quota monitoring. The Councils also concluded that the proposed action best meets the Amendment's purpose and need to bring the Spiny Lobster FMP into compliance with Magnuson-Stevens Act requirements for ACLs and AMs to prevent overfishing.

Acceptable Biological Catch (ABC) Control Rule, Annual Catch Limits (ACLs), and Annual Catch Targets (ACTs) for Caribbean Spiny Lobster

Including options, seven alternatives, including the no-action alternative (status quo), were considered for the action to specify an ABC control rule, and the proposed action specifies the Gulf Council's ABC Control Rule, for which ABC = (10-year mean of landings plus 1.5 standard deviations) = 7.32 mp (ww). Apart from the no-action alternative, which would not meet Magnuson-Stevens Act requirements, the other five alternatives to the proposed action would specify a higher or lower ABC. Because specifying an ABC control rule is an administrative action, no direct economic effects on any small entities would be expected to result from any of these alternatives. The proposed action was adopted because it would be consistent with decisions made for other species managed by the Councils and would provide a statistically based way of setting ABC, even if a new stock assessment changed the status of the stock. Further, the remaining alternatives, other than the no action alternative, were not adopted because they would not allow for changes to the ABC based on subsequent stock assessments.

Including options, seven alternatives, including the no-action alternative (status quo), were considered for the action to set ACLs, and the proposed action specifies that ACL = OY = ABC = 7.32 mp. The no-action (status-quo) alternative would not meet Magnuson-Stevens Act requirements. The remaining five alternatives to the proposed action would specify higher or lower ACLs, with each alternative specifying either a single ACL for the entire fishery or a sector specific ACL, one ACL for commercial fishing, and another ACL for recreational fishing. The alternatives that would have resulted in sector ACLs were not adopted because the adoption of sector ACLs would have been inconsistent with the decision to not adopt allocation ratios for the sectors. Among the alternatives that would not establish sector ACLs, the proposed action would be expected to result in the greatest economic benefits because it would allow the greatest total harvest.

Including options, seven alternatives, including the no-action alternative (status quo), were considered for the action to set ACTs. The proposed action specifies that ACT = 6.59 mp. Although an ACT is not a required component of an FMP and the absence of an ACT would allow the largest harvest, 7.32 mp (subject to ACL = OY = ABC), the no-action alternative was not adopted because the Councils believed that an ACT was appropriate for this stock due to the uncertainty associated with harvest monitoring, particularly recreational landings. Similar to the action to specify the ACL, the remaining five alternatives to the proposed action would specify different ACTs, with each alternative specifying either a single ACT for the entire fishery or a sector specific ACT, one ACT for commercial fishing, and another ACT for recreational fishing. The alternatives that would have resulted in sector ACTs were not adopted because the adoption of sector ACTs would have been inconsistent with the decision to not adopt allocation ratios or ACLs for the sectors. Among the alternatives that would not establish sector ACTs, other than the no-action alternative, the proposed action would be expected to result in the greatest economic benefits because it would allow the greatest total harvest.

Accountability Measures

Including options and sub-options, 12 alternatives, including the no-action alternative (status quo), were considered for the action to establish accountability measures (AMs). The no-action alternative would not meet Magnuson-Stevens Act requirements. The proposed action would establish that AM = ACT = 6.59 mp. With the exception of the no-action alternative, the alternatives to the proposed action would be inconsistent with the adoption of other actions in this proposed amendment, notably the actions that tier off the decision to not specify sector allocations. Absent sector allocations, ACLs, and ACTs, the adoption of sector AMs would be inappropriate. Further, adjustment of sector seasons is not practical in the absence of sector ACLs or ACTs. As a result, the Councils concluded that the proposed action best meets the purpose and need to bring the Spiny Lobster FMP into compliance with Magnuson-Stevens Act requirements for ACLs and AMs to prevent overfishing.

Develop or Update a Framework Procedure and Protocol for Enhanced Cooperative Management for Spiny Lobster

Including options and sub-options, six alternatives, including the no-action alternative (status quo), were considered for the action to establish the framework procedure. The proposed action incorporates two of the alternatives, updating the current protocol for cooperative management and revising the current regulatory amendment procedures by adopting the base framework procedure. The no-action alternative was not adopted because the current protocol and framework procedure are out of date and not consistent with current assessment and management methods. The proposed action would facilitate implementation of changes in management measures required under the Magnuson-Stevens Act, such as changes in ACL, ACT, and AM. The remaining alternatives to the proposed action, other than the no-action alternative, were not adopted because they could result in a delay in the implementation of necessary changes relative to the proposed action. Although such delay could have either positive or negative short-term economic impacts on small entities, the delay would nevertheless impede effective and efficient management of the stock.

Modify Regulations Regarding Possession and Handling of Short Caribbean Spiny Lobsters as "Undersized Attractants"

Including options and sub-options, five alternatives, including the no-action alternative (status quo), were considered for the action to modify the regulations regarding undersized spiny lobsters. The proposed action would allow undersized spiny lobster not exceeding 50 per vessel plus 1 per trap aboard each vessel if used in the EEZ exclusively for luring, decoying, or otherwise attracting non-captive spiny lobsters into the trap and would be expected to result in an increase in economic benefits to affected fishermen. Each of the non-adopted alternatives, including the no-action alternative, were not adopted because they would result in greater restrictions on the possession of undersized spiny lobsters used as attractants. As a result, each of these alternatives would be expected to result in lower economic benefits than the proposed action.

Modify Tailing Requirements for Caribbean Spiny Lobster for Vessels that Obtain a Tailing Permit

Four alternatives, including the no-action (status quo) alternative, were considered for the action to modify tailing requirements. Two of the alternatives are included in the proposed action, which would require that all lobsters from the EEZ be landed all whole or all tails on a single trip and require that vessels receiving a tailing permit must have either the requisite Florida permits/licenses for commercial fishing for lobster or a federal spiny lobster permit. The no-action alternative was not adopted because the tailing permit was intended to allow tailing by commercial fishermen on long trips but, instead, current regulatory language and application has allowed recreational fishermen to obtain the permit, contrary to Council intent. The remaining alternative to the proposed action would disallow any lobster tail-separation permits and was not adopted because it would not be consistent with the Council's intent and would be expected to result in greater economic losses than the proposed action.

Limit Spiny Lobster Fishing in Certain Areas in the EEZ off Florida to Protect Threatened Staghorn and Elkhorn Corals (*Acropora* spp.)

Including options and sub-options, eight alternatives, including the no-action alternative (status quo), were considered for the action to limit spiny lobster fishing to certain areas in the EEZ off Florida. Each of the alternatives to the proposed action would increase the restrictions on where spiny lobster fishing could occur relative to the status quo. As a result, each of these alternatives would be expected to result in adverse economic effects to spiny lobster fishermen relative to the status quo. The no action alternative was adopted as the proposed action in order to allow more public input before taking additional action and this action will be re-addressed in a subsequent amendment to the FMP.

Require Gear Markings so All Spiny Lobster Trap Lines in the EEZ off Florida are Identifiable.

Three alternatives, including the no-action alternative (status quo), were considered for the action to require gear markings on all lobster trap lines used in the EEZ off Florida. Each of the alternatives to the proposed action would impose new gear marking requirements and, as a result, each of these alternatives would be expected to result in adverse economic effects to spiny lobster fishermen relative to the status quo. The no action alternative was adopted as the proposed action in order to allow more public input before taking additional action and this action will be re-addressed in a subsequent amendment to the FMP.

Allow the Public to Remove Derelict or Abandoned Spiny Lobster Traps Found in the EEZ off Florida.

Six alternatives, including the no-action alternative (status quo), were considered for the action to designate authority to remove derelict or abandoned spiny lobster traps in the EEZ off Florida. The no-action alternative was not adopted because it would not allow the removal of derelict or abandoned traps and would not, therefore, be consistent with the Council's objectives. The proposed action would delegate authority for removal of derelict or abandoned traps to the Florida FWC, which has such responsibilities in Florida waters, and would be expected to have the least economic impact on small entities, based on comments by commercial fishermen. The other alternatives to the proposed action would allow the public to remove derelict or abandoned traps, or portions thereof, during different portions of the closed season. Assuming such authority only resulted in the removal of derelict or abandoned traps, none of the alternatives to the proposed action, other than the no-action alternative, would be expected to adversely affect ongoing commercial fishing activity during the open season or respective fishing businesses because, by definition, the traps removed would no longer be part of an active business operation. Nevertheless, the proposed action was adopted by the Council to allow the traps to be removed through an existing, coordinated, and well-managed program that minimizes the likelihood of valid traps being removed or molested.

Appendix D. Bycatch Practicability Analysis

Bycatch Practicability Analysis

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 Caribbean spiny lobster fishery is concentrated off south Florida and the Florida Keys. The commercial component of the fishery is prosecuted primarily by traps, but some commercial fishers harvest Caribbean spiny lobster by SCUBA diving and a small percentage (1-2%) use bully nets or hoop nets, primarily in state waters, to harvest lobsters. The recreational component of the fishery harvests Caribbean spiny lobster by SCUBA diving typically using allowable equipment, such as tickle sticks and hand nets, and the required underwater measuring devices to meet minimum size limit requirements.

Federal regulations require lobster traps be no larger than 3 ft x 2 ft x 2 ft, or the volume equivalent. Most fishermen use wooden traps. A trap constructed of material other than wood must have a degradable panel on the upper half of the sides or on top of the trap. When the degradable panel is removed, the opening should be no smaller than the diameter of the entrance of the trap.

A study documenting bycatch in commercial lobster traps sampled the contents of wooden traps and documented bycatch of 232 individuals representing 23 species (n = 774 traps) in the Gulf of Mexico (Gulf) (Matthews and Donahue 1997). Plastic traps were also sampled in the same area in the Gulf and documented bycatch of 386 individuals representing 25 species (n = 517 traps). Wooden traps sampled from South Atlantic waters documented 758 individuals representing 63 species (n = 1,480). It was noted that wooden traps captured more invertebrates and grunts than plastic traps. Grunts (i.e., tomtates and white grunts) as well as stone crab, and spider crabs dominated bycatch from the all traps accounting for 64% of the bycatch. Economically valuable snapper and grouper species composed 2.6% and 1.3% of the bycatch in wooden and plastic traps in the Gulf; however, in the South Atlantic groupers and snappers comprised 7% of the bycatch from wooden traps. No legal-sized commercially valuable species were documented from the Gulf during the study, and only one out of 300 (0.3%) traps fishing in South Atlantic waters had these species. Daily bycatch mortality during this experiment was estimated to be between 0.0009 and 0.0027 animals per wooden trap/day. Diver observations indicated immediate escape for tomtates approximately 6.3 in (16 cm), and 90% of gray snapper approximately 10 in (25 cm) escaped in less than 24 hours and all escaped in less than 48 hours. Most importantly, during this study no confinement-induced mortality was observed among fish.

Lost or abandoned traps may "ghost fish" – continue to catch target and non-target species. However, most fishermen use wooden traps which degrade over time, and those constructed of material other than wood are required to have a degradable wood panel. No studies have quantified the level of ghost fishing by lobster traps, but these requirements ensure that traps do not ghost fish indefinitely.

There is limited information on bycatch and the potential for bycatch mortality in the recreational or commercial dive sectors. However, Parsons and Eggleston (2005) documented the frequency of undersized injured Caribbean spiny lobsters after the two-day recreational mini-season which is exclusively for sport divers. This season opens one week prior to the opening of the regular lobster fishing season for commercial and recreational fishers. The study documented a low percentage of injured lobsters before the mini-season; after the mini-season the percentage of injured lobsters had increased to 27.16% on patch reefs and 3.77% on patch heads. Parsons and Eggleston (2005) also documented that injured lobsters were unable to attract other lobsters and maintain the usual gregarious behavior of uninjured lobsters. In addition, they found in this study and an additional laboratory experiment that predation was documented more frequently on injured lobsters compared to uninjured lobsters, possibly due to the changes in species behaviors (Parsons and Eggleston 2005; 2006). The results of these studies determined that human disturbance and injury of lobsters on patch reef habitats greater than 25% during the mini-season causes lobsters to alter their behavior and reduce subsequent survival in the presence of natural predators such as gray triggerfish (Parsons and Eggleston 2006).

1. Population Effects for the bycatch species

The population effects of bycatch from the commercial trap fishery are expected to be minimal to none. Studies documented low bycatch and bycatch mortality of finfish by the commercial trap fishery for both wooden and plastic traps. Most of the finfish caught in commercial spiny lobster traps are juveniles and all escape within 48 hours (Matthews and Donahue 1997). Stone crabs were by far the most dominant species caught in two studies of lobster traps (Matthews et al. 1994, Matthews and Donahue 1997). Most lobster fishermen retain stone crabs caught in lobster traps. Stone crabs are predators on mollusks, and changes in stone crab populations would affect mollusk populations.

In the recreational fishery bycatch primarily consists of undersized Caribbean spiny lobsters. Because the gear types used by SCUBA divers and snorkelers targeting spiny lobster are considered highly selective for spiny lobster, very little bycatch of non-target species is expected in the recreational sector of the Caribbean spiny lobster fishery. Based on studies documenting injury of Caribbean spiny lobster during the two-day mini-season, a decrease in the use of shelters and gregarious behavior contributed to decreased survival when lobsters were exposed to natural predators such as gray triggerfish (Parson and Eggleston 2006). If these undersized lobsters have already spawned prior to opening the season it is unlikely the reproductive potential of a stock would be compromised. In addition, the 2010 update assessment determined that the majority of United States stock of Caribbean spiny lobsters is based on outside recruitment from other areas of the Caribbean; therefore, the recreational component of the fishery is not expected to have detrimental effects on the population within the fishery management area.

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. Bycatch mortality is incorporated in assessments of finfish stocks if estimates are available. Stone crab caught in lobster traps are usually sold and recorded as commercial landings. Mortality of commercially and recreationally important finfish is negligible (Matthews and Donahue 1997). Little is known about the status of many finfish (e.g., grunts, cowfish, porgies) and invertebrate (e.g., spider crabs, urchins) species that are bycatch in lobster traps in the greatest numbers. None of these species have undergone (or are likely to undergo) formal stock assessments, because most are not targeted in commercial or recreational fisheries.

In the 2009 Biological Opinion, NOAA Fisheries Service determined the spiny lobster trap fishery as it currently operates may adversely affect the green, hawksbill, Kemp's ridley, leatherback, or loggerhead sea turtles, *Acropora* spp., or smalltooth sawfish, but is not likely to jeopardize their continued existence. This amendment contains an action to create protected areas for *Acropora* spp. corals in the South Atlantic within which deployment of spiny lobster traps would be prohibited. However, the Council deferred action on this closure until Amendment 11. Protected areas should be established before the beginning of the 2012 fishing season and are likely to reduce incidence of trap interactions with protected coral species.

2. Ecological effects due to changes in bycatch of lobster species

Actions setting annual catch limits (ACLs) and annual catch targets (ACTs) may limit effort if levels are set lower than average landings. Lower overall effort would reduce economic and regulatory discards of spiny lobster and may reduce the use of undersized lobsters as attractants. These changes may not impact the population if most recruits are from other areas of the Caribbean and not managed by U.S. regulations.

Currently, up to 50 Caribbean spiny lobsters under the minimum size limit or one per trap, whichever is greater, may be retained aboard a vessel, provided they are held in a live well. When in a trap, such "shorts" are used to attract other lobsters for harvest. Federal regulations are not consistent with State of Florida regulations, which allow up to 50 Caribbean spiny lobsters under the minimum size limit on board <u>and</u> one per trap. The practice of using shorts as attractants may increase the fishing mortality on juvenile lobsters and could facilitate their illegal trade. Questions have also arisen as to whether these shorts could be considered bycatch as defined under the Magnuson-Stevens Fishery Management and Conservation Act (Magnuson-Stevens Act).

Undersized lobster used as attractants are kept for personal use as bait under 50 CFR 640.21(c) and therefore meet the definition of bycatch in the Magnuson-Stevens Act. Lobsters in the range of 70-76 mm carapace length are retained by fishermen because they are of a desirable size to attract larger lobsters; clearly they are not economic discards. They are also not regulatory discards because fishermen are not *required* to discard or retain them; rather they are *allowed* to retain them. Fishermen release shorts alive after using them as bait, and about 1% percent per night escape from traps (J. Hunt and W. Sharp, pers. comm.).

Federal regulations provide specifications for live wells to hold shorts while on board a vessel. An undersized lobster held under these conditions must be released alive and unharmed when not used in a trap. Hunt et al. (1986) indicated an exposure and confinement mortality rate of 26.3% for lobsters exposed to air and confined in traps for four weeks. Lobsters that were held in live wells and confined for the same amount of time showed a mortality rate of 10.1%. A study conducted by Matthews (2001) indicated similar reductions in the mortality rates of spiny lobster kept for use as attractants based on observation of commercial lobster traps, due to the implementation of the live well requirement. Additionally, the Matthews (2001) study showed commercial and recreational harvest of spiny lobster increased notably as a result of decreased mortality of undersized lobsters maintained in live wells.

Experiments have shown that traps baited with shorts catch approximately three times more lobster than traps baited with any other method (Heatwole et al. 1988). Further, traps using non-lobster bait catch fewer lobsters than unbaited traps, probably because the bait attracted stone crabs, which lobsters avoid. Traps using non-lobster bait or no bait take two to three times longer to harvest the same amount of lobsters as traps using lobster bait. This increase in effort may actually increase bycatch of other species. Increased soak time (time traps are left in the water before being serviced) may also increase bycatch mortality. Therefore, allowing use of undersized attractants at the same level as allowed by Florida would be practicable from both an enforcement and biological aspect.

3. Changes in bycatch of other species and resulting population and ecosystem effects

If affected finfish are lobster predators, reductions in finfish bycatch may result in increased predation on the lobster population. Predator-prey relationships largely depend on the size structure of predator and prey populations. Gray triggerfish and octopus are suspected predators of lobsters, and lobster fishermen will often kill and discard these species (Matthews et al. 1994). Changes in the bycatch of non-lobster 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, which are often attached to traps, condition habitat for other organisms by providing a growing surface or by contributing to the bioturbation of bottom sediments. Depending on behavior of the fishermen, many of these organisms are crushed or die of exposure when traps are brought on deck (Matthews et al. 1994).

4. Effects on marine mammals and birds

Bycatch of marine mammals and seabirds is not considered to be a problem in the spiny lobster fishery and actions evaluated in this amendment are not expected to significantly affect interactions with these animals. As noted in Section 4.14, the Florida spiny lobster trap fishery is listed as a Category III Fishery under the MMPA, 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 (75 FR 68468; November 8, 2010).

Matthews et al. (1994) observed five dead cormorants (*Phalacrocorax auritus*) in 21,309 traps. Presumably these birds were attempting to remove bait or bycatch from the traps and became entangled. There is no information to indicate marine mammals and birds rely on Caribbean spiny lobster for food.

5. Changes in fishing, processing, disposal, and marketing costs

Changes in the number of shorts allowed on board vessels could change costs to fishermen. If undersized attractants were not allowed to be retained, fishermen who commonly use them as bait would need to purchase other bait. Common non-lobster baits include cowhide, cat food, mullet, and herring. Commercial trap fishermen who reported use of shorts as attractants had much lower average trip costs for bait compared with those who used purchased bait, and they had shorter trips and lower average trip costs for other major items as well (Shivlani et al. 2004). Trip costs for bait ranged $12.72 (Middle Keys) to $133.24 (Key West), with the average trip cost for bait of $60.90 (data in current dollars for 2001/2002).

6. Changes in fishing practices and behavior of fishermen

Any ACL or ACTM that limits the catch of lobster could change fishing practices and behavior of fishermen. Fishermen may deploy more traps early in the season, and retrieve those traps more often to try to obtain more of the allowed catch. However, the ACL and ACT chosen by the Councils are higher than recent landings and would not be expected to limit catch.

Changes to the number of shorts may impact behavior of fishermen. Experiments have shown that traps baited with shorts caught approximately three times more lobster than traps baited with any other method (Heatwole et al. 1988); therefore, traps using non-lobster bait or no bait would take two to three times longer to harvest the same amount of lobsters as traps using lobster bait. Although mortality of shorts may result in some foregone yield, a prohibition on the use of shorts would result in decreased economic benefits and changes in fishing practices, such as requiring traps to soak longer before servicing them.

7. Changes in research, administration, and enforcement costs and management effectiveness

Proposed actions that will affect bycatch are not expected to significantly impact research costs. Implementation of an ACL may require an additional administrative burden to monitor landings. Enforcement costs may be reduced if federal regulations concerning use of shorts are changed to be the same as Florida regulations.

8. Changes in the economic, social, or cultural value of fishing activities and non-consumptive uses of fishery resources

Most commercial spiny lobster fishermen do not consider keeping shorts for use as attractants as a form of bycatch or bycatch mortality because they are "borrowing" from the resource with the intent to release the lobsters back into the environment alive. In addition, about 1% percent per night escapes from traps (J. Hunt and W. Sharp, pers. comm.). Prohibiting or further restricting use of shorts may be viewed by commercial fishermen as an unnecessary regulation on a practice that has been used for a long time and results in low mortality under requirements for holding lobsters. On the other hand, recreational fishermen view the use of shorts as unnecessary mortality of lobsters that could eventually contribute to the fishable stock.

9. Changes in the distribution of benefits and costs

Actions setting an ACL or ACT may limit effort if levels are lower than average landings. In this case, lower effort would result in lower bycatch. Because limits would be set for the fishery as a whole, all sectors are expected to be affected in the same way.

Actions addressing use of undersized lobster as attractants apply only to the commercial trap sector and do not directly affect the commercial dive sector or the recreational sector. Therefore, any benefits or costs associated with increasing or decreasing the number of shorts allowed would directly affect only the commercial trap sector. The other sectors may be indirectly affected by changes in the mortality associated with the use of shorts.

10. Social effects

Bycatch is considered wasteful because it reduces overall yield obtained from the fishery. Yet, commercial lobster fishermen do not consider the use of shorts as attractants to be bycatch. Measures that reduce bycatch to the extent practicable will increase efficiency, reduce waste, and benefit stock recovery, thereby resulting in net social benefits. However, reducing one type of bycatch is not always practicable, especially if another type of bycatch is increased. Because it has been shown that traps must soak longer when shorts are not used as attractants, it is likely that the bycatch of other species will be increased if the use of shorts were to be prohibited. Therefore, any measures that may change bycatch, such as changing the allowance of undersized lobsters as attractants, should be considered in light of potential unintended consequences, including changes in efficiency (longer soak times) and bycatch of other species.

Conclusion

This section evaluates the practicability of taking additional action to minimize bycatch and bycatch mortality in the Gulf and South Atlantic Caribbean spiny lobster fishery by using the ten factors provided at 50 CFR 600.350(d)(3)(i). In summary, setting ACLs and ACTs would impact bycatch only if set at levels that curtail the fishery to landings lower than those of recent years. Increasing the number of shorts allowed on board a vessel may slightly increase the mortality of those shorts, but ultimately may decrease total bycatch and bycatch mortality of other species. Therefore, the Councils concluded that current and proposed management measures minimize bycatch and bycatch mortality to the extent practicable in the Caribbean spiny lobster fishery.

Appendix E. Other Applicable Laws

The Magnuson-Stevens Fishery Conservation and Management Act (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.

Administrative Procedures Act (APA)

All federal rulemaking is governed under the provisions of the 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.

Coastal Zone Management Act (CZMA)

The 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 Service 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.

Data Quality Act (DQA)

The 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 DQA 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 Magnuson-Stevens Act. To be consistent with the Act, fishery management plans (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.

Endangered Species Act (ESA)

The (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 Service, 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 August 27, 2009, formal consultation was completed on the continued authorization of the spiny lobster fishery in the South Atlantic and Gulf of Mexico (NMFS 2009). The biological opinion concluded the fishery would not affect ESA-listed marine mammals, or adversely affect Gulf sturgeon and *Acropora* spp. critical habitat. The biological opinion determined the continued authorization of the fishery was likely to adversely affect sea turtles, smalltooth sawfish and *Acropora* spp., but is not likely to jeopardize the continued existence of these species. An incidental take statement authorizing a limited amount of take for these species was issued.

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.

Clean Water Act (CWA)

In 1972, Congress passed the 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 CWA (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. 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.

National Marine Sanctuaries Act

Under the National Marine Sanctuaries Act (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.

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 (FWS) 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 Service 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 Service a public notice of a Section 404 permit. FWS or NOAA Fisheries Service 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.

Executive Orders

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.

It has been determined in Section 4 there will be significant biological affects in a positive form as a result of actions in this amendment; 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.

E.O. 12866: Regulatory Planning and Review

Executive Order 12866, 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 Service 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.

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.

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).

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.

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 Service, the states, and local authorities in managing coastal resources, including fisheries, and 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 FMP have been developed with the local and federal officials.

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.

E.O. 12898: Environmental Justice (EJ)

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 EJ 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 EJ issues are anticipated and no modifications to any proposed actions have been made to address EJ issues.

Marine Mammal Protection Act (MMPA)
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 Service) 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; and 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), they must accommodate an observer if requested (50 CFR 229.7(c)), and comply with any applicable take reduction plans.

The 2011 List of Fisheries (LOF) classifies the Florida spiny lobster trap/pot fishery as a Category III fishery (75 FR 68468; November 8, 2010). The 2011 LOF also classifies the bully net and commercial dive portions of the fishery (called the “Atlantic Ocean, Gulf of Mexico, Caribbean shellfish dive, hand/mechanical collection” fishery) as a Category III because there has never been a documented interaction with marine mammals.

Paperwork Reduction Act (PRA)
The 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 Service to obtain approval from OMB before requesting most types of fishery information from the public. Modifications to the Tail Separation Permit requirements have been submitted to OMB to meet PRA requirements.

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 Small Business Association (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, NOAA Fisheries Service, 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).

Magnuson-Stevens Act Essential Fish Habitat (EFH) 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. Spiny lobster EFH, in both the Gulf of Mexico and South Atlantic, was identified and described only for the Caribbean spiny lobster (*Panulirus argus*). Therefore, the proposed removal of species from the FMU would not alter current EFH designations in the Spiny Lobster FMP. Additionally, the Councils and NMFS have determined there are no adverse effects to EFH that may occur as a result of the other actions proposed in this amendment as discussed in the Environmental Consequences section (Section 4).

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 was issued in 2001, which directs federal agencies, including NOAA Fisheries Service, to take certain actions to further implement the MBTA.

National Environmental Policy Act (NEPA)
The 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.

Regulatory Flexibility Act (RFA)
The purpose of the 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. To make this determination, the agency conducts a threshold analysis, which has the following five 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.

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.

Appendix F. Scoping Summary

SUMMARY MINUTES
PUBLIC HEARING – MARATHON, FL
SPINY LOBSTER AMENDMENT 10
JOINT AMENDMENT FOR THE GULF OF MEXICO AND SOUTH ATLANTIC FISHERY MANAGEMENT COUNCILS

September 22, 2009

Attendance:
Bob Gill, Gulf Council
Dr. Gregg Waugh, SAFMC
Dr. Carrie Simmons, Gulf Council Staff
Phyllis Miranda, Gulf Council Staff

36 Members of the Public

The public hearing was convened by Chairman Bob Gill at 6:00 p.m. Dr. Carrie Simmons reviewed the PowerPoint presentation with the public. The public was then invited to provide their comments.

Karl Lessard, Florida Keys Commercial Fishermen's Association. He read into the record from two written letters which had previously been provided to the Council at the June Council meeting and which are attached. In summary, these letters stated that they do not want the Councils to repeal the Spiny Lobster FMP, because it is felt that the state is not able to do a stock assessment alone. In addition, the size limit requirements on imports are crucial to maintain an economically viable fishery. The FKCFA is in support of the following allocation: 72% commercial trap fishery, 22% recreational divers, 5% commercial divers, and 1% bully net fishing. He requested that the Council set the ACL using a quota instead of using landing records. He added that they are mainly concerned about spiny lobster and the Council should do what they think is appropriate for the other lesser landed species in the FMP. He stated that mortality of short lobsters is estimated to be low, 8-10%; which is lower than fishing mortality on most other species.

Tim Daniels, Marathon, FL. He stated that the fishermen are scared that the catch limit on the lobster would be limited because of the data resulting from hurricanes and illegal fishing. The population has been reduced due to the hurricanes and this has caused them to not be able to catch as many lobsters. He stated that he would like to see the historical data to go back 20-30 years and that data be considered when setting an ACL. He felt that management of spiny lobster or stone crab should not be turned over to the state of Florida. He was in agreement with the previous allocation for Monroe County that Karl Lessard stated. He noted that the recreational diver mini-season is difficult to measure and control. He added that the use of shorts as an attractant is a necessary component of lobster fishing. He added that economic and social impact studies should be done on all the fisheries that are mandated under the MSA.

Hal Osburn, Florida Keys Commercial Fishermen's Association. He stated that sociological cultural information needs to be a focus of the studies and that ACLs and AMs should be based on the current stock assessment, not a future stock assessment as it is the best available data. He felt that the spiny lobster FMP should remain under the joint jurisdiction of the GMFMC, the SAFMC, and the FFWC. He added that the state cannot keep up with the requirements of managing the spiny lobster fishery and that the restriction on the importation of illegal size spiny lobster is very important and would not exist anymore under state management. He was of the opinion that all Caribbean spiny lobster landed should be landed either all whole or all tailed, and that having that regulation would prevent the abuse of having a short carapace but a long tail.

Gary Nichols, Nichols Seafood, Islamorada, FL and Organized Fishermen of Florida. He stated that lobster catch can historically be sustained to 6 million pounds. He would like to see an allocation that is closest to the 6 million pounds. He felt that the ACL should be based on the current stock assessment. He believed that the Councils should retain management of the spiny lobster. He stated that he is in favor of modifying the tailing permit to all tailed or all whole lobster landed. He added that the coral needs to be protected and that the coral working group and the Sanctuary were trying to identify more areas that needed to be closed to achieve that goal. He noted that he lobsters in deeper water and catches ridged slipper lobster, and he felt that whatever is appropriate to protect the spawning stock, such as egg bearing females, is important.

Jeff Cramer, Organized Fishermen of Florida. He stated that the current stock assessment should be used instead of using an updated assessment that may not reflect the true condition of the spiny lobster stock because of the hurricanes and other issues. He added that about a dozen fishermen in the coral workgroup were working with NOAA's Protected Species Division to identify areas that the corals are located. He said that the fishermen were willing to do anything to protect the corals and that the lobsters are not typically located near the corals. He felt that the Councils should maintain control over the FMP. He felt that the trip ticket system was flawed because on any given day he may fish in three areas, but only records one on the trip ticket. In general, he felt that fishing in federal waters was underreported and traps were moved between federal and state waters based on season and movement of the lobster. He stated that undersized lobsters imported from other countries were a big problem for local fishers. He indicated that he uses shorts as an attractant and that they were kept in good condition before going into the trap. He added that often the shorts escape the trap indicating that they could leave the trap at any time.

Richard Stiglitz, commercial fisherman, Monroe County, FL. He indicated that he has used shorts for 40 years. He stated that he takes care of the lobsters on his boat that he uses for shorts and that there is next to no short mortality on their boats. He felt that the ACLs need to be set high on the spiny lobster because a number set too low would be devastating to the Keys communities. He also stated that in the northern Gulf (Naples to Tampa) is a population of large spawning females and it should always be protected. He did not think any fishers were currently targeting this area, but it should be protected. He was in agreement with other speakers, that federal management should stay involved.

Additional attendees who chose not to speak on Spiny Lobster:
Chris Johnson, charter boat captain, Marathon, FL
Christy Johnson, Seasquared Charters
John Bartus, Marathon Chamber of Commerce
Rick Turner, charter boat captain, Marathon, FL
Don Moll, charter boat captain
Michelle Owen, Environmental Defense Fund
David McKinney, Environmental Defense Fund
Elizabeth Prieto, Marathon, FL
Edwin Prieto, Marathon, FL
Barbara Maddox, Captain Pip's Marina & Hideaway, Marathon, FL
Leda Dunmire, Pew Environmental Group
Dawn Ward, University of Florida, Gainesville, FL
Toby Kight, Marathon, FL
John Harrison, Marathon, FL
Gigi Harrison, Marathon, FL
Donald Beechum, Marathon, FL
Paul Lebo, Marathon, FL
Gene Trag, Marathon, FL
Capt. Don Muller
Richard Turner, Marathon, FL

SUMMARY MINUTES
PUBLIC HEARING – KEY WEST, FL
SPINY LOBSTER AMENDMENT 10
JOINT AMENDMENT FOR THE GULF OF MEXICO AND SOUTH ATLANTIC FISHERY MANAGEMENT COUNCILS

September 21, 2009

Attendance:
Bob Gill, Gulf Council
Dr. Gregg Waugh, SAFMC
Dr. Carrie Simmons, Gulf Council Staff
Phyllis Miranda, Gulf Council Staff

43 Members of the Public

The public hearing was convened by Chairman Bob Gill at 6:00 p.m. Dr. Carrie Simmons reviewed the PowerPoint presentation with the public. The public was then invited to provide their comments.

John Coffin, Big Pine Key, FL. He read into the record a written statement, which is attached. In summary, he said the spiny lobster fishery should be left to Florida FWC. They are vested in dealing with allocation issues and knowledgeable of the history of the fishery as well as the diverse groups of people competing in the fishery. He listed several positive and negative reasons for the Florida FWC to take over management of the fishery. He noted that the federal management system would have a lot do deal with as far as allocation issues in the fishery if management was not given to Florida FWC.

Jim Sharpe, Jr., Big Pine Key, FL. He read into the record a written statement which is attached. In summary, he felt that Florida FWC should have full and unrestricted management of the spiny lobster fishery, because 95% of the lobster fishery occurs in state waters. He added that the state has been studying and managing the lobster fishery for years and should continue managing the fishery. He noted that the state had received money to study casitas to see if it can be used as a viable commercial gear in a portion of the commercial fishery. He indicated that the state is also studying new trap designs to decrease wind driven trap movement.

George Niles, Florida Keys Commercial Fishermen's Association. He stated that he felt that the ACL for lobster should be set using the data from SEDAR. He added that the federal government should retain management of lobster, because the resources they had access to were of more value to the fishery than those that the state government had.

Bobby Pillar, Summerland Key, FL. He stated that he supported Mr. Niles' position with regard to lobster being federally managed as opposed to state managed. He felt that something needed to be done about lobster being imported from other countries into the states before lobster season actually opens. He noted that in agreement with spiny lobsters being landed all tailed or all whole, the tailing permit could be modified.

Peter Bacle, Stock Island Lobster Co. He stated that neither state nor federal would do a good job of managing spiny lobster. He recommended no action on splitting the recreational and charterboat sectors. He felt that the ACL should be set for the fisheries in which there is an identifiable catch, i.e. the commercial industry. He added that there was no way to identify amounts of recreational catch. He was in agreement that short mortality was not a problem, because shorts really have lower mortality inside the traps because it is safer than outside the traps. He believes that the tailing permit should be kept, and that it was not an issue because his fish house handles very few tailed lobsters.

Lee Starling, commercial diver and spear fisherman, Key West, FL. He felt that the Gulf Council should retain management of spiny lobster. He stated that he was against the use of casitas, because he felt that they do impact migration patterns. He wanted to note that all types of fisheries have bycatch or potentially unintended consequences on other species, even divers. He felt that short lobsters used as attractants can get out of the traps and that mortality is not a problem.

<u>Additional attendees who chose not to speak on Spiny Lobster</u>:
Billy Wickers III, Big Coppit Key, FL
Capt. Bill Wickers, Key West Charter Boat Assoc.
Richard Gomez, Capt. Conch, Key West, FL
Robert Nevius, charter boat captain
Daniel Padron, Key West, FL
Craig Jiovani, C&J Ent. Co. Inc. d/b/a Charter Boat Grand Slam
Brice Barr, Double Down Sportfishing
Mimi Stafford, Key West, FL
Rob Harris, Conchy Joe's Marine & Tackle
Steven Lamp, Dream Catcher Charters
Gennifer Lamp, Key West, FL
Ron Meyers, Little Torch Key, FL
David McKinney, Environmental Defense Fund
Michelle Owen, Environmental Defense Fund
Kari MacLauchlin, University of Florida
Marlin Scott, Keys Radio Group
Chuck Coleman, Key West, FL
Josh Nicklaus, Key West, FL
Juan Blanco, Key West, FL

Appendix G. Public Hearing Summary

SUMMARY OF THE PUBLIC HEARING ON
SPINY LOBSTER AMENDMENT 10
SAINT PETERSBURG BEACH, FLORIDA
MAY 9, 2011

<u>Council and Staff</u>
Ed Sapp
Carrie Simmons
Emily Muehlstein

6 members of the Public in Attendance

Dennis O'Hern, Fishing Rights Alliance, St. Petersburg, FL – He felt that the Councils should stop trying to set annual catch limits because it is in defiance of the Magnuson-Stevens Act to reduce the maximum sustainable yield to the annual catch limits and annual catch targets. He stated that he sent letters to NOAA legal counsel, Eric Schwaab, and Congress about his opinion that there is a problem with establishing annual catch limits. He added that this defiance of the Magnuson-Stevens Act also holds true for lobster and for finfish by setting an artificial limit on data poor fisheries that the Councils know nothing about. He also stated that, in a good lobster fishing year with good weather, the annual catch limit would get exceeded in the season and then the fishery would be penalized for it. He felt that the process for establishing annual catch limits for data poor species needed to be revised.

<u>Additional comments</u>
Mr. O'Hern stated that nobody was at this public hearing because he did not tell anyone to attend because it was not his job. He added that he did not tell anyone to attend because he felt that it was a waste of time based on the previous scoping meetings. He mentioned that last year the recreational sector told the Council they did not want catch shares or sector separation.

He felt that a 24-inch minimum size limit for gag should be instituted and that when annual catch limits are not met in a current year, that the underage be added to the following year's catch limit. He warned the Council that the laws are about to come tumbling down because Congress is paying attention and that the state Governors will recall some of the members of the Council due to their defiance of Congress and the Jones Amendment by using catch share money which should have been frozen.

He mentioned that the change in location of the Kenner, Louisiana and the Biloxi, Mississippi public hearings at such short notice was illegal and that no information was given about the cancelation of the Mackerel Amendment. He questioned why there was no press release that notified the public that the public hearing documents were ready and available.

Post Lobster Testimony – Informal Discussion

Some members of the public made suggestions about notifying the public for better involvement in the comment process by using the saltwater license information from the states. It was added that possibly all people with lobster stamps could be given some type of notice about upcoming public hearings. They also suggested that we send information to bait shops so it can be posted on the walls for upcoming meetings to get more public involvement and input. Some members complained that using public hearing venues near the beach was not a good area because it was not easily accessible to the general public. They also requested that we start the meetings at 6:30 p.m. so that more people could attend after the workday.

The meeting was adjourned at 7:45 p.m.

Others who attended but chose not to speak:

Libby Carnahan
Ira Pearson
Cheryl Pearson
Robert Aylesworth
Russell Arsenault

SUMMARY OF THE JOINT PUBLIC HEARINGS THE SOUTH ATLANTIC COUNCIL HOSTED ON SPINY LOBSTER AMENDMENT 10
APRIL 2011

Public Hearings: April 2011	
Location	# comments
New Bern, NC	1
N. Charleston, SC	0
Pooler, GA	1
Jacksonville, FL	1
Cape Canaveral, FL	3
Duck Key, FL	9
Key West, FL	14

Letters Received	11

Most Common Concerns for the Public
[mostly commercial trap fishermen in the Florida Keys]

1) Require gear markings on trap lines **[Action 10]**
- most commenters supported No Action, including representatives/members of Organized Fishermen of Florida (OFF) and the Florida Keys Commercial Fishermen's Association (FKCFA)
- replacing trap lines will be very costly for the trap fishermen, with few benefits for the turtles, corals, etc.
- certain colors may even attract turtles, which would create more problems
- if there has to be one color for all lobster trap lines, it should be black
- Bill Kelly (FKCFA) provided an estimate for cost of replacing all trap lines with a specific color at: $12.6 million to replace all trap lines, and loss of over $6 million in discarded rope.

2) Closed areas to protect Elkhorn and Staghorn coral **[Action 9]**
- most commenters supported No Action, including representatives/members of the Gulf Spiny Lobster Advisory Panel, Organized Fishermen of Florida (OFF), the Florida Keys Commercial Fishermen's Association (FKCFA), the Florida Keys Sanctuary Advisory Council, and the SAFMC Coral AP.
- fishermen and Sanctuary Council representatives did not feel they were adequately involved in the process of designating the areas
- industry should be involved, and can help identify more useful areas to close to protect the corals
- existing closed areas in the Keys and the limit on the number of lobster traps are sufficient in protecting Elkhorn and Staghorn corals

3) Modify Tailing Permits **[Action 8]**

- overall, comments are mixed on which alternatives would best address the problem of eliminating illegal harvest by some divers but keeping the tailing permit available for Keys trap fishermen who work in the Tortugas and other places, requiring multi-day trips.
- some supported eliminating all tailing permits (Alternative 2), including two AP members who submitted letters
- others supported the additional requirements to obtain a tailing permit (Pref Alt 3), such as boat size requirements and longer trips
- some commenters suggested limiting tailing permits to Monroe County only

4) Use of Shorts as Attractants [**Action 7]**

- most commenters supported Preferred Alternative 4 (50/boat and 1/trap) because it is consistent with Florida regulations; use of shorts make traps more efficient; using shorts as attractants does not harm the stock and has been a traditional method of fishing
- four commenters, including two South Atlantic lobster AP members, commented in support Alternative 2 (prohibition on shorts) due to high mortality and the potential spread of PaV1 in traps via shorts

5) ACL and ACT values [**Action 4]**

- most commenters felt that the ACL/ACT is set too low
- some commenters stated that the most recent season (2010-11) was already projected to exceed the ACT; the stock is considered healthy and the limits leave no room to grow
- some commenters felt that the Council should not set ACLs without adequate data and an accepted stock assessment, regardless of MSA requirements

Action 1: Remove species from the management unit.	
Public Hearings	- Few comments, but all in support of Preferred Alternative
Letters	- None

Action 2: Set MSY, Overfishing Threshold, Overfished Threshold	
Public Hearings	- Two in support of Preferred Alternative (OFL= 7.9 MP)
Letters	- None

Action 3: Sector Allocations	
Public Hearings	- None
Letters	- None

Action 4-1: ABC Control Rule	
Public Hearings	- One in support of Preferred Alternative
Letters	- None

Action 4-2: Set ACL.	
Public Hearings	- Some support for Preferred Alternative, but in general most suggested a higher ACL
Letters	- One in support of more conservative ACL (AP member)

Action 4-3: Set ACT
- Discussed in the first section, #5

Action 5: Set AMs	
Public Hearings	- One in support of AM
Letters	- None

Action 6: Update Framework Procedure and Protocol	
Public Hearings	- one in support of Preferred Alternative
Letters	- None

Action 7: Use of Shorts as Attractants [extended from #4 in the first section]	
Public Hearings	- most supported Preferred Alternative 4 - two supported Alternative 2 (no possession or use)
Letters	- two supporting Alternative 2 - three supported Preferred Alternative 4

Action 8: Modifying Tailing Permits [extended from #3 in the first section]	
Public Hearings	- mixed reactions from commenters - some commenters supported divers being allowed to have tailing permits, because divers are switching to multi-day trips to offset fuel costs - one commenter opposed Preferred Alternative 4 (all whole or all tails) because it limits flexibility for tailoring long trips for the market; another opposed because it would require lobsters caught at the end of a multi-day trip to be tailed for no reason - one commenter supported Preferred Alternative 4 because it eliminates a loophole for illegal harvest of shorts
Letters	- two commenters, including one AP member, supported Alternative 2 (eliminating tailing permits) due to enforcement problems and too many criteria that would be difficult to monitor

Action 9: Establish closed areas to protect Elkhorn and Staghorn corals [extended from #2 in the first section]	
Public Hearings	- most commenters want No Action, or this action removed from Amendment 10 and added to a future amendment to allow for a better process - some commenters brought up the impact of divers, anchors, etc. on the corals, none of which are addressed in this action - fishermen feel their input would be valuable in identifying better areas - one commenter felt that additional closed areas would result in crowding - one commenter felt that closed areas could not be enforced and would cause more problems
Letters	- one commenter supported prohibiting lobster traps in waters 30m or less - one commenter supported delayed action and more industry involvement - one commenter felt that existing closed areas were sufficient

Action 10: Require gear markings on trap lines [extended from #1 in the first section]	
Public Hearings	- most commenters want No Action or at least have the color be black - need to better evaluate effects of traps on protected species before implementing something so costly, without being sure of the benefits - one commenter suggested requiring just a spot of spray paint color to identify the lobster trap lines - one commenter suggested replacing all existing rope would generate unnecessary landfill waste
Letters	- one commenter supported color for trap lines

Action 11: Allow public to remove derelict lobster traps in the Florida EEZ	
Public Hearings	- few comments, mostly in support of Preferred Alternative
Letters	- one commenter supported Alternative 2 to allow public to remove any derelict traps

Additional Comments From Public Hearings and Letters

- One commenter felt that there was a disconnect between findings (minimal impact on protected species by lobster traps) in the Biological Opinion and the recommendations.
- Four letters recommended that: "all SAFMC council members should demand to see the PaV1 PowerPoint presentation by Mark Butler of Old Dominion University and see how the PaV1 virus is transmitted from lobster to lobster at the June 7th SAFMC meeting in Key West."
- Several commenters felt we need better science and stock assessments to make good decisions
- Two commenters raised the concern that the diving sector needed more regulations
- Two commenters felt that the State of Florida should take over management of spiny lobster

Appendix H. Maps Showing Known Locations and Conservation Priorities of *Acropora* spp. colonies in the Florida Keys.

This appendix includes 15 maps, similar to those seen in section 4. The maps in that section superimposed all proposed closed areas on top of one another in an attempt to conserve space and allow for a direct comparison of relative size. However, there was also some concern that those maps may not be entirely clear because of all the information provided. Therefore, these maps present the same information as the maps in section 4 with the exception that the large, medium, and small proposed area closures appear separately. Each map depicts the identified locations of *Acropora* spp. from 1996-2010; the location and size of the proposed closed area; the boundary between state and federal waters; known areas of hardbottom habitat; any areas currently closed to trapping for spiny lobster; along with any existing Florida Keys National Marine Sanctuary Management Areas. "*Acropora* Priority Sites" also appear on these maps. These areas represent locations requiring high priority response from individuals responding to an environmentally damaging event, such as an oil spill, because of the nature of the natural resources occurring there. These priority sites are included here only for reference and do not have any regulatory impact of fishing. The charts also show hardbottom areas that may support *Acropora* spp.*,* even if the presence of *Acropora* spp. has not been confirmed there. *Acropora* spp. is not anticipated in non-hardbottom habitat. Since *Acropora* spp. are only known to occur on hardbottom habitat and south of U.S. Highway 1, only the maps have been truncated to only show those areas. Some overlap exists between charts.

A list of coordinates for the proposed closed areas can be found after the maps.

Maps of Proposed Large Area Closures

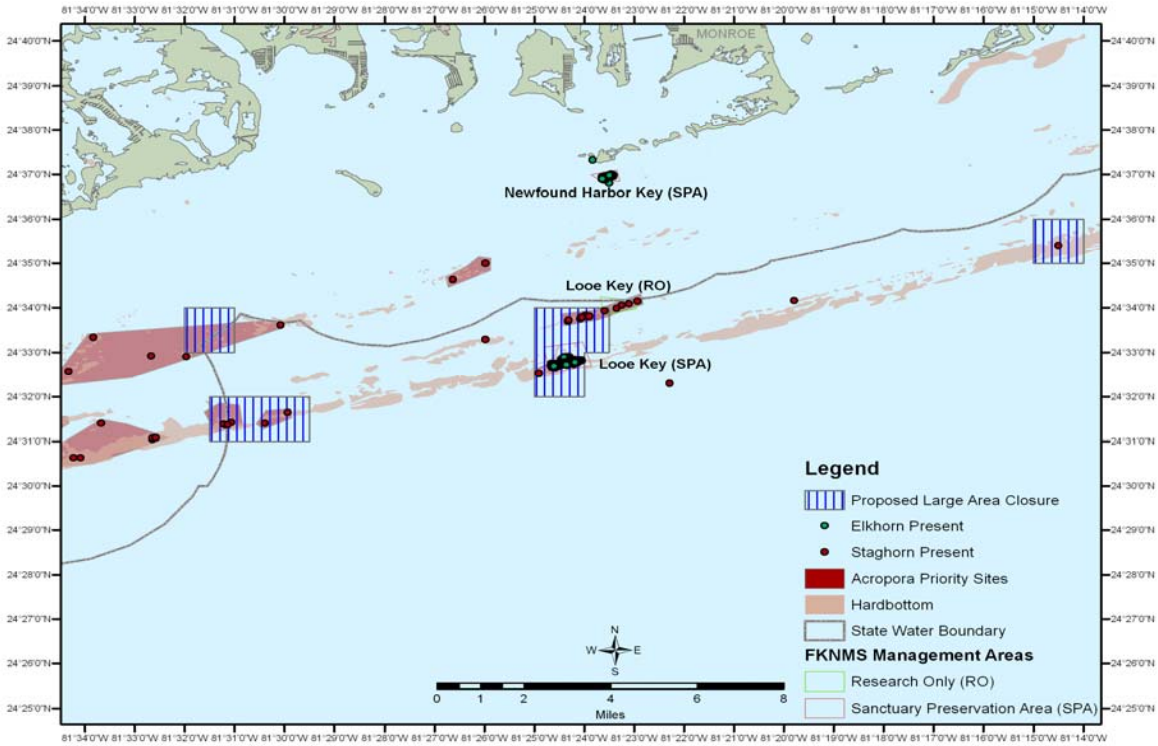

Figure 1 Proposed Large Area Closures in the Lower Keys

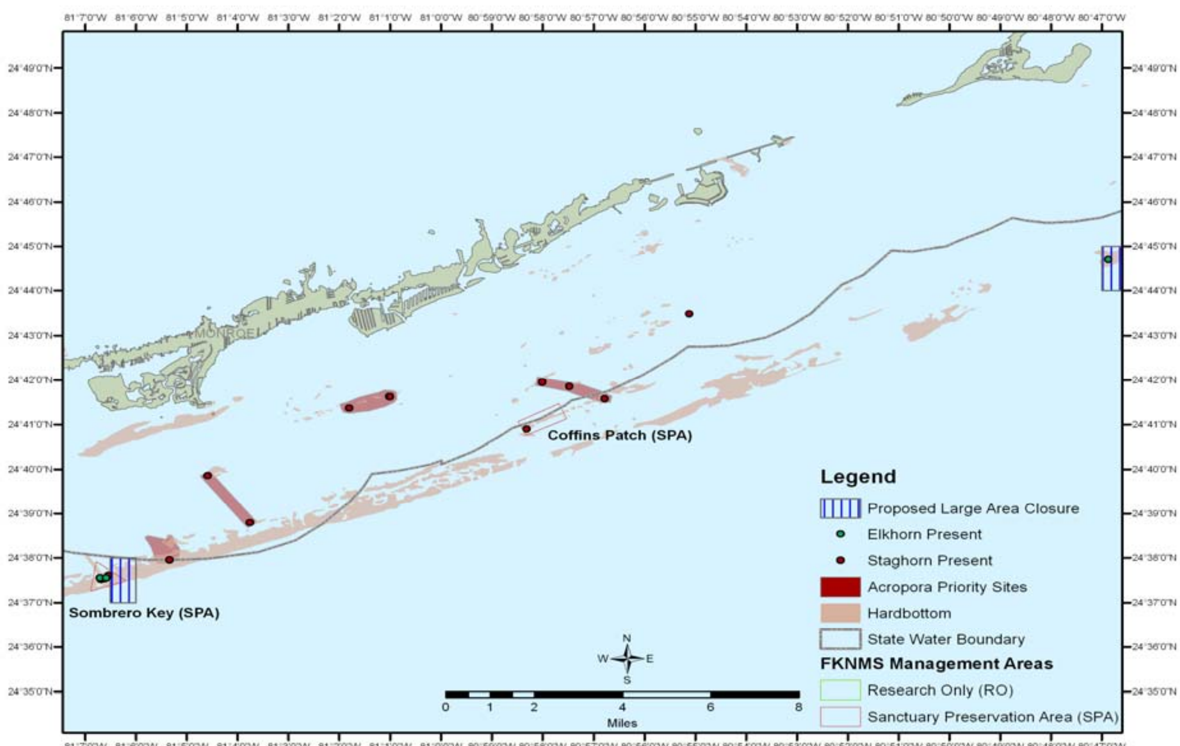

Figure 2 Proposed Large Area Closures in the Middle Keys

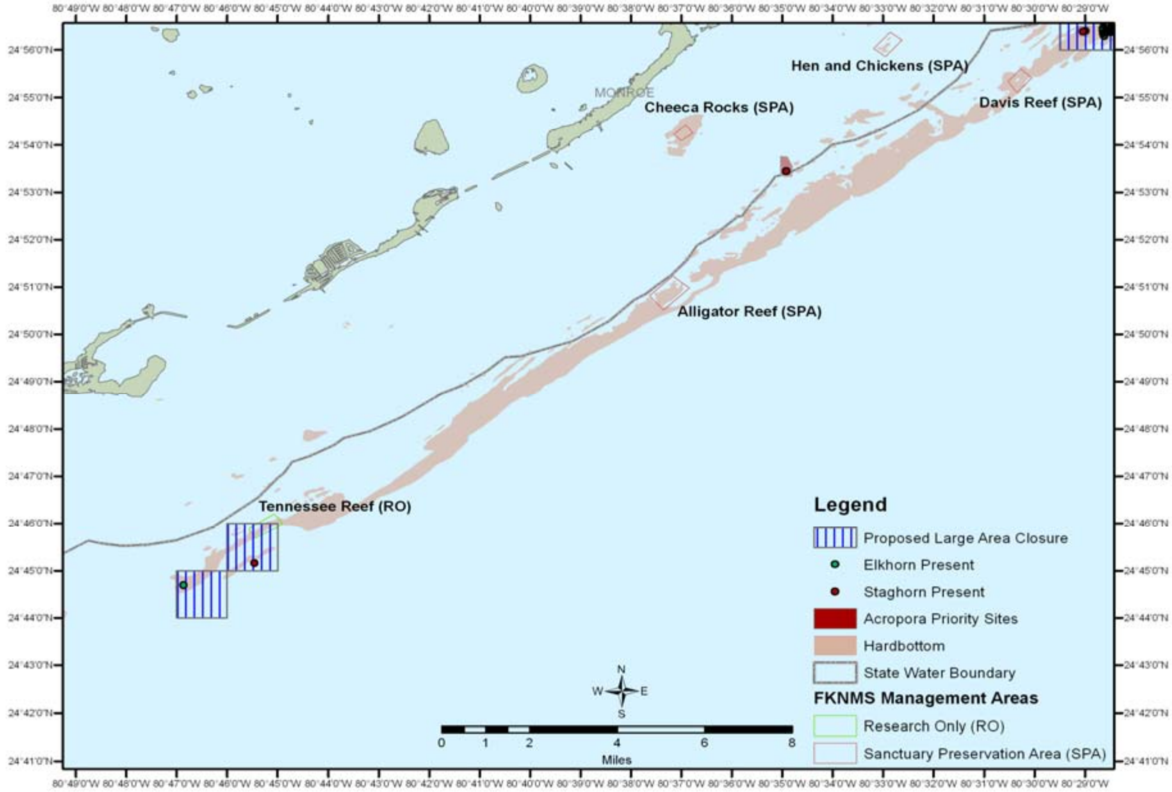

Figure 3 Proposed Large Area Closures in the Upper Keys

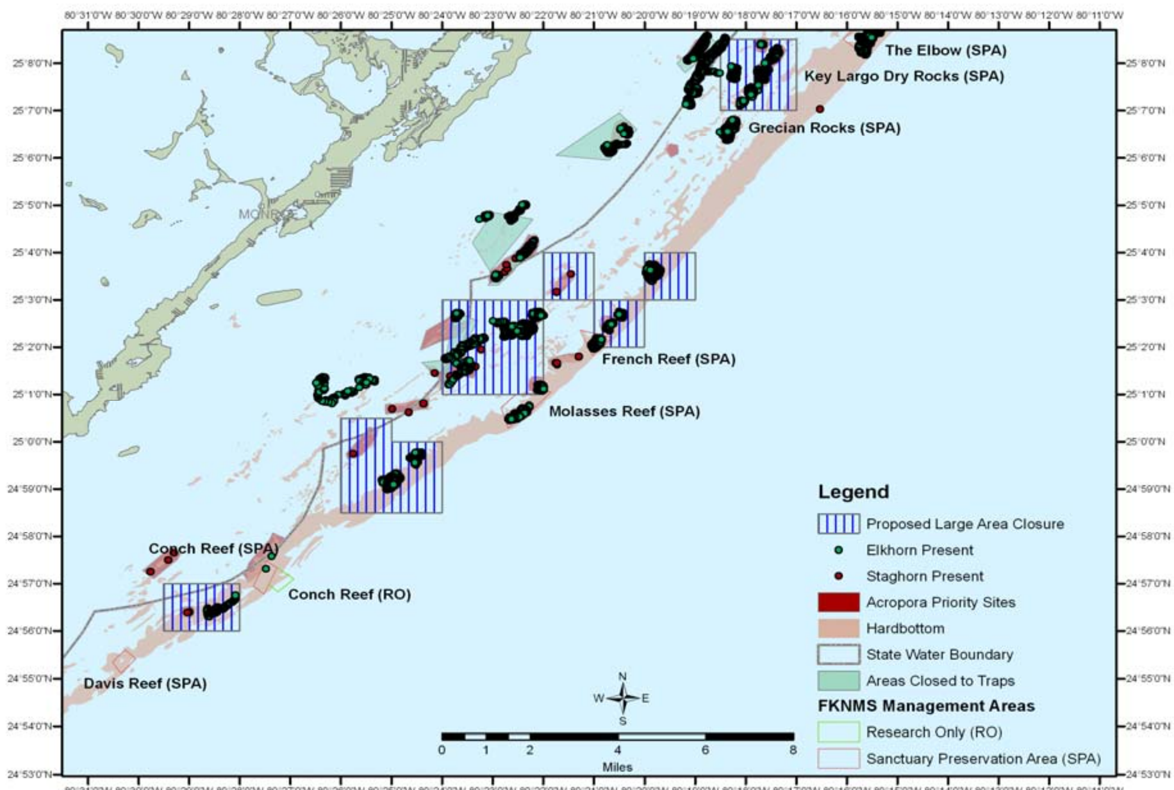

Figure 4 Proposed Large Area Closures in the Upper Keys (cont'd)

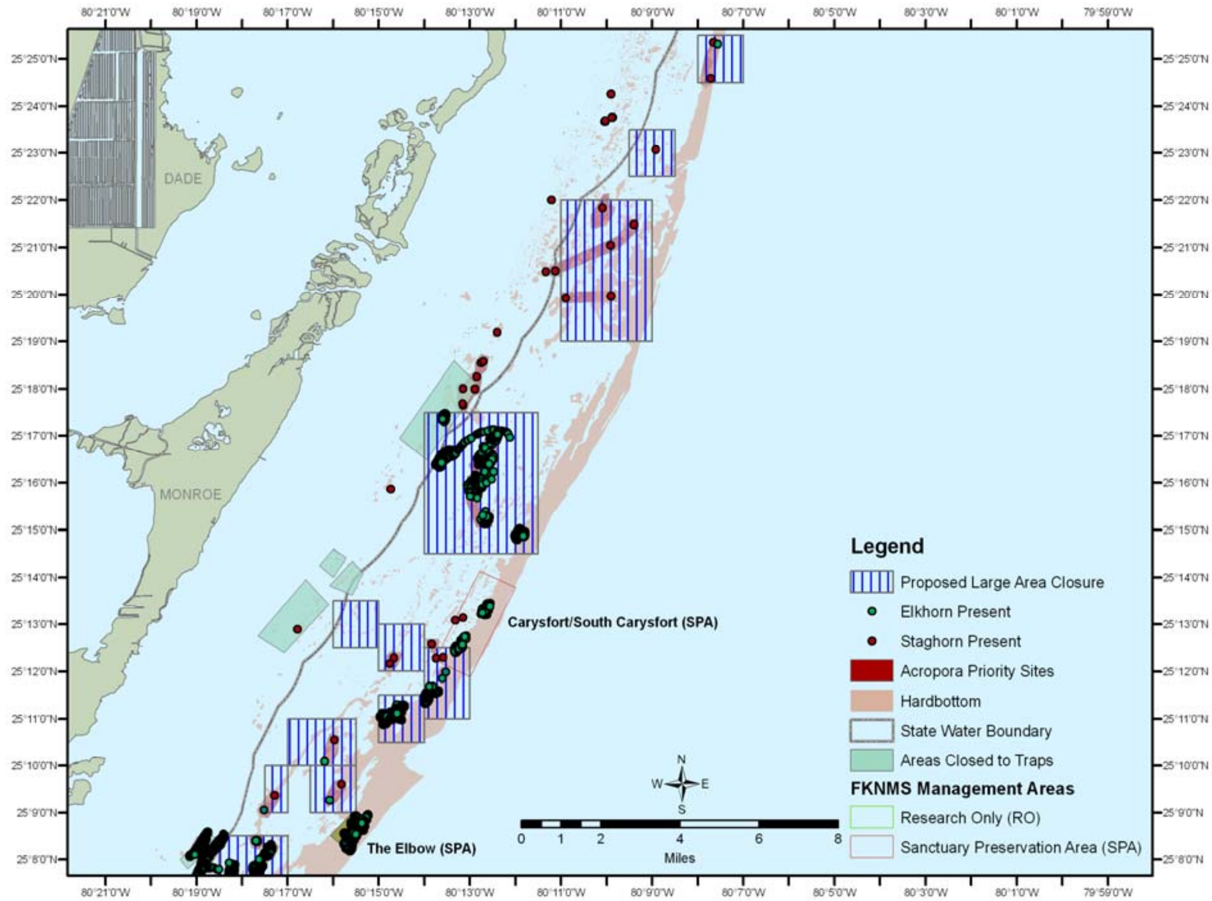

Figure 5 Proposed Large Area Closures in the Upper Keys (cont'd)

Maps of Proposed Medium Area Closures

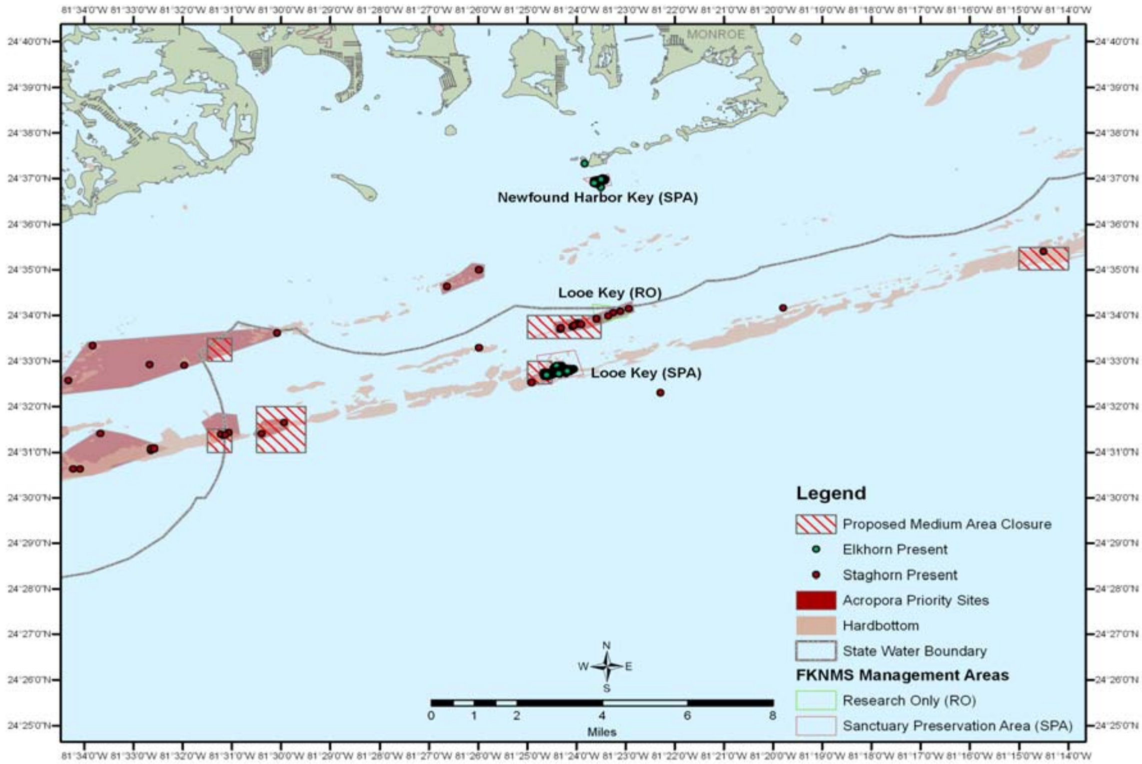

Figure 6 Proposed Medium Area Closures in the Lower Keys

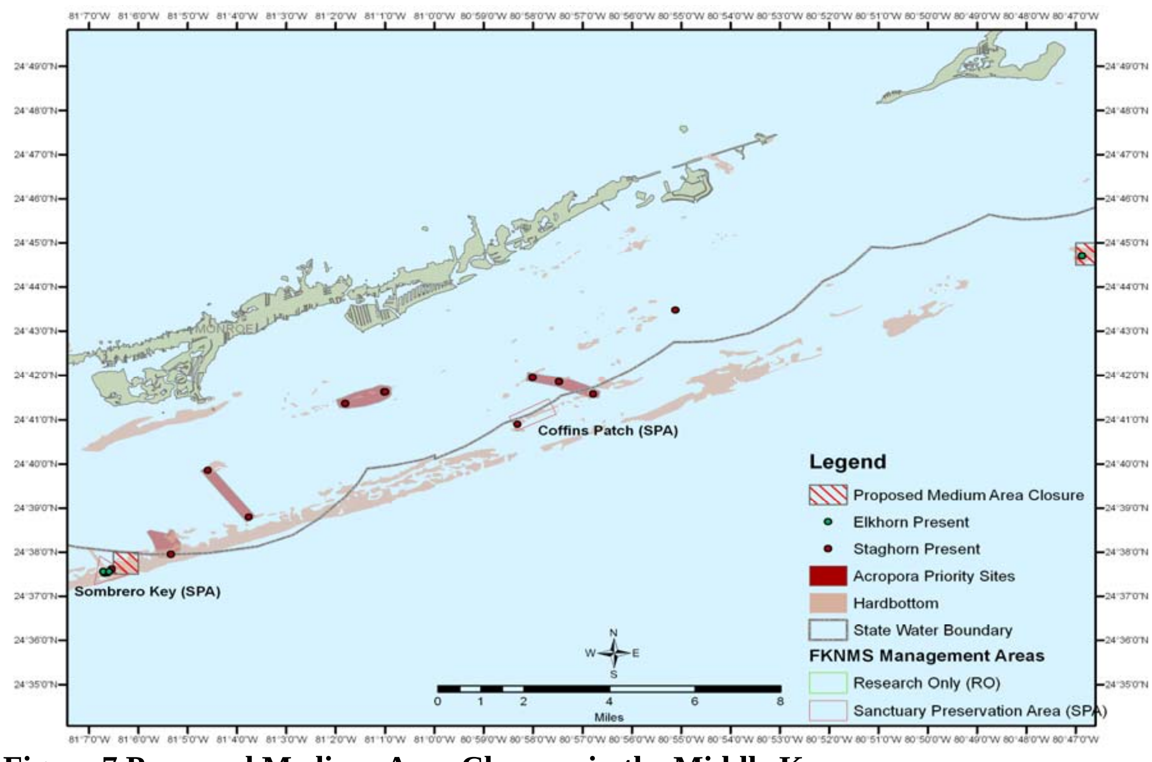

Figure 7 Proposed Medium Area Closures in the Middle Keys

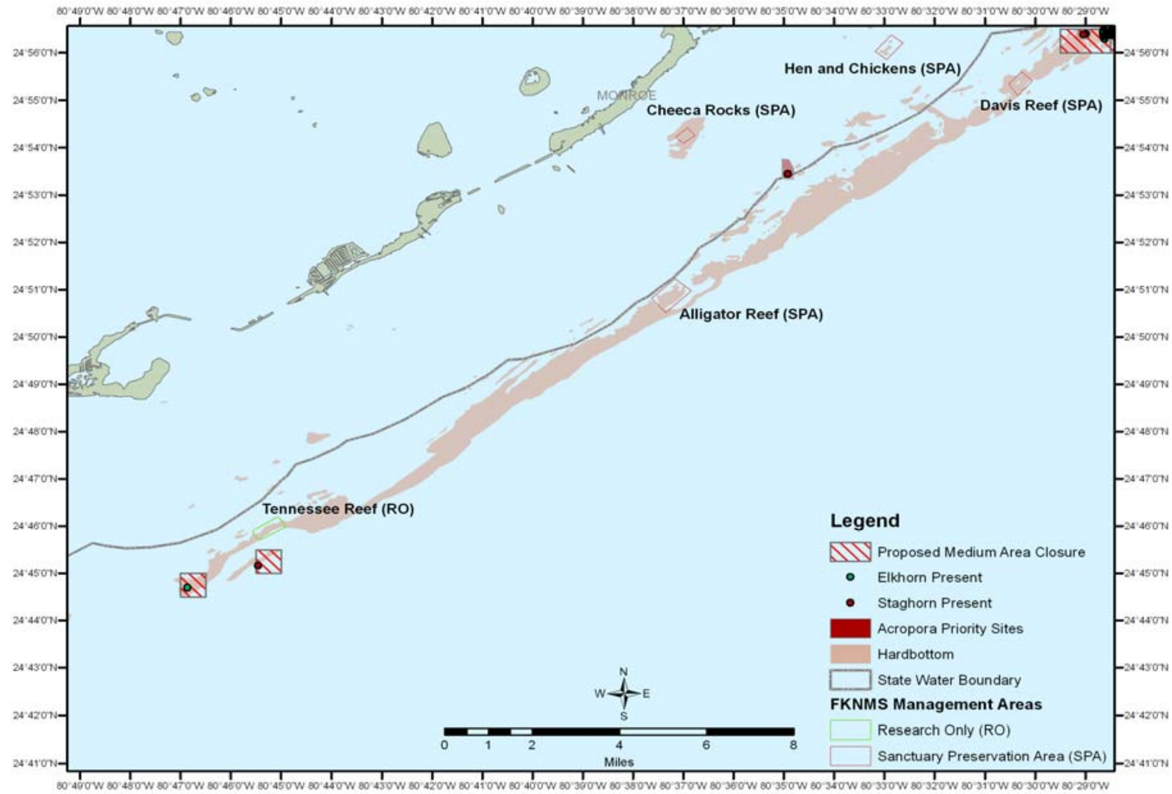

Figure 8 Proposed Medium Area Closures in the Upper Keys

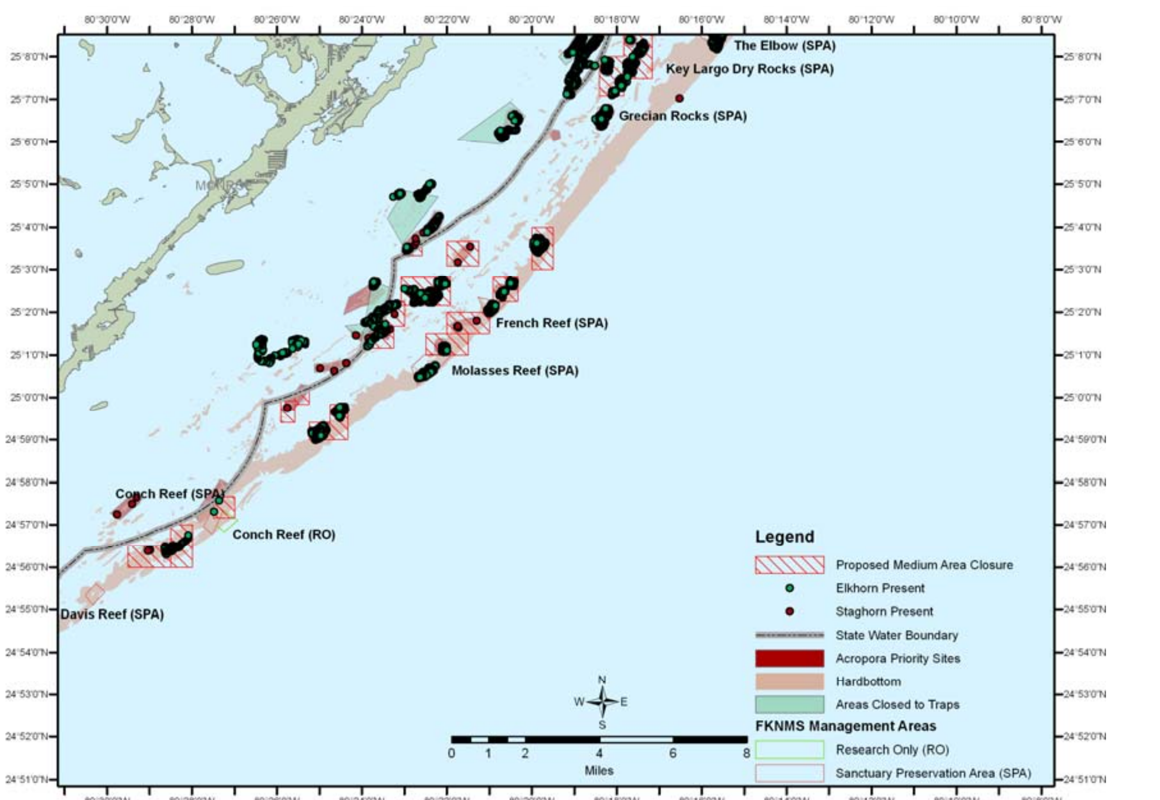

Figure 9 Proposed Medium Area Closures in the Upper Keys (cont'd)

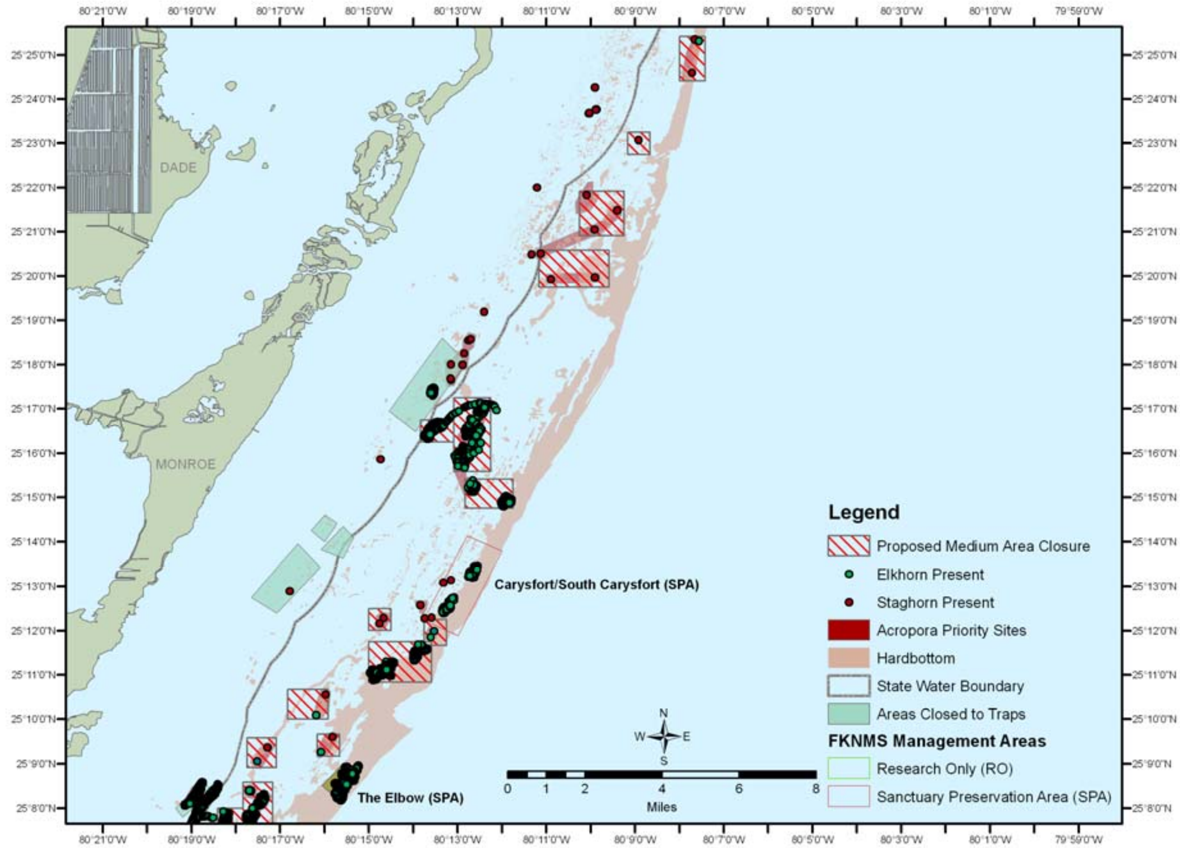

Figure 10 Proposed Medium Area Closures in the Upper Keys (cont'd)

Maps of Proposed Small Area Closures

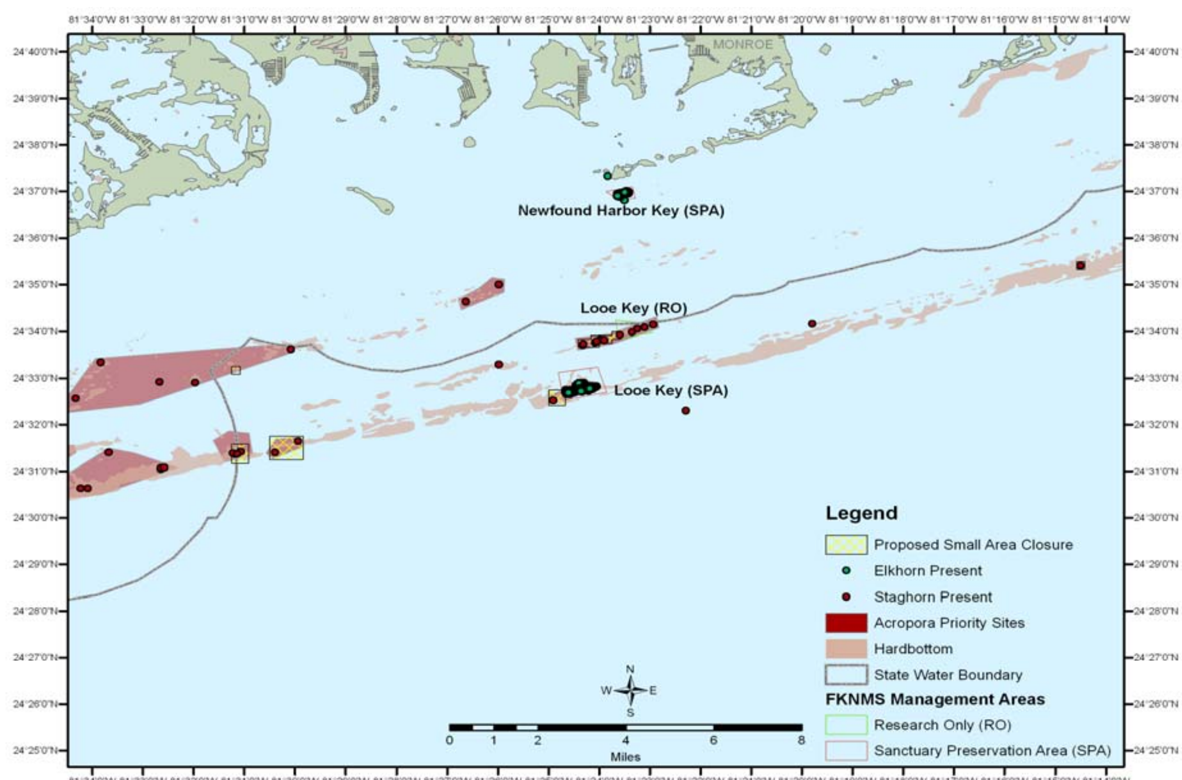

Figure 11 Proposed Small Area Closures in the Lower Keys

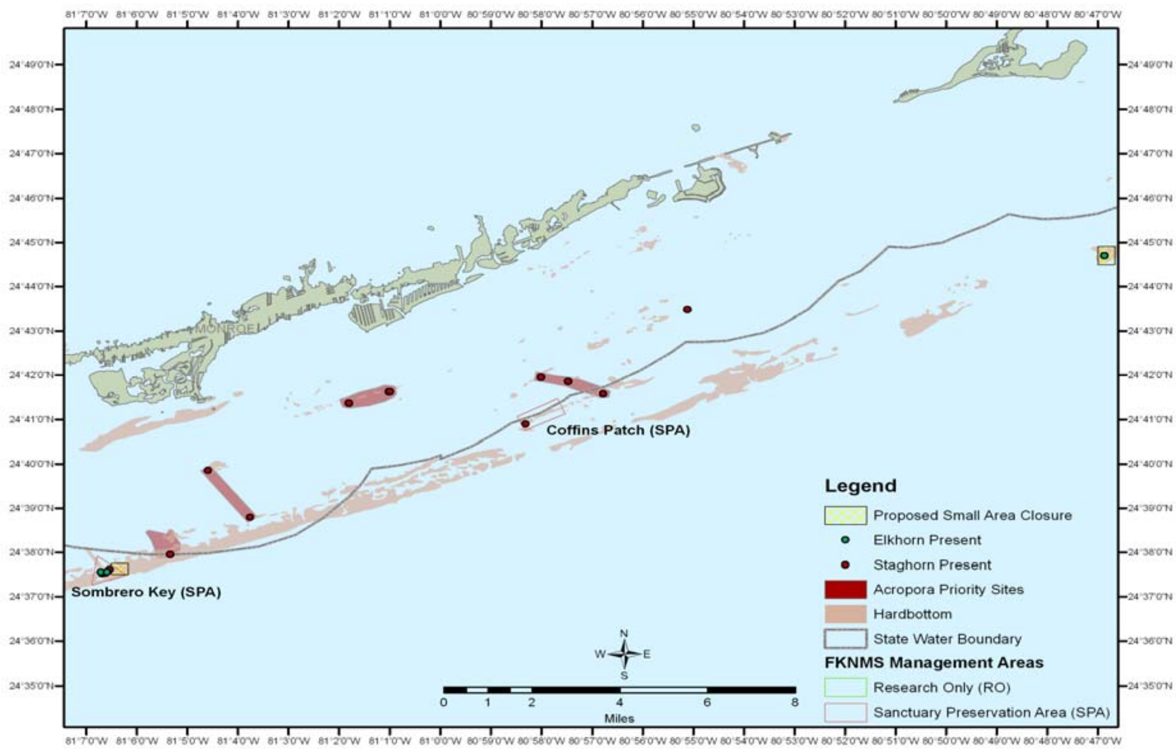

Figure 12 Proposed Small Area Closures in the Middle Keys

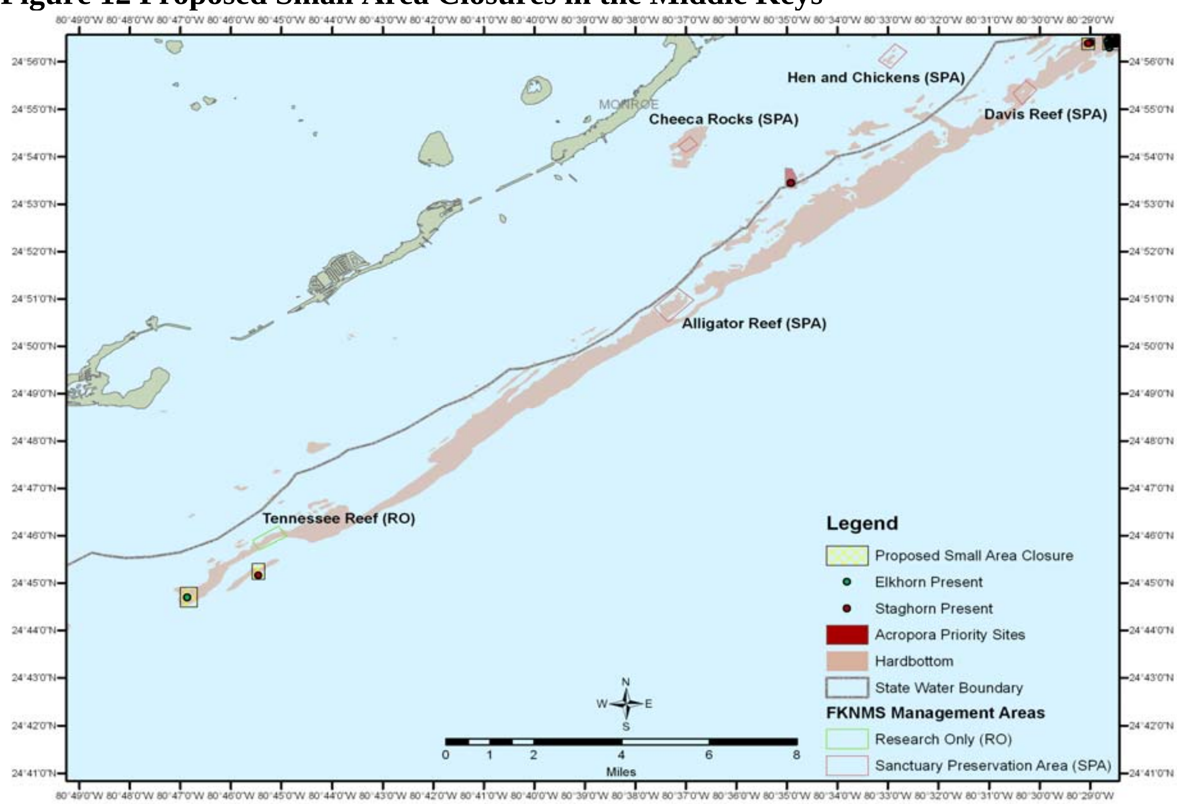

Figure 13 Proposed Small Area Closures in the Upper Keys

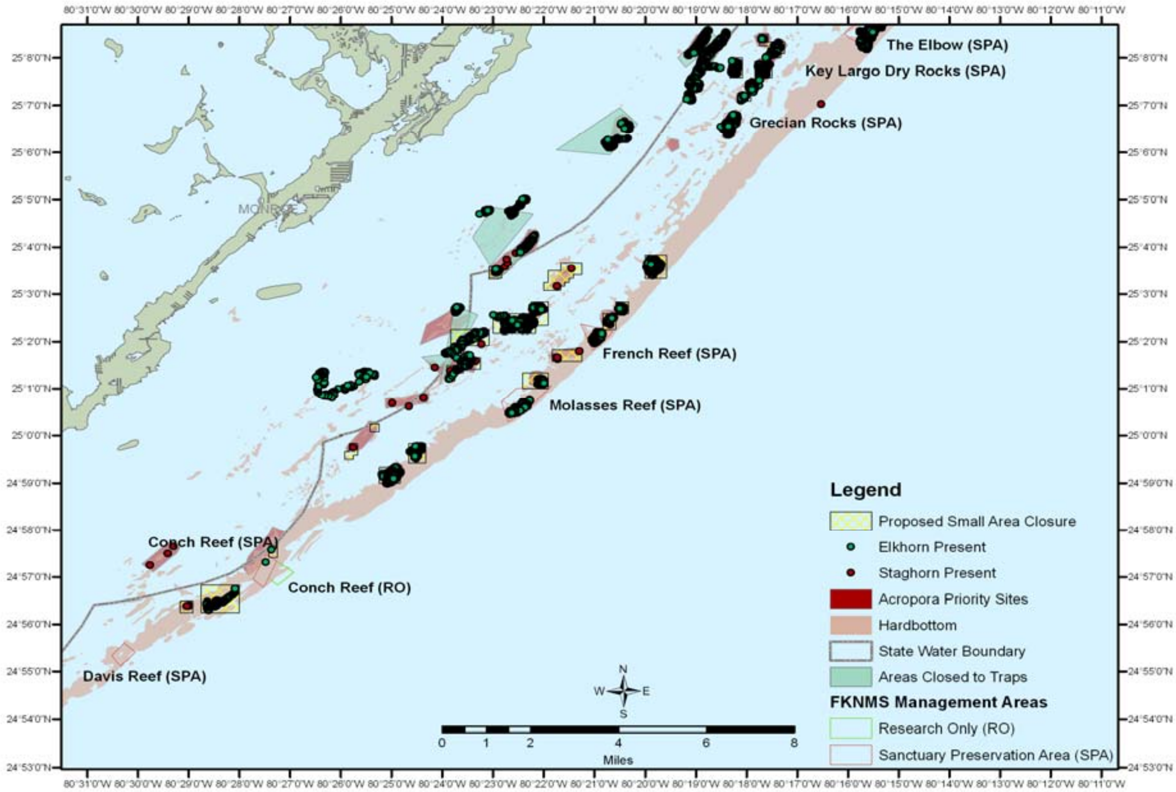

Figure 14 Proposed Small Area Closures in the Upper Keys (cont'd)

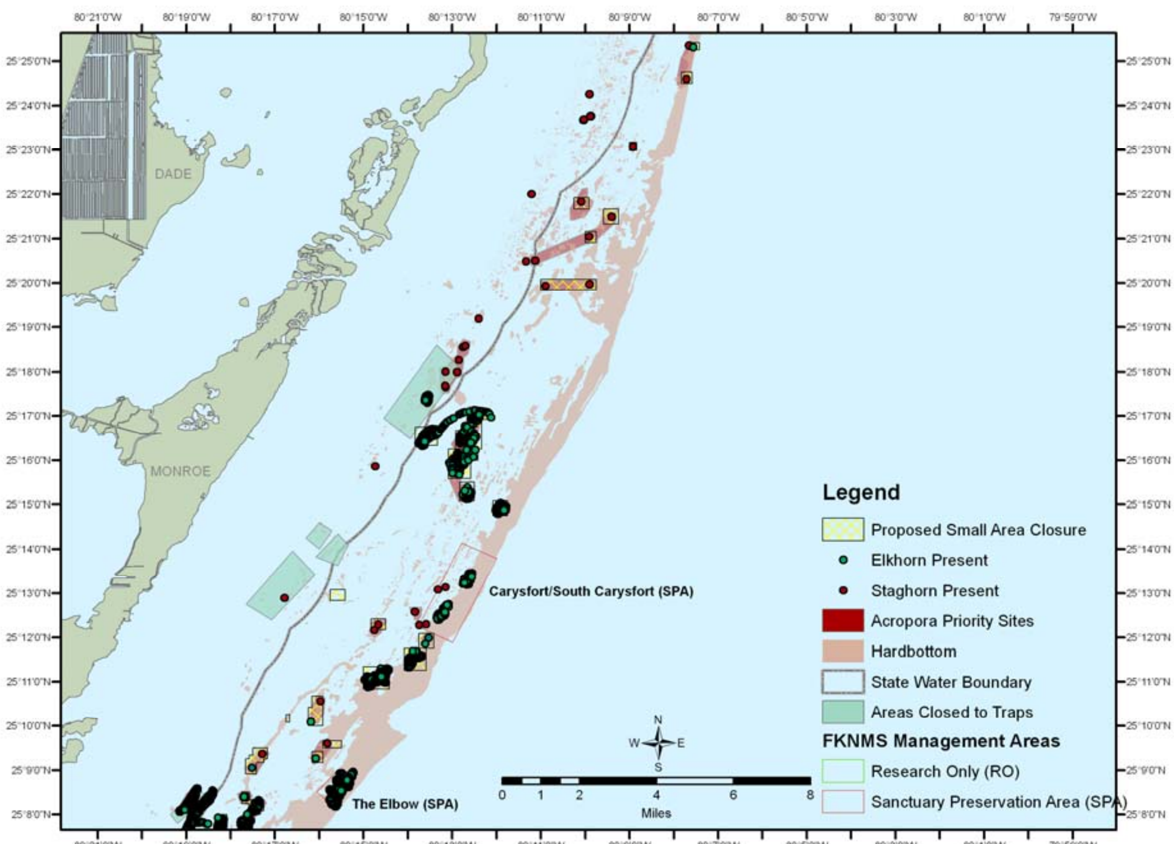

Figure 15 Proposed Small Area Closures in the Upper Keys (cont'd)

Table 1. Coordinates for Proposed Large Area Closures

Lobster Large Area 1		
Point	North Lat.	West Long.
A	24°34'0"	81°32'0"
B	24°34'0"	81°31'0"
C	24°33'0"	81°31'0"
D	24°33'0"	81°32'0"
A	24°34'0"	81°32'0"
Lobster Large Area 2		
Point	North Lat.	West Long.
A	24°32'0"	81°31'30"
B	24°32'0"	81°29'30"
C	24°31'0"	81°29'30"
D	24°31'0"	81°31'30"
A	24°32'0"	81°31'30"
Lobster Large Area 3		
Point	North Lat.	West Long.
A	24°34'0"	81°25'0"
B	24°34'0"	81°23'30"
C	24°33'0"	81°23'30"
D	24°33'0"	81°24'0"
E	24°32'0"	81°24'0"
F	24°32'0"	81°25'0"
A	24°34'0"	81°25'0"
Lobster Large Area 4		
Point	North Lat.	West Long.
A	24°36'0"	81°15'0"
B	24°36'0"	81°14'0"
C	24°35'0"	81°14'0"
D	24°35'0"	81°15'0"
A	24°36'0"	81°15'0"
Lobster Large Area 5		
Point	North Lat.	West Long.
A	24°38'0"	81°6'30"
B	24°38'0"	81°6'0"
C	24°37'0"	81°6'0"
D	24°37'0"	81°6'30"
A	24°38'0"	81°6'30"

Lobster Large Area 6		
Point	North Lat.	West Long.
A	24°45'0"	80°47'0"
B	24°45'0"	80°46'0"
C	24°46'0"	80°46'0"
D	24°46'0"	80°45'0"
E	24°45'0"	80°45'0"
F	24°45'0"	80°46'0"
G	24°44'0"	80°46'0"
H	24°44'0"	80°47'0"
A	24°45'0"	80°47'0"
Lobster Large Area 7		
Point	North Lat.	West Long.
A	24°57'0"	80°29'30"
B	24°57'0"	80°28'0"
C	24°56'0"	80°28'0"
D	24°56'0"	80°29'30"
A	24°57'0"	80°29'30"
Lobster Large Area 8		
Point	North Lat.	West Long.
A	25°0'30"	80°26'0"
B	25°0'30"	80°25'0"
C	25°0'0"	80°25'0"
D	25°0'0"	80°24'0"
E	24°58'30"	80°24'0"
F	24°58'30"	80°26'0"
A	25°0'30"	80°26'0"
Lobster Large Area 9		
Point	North Lat.	West Long.
A	25°3'0"	80°24'0"
B	25°3'0"	80°22'0"
C	25°1'0"	80°22'0"
D	25°1'0"	80°24'0"
A	25°3'0"	80°24'0"

Lobster Large Area 10		
Point	North Lat.	West Long.
A	25°4'0"	80°22'0"
B	25°4'0"	80°21'0"
C	25°3'0"	80°21'0"
D	25°3'0"	80°22'0"
A	25°4'0"	80°22'0"
Lobster Large Area 11		
Point	North Lat.	West Long.
A	25°3'0"	80°21'0"
B	25°3'0"	80°20'0"
C	25°2'0"	80°20'0"
D	25°2'0"	80°21'0"
A	25°3'0"	80°21'0"
Lobster Large Area 12		
Point	North Lat.	West Long.
A	25°4'0"	80°20'0"
B	25°4'0"	80°19'0"
C	25°3'0"	80°19'0"
D	25°3'0"	80°20'0"
A	25°4'0"	80°20'0"
Lobster Large Area 13		
Point	North Lat.	West Long.
A	25°8'30"	80°18'30"
B	25°8'30"	80°17'0"
C	25°7'0"	80°17'0"
D	25°7'0"	80°18'30"
A	25°8'30"	80°18'30"
Lobster Large Area 14		
Point	North Lat.	West Long.
A	25°10'0"	80°17'30"
B	25°10'0"	80°17'0"
C	25°9'0"	80°17'0"
D	25°9'0"	80°17'30"
A	25°10'0"	80°17'30"

Lobster Large Area 15		
Point	North Lat.	West Long.
A	25°10'0"	80°16'30"
B	25°10'0"	80°15'30"
C	25°9'0"	80°15'30"
D	25°9'0"	80°16'30"
A	25°10'0"	80°16'30"
Lobster Large Area 16		
Point	North Lat.	West Long.
A	25°11'0"	80°17'0"
B	25°11'0"	80°15'30"
C	25°10'0"	80°15'30"
D	25°10'0"	80°17'0"
A	25°11'0"	80°17'0"
Lobster Large Area 17		
Point	North Lat.	West Long.
A	25°13'30"	80°16'0"
B	25°13'30"	80°15'0"
C	25°12'30"	80°15'0"
D	25°12'30"	80°16'0"
A	25°13'30"	80°16'0"
Lobster Large Area 18		
Point	North Lat.	West Long.
A	25°11'30"	80°15'0"
B	25°11'30"	80°14'0"
C	25°10'30"	80°14'0"
D	25°10'30"	80°15'0"
A	25°11'30"	80°15'0"
Lobster Large Area 19		
Point	North Lat.	West Long.
A	25°13'0"	80°15'0"
B	25°13'0"	80°14'0"
C	25°12'0"	80°14'0"
D	25°12'0"	80°15'0"
A	25°13'0"	80°15'0"

Lobster Large Area 20		
Point	North Lat.	West Long.
A	25°12'30"	80°14'0"
B	25°12'30"	80°13'0"
C	25°11'0"	80°13'0"
D	25°11'0"	80°14'0"
A	25°12'30"	80°14'0"
Lobster Large Area 21		
Point	North Lat.	West Long.
A	25°17'30"	80°14'0"
B	25°17'30"	80°11'30"
C	25°14'30"	80°11'30"
D	25°14'30"	80°14'0"
A	25°17'30"	80°14'0"
Lobster Large Area 22		
Point	North Lat.	West Long.
A	25°22'0"	80°11'0"
B	25°22'0"	80°9'0"
C	25°19'0"	80°9'0"
D	25°19'0"	80°11'0"
A	25°22'0"	80°11'0"
Lobster Large Area 23		
Point	North Lat.	West Long.
A	25°23'30"	80°9'30"
B	25°23'30"	80°8'30"
C	25°22'30"	80°8'30"
D	25°22'30"	80°9'30"
A	25°23'30"	80°9'30"
Lobster Large Area 24		
Point	North Lat.	West Long.
A	25°25'30"	80°8'0"
B	25°25'30"	80°7'0"
C	25°24'30"	80°7'0"
D	25°24'30"	80°8'0"
A	25°25'30"	80°8'0"

Table 2. Coordinates of Proposed Medium Area Closures

Lobster Medium Area 1		
Point	North Lat.	West Long.
A	24°33'30"	81°31'30"
B	24°33'30"	81°31'0"
C	24°33'0"	81°31'0"
D	24°33'0"	81°31'30"
A	24°33'30"	81°31'30"
Lobster Medium Area 2		
Point	North Lat.	West Long.
A	24°31'30"	81°31'30"
B	24°31'30"	81°31'0"
C	24°31'0"	81°31'0"
D	24°31'0"	81°31'30"
A	24°31'30"	81°31'30"
Lobster Medium Area 3		
Point	North Lat.	West Long.
A	24°32'0"	81°30'30"
B	24°32'0"	81°29'30"
C	24°31'0"	81°29'30"
D	24°31'0"	81°30'30"
A	24°32'0"	81°30'30"
Lobster Medium Area 4		
Point	North Lat.	West Long.
A	24°34'0"	81°25'0"
B	24°34'0"	81°23'30"
C	24°33'30"	81°23'30"
D	24°33'30"	81°25'0"
A	24°34'0"	81°25'0"
Lobster Medium Area 5		
Point	North Lat.	West Long.
A	24°33'0"	81°25'0"
B	24°33'0"	81°24'30"
C	24°32'30"	81°24'30"
D	24°32'30"	81°25'0"
A	24°33'0"	81°25'0"

Lobster Medium Area 6		
Point	North Lat.	West Long.
A	24°35'30"	81°15'0"
B	24°35'30"	81°14'0"
C	24°35'0"	81°14'0"
D	24°35'0"	81°15'0"
A	24°35'30"	81°15'0"
Lobster Medium Area 7		
Point	North Lat.	West Long.
A	24°38'0"	81°6'30"
B	24°38'0"	81°6'0"
C	24°37'30"	81°6'0"
D	24°37'30"	81°6'30"
A	24°38'0"	81°6'30"
Lobster Medium Area 8		
Point	North Lat.	West Long.
A	24°45'0"	80°47'0"
B	24°45'0"	80°46'30"
C	24°44'30"	80°46'30"
D	24°44'30"	80°47'0"
A	24°45'0"	80°47'0"
Lobster Medium Area 9		
Point	North Lat.	West Long.
A	24°45'30"	80°45'30"
B	24°45'30"	80°45'0"
C	24°45'0"	80°45'0"
D	24°45'0"	80°45'30"
A	24°45'30"	80°45'30"
Lobster Medium Area 10		
Point	North Lat.	West Long.
A	24°56'30"	80°29'30"
B	24°56'30"	80°28'30"
C	24°56'0"	80°28'30"
D	24°56'0"	80°29'30"
A	24°56'30"	80°29'30"

Lobster Medium Area 11		
Point	North Lat.	West Long.
A	24°57'0"	80°28'30"
B	24°57'0"	80°28'0"
C	24°56'0"	80°28'0"
D	24°56'0"	80°28'30"
A	24°57'0"	80°28'30"
Lobster Medium Area 12		
Point	North Lat.	West Long.
A	24°57'40"	80°27'30"
B	24°57'40"	80°27'0"
C	24°57'10"	80°27'0"
D	24°57'10"	80°27'30"
A	24°57'40"	80°27'30"
Lobster Medium Area 13		
Point	North Lat.	West Long.
A	24°59'41"	80°25'55"
B	24°59'55"	80°25'55"
C	24°59'55"	80°25'35"
D	25°0'15"	80°25'35"
E	25°0'15"	80°25'15"
F	24°59'50"	80°25'15"
G	24°59'50"	80°25'35"
H	24°59'25"	80°25'35"
I	24°59'25"	80°25'55"
A	24°59'41"	80°25'55"
Lobster Medium Area 14		
Point	North Lat.	West Long.
A	24°59'25"	80°25'15"
B	24°59'25"	80°24'45"
C	24°59'50"	80°24'45"
D	24°59'50"	80°24'20"
E	24°59'0"	80°24'20"
F	24°59'0"	80°25'15"
A	24°59'25"	80°25'15"

Lobster Medium Area 15		
Point	North Lat.	West Long.
A	25°2'15"	80°24'0"
B	25°2'15"	80°23'0"
C	25°1'40"	80°23'0"
D	25°1'40"	80°24'0"
A	25°2'15"	80°24'0"
Lobster Medium Area 16		
Point	North Lat.	West Long.
A	25°1'40"	80°23'55"
B	25°1'40"	80°23'15"
C	25°1'10"	80°23'15"
D	25°1'10"	80°23'55"
A	25°1'40"	80°23'55"
Lobster Medium Area 17		
Point	North Lat.	West Long.
A	25°2'50"	80°23'5"
B	25°2'50"	80°21'55"
C	25°2'10"	80°21'55"
D	25°2'10"	80°23'5"
A	25°2'50"	80°23'5"
Lobster Medium Area 18		
Point	North Lat.	West Long.
A	25°3'50"	80°23'5"
B	25°3'50"	80°22'35"
C	25°3'20"	80°22'35"
D	25°3'20"	80°23'5"
A	25°3'50"	80°23'5"
Lobster Medium Area 19		
Point	North Lat.	West Long.
A	25°3'40"	80°22'0"
B	25°3'40"	80°21'15"
C	25°3'5"	80°21'15"
D	25°3'5"	80°22'0"
A	25°3'40"	80°22'0"

Lobster Medium Area 20		
Point	North Lat.	West Long.
A	25°1'30"	80°22'30"
B	25°1'30"	80°21'30"
C	25°1'0"	80°21'30"
D	25°1'0"	80°22'30"
A	25°1'30"	80°22'30"
Lobster Medium Area 21		
Point	North Lat.	West Long.
A	25°2'0"	80°22'0"
B	25°2'0"	80°21'0"
C	25°1'30"	80°21'0"
D	25°1'30"	80°22'0"
A	25°2'0"	80°22'0"
Lobster Medium Area 22		
Point	North Lat.	West Long.
A	25°2'50"	80°20'55"
B	25°2'50"	80°20'20"
C	25°2'15"	80°20'20"
D	25°2'15"	80°20'55"
A	25°2'50"	80°20'55"
Lobster Medium Area 23		
Point	North Lat.	West Long.
A	25°4'0"	80°20'0"
B	25°4'0"	80°19'30"
C	25°3'0"	80°19'30"
D	25°3'0"	80°20'0"
A	25°4'0"	80°20'0"
Lobster Medium Area 24		
Point	North Lat.	West Long.
A	25°8'0"	80°18'25"
B	25°8'0"	80°17'50"
C	25°8'35"	80°17'50"
D	25°8'35"	80°17'10"
E	25°7'30"	80°17'10"
F	25°7'30"	80°17'50"
G	25°7'5"	80°17'50"
H	25°7'5"	80°18'25"
I	25°7'30"	80°18'25"
A	25°8'0"	80°18'25"

Lobster Medium Area 25		
Point	North Lat.	West Long.
A	25°9'35"	80°17'45"
B	25°9'35"	80°17'5"
C	25°8'55"	80°17'5"
D	25°8'55"	80°17'45"
A	25°9'35"	80°17'45"
Lobster Medium Area 26		
Point	North Lat.	West Long.
A	25°9'40"	80°16'10"
B	25°9'40"	80°15'40"
C	25°9'10"	80°15'40"
D	25°9'10"	80°16'10"
A	25°9'40"	80°16'10"
Lobster Medium Area 27		
Point	North Lat.	West Long.
A	25°10'40"	80°16'50"
B	25°10'40"	80°15'55"
C	25°10'0"	80°15'55"
D	25°10'0"	80°16'50"
A	25°10'40"	80°16'50"
Lobster Medium Area 28		
Point	North Lat.	West Long.
A	25°12'30"	80°15'0"
B	25°12'30"	80°14'30"
C	25°12'0"	80°14'30"
D	25°12'0"	80°15'0"
A	25°12'30"	80°15'0"
Lobster Medium Area 29		
Point	North Lat.	West Long.
A	25°11'45"	80°15'0"
B	25°11'45"	80°13'35"
C	25°10'50"	80°13'35"
D	25°10'50"	80°15'0"
A	25°11'45"	80°15'0"

Lobster Medium Area 30		
Point	North Lat.	West Long.
A	25°12'15"	80°13'45"
B	25°12'15"	80°13'15"
C	25°11'40"	80°13'15"
D	25°11'40"	80°13'45"
A	25°12'15"	80°13'45"
Lobster Medium Area 31		
Point	North Lat.	West Long.
A	25°16'45"	80°13'50"
B	25°16'45"	80°13'5"
C	25°16'15"	80°13'5"
D	25°16'15"	80°13'50"
A	25°16'45"	80°13'50"
Lobster Medium Area 32		
Point	North Lat.	West Long.
A	25°17'15"	80°13'5"
B	25°17'15"	80°12'15"
C	25°15'35"	80°12'15"
D	25°15'35"	80°13'5"
A	25°17'15"	80°13'5"
Lobster Medium Area 33		
Point	North Lat.	West Long.
A	25°15'25"	80°12'50"
B	25°15'25"	80°11'45"
C	25°14'45"	80°11'45"
D	25°14'45"	80°12'50"
A	25°15'25"	80°12'50"
Lobster Medium Area 34		
Point	North Lat.	West Long.
A	25°20'35"	80°11'10"
B	25°20'35"	80°9'35"
C	25°19'45"	80°9'35"
D	25°19'45"	80°11'10"
A	25°20'35"	80°11'10"

Lobster Medium Area 35		
Point	North Lat.	West Long.
A	25°21'55"	80°10'15"
B	25°21'55"	80°9'15"
C	25°20'55"	80°9'15"
D	25°20'55"	80°10'15"
A	25°21'55"	80°10'15"
Lobster Medium Area 36		
Point	North Lat.	West Long.
A	25°23'15"	80°9'10"
B	25°23'15"	80°8'40"
C	25°22'45"	80°8'40"
D	25°22'45"	80°9'10"
A	25°23'15"	80°9'10"
Lobster Medium Area 37		
Point	North Lat.	West Long.
A	25°25'25"	80°8'0"
B	25°25'25"	80°7'25"
C	25°24'25"	80°7'25"
D	25°24'25"	80°8'0"
A	25°25'25"	80°8'0"

Table 3. Coordinates of Proposed Small Area Closures

Lobster Small Area 1		
Point	North Lat.	West Long.
A	24°33'15"	81°31'15"
B	24°33'15"	81°31'5"
C	24°33'5"	81°31'5"
D	24°33'5"	81°31'15"
A	24°33'15"	81°31'15"
Lobster Small Area 2		
Point	North Lat.	West Long.
A	24°31'35"	81°31'15"
B	24°31'35"	81°30'55"
C	24°31'10"	81°30'55"
D	24°31'10"	81°31'15"
A	24°31'35"	81°31'15"
Lobster Small Area 3		
Point	North Lat.	West Long.
A	24°31'45"	81°30'30"
B	24°31'45"	81°29'50"
C	24°31'15"	81°29'50"
D	24°31'15"	81°30'30"
A	24°31'45"	81°30'30"
Lobster Small Area 4		
Point	North Lat.	West Long.
A	24°32'45"	81°25'0"
B	24°32'45"	81°24'40"
C	24°32'25"	81°24'40"
D	24°32'25"	81°25'0"
A	24°32'45"	81°25'0"

Lobster Small Area 5		
Point	North Lat.	West Long.
A	24°33'50"	81°24'25"
B	24°33'50"	81°24'10"
C	24°33'55"	81°24'10"
D	24°33'55"	81°24'5"
E	24°33'55"	81°23'45"
F	24°34'0"	81°23'45"
G	24°34'0"	81°23'40"
H	24°34'0"	81°23'35"
I	24°33'50"	81°23'35"
J	24°33'50"	81°23'45"
K	24°33'45"	81°23'45"
L	24°33'45"	81°23'50"
M	24°33'45"	81°24'0"
N	24°33'40"	81°24'0"
O	24°33'40"	81°24'25"
A	24°33'50"	81°24'25"
Lobster Small Area 6		
Point	North Lat.	West Long.
A	24°35'30"	81°14'35"
B	24°35'30"	81°14'25"
C	24°35'20"	81°14'25"
D	24°35'20"	81°14'35"
A	24°35'30"	81°14'35"
Lobster Small Area 7		
Point	North Lat.	West Long.
A	24°37'45"	81°6'30"
B	24°37'45"	81°6'10"
C	24°37'30"	81°6'10"
D	24°37'30"	81°6'30"
A	24°37'45"	81°6'30"
Lobster Small Area 8		
Point	North Lat.	West Long.
A	24°44'55"	80°47'0"
B	24°44'55"	80°46'40"
C	24°44'30"	80°46'40"
D	24°44'30"	80°47'0"
A	24°44'55"	80°47'0"

Lobster Small Area 9		
Point	North Lat.	West Long.
A	24°45'25"	80°45'35"
B	24°45'25"	80°45'20"
C	24°45'5"	80°45'20"
D	24°45'5"	80°45'35"
A	24°45'25"	80°45'35"
Lobster Small Area 10		
Point	North Lat.	West Long.
A	24°56'30"	80°29'10"
B	24°56'30"	80°28'55"
C	24°56'15"	80°28'55"
D	24°56'15"	80°29'10"
A	24°56'30"	80°29'10"
Lobster Small Area 11		
Point	North Lat.	West Long.
A	24°56'50"	80°28'45"
B	24°56'50"	80°28'0"
C	24°56'15"	80°28'0"
D	24°56'15"	80°28'45"
A	24°56'50"	80°28'45"
Lobster Small Area 12		
Point	North Lat.	West Long.
A	24°57'40"	80°27'25"
B	24°57'40"	80°27'15"
C	24°57'25"	80°27'15"
D	24°57'25"	80°27'25"
A	24°57'40"	80°27'25"

Lobster Small Area 13		
Point	North Lat.	West Long.
A	24°59'40"	80°25'55"
B	24°59'40"	80°25'50"
C	24°59'50"	80°25'50"
D	24°59'50"	80°25'45"
E	24°59'50"	80°25'40"
F	24°59'35"	80°25'40"
G	24°59'35"	80°25'45"
H	24°59'30"	80°25'45"
I	24°59'30"	80°25'55"
K	24°59'35"	80°25'55"
A	24°59'40"	80°25'55"
Lobster Small Area 14		
Point	North Lat.	West Long.
A	25°0'15"	80°25'25"
B	25°0'15"	80°25'15"
C	25°0'5"	80°25'15"
D	25°0'5"	80°25'25"
A	25°0'15"	80°25'25"
Lobster Small Area 15		
Point	North Lat.	West Long.
A	24°59'20"	80°25'15"
B	24°59'20"	80°24'50"
C	24°59'0"	80°24'50"
D	24°59'0"	80°25'15"
A	24°59'20"	80°25'15"
Lobster Small Area 16		
Point	North Lat.	West Long.
A	24°59'50"	80°24'40"
B	24°59'50"	80°24'20"
C	24°59'25"	80°24'20"
D	24°59'25"	80°24'40"
A	24°59'50"	80°24'40"

Lobster Small Area 17		
Point	North Lat.	West Long.
A	25°2'15"	80°23'35"
B	25°2'15"	80°23'5"
C	25°1'55"	80°23'5"
D	25°1'55"	80°23'35"
E	25°1'40"	80°23'35"
F	25°1'40"	80°23'50"
G	25°2'15"	80°23'50"
A	25°2'15"	80°23'35"
Lobster Small Area 18		
Point	North Lat.	West Long.
A	25°1'40"	80°23'40"
B	25°1'40"	80°23'15"
C	25°1'25"	80°23'15"
D	25°1'25"	80°23'35"
E	25°1'20"	80°23'35"
F	25°1'20"	80°23'45"
G	25°1'10"	80°23'45"
H	25°1'10"	80°23'55"
I	25°1'30"	80°23'55"
J	25°1'30"	80°23'40"
A	25°1'40"	80°23'40"
Lobster Small Area 19		
Point	North Lat.	West Long.
A	25°3'35"	80°23'5"
B	25°3'35"	80°22'50"
C	25°3'20"	80°22'50"
D	25°3'20"	80°23'5"
A	25°3'35"	80°23'5"

Lobster Small Area 20		
Point	North Lat.	West Long.
A	25°2'35"	80°23'0"
B	25°2'35"	80°22'15"
C	25°2'50"	80°22'15"
D	25°2'50"	80°21'55"
E	25°2'20"	80°21'55"
F	25°2'20"	80°22'10"
G	25°2'10"	80°22'10"
H	25°2'10"	80°23'0"
A	25°2'35"	80°23'0"
Lobster Small Area 21		
Point	North Lat.	West Long.
A	25°1'20"	80°22'25"
B	25°1'20"	80°21'55"
C	25°1'0"	80°21'55"
D	25°1'0"	80°22'25"
A	25°1'20"	80°22'25"

Lobster Small Area 22		
Point	North Lat.	West Long.
A	25°3'15"	80°22'0"
B	25°3'15"	80°21'55"
C	25°3'30"	80°21'55"
D	25°3'30"	80°21'40"
E	25°3'30"	80°21'40"
F	25°3'40"	80°21'40"
G	25°3'40"	80°21'35"
H	25°3'40"	80°21'20"
I	25°3'40"	80°21'15"
J	25°3'25"	80°21'15"
K	25°3'25"	80°21'20"
L	25°3'25"	80°21'25"
M	25°3'20"	80°21'25"
N	25°3'20"	80°21'30"
O	25°3'15"	80°21'30"
P	25°3'15"	80°21'35"
Q	25°3'10"	80°21'35"
R	25°3'10"	80°21'40"
S	25°3'5"	80°21'40"
T	25°3'5"	80°22'0"
A	25°3'15"	80°22'0"
Lobster Small Area 23		
Point	North Lat.	West Long.
A	25°1'50"	80°21'50"
B	25°1'50"	80°21'15"
C	25°1'35"	80°21'15"
D	25°1'35"	80°21'50"
A	25°1'50"	80°21'50"
Lobster Small Area 24		
Point	North Lat.	West Long.
A	25°2'35"	80°20'50"
B	25°2'35"	80°20'35"
C	25°2'15"	80°20'35"
D	25°2'15"	80°20'50"
A	25°2'35"	80°20'50"

Lobster Small Area 25		
Point	North Lat.	West Long.
A	25°2'50"	80°20'35"
B	25°2'50"	80°20'20"
C	25°2'35"	80°20'20"
D	25°2'35"	80°20'35"
A	25°2'50"	80°20'35"
Lobster Small Area 26		
Point	North Lat.	West Long.
A	25°3'50"	80°20'0"
B	25°3'50"	80°19'35"
C	25°3'20"	80°19'35"
D	25°3'20"	80°20'0"
A	25°3'50"	80°20'0"
Lobster Small Area 27		
Point	North Lat.	West Long.
A	25°8'0"	80°18'20"
B	25°8'0"	80°18'5"
C	25°7'35"	80°18'5"
D	25°7'35"	80°18'20"
A	25°8'0"	80°18'20"
Lobster Small Area 28		
Point	North Lat.	West Long.
A	25°7'15"	80°18'10"
B	25°7'15"	80°17'55"
C	25°7'5"	80°17'55"
D	25°7'5"	80°18'10"
A	25°7'15"	80°18'10"
Lobster Small Area 29		
Point	North Lat.	West Long.
A	25°7'55"	80°17'50"
B	25°7'55"	80°17'30"
C	25°7'35"	80°17'30"
D	25°7'35"	80°17'50"
A	25°7'55"	80°17'50"

Lobster Small Area 30		
Point	North Lat.	West Long.
A	25°8'30"	80°17'45"
B	25°8'30"	80°17'35"
C	25°8'20"	80°17'35"
D	25°8'20"	80°17'15"
E	25°8'5"	80°17'15"
F	25°8'5"	80°17'20"
G	25°8'0"	80°17'20"
H	25°8'0"	80°17'40"
I	25°8'5"	80°17'40"
J	25°8'5"	80°17'35"
K	25°8'15"	80°17'35"
L	25°8'15"	80°17'45"
A	25°8'30"	80°17'45"
Lobster Small Area 31		
Point	North Lat.	West Long.
A	25°9'15"	80°17'40"
B	25°9'15"	80°17'35"
C	25°9'20"	80°17'35"
D	25°9'20"	80°17'30"
E	25°9'30"	80°17'30"
F	25°9'30"	80°17'10"
G	25°9'15"	80°17'10"
H	25°9'15"	80°17'15"
I	25°9'10"	80°17'15"
J	25°9'10"	80°17'25"
K	25°8'55"	80°17'25"
L	25°8'55"	80°17'40"
A	25°9'15"	80°17'40"
Lobster Small Area 32		
Point	North Lat.	West Long.
A	25°10'15"	80°16'45"
B	25°10'15"	80°16'40"
C	25°10'5"	80°16'40"
D	25°10'5"	80°16'45"
A	25°10'15"	80°16'45"

Lobster Small Area 33		
Point	North Lat.	West Long.
A	25°10'25"	80°16'15"
B	25°10'25"	80°16'10"
C	25°10'40"	80°16'10"
D	25°10'40"	80°15'55"
E	25°10'0"	80°15'55"
F	25°10'0"	80°16'15"
A	25°10'25"	80°16'15"
Lobster Small Area 34		
Point	North Lat.	West Long.
A	25°9'25"	80°16'10"
B	25°9'25"	80°15'55"
C	25°9'10"	80°15'55"
D	25°9'10"	80°16'10"
A	25°9'25"	80°16'10"
Lobster Small Area 35		
Point	North Lat.	West Long.
A	25°9'40"	80°15'55"
B	25°9'40"	80°15'30"
C	25°9'30"	80°15'30"
D	25°9'30"	80°15'55"
A	25°9'40"	80°15'55"
Lobster Small Area 36		
Point	North Lat.	West Long.
A	25°13'5"	80°15'45"
B	25°13'5"	80°15'25"
C	25°12'50"	80°15'25"
D	25°12'50"	80°15'45"
A	25°13'5"	80°15'45"
Lobster Small Area 37		
Point	North Lat.	West Long.
A	25°12'25"	80°14'50"
B	25°12'25"	80°14'30"
C	25°12'10"	80°14'30"
D	25°12'10"	80°14'50"
A	25°12'25"	80°14'50"

Lobster Small Area 38		
Point	North Lat.	West Long.
A	25°11'20"	80°15'0"
B	25°11'20"	80°14'25"
C	25°10'50"	80°14'25"
D	25°10'50"	80°15'0"
A	25°11'20"	80°15'0"
Lobster Small Area 39		
Point	North Lat.	West Long.
A	25°11'45"	80°14'5"
B	25°11'45"	80°13'35"
C	25°11'15"	80°13'35"
D	25°11'15"	80°14'5"
A	25°11'45"	80°14'5"
Lobster Small Area 40		
Point	North Lat.	West Long.
A	25°12'5"	80°13'45"
B	25°12'5"	80°13'25"
C	25°11'45"	80°13'25"
D	25°11'45"	80°13'45"
A	25°12'5"	80°13'45"
Lobster Small Area 41		
Point	North Lat.	West Long.
A	25°16'45"	80°13'50"
B	25°16'45"	80°13'20"
C	25°16'20"	80°13'20"
D	25°16'20"	80°13'50"
A	25°16'45"	80°13'50"

Lobster Small Area 42		
Point	North Lat.	West Long.
A	25°17'10"	80°12'40"
B	25°17'10"	80°12'10"
C	25°16'55"	80°12'10"
D	25°16'55"	80°12'20"
E	25°16'15"	80°12'20"
F	25°16'15"	80°12'55"
G	25°16'40"	80°12'55"
H	25°16'40"	80°12'45"
I	25°16'50"	80°12'45"
J	25°16'50"	80°12'40"
A	25°17'10"	80°12'40"
Lobster Small Area 43		
Point	North Lat.	West Long.
A	25°16'15"	80°13'5"
B	25°16'15"	80°12'25"
C	25°16'0"	80°12'25"
D	25°16'0"	80°12'35"
E	25°15'35"	80°12'35"
F	25°15'35"	80°13'5"
A	25°16'15"	80°13'5"
Lobster Small Area 44		
Point	North Lat.	West Long.
A	25°15'30"	80°12'50"
B	25°15'30"	80°12'30"
C	25°15'5"	80°12'30"
D	25°15'5"	80°12'50"
A	25°15'30"	80°12'50"
Lobster Small Area 45		
Point	North Lat.	West Long.
A	25°15'5"	80°12'5"
B	25°15'5"	80°11'45"
C	25°14'45"	80°11'45"
D	25°14'45"	80°12'5"
A	25°15'5"	80°12'5"

Lobster Small Area 46		
Point	North Lat.	West Long.
A	25°21'55"	80°10'15"
B	25°21'55"	80°9'55"
C	25°21'40"	80°9'55"
D	25°21'40"	80°10'15"
A	25°21'55"	80°10'15"
Lobster Small Area 47		
Point	North Lat.	West Long.
A	25°21'10"	80°10'0"
B	25°21'10"	80°9'45"
C	25°20'55"	80°9'45"
D	25°20'55"	80°10'0"
A	25°21'10"	80°10'0"

Lobster Small Area 48		
Point	North Lat.	West Long.
A	25°20'5"	80°11'0"
B	25°20'5"	80°9'45"
C	25°19'50"	80°9'45"
D	25°19'50"	80°11'0"
A	25°20'5"	80°11'0"
Lobster Small Area 49		
Point	North Lat.	West Long.
A	25°21'40"	80°9'35"
B	25°21'40"	80°9'15"
C	25°21'20"	80°9'15"
D	25°21'20"	80°9'35"
A	25°21'40"	80°9'35"
Lobster Small Area 50		
Point	North Lat.	West Long.
A	25°23'10"	80°9'0"
B	25°23'10"	80°8'50"
C	25°23'0"	80°8'50"
D	25°23'0"	80°9'0"
A	25°23'10"	80°9'0"
Lobster Small Area 51		
Point	North Lat.	West Long.
A	25°24'45"	80°7'50"
B	25°24'45"	80°7'35"
C	25°24'30"	80°7'35"
D	25°24'30"	80°7'50"
A	25°24'45"	80°7'50"
Lobster Small Area 52		
Point	North Lat.	West Long.
A	25°25'25"	80°7'40"
B	25°25'25"	80°7'25"
C	25°25'15"	80°7'25"
D	25°25'15"	80°7'40"
A	25°25'25"	80°7'40"

Appendix I: Biological Opinion

Endangered Species Act - Section 7 Consultation
Biological Opinion

Action Agency: National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service (NMFS), Southeast Regional Office (SERO), Sustainable Fisheries Division (F/SER2)

Activity: The Continued Authorization of Fishing under the Fishery Management Plan (FMP) for Spiny Lobster in the South Atlantic and Gulf of Mexico (F/SER/2005/07518)

Consulting Agency: NOAA, NMFS, SERO, Protected Resources Division (F/SER3)

Approved by: Roy E. Crabtree, Ph.D., Regional Administrator

Date Issued: AUG 27 2009

Introduction

Section 7(a)(2) of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. § 1531 et seq.), requires each federal agency to ensure any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of any critical habitat of such species. When the action of a federal agency may affect an ESA-listed species or its critical habitat, that agency is required to consult with either NMFS or the U.S. Fish and Wildlife Service (USFWS), depending upon the protected species that may be affected.

Consultations on most listed marine species and their critical habitat are conducted between the action agency and NMFS. These consultations are concluded after NMFS has determined that an action is not likely to adversely affect listed species or designated critical habitat, or issues a biological opinion (opinion) identifying whether the proposed action is likely to jeopardize the continued existence of a listed species, or destroy or adversely modify any critical habitat. If jeopardy or destruction or adverse modification is found to be likely, NMFS must identify reasonable and prudent alternatives to the action, if any, that would avoid jeopardizing any listed species and avoid destruction or adverse modification of any designated critical habitat. The opinion establishes an incidental take statement (ITS) specifying the amount or extent of incidental take of the listed species that may occur, reasonable and prudent measures (RPMs) to reduce the effect of take, and may recommend conservation measures to further conserve the species. Notably, no incidental destruction or adverse modification of critical habitat can be authorized. Thus, there are no RPMs for critical habitat, only reasonable and prudent alternatives that must avoid destruction and adverse modification.

This document constitutes NMFS' opinion on the effects of the continued authorization of spiny lobster fishing in the U.S. South Atlantic and Gulf of Mexico Exclusive Economic Zones (EEZ) on threatened and endangered species and designated critical habitat, in accordance with section 7 of the ESA. This consultation considers the operation of the spiny lobster fishery as managed under the Joint Spiny Lobster Fishery Management Plan (SLFMP), including all amendments implemented to date. NMFS has dual responsibilities as both the action agency under the Magnuson-Stevenson Fishery Conservation and Management Act (MSFMCA) (16 U.S.C. §1801 *et seq.*) and the consulting agency under the ESA. For the purposes of this consultation, F/SER2 is considered the action agency and the consulting agency is F/SER3.

This opinion is based on information provided in: the Fishery Management Plan for Spiny Lobster (GMFMC and SAFMC 1982), Amendment 1 to the Spiny Lobster Fishery Management Plan, including an Environmental Assessment, Supplemental Regulatory Impact Review, and Initial Regulatory Flexibility Analysis (GMFMC and SAFMC 1987); sea turtle recovery plans; past and current sea turtle research and population modeling efforts; sea turtle stranding data; smalltooth sawfish encounter database entries; the *Acropora* status review document (*Acropora* BRT 2005); *Acropora cervicornis* and

A. palmata colonial density estimates (Miller et al. 2007); other relevant scientific data and reports; consultation with F/SER2 staff; and previous opinions on other fisheries.

1.0 Consultation History

An informal consultation was conducted on the impacts of the draft Council Fishery Management Plan for the lobster fishery in the Gulf of Mexico and South Atlantic Fishery Conservation Zone in 1979. It concluded the proposed action was not likely to jeopardize the continued existence of threatened of endangered sea turtles or marine mammals. The consultation did not analyze the effects of the fishery itself.

In 1981, a formal consultation was reinitiated on a new draft Council Fishery Management Plan for the lobster fishery in the Gulf of Mexico and South Atlantic Fishery Conservation Zone, after it was determined the previous "opinion did not adequately satisfy section 7 requirements." The formal opinion concluded the proposed action was not likely to jeopardize the continued existence of endangered or threatened species or result in the destruction or adverse modification of critical habitat.

The effects of the South Atlantic and Gulf of Mexico spiny lobster fishery on threatened and endangered species were examined again as part of a larger April 28, 1989, opinion, which analyzed the impacts of all commercial fishing activities in the Southeast Region. The opinion stated that there were no known records of threatened or endangered species incidentally taken in the spiny lobster trap fishery[1] at the time of opinion, and that "the fishery was not likely to impact threatened or endangered species." The opinion concluded that no commercial fishing activities in the Southeast Region were likely to jeopardize the continued existence of any threatened or endangered species. The incidental take of ten documented green, hawksbill, Kemp's ridley, or leatherback sea turtles; 100 loggerhead sea turtles; and 100 shortnose sturgeon was allotted to each fishery identified in the ITS. The amount of incidental take was later reduced in a July 5, 1989, opinion to only ten-documented green, hawksbill, Kemp's ridley, or leatherback sea turtles; 100 loggerhead sea turtles; and 100 shortnose sturgeon for all commercial fishing activities conducted in the South Atlantic and the Gulf of Mexico regions combined.

Amendments 1 through 7 and two regulatory amendments to the South Atlantic and Gulf of Mexico spiny lobster fishery management plan (FMP) were all either consulted on informally and found not likely to adversely affect threatened or endangered species, or were determined by F/SER2 to have no effect on ESA-listed species. These consultations determined that amendments to the FMP would not alter the prosecution of the spiny lobster fishery in ways that would cause effects to listed species not previously considered. Likewise, they determined there was no new information revealing effects to threatened and endangered species, or their designated critical habitats, not previously considered in the July 5, 1989, opinion.

[1] The impacts of other gear types in the spiny lobster fishery were not analyzed in this opinion.

Formal consultation on the South Atlantic and Gulf of Mexico Spiny Lobster Fishery was reinitiated on August 25, 2005. 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.

In an August 25, 2005, memorandum F/SER2 evaluated the impacts of the implementation of Generic Amendment 3 to the South Atlantic and Gulf of Mexico spiny lobster fishery. Since NMFS considers the effects of the specific management measures proposed, and the effects of all discretionary fishing activity authorized under affected FMPs, the operation of the entire fishery was evaluated. The analysis concluded new data were available that revealed the fishery may be affecting ESA-listed species in a way not previously considered. Additionally, the impacts of spiny lobster fishing on the U.S. distinct population segment (DPS) of smalltooth sawfish and *Acropora* species were not analyzed in previous consultations.

The presence of these reinitiating factors led F/SER2 to request reinitiation of formal consultation on the Spiny Lobster FMP. An ESA section 7(a)(2) and 7(d) determination concluded the continued operation of the fishery during the reinitiation period is not likely to jeopardize the continued existence of any listed species; nor would it represent an irreversible or irretrievable commitment of resources by the agency. The appropriateness of the section 7(a)(2) and 7(d) determination has been monitored during the course of the consultation as data has been collected and its conclusion has remained valid.

2.0 Description of Proposed Action

F/SER2 is proposing to continue its authorization of the spiny lobster fishery in the Gulf of Mexico and South Atlantic regions. The Gulf of Mexico and South Atlantic spiny lobster fishery is currently managed jointly via the FMP for the Spiny Lobster in the Gulf of Mexico and South Atlantic (SLFMP), and implementing regulations at 50 CFR Part 640, under the authority of the Magnuson Stevens Fishery Management and Conservation Act (MSFMCA). The MSFMCA is the governing authority for all fishery management activities that occur in federal waters within the United States' 200-nautical-mile (nmi) EEZ. Responsibility for federal fishery management decision-making under the Joint SLFMP is divided between NMFS, the South Atlantic Fishery Management Council (SAFMC), and the Gulf of Mexico Fishery Management Council (GMFMC), with the GMFMC acting as the lead agency. This opinion analyzes the effects of all fishing activities prosecuted under the SLFMP, as amended to date.

When consulting on FMP actions, NMFS must consider not only the effects of specific management measures (described in Section 2.1 below) but also the effects of all fishing activity authorized under the FMP. A description of the Gulf of Mexico and South Atlantic spiny lobster fishery is provided below in Section 2.2. It provides a summary of the overall characteristics of the Gulf of Mexico and South Atlantic spiny lobster fishery authorized under the Joint SLFMP, which are relevant to the analysis of its potential effects on threatened and endangered species.

2.1 Overview of Management and Current Regulations

The joint jurisdiction of the GMFMC and SAFMC spans from the North Carolina/Virginia border in the South Atlantic to the Texas/Mexico border in the Gulf of Mexico. The spiny lobster fishery has been jointly managed by these Councils since the inception of the SLFMP in 1982. The original FMP was drafted to address five primary issues within the fishery: (1) an increase in the harvest and sale of undersized lobsters, (2) gear conflicts between lobster trappers and direct trawl and drift-net fishers, (3) concern over the mortality rate of undersized lobster used as attractants in the traps, (4) concern over an increasing number of traps in the fishery, and (5) harvest of lobsters during the spawning season. The original FMP established five management objectives aimed at addressing these issues: (1) protect the long-run yields and prevent depletion of lobster stocks, (2) increase yield by weight from the fishery, (3) reduce user group and gear conflicts in the fishery, (4) acquire the necessary information to manage the fishery, and (5) promote efficiency in the fishery (GMFMC and SAFMC 1982). Since its implementation, the original FMP has been amended seven times and undergone three regulatory amendments. Appendix 1 provides a brief summary of those amendments.

The federal fishery is currently managed through regulations affecting the EEZs off states in three areas: the South Atlantic states (North Carolina, South Carolina, and Georgia), not including Florida; the State of Florida; and the Gulf of Mexico states (Texas, Louisiana, Mississippi, and Alabama) not including Florida. Management measures have been structured this way to reflect differences in spiny lobster occurrence and fishing effort in these regions. Below is a brief summary of the management measures in place for these regions; Table 2.2 provides more specific information on these requirements.

EEZs Occurring off the South Atlantic States (not including Florida)
The regulations on commercial and recreational fishers are identical throughout the South Atlantic states. The fishery is managed through permit requirements, minimum size and bag limits, gear restrictions, and trap construction requirements.

EEZs Occurring off the Gulf of Mexico States (not including Florida)
The Gulf of Mexico states also have spiny lobster regulations separate from Florida's requirements. However, certain regulations are simultaneously in effect for both Florida and the Gulf of Mexico states. The fishery in the Gulf of Mexico is managed through minimum size limits, a special recreational season, an otherwise closed season for commercial and recreational fishing, gear restrictions, bag limits, and trap construction requirements.

State of Florida

The spiny lobster fishery off Florida is managed under a separate set of regulations due to the relatively high level of fishing effort, and because of the relatively high abundance of spiny lobsters in these waters. The spiny lobster fishery off Florida is primarily a state fishery, with approximately 80 percent of fishing effort occurring in state waters on average annually. In the early 1990s, the SLFMP was amended to establish compatible regulations between the federal and state fisheries. Thereafter, the State of Florida has taken the lead in spiny lobster fishery management, with NMFS establishing compatible regulations when applicable. The fishery is currently managed via bag limits, minimum size limits, regulated fishing seasons for the commercial and recreational sectors, gear restrictions, trap construction requirements, and a trap limitation and permitting program.[2]

The State of Florida implemented a Lobster Trap Certificate Program (LTC) in 1993 because the spiny lobster fishery was experiencing increased congestion and conflict on the water. Excessive mortality of undersized lobsters, a declining yield per trap, and an increasing concern over petroleum and debris pollution were also at issue. To legally fish spiny lobster traps in the State of Florida, fishers must have valid trap certificates. The rationale for the LTC was that the fishery was overcapitalized and fewer traps could maintain lobster harvest at historic catch levels. The LTC was expected to stabilize the fishery by reducing the total number of traps while maintaining or increasing overall landings, which would result in increased yield per trap (FFWCC 2006).

The main component of the LTC was the reduction of traps in the fishery to 250,000 traps, based on historic catch and effort information. Annual 10 percent reductions in the total number of trap permits available from Florida Fish and Wildlife Conservation Commission (FFWCC) were implemented to achieve this goal (referred to as active reductions). Intense resistance to the trap reduction policy caused periodic suspension of the annual reduction and ultimately the trap reduction policy was revised to a passive/active reduction policy. This policy dictated that 25 percent of those trap permits transferred between fishermen, outside of immediate family, were removed from the fishery (referred to as passive reductions). A supplemental reduction program was also established to reduce the number of traps issued by the state (referred to as active reductions) to achieve an annual reduction of at least four percent, if the passive reduction program did not meet that goal. Active and passive reductions were intended to continue until 400,000 traps remained in the fishery. Currently, there are approximately 480,000 trap certificates issued for the fishery. Each certificate entitles the holder to own an individual trap. Reductions in the number of traps in the fishery are currently suspended, pending a reevaluation of all lobster fishing regulations (FFWCC 2006). Table 2.1 summarizes the reductions for each fishing season and Figure 2.1 illustrates the reductions in traps available and issued.

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[2] Due to shifts in historic harvest proportion among components of the commercial fishery and the recreational fishery, as well as other issues, the annual trap reductions under this program are currently suspended (FWCC 2005, 2006).

Table 2.1 Lobster Trap Reductions for the 1993/94-2006/07 Fishing Seasons (FFWCC 2007)

Fishing Season Reduction Effective	No. of Lobster Trap Certificates Available from FFWCC	Reduction Amount (%)	Type of Reduction
1993/94	750,327	10	Active
1994/95	674,081	10	Active
1995/96	606,190	10	Active
1996/97	613,428	0	Lottery Followed This Ruling
1997/98	605,973	0	No Active or Passive Reduction
1998/99	544,056	10	Active
1999/00	543,497	0	No Active or Passive Reduction
2000/01	542,704	0	No Active or Passive Reduction
2001/02	540,083	4/25	Active/Passive
2002/03	520,562	3.196/25	Active/Passive
2003/04	499,105	2.41/25	Active/Passive
2004-2005	498,409	2.41/25	Active/Passive
2005-2006	497,042	0	No Active or Passive Reduction
2006-2007	495,770	0	No Active or Passive Reduction
2007/08	N/A	0	No Active or Passive Reduction

Figure 2.1 Spiny Lobster Trap Tags Available and Issued, 1993/94-2006-2007 (FFWCC 2007)

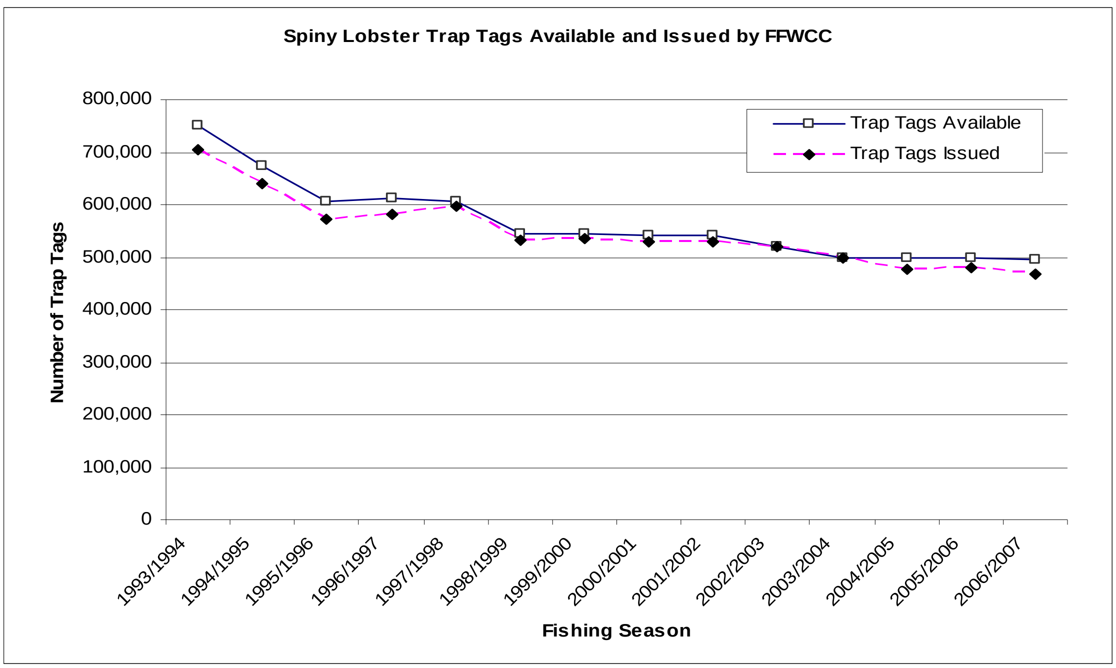


Table 2.2 Summary of Federal Spiny Lobster Fishing Regulations (50 CFR Part 640)

Fishing Area	Permit Requirement	Fishing Season	Size Limit	Daily Bag Limit	Trap Requirements	Gear Restrictions and Requirements
Commercial Regulations						
EEZ off South Atlantic states not including Florida	Federal Permit[1]	Year-Round (no closed season)	3-inch Carapace Length[2]	2 per person	Traps must meet construction requirements in 50 CFR 640.22 and may only be pulled or tended during daylight hours.	Divers must have a device with them to allow for the measurement of carapace length while in the water; no hooks, spears, poisons, dynamite, chemicals, or other such substance or device may be used to harvest lobster; directed use of trawls is also prohibited.
EEZ off Gulf of Mexico states not including Florida	Federal Permit[1]	August 6-March 31		6 per person[3]		
EEZ off Florida	State of Florida Permit[1,5]					
Recreational Regulations						
EEZ off South Atlantic states not including Florida	None	Year-Round (no closed season)	3-inch Carapace Length[2]	2 per person	Traps are not permitted for recreational use.	Divers must have a device with them to allow for the measurement of carapace length while in the water; no hooks, spears, poisons, dynamite, chemicals, or other such substance or device may be used to harvest lobster.
EEZ off Gulf of Mexico states not including Florida	None	August 6-March 31; last Saturday and Sunday of July		6 per person[3]		
EEZ off Florida	State of Florida Permit[1,5,7]	August 6-March 31; last Wednesday and Thursday of July		6 per person; 12 per person[6]		

[1] An additional tail-separation permit is required for anyone wishing to possess tails removed from the carapace while at sea.
[2] Separated tails must be at least 5.5inches in length.
[3] A person is exempt from these limits during the commercial fishing season if they harvest lobster via diving or by use of bully net, hoop net, or lobster trap, and if they possess the appropriate commercial federal/state permits.
[4] All fishing is prohibited inside the Tortugas Marine Reserve.
[5] Anyone landing lobster in Florida or harvesting and/or landing lobster from the EEZ off Florida must have a valid State of Florida spiny lobster permit.
[6] During the last Wednesday and Thursday of July the daily bag limit increases to 12 lobsters per person in the EEZ off Florida, excluding Monroe County. During that period, the daily bag limit remains six lobsters per person in Monroe County.
[7] An additional Special Recreational Crawfish license may be obtained to allow a fisher to harvest lobsters in excess of the recreational bag limit.

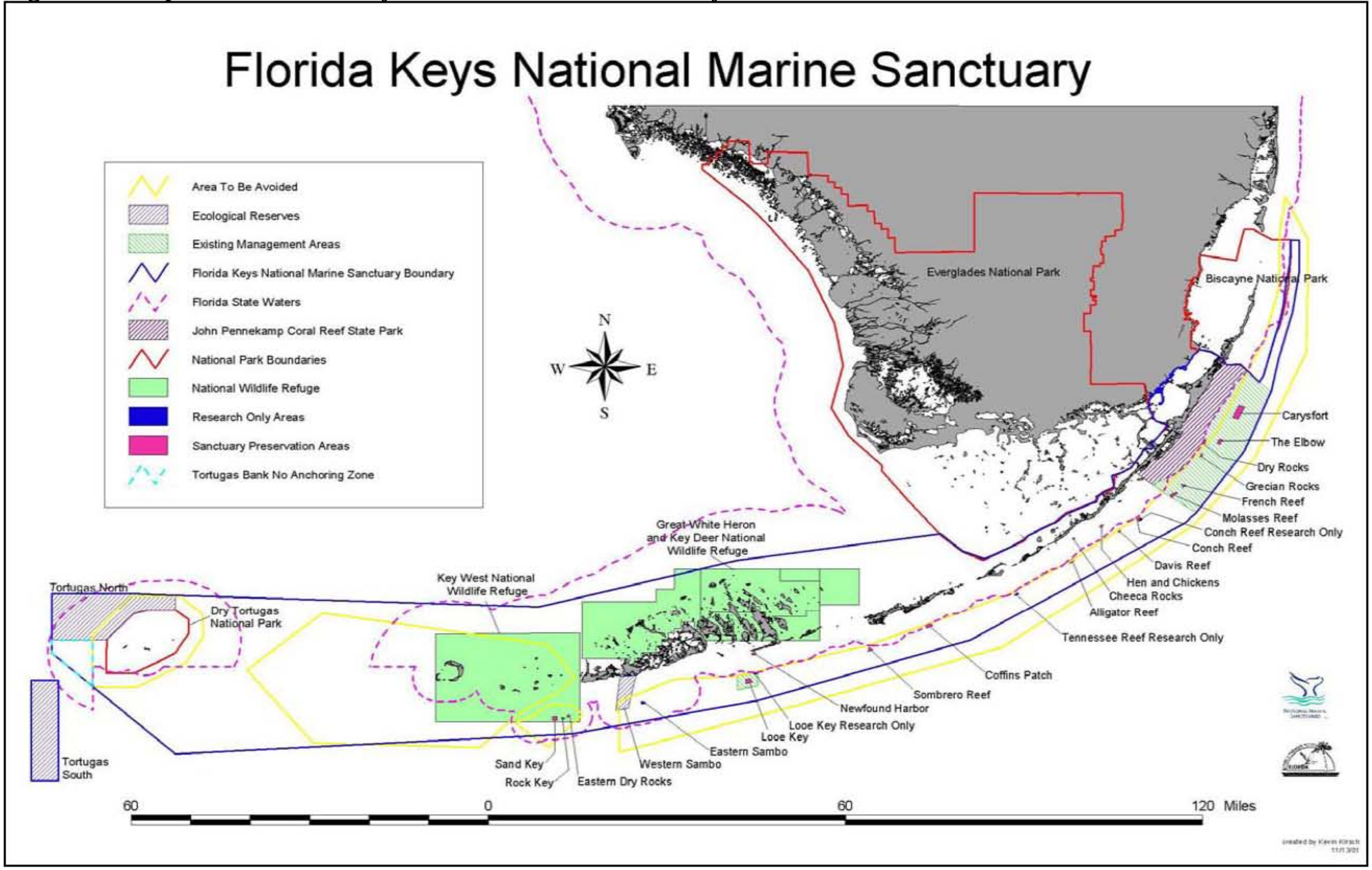
Florida Keys National Marine Sanctuary

The Florida Keys National Marine Sanctuary (FKNMS) encompasses a large portion of the Florida Reef Tract where the vast majority of spiny lobster fishing occurs. As such, the spiny lobster fishery is subject to applicable FKNMS regulations. Spiny lobster fishing is considered a “traditional fishing activity” and therefore, is allowed inside the FKNMS.[3] However, regulations at 15 CFR 922.163 prohibiting the removal of, injury to, or possession of coral or live rock are applicable to spiny lobster fishers. Prohibitions on adversely affecting corals also extend to the operation of vessels. FKNMS regulations prohibit the operation of a vessel in such a manner that will injure coral, as well as anchoring on live coral in water depths less than 40 ft when the bottom can be seen [15 CFR 922.163(i) and (ii)]. Likewise, take or possession of protected wildlife, including ESA-listed species, is prohibited within the FKNMS unless that take is otherwise authorized under the ESA or MMPA [15 CFR 922.163(10)].

Spiny lobster fishing is also subject to area closures established within the FKNMS. FKNMS regulations prohibit spiny lobster fishing inside ecological reserves and sanctuary preservation areas (SPAs) [15 CFR 922.164(d)]. The Director of the Office of Ocean and Coastal Resource Management, or their designee, can also establish “special use areas” (SUAs). Four specific SUA types have been developed, each with a specific purpose: (1) recovery areas, (2) restoration areas, (3) research-only areas, and (4) facilitated-use areas. Spiny lobster fishing is prohibited in the first three SUA types [15 CFR 922.134(e)]. Presently, just research-only SUAs have been designated in the FKNMS. Figure 2.2 displays the current management areas, SUAs, and boundaries of the FKNMS.

[3] Traditional fishing activities are those commercial and recreational activities that occurred in the Sanctuary prior to its designation [15 CFR 922.163(a)].

Figure 2.2 Map of the Florida Keys National Marine Sanctuary



2.1.1 Management of Gulf of Mexico and South Atlantic Spiny Lobster Exempted Fishing, Scientific Research, and Exempted Educational Activity

Regulations at 50 CFR 600.745 allow the Regional Administrator of NMFS' SERO to authorize the target or incidental harvest of species managed under an FMP or fishery regulations that would otherwise be prohibited, for scientific research activity, limited testing, public display, data collection, exploratory health and safety, environmental cleanup, hazardous waste removal purposes, or educational purposes. Every year, the SERO may issue a small number (e.g., three were issued in 2005, one in 2006, and one in 2007) of exempted fishing permits (EFPs), scientific research permits (SRPs), and/or exempted educational activity authorizations (EEAAs). Such a permit would exempt the collection of a limited number of spiny lobster, occurring in Gulf of Mexico and South Atlantic federal waters, from regulations implementing the SLFMP. These EFPs, SRPs, and EEAAs involve fishing by commercial or research vessels, using fishing methods similar or identical to those used in the spiny lobster fishery. Under these circumstances, the types and rates of interactions with listed species from the EFP, SRP, and EEAA activities would be expected to be similar to those analyzed in this opinion. If the fishing methods are similar and the associated fishing effort does not represent a significant increase beyond the levels expected in the fishery considered herein, then issuance of some EFPs, SRPs, and EEAAs would be expected to fall within the level of effort and impacts considered in this opinion. For example, issuance of an EFP to an active commercial vessel is unlikely to add additional effects or increase fishing effort beyond what is otherwise likely to accrue from the vessel's normal commercial activities. Therefore, we consider SERO's issuance of EFPs, SRPs, and EEAAs for fishing that is consistent with the description of spiny lobster fishing in Section 2, and is not expected to increase fishing effort significantly, to be within the scope of this opinion.

2.2 Description of Gulf of Mexico/South Atlantic Spiny Lobster Fishery

2.2.1 Overview of the Federal Fishery off the South Atlantic States (Not Including Florida)

North Carolina

There is currently no commercial effort directed at harvesting spiny lobsters off North Carolina. The fishery is primarily opportunistic with very few commercial landings. From 1994-2005 only 35 pounds of spiny lobster were landed from the federal waters off North Carolina. Rod-and-reel and diving spears were used to harvest these landings. The spiny lobsters taken by rod-and-reel gear appear to be incidental catches by fishers targeting snapper-grouper species with bottom longline (A. Bianchi, North Carolina Department of Marine Fisheries, pers. comm. 2007).

South Carolina

There is currently no directed commercial fishery for spiny lobster off South Carolina, nor has there been for some time. There are no recorded commercial landings of spiny lobster going back 10 years. In the mid-1980s an offshore commercial trap fishery for spiny lobster was explored, but the landing amounts were too low to warrant a directed fishery (M. Bell, pers. comm. 2006).

Spiny lobsters are collected recreationally off South Carolina. Most fishing is conducted by divers operating from privately-owned vessels. These fishers generally travel 25 miles or more offshore and dive in waters 90 ft or deeper. Lobsters are most frequently taken from rocky outcroppings, artificial reefs, or shipwrecks. A small offshore dive charter industry does exist, but most of these operators discourage the collection of spiny lobsters during dives (M. Bell, pers. comm. 2006).

The numbers of participants in the recreational fishery is currently unknown. Given the depths involved, distances from shore, and the patchiness of ideal habitat, it is believed that the number of fishers participating in the fishery and overall effort are minimal. However, advances in navigational technology and diving equipment seem to be allowing an increasing number of recreational fishers access to offshore spiny lobster stocks (M. Bell, pers. comm. 2006).

Georgia

There is currently no directed commercial fishery for spiny lobster off Georgia, nor has there been for some time (J. Califf, Georgia Department of Natural Resources, pers. comm. 2007). The last commercial landings of spiny lobster from federal waters were recorded in 1969. The state of Georgia does not currently regulate spiny lobster fishing, presumably because the level of effort does not warrant regulation.

2.2.2 Overview of the Federal Fishery off the Gulf of Mexico States (Not Including Florida)

There is little commercial or recreational harvest of spiny lobster outside of Florida. Since the implementation of the Spiny Lobster FMP in 1983, only 7,214 pounds of lobster have been landed commercially in the Gulf States outside of Florida (NMFS unpublished data). Due to variability in the oceanic currents that carry spiny lobster larvae, the occurrence of adult spiny lobster in these areas is inconsistent. As a result, most fishing for spiny lobster in these areas is considered opportunistic with very little consistent directed effort. Lobsters that are landed tend to be large in size (nine pound or more [Moe 1991]) but are generally not landed in large quantities

2.3 Overview of the Federal Fishery off Florida

2.3.1 Description of the Florida Spiny Lobster Fishery

The distribution of the commercial and recreational spiny lobster harvest off Florida is almost exclusively limited to the waters off southern Florida (GMFMC and SAFMC 1982). The fishery here has been in existence since the early 1900s and fishing gears and techniques have changed little in that time. The overview of fishing practices and techniques in the original SLFMP and subsequent amendments still accurately depict the fishery's operation. The following sections summarize those discussions.

2.3.2 Commercial Fishery

Spiny lobster is an important fishery resource in southern Florida, especially the Florida Keys. Spiny lobsters are commercially harvested via traps (Figure 2.3) and divers collecting lobsters by hand, including bully nets. During the late 1980s and early 1990s, NMFS established regulations compatible with the State of Florida's management measures for spiny lobster. As a result, only one permit, issued by the State of Florida, is currently required to commercially harvest lobster in both federal and state waters. Trap fishing is the most common gear type used in the Florida Keys, while diving is utilized most frequently north of Dade County, Florida. The dockside value of the entire commercial fishery is estimated to be worth approximately $21 million annually since 1980 (Robson 2006).

Figure 2.3 Example of a Commercial Spiny Lobster Trap

Photo Credit: T Matthews, FFWCC

Commercial Bully Net
Bully nets (Figure 2.4) consist of a long pole with a bag of netting of varying mesh size. Fishers generally stand at the bow of the boat and lowered the net into the water when a lobster is seen on the bottom. Since lobsters must been seen from the surface bully net fishing requires relatively clear, shallow water. For these reasons, the likelihood of bycatch by this gear is extremely small.

Bully nets are occasionally used during the first few weeks of the commercial season (D. Gregory, Florida Sea Grant, pers. comm. 2006), though the commercial landings attributed to this gear type are very low. Bully net landings statewide account for less than one percent of all spiny lobster landings (FFWCC 2005). Since implementation of the LTC the number of fishers reporting bully net-caught landings has ranged from 34 to 84 (FFWCC 2005). Because bully nets can only be used effectively in very shallow water, the fishery is primarily confined to Monroe County. The vast majority bully net fishing occurs on seagrass and mud flats on the northern side of Florida Keys (T. Matthews, FFWCC, pers. comm. 2008).

Figure 2.4 Example of a Bully Net

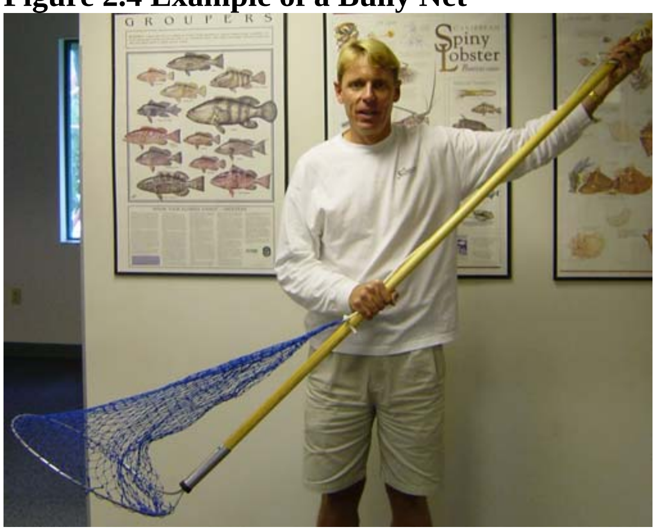


Photo Credit: B. Sharp, FFWCC

Commercial Trapping
As of June 10, 2008, 1,301 fishers had a license/certificate to use traps to harvest lobsters commercially during the 2006-07 fishing season (FFWCC 2008). A trap limitation program initiated in 1993 has reduced the number of lobster traps available annually from approximately one million to 498,000 at the beginning of the 2006-07 fishing season. Trap fishers generally land about five million pounds of lobster, on average, during a fishing season. Due to major trap losses resulting from three major hurricanes striking the fishing grounds, only 2.5 million pounds of lobster were landed during the 2005-06 season. Over the last 10 years, commercial trap fishing has been the dominant gear type in the spiny lobster fishery, accounting for approximately 70 percent of all commercial landings (Robson 2006).

Wire traps are occasionally used, frequently in deeper water, but the majority of traps currently used by commercial trappers are made of wooden slats. Concrete is typically poured in the bottom of traps to weight them. A buoy is attached to the trap and floated at the surface. Fishing occurs from very nearshore areas out to water depths of 200 ft, although most fishing occurs in waters less than 100 ft. The type of bait used in traps depends on fisher preference. Some traps are set unbaited, some are baited with fish scraps, sardines, cat food or cowhide, while others are baited with undersized lobsters used to attract larger lobsters. This last practice is believed to be so effective at increasing trap efficiency that some fishers use legal sized lobsters as bait when undersized lobsters are not available. Regardless of how the trap is baited, soak times average from 8 to 28 days, with soak times increasing as the season progresses and catch rates decline (Matthews 2001).

Fishing vessels in the Lower Florida Keys (Marathon to Key West) are generally larger than those in operation in the Upper Florida Keys (Key Largo to Long Key) (GMFMC and SAFMC 1987). Vessels operating in the Lower Florida Keys tend to be 50 ft in length, operate with crews of two or three, and typically fish up to 2,000 traps, but a few fishers may use as many as 5,000 traps (D. Gregory, Florida Sea Grant, pers. comm. 2006). These vessels may set traps several miles apart and usually allow traps to soak for up to two weeks (Powers and Bannerot 1984). Vessels of this size are also capable of fishing five hundred traps a day (GMFMC and SAFMC 1982). Many of these vessels are capable of taking multiple-day trips. However, only a few fishers that fish the waters near the Dry Tortugas actually make multi-day trips, and they maintain iced storage areas on board. Ice storage allows the crew to separate and ice the tails while at sea, to preserve the quality of the catch, since, unlike the typical day boat, they cannot keep the lobsters alive for the entire fishing trip (D. Gregory, Florida Sea Grant, pers. comm. 2007).

Vessels fishing off the Upper Florida Keys are generally smaller day crafts with crews of one. These vessels tend to be 30 ft on average, carrying no more than 500-800 traps per craft. Unlike the larger vessels fishing in the Lower Keys, these fishers tend to pull 100-300 traps per day. They also stay closer to shore and the duration of their trips is shorter than the larger vessels operating out of the Lower Keys (GMFMC and SAFMC 1987).

Commercial Diving

As of June 10, 2008, 335 fishers had licenses/endorsements to commercially harvest lobster via diving during the 2006-07 fishing season (FFWCC 2008). A fisher in possession of a license/certificate to fish traps is not eligible for a commercial dive permit unless they relinquish their trap certificate (Chapter 68B-24.0055(2)(b), F.A.C.). In the years immediately following the 1993 implementation of the trap limitation program, the proportion of landings attributed to the commercial dive component of the fishery increased steadily. That increase continued until 2003 when a commercial dive endorsement program was instituted that required an additional fee and license. During the 2005-06 fishing season, commercial divers landed approximately 250,000 pounds of lobster. Over the last year 10 years, commercial divers have accounted for approximately six percent of total lobster landings on average (Robson 2006).

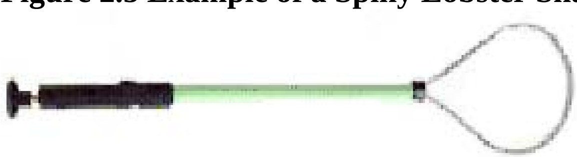
Commercial diving is most common off the Florida Keys and frequently occurs in the channels under the Overseas Highway. Divers also utilize shallow natural and artificial habitats occurring between shore and the offshore reef break. Significant harvest of spiny lobster by commercial diving also occurs in the Florida Bay south of the Everglades National Park and out into the Gulf of Mexico. Commercial divers collect lobsters by hand. The use of spears, hooks, or other gear types that would otherwise pierce the carapace are prohibited. Some of the shallow areas targeted by commercial divers also attract fishers harvesting lobsters with bully nets (GMFMC and SAFMC 1987).

2.3.3. Recreational Fishery

The magnitude of the recreational fishery was unknown until 1991 when a recreational permit requirement was implemented. An average of 130,000 recreational harvest permits are sold annually, though not all permits holders engage in lobster fishing (Robson 2006). Estimating the overall effort in the recreational fishery is difficult. Mail surveys, randomly dispatched to 5,000 individuals holding recreational lobster permits, are currently used to estimate recreational effort (see Eaken 2001 for survey details). Those surveys provide estimates of recreational landings during the 2-day special recreational season, and the first month of the regular commercial season. The two-day special recreational season is held during the last Wednesday and Thursday of July. The regular recreational fishing season otherwise coincides with the commercial season running from August 6 through March 31. During the 2005 2-day special recreational season, approximately 291,000 pounds of spiny lobster were harvested (R. Beaver, Florida Fish and Wildlife Conservation Commission, pers. comm. 2006).

Recreational fishing for spiny lobsters is primarily conducted by divers using scuba equipment, hookah rigs or freediving to collect lobsters by hand (GMFMC and SAFMC 1987). Snares are commonly used by recreational divers targeting lobsters. A snare consists of a long, thin pole that has a loop of coated wire on the end. 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 to capture and extract the lobster (Figure 2.4) (Barnette 2001). Bully nets are also used to collect lobster on shallow flats but the recreational catch attributed to this gear is very small. Traps are prohibited for recreational use, as are spears, hooks, or other gear types that would otherwise pierce the carapace. Lobsters taken in the recreational fishery are generally kept for personal consumption and not sold (GMFMC and SAFMC 1982).

Figure 2.5 Example of a Spiny Lobster Snare



From: Barnette 2001

There is little difference in the techniques and gears used by recreational and commercial divers targeting spiny lobsters. Like the commercial fishery, most recreational fishing effort occurs in Monroe County. Most recreational divers use their own boats or rent a boat from a local vendor while in Monroe County. Three to four divers per boat is common during the 2-day special recreational season (GMFMC and SAFMC 1982). Most divers stay in relatively shallow water (no deeper than 30 ft), though a few are believed to dive below 80 ft (Austin et al. 1977). Recreational divers target spiny lobsters in the same natural and artificial habitats commercial divers utilize and tend to also fish the same shelf areas, from shore seaward to the reef tract. Outside of Monroe County, the majority of recreationally harvested spiny lobsters are landed in Dade and Broward Counties, Florida. Recreational divers in these areas tend to fish the channels and flats between Cape Florida and Ragged Keys, as well as the creeks from Ragged Keys to Key Largo. Some recreational diving occurs as far north as West Palm Beach (GMFMC and SAFMC 1987).

2.4 Action Area

The action area for a biological opinion is defined as the area affected, directly or indirectly, by the fishery and not merely the immediate area where the action is occurring. The federal spiny lobster fishery, managed jointly by the GMFMC and SAFMC under the SLFMP, occurs throughout the South Atlantic and Gulf of Mexico regions. The SAFMC has jurisdiction throughout the South Atlantic states' EEZs, which extends from 3 nmi seaward of Florida, Georgia, South Carolina and North Carolina to 200 nmi.[4] The GMFMC has jurisdiction over the Gulf of Mexico states' EEZs, which include the waters 9 nmi seaward of the states of Florida and Texas, and 3 nmi seaward of the states of Alabama, Mississippi, and Louisiana, to 200 nmi from the seaward boundary of each coastal state. Gears likely to affect one or more of the listed species known to occur within these regions (detailed discussion to follow in Section 3) are only used off Florida. However, because the fishery is authorized to occur anywhere in the South Atlantic and Gulf of Mexico EEZs, the federal action indirectly affects both areas. Therefore, the action area of this consultation includes all of the U.S. South Atlantic and Gulf of Mexico EEZ.

[4] The EEZ off Florida does not extend all the way out 200 nm due to the close proximity of the Bahamas and Cuba.

3.0 Status of Species and Critical Habitat

Marine Mammals	Status
Blue whale (*Balaenoptera musculus*)	Endangered
Sei whale (*Balaenoptera borealis*)	Endangered
Sperm whale (*Physeter macrocephalus*)	Endangered
Fin whale (*Balaenoptera physalus*)	Endangered
Humpback whale (*Megaptera novaeangliae*)	Endangered
North Atlantic right whale (*Eubalaena glacialis*)	Endangered
Sea Turtles	
Green sea turtle (*Chelonia mydas*)	Endangered/Threatened*
Hawksbill sea turtle (*Eretmochelys imbricata*)	Endangered
Kemp's ridley sea turtle (*Lepidochelys kempii*)	Endangered
Leatherback sea turtle (*Dermochelys coriacea*)	Endangered
Loggerhead sea turtle (*Caretta caretta*)	Threatened
Invertebrates	
Elkhorn coral (*Acropora palmata*)	Threatened
Staghorn coral (*Acropora cervicornis*)	Threatened
Fish	
Smalltooth sawfish (*Pristis pectinata*)	Endangered**
Gulf sturgeon (*Acipencer oxyrinchus desotoi*)	Threatened

**Green sea turtles in U.S. waters are listed as threatened except for the Florida breeding population, which is listed as endangered.*
***The U.S. distinct population segment (DPS).*

Critical Habitat

Acropora critical habitat has been designated in the action area. The Florida area contains three sub-areas: (1) The shoreward boundary for Florida sub-area A begins at the 6-ft (1.8 m) contour at the south side of Boynton Inlet, Palm Beach County at 26° 32' 42.5" N; then runs due east to the point of intersection with the 98-ft (30 m) contour; then follows the 98-ft (30 m) contour to the point of intersection with latitude 25° 45' 55" N, Government Cut, Miami-Dade County; then runs due west to the point of intersection with the 6-ft (1.8 m) contour, then follows the 6-ft (1.8 m) contour to the beginning point; (2) The shoreward boundary of Florida sub-area B begins at the MLW line at 25° 45' 55" N, Government Cut, Miami-Dade County; then runs due east to the point of intersection with the 98-ft (30 m) contour; then follows the 98-ft (30 m) contour to the point of intersection with longitude 82° W; then runs due north to the point of intersection with the South Atlantic Fishery Management Council (SAFMC) boundary at 24° 31' 35.75" N; then follows the SAFMC boundary to a point of intersection with the MLW line at Key West, Monroe County; then follows the MLW line, the SAFMC boundary (see 50 CFR 600.105(c)), and the COLREGS line (see 33 CFR 80.727. 730, 735, and 740) to the beginning point; and (3) The seaward boundary of Florida sub-area C (the Dry Tortugas) begins at the northern intersection of the 98-ft (30 m) contour and longitude 82° 45’ W; then follows the 98-ft (30 m) contour west around the Dry Tortugas, to the southern point of intersection with longitude 82° 45’ W; then runs due north to the beginning point.

We have determined that the proposed action being considered in this opinion is not likely to adversely affect the following species or critical habitat listed under the ESA: blue whales, sei whales, sperm whales, fin whales, humpback whales, North Atlantic right whales, Gulf sturgeon, North Atlantic right whale and *Acropora* critical habitat**.** These species and critical habitat are therefore excluded from further analysis and consideration in this opinion. The following discussion summarizes our rationale for these determinations and conclusions.

Blue, Sei, and Sperm Whales
The proposed action is not likely to adversely affect blue, sei, or sperm whales. In the Gulf of Mexico and South Atlantic region, blue, sei, and sperm whales are predominantly found seaward of the continental shelf. Sightings of sperm whales are almost exclusively in the continental shelf edge and continental slope areas (Scott and Sadove 1997). Sei and blue whales also typically occur in deeper waters and neither is commonly observed in the waters of the Gulf of Mexico or off the East Coast (CETAP 1982, Wenzel et al. 1988, Waring et al. 2002 and 2006). The depth at which these species are found makes any interaction with the spiny lobster fishery extremely unlikely. There are no documented take of these species by the spiny lobster fishery. For these reasons, NMFS believes the likelihood of these species being adversely affected by the proposed action is extremely low and therefore discountable.

Fin Whales
The proposed action is not likely to adversely affect fin whales. Fin whales are frequently found along the U.S. east coast, north of Cape Hatteras, North Carolina. They are also closely associated with the 100-m isobath, with sightings also spread over deeper water including canyons along the shelf break (Waring et al. 2006). The geographic range of the fin whale does not overlap areas of spiny lobster trap fishing as described above in Section 2. Some fishing effort for spiny lobster does occur off North Carolina, but the gears and techniques prosecuted there (see Section 2.2.1) make any interaction between the fishery and the fin whale extremely unlikely. Additionally, the 2008 List of Fisheries (72 FR 227; November 27, 2007) lists the Florida Spiny Lobster Trap/Pot fishery as a Category III Fishery under the MMPA. Category III fisheries are those where annual mortality and serious injury of a stock resulting from a fishery is less than or equal to one percent 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. There has never been documented interaction or take of a large whale with a spiny lobster trap since the List of Fisheries was implemented in 1996. For these reasons, NMFS believes the likelihood of this species being adversely affected by the proposed action is extremely low and therefore discountable.

Humpback Whales
The proposed action is not likely to adversely affect humpback whales. Humpback whales are considered coastal whale species and are sighted most frequently in the South Atlantic along the southeastern U.S. from November through March on their migration south. December and January are peak times for humpbacks to occur off North Carolina as they migrate southward through coastal waters to their wintering grounds, with a second peak occurrence in March and April as they migrate north again to their summer feeding grounds.

There is no directed commercial fishing effort for spiny lobster in North Carolina. The gears used (rod-and-reel and diving spear) to take spiny lobster opportunistically are extremely unlikely to interact with humpbacks. There are no documented takes of this species by the spiny lobster fishery. For these reasons, NMFS believes the likelihood of this species being adversely affected by the proposed action is extremely low and therefore discountable.

North Atlantic Right Whales
The continued authorization of the Gulf of Mexico and South Atlantic Spiny Lobster Fishery is not likely to adversely affect right whales. North Atlantic right whales are likely to occur in the action area, from approximately November through March. These animals rarely migrate far enough to the south to overlap the areas where the majority of spiny lobster harvest occurs. The hand harvest methods used in the fishery (scuba and bully nets) will not affect right whales. Bully nets require an active fishing technique only used when target prey can be seen and the nets must be tended constantly. Due to the dynamic nature of this fishing technique, it is highly unlikely that a right whale would be accidentally entangled in this gear. Scuba diving is also extremely unlikely to adversely affect right whales. We believe any right whales coming in close proximity to divers would change their route to avoid them and any behavioral effects resulting from the presence of divers will be insignificant.

Traps used to commercially harvest spiny lobsters are also not likely to adversely affect right whales. Trap fishing within the action area occurs primarily in the Florida Keys (GMFMC and SAFMC 1987). Right whales occur only very rarely in areas where the trap fishery may occur. From 1935-2006, 820 right whales sightings have been documented off Florida, only 11 have occurred south of Cape Canaveral, Florida, and none were sighted in the Florida Keys (Read et al. 2007). Likewise, NMFS' List of Fisheries has never documented an interaction between a large whale and a spiny lobster trap since the List of Fisheries was implemented in 1996. For these reasons, NMFS believes the likelihood of this species being adversely affected by trap gear is extremely low and therefore discountable.

Gulf Sturgeon
Gulf sturgeon are not likely to be adversely affected by the proposed action. The Gulf sturgeon is an anadromous fish, inhabiting coastal rivers from Louisiana to Florida during the warmer months and over-wintering in estuaries, bays, and the Gulf of Mexico. Available data indicates Gulf sturgeon in the estuarine and marine environment show a

preference for sandy shoreline habitats with water depths less than 3.5 m and salinity less than 6.3 parts per thousand (ppt) (Fox and Hightower 1998, Parauka et al. 2001). The federal spiny lobster fishery in the Gulf of Mexico operates well outside of the preferred habitat and salinity ranges of Gulf sturgeon. For these reasons, NMFS believes the likelihood of this species being adversely affected by the proposed action is extremely low and therefore discountable.

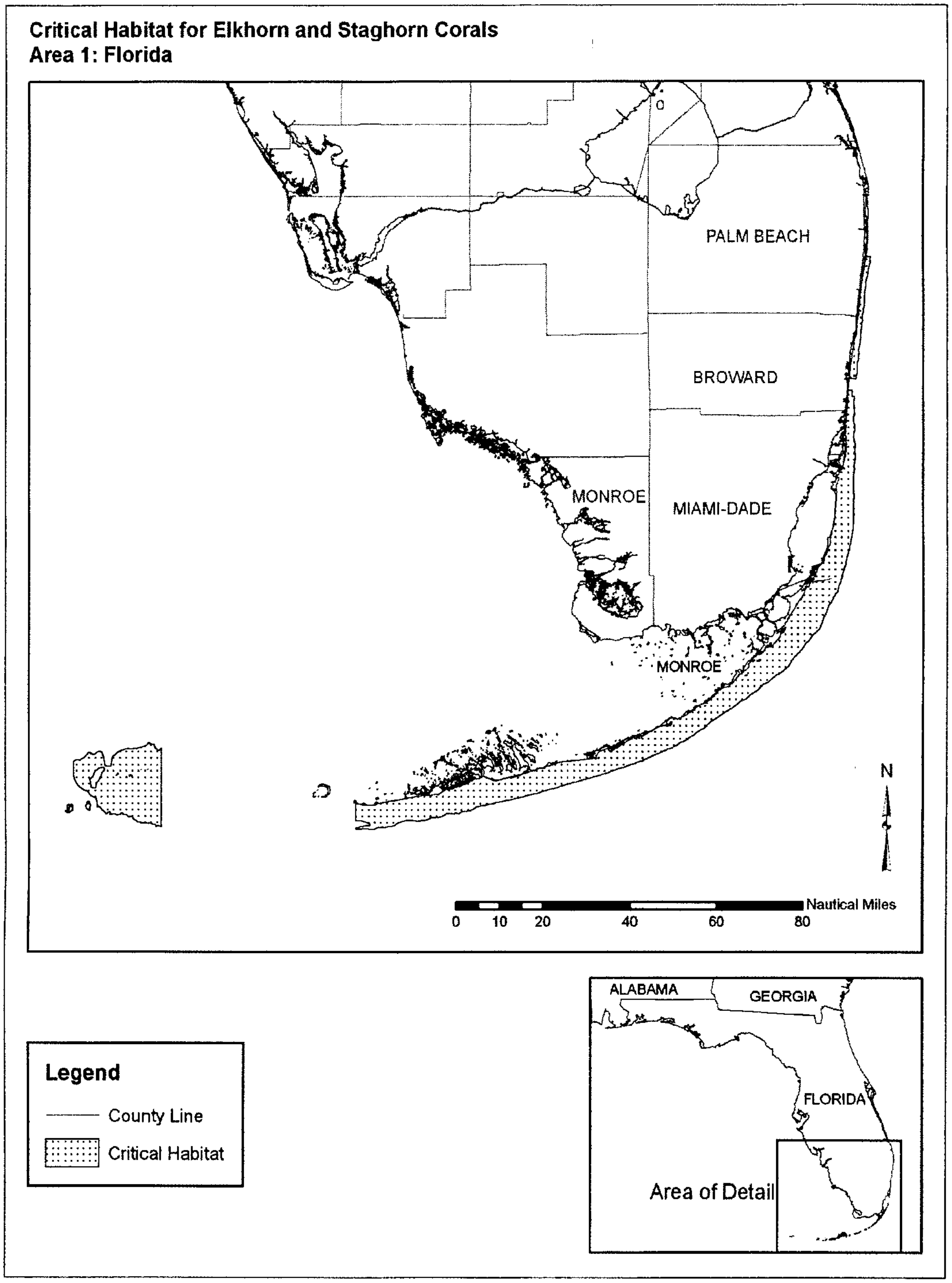
Acropora Critical Habitat

The physical or biological feature of *Acropora* critical habitat essential to their conservation (typically referred to as the primary constituent element, PCE) is substrate of suitable quality and availability to support larval settlement and recruitment, and reattachment and recruitment of asexual fragments. Substrate of suitable quality and availability is defined as consolidated hardbottom or dead coral skeleton that is free from fleshy macroalgae cover and sediment cover, occurring in water depths from the mean high water (MHW) line to 30 meters (98 feet). This feature has been identified in four locations within the jurisdiction of the United States: Florida, Puerto Rico, St. Thomas/St. John, and St. Croix. Only the Florida area falls within the action area. The Florida area contains three sub-areas: (1) The shoreward boundary for Florida sub-area A begins at the 6-ft (1.8 m) contour at the south side of Boynton Inlet, Palm Beach County at 26° 32' 42.5" N; then runs due east to the point of intersection with the 98-ft (30 m) contour; then follows the 98-ft (30 m) contour to the point of intersection with latitude 25° 45' 55" N, Government Cut, Miami-Dade County; then runs due west to the point of intersection with the 6-ft (1.8 m) contour, then follows the 6-ft (1.8 m) contour to the beginning point; (2) The shoreward boundary of Florida sub-area B begins at the MLW line at 25° 45' 55" N, Government Cut, Miami-Dade County; then runs due east to the point of intersection with the 98-ft (30 m) contour; then follows the 98-ft (30 m) contour to the point of intersection with longitude 82° W; then runs due north to the point of intersection with the South Atlantic Fishery Management Council (SAFMC) boundary at 24° 31’ 35.75” N; then follows the SAFMC boundary to a point of intersection with the MLW line at Key West, Monroe County; then follows the MLW line, the SAFMC boundary (see 50 CFR 600.105(c)), and the COLREGS line (see 33 CFR 80.727. 730, 735, and 740) to the beginning point; and (3) The seaward boundary of Florida sub-area C (the Dry Tortugas) begins at the northern intersection of the 98-ft (30 m) contour and longitude 82° 45’ W; then follows the 98-ft (30 m) contour west around the Dry Tortugas, to the southern point of intersection with longitude 82° 45’ W; then runs due north to the beginning point (Figure 3.1)(73 FR 72210; November 26, 2008).

Commercial/recreational bully netting and commercial/recreational diving for spiny lobster does not affect the PCE identified for *Acropora* critical habitat, or occurs so rarely that any affect on the PCE is discountable. Commercial trapping may affect *Acropora* critical habitat, but any affects will be temporary and insignificant. While commercial trapping does occur in areas where the PCE is present, the proposed action will not adversely affect the physical or biological features essential for conservation. Traps do not cause consolidated hardbottom to become unconsolidated, nor do they cause growth of macroalgae or cause sedimentation. For these reasons, we believe the annual deployment of traps will have no effect on consolidated hardbottom, macroalgal growth, or sedimentation, and we do not expected cumulative effects from trap deployment year after year. A trap could temporarily cover an area with the desired physical or biological characteristics. However, once a trap is retrieved the area it covered immediately becomes available. Therefore, we believe that trap impacts to *Acropora* critical habitat will be temporary and of such limited scope, that any adverse affects will be insignificant.

Likewise, any adverse affects to dead coral skeletons from spiny lobster trap fishing are discountable. No estimates are available regarding the area of dead coral skeletons in the action area. Therefore, to evaluate the impact of trap fishing on dead coral skeletons, we assumed dead coral skeletons suitable for *Acropora* larvae settlement covered each square meter of critical habitat. While we believe this circumstance is extremely unlikely to exist, this allowed us to make the most conservative estimate of impacts. Even under this highly unlikely set of conditions, only 0.25 percent of dead coral skeletons would be adversely impacted annually by traps mobilization and fishing, based on our estimate of trap impacts to ASH calculated in Section 5.0. This suggests that the rates of interaction between traps and dead coral skeletons are incredibly low even in this unlikely, but conservative, scenario. Under conditions more representative of the natural environment, we believe trap impacts to dead coral skeletons would be orders of magnitude lower. Thus, we believe any adverse affects to dead coral skeletons from spiny lobster trap fishing are discountable.

Figure 3.1 Map of the Elkhorn and Staghorn Critical Habitat Designated in Florida



3.2 Analysis of the Species Likely to be Adversely Affected

The following subsections are synopses of the best available information on the life history, distribution, population trends, and current status of the five species of sea turtles that are likely to be adversely affected by one or more components of the proposed action. Additional background information on the status of sea turtle species can be found in a number of published documents, including: recovery plans for the Atlantic green sea turtle (NMFS and USFWS 1991a), hawksbill sea turtle (NMFS and USFWS 1993), Kemp's ridley sea turtle (USFWS and NMFS 1992), leatherback sea turtle (NMFS and USFWS 1992), loggerhead sea turtle (NMFS and USFWS 2008); Pacific sea turtle recovery plans (NMFS and USFWS, 1998a-e); and sea turtle status reviews and biological reports (NMFS and USFWS 1995, Marine Turtle Expert Working Group (TEWG) 1998, 2000, and 2007, NMFS SEFSC 2001). Information on life history and threats to *Acropora* corals comes primarily for the *Acropora* status review document (*Acropora* BRT 2005). Sources of background information on the smalltooth sawfish include the smalltooth sawfish status review (NMFS 2000), the proposed and final listing rules, and several publications (Simpfendorfer 2001, Seitz and Poulakis 2002, Simpfendorfer and Wiley 2004, Poulakis and Seitz 2004).

3.2.1 Green Sea Turtle

Green turtles are distributed circumglobally, and can be found in the Pacific, Indian and Atlantic Oceans as well as the Mediterranean Sea (NMFS and USFWS 1991a; Seminoff 2004; NMFS and USFWS 2007a). In 1978, the Atlantic population of the green sea turtle was listed as threatened under the ESA, except for the breeding populations in Florida and on the Pacific coast of Mexico, which were listed as endangered.

3.2.1.1 Pacific Ocean

Green turtles occur in the eastern, central, and western Pacific. Foraging areas are also found throughout the Pacific and along the southwestern U.S. coast (NMFS and USFWS 1998a). Nesting is known to occur in the Hawaiian archipelago, American Samoa, Guam, and various other sites in the Pacific. The only major population (>2,000 nesting females) of green turtles in the western Pacific occurs in Australia and Malaysia, with smaller colonies throughout the area. Green turtles have generally been thought to be declining throughout the Pacific Ocean, with the exception of Hawaii, from a combination of overexploitation and habitat loss (Seminoff 2002). Indonesia has a widespread distribution of green turtles, but has experienced large declines over the past 50 years. Historically, green turtles were used in many areas of the Pacific for food. They were also commercially exploited and this, coupled with habitat degradation led to their decline in the Pacific (NMFS and USFWS 1998a). Green turtles in the Pacific continue to be affected by poaching, habitat loss or degradation, fishing gear interactions, and fibropapillomatosis (NMFS and USFWS 1998a, NMFS 2004a).

Hawaiian green turtles are genetically distinct and geographically isolated, and the population appears to be increasing in size despite the prevalence of fibropapilloma and spirochidiasis (Aguirre et al. 1998 in Balazs and Chaloupka 2003). The East Island nesting beach in Hawaii is showing a 5.7 percent annual growth rate over 25 plus years (Chaloupka et al. 2007). In the eastern Pacific, mitochondrial DNA analysis has indicated that there are three key nesting populations: Michoacán, Mexico; Galapagos Islands, Ecuador; and Islas Revillagigedos, Mexico (Dutton 2003). The number of nesting females per year exceeds 1,000 females at each site (NMFS and USFWS 2007a). However, historically, greater than 20,000 females per year are believed to have nested in Michoacán, alone (Cliffton et al. 1982, NMFS and USFWS 2007a). Thus the current number of nesting females is still far below what has historically occurred. There is also sporadic green turtle nesting along the Pacific coast of Costa Rica. However, at least a few of the non-Hawaiian nesting stocks in the Pacific have recently been found to be undergoing long-term increases. Data sets over 25 years in Chichi-jima, Japan, Heron Island, Australia, and Raine Island, Australia, show increases (Chaloupka et al. 2007). These increases are thought to be the direct result of long-term conservation measures.

3.2.1.2 Indian Ocean

There are numerous nesting sites for green sea turtles in the Indian Ocean. One of the largest nesting sites for green sea turtles worldwide occurs on the beaches of Oman where an estimated 20,000 green sea turtles nest annually (Hirth 1997, Ferreira et al. 2003). Based on a review of the 32 index sites used to monitor green sea turtle nesting worldwide, Seminoff (2004) concluded that declines in green turtle nesting were evident for many of the Indian Ocean index sites. While several of these had not demonstrated further declines in the more recent past, only the Comoros Island index site in the western Indian Ocean showed evidence of increased nesting (Seminoff 2004).

3.2.1.3 Atlantic Ocean

Life History and Distribution
The estimated age at sexual maturity for green sea turtles is between 20-50 years (Balazs 1982, Frazer and Ehrhart 1985). Green sea turtle mating occurs in the waters off the nesting beaches. Each female deposits 1-7 clutches (usually 2-3) during the breeding season at 12-14 day intervals. Mean clutch size is highly variable among populations, but averages 110-115 eggs/nest. Females usually have 2-4 or more years between breeding seasons, whereas males may mate every year (Balazs 1983). After hatching, green sea turtles go through a post-hatchling pelagic stage where they are associated with drift lines of algae and other debris. At approximately 20- to 25-cm carapace length, juveniles leave pelagic habitats and enter benthic foraging areas (Bjorndal 1997).

Green sea turtles are primarily herbivorous, feeding on algae and sea grasses, but also occasionally consume jellyfish and sponges. The post-hatchling, pelagic-stage individuals are assumed to be omnivorous, but little data are available.

Green sea turtle foraging areas in the southeastern United States include any coastal shallow waters having macroalgae or seagrasses. This includes areas near mainland coastlines, islands, reefs, or shelves, and any open-ocean surface waters, especially where advection from wind and currents concentrates pelagic organisms (Hirth 1997, NMFS and USFWS 1991a). Principal benthic foraging areas in the southeastern United States include Aransas Bay, Matagorda Bay, Laguna Madre, and the Gulf inlets of Texas (Doughty 1984, Hildebrand 1982, Shaver 1994), the Gulf of Mexico off Florida from Yankeetown to Tarpon Springs (Caldwell and Carr 1957, Carr 1984), Florida Bay and the Florida Keys (Schroeder and Foley 1995), the Indian River Lagoon system, Florida (Ehrhart 1983), and the Atlantic Ocean off Florida from Brevard through Broward Counties (Wershoven and Wershoven 1992, Guseman and Ehrhart 1992). Adults of both sexes are presumed to migrate between nesting and foraging habitats along corridors adjacent to coastlines and reefs.

Population Dynamics and Status

Some of the principal feeding pastures in the western Atlantic Ocean include the upper west coast of Florida and the northwestern coast of the Yucatán Peninsula. Additional important foraging areas in the western Atlantic include the Mosquito Lagoon and Indian River Lagoon systems and nearshore wormrock reefs between Sebastian and Ft. Pierce Inlets in Florida, Florida Bay, the Culebra archipelago and other Puerto Rico coastal waters, the south coast of Cuba, the Caribbean coast of Panama, the Miskito Coast in Nicaragua, and scattered areas along Colombia and Brazil (Hirth 1997). The summer developmental habitat for green turtles also encompasses estuarine and coastal waters from North Carolina to as far north as Long Island Sound (Musick and Limpus 1997).

The vast majority of green sea turtle nesting within the southeastern United States occurs in Florida (Meylan et al. 1995, Johnson and Ehrhart 1994). Green sea turtle nesting in Florida has been increasing since 1989 (Florida Fish and Wildlife Conservation Commission, Florida Marine Research Institute Index Nesting Beach Survey Database). Nest counts can also be used to estimate the number of reproductively mature females nesting annually. The 5-year status review for the species identified eight geographic areas considered primary sites for green sea turtle nesting in the Atlantic/Caribbean and reviewed the trend in nest count data for each (NMFS and USFWS 2007a). These include: (1) Yucatán Peninsula, Mexico, (2) Tortuguero, Costa Rica, (3) Aves Island, Venezuela, (4) Galibi Reserve, Suriname, (5) Isla Trindade, Brazil, (6) Ascension Island, United Kingdom, (7) Bioko Island, Equatorial Guinea, and (8) Bijagos Archipelago (Guinea-Bissau) (NMFS and USFWS 2007a). Nesting at all of these sites was considered stable or increasing with the exception of Bioko Island and the Bijagos Archipelago where the lack of sufficient data precluded a meaningful trend assessment for either site (NMFS and USFWS 2007a). Seminoff (2004) likewise reviewed green sea turtle nesting data for eight sites in the western, eastern, and central Atlantic, including all of the above with the exception that nesting in Florida was reviewed in place of Isla Trindade, Brazil. Seminoff (2004) concluded that all sites in the central and western Atlantic showed increased nesting with the exception of nesting at Aves Island, Venezuela, while both sites in the eastern Atlantic demonstrated decreased nesting. These sites are not inclusive of all green sea turtle nesting in the Atlantic. However, other sites are not believed to support nesting levels high enough that would change the overall status of the species in the Atlantic (NMFS and USFWS 2007a).

By far, the most important nesting concentration for green turtles in the western Atlantic is in Tortuguero, Costa Rica (NMFS and USFWS 2007a). Nesting in the area has increased considerably since the 1970s and nest count data from 1999-2003 suggest nesting by 17,402-37,290 females per year (NMFS and USFWS 2007a). The number of females nesting per year on beaches in the Yucatán, Aves Island, Galibi Reserve, and Isla Trindade number in the hundreds to low thousands, depending on the site (NMFS and USFWS 2007a). In the United States, certain Florida nesting beaches have been designated index beaches. Index beaches were established to standardize data collection methods and effort on key nesting beaches. The pattern of green turtle nesting shows biennial peaks in abundance with a generally positive trend during the ten years of regular monitoring since establishment of the index beaches in 1989, perhaps due to increased protective legislation throughout the Caribbean (Meylan et al. 1995). An average of 5,039 green turtle nests were laid annually in Florida between 2001 and 2006, with a low of 581 in 2001 and a high of 9,644 in 2005 (NMFS and USFWS 2007a). Data from index nesting beaches program in Florida support the dramatic increase in nesting. In 2007, there were 9,455 green turtle nests found just on index-nesting beaches, the highest since index beach monitoring began in 1989. The number fell back to 6,385 in 2008, but that is thought to be part of the normal biennial nesting cycle for green turtles (FWCC Index Nesting Beach Survey Database). Occasional nesting has been documented along the Gulf coast of Florida, at southwest Florida beaches, as well as the beaches on the Florida Panhandle (Meylan et al. 1995). More recently, green turtle nesting occurred on Bald Head Island, North Carolina; just east of the mouth of the Cape Fear River; on Onslow Island; and on Cape Hatteras National Seashore. Increased nesting has also been observed along the Atlantic coast of Florida, on beaches where only loggerhead nesting was observed in the past (Pritchard 1997). Recent modeling by Chaloupka et al. (2007) using data sets of 25 years or more has resulted in an estimate of the Florida nesting stock at the Archie Carr National Wildlife Refuge growing at an annual rate of 13.9 percent, and the Tortuguero, Costa Rica, population growing at 4.9 percent annually.

There are no reliable estimates of the number of immature green sea turtles that inhabit coastal areas (where they come to forage) of the southeastern United States. However, information on incidental captures of immature green sea turtles at the St. Lucie Power Plant (they have averaged 215 green sea turtle captures per year since 1977) in St. Lucie County, Florida (on the Atlantic coast of Florida), show that the annual number of immature green sea turtles captured has increased significantly in the past 26 years (FPL 2002). Ehrhart et al. (2007) has also documented a significant increase in in-water abundance of green turtles in the Indian River Lagoon area. It is likely that immature green sea turtles foraging in the southeastern United States come from multiple genetic stocks; therefore, the status of immature green sea turtles in the southeastern United States might also be assessed from trends at all of the main regional nesting beaches, principally Florida, Yucatán, and Tortuguero.

Threats

The principal cause of past declines and extirpations of green sea turtle assemblages has been the over-exploitation of green sea turtles for food and other products. Although intentional take of green sea turtles and their eggs is not extensive within the southeastern United States, green sea turtles that nest and forage in the region may spend large portions of their life history outside the region and outside U.S. jurisdiction, where exploitation is still a threat. However, there are still significant and ongoing threats to green sea turtles from human-related causes in the United States. These threats include beach armoring, erosion control, artificial lighting, beach disturbance (e.g., driving on the beach), pollution, foraging habitat loss as a result of direct destruction by dredging, siltation, boat damage, other human activities, and interactions with fishing gear. Sea sampling coverage in the pelagic driftnet, pelagic longline, Southeast shrimp trawl, and summer flounder bottom trawl fisheries has recorded takes of green turtles. There is also the increasing threat from green sea turtle fibropapillomatosis disease. Presently, this disease is cosmopolitan and has been found to affect large numbers of animals in some areas, including Hawaii and Florida (Herbst 1994, Jacobson 1990, Jacobson et al. 1991).

There is a large and growing body of literature on past, present, and future impacts of global climate change induced by human activities, i.e., global warming. Some of the likely effects commonly mentioned are sea level rise, increased frequency of severe weather events, and change in air and water temperatures. The Environmental Protection Agency's climate change webpage provides basic background information on these and other measured or anticipated effects (see www.epa.gov/climatechange/index.html). However, the impacts on sea turtles currently cannot be predicted, for the most part, with any degree of certainty.

The Intergovernmental Panel on Climate Change has stated that global climate change is unequivocal (IPCC 2007) and its impacts may have significant impacts to the hatchling sex ratios of green turtles (NMFS and USFWS 2007a). In marine turtles, sex is determined by temperature in the middle third of incubation with female offspring produced at higher temperatures and males at lower temperatures within a thermal tolerance range of 25º-35°C (Ackerman 1997). Increases in global temperature could potentially skew future sex ratios toward a higher numbers of females (NMFS and USFWS 2007a). Green sea turtle hatchling size also appears to be influenced by incubation temperatures, with smaller hatchlings produced at higher temperatures (Glenn et al. 2003).

The effects from increased temperatures may be exacerbated on developed nesting beaches where shoreline armoring and construction has denuded vegetation. Sea level rise from global climate change (IPCC 2007) is also a potential problem, particularly for areas with low-lying beaches where sand depth is a limiting factor, as the sea may inundate nesting sites and decrease available nesting habitat (Daniels et al. 1993, Fish et al. 2005, Baker et al. 2006). The loss of habitat because of climate change could be accelerated due to a combination of other environmental and oceanographic changes such as increased frequency of storms and/or changes in prevailing currents, both of which could lead to increased beach loss via erosion (Antonelis et al. 2006, Baker et al. 2006).

Other changes in the marine ecosystem caused by global climate change (e.g., salinity, oceanic currents, dissolved oxygen levels, nutrient distribution, etc.) could influence the distribution and abundance of phytoplankton, zooplankton, submerged aquatic vegetation, forage fish, etc., which could ultimately affect the primary foraging areas of green sea turtles.

3.2.1.4 Summary of Status for Atlantic Green Sea Turtles

Green turtles range in the western Atlantic from Massachusetts to Argentina, including the Gulf of Mexico and Caribbean, but are considered rare in benthic areas north of Cape Hatteras (Wynne and Schwartz 1999). Green turtles face many of the anthropogenic threats described above. In addition, green turtles are also susceptible to fibropapillomatosis, which can result in death. In the continental United States, green turtle nesting occurs on the Atlantic coast of Florida (Ehrhart 1979). Recent population estimates for the western Atlantic area are not available. The pattern of green turtle nesting shows biennial peaks in abundance, with a generally positive trend during the almost 20 years of regular monitoring since establishment of index beaches in Florida in 1989. However, given the species' late sexual maturity, caution is warranted about over-interpreting nesting trend data collected for less than 20 years.

3.2.2 Hawksbill Sea Turtle

The hawksbill turtle was listed as endangered under the precursor of the ESA on June 2, 1970, and is considered Critically Endangered by the International Union for the Conservation of Nature (IUCN). The hawksbill is a medium-sized sea turtle, with adults in the Caribbean ranging in size from approximately 62.5 to 94.0 cm straight carapace length. The species occurs in all ocean basins, although it is relatively rare in the Eastern Atlantic and Eastern Pacific, and absent from the Mediterranean Sea. Hawksbills are the most tropical sea turtle species, ranging from approximately 30°N latitude to 30°S latitude. They are closely associated with coral reefs and other hardbottom habitats, but they are also found in other habitats including inlets, bays and coastal lagoons (NMFS and USFWS 1993). There are only five remaining regional nesting populations with more than 1,000 females nesting annually. These populations are in the Seychelles, Mexico, Indonesia, and two in Australia (Meylan and Donnelly 1999). There has been a global population decline of over 80 percent during the last three generations (105 years) (Meylan and Donnelly 1999).

3.2.2.1 Indian Ocean

Approximately 83 nesting rookeries have been identified for hawksbill sea turtles, 31 occur in the Indian Ocean. Many of those nesting areas are relatively small hosting 100 or fewer nesting females annually. However, some nesting rookeries in Madagascar, Iran, and Western Australia may have as many as 1,000 to 2,000 nesting females annually. Based on the number of nesting females the population trends at the 31 nesting rookeries over the recent past (last 20 years) have remained stable in 2 locations, declined at 5, and are unknown for 24. Historically (20 to 100 years ago), populations trends at these nesting rookeries have been in decline at 17 sites and are unknown for 14 (NMFS and USFWS 2007b).

3.2.2.2 Pacific Ocean

Anecdotal reports throughout the Pacific indicate that the current Pacific hawksbill population is well below historical levels (NMFS 2004a). It is believed that this species is rapidly approaching extinction in the Pacific because of harvesting for its meat, shell, and eggs as well as destruction of nesting habitat (NMFS 2004a). Hawksbill sea turtles nest in the Hawaiian Islands as well as the islands and mainland of Southeast Asia, from China to Japan, and throughout the Philippines, Malaysia, Indonesia, Papua New Guinea, the Solomon Islands, and Australia (NMFS 2004a). However, along the eastern Pacific Rim where nesting was common in the 1930s, hawksbills are now rare or absent (Cliffton et al. 1982, NMFS 2004a).

3.2.2.3 Atlantic Ocean

In the western Atlantic, the largest hawksbill nesting population occurs on the Yucatán Peninsula of Mexico (Garduño-Andrade et al. 1999). With respect to the United States, nesting occurs in Puerto Rico, the U.S. Virgin Islands, and along the southeast coast of Florida. Nesting also occurs outside of the United States and its territories, in Antigua, Barbados, Costa Rica, Cuba, and Jamaica (Meylan 1999a). Outside of the nesting areas, hawksbills have been seen off the U.S. Gulf of Mexico states and along the Eastern Seaboard as far north as Massachusetts, although sightings north of Florida are rare (NMFS and USFWS 1993).

Life History and Distribution
The best estimate of age at sexual maturity for hawksbill sea turtles is about 20-40 years (Chaloupka and Limpus 1997, Crouse 1999a). Reproductive females undertake periodic (usually non-annual) migrations to their natal beach to nest. Movements of reproductive males are less well known, but are presumed to involve migrations to their nesting beach or to courtship stations along the migratory corridor (Meylan 1999b). Females nest an average of 3-5 times per season (Meylan and Donnelly 1999, Richardson et al. 1999). Clutch size is larger on average (up to 250 eggs) than that of other sea turtles (Hirth 1980). Reproductive females may exhibit a high degree of fidelity to their nest sites.

The life history of hawksbills consists of a pelagic stage that 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), followed by residency in developmental habitats (foraging areas where juveniles reside and grow) in coastal waters. Adult foraging habitat, which may or may not overlap with developmental habitat, is typically coral reefs, although other hard-bottom communities and occasionally mangrove-fringed bays may be occupied. Hawksbills show fidelity to their foraging areas over several years (van Dam and Díez 1998).

The hawksbill's diet is highly specialized and consists primarily of sponges (Meylan 1988). Other food items, notably corallimorphs and zooanthids, have been documented to be important in some areas of the Caribbean (van Dam and Díez 1997, Mayor et al. 1998, León and Díez 2000).

Population Dynamics and Status

Nesting within the southeastern United States and U.S. Caribbean is restricted to Puerto Rico (>650 nests/yr), the U.S. Virgin Islands (~400 nests/yr), and, rarely, Florida (0-4 nests/yr) (Eckert 1995, Meylan 1999a, Florida Fish and Wildlife Conservation Commission, Florida Marine Research Institute's Statewide Nesting Beach Survey data 2002). At the two principal nesting beaches in the U.S. Caribbean where long-term monitoring has been carried out, populations appear to be increasing (Mona Island, Puerto Rico) or stable (Buck Island Reef National Monument, St. Croix, USVI) (Meylan 1999a).

Threats

As with other sea turtle species, hawksbill sea turtles are affected by habitat loss, habitat degradation, marine pollution, marine debris, fishery interactions, and poaching in some parts of their range. A complete list of other indirect factors can be found in NMFS SEFSC (2001). There continues to be a black market for hawksbill shell products ("tortoiseshell"), which likely contributes to the harvest of this species.

There is a large and growing body of literature on past, present, and future impacts of global climate change induced by human activities, i.e., global warming. Some of the likely effects commonly mentioned are sea level rise, increased frequency of severe weather events, and change in air and water temperatures. The Environmental Protection Agency's climate change webpage provides basic background information on these and other measured or anticipated effects (see www.epa.gov/climatechange/index.html). However, the impacts on sea turtles currently cannot be predicted, for the most part, with any degree of certainty.

The Intergovernmental Panel on Climate Change has stated that global climate change is unequivocal (IPCC 2007) and its impacts may have affected the hatchling sex ratios of hawksbill sea turtles (NMFS and USFWS 2007b). In marine turtles, sex is determined by temperature in the middle third of incubation with female offspring produced at higher temperatures and males at lower temperatures within a thermal tolerance range of 25º-35°C (Ackerman 1997). Increases in global temperature could potentially skew future sex ratios toward a higher numbers of females (NMFS and USFWS 2007b).

The effects from increased temperatures may be exacerbated on developed nesting beaches where shoreline armoring and construction has denuded vegetation. Sea level rise from global climate change (IPCC 2007) is also a potential problem, particularly for areas with low-lying beaches where sand depth is a limiting factor, as the sea may inundate nesting sites and decrease available nesting habitat (Daniels et al. 1993, Fish et al. 2005, Baker et al. 2006). The loss of habitat because of climate change could be accelerated due to a combination of other environmental and oceanographic changes such as increased frequency of storms and/or changes in prevailing currents, both of which could lead to increased beach loss via erosion (Antonelis et al. 2006, Baker et al. 2006).

Other changes in the marine ecosystem caused by global climate change (e.g., salinity, oceanic currents, dissolved oxygen levels, nutrient distribution, etc.) could influence the distribution and abundance of phytoplankton, zooplankton, submerged aquatic vegetation, coral reefs, forage fish, etc. Since hawksbills are typically associated with coral reef ecosystems, increases in global temperatures leading to coral death (Sheppard 2006) could adversely affect the foraging habitats of this species.

3.2.2.4 Summary of Status for Hawksbill Sea Turtles

Worldwide, hawksbill sea turtle populations are declining. They face many of the same threats affecting other sea turtle species. In addition, there continues to be a commercial market for hawksbill shell products, despite protections afforded to the species under U.S. law and international conventions.

3.2.3 Kemp's Ridley Sea Turtle

The Kemp's ridley was listed as endangered on December 2, 1970. Internationally, the Kemp's ridley is considered the most endangered sea turtle (Zwinenberg 1977, Groombridge 1982, TEWG 2000). Kemp's ridleys nest primarily at Rancho Nuevo, a stretch of beach in Mexico's Tamaulipas State. This species occurs mainly in coastal areas of the Gulf of Mexico and the northwestern Atlantic Ocean. Occasional individuals reach European waters (Brongersma 1972). Adults of this species are usually confined to the Gulf of Mexico, although adult-sized individuals sometimes are found on the east coast of the United States.

Life History and Distribution

The TEWG (1998) estimates age at maturity from 7-15 years. Females return to their nesting beach about every 2 years (TEWG 1998). Nesting occurs from April into July and is essentially limited to the beaches of the western Gulf of Mexico, near Rancho Nuevo in southern Tamaulipas, Mexico. The mean clutch size for Kemp's ridleys is 100 eggs/nest, with an average of 2.5 nests/female/season.

Little is known of the movements of the post-hatchling stage (pelagic stage) within the Gulf of Mexico. Studies have shown the post-hatchling pelagic stage varies from 1-4 or more years, and the benthic immature stage lasts 7-9 years (Schmid and Witzell 1997). Benthic immature Kemp's ridleys have been found along the Eastern Seaboard of the U.S. and in the Gulf of Mexico. Atlantic benthic immature sea turtles travel northward as the water warms to feed in the productive, coastal waters off Georgia through New England, returning southward with the onset of winter (Lutcavage and Musick 1985, Henwood and Ogren 1987, Ogren 1989). Studies suggest that benthic immature Kemp's ridleys stay in shallow, warm, nearshore waters in the northern Gulf of Mexico until cooling waters force them offshore or south along the Florida coast (Renaud 1995).

Stomach contents of Kemp's ridleys along the lower Texas coast consisted of nearshore crabs and mollusks, as well as fish, shrimp, and other foods considered to be shrimp fishery discards (Shaver 1991). A 2005 dietary study of immature Kemp's ridleys off southwest Florida documented predation on benthic tunicates, a previously undocumented food source for this species (Witzell and Schmid 2005). These pelagic stage Kemp's ridleys presumably feed on the available *Sargassum* and associated infauna or other epipelagic species found in the Gulf of Mexico.

Population Dynamics and Status

Of the seven extant species of sea turtles in the world, the Kemp's ridley has declined to the lowest population level. Most of the population of adult females nest on the Rancho Nuevo beaches (Pritchard 1969). When nesting aggregations at Rancho Nuevo were discovered in 1947, adult female populations were estimated to be in excess of 40,000 individuals (Hildebrand 1963). By the mid-1980s, nesting numbers were below 1,000 (with a low of 702 nests in 1985). However, observations of increased nesting (with 6,277 nests recorded in 2000) suggest that the decline in the ridley population has stopped and the population is now increasing (USFWS 2000). The number of nests observed at Rancho Nuevo and nearby beaches increased at a mean rate of 11.3 percent per year from 1985 to 1999 (TEWG 2000). These trends are further supported by 2004-2007 nesting data from Mexico. The number of nests over that period has increased from 7,147 in 2004, to 10,099 in 2005, to 12,143 in 2006, and 15,032 during the 2007 nesting season (Gladys Porter Zoo 2007). An unofficial estimate for 2008 stands at 17, 882 nests (S. Epperly, NMFS, SEFSC, pers. comm.). A small nesting population is also emerging in the United States, primarily in Texas, rising from 6 nests in 1996 to 128 in 2007, and a record 195 in 2008 (National Park Service data).

A period of steady increase in benthic immature ridleys has been occurring since 1990 and appears to be due to increased hatchling production and an apparent increase in survival rates of immature sea turtles beginning in 1990. The increased survivorship of immature sea turtles is attributable, in part, to the introduction of TEDs in the United States' and Mexico's shrimping fleets. As demonstrated by nesting increases at the main nesting sites in Mexico, adult ridley numbers have increased over the last decade. The population model used by TEWG (2000) projected that Kemp's ridleys could reach the Recovery Plan's intermediate recovery goal of 10,000 nesters by the year 2015. Recent calculations of nesting females determined from nest counts show that the population trend is increasing towards that recovery goal, with an estimate of 4,047 nesters in 2006 and 5,500 in 2007 (NMFS and USFWS 2007c, Gladys Porter Zoo 2007).

Next to loggerheads, Kemp's ridleys are the second most abundant sea turtle in Virginia and Maryland waters, arriving in these areas during May and June (Keinath et al. 1987, Musick and Limpus 1997). The juvenile population of Kemp's ridley sea turtles in Chesapeake Bay is estimated to be 211 to 1,083 sea turtles (Musick and Limpus 1997). These juveniles frequently forage in submerged aquatic grass beds for crabs (Musick and Limpus 1997). Kemp's ridleys consume a variety of crab species, including *Callinectes* spp., *Ovalipes* spp., *Libinia* spp., and *Cancer* spp. Mollusks, shrimp, and fish are consumed less frequently (Bjorndal 1997). Upon leaving Chesapeake Bay in autumn, juvenile Kemp's ridleys migrate down the coast, passing Cape Hatteras in December and January (Musick and Limpus 1997). These larger juveniles are joined there by juveniles of the same size from North Carolina sounds and smaller juveniles from New York and

New England to form one of the densest concentrations of Kemp's ridleys outside of the Gulf of Mexico (Musick and Limpus 1997, Epperly et al. 1995a, Epperly et al. 1995b).

Threats

Kemp's ridleys face many of the same threats as other sea turtle species, including destruction of nesting habitat from storm events, natural predators at sea, and oceanic events such as cold stunning. Although cold stunning can occur throughout the range of the species, it may be a greater risk for sea turtles that utilize the more northern habitats of Cape Cod Bay and Long Island Sound. For example, in the winter of 1999-2000, there was a major cold-stunning event where 218 Kemp's ridleys, 54 loggerheads, and 5 green sea turtles were found on Cape Cod beaches (R. Prescott, NMFS, pers. comm. 2001). Annual cold-stunning events do not always occur at this magnitude; the extent of episodic major cold-stun events may be associated with numbers of sea turtles utilizing Northeast waters in a given year, oceanographic conditions, and the occurrence of storm events in the late fall. Many cold-stunned sea turtles can survive if found early enough, but cold-stunning events can still represent a significant cause of natural mortality. A complete list of other indirect factors can be found in NMFS SEFSC (2001).

Although changes in the use of shrimp trawls and other trawl gear have helped to reduce mortality of Kemp's ridleys, this species is also affected by other sources of anthropogenic impacts similar to those discussed in previous sections. For example, in the spring of 2000, a total of five Kemp's ridley carcasses were recovered from the same North Carolina beaches where 275 loggerhead carcasses were found. Cause of death for most of the sea turtles recovered was unknown, but the mass mortality event was suspected to have been from a large-mesh gillnet fishery operating offshore in the preceding weeks. The five Kemp's ridley carcasses that were found are likely to have been only a minimum count of the number of Kemp's ridleys that were killed or seriously injured because of the fishery interaction because it is unlikely that all of the carcasses washed ashore.

There is a large and growing body of literature on past, present, and future impacts of global climate change induced by human activities, i.e., global warming. Some of the likely effects commonly mentioned are sea level rise, increased frequency of severe weather events, and change in air and water temperatures. The Environmental Protection Agency's climate change webpage provides basic background information on these and other measured or anticipated effects (see www.epa.gov/climatechange/index.html). However, the impacts on sea turtles currently cannot be predicted, for the most part, with any degree of certainty.

The Intergovernmental Panel on Climate Change has stated that global climate change is unequivocal (IPCC 2007) and its impacts may have significant impacts to the hatchling sex ratios of Kemp's ridley sea turtles (Wibbels 2003, NMFS and USFWS 2007c). In marine turtles, sex is determined by temperature in the middle third of incubation with female offspring produced at higher temperatures and males at lower temperatures within a thermal tolerance range of 25º-35°C (Ackerman 1997). Increases in global temperature could potentially skew future sex ratios toward a higher numbers of females (NMFS and USFWS 2007c).

The effects from increased temperatures may be exacerbated on developed nesting beaches where shoreline armoring and construction has denuded vegetation. Sea level rise from global climate change (IPCC 2007) is also a potential problem, particularly for areas with low-lying beaches where sand depth is a limiting factor, as the sea may inundate nesting sites and decrease available nesting habitat (Daniels et al. 1993, Fish et al. 2005, Baker et al. 2006). The loss of habitat because of climate change could be accelerated due to a combination of other environmental and oceanographic changes such as increased frequency of storms and/or changes in prevailing currents, both of which could lead to increased beach loss via erosion (Antonelis et al. 2006, Baker et al. 2006).

Other changes in the marine ecosystem caused by global climate change (e.g., salinity, oceanic currents, dissolved oxygen levels, nutrient distribution, etc.) could influence the distribution and abundance of phytoplankton, zooplankton, submerged aquatic vegetation, forage fish, etc., which could ultimately affect the primary foraging areas of Kemp's ridley sea turtles.

3.2.3.1 Summary of Kemp's Ridley Status

The only major nesting site for Kemp's ridleys is a single stretch of beach near Rancho Nuevo, Tamaulipas, Mexico (Carr 1963). The number of nests observed at Rancho Nuevo and nearby beaches increased from 1985 to 2008. Nesting has also exceeded 12,000 nests per year from 2004-2008 (Gladys Porter Zoo database). Kemp's ridleys mature at an earlier age (7-15 years) than other chelonids; thus, 'lag effects' as a result of unknown impacts to the non-breeding life stages would likely have been seen in the increasing nest trend beginning in 1985 (USFWS and NMFS 1992).

The largest contributors to the decline of Kemp's ridleys in the past were commercial and local exploitation, especially poaching of nests at the Rancho Nuevo site, as well as the Gulf of Mexico trawl fisheries. The advent of TED regulations for trawlers and protections for the nesting beaches has allowed the species to begin to recover. Many threats to the future of the species remain, including interactions with fishery gear, marine pollution, foraging habitat destruction, illegal poaching of nests and potential threats to the nesting beaches from such sources as global climate change, development, and tourism pressures.

3.2.4 Leatherback Sea Turtle

The leatherback sea turtle was listed as endangered throughout its global range on June 2, 1970. Leatherbacks are widely distributed throughout the oceans of the world and are found in waters of the Atlantic, Pacific, and Indian Oceans (Ernst and Barbour 1972). Leatherback sea turtles are the largest living turtles and range farther than any other sea turtle species. The large size of adult leatherbacks and their tolerance to relatively low temperatures allows them to occur in northern waters such as off Labrador and in the

Barents Sea (NMFS and USFWS 1995). Adult leatherbacks forage in temperate and subpolar regions from 71ºN to 47ºS latitude in all oceans and undergo extensive migrations to and from their tropical nesting beaches. In 1980, the leatherback population was estimated at approximately 115,000 adult females globally (Pritchard 1982). That number, however, is probably an overestimation as it was based on a particularly good nesting year in 1980 (Pritchard 1996). By 1995, the global population of adult females had declined to 34,500 (Spotila et al. 1996). Pritchard (1996) also called into question the population estimates from Spotila et al. (1996), and felt they may be somewhat low, because it ended the modeling on data from a particularly bad nesting year (1994) while excluding nesting data from 1995, which was a good nesting year. However, the most recent population estimate for leatherback sea turtles from just the North Atlantic breeding groups is a range of 34,000-90,000 adult individuals (20,000-56,000 adult females) (TEWG 2007).

3.2.4.1 Indian Ocean

Long-term leatherback nesting data for many areas of the Indian Ocean are not available. In locations where data do exist, the number of nesting females is variable. In Sri Lanka, Andaman and Nicobar Islands (India) current nesting populations range from 100 to 600 females annually. Nesting beach populations are far less than that in Thailand, Mozambique, South Africa, and Meru Betiri (Java), where no more than 40 females nest annually at each location. Alas Perwo (Java) appears to be increasing in significance as a nesting beach in the Indian Ocean. The number of eggs recorded annually doubled from 500 to 1000, from the 1980s through the early 2000s (Hamann et al. 2006, NMFS and USFWS 2007d).

Population trends of leatherbacks in the Indian Ocean are difficult to ascertain. Annual fluctuations in the number of nest observed in South Africa over the last 42 years makes it difficult to estimates populations trends for this region. No nesting beach population trends are available for Sri Lanka, Thailand, and Andaman and Nicobar Islands (India). Nesting trends have increased in Alwas Perwo (Java) from the 1980s to the early 2000s, but a declining trend has been seen in Meru Betiri (Java) during the same period. The nesting trend in Mozambique appears stable (Hamann et al 2006, NMFS and USFWS 2007d).

3.2.4.2 Pacific Ocean

Based on published estimates of nesting female abundance, leatherback populations have collapsed or have been declining at all major Pacific basin nesting beaches for the last two decades (Spotila et al. 1996, NMFS and USFWS 1998c, Sarti et al. 2000, Spotila et al. 2000). For example, the nesting assemblage on Terengganu, Malaysia – which was one of the most significant nesting sites in the western Pacific Ocean – has declined severely from an estimated 3,103 females in 1968 to two nesting females in 1994 (Chan and Liew 1996). Nesting assemblages of leatherback turtles are in decline along the coasts of the Solomon Islands, a historically important nesting area (D. Broderick, pers. comm., in Dutton et al. 1999). In Fiji, Thailand, Australia, and Papua New Guinea (East

Papua), leatherback turtles have only been known to nest in low densities and scattered colonies.

Only an Indonesian nesting assemblage has remained relatively abundant in the Pacific basin. The largest extant leatherback nesting assemblage in the Indo-Pacific lies on the north Vogelkop coast of Irian Jaya (West Papua), Indonesia, with over 3,000 nests recorded annually (Putrawidjaja 2000, Suárez et al. 2000). During the early-to-mid 1980s, the number of female leatherback turtles nesting on the two primary beaches of Irian Jaya appeared to be stable. More recently, this population has come under increasing threats that could cause this population to experience a collapse that is similar to what occurred at Terengganu, Malaysia. In 1999, for example, local Indonesian villagers started reporting dramatic declines in sea turtle populations near their villages (Suárez 1999). Unless hatchling and adult turtles on nesting beaches receive more protection, this population will continue to decline. Declines in nesting assemblages of leatherback turtles have been reported throughout the western Pacific region, with nesting assemblages well below abundance levels observed several decades ago (e.g., Suárez 1999).

In the western Pacific Ocean and South China Seas, leatherback turtles are captured, injured, or killed in numerous fisheries, including Japanese longline fisheries. The poaching of eggs, killing of nesting females, human encroachment on nesting beaches, beach erosion, and egg predation by animals also threaten leatherback turtles in the western Pacific.

In the eastern Pacific Ocean, nesting populations of leatherback turtles are declining along the Pacific coast of Mexico and Costa Rica. According to reports from the late 1970s and early 1980s, three beaches on the Pacific coast of Mexico supported as many as half of all leatherback turtle nests for the eastern Pacific. Since the early 1980s, the eastern Pacific Mexican population of adult female leatherback turtles has declined to slightly more than 200 individuals during 1998-99 and 1999-2000 (Sarti et al. 2000). Spotila et al. (2000) reported the decline of the leatherback turtle population at Playa Grande, Costa Rica, which had been the fourth largest nesting colony in the world. Between 1988 and 1999, the nesting colony declined from 1,367 to 117 female leatherback turtles. Based on their models, Spotila et al. (2000) estimated that the colony could fall to less than 50 females by 2003-2004. Leatherback turtles in the eastern Pacific Ocean are captured, injured, or killed in commercial and artisanal swordfish fisheries off Chile, Columbia, Ecuador, and Peru, and purse seine fisheries for tuna in the eastern tropical Pacific Ocean, and California/Oregon drift gillnet fisheries. Because of the limited data, we cannot provide high-certainty estimates of the number of leatherback turtles captured, injured, or killed through interactions with these fisheries. However, between 8-17 leatherback turtles were estimated to have died annually between 1990 and 2000 in interactions with the California/Oregon drift gillnet fishery; 500 leatherback turtles are estimated to die annually in Chilean and Peruvian fisheries; 200 leatherback turtles are estimated to die in direct harvests in Indonesia; and before 1992, the North Pacific driftnet fisheries for squid, tuna, and billfish captured an estimated 1,000 leatherback turtles each year, killing about 111 of them each year.

Although all causes of the declines in leatherback turtle colonies in the eastern Pacific have not been documented, Sarti et al. (1998) suggest that the declines result from egg poaching, adult and sub-adult mortalities incidental to high seas fisheries, and natural fluctuations due to changing environmental conditions. Some published reports support this suggestion. Sarti et al. (2000) reported that female leatherback turtles have been killed for meat on nesting beaches like Píedra de Tiacoyunque, Guerrero, Mexico. Eckert (1997) reported that swordfish gillnet fisheries in Peru and Chile contributed to the decline of leatherback turtles in the eastern Pacific. The decline in the nesting population at Mexiquillo, Mexico, occurred at the same time that effort doubled in the Chilean driftnet fishery. In response to these effects, the eastern Pacific population has continued to decline, leading some researchers to conclude that the leatherback is on the verge of extinction in the Pacific Ocean (e.g., Spotila et al. 1996, Spotila et al. 2000). The NMFS assessment of three nesting aggregations in its February 23, 2004, opinion supports this conclusion: If no action is taken to reverse their decline, leatherback sea turtles nesting in the Pacific Ocean either have high risks of extinction in a single human generation (for example, nesting aggregations at Terrenganu and Costa Rica) or they have a high risk of declining to levels where more precipitous declines become almost certain (e.g., Irian Jaya) (NMFS 2004a).

3.2.4.3 Atlantic Ocean

In the Atlantic Ocean, leatherbacks have been recorded as far north as Newfoundland, Canada, and Norway, and as far south as Uruguay, Argentina, and South Africa (NMFS SEFSC 2001). Female leatherbacks nest from the southeastern United States to southern Brazil in the western Atlantic and from Mauritania to Angola in the eastern Atlantic. The most significant nesting beaches in the Atlantic, and perhaps in the world, are in French Guiana and Suriname (NMFS SEFSC 2001). Previous genetic analyses of leatherbacks using only mitochondrial DNA (mtDNA) resulted in an earlier determination that within the Atlantic basin there are at least three genetically different nesting populations: the St. Croix nesting population (U.S. Virgin Islands), the mainland nesting Caribbean population (Florida, Costa Rica, Suriname/French Guiana), and the Trinidad nesting population (Dutton et al. 1999). Further genetic analyses using microsatellite markers in nuclear DNA along with the mtDNA data and tagging data has resulted in Atlantic Ocean leatherbacks now being divided into seven groups or breeding populations: Florida, Northern Caribbean, Western Caribbean, Southern Caribbean/Guianas, West Africa, South Africa, and Brazil (TEWG 2007). When the hatchlings leave the nesting beaches, they move offshore but eventually utilize both coastal and pelagic waters. Very little is known about the pelagic habits of the hatchlings and juveniles, and they have not been documented to be associated with the *Sargassum* areas as are other species. Leatherbacks are deep divers, with recorded dives to depths in excess of 1,000 m (Eckert et al. 1989, Hayes et al. 2004).

Life History and Distribution
Leatherbacks are a long-lived species, living for well over 30 years. It has been thought that they reach sexual maturity somewhat faster than other sea turtles (except Kemp's

ridley), with an estimated range from 3-6 years (Rhodin 1985) to 13-14 years (Zug and Parham 1996). However, some recent research using sophisticated methods of analyzing leatherback ossicles has cast doubt on the previously accepted age to maturity figures, with leatherbacks in the western North Atlantic possibly not reaching sexual maturity until as late as 29 years of age (Avens and Goshe 2007). Continued research in this area is vitally important to understanding the life history of leatherbacks and has important implications in management of the species.

Female leatherbacks nest frequently (up to 10 nests per year) during a nesting season and nest about every 2-3 years. During each nesting, they produce 100 eggs or more in each clutch and, thus, can produce 700 eggs or more per nesting season (Schultz 1975). However, a significant portion (up to approximately 30 percent) of the eggs can be infertile. Thus, the actual proportion of eggs that can result in hatchlings is less than this seasonal estimate. The eggs incubate for 55-75 days before hatching. Based on a review of all sightings of leatherback sea turtles of <145 cm curved carapace length (ccl), Eckert (1999) found that leatherback juveniles remain in waters warmer than 26ºC until they exceed 100 ccl.

Although leatherbacks are the most pelagic of the sea turtles, they enter coastal waters on an irregular basis to feed in areas where jellyfish are concentrated. Leatherback sea turtles feed primarily on cnidarians (medusae, siphonophores) and tunicates.

Evidence from tag returns and strandings in the western Atlantic suggests that adult leatherback sea turtles engage in routine migrations between boreal, temperate, and tropical waters (NMFS and USFWS 1992). A 1979 aerial survey of the outer continental shelf from Cape Hatteras, North Carolina, to Cape Sable, Nova Scotia, showed leatherbacks to be present throughout the area with the most numerous sightings made from the Gulf of Maine south to Long Island. Leatherbacks were sighted in waters where depths ranged from 1 to 4,151 m, but 84.4 percent of sightings were in areas where the water was less than 180 m deep (Shoop and Kenney 1992). Leatherbacks were sighted in waters of a similar sea surface temperature as loggerheads - from 7º to 27.2ºC (Shoop and Kenney 1992). However, this species appears to have a greater tolerance for colder waters because more leatherbacks were found at the lower temperatures (Shoop and Kenney 1992). This aerial survey estimated the in-water leatherback population from near Nova Scotia, Canada to Cape Hatteras, North Carolina at approximately 300-600 animals.

General differences in migration patterns and foraging grounds may occur between the seven nesting assemblages, but data is limited. Per TEWG (2007):

> Marked or satellite tracked turtles from the Florida and North Caribbean assemblages have been re-sighted off North America, in the Gulf of Mexico and along the Atlantic coast and a few have moved to western Africa, north of the equator. In contrast, Western Caribbean and Southern Caribbean/Guianas animals have been found more commonly in the eastern Atlantic, off Europe and northern Africa, as well as along the

North American coast. There are no reports of marked animals from the Western North Atlantic assemblages entering the Mediterranean Sea or the South Atlantic Ocean, though in the case of the Mediterranean this may be due more to a lack of data rather than failure of Western North Atlantic turtles moving into the Sea. The tagging data coupled with the satellite telemetry data indicate that animals from the western North Atlantic nesting subpopulations use virtually the entire North Atlantic Ocean. In the South Atlantic Ocean, tracking and tag return data follow three primary patterns. Although telemetry data from the West African nesting assemblage showed that all but one remained on the shallow continental shelf, there clearly is movement to foraging areas of the south coast of Brazil and Argentina. There is also a small nesting aggregation of leatherbacks in Brazil, and while data are limited to a few satellite tracks, these turtles seem to remain in the southwest Atlantic foraging along the continental shelf margin as far south as Argentina. South African nesting turtles apparently forage primarily south, around the tip of the continent.

Population Dynamics and Status

The status of the Atlantic leatherback population has been less clear than the Pacific population. This uncertainty has been a result of inconsistent beach and aerial surveys, cycles of erosion and reformation of nesting beaches in the Guianas (representing the largest nesting area), a lesser degree of nest-site fidelity than occurs with the hardshell sea turtle species, and inconsistencies in the availability and analyses of data. However, recent coordinated efforts at data collection and analyses by the Leatherback Turtle Expert Working Group have helped to clarify the understanding of the Atlantic population status (TEWG 2007).

The Southern Caribbean/Guianas stock is the largest known Atlantic leatherback nesting aggregation (TEWG 2007). This area includes the Guianas (Guyana, Suriname, and French Guiana), Trinidad, Dominica, and Venezuela, with the vast majority of the nesting occurring in the Guianas and Trinidad. Past analyses had shown that the nesting aggregation in French Guiana had been declining at about 15 percent per year since 1987 (NMFS SEFSC 2001). However, from 1979-1986, the number of nests was increasing at about 15 percent annually which could mean that the current decline could be part of a nesting cycle which coincides with the erosion cycle of Guiana beaches described by Schultz (1975). It is thought that the cycle of erosion and reformation of beaches has resulted in shifting nesting beaches throughout this region. This was supported by the increased nesting seen in Suriname, where leatherback nest numbers have shown large recent increases concurrent with declines elsewhere (with more than 10,000 nests per year since 1999 and a peak of 30,000 nests in 2001), and the long-term trend for the overall Suriname and French Guiana population was thought to possibly show an increase (Girondot 2002 in Hilterman and Goverse 2003). In the past many sea turtle scientists have agreed that the Guianas (and some would include Trinidad) should be viewed as one population and that a synoptic evaluation of nesting at all beaches in the region is necessary to develop a true picture of population status (Reichart et al. 2001). Genetics studies have added support to this notion and have resulted in the designation of the Southern Caribbean/Guianas stock. Using both Bayesian modeling and regression analyses, the TEWG (2007) determined that the Southern Caribbean/Guianas stock had demonstrated a long-term, positive population growth rate (using nesting females as a proxy for population). This positive growth was seen within major nesting areas for the stock, including Trinidad, Guyana, and the combined beaches of Suriname and French Guiana (TEWG 2007).

The Western Caribbean stock includes nesting beaches from Honduras to Colombia. The most intense nesting in that area occurs in Costa Rica, Panama, and the Gulf of Uraba in Colombia (Duque et al. 2000). The Caribbean coast of Costa Rica and extending through Chiriquí Beach, Panama, represents the fourth-largest known leatherback rookery in the world (Troëng et al. 2004). Examination of data from three index nesting beaches in the region (Tortuguero, Gandoca, and Pacuare, in Costa Rica) using various Bayesian and regression analyses indicated that the nesting population was likely not growing over the 1995-2005 time series of available data (TEWG 2007), though modeling of the nesting data for Tortuguero indicates a possible 67.8 percent decline between 1995 and 2006 (Troëng et al. 2007).

Nesting data for the Northern Caribbean stock is available from Puerto Rico, the U.S. Virgin Islands (St. Croix), and the British Virgin Islands (Tortola). In Puerto Rico, the primary nesting beaches are at Fajardo and on the island of Culebra. Nesting between 1978 and 2005 has ranged between 469-882 nests, and the population has been growing since 1978, with an overall annual growth rate of 1.1 percent (TEWG 2007). At the primary nesting beach on St. Croix, the Sandy Point National Wildlife Refuge, nesting has fluctuated from a few hundred nests to a high of 1008 in 2001, and the average annual growth rate has been approximately 1.1 percent from 1986-2004 (TEWG 2007). Nesting in Tortola is limited, but has been increasing from 0-6 nests per year in the late 1980s to 35-65 per year in the 2000s, with an annual growth rate of approximately 1.2 percent between 1994 and 2004 (TEWG 2007).

The Florida nesting stock nests primarily along the east coast of Florida. This stock is of growing importance, with total nests between 800-900 per year in the 2000s following nesting totals fewer than 100 nests per year in the 1980s (Florida Fish and Wildlife Conservation Commission, unpublished data). Using data from the index nesting beach surveys, the TEWG (2007) estimated a significant annual nesting growth rate of 1.17 percent between 1989 and 2005. In 2007, a record 517-leatherback nests were observed on the index beaches in Florida, with 265 in 2008 (FWCC Index Nesting Beach database). The reduction in nesting from 2007 to 2008 is thought to be a result of the cyclical nature of leatherback nesting, similar to the biennial cycle of green turtle nesting.

The West African nesting stock of leatherbacks is a large, important, but mostly unstudied aggregation. Nesting occurs in various countries along Africa's Atlantic coast, but much of the nesting is undocumented and the data is inconsistent. However, it is known that Gabon has a very large amount of leatherback nesting, with at least 30,000 nests laid along its coast in one season (Fretey et al. in press). Fretey et al. (in press) also provide detailed information about other known nesting beaches and survey efforts along the Atlantic African coast. Because of the lack of consistent effort and minimal available data, trend analyses were not possible for this stock (TEWG 2007).

Two other small but growing nesting stocks utilize the beaches of Brazil and South Africa. For the Brazilian stock, the TEWG (2007) analyzed the available data and determined that between 1988 and 2003 there was a positive annual average growth rate of 1.07 percent using regression analyses, and 1.08 percent using Bayesian modeling. The South African stock has an annual average growth rate of 1.06 based on regression modeling and 1.04 percent using the Bayesian approach (TEWG 2007).

Estimates of total population size for Atlantic leatherbacks are difficult to ascertain due to the inconsistent nature of the available nesting data. In 1996, the entire western Atlantic population was characterized as stable at best (Spotila et al. 1996), with numbers of nesting females reported to be about 18,800. A subsequent analysis by Spotila (pers. comm.) indicated that by 2000, the western Atlantic nesting population had decreased to about 15,000 nesting females. Spotila et al. (1996) estimated that the leatherback population for the entire Atlantic basin, including all nesting beaches in the Americas, the Caribbean, and West Africa, totaled approximately 27,600 nesting females, with an estimated range of 20,082-35,133. This is consistent with the estimate of 34,000-95,000 total adults (20,000-56,000 adult females; 10,000-21,000 nesting females) determined by the TEWG (2007).

Threats
Zug and Parham (1996) pointed out that the main threat to leatherback populations in the Atlantic is the combination of fishery-related mortality (especially entanglement in gear and drowning in trawls) and the intense egg harvesting on the main nesting beaches. Other important ongoing threats to the population include pollution, loss of nesting habitat, and boat strikes.

Of sea turtle species, leatherbacks seem to be the most vulnerable to entanglement in fishing gear. This susceptibility may be the result of their body type (large size, long pectoral flippers, and lack of a hard shell), their attraction to gelatinous organisms and algae that collect on buoys and buoy lines at or near the surface, possibly their method of locomotion, and perhaps their attraction to the lightsticks used to attract target species in longline fisheries. They are also susceptible to entanglement in gillnets and pot/trap lines (used in various fisheries) and capture in trawl gear (e.g., shrimp trawls).

Leatherbacks are exposed to pelagic longline fisheries in many areas of their range. Unlike loggerhead turtle interactions with longline gear, leatherback turtles do not usually ingest longline bait. Instead, leatherbacks are typically foul-hooked by longline gear (e.g., on the flipper or shoulder area) rather than getting mouth-hooked or swallowing the hook (NMFS SEFSC 2001). A total of 24 nations, including the United States (accounting for 5-8 percent of the hooks fished), have fleets participating in pelagic longline fisheries in the area. Basin-wide, Lewison et al. (2004) estimated that 30,000-60,000 leatherback sea turtle captures occurred in Atlantic pelagic longline fisheries in the year 2000 alone (note that multiple captures of the same individual are known to occur, so the actual number of individuals captured may not be as high). Genetic studies performed within the Northeast Distant Fishery Experiment indicate that the leatherbacks captured in the Atlantic highly migratory species pelagic longline fishery were primarily from the French Guiana and Trinidad nesting stocks (over 95 percent); individuals from West African stocks were surprisingly absent (Roden et al. in press).

Leatherbacks are also susceptible to entanglement in the lines associated with trap/pot gear used in several fisheries. From 1990-2000, 92 entangled leatherbacks were reported from New York through Maine (Dwyer et al. 2002). Additional leatherbacks stranded wrapped in line of unknown origin or with evidence of a past entanglement (Dwyer et al. 2002). Fixed gear fisheries in the mid-Atlantic have also contributed to leatherback entanglements. In North Carolina, two leatherback sea turtles were reported entangled in a crab pot buoy inside Hatteras Inlet (D. Fletcher, pers. comm. to S. Epperly in NMFS SEFSC 2001). A third leatherback was reported entangled in a crab pot buoy in Pamlico Sound near Ocracoke. This turtle was disentangled and released alive; however, lacerations on the front flippers from the lines were evident (D. Fletcher, pers. comm. to S. Epperly in NMFS SEFSC 2001). In the Southeast, leatherbacks are vulnerable to entanglement in Florida's lobster pot and stone crab fisheries. In the U.S. Virgin Islands, where one of five leatherback strandings from 1982 to 1997 was due to entanglement (Boulon 2000), leatherbacks have been observed with their flippers wrapped in the line of West Indian fish traps (R. Boulon, pers. comm. to J. Braun-McNeill in NMFS SEFSC 2001). Because many entanglements of this typically pelagic species likely go unnoticed, entanglements in fishing gear may be much higher.

Leatherback interactions with the southeast Atlantic shrimp fishery, which operates predominately from North Carolina through southeast Florida (NMFS 2002a), have also been a common occurrence. Leatherbacks, which migrate north annually, are likely to encounter shrimp trawls working in the coastal waters off the Atlantic coast from Cape Canaveral, Florida, to the Virginia/North Carolina border. Leatherbacks also interact with the Gulf of Mexico shrimp fishery. For many years, TEDs required for use in these fisheries were less effective at excluding leatherbacks than the smaller, hard-shelled turtle species. To address this problem, on February 21, 2003, the NMFS issued a final rule to amend the TED regulations. Modifications to the design of TEDs are now required in order to exclude leatherbacks and large and sexually mature loggerhead and green turtles.

Other trawl fisheries are also known to interact with leatherback sea turtles. In October 2001, a Northeast Fisheries Science Center (NEFSC) observer documented the take of a leatherback in a bottom otter trawl fishing for *Loligo* squid off Delaware; TEDs are not required in this fishery. The winter trawl flounder fishery, which did not come under the revised TED regulations, may also interact with leatherback sea turtles.

Gillnet fisheries operating in the nearshore waters of the Mid-Atlantic States are also suspected of capturing, injuring, and/or killing leatherbacks when these fisheries and leatherbacks co-occur. Data collected by the NEFSC Fisheries Observer Program from 1994 through 1998 (excluding 1997) indicate that 37 leatherbacks were incidentally captured (16 lethally) in drift gillnets set in offshore waters from Maine to Florida during this period. Observer coverage for this period ranged from 54 to 92 percent.

Poaching is not known to be a problem for nesting populations in the continental United States. However, in 2001 the NMFS Southeast Fishery Science Center (SEFSC) noted that poaching of juveniles and adults was still occurring in the U.S. Virgin Islands and the Guianas. In all, four of the five strandings in St. Croix were the result of poaching (Boulon 2000). A few cases of fishermen poaching leatherbacks have been reported from Puerto Rico, but most of the poaching is on eggs.

Leatherback sea turtles may be more susceptible to marine debris ingestion than other species due to their pelagic existence and the tendency of floating debris to concentrate in convergence zones that adults and juveniles use for feeding areas and migratory routes (Lutcavage et al. 1997, Shoop and Kenney 1992). Investigations of the stomach contents of leatherback sea turtles revealed that a substantial percentage (44 percent of the 16 cases examined) contained plastic (Mrosovsky 1981). Along the coast of Peru, intestinal contents of 19 of 140 (13 percent) leatherback carcasses were found to contain plastic bags and film (Fritts 1982). The presence of plastic debris in the digestive tract suggests that leatherbacks might not be able to distinguish between prey items and plastic debris (Mrosovsky 1981). Balazs (1985) speculated that the object might resemble a food item by its shape, color, size or even movement as it drifts about, and induce a feeding response in leatherbacks.

It is important to note that, like marine debris, fishing gear interactions and poaching are problems for leatherbacks throughout their range. Entanglements are common in Canadian waters where Goff and Lien (1988) reported that 14 of 20 leatherbacks encountered off the coast of Newfoundland/Labrador were entangled in fishing gear including salmon net, herring net, gillnet, trawl line and crab pot line. Leatherbacks are reported taken by many other nations that participate in Atlantic pelagic longline fisheries, including Taipei, Brazil, Trinidad, Morocco, Cyprus, Venezuela, Korea, Mexico, Cuba, U.K., Bermuda, People's Republic of China, Grenada, Canada, Belize, France, and Ireland (see NMFS SEFSC 2001, for a description of take records). Leatherbacks are known to drown in fish nets set in coastal waters of Sao Tome, West Africa (Castroviejo et al. 1994, Graff 1995). Gillnets are one of the suspected causes of the decline in the leatherback sea turtle population in French Guiana (Chevalier et al. 1999), and gillnets targeting green and hawksbill turtles in the waters of coastal Nicaragua also incidentally catch leatherback turtles (Lageux et al. 1998). Observers on shrimp trawlers operating in the northeastern region of Venezuela documented the capture of six leatherbacks from 13,600 trawls (Marcano and Alio-M. 2000). A study by the Trinidad and Tobago's Institute for Marine Affairs (IMA) in 2002 confirmed that bycatch of leatherbacks is high in Trinidad. IMA estimated that more than 3,000 leatherbacks were captured incidental to gillnet fishing in the coastal waters of Trinidad in 2000. As much as one-half or more of the gravid turtles in Trinidad and Tobago waters may be killed (Lee Lum 2003). However, many of the turtles do not die because of drowning, but rather because the fishermen butcher them in order to get them out of their nets (NMFS SEFSC 2001).

There is a large and growing body of literature on past, present, and future impacts of global climate change induced by human activities, i.e., global warming. Some of the likely effects commonly mentioned are sea level rise, increased frequency of severe weather events, and change in air and water temperatures. The Environmental Protection Agency's climate change webpage provides basic background information on these and other measured or anticipated effects (see www.epa.gov/climatechange/index.html). However, the impacts on sea turtles currently cannot be predicted, for the most part, with any degree of certainty. However, leatherback sea turtles are speculated to be the most capable of coping with climate change because they have the widest geographical distribution of any sea turtle and show relatively weak beach nesting site fidelity (Dutton et al. 1999).

The Intergovernmental Panel on Climate Change has stated that global climate change is unequivocal (IPCC 2007) and its impacts may alter the hatchling sex ratios of leatherback sea turtles (Mrosovsky et al. 1984, Hawkes et al. 2007, NMFS and USFWS 2007d). In marine turtles, sex is determined by temperature in the middle third of incubation with female offspring produced at higher temperatures and males at lower temperatures within a thermal tolerance range of 25º-35°C (Ackerman 1997). However, unlike other sea turtles species, leatherbacks tend to select nest locations in the cooler tidal zone of beaches (Kamel and Mrosovsky 2003). This preference may help mitigate the effects from increased beach temperature (Kamel and Mrosovsky 2003).

Sea level rise from global climate change (IPCC 2007) is also a potential problem, particularly for areas with low-lying beaches where sand depth is a limiting factor, as the sea may inundate nesting sites and decrease available nesting habitat (Daniels et al. 1993, Fish et al. 2005, Baker et al. 2006). The loss of habitat because of climate change could be accelerated due to a combination of other environmental and oceanographic changes such as increase in the frequency of storms and/or changes in prevailing currents, both of which could lead to increased beach loss via erosion (Antonelis et al. 2006, Baker et al. 2006).

Global climate change is likely to influence the distribution and abundance of jellyfish, the primary prey item of leatherbacks (NMFS and USFWS 2007d). Several studies have shown leatherback distribution is influenced by jellyfish abundance (e.g., Houghton et al. 2006, Witt et al. 2006, Witt et al. 2007). How these changes in jellyfish abundance and distribution will affect leatherback sea turtle foraging behavior and distribution is currently unclear (Witt et al. 2007).

3.2.4.4 Summary of Leatherback Status

In the Pacific Ocean, the abundance of leatherback turtle nesting individuals and colonies has declined dramatically over the past 10 to 20 years. Nesting colonies throughout the eastern and western Pacific Ocean have been reduced to a fraction of their former abundance by the combined effects of human activities that have reduced the number of nesting females. In addition, egg poaching has reduced the reproductive success of the remaining nesting females. At current rates of decline, leatherback turtles in the Pacific basin are a critically endangered species with a low probability of surviving and recovering in the wild.

In the Atlantic Ocean, our understanding of the status and trends of leatherback turtles is somewhat more confounded, although the overall trend appears to be stable to increasing. The data indicates increasing or stable nesting populations in all of the regions except West Africa (no long-term data are available) and the Western Caribbean (TEWG 2007). Some of the same factors that led to precipitous declines of leatherbacks in the Pacific also affect leatherbacks in the Atlantic (i.e., leatherbacks are captured and killed in many kinds of fishing gear and interact with fisheries in state, federal, and international waters). Poaching is also a problem that affects leatherbacks occurring in U.S. waters. Leatherbacks are also more susceptible to death or injury from ingesting marine debris than other turtle species.

3.2.5 Loggerhead Sea Turtle

The loggerhead sea turtle was listed as a threatened species throughout its global range on July 28, 1978. It was listed because of direct take, incidental capture in various fisheries, and the alteration and destruction of its habitat. Loggerhead sea turtles inhabit the continental shelves and estuarine environments along the margins of the Atlantic, Pacific, and Indian Oceans. The majority of loggerhead nesting occurs in the western Atlantic Ocean (south Florida, United States), and the western Indian Ocean (Masirah, Oman); in both locations nesting assemblages have more than 10,000 females nesting each year (NMFS and USFWS 2008). Loggerhead sea turtles are the most abundant species of sea turtle in U.S. waters.

3.2.5.1 Pacific Ocean

In the Pacific Ocean, major loggerhead nesting grounds are generally located in temperate and subtropical regions with scattered nesting in the tropics. Within the Pacific Ocean, loggerhead sea turtles are represented by a northwestern Pacific nesting aggregation (located in Japan) and a smaller southwestern nesting aggregation that occurs in eastern Australia (Great Barrier Reef and Queensland) and New Caledonia (NMFS SEFSC 2001). There are no reported loggerhead nesting sites in the eastern or central Pacific Ocean basin. Data from 1995 estimated the Japanese nesting aggregation at 1,000 female loggerhead sea turtles (Bolten et al. 1996). Information that is more recent suggests that nest numbers have increased somewhat over the period 1998-2004 (NMFS and USFWS 2007e). However, this period is too short to make a determination of the overall trend in nesting (NMFS and USFWS 2007e). Recent genetic analyses on female loggerheads nesting in Japan suggest that this “subpopulation” is comprised of genetically distinct nesting colonies (Hatase et al. 2002) with precise natal homing of individual females. As a result, Hatase et al. (2002) indicate that loss of one of these colonies would decrease the genetic diversity of Japanese loggerheads; recolonization of the site would not be expected on an ecological time scale. In Australia, long-term census data have been collected at some rookeries since the late 1960s and early 1970s, and nearly all the data show marked declines in nesting populations since the mid-1980s (Limpus and Limpus 2003). The nesting aggregation in Queensland, Australia, was as low as 300 females in 1997.

Pacific loggerhead turtles are captured, injured, or killed in numerous Pacific fisheries including Japanese longline fisheries in the western Pacific Ocean and South China Seas; direct harvest and commercial fisheries off Baja California, Mexico; commercial and artisanal swordfish fisheries off Chile, Columbia, Ecuador, and Peru; purse seine fisheries for tuna in the eastern tropical Pacific Ocean; and California/Oregon drift gillnet fisheries. In Australia, where turtles are taken in bottom trawl and longline fisheries, efforts have been made to reduce fishery bycatch (NMFS and USFWS 2007e).
In addition, the abundance of loggerhead sea turtles in nesting colonies throughout the Pacific basin has declined dramatically over the past 10 to 20 years. Loggerhead turtle colonies in the western Pacific Ocean have been reduced to a fraction of their former abundance by the combined effects of human activities that have reduced the number of nesting females and reduced the reproductive success of females that manage to nest (e.g., due to egg poaching).

In July 2007, NMFS received a petition requesting that loggerhead sea turtles in the North Pacific be classified as a distinct population segment (DPS) with endangered status and critical habitat designated. The petition also requested that if the North Pacific loggerhead is not determined to meet the DPS criteria, that loggerheads throughout the Pacific Ocean be designated as a DPS and listed as endangered. A thorough review by the Loggerhead Turtle Biological Review Team determined that Pacific loggerheads could be divided into two DPSs, the North Pacific DPS and South Pacific DPS (Conant et al. 2009).

3.2.5.2 Indian Ocean

Loggerhead sea turtles are distributed throughout the Indian Ocean, along most mainland coasts and island groups (Baldwin et al. 2003). Throughout the Indian Ocean, loggerhead sea turtles face many of the same threats as in other parts of the world including loss of nesting beach habitat, fishery interactions, and turtle meat and/or egg harvesting.

In the southwestern Indian Ocean, loggerhead nesting has shown signs of recovery in South Africa where protection measures have been in place for decades. However, in other southwestern areas (e.g., Madagascar and Mozambique) loggerhead nesting groups are still affected by subsistence hunting of adults and eggs (Baldwin et al. 2003). The largest known nesting group of loggerheads in the world occurs in Oman in the northern Indian Ocean. An estimated 20,000-40,000 females nest each year at Masirah, the largest nesting site within Oman (Baldwin et al. 2003). In the eastern Indian Ocean, all known nesting sites are found in Western Australia (Dodd 1988). As has been found in other areas, nesting numbers are disproportionate within the area, with the majority of nesting occurring at a single location. However, this may be the result of fox predation on eggs at other Western Australia nesting sites (Baldwin et al. 2003). A thorough review by the Loggerhead Turtle Biological Review Team determined that Indian Ocean loggerheads could be divided into three DPSs, the North Indian Ocean DPS, Southeast Indo-Pacific Ocean DPS, and Southwest Indian Ocean DPS (Conant et al. 2009).

3.2.5.3 Mediterranean Sea

Nesting in the Mediterranean is confined almost exclusively to the eastern basin. The highest level of nesting in the Mediterranean occurs in Greece, with an average of 3,050 nests per year. There is a long history of exploitation of loggerheads in the Mediterranean. Although much of this is now prohibited, some directed take still occurs. Loggerheads in the Mediterranean also face the threat of habitat degradation, incidental fishery interactions, vessel strikes, and marine pollution (Margaritoulis et al. 2003). Longline fisheries, in particular, are believed to catch thousands of juvenile loggerheads each year (NMFS and USFWS 2007e), although genetic analyses indicate that only a portion of the loggerheads captured originate from nesting groups in the Mediterranean (Laurent et al. 1998). A thorough review by the Loggerhead Turtle Biological Review Team determined that Mediterranean loggerheads could comprise a separate DPS, denoted the Mediterranean Sea DPS (Conant et al. 2009).

3.2.5.4 Atlantic Ocean

In the western Atlantic, most loggerhead sea turtles nest from North Carolina to Florida and along the Gulf coast of Florida. Previous section 7 analyses have recognized at least five western Atlantic subpopulations, divided geographically as follows: (1) a northern nesting subpopulation, occurring from North Carolina to northeast Florida at about 29ºN; (2) a south Florida nesting subpopulation, occurring from 29ºN on the east coast to Sarasota on the west coast; (3) a Florida Panhandle nesting subpopulation, occurring at Eglin Air Force Base and the beaches near Panama City, Florida; (4) a Yucatán nesting subpopulation, occurring on the eastern Yucatán Peninsula, Mexico (Márquez 1990 and TEWG 2000); and (5) a Dry Tortugas nesting subpopulation, occurring in the islands of the Dry Tortugas, near Key West, Florida (NMFS SEFSC 2001). The recently published Recovery Plan for the northwest Atlantic population of loggerhead sea turtles concluded, based on recent advances in genetic analyses, that there is no genetic distinction between loggerheads nesting on adjacent beaches along the Florida Peninsula, and that specific boundaries for subpopulations could not be designated based on genetic differences alone. Thus, the Plan uses a combination of geographic distribution of nesting densities, geographic separation, and geopolitical boundaries, in addition to genetic differences, to identify recovery units. The recovery units are: the (1) Northern Recovery Unit (Florida/Georgia border north through southern Virginia); (2) the Peninsular Florida Recovery Unit (Florida/Georgia border through Pinellas County, Florida); (3) the Dry Tortugas Recovery Unit (islands located west of Key West, Florida); (4) the Northern Gulf of Mexico Recovery Unit (Franklin County, Florida, through Texas); and (5) the Greater Caribbean Recovery Unit (Mexico through French Guiana, the Bahamas, Lesser Antilles, and Greater Antilles) (NMFS and USFWS 2008). The Recovery Plan concluded that all recovery units are essential to the recovery of the species. The Loggerhead Biological Review Team determined that loggerhead turtles in the Atlantic meet the required characteristics for listing as three separate DPSs, the Northwest Atlantic DPS, Northeast Atlantic DPS, and South Atlantic DPS (Conant et al. 2009).

Life History and Distribution
Past literature gave an estimated age at maturity of 21-35 years (Frazer and Ehrhart 1985, Frazer et al. 1994) with the benthic immature stage lasting at least 10-25 years. However, based on new data from tag returns, strandings, and nesting surveys NMFS SEFSC (2001) estimated ages of maturity ranging from 20-38 years and benthic immature stage lasting from 14-32 years.

Mating takes place in late March-early June, and eggs are laid throughout the summer, with a mean clutch size of 100-126 eggs in the southeastern United States. Individual females nest multiple times during a nesting season, with a mean of 4.1 nests per individual (Murphy and Hopkins 1984). Nesting migrations for an individual female loggerhead are usually on an interval of 2-3 years, but can vary from 1-7 years (Dodd 1988). Generally, loggerhead sea turtles originating from the western Atlantic nesting aggregations are believed to lead a pelagic existence in the North Atlantic Gyre for as long as 7-12 years or more. 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 and Gulf of Mexico, although some loggerheads may move back and forth between the pelagic and benthic environment (Witzell 2002). Benthic immature loggerheads (sea turtles that have come back to inshore and nearshore waters), the life stage following the pelagic immature stage, have been found from Cape Cod, Massachusetts, to southern Texas, and occasionally strand on beaches in northeastern Mexico.

Tagging studies have shown loggerheads that have entered the benthic environment undertake routine migrations along the coast that are limited by seasonal water temperatures. Loggerhead sea turtles occur year-round in offshore waters off North Carolina where water temperature is influenced by the Gulf Stream. As coastal water temperatures warm in the spring, loggerheads begin to immigrate to North Carolina inshore waters (e.g., Pamlico and Core Sounds) and also move up the coast (Epperly et al. 1995a-c), occurring in Virginia foraging areas as early as April and on the most northern foraging grounds in the Gulf of Maine in June. The trend is reversed in the fall as water temperatures cool. The large majority of loggerheads leave the Gulf of Maine by mid-September but some may remain in mid-Atlantic and Northeast areas until late fall. By December, loggerheads have emigrated from inshore North Carolina waters and coastal waters to the north to waters offshore of North Carolina, particularly off of Cape Hatteras, and waters further south where the influence of the Gulf Stream provides temperatures favorable to sea turtles ($\geq$ 11°C) (Epperly et al. 1995a-c). Loggerhead sea turtles are year-round residents of central and south Florida.

Pelagic and benthic juveniles are omnivorous and forage on crabs, mollusks, jellyfish, and vegetation at or near the surface (Dodd 1988). Sub-adult and adult loggerheads are primarily coastal dwelling and typically prey on benthic invertebrates such as mollusks and decapod crustaceans in hardbottom habitats.

Studies that are more recent are revealing that the loggerhead's life history is more complex than previously believed. Rather than making discrete developmental shifts from oceanic to neritic environments, research is showing that both adults and (presumed) neritic stage juveniles continue to use the oceanic environment and will move back and forth between the two habitats (Witzell 2002, Blumenthal et al. 2006, Hawkes et al. 2006, McClellan and Read 2007). One of the studies tracked the movements of adult females post-nesting and found a difference in habitat use was related to body size, with larger turtles staying in coastal waters and smaller turtles traveling to oceanic waters (Hawkes et al. 2006). A tracking study of large juveniles found that the habitat preferences of this life stage were also diverse, with some remaining in neritic waters while others moved off into oceanic waters (McClellan and Read 2007). However, unlike the Hawkes et al. study (2006), there was no significant difference in the body size of turtles that remained in neritic waters versus oceanic waters (McClellan and Read 2007). In either case, the research not only supports the need to revise the life history model for loggerheads but also demonstrates that threats to loggerheads in both the neritic and oceanic environments are likely affecting multiple life stages of this species.

Population Dynamics and Status

A number of stock assessments and similar reviews (TEWG 1998, TEWG 2000, NMFS SEFSC 2001, Heppell et al. 2003, NMFS and USFWS 2008, Conant et al. 2009, TEWG 2009) have examined the stock status of loggerheads in the Atlantic Ocean, but none have been able to develop a reliable estimate of absolute population size.

Numbers of nests and nesting females can vary widely from year to year. However, nesting beach surveys can provide a reliable assessment of trends in the adult female population, due to the strong nest site fidelity of females turtles, as long as such studies are sufficiently long, and effort and methods are standardized (see, e.g., NMFS and USFWS 2008; Meylan 1982). NMFS and USFWS (2008) concluded that the lack of change in two important demographic parameters of loggerheads, remigration interval and clutch frequency, indicate that time series on numbers of nests can provide reliable information on trends in the female population. Recent analysis of available data for the Peninsular Florida Recovery Unit has led to the conclusion that the observed decline in nesting for that unit over the last several years can best be explained by an actual decline in the number of adult female loggerheads in the population (Witherington et al. 2009).

Annual nest totals from beaches within what NMFS and USFWS have defined as the Northern Recovery Unit (NRU) averaged 5,215 nests from 1989-2008, a period of near-complete surveys of NRU nesting beaches (GDNR unpublished data, NCWRC unpublished data, SCDNR unpublished data), representing approximately 1,272 nesting females per year (4.1 nests per female, Murphy and Hopkins 1984). The loggerhead-nesting trend from daily beach surveys showed a significant decline of 1.3 percent annually. Nest totals from aerial surveys conducted by SCDNR showed a 1.9 percent annual decline in nesting in South Carolina since 1980. Overall, there is strong statistical data to suggest the NRU has experienced a long-term decline. Data in 2008 has shown improved nesting numbers, but future nesting years will need to be analyzed to determine if a change in trend is occurring. In 2008, 841 loggerhead nests were observed compared to the 10-year average of 715 nests in North Carolina. In South Carolina, 2008 was the seventh-highest nesting year on record since 1980, with 4,500 nests, but this did not change the long-term trend line indicating a decline on South Carolina beaches. Georgia beach surveys located 1,648 nests in 2008. This number surpassed the previous statewide record of 1,504 nests in 2003. According to analyses by Georgia DNR, the 40-year time-series trend data shows an overall decline in nesting, but the shorter comprehensive survey data (20 years) indicates a stable population (SCDNR 2008, GDNR unpublished data, NCWRC unpublished data, SCDNR unpublished data).

Another consideration that may add to the importance and vulnerability of the NRU is the sex ratios of this subpopulation. NMFS scientists have estimated that the Northern subpopulation produces 65 percent males (NMFS SEFSC 2001). However, research conducted over a limited period has found opposing sex ratios (Wyneken et al. 2004), so further information is needed to clarify the issue. Since nesting female loggerhead sea turtles exhibit nest fidelity, the continued existence of the Northern subpopulation is related to the number of female hatchlings that are produced. Producing fewer females will limit the number of subsequent offspring produced by the subpopulation.

The Peninsular Florida Recovery Unit (PFRU) is the largest loggerhead nesting assemblage in the northwest Atlantic. A near-complete nest census undertaken from 1989 to 2007 showed a mean of 64,513 loggerhead nests per year, representing approximately 15,735 nesting females per year (from NMFS and USFWS 2008). An analysis of index nesting beach data shows a decline in nesting by the PFRU between 1989 and 2008 of 26 percent over the period, and a mean annual rate of decline of 1.6 percent (Witherington et al. 2009, NMFS and USFWS 2008).

The remaining three recovery units—the Dry Tortugas (DTRU), Northern Gulf of Mexico (NGMRU), and Greater Caribbean (GCRU)—are much smaller nesting assemblages but still considered essential to the continued existence of the species. Nesting surveys for the DTRU are conducted as part of Florida's statewide survey program. Survey effort has been relatively stable during the 9-year period from 1995-2004 (although the 2002 year was missed). Nest counts ranged from 168-270, with a mean of 246, but with no detectable trend during this period (Florida Fish and Wildlife Conservation Commission, Florida Marine Research Institute, Statewide Nesting Beach Survey Data; NMFS and USFWS 2008). Nest counts for the NGMRU are focused on index beaches rather than all beaches where nesting occurs. The 12-year dataset (1997-2008) of index nesting beaches in the area shows a significant declining trend of 4.7 percent annually (NMFS and USFWS 2008). Similarly, nesting survey effort has been inconsistent among the GCRU nesting beaches and no trend can be determined for this subpopulation. Zurita et al. (2003) found a statistically significant increase in the number of nests on seven of the beaches on Quintana Roo, Mexico, from 1987-2001, where survey effort was consistent during the period. However, nesting has declined since 2001 and the previously reported increasing trend appears to not have been sustained (NMFS and USFWS 2008)

Determining the meaning of the nesting decline data is confounded by various in-water research that suggest the abundance of neritic juvenile loggerheads is steady or increasing (Ehrhart et al. 2007; M. Bersette pers. comm. regarding captures at the St. Lucie Power Plant; SCDNR unpublished SEAMAP-SA data; Epperly et al. 2007). Ehrhart et al. (2007) found no significant regression-line trend in the long-term dataset. However, notable increases in recent years and a statistically significant increase in CPUE of 102.4 percent from the 4-year period of 1982-1985 to the 2002-2005 periods were found. Epperly et al. (2007) determined the trends of increasing loggerhead catch rates from all the aforementioned studies in combination provide evidence that there has been an increase in neritic juvenile loggerhead abundance in the southeastern United States in the recent past. A study led by the South Carolina Department of Natural Resources found that standardized trawl survey CPUEs for loggerheads from South Carolina to north Florida was 1.5 times higher in summer 2008 than summer 2000. However, even though there were persistent inter-annual increases from 2000-2008, the difference was not statistically significant, likely due to the relatively short time-series. Comparison to other data sets from the 1950s through 1990s showed much higher CPUEs in recent years regionally and in the South Atlantic Bight, leading SCDNR to conclude that it is highly improbable that CPUE increases of such magnitude could occur without a real and substantial increase in actual abundance (Arendt et al. 2009). Whether this increase in abundance represents a true population increase among juveniles or merely a shift in spatial occurrence is not clear. NMFS and USFWS (2008), citing Bjorndal et al. 2005, caution about extrapolating localized in-water trends to the broader population, and relating localized trends in neritic sites to population trends at nesting beaches. The apparent overall increase in the abundance of neritic loggerheads in the southeastern United States may be due to increased abundance of the largest Stage III individuals (oceanic/neritic juveniles, historically referred to as small benthic juveniles), which could indicate a relatively large cohort that will recruit to maturity in the near future. However, the increase in adults may be temporary, as in-water studies throughout the eastern United States also indicate a substantial decrease in the abundance of the smallest Stage III loggerheads, a pattern also corroborated by stranding data (TEWG 2009).

The NMFS Southeast Fishery Science Center has developed a preliminary stage/age demographic model to help determine the estimated impacts of mortality reductions on loggerhead sea turtle population dynamics (NMFS SEFSC 2009). This model does not incorporate existing trends in the data (such as nesting trends), but relies on utilizing the available information on the relevant life-history parameters for sea turtles and then predicts future population trajectories based upon model runs using those parameters. Therefore, the model results do not build upon, but instead are complementary to, the trend data obtained through nest counts and other observations. The model uses the range of published information for the various parameters including mortality by stage, stage duration (years in a stage), and fecundity parameters such as eggs per nest, nests per nesting female, hatchling emergence success, sex ratio, and remigration interval. Model runs were done for each individual recovery unit as well as the western North Atlantic population as a whole, and the resulting trajectories were found to be very similar. One of the most robust results from the model was an estimate of the adult female population size for the western North Atlantic over the 2004-2008 period. The distribution resulting from the model runs suggest the adult female population size to be likely between approximately 20,000 to 40,000 individuals, with a low likelihood of being up to 70,000. A much less robust estimate for total benthic females in the western North Atlantic ranged from approximately 30,000-300,000 individuals, up to less than 1 million.

The results of one set of model runs suggest that the population is most likely declining, but this result was very sensitive to the choice of the position of the parameters within their range and hypothesized distributions. This example was run to predict the distribution of projected population trajectories for benthic females using a range of starting population numbers from the estimated minimum of 30,000 to the greater than 300,000 upper end of the range and declining trajectories were estimated for all of the population estimates. After 10,000 simulation runs of the models using the parameter ranges, 14 percent of the runs resulted in growing populations, while 86 percent resulted in declining populations. While this does not translate to an equivalent statement that there is an 86 percent chance of a declining population, it does illustrate that given the life history parameter information currently thought to comprise the likely range of possibilities, it appears most likely that with no changes to those parameters the population is projected to decline. Additional model runs using the range of values for each life history parameter, the assumption of non-uniform distribution for those parameters, and a 5 percent natural (non-anthropogenic) mortality for the benthic stages, resulted in a determination that a 60-70 percent reduction in anthropogenic mortality in the benthic stages would be needed to bring 50 percent of the model runs to a static (zero growth or decline) or increasing trajectory (NMFS SEFSC 2009).

Predicting the future populations or population trajectories of loggerhead sea turtles with precision is currently very difficult because of the large uncertainty in our knowledge of loggerhead life history. Therefore, fine-scale examinations of how individual fisheries or actions affect the population trajectories cannot be resolved. However, the model results are useful in guiding future research needs to better understand the life history parameters that have the most significant impact in the model. Additionally, the model results provide valuable insights into the likely overall declining status of the species and in the impacts of large-scale changes to various life history parameters (such as mortality rates for given stages) and how they may change the trajectories. The results of the model, in conjunction with analyses conducted on nest count trends (such as Witherington et al. 2009), which have suggested that the population decline is real, provides a strong basis for the conclusion that the western North Atlantic loggerhead population is in decline. NMFS also convened a new Turtle Expert Working Group (TEWG) for loggerhead sea turtles that is gathering available data and examining the potential causes of the nesting decline and what the decline means in terms of population status. The TEWG ultimately could not determine whether or not decreasing annual numbers of nests among the Western North Atlantic loggerhead subpopulations were due to stochastic processes resulting in fewer nests, a decreasing average reproductive output of the adult females, decreasing numbers of adult females, or a combination of those factors. Past and present mortality factors that could affect current loggerhead nest numbers are many, and it is likely that several factors compound to create the current decline. Regardless of the source of the decline, it is clear that the reduced nesting will result in depressed recruitment to subsequent life stages over the coming decades (TEWG 2009).

Threats

The 5-year status review of loggerhead sea turtles recently completed by NMFS and the USFWS provides a summary of natural as well as anthropogenic threats to loggerhead sea turtles (NMFS and USFWS 2007e). The Loggerhead Recovery Team also undertook a comprehensive evaluation of threats to the species, and described them separately for the terrestrial, neritic, and oceanic zones (NMFS and USFWS 2008). The diversity of sea turtles' life history leaves them susceptible to many natural and human impacts, including impacts while they are on land, in the benthic environment, and in the pelagic environment. Hurricanes are particularly destructive to sea turtle nests. Sand accretion and rainfall that result from these storms, as well as wave action, can appreciably reduce hatchling success. For example, in 1992, all of the eggs over a 90-mile length of coastal Florida were destroyed by storm surges on beaches that were closest to the eye of Hurricane Andrew (Milton et al. 1994). In addition, many nests were destroyed during the 2004 and 2005 hurricane seasons. Other sources of natural mortality include cold-stunning and biotoxin exposure.

Anthropogenic factors that affect hatchlings and adult female sea turtles on land, or the success of nesting and hatching include: beach erosion, beach armoring and nourishment, artificial lighting, beach cleaning, increased human presence, recreational beach equipment, beach driving, coastal construction and fishing piers, exotic dune and beach vegetation, and poaching. An increase in human presence at some nesting beaches or close to nesting beaches has led to secondary threats such as the introduction of exotic fire ants, feral hogs, dogs and an increased presence of native species (e.g., raccoons, armadillos, and opossums) which raid and feed on turtle eggs. Although sea turtle nesting beaches are protected along large expanses of the northwest Atlantic coast (in areas like Merritt Island, Archie Carr, and Hobe Sound National Wildlife Refuges), other areas along these coasts have limited or no protection. Sea turtle nesting and hatching success on unprotected high-density east Florida nesting beaches from Indian River to Broward County are affected by all of the above threats.

Loggerhead sea turtles are affected by a completely different set of anthropogenic threats in the marine environment. These include oil and gas exploration, coastal development, and transportation, marine pollution, underwater explosions, hopper dredging, offshore artificial lighting, power plant entrainment and/or impingement, entanglement in debris, ingestion of marine debris, marina and dock construction and operation, boat collisions, poaching, and fishery interactions. Loggerheads in the pelagic environment are exposed to a series of longline fisheries, which include the highly migratory species' Atlantic pelagic longline fisheries, an Azorean longline fleet, a Spanish longline fleet, and various longline fleets in the Mediterranean Sea (Aguilar et al. 1995, Bolten et al. 1994, Crouse 1999b). Loggerheads in the benthic environment in waters off the coastal United States are exposed to a suite of fisheries in federal and state waters including trawl, purse seine, hook-and-line, gillnet, pound net, longline, and trap fisheries. The sizes and reproductive values of sea turtles taken by fisheries vary significantly, depending on the location and season of the fishery, and size-selectivity resulting from gear characteristics. Therefore, it is possible for fisheries that interact with fewer, more reproductively valuable turtles to have a greater detrimental effect on the population than one that takes greater numbers of less reproductively valuable turtles if the fishery removes a higher overall reproductive value from the population (Wallace et al. 2008). The Loggerhead Biological Review Team determined that the greatest threats to the Northwest Atlantic DPS of loggerheads result from cumulative fishery bycatch in neritic and oceanic habitats (Conant et al. 2009). Attaining a more thorough understanding of the characteristics, as well as the quantity, of sea turtle bycatch across all fisheries is of great importance.

Loggerheads may also be facing a new threat that could be either natural or anthropogenic. A little understood disease may pose a new threat to loggerheads sea turtles. From October 5, 2000, to March 24, 2001, 49 debilitated loggerheads associated with the disease were found in southern Florida from Manatee County on the west coast through Brevard County on the east coast (Foley 2002). From the onset of the epizootic through its conclusion, affected sea turtles were found throughout south Florida. Most (N=34) were found in the Florida Keys (Monroe County). The number of dead or debilitated loggerheads found during the epizootic (N=189) was almost six times greater than the average number found in south Florida from October to March during the previous ten years. After determining that no other unusual mortality factors appeared to have been operating during the epizootic, 156 of the strandings were likely to be attributed to disease outbreak. These numbers may represent only 10 to 20 percent of the sea turtles that were affected by this disease because many dead or dying sea turtles likely never wash ashore. Overall mortality associated with the epizootic was estimated between 156 and 2,229 loggerheads (Foley 2002). Scientists were unable to attribute the illness and epidemic to any one specific pathogen or toxin. If the agent responsible for debilitating these sea turtles re-emerges in Florida, and if the agent is infectious, nesting females could spread the disease throughout the range of the adult loggerhead population.

There is a large and growing body of literature on past, present, and future impacts of global climate change induced by human activities, i.e., global warming. Some of the likely effects commonly mentioned are sea level rise, increased frequency of severe weather events, and change in air and water temperatures. The Environmental Protection Agency's climate change webpage provides basic background information on these and other measured or anticipated effects (see www.epa.gov/climatechange/index.html). However, the impacts on sea turtles currently cannot be predicted, for the most part, with any degree of certainty.

The Intergovernmental Panel on Climate Change has stated that global climate change is unequivocal (IPCC 2007) and its impacts may have significant impacts to the hatchling sex ratios of loggerhead sea turtles (NMFS and USFWS 2007e). In marine turtles, sex is determined by temperature in the middle third of incubation with female offspring produced at higher temperatures and males at lower temperatures within a thermal tolerance range of 25º-35°C (Ackerman 1997). Increases in global temperature could potentially skew future sex ratios toward a higher numbers of females (NMFS and USFWS 2007e). Modeling suggests that an increase of 2°C in air temperature would result in a sex ratio of over 80 percent female offspring for loggerheads nesting near Southport, North Carolina. The same increase in air temperatures at nesting beaches in Cape Canaveral, Florida, would result in close to 100 percent female offspring. More ominously, an air temperature increase of 3°C is likely to exceed the thermal threshold of most clutches, leading to death (Hawkes et al. 2007).

Warmer sea surface temperatures have been correlated to an earlier onset of loggerhead nesting in the spring (Weishampel et al. 2004, Hawkes et al. 2007), as well as short inter-nesting intervals (Hays et al. 2002), and shorter nesting season (Pike et al. 2006).

The effects from increased temperatures may be exacerbated on developed nesting beaches where shoreline armoring and construction have denuded vegetation. Erosion control structures could potentially result in the permanent loss of nesting beach habitat or deter nesting females (NRC 1990). Alternatively, nesting females may nest on the seaward side of the erosion control structures, potentially exposing them to repeated tidal over wash (NMFS and USFWS 2007e). Sea level rise from global climate change (IPCC 2007) is also a potential problem, particularly for areas with low-lying beaches where sand depth is a limiting factor, as the sea may inundate nesting sites and decrease available nesting habitat (Daniels et al. 1993, Fish et al. 2005, Baker et al. 2006). The loss of habitat because of climate change could be accelerated due to a combination of other environmental and oceanographic changes such as an increase in the frequency of storms and/or changes in prevailing currents, both of which could lead to increased beach loss via erosion (Antonelis et al. 2006, Baker et al. 2006).

Other changes in the marine ecosystem caused by global climate change (e.g., salinity, oceanic currents, dissolved oxygen levels, nutrient distribution, etc.) could influence the distribution and abundance of phytoplankton, zooplankton, submerged aquatic vegetation, crustaceans, mollusks, forage fish, etc., which could ultimately affect the primary foraging areas of loggerhead sea turtles.

Actions have been taken to reduce anthropogenic impacts to loggerhead sea turtles from various sources, particularly since the early 1990s. These include lighting ordinances, predation control, and nest relocations to help increase hatchling survival, as well as measures to reduce the mortality of pelagic immatures, benthic immatures, and sexually mature age classes in various fisheries and other marine activities. Recent actions have taken significant steps towards reducing the environmental baseline and improving the status of all loggerhead subpopulations. For example, the TED regulation published on February 21, 2003, (68 FR 8456) represents a significant improvement in the baseline affecting loggerhead sea turtles. Shrimp trawling is considered the largest source of anthropogenic mortality on loggerheads.

3.2.5.5 Summary of Status for Loggerhead Sea Turtles

In the Pacific Ocean, loggerhead sea turtles are represented by a northwestern Pacific nesting aggregation (located in Japan) and a smaller southwestern nesting aggregation that occurs in Australia (Great Barrier Reef and Queensland) and New Caledonia. The abundance of loggerhead sea turtles on nesting colonies throughout the Pacific basin has declined dramatically over the past 10 to 20 years. Data from 1995 estimated the Japanese nesting aggregation at 1,000 female loggerhead sea turtles (Bolten et al. 1996), but it has probably declined since 1995 and continues to decline (Tillman 2000). The nesting aggregation in Queensland, Australia, was as low as 300 females in 1997.

In the Atlantic Ocean, absolute population size is not known, but based on extrapolation of nesting information, loggerheads are likely much more numerous than in the Pacific Ocean. The NMFS recognizes five recovery units of loggerhead sea turtles in the western north Atlantic based on genetic studies and management regimes. Cohorts from all of these are known to occur within the action area of this consultation. There are long-term declining nesting trends for the two largest western Atlantic recovery units: the PFRU and the NRU. Furthermore, no long-term data suggest any of the loggerhead subpopulations throughout the entire North Atlantic are increasing in annual numbers of nests (TEWG 2009). Additionally, using both computation of susceptibility to quasi-extinction and stage-based deterministic modeling to determine the effects of known threats to the Northwest Atlantic DPS, the Loggerhead Biological Review Team determined that this DPS is likely to decline in the foreseeable future, driven primarily by the mortality of juvenile and adult loggerheads from fishery bycatch throughout the North Atlantic Ocean. These computations were done for each of the recovery units, and all of them resulted in an expected decline (Conant et al. 2009). Because of its size, the PFRU may be critical to the survival of the species in the Atlantic Ocean. In the past, this nesting aggregation was considered second in size only to the nesting aggregation on islands in the Arabian Sea off Oman (Ross 1979, Ehrhart 1989, NMFS and USFWS 1991b). However, the status of the Oman colony has not been evaluated recently and it is located in an area of the world where it is highly vulnerable to disruptive events such as political upheavals, wars, catastrophic oil spills, and lack of strong protections for sea turtles (Meylan et al. 1995). Given the lack of updated information on this population, the status of loggerheads in the Indian Ocean basin overall is essentially unknown. On March 5, 2008, NMFS and USFWS published a 90-day finding that a petitioned request to reclassify loggerhead turtles in the western North Atlantic Ocean as a distinct population segment may be warranted (73 FR 11849). NMFS and USFWS have formed a biological review team to assess the data and will complete the petition findings and plan of action by May 1, 2009. The Loggerhead Biological Review Team determined that loggerhead sea turtles in the Atlantic meet the required characteristics to be separated into three DPSs, the Northwest Atlantic DPS, Northeast Atlantic DPS, and South Atlantic DPS (Conant et al. 2009). NMFS and USFWS will use the information in that review, along with other available information, to determine the listing status (threatened or endangered) for each DPS.

All loggerhead subpopulations are faced with a multitude of natural and anthropogenic effects that negatively influence the status of the species. Many anthropogenic effects occur because of activities outside of U.S. jurisdiction (i.e., fisheries in international waters).

3.2.6 Elkhorn Coral

Elkhorn coral was listed as threatened under the ESA on May 9, 2006. The Atlantic *Acropora* Status Review presents a summary of published literature and other currently available scientific information regarding the biology and status of both elkhorn and staghorn corals. The following discussion summarizes those findings relevant to elkhorn coral and our evaluation of the proposed action.

Elkhorn coral is one of major reef-building corals in the wider Caribbean. Colonies are flattened to nearly round, with frond-like branches that typically radiate outward from a central trunk, firmly attached to the sea floor. Historically, this 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. Early descriptions of Florida Keys reefs referred to reef zones, of which the elkhorn zone was described for many shallow-water reefs (Figure 3.3) (Jaap 1984, Dustan 1985, Dustan and Halas 1987). However, the structural and ecological roles of elkhorn coral in the wider Caribbean are unique and cannot be filled by other reef-building corals in terms of accretion rates and the formation of structurally complex reefs (Bruckner 2002).

Life History

The maximum range in depth reported for elkhorn coral is <1 m to 30 m, but the optimal depth range for this coral is considered to be 1 to 5 m (Goreau and Wells 1967). Currently, the deepest known colonies of elkhorn coral 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 elkhorn coral is the seaward face of a reef (turbulent shallow water), including the reef crest, and the shallow spur-and-groove zone (Shinn 1963, Cairns 1982, Rogers et al. 1982). Colonies are occasionally exposed during low tide. Colonies of elkhorn coral often grow in nearly monospecific,[5] dense stands and form interlocking frameworks, known as thickets, in fringing and barrier reefs (Jaap 1984, Tomascik and Sander 1987, Wheaton and Jaap 1988). Colonies generally do not form a thicket below 5 m depth, with maximum water depths of framework construction ranging from 3 to 12 m (see Table 1 in Lighty et al. 1982).

Typical water temperatures for elkhorn coral range from 21°-29°C, although colonies in the U.S.V.I. have been known to tolerate short-term temperatures around 30°C without obvious bleaching.[6] Jaap (1979) and Roberts et al. (1982) note an upper temperature tolerance of 35.8°C for elkhorn coral. All *Acropora* species are susceptible to bleaching due to adverse environmental conditions (Ghiold and Smith 1990, Williams and Bunkley-Williams 1990). Major mortality of elkhorn corals occurred in the Dry Tortugas, Florida, in 1977 due to a winter cold front that depressed surface water temperatures to 14°-16°C. All *Acropora* species require near-oceanic salinities (34 to 37 ppt).

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[5] Monospecific stands refer to stands made up of only one species of coral.
[6] Bleaching refers to the loss of zooxanthellae.

Elkhorn coral, like many stony coral species, employ both sexual and asexual reproductive propagation. Elkhorn corals reproduce sexually by broadcast spawning. During these spawning events, colonies are simultaneously hermaphroditic[7] and coral larvae develop externally to the parental colonies (Szmant 1986). The spawning season for elkhorn coral is relatively short, with gametes released only during a few nights in July, August, and/or September. In some populations, spawning is synchronous after the full moon during any of these three months. Annual egg production by elkhorn coral populations studied in Puerto Rico was estimated to be 600 to 800 eggs per cm^2 of living coral tissue (Szmant 1986).

Fertilization and development of elkhorn corals is exclusively external. Embryonic development culminates with the development of planktonic larvae called planulae. Little is known about the settlement patterns of planulae (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, in this case preferably coralline algae. Unlike most other coral larvae, elkhorn 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. 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.

Studies of elkhorn corals on the Caribbean coast of Panama indicated that larger colonies[8] had higher fertility rates than smaller colonies (Soong and Lang 1992). For example, over 80 percent of the elkhorn colonies larger than 4000 cm^2 were fertile. The estimated size at puberty for elkhorn coral was 1600 cm^2 and the smallest reproductive colony observed was 16 x 8 cm^2 (128 cm^2)(Soong and Lang 1992).

The growth rate of elkhorn coral, expressed as the linear extension of branches, is reported to range from 4 to 11 cm annually (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). Wells (1933) reported from observations in 1932 that colonies of elkhorn coral 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.

Few data on the genetic population structure of elkhorn coral exist; however, due to recent advances in technology, the genetic population structure of the current, depleted population is beginning to be characterized. Baums et al. (2005) examined the genetic exchange in elkhorn coral by sampling and genotyping colonies from 11 locations throughout its geographic range using microsatellite markers. Results indicate that

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[7] Simultaneously hermaphroditic refers to colonies with both female and male reproductive parts. Gametes (eggs and sperm) of these colonies are located in different mesenteries of the same polyp (Soong 1991). However, gametes from the same colony cannot combine to produce viable recruits.

[8] As measured by surface area of the live colony.

elkhorn populations in the eastern Caribbean (St. Vincent and the Grenadines, U.S.V.I., Curacao, and Bonaire) have experienced little or no genetic exchange with populations in the western Caribbean (Bahamas, Florida, Mexico, Panama, Navassa, and Mona Island). Mainland Puerto Rico is an area of mixing where elkhorn 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.

Status and Distribution
Historically, elkhorn coral comprised the elkhorn zone (Figure 3.3) at 1 to 8 m depths (reef flat, wave zone, reef crest) throughout much of the wider Caribbean. These corals populated these reefs zones in areas like Jamaica (Goreau 1959); Alacrán Reef, Yucatán 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). Elkhorn coral also 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. The predominance of elkhorn coral 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 conditions (Geister 1977). 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 and Brown 1979). Although considered a turbulent water species, elkhorn coral is sensitive to breakage by wave action and is often replaced by coralline algae in heavy surf zones (Adey 1977).

Studies of historical distribution and abundance patterns focus on percent coverage, density, and relative size of the corals during three periods: pre-1980, the 1980-1990 decades, and recent (since 2000). Few data are present before 1980, likely due in part to researchers' tendencies to neglect careful measurement of abundance for ubiquitous species.

Both species underwent precipitous declines in the early 1980s throughout their ranges and this decline has continued. Although quantitative data on former distribution and abundance are scarce, in the few locations where quantitative data are available (e.g., Florida Keys, Dry Tortugas, Belize, Jamaica, and the U.S.V.I.), declines in abundance (coverage and colony numbers) are estimated at >97 percent. Although this decline has been documented as on-going during in the late 1990s, and even in the past five years in some locations, local extirpations (i.e., at the island or country scale) have not been rigorously documented.

Figure 3.4 summarizes the abundance trends of specific locations throughout the wider Caribbean where quantitative data exist, illustrating the overall trends of decline for elkhorn corals since the 1980s. It is important to note that the data are from the same geographic area, not repeated measures at an exact reef/site that would indicate more general trends. The overall regional trend depicted is a >97 percent loss of coverage (area of substrate the species occupy).

Threats
Elkhorn corals are facing a myriad of threats that are in some cases acting synergistically. Diseases, temperature-induced bleaching, and physical damage from hurricanes are deemed the greatest threats to elkhorn corals. The threat from disease, though clearly severe, is poorly understood in terms of etiology and possible links to anthropogenic stressors. Threats from anthropogenic physical damage (e.g., vessel groundings, anchors, divers/snorkelers, etc.), coastal development, competition, and predation are deemed moderate (*Acropora* BRT 2005). Table 3.2 summarizes the factors affecting the status of elkhorn coral and the identified sources of those threats.

There is a large and growing body of literature on past, present, and future impacts of global climate change induced by human activities – frequently referred to in layman's terms as "global warming." Some of the likely effects to elkhorn coral are: increased water temperature and frequency of bleaching events, elevated CO_2 levels and reduced calcification for coral skeletal growth, sea-level rise, and changes in the frequency or intensity of storms (*Acropora* BRT 2005). The Environmental Protection Agency's climate change webpage provides basic background information on these and other measured or anticipated effects (see www.epa.gov/climatechange/index.html). However, the impacts on elkhorn coral currently cannot be predicted, for the most part, with any degree of certainty.

Increased temperatures resulting from global climate change could allow reef distribution to shift to more northern latitudes; however, Buddemeier et al. (2004) argued that such migration would be impeded because humans have negatively altered the coastal areas where future reefs might form. If global climate change alters the northward flowing warm oceanic currents, high latitude reefs may be threatened.

Coral bleaching patterns are complex and seasonal cycles in symbiotic dinoflagellate density occur in many species (Fitt et al. 2001), but there is general agreement that thermal stress leading to bleaching and mass mortality has increased during the past 25 years (Brown 1997). Most corals are able to withstand seasonal variations in water temperatures though an increase of 1° to 2°C above the normal seasonal maximum can induce bleaching (Fitt and Warner 1995). Bleaching events lasting for more than a few weeks may cause mortality (Jaap 1979, Jaap 1985). Trends in global sea surface temperatures show an increase in the frequency of warm-season temperature extremes during the past two decades. These increases have caused more frequent episodes of coral bleaching (*Acropora* BRT 2005). Using global climate models, Hoegh-Guldberg (1999) predict the frequency of thermal events in the future exceeding the bleaching threshold for a given area will become more commonplace within 15 years and will occur annually in about 40 years.

Although both *Acropora* species may be somewhat more resistant to bleaching than other stony corals, they are still susceptible. Bleaching of *A. palmata* was observed during a mass bleaching event in 1998 at Looe Key, Coffins Patch, and Western Sambo Reefs in the Florida Keys (Causey pers. comm., in *Acropora* BRT 2005) and at several sites in the upper Florida Keys where substantial mortality (largely partial mortality of colonies) ensued (Miller et al. 2002).

Increases in atmospheric carbon dioxide (CO_2) can also affect elkhorn coral. Atmospheric CO_2 has increased from about 280 parts per million (ppm) in the early 1800s to current levels of about 380 ppm (Prentice 2001). As atmospheric CO_2 is dissolved in surface seawater, it becomes more acidic, shifting the balance of inorganic carbon away from CO_2 and carbonate (CO_3^{-2}) toward bicarbonate (HCO_3^{-1}). These changes affect corals' ability to create new skeletal material because corals are thought to use CO_3^{-2} as the source of carbonate to build their aragonite ($CaCO_3$) skeletons. Numerous experiments have shown a relationship between elevated CO_2 and decreased calcification rates in corals and other $CaCO_3$ secreting organisms (Reibesell et al. 2000, Barker and Elderfield 2002, Hoegh-Guldberg et al. 2007). Kleypas et al. (1999) calculated that coral calcification could be reduced by 30 percent in the tropics by the middle of the 21st century. Corals grown during laboratory experiments that doubled atmospheric CO_2 manifested an 11 to 37 percent reduction in calcification (Gattuso et al. 1999, Langdon 2003, Marubini et al. 2003).

Rapid rises in sea level will likely affect elkhorn coral by both submerging it below its common depth range and by degrading water quality through coastal erosion or enlargement of lagoons and shelf areas. Blanchon and Shaw (1995) argued that a sustained sea-level rise of more than 14 mm/yr will displace elkhorn coral from its framework range (0 to 5 m) into its remaining habitat range (5 to 10 m) where a mixed framework is likely to develop. Sea-level change is unlikely to lead to extinction in the next several hundred years by this process because sea level is not predicted to rise that rapidly in the near future (Church and Gregory 2001).

Elkhorn coral would likely be affected by decreased water quality because of shoreline erosion and flooding of shallow banks and lagoons caused by sea-level rise. Where topography is low and/or shoreline sediments are easily eroded, corals may be stressed by degrading water quality as sea-level rise proceeds. Flooded shelves and banks at higher latitudes (greater than 15°N) may alter the temperature or salinity of seawater to extremes that can then affect corals during offshore flows. Although this process could be widespread, there will be many areas, particularly on the windward side of rocky islands, where erosion and lagoon formation will be minimal (*Acropora* BRT 2005).

The impacts of global climate change on the severity and frequency of tropical weather events (e.g., typhoons and hurricanes) are currently being debated. The Intergovernmental Panel on Climate Change stated that based on a range of models it was likely that future tropical weather events will become more intense, with larger peak wind speeds and more heavy precipitation associated with ongoing increases of tropical sea surface temperatures (IPCC 2007). However, a statement on tropical cyclones and climate change developed by the participants of the World Meteorological Organization states that while "there is evidence both for and against the existence of a detectable anthropogenic signal in the tropical cyclone climate record to date, no firm conclusion can be made on this point" (WMO 2006).

3.2.6.1 Summary of Elkhorn Coral

Many factors, including both life history characteristics and external threats, are important to consider in assessing the status and vulnerability of elkhorn coral. Recovery of elkhorn coral from its current level of decreased abundance depends upon rates of recruitment and growth outpacing rates of mortality. This species has a rapid growth rate and high potential for propagation via fragmentation. However, while fragmentation is an excellent life history strategy for recovery from physical disturbance, it is not as effective when fragment sources (i.e., large extant colonies) are scarce.

Thus, it is anticipated that successful sexual reproduction will need to play a major role in elkhorn coral recovery (Bruckner 2002). Meanwhile, there is substantial evidence to suggest that sexual recruitment of elkhorn corals is currently compromised. Reduced colony density in this broadcast spawning, compounded in some geographic areas with low genetic diversity, suggests that fertilization success and consequently, larval availability, has been reduced. In addition, appropriate substrate available for fragments to attach to is likely reduced due to changes in benthic community structure on many Caribbean reefs. Coupled with impacts from coastal development (i.e., dominance by macroalgal, turf, and/or sediment-coated substrates), these factors are expected to further reduce successful larval recruitment below a threshold that can compensate for observed rates of ongoing mortality.

Species at reduced abundance are at a greater risk of extinction due to stochastic environmental and demographic factors (e.g., episodic recruitment factors). Elkhorn corals have persisted at extremely reduced abundance levels (in most areas with quantitative data available, less than 3 percent of prior abundance) for at least two decades.

The major threats (e.g., disease, elevated sea surface temperature, and hurricanes) to elkhorn coral are severe, unpredictable, likely to increase in the foreseeable future, and currently unmanageable. However, managing some of the less severe stressors (e.g., nutrients, sedimentation) may help slow the rate of elkhorn coral decline by enhancing coral condition and decreasing synergistic stress effects.

The impacts on elkhorn coral from all of the above-mentioned threats could be exacerbated by reduced genetic diversity, which often results when species undergo rapid decline like elkhorn coral has in recent decades. This expectation is heightened when the decline is due to a potentially selective factor such as disease, in contrast to a less selective factor such as hurricane damage, which will likely cause disturbance independent of genotype. If the species remains at low densities for prolonged periods, genetic diversity may be significantly reduced. Thus, given the current dominance of asexual reproduction, the rapid abundance decline (largely from a selective factor), and the lack of rapid recovery, it is plausible that these populations have suffered a loss of genetic diversity that could compromise their ability to adapt to future changes in environmental conditions. No quantitative information is available regarding genetic diversity for this species.

3.2.7 Staghorn coral

Staghorn coral was listed with elkhorn coral as threatened under the ESA on May 9, 2006. The Atlantic *Acropora* Status Review presents a summary of published literature and other currently available scientific information regarding the biology and status of both elkhorn and staghorn corals. The following discussion summarizes those findings relevant to staghorn coral and our evaluation of the proposed action.

Staghorn coral is one of the major reef-building corals in the wider Caribbean. Staghorn coral is characterized by staghorn-antler-like colonies, with cylindrical, straight, or slightly curved branches. Early descriptions of Florida Keys reefs referred to reef zones, of which the staghorn zone was described for many shallow-water reefs (Figure 3.3) (Jaap 1984, Dustan 1985, Dustan and Halas 1987). Like elkhorn coral, the structural and ecological roles of staghorn are unique and cannot be filled by other reef-building corals (Bruckner 2002).

Life History

Historically, staghorn coral was reported from depths ranging from <1 to 60 m (Goreau and Goreau 1973). It is suspected 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). Colonies have been common in back- and patch-reef habitats (Gilmore and Hall 1976, Cairns 1982). Although staghorn coral colonies are sometimes found interspersed among colonies of elkhorn coral, they are generally in deeper water or seaward of the elkhorn zone and, hence, more protected from waves. Historically, staghorn coral was also 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 Yucatán peninsula (Adey 1978).

Staghorn coral is considered environmentally sensitive, requiring relatively clear, well-circulated water (Jaap et al. 1989). These corals have the same sunlight requirements as noted above for elkhorn corals and are subsequently susceptible to similar increases in turbidity (see Section 3.2.6). As a result, staghorn coral is susceptible to long-term reductions in water clarity and may not be able to compensate with an alternate food source, such as zooplankton and suspended particulate matter, like other corals.

Staghorn coral also has the same optimal water temperature range as elkhorn corals. Bleaching of staghorn coral will also occur under the same environmental conditions that precipitate these events in elkhorn corals. Staghorn corals were also affected during the major mortality event that occurred in the Dry Tortugas, Florida, in 1977, which also affect elkhorn corals. Some reduction in growth rates of staghorn coral was reported in Florida when temperatures dropped to less than 26°C (Shinn 1966).

Staghorn coral employs the same reproductive propagation strategy as elkhorn coral (see Section 3.2.6). Likewise, the fertilization and development of staghorn coral follow the same patterns noted above for elkhorn corals (see Section 3.2.6).

Studies of elkhorn and staghorn corals on the Caribbean coast of Panama indicated that larger colonies have higher fertility rates (Soong and Lang 1992). Only colonies of staghorn coral with a branch length greater than 9 cm were fertile and over 80 percent of colonies with branches longer than 17 cm (n=18) were fertile. The estimated size at puberty for staghorn coral was 17 cm in branch length and the smallest reproductive colony observed was 9 cm in branch length (Soong and Lang 1992).

The growth rate for staghorn coral has been reported to range from 3 to 11.5 cm/yr. This growth rate is relatively fast compared to other corals and historically enabled the species to construct significant reefs in several locations throughout the wider Caribbean (Adey 1978). Growth in staghorn coral 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 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 staghorn coral relative to other corals and other benthic organisms (Shinn 1976, Neigel and Advise 1983, Jaap et al. 1989).

Few data on the genetic population structure of staghorn coral exist; however, due to recent advances in technology, the genetic population structure of the current, depleted population is beginning to be characterized. Vollmer and Palumbi (2007) examined multilocus sequence data from 276 colonies of staghorn coral spread across 22 populations from 9 regions in the Caribbean, Florida, and the Bahamas. Their data were consistent with the Western-Eastern Caribbean subdivision observed in elkhorn coral populations by Baums et al. (2005).

Status and Distribution

Historically, throughout much of the wider Caribbean, staghorn coral so dominated the reef within the 7- to 15-m depth that the area became known as the staghorn zone (Figure 3.3). It was documented in several reef systems such as the north coast of Jamaica (Goreau 1959) and the leeward coast of Bonaire (Scatteryday 1974). In many other reef systems in the wider Caribbean, most notably the western Caribbean areas of Jamaica, Cayman Islands, Belize, and eastern Yucatán (Adey 1977), staghorn coral was a major mid-depth (10 to 25 m) reef-builder. Principally due to wind conditions and rough seas, staghorn coral has not been known to build extensive reef structures in the Lesser Antilles and southwestern Caribbean.

Like elkhorn corals, few data on historical distribution and abundance patterns of staghorn coral are present before the 1980 baseline, likely due in part to researchers' tendencies to neglect careful measurement of abundance for ubiquitous species. Similarly, staghorn corals underwent a decline in abundance very similar to the one noted above for elkhorn coral (see Section 3.2.6).

Figure 3.4 summarizes the abundance trends of specific locations throughout the wider Caribbean where quantitative data exist illustrating the overall trends of decline of elkhorn and staghorn corals since the 1980s. It is important to note that the data are from the same geographic area, not repeated measures at an exact reef/site that would indicate more general trends. The overall regional trend depicted is a >97 percent loss of coverage (area of substrate the species occupy).

Threats

Staghorn corals face the same threats as elkhorn corals (see Table 3.2). Diseases, temperature-induced bleaching, and physical damage from hurricanes are the greatest threats to staghorn corals. The threat from disease, though clearly severe, is poorly understood in terms of etiology and possible links to anthropogenic stressors. Threats from anthropogenic physical damage (e.g., vessel groundings, anchors, divers/snorkelers, etc.), coastal development, competition, and predation are deemed moderate (*Acropora* BRT 2005). Table 3.2 summarizes the factors affecting the status of staghorn coral and the identified sources of those threats.

There is a large and growing body of literature on past, present, and future impacts of global climate change induced by human activities – frequently referred to in layman's terms as "global warming." Some of the likely effects to staghorn coral are: increased water temperature and frequency of bleaching events, elevated CO_2 levels and reduced calcification for coral skeletal growth, sea-level rise, and changes in the frequency or intensity of storms (*Acropora* BRT 2005). The Environmental Protection Agency's climate change webpage provides basic background information on these and other measured or anticipated effects (see www.epa.gov/climatechange/index.html). However, the impacts on staghorn coral currently cannot be predicted, for the most part, with any degree of certainty.

Increased temperatures resulting from global climate change could allow reef distribution to shift to more northern latitudes; however, Buddemeier et al. (2004) argued that such migration would be impeded because humans have negatively altered the coastal areas where future reefs might form. If global climate change alters the northward flowing warm oceanic currents, high latitude reefs may be threatened.

Coral bleaching patterns are complex and seasonal cycles in symbiotic dinoflagellate density occur in many species (Fitt et al. 2001), but there is general agreement that thermal stress leading to bleaching and mass mortality has increased during the past 25 years (Brown 1997). Most corals are able to withstand seasonal variations in water temperatures though an increase of 1º to 2°C above the normal seasonal maximum can induce bleaching (Fitt and Warner 1995). Though bleaching events lasting for more than a few weeks may cause mortality (Jaap 1979, Jaap 1985). Trends in global sea surface temperatures show an increase in the frequency of warm-season temperature extremes during the past two decades. These increases have caused more frequent episodes of coral bleaching (*Acropora* BRT 2005). Using global climate models, Hoegh-Guldberg (1999) predict the frequency of thermal events in the future exceeding the bleaching threshold for a given area will become more commonplace within 15 years and will occur annually in about 40 years.

Although both *Acropora* species may be somewhat more resistant to bleaching than other stony corals, they are still susceptible. However, bleaching in staghorn coral has rarely been described (Ghiold and Smith 1990, Williams and Bunkley-Williams 1990) and most of the documented loss during the past two decades is apparently due to disease (Peters 1984).

Increases in atmospheric carbon dioxide (CO_2) can also affect staghorn coral. Atmospheric CO_2 has increased from about 280 parts per million (ppm) in the early 1800s to current levels of about 380 ppm (Prentice 2001). As atmospheric CO_2 is dissolved in surface seawater, it becomes more acidic, shifting the balance of inorganic carbon away from CO_2 and carbonate (CO_3^{-2}) toward bicarbonate (HCO_3^{-1}). These changes affect corals' ability to create new skeletal material because corals are thought to use CO_3^{-2} as the source of carbonate to build their aragonite ($CaCO_3$) skeletons. Numerous experiments have shown a relationship between elevated CO_2 and decreased calcification rates in corals and other $CaCO_3$ secreting organisms (Reibesell et al. 2000, Barker and Elderfield 2002, Hoegh-Guldberg et al. 2007). Kleypas et al. (1999) calculated that coral calcification could be reduced by 30 percent in the tropics by the middle of the 21st century. Corals grown during laboratory experiments that doubled atmospheric CO_2 manifested an 11 to 37 percent reduction in calcification (Gattuso et al. 1999, Langdon 2003, Marubini et al. 2003).

Rapid rises in sea level will likely affect staghorn coral by degrading water quality through coastal erosion or enlargement of lagoons and shelf areas. Blanchon and Shaw (1995) argued that a sustained sea-level rise of more than 14 mm/yr would displace elkhorn coral. This is less of a concern for staghorn coral given its deeper depth range preference._However, sea-level change is unlikely to lead to extinction in the next several hundred years by this process because sea level is not predicted to rise that rapidly in the near future (Church and Gregory 2001).

Staghorn coral would also likely be affected by decreased water quality because of shoreline erosion and flooding of shallow banks and lagoons caused by sea-level rise. Where topography is low and/or shoreline sediments are easily eroded, corals may be stressed by degrading water quality as sea-level rise proceeds. Flooded shelves and banks at higher latitudes (greater than 15°N) may alter the temperature or salinity of seawater to extremes that can then affect corals during offshore flows. Although this process could be widespread, there will be many areas, particularly on the windward side of rocky islands, where erosion and lagoon formation will be minimal (*Acropora* BRT 2005).

The impacts of global climate change on the severity and frequency of tropical weather events (e.g., typhoons and hurricanes) are currently being debated. The Intergovernmental Panel on Climate Change stated that based on a range of models it was likely that future tropical weather events will become more intense, with larger peak wind speeds and more heavy precipitation associated with ongoing increases of tropical sea surface temperatures (IPCC 2007). However, a statement on tropical cyclones and climate change developed by the participants of the World Meteorological Organization states that while "there is evidence both for and against the existence of a detectable anthropogenic signal in the tropical cyclone climate record to date, no firm conclusion can be made on this point" (WMO 2006).

3.2.7.1 Summary of Staghorn Coral Status

Many factors, including both life history characteristics and external threats are important to consider in assessing the status and vulnerability of staghorn coral. Recovery of staghorn coral from its current level of decreased abundance depends upon rates of recruitment and growth outpacing rates of mortality. This species has a rapid growth rate and high potential for propagation via fragmentation. However, while fragmentation is an excellent life history strategy for recovery from physical disturbance, it is not as effective when fragment sources (i.e., large extant colonies) are scarce.

Thus, it is anticipated that successful sexual reproduction will need to play a major role in recovery (Bruckner 2002). Meanwhile, there is substantial evidence to suggest that sexual recruitment of staghorn corals is currently compromised. Reduced colony density in this broadcast spawning, compounded in some geographic areas with low genotypic diversity, suggests that fertilization success and consequently, larval availability, has been reduced. In addition, appropriate substrate available for fragments to attach to is likely reduced due to changes in benthic community structure on many Caribbean reefs. Coupled with impacts from coastal development (i.e., dominance by macroalgal, turf, and/or sediment-coated substrates), these factors are expected to further reduce successful larval recruitment below a threshold that can compensate for observed rates of ongoing mortality.

Species at reduced abundance are at a greater risk of extinction due to stochastic environmental and demographic factors (e.g., episodic recruitment factors). Both acroporids have persisted at extremely reduced abundance levels (in most areas with quantitative data available, less than 3 percent of prior abundance) for at least two decades.

Although the major threats (e.g., disease, elevated sea surface temperature, and hurricanes) to staghorn coral's persistence are severe, unpredictable, likely to increase in the foreseeable future, and, at current levels of knowledge, unmanageable, managing some of the stressors identified as less severe (e.g., nutrients, sedimentation) may assist in decreasing the rate of elkhorn and staghorn corals' decline by enhancing coral condition and decreasing synergistic stress effects.

The impacts on staghorn coral from all of the above-mentioned threats could be exacerbated by reduced genetic diversity, which often results when species undergo rapid decline like staghorn coral has in recent decades. This expectation is heightened when the decline is due to a potentially selective factor such as disease, in contrast to a less selective factor such as hurricane damage, which will likely cause disturbance independent of genotype. If the species remains at low densities for prolonged periods, genetic diversity may be significantly reduced. Thus, given the current dominance of asexual reproduction, the rapid decline (largely from a selective factor), and the lack of rapid recovery of elkhorn and staghorn corals, it is plausible that these populations have suffered a loss of genetic diversity that could compromise their ability to adapt to future changes in environmental conditions. No quantitative information is available regarding genetic diversity for either species.

Figure 3.3 Reef zonation schematic example modified from several reef zonation-descriptive studies (Goreau 1959, Kinzie 1973, Bak 1977)

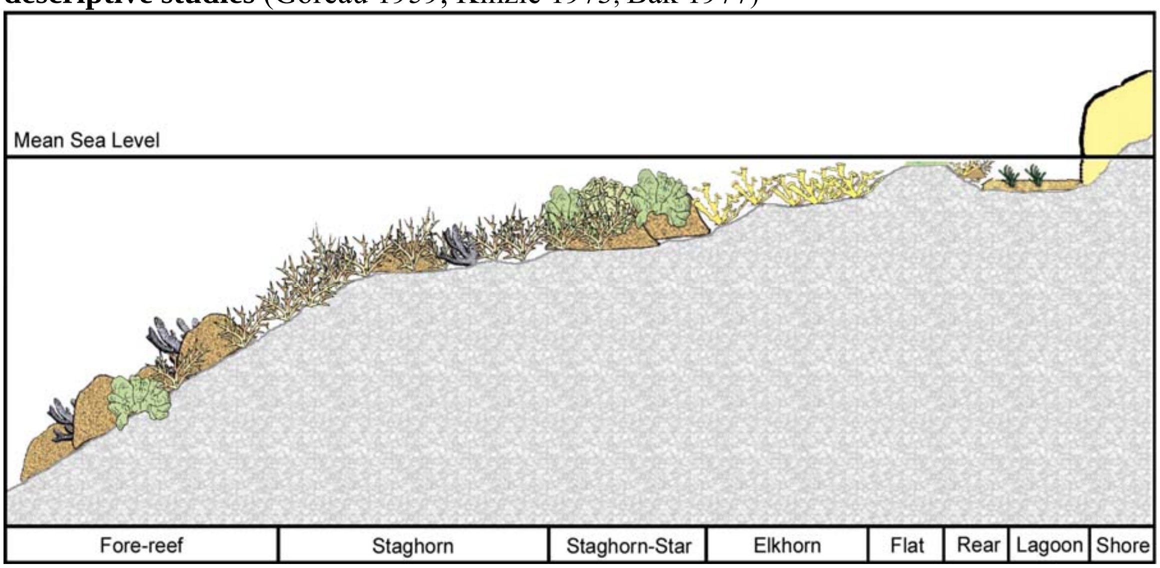
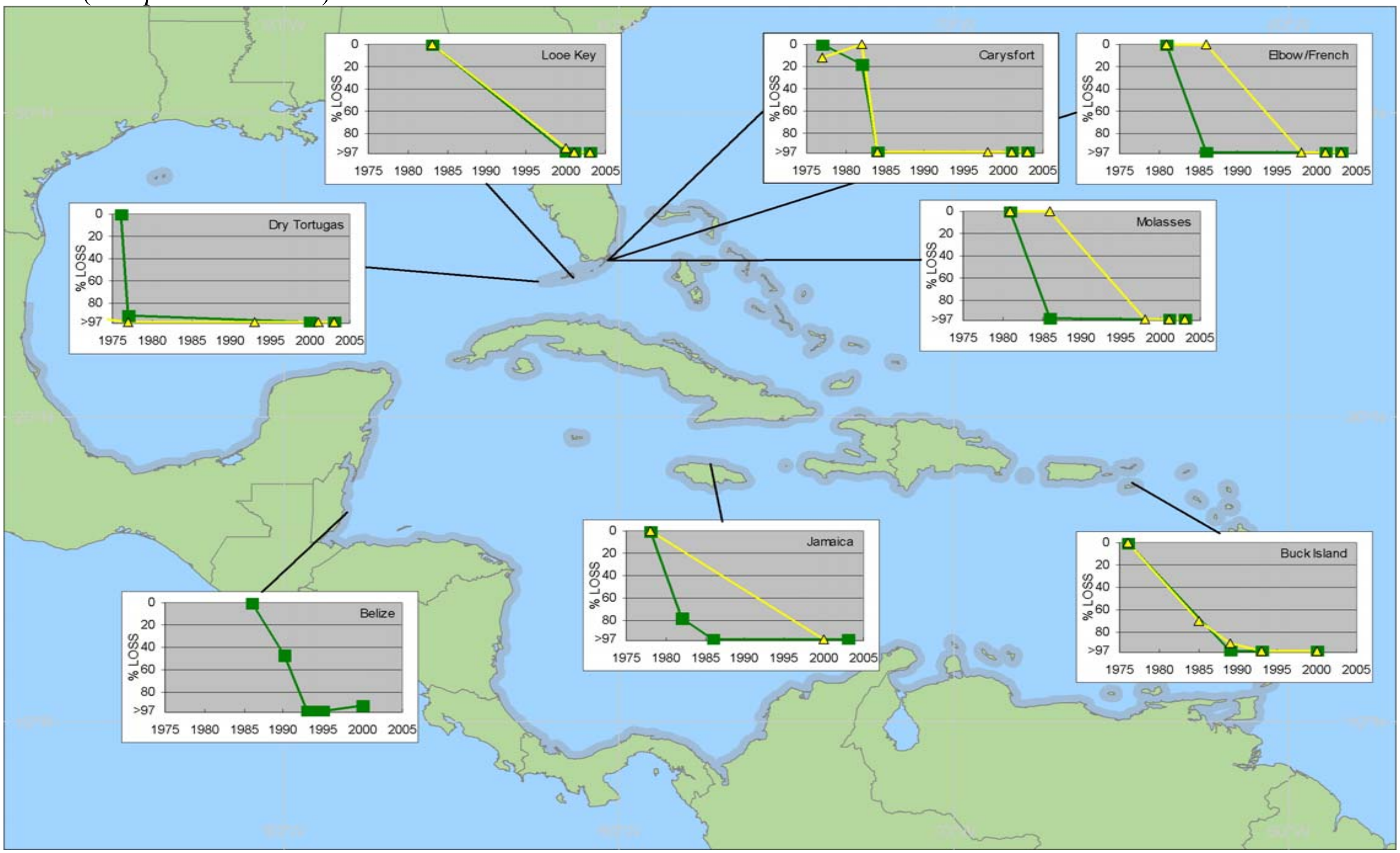


Table 3.2 Factors Affecting the Species

Natural abrasion and breakage Source: storm events	**Disease** Source: undetermined/understudied
Sedimentation Source: land development/run-off dredging/disposal sea level rise major storm events	**Anthropogenic abrasion and breakage** Source: divers vessel groundings anchor impact fishing debris
Temperature Source: hypothermal events global climate change power plant effluents ENSO* events	**Predation** Source: overfishing natural trophic reef interactions **Loss of genetic diversity** Source: population decline/bottleneck
Nutrients Source: point-source non-point-source	**Contaminants** Source: point-source non-point-source
Competition Source: overfishing	**CO_2** Source: fossil fuel consumption
Sea level rise Source: global climate change	**Sponge boring** Source: undetermined/understudied

* El Niño-Southern Oscillation

Figure 3.4 Percent loss of staghorn coral (green squares) and elkhorn coral (yellow triangles) throughout the Caribbean for all locations (n=8) where quantitative trend data exist. Shaded areas on map illustrate the general range of elkhorn and staghorn corals (*Acropora* BRT 2005)



3.2.8 Smalltooth Sawfish

The U.S. smalltooth sawfish distinct population segment (DPS) was listed as endangered under the ESA on April 1, 2003 (68 FR 15674). The smalltooth sawfish is the first marine fish to be listed in the United States. On November 20, 2008, NMFS proposed to designate critical habitat for smalltooth sawfish (73 FR 70290). The proposed critical habitat would comprise of two units off southwestern Florida – the Charlotte Harbor Estuary and the Ten Thousand Island/Everglades unit – comprising approximately 619,013 acres. Historically, smalltooth sawfish occurred commonly in the inshore waters of the Gulf of Mexico and the U.S. Eastern Seaboard up to North Carolina, and more rarely as far north as New York. Based on smalltooth sawfish encounter data, the current core range for the smalltooth sawfish is currently from the Caloosahatchee River to Florida Bay (Simpfendorfer and Wiley 2004).

All extant sawfish belong to the Suborder Pristoidea, Family Pristidae, and Genus Pristis. Although they are rays, sawfish appear to more resemble sharks, with only the trunk and especially the head ventrally flattened. Smalltooth sawfish are characterized by their "saw," a long, narrow, flattened rostral blade with a series of transverse teeth along either edge.

Life History and Distribution
Life history information on smalltooth sawfish is limited. Small amounts of data exist in old taxonomic works and occurrence notes (e.g., Breder 1952, Bigelow and Schroeder 1953, Wallace 1967, Thorson et al. 1966). However, as Simpfendorfer and Wiley (2004) note, these relate primarily to occurrence and size. Recent research and sawfish public encounter information is now providing new data and hypotheses about smalltooth sawfish life history (e.g., Simpfendorfer 2001 and 2003, Seitz and Poulakis 2002, Poulakis and Seitz 2004, Simpfendorfer and Wiley 2004), but more data are still needed to confirm many of these new hypotheses.

As in all elasmobranchs, fertilization is internal. Bigelow and Schroeder (1953) report the litter size as 15 to 20. However, Simpfendorfer and Wiley (2004), caution that this may be an overestimate, with recent anecdotal information suggesting smaller litter sizes (~10). Smalltooth sawfish mating and pupping seasons, gestation, and reproductive periodicity are all unknown. Gestation and reproductive periodicity, however, may be inferred based on that of the largetooth sawfish, sharing the same genus and having similarities in size and habitat. Thorson (1976) reported the gestation period for largetooth sawfish was approximately five months and concluded that females probably produce litters every second year.

Bigelow and Schroeder (1953) describe smalltooth sawfish as generally about two feet long (61 cm) at birth and growing to a length of 18 feet (549 cm) or greater. Recent data from smalltooth sawfish caught off Florida, however, demonstrate young are born at 75-85 cm , with males reaching maturity at approximately 270 cm and females at approximately 360 cm (Simpfendorfer 2002, Simpfendorfer and Wiley 2004). The maximum reported size of a smalltooth sawfish is 760 cm (Last and Stevens 1994), but the maximum size normally observed is 600 cm (Adams and Wilson 1995). No formal studies on the age and growth of the smalltooth sawfish have been conducted to date, but growth studies of largetooth sawfish suggest slow growth, late maturity (10 years) and long lifespan (25-30 years) (Thorson 1982, Simpfendorfer 2000). These characteristics suggest very a low intrinsic rate of increase (Simpfendorfer 2000).

Smalltooth sawfish feed primarily on fish, with mullet, jacks, and ladyfish believed to be their primary food resources (Simpfendorfer 2001). By moving its saw rapidly from side to side through the water, the relatively slow-moving sawfish is able to strike at individual fish (Breder 1952). The teeth on the saw stun, impale, injure, or kill the fish. Smalltooth sawfish then rub their saw against bottom substrate to remove the fish, which are then eaten. In addition to fish, smalltooth sawfish also prey on crustaceans (mostly shrimp and crabs), which are located by disturbing bottom sediment with their saw (Norman and Fraser 1938, Bigelow and Schroeder 1953).

Smalltooth sawfish are euryhaline, occurring in waters with a broad range of salinities from freshwater to full seawater (Simpfendorfer 2001). Their occurrence in freshwater is suspected to be only in estuarine areas temporarily freshwater from receiving high levels of freshwater input. Many encounters are reported at the mouths of rivers or other sources of freshwater inflows, suggesting estuarine areas may be an important factor in the species distribution (Simpfendorfer and Wiley 2004).

The literature indicates that smalltooth sawfish are most common in shallow coastal waters less than 25 m (Bigelow and Schroeder 1953, Adams and Wilson 1995). Indeed, the distribution of the smallest size classes of smalltooth sawfish indicate that nursery areas occur throughout Florida in areas of shallow water, close to shore and typically associated with mangroves (Simpfendorfer and Wiley 2004). However, encounter data indicate there is a tendency for smalltooth sawfish to move offshore and into deeper water as they grow. An examination of the relationship between the depth at which sawfish occur and their estimated size indicates that larger animals are more likely to be found in deeper waters. Since large animals are also observed in very shallow waters, it is believed that smaller (younger) animals are restricted to shallow waters, while large animals roam over a much larger depth range (Simpfendorfer 2001). Mature animals are known to occur in water depths of 100 m or more (C. Simpfendorfer pers. comm. 2006).

Data collected by Mote Marine Laboratory indicate smalltooth sawfish occur over a range of temperatures but appear to prefer water temperatures greater than 64.4°F (18°C) (Simpfendorfer 2001). The data also suggest that smalltooth sawfish may utilize warm water outflows of power stations as thermal refuges during colder months to enhance their survival or become trapped by surrounding cold water from which they would normally migrate. Almost all occurrences of smalltooth sawfish in warm water outflows were during the coldest part of the year, when water temperatures in these outfalls are typically well above ambient temperatures. Further study of the importance of thermal refuges to smalltooth sawfish is needed. Significant use of these areas by sawfish may disrupt their normal migratory patterns (Simpfendorfer and Wiley 2004).

Smalltooth sawfish historically occurred commonly in the shallow waters of the Gulf of Mexico and along the Eastern Seaboard as far north as North Carolina, with rare records of occurrence as far north as New York. The smalltooth sawfish range has subsequently contracted to areas predominantly around peninsular Florida and, within that area, they can only be found with any regularity off the extreme southern portion of the state. Historic records of smalltooth sawfish indicate that some large mature individuals migrate north along the U.S. Atlantic coast as temperatures warmed in the summer and then south as temperatures cooled (Bigelow and Schroeder 1953). However, recent Florida encounter data do not suggest such migration. One smalltooth sawfish has been recorded north of Florida since 1963 - captured off Georgia in July 2000 - but it is unknown whether this individual resided in Georgia waters annually or had migrated north from Florida. Given the very limited number of encounter reports from the east coast of Florida, Simpfendorfer and Wiley (2004) hypothesize the population previously undertaking the summer migration has declined to a point where the migration is undetectable or does not occur. NMFS observers have been collecting data in the Atlantic longline fishery since 1992 and have no documented interactions between the HMS pelagic longline fishery and smalltooth sawfish, which provides some additional support to these range estimates. Further research focusing on states north of Florida or using satellite telemetry is needed to test this hypothesis.

Population Dynamics, Status, and Trends
Despite being widely recognized as common throughout their historic range up until the middle of the 20th century, the smalltooth sawfish population declined dramatically during the middle and later parts of the century. The decline in the population of smalltooth sawfish is attributed to fishing (both commercial and recreational), habitat modification, and sawfish life history. Large numbers of smalltooth sawfish were caught as bycatch in the early part of this century. Smalltooth sawfish were historically caught as bycatch in various fishing gears throughout their historic range, including gillnet, otter trawl, trammel net, seine, and to a lesser degree, handline. Frequent accounts in earlier literature document smalltooth sawfish being entangled in fishing nets from areas where smalltooth sawfish were once common but are now rare (Everman and Bean 1898). Loss and degradation of habitat contributed to the decline of many marine species and is expected to have affected the distribution and abundance of smalltooth sawfish.

Estimates of the magnitude of the decline in the smalltooth sawfish are difficult to make. Because of the species' limited importance in commercial and recreational fisheries and its large size and toothed rostrum, making it difficult to handle, it was not well studied before incidental bycatch severely reduced its numbers. However, based on the contraction of the species' range, and other anecdotal data, Simpfendorfer (2001) estimated that the U.S. population size is currently less than five percent of its size at the time of European settlement.

Seitz and Poulakis (2002) and Poulakis and Seitz (2004) document recent (1990 to 2002) occurrences of sawfish along the southwest coast of Florida, and in Florida Bay and the Florida Keys, respectively. The information was collected by soliciting information from anyone who would possibly encounter these fish via posters displaying an image of a sawfish and requesting anyone with information on these fish since 1990 to contact the authors. Posters were distributed beginning in January 1999 and continue to be maintained from Charlotte County to Monroe County in places where anglers and boaters would likely encounter them (e.g., bait and tackle shops, boat ramps, fishing tournaments). In addition to circulating posters, information was obtained by contacting other fishery biologists, fishing guides, guide associations, rod and gun clubs, recreational and commercial fishers, scuba divers, mosquito control districts, and newspapers. At least 2,620 smalltooth sawfish encounters have been reported (G. Poulakis, pers. comm. 2005).

Mote Marine Laboratory also maintains a smalltooth sawfish public encounter database, established in 2000 to compile information on the distribution and abundance of sawfish. Encounter records are collected using some of the same outreach tactics as above in Florida statewide. To ensure the requests for information are spread evenly throughout the state, awareness-raising activities were divided into six regions and focused in each region on a biannual basis between May 2002 and May 2004. Prior to 2002, awareness-raising activities were organized on an ad-hoc basis because of limited resources. The records in the database extend back to the 1950s, but are mostly from 1998 to the present. The data are validated using a variety of methods (photographs, video, directed questions). As of October 2006, 754 sawfish encounters have been reported since 1998, most from recreational fishers (Simpfendorfer and Wiley 2004).

The Florida Museum of Natural History is in the process of creating the National Sawfish Encounter Database to act as the single repository for all smalltooth sawfish encounter records. As of July 2008, this consolidation was still underway.

The majority of smalltooth sawfish encounters today are from the southwest coast of Florida between the Caloosahatchee River and Florida Bay. Outside of this core area, the smalltooth sawfish appears more common on the west coast of Florida and in the Florida Keys than on the east coast, and occurrences decrease the greater the distance from the core area (Simpfendorfer and Wiley 2004). The capture of a smalltooth sawfish off Georgia in 2003 is the first record north of Florida since 1963. New reports during 2004 extend the current range of the species from Panama City, offshore Louisiana (south of Timbalier Island in 100 ft of water), southern Texas, and the northern coast of Cuba. The Texas sighting was not confirmed to be a smalltooth sawfish so might have been a largetooth sawfish.

There are no data available to estimate the present population size. Although smalltooth sawfish encounter databases may provide a useful future means of measuring changes in the population and its distribution over time, conclusions about the abundance of smalltooth sawfish now cannot be made because outreach efforts and observation effort is not expanded evenly across each study period. Dr. Simpfendorfer reluctantly gives an estimate of 2,000 individuals based on his four years of field experience and data collected from the public, but cautions that actual numbers may be plus or minus at least 50 percent.

Recent encounters with neonates (young of the year), juveniles, and sexually mature sawfish indicate that the population is reproducing (Seitz and Poulakis 2002, Simpfendorfer 2003). The abundance of juveniles encountered, including very small individuals, suggests that the population remains reproductively active and viable (Simpfendorfer and Wiley 2004). In addition, the declining numbers of individuals with increasing size is consistent with the historic size composition data (G. Burgess, pers. comm. in Simpfendorfer and Wiley 2004). This information and recent encounters in new areas beyond the core abundance area suggest that the population may be increasing. However, smalltooth sawfish encounters are still rare along much of their historical range and absent from areas historically abundant such as the Indian River Lagoon and Johns Pass (Simpfendorfer and Wiley 2004). With recovery of the species expected to be slow based on the species' life history and other threats to the species remaining (see below), the population's future remains tenuous.

Threats

Smalltooth sawfish are threatened today by the loss of southeastern coastal habitat through such activities as agricultural and urban development, commercial activities, dredge-and-fill operations, boating, erosion, and diversions of freshwater runoff. Dredging, canal development, seawall construction, and mangrove clearing have degraded a significant proportion of the coastline. Smalltooth sawfish may be especially vulnerable to coastal habitat degradation due to their affinity to shallow, estuarine systems (NMFS 2000).

Fisheries also still pose a threat to smalltooth sawfish. Although changes over the past decade to U.S. fishing regulations such as Florida's net ban have started to reduce threats to the species over parts of its range, smalltooth sawfish are still occasionally incidentally caught in commercial shrimp trawls, bottom longlines, and recreational rod-and-reel. The current and future abundance of the smalltooth sawfish is limited by its life history characteristics (NMFS 2000). Slow growing, late maturing, and long-lived, these combined characteristics result in a very low intrinsic rate of population increase and are associated with the life history strategy known as "k-selection". K-selected animals are usually successful at maintaining relatively small, persistent population sizes in relatively constant environments. Consequently, they are not able to respond effectively (rapidly) to additional and new sources of mortality resulting from changes in their environment (Musick 1999). Simpfendorfer (2000) demonstrated that the life history of this species makes it impossible to sustain any significant level of fishing and makes it slow to recover from any population decline. Thus, the species is susceptible to population decline, even with relatively small increases in mortality.

There is a large and growing body of literature on past, present, and future impacts of global climate change induced by human activities, i.e., global warming. Some of the likely effects commonly mentioned are sea level rise, increased frequency of severe weather events, and change in air and water temperatures. The Environmental Protection Agency's climate change webpage provides basic background information on these and other measured or anticipated effects (see www.epa.gov/climatechange/index.html).

However, the impacts on smalltooth sawfish currently cannot, for the most part, be predicted with any degree of certainty.

Changes in water temperature because of global climate change may affect prey distribution and/or abundance, habitat suitability, and other biological and ecological processes important to smalltooth sawfish. Stochastic events such as hurricanes are also common throughout the range of the smalltooth sawfish, especially in the current core of its range (i.e., south and southwest Florida). The effects global climate change will have on the frequency and/or severity of tropical weather events, such as hurricanes, is currently being debated. These events are by nature unpredictable and their effects on the smalltooth sawfish are currently unknown.

4.0 Environmental Baseline

This section contains an analysis of the effects of past and ongoing human and natural factors leading to the current status of the species, their habitat, and ecosystem, within the action area. The environmental baseline is a snapshot of a species' health at a specified point in time and includes state, tribal, local, and private actions already affecting the species, or that will occur contemporaneously with the consultation in progress. Unrelated federal actions affecting the same species or critical habitat that have completed formal consultation are also part of the environmental baseline, as are federal and other actions within the action area that may benefit listed species or critical habitat.

The environmental baseline for this biological opinion includes the effects of several activities that affect the survival and recovery of threatened and endangered species in the action area. The activities that shape the environmental baseline in the action area of this consultation are primarily federal fisheries. Other environmental impacts include effects of vessel operations, additional military activities, dredging, oil and gas exploration, permits allowing take under the ESA, private vessel traffic, and marine pollution.

4.1 Status of Sea Turtles in the Action Area

The five species of sea turtles that occur in the action area are all highly migratory. NMFS believes that no individual members of any of the species are likely to be year-round residents of the action area. Individual animals will make migrations into near shore waters as well as other areas of the North Atlantic Ocean, including the Gulf of Mexico and the Caribbean Sea. Therefore, the status of the five species of sea turtles in the Atlantic (see Section 3) most accurately reflects the species status within the action area.

4.2 Factors Affecting Sea Turtles in the Action Area

In recent years, NMFS has undertaken several section 7 consultations to address the effects of federally permitted fisheries and other federal actions on threatened and endangered sea turtle species, and when appropriate, has authorized the incidental taking of these species. Each of those consultations sought to minimize the adverse impacts of the action on sea turtles. Similarly, NMFS has undertaken recovery actions under the ESA to address sea turtle takes in the fishing and shipping industries and other activities such as Army Corps of Engineers (COE) dredging operations. The summaries below address anticipated sources of incidental take of sea turtles and include only those federal actions in the U.S. Atlantic and Gulf of Mexico EEZ, which have already concluded formal section 7 consultation.

4.2.1 Fisheries

Threatened and endangered sea turtles are adversely affected by several types of fishing gears used throughout the action area. Gillnet, longline, other types of hook-and-line gear, trawl gear, and pot fisheries have all been documented as interacting with sea turtles. Available information suggests sea turtles can be captured in any of these gear types when the operation of the gear overlaps with the distribution of sea turtles. For all fisheries for which there is an FMP or for which any federal action is taken to manage that fishery, impacts have been evaluated under section 7. Formal section 7 consultation have been conducted on the following fisheries, occurring at least in part within the action area, found likely to adversely affect threatened and endangered sea turtles: Atlantic bluefish, Atlantic mackerel/squid/butterfish, Atlantic swordfish/tuna/shark/billfish, coastal migratory pelagic, dolphin-wahoo, Gulf of Mexico reef fish, monkfish, Northeast multispecies, South Atlantic snapper-grouper, Southeast shrimp trawl, spiny dogfish, and summer flounder/scup/black sea bass fisheries. An Incidental Take Statement (ITS) has been issued for the take of sea turtles in each of these fisheries (Appendix 2).

In a July 2, 1999, biological opinion on the *Atlantic bluefish fishery,* NMFS found the operation of the fishery was likely to adversely affect Kemp's ridley and loggerhead sea turtles, but not likely to jeopardize their continued existence (NMFS 1999a). The Atlantic States Marine Fisheries Commission and the Mid-Atlantic Fishery Management Council jointly manage bluefish under Amendment 5 to the Bluefish FMP (NEFSC 2005a). The majority of commercial fishing activity in the North and Mid-Atlantic occurs in the late spring to early fall, when bluefish (and sea turtles) are most abundant in these areas (NEFSC 2005a). In 2006, gillnet gear accounted for 32.4 percent of the total commercial trips targeting bluefish, and landed 72 percent of the commercial catch for that year. Bottom otter trawls accounted for 44 percent of the total commercial trips targeting bluefish and landed 20.4 percent of the catch (MAFMC 2007). Based on documented take in gillnets targeting bluefish and bottom otter trawls catching bluefish, NMFS provided an ITS for Kemp's ridley and loggerhead sea turtles.

Atlantic mackerel/squid/butterfish fisheries are managed under a single FMP, which was first implemented on April 1, 1983. The most recent biological opinion completed on these federal fisheries was completed on April 28, 1999. The opinion concluded that the continued authorization of the FMP was likely to adversely affect sea turtles, but not jeopardize their continued existence (NMFS 1999b). Trawl gear is the primary fishing gear for these fisheries, but several other types of gear may also be used, including hook-and-line, pot/trap, dredge, pound net, and bandit gear. Entanglements or entrapments of sea turtles have been recorded in one or more of these gear types. An ITS for sea turtles was provided with the opinion. In August 2007, NMFS received a new estimate of loggerhead sea turtle takes in bottom otter trawl gear used in the mackerel, squid, butterfish fisheries (Memo from K. Murray, NEFSC to L. Lankshear, NERO, PRD). Using vessel trip report (VTR) data from 2000-2004 and the average annual bycatch of sea turtles as described in Murray (2006), the average annual bycatch of loggerhead sea turtles in bottom otter trawl gear used in the mackerel, squid, and butterfish fisheries was estimated to be 62 loggerhead sea turtles a year (Memo from K. Murray, NEFSC to L. Lankshear, NERO, PRD). NMFS has determined that this new information on the capture of loggerhead sea turtles in the mackerel, squid, butterfish fisheries triggers the need to reinitiate section 7 consultation on the Mackerel, Squid, Butterfish FMP.

Atlantic pelagic fisheries for swordfish, tuna, and billfish are known to incidentally capture large numbers of sea turtles, particularly in the pelagic longline component. Pelagic longline, pelagic driftnet, bottom longline, and/or purse seine gear have all been documented taking sea turtles. The Northeast swordfish driftnet portion of the fishery was prohibited during an emergency closure that began in December 1996, and was subsequently extended. A permanent prohibition on the use of driftnet gear in the swordfish fishery was published in 1999. NMFS reinitiated consultation on the pelagic longline component of this fishery (NMFS 2004b) because of exceeded incidental take levels for loggerheads and leatherbacks sea turtles. The resulting biological opinion stated the long-term continued operation this sector of the fishery was likely to jeopardize the continued existence of leatherback sea turtles, but RPAs were implemented allowing for the continued authorization of the pelagic longline fishing that would not jeopardize leatherback sea turtles.

NMFS has completed a section 7 consultation on the continued authorization of *HMS Atlantic shark fisheries* (NMFS 2008). The commercial fishery uses bottom longline and gillnet gear. The recreational sector of the fishery uses only hook-and-line gear. To protect declining shark stocks the proposed action seeks to greatly reduce the fishing effort in the commercial component of the fishery. These reductions are likely to greatly reduce the interactions between the commercial component of the fishery and sea turtles. The biological opinion concluded that green, hawksbill, Kemp's ridley, leatherback, and loggerhead sea turtles may be adversely affected by operation of the fishery. However, the proposed action was not expected to jeopardize the continued existence of any of these species and an ITS was provided.

NMFS recently completed a section 7 consultation on the continued authorization of the *coastal migratory pelagic* fishery in the Gulf of Mexico and South Atlantic (NMFS 2007). In the Gulf of Mexico, hook-and-line, gillnet, and cast net gears are used. Gillnets are the primary gear type used by commercial fishermen in the South Atlantic regions as well, while the recreational sector uses hook-and-line gear. The hook-and-line effort is primarily trolling. The biological opinion concluded that green, hawksbill, Kemp's ridley, leatherback, and loggerhead sea turtles may be adversely affected by operation of the fishery. However, the proposed action was not expected to jeopardize the continued existence of any of these species and an ITS was provided.

The South Atlantic FMP for the *dolphin-wahoo fishery* was approved in December 2003. The stated purpose of the Dolphin and Wahoo FMP is to adopt precautionary management strategies to maintain the current harvest level and historical allocations of dolphin (90 percent recreational) and ensure no new fisheries develop. NMFS conducted a formal section 7 consultation to consider the effects on sea turtles of authorizing fishing under the FMP (NMFS 2003a). The August 27, 2003, opinion concluded that green, hawksbill, Kemp's ridley, leatherback, and loggerhead sea turtles may be adversely affected by the longline component of the fishery, but it was not expected to jeopardize their continued existence. An ITS for sea turtles was provided with the opinion. In addition, pelagic longline vessels can no longer target dolphin-wahoo with smaller hooks because of hook size requirements in the pelagic longline fishery.

NMFS requested reinitiation of ESA section 7 consultation on the *Gulf of Mexico reef fish fishery*, on September 3, 2008. Reinitiation was triggered because recent observer data indicate the overall amount and extent of incidental take for sea turtles specified in the incidental take statement of the February 25, 2005, biological opinion on the reef fish fishery had been substantially exceeded by the bottom longline component of the fishery. The 2005 biological opinion (NMFS 2005a) authorized 113 hardshell sea turtle takes by the longline component of the reef fish fishery cumulative over a three-year period to account for the variability in the sea turtle takes between years. However, operation of the longline fishery resulted in an estimated take of 967 hardshell sea turtle take from July 2006 through December 2008, more than 8 times the number of hardshell sea turtle takes authorized by the opinion. On May 1, 2009, NMFS published an emergency rule, which, effective May 18, 2009, prohibits the use of bottom longline gear to harvest reef fish east of 85°30'W longitude in waters less than 50 fathoms as long as the 2009 deepwater grouper and tilefish quotas are unfilled. Once these quotas have been filled, the use of bottom longline gear to harvest reef fish in water of all depths east of 85°30'W longitude is prohibited. The emergency rule is intended to reduce the number of sea turtle takes by the reef fish fishery in the short-term while the Gulf of Mexico Fishery Management Council develops long-term measures in Amendment 31 to the Reef Fish Fishery Management Plan (RFFMP). The new biological opinion, which will consider the continued authorization of reef fish fishing under the RFFMP, including any measures proposed in Amendment 31, is expected to be completed in the fall of 2009.

The federal *monkfish fishery* occurs from Maine to the North Carolina/South Carolina border and is jointly managed by the New England Fishery Management Council (NEFMC) and Mid-Atlantic Fishery Management Council (MAFMC), under the Monkfish FMP (NEFSC 2005b). A section 7 consultation conducted in 2001 concluded that the operation of the fishery may adversely affect sea turtles, but was not likely to jeopardize their continued existence. In 2003, proposed changes to the Monkfish FMP led to reinitiation of consultation to determine the effects of those actions on ESA-listed species. The resulting biological opinion concluded the proposed changes were likely to adversely affect green, Kemp's ridley, loggerhead and leatherback sea turtles, but were not likely to jeopardize their continued existence (NMFS 2003b). Although the estimated capture of sea turtles in monkfish gillnet gear is relatively low, there is concern that much higher levels of interaction could occur. Following an event in which over 200 sea turtle carcasses washed ashore in an area where large-mesh gillnetting had been occurring, NMFS published new restrictions for the use of gillnets with larger than 8-inch stretched mesh, in the EEZ off of North Carolina and Virginia (67 FR 71895, December 3, 2002). The rule was subsequently modified on April 26, 2006, by modifying the restrictions to the use of gillnets with greater than or equal to 7-inch stretched mesh when fished in federal waters from the North Carolina/South Carolina border to Chincoteague, Virginia.

A section 7 consultation on the *South Atlantic snapper-grouper fishery* (NMFS 2006a) has also recently been completed by NMFS. The fishery uses spear and powerhead, black sea bass pot, and hook-and-line gear. Hook-and-line gear used in the fishery includes commercial bottom longline gear and commercial and recreational vertical line gear (e.g., handline, bandit gear, and rod-and-reel). The consultation found only hook-and-line gear likely to adversely affect, green, hawksbill, Kemp's ridley leatherback, and loggerhead sea turtles. The consultation concluded the proposed action was not likely to jeopardize the continued existence of any of these species, and an ITS was provided.

The *Southeast shrimp trawl fishery* affects more sea turtles than all other activities combined (NRC 1990). On December 2, 2002, NMFS completed the biological opinion for shrimp trawling in the southeastern United States (NMFS 2002) under proposed revisions to the TED regulations (68 FR 8456, February 21, 2003). This opinion determined that the shrimp trawl fishery under the revised TED regulations would not jeopardize the continued existence of any sea turtle species. This determination was based, in part, on the opinion's analysis that shows the revised TED regulations are expected to reduce shrimp trawl related mortality by 94 percent for loggerheads and 97 percent for leatherbacks. Interactions between sea turtles and the shrimp fishery may also be declining because of reductions of fishing effort unrelated to fisheries management actions. In recent years, low shrimp prices, rising fuel costs, competition with imported products, and the impacts of recent hurricanes in the Gulf of Mexico have all impacting the shrimp fleets; in some cases reducing fishing effort by as much as 50 percent for offshore waters of the Gulf of Mexico (GMFMC 2007).

The primary gear types for the *spiny dogfish fishery* are sink gillnets, otter trawls, bottom longline, and driftnet gear (NEFSC 2003). NMFS reinitiated consultation on the Spiny Dogfish FMP on May 4, 2000, to reevaluate, in part, the effects of the spiny dogfish gillnet fishery on sea turtles (NMFS 2001b). The FMP for spiny dogfish called for a 30 percent reduction in quota allocation levels for 2000 and a 90 percent reduction in 2001. Although there have been delays in implementing the plan, quota allocations are expected to be substantially reduced over the 4.5-year rebuilding schedule; this should result in a substantial decrease in effort directed at spiny dogfish. The reduction in effort should be of benefit to protected species by reducing the number of gear interactions that occur. A new ITS was provided for the take of sea turtles in the fishery.

The *summer flounder, scup, and black sea bass fisheries* are known to interact with sea turtles. The most recent opinion on the fishery (NMFS 2001c) found it was likely to adversely affect green and Kemp's ridley sea turtles, but would not jeopardize their continued existence. An ITS was provided for these species. In the Mid-Atlantic, summer flounder, scup, and black sea bass are managed under one FMP since these species occupy similar habitat and are often caught at the same time. Otter trawl gear is used in the commercial fisheries for all three species. Floating traps and pots/traps are used in the scup and black sea bass fisheries, respectively (MAFMC 2007). Significant measures have been developed to reduce the take of sea turtles in summer flounder trawls and trawls that meet the definition of a summer flounder trawl (which would include fisheries for other species like scup and black sea bass). TEDs are required throughout the year for trawl nets fished from the North Carolina/South Carolina border to Oregon Inlet, North Carolina, and seasonally (March 16-January 14) for trawl vessels fishing between Oregon Inlet, North Carolina, and Cape Charles, Virginia. In August 2007, NMFS received an estimate of loggerhead sea turtle takes in bottom otter trawl gear used in the summer flounder, scup, black sea bass fisheries (Memo from K. Murray, NEFSC to L. Lankshear, NERO, PRD). Using VTR data from 2000-2004 and the average annual bycatch of sea turtles as described in Murray (2006), the average annual bycatch of loggerhead sea turtles in bottom otter trawl gear used in the summer flounder, scup, black sea bass fisheries was estimated to be 200 loggerhead sea turtles a year (Memo from K. Murray, NEFSC to L. Lankshear, NERO, PRD). This information represents new information on the capture of loggerhead sea turtles in the summer flounder, scup, black sea bass fisheries.

4.2.2 Vessel Operations

Potential sources of adverse effects from federal vessel operations in the action area include operations of the U.S. Navy (USN) and Coast Guard (USCG), the Environmental Protection Agency (EPA), the National Oceanic and Atmospheric Administration (NOAA), and the COE. NMFS has conducted formal consultations with the USCG, the USN, and NOAA on their vessel operations. Through the section 7 process, where applicable, NMFS has and will continue to establish conservation measures for all these agency vessel operations to avoid or minimize adverse effects to listed species. At the present time, however, they present the potential for some level of interaction. Refer to the biological opinions for the USCG (NMFS 1995) and the USN (NMFS 1997) for details on the scope of vessel operations for these agencies and conservation measures being implemented as standard operating procedures.

The USN consultation only covered operations out of Mayport, Florida, and the potential exists for USN vessels to adversely affect sea turtles when they are operating in other areas within the range of these species. Similarly, operations of vessels by other federal agencies within the action area (NOAA, EPA, COE) may adversely affect sea turtles. However, the in-water activities of those agencies are limited in scope, as they operate a limited number of vessels or are engaged in research/operational activities that are unlikely to contribute a large amount of risk.

4.2.3 Additional Military Activities

Additional activities including ordnance detonation, also affect listed species of sea turtles. Section 7 consultations were conducted for USN aerial bombing training in the ocean off the southeast U.S. coast, involving drops of live ordnance (500 and 1,000-lb bombs) (NMFS 1997), and the operation of USCG's boats and cutters in the U.S. Atlantic (NMFS 1995). These consultations determined each activity was likely to adversely affect sea turtles but would not jeopardize their continued existence. An ITS was issued for each activity.

NMFS has also consulted on military training operations conducted by the U.S. Air Force (USAF) and U.S. Marine Corps (USMC). From 1995-2007, three consultations have been completed that evaluated the impacts of ordnance detonation during gunnery training or aerial bombing exercises (NMFS 1998a, NMFS 2004c, NMFS 2005b). These consultations determined each activity was likely to adversely affect sea turtles but would not jeopardize their continued existence. An ITS was issued for each activity. A consultation evaluating the impacts from USAF search-and-rescue training operations in the Gulf of Mexico was completed in the 1999 (NMFS 1999c). This consultation determined the training operations would adversely affect sea turtles but would not jeopardize their continued existence and an ITS was issued.

4.2.4 Oil and Gas Exploration

COE and MMS authorize oil and gas exploration, well development, production, and abandonment/rig removal activities that may adversely affect sea turtles. Both of these agencies have consulted frequently with NMFS on these types of activities. These activities include the use of seismic arrays for oil and gas exploration in the Gulf of Mexico, the impacts vessel strikes, noise, and marine debris have been analyzed in biological opinions for individual and multi-lease sales.

Explosive removal of offshore structures may adversely affect sea turtles. Section 7 consultation for COE-New Orleans District rig removal activities found them likely to adversely affect, but not jeopardize, the continued existence of green, hawksbill, Kemp's ridley, leatherback, or loggerhead sea turtles (NMFS 1998b). An ITS for this activity was provided. In July 2004, MMS completed a programmatic environmental assessment (PEA) on geological and geophysical exploration on the Gulf of Mexico Outer Continental Shelf (MMS 2004). The MMS has also recently completed a PEA on removal and abandonment of offshore structures and effects on protected species in the Gulf of Mexico (MMS 2005).

4.2.5 ESA Permits

Regulations developed under the ESA allow for the issuance of permits allowing take of certain ESA-listed species for the purposes of scientific research under section 10(a)(1)(A) of the ESA. In addition, section 6 of the ESA allows NMFS to enter into cooperative agreements with states to assist in recovery actions of listed species. Prior to issuance of these permits, the proposal must be reviewed for compliance with section 7 of the ESA.

Sea turtles are the focus of research activities authorized by section 10 permits under the ESA. As of January 2009, there were 21 active scientific research permits directed toward sea turtles that are applicable to the action area of this biological opinion. Authorized activities range from photographing, weighing, and tagging sea turtles incidentally taken in fisheries, to blood sampling, tissue sampling (biopsy), and performing laparoscopy on intentionally captured sea turtles. The number of authorized takes varies widely depending on the research and species involved but may involve the taking of hundreds of sea turtles annually. Most takes authorized under these permits are expected to be non-lethal. Before any research permit is issued, the proposal must be reviewed under the permit regulations (i.e., must show a benefit to the species). In addition, since issuance of the permit is a federal activity, issuance of the permit by NMFS must also undergo a section 7 analysis to ensure the issuance of the permit does not result in jeopardy to the species.

4.2.6 Vessel Traffic

Commercial traffic and recreational pursuits can adversely affect sea turtles through propeller and boat strikes. The Sea Turtle Stranding and Salvage Network (STSSN) includes many records of vessel interaction (propeller injury) with sea turtles off Gulf of Mexico coastal states such as Florida, where there are high levels of vessel traffic. The extent of the problem is difficult to assess because of not knowing whether the majority of sea turtles are struck pre- or post-mortem. Private vessels in the action area participating in high-speed marine events (e.g., boat races) are a particular threat to sea turtles. NMFS and the USCG have completed several formal consultations on individual marine events that may affect sea turtles. NMFS and USCG St. Petersburg Sector are currently conducting a formal consultation regarding high-speed boating events and fishing tournaments occurring off the west coast of Florida that may affect sea turtles.

4.2.7 Marine Pollution

Anthropogenic sources of marine pollution, while difficult to attribute to a specific federal, state, local or private action, may indirectly affect sea turtles in the action area. Sources of pollutants in the action area include atmospheric loading of pollutants such as PCBs; storm water runoff from coastal towns, cities, and villages; and runoff into rivers that empty into bays and groundwater. The pathological effects of oil spills have been documented in laboratory studies of marine mammals and sea turtles (Vargo et al. 1986).

Nutrient loading from land-based sources, such as coastal communities and agricultural operations, are known to stimulate plankton blooms in closed or semi-closed estuarine systems. An example is the large area of the Louisiana continental shelf with seasonally depleted oxygen levels (< 2mg/l), caused by eutrophication from both point and non-point sources. Most aquatic species cannot survive at such low oxygen levels and these areas are known as “dead zones.” The oxygen depletion, referred to as hypoxia, begins in late spring, reaches a maximum in mid summer, and disappears in the fall. Since 1993, the average extent of mid-summer bottom-water hypoxia in the northern Gulf of Mexico has been approximately 16,000 square kilometers, approximately twice the average size measured between 1985 and 1992. The hypoxic zone attained a maximum measured extent in 2001, when it was 21,700 square kilometers (Rabalais et al. 2002). The hypoxic zone has impacts on the animals found there, including sea turtles, and the ecosystem-level impacts continue to be investigated.

4.3 Conservation and Recovery Actions Benefiting Sea Turtles

NMFS has implemented a series of regulations aimed at reducing potential for incidental mortality of sea turtles from commercial fisheries in the action area. These include sea turtle release gear requirements for Atlantic HMS, Gulf of Mexico reef fish, and South Atlantic snapper-grouper fishery, and TED requirements for Southeast shrimp trawl fishery. In addition to regulations, outreach programs have been established and data on sea turtle interactions with recreational fisheries has been collected through the Marine Recreational Fishing Statistical Survey (MRFSS). The summaries below discuss all of these measures in more detail.

4.3.1 Regulations Reducing Threats to Sea Turtles from Fisheries

Reducing Threats from Pelagic Longline and Other Hook-and-Line Fisheries
On May 1, 2009 NMFS published an emergency rule (74 FR 20229), effective from May 18, 2009 through October 28, 2009, prohibiting bottom longlining for Gulf reef fish east of 85°30'W longitude (near Cape San Blas, Florida) and in the portion of the EEZ shoreward of the 50-fathom depth contour. The emergency rule is intended to reduce sea turtle takes in the short-term while the Gulf of Mexico Fishery Management Council develops long-term protective measures through Amendment 31 to the Fishery Management Plan for Reef Fish Resources in the Gulf of Mexico.

NMFS published the final rule to implement sea turtle release gear requirements and sea turtle careful release protocols in the Gulf of Mexico reef fish fishery on August 9, 2006 (71 FR 45428). These measures require owners and operators of vessels with federal commercial or charter vessel/headboat permits for Gulf reef fish to comply with sea turtle (and smalltooth sawfish) release protocols and have on board specific sea turtle release gear. NMFS is currently conducting rulemaking to implement similar release gear and handling requirements for the South Atlantic snapper-grouper fishery.

On July 6, 2004, NMFS published a final rule to implement management measures to reduce bycatch and bycatch mortality of Atlantic sea turtles in the Atlantic pelagic longline fishery (69 FR 40734). The management measures include mandatory circle hook and bait requirements, and mandatory possession and use of sea turtle release equipment to reduce bycatch mortality. The rulemaking, based on the results of the 3-year Northeast Distant Closed Area research experiment and other available sea turtle bycatch reduction studies, is expected to have significant benefits to endangered and threatened sea turtles.

Revised Use of Turtle Excluder Devices in Trawl Fisheries
NMFS has also implemented a series of regulations aimed at reducing potential for incidental mortality of sea turtles in commercial shrimp trawl fisheries. In particular, NMFS has required the use of TEDs in southeast United States shrimp trawls since 1989 and in summer flounder trawls in the Mid-Atlantic area (south of Cape Charles, Virginia) since 1992. It has been estimated that TEDs exclude 97 percent of the sea turtles caught in such trawls. These regulations have been refined over the years to ensure that TED effectiveness is maximized through proper placement and installation, configuration (e.g., width of bar spacing), floatation, and more widespread use.

Significant measures have been developed to reduce the take of sea turtles in summer flounder trawls and trawls that meet the definition of a summer flounder trawl (which would include fisheries for other species like scup and black sea bass) by requiring TEDs in trawl nets fished from the North Carolina/South Carolina border to Cape Charles, Virginia. However, the TED requirements for the summer flounder trawl fishery do not require the use of larger TEDs that are used in the shrimp trawl fishery to exclude leatherbacks, as well as large, benthic, immature and sexually mature loggerheads and green sea turtles.

NMFS has also been working to develop a TED, which can be effectively used in a type of trawl known as a flynet, which is sometimes used in the Mid-Atlantic and Northeast fisheries to target sciaenids and bluefish. Limited observer data indicate that takes can be quite high in this fishery. A top-opening flynet TED was certified this summer, but experiments are still ongoing to certify a bottom-opening TED.

Placement of Fisheries Observers to Monitor Sea Turtle Takes
On August 3, 2007, NMFS published a final rule required selected fishing vessels to carry observers on board to collect data on sea turtle interactions with fishing operations, to evaluate existing measures to reduce sea turtle takes, and to determine whether additional measures to address prohibited sea turtle takes may be necessary (72 FR 43176). This rule also extended the number of days NMFS observers placed in response to a determination by the Assistant Administrator that the unauthorized take of sea turtles may be likely to jeopardize their continued existence under existing regulations, from 30 to 180 days.

Final Rules for Large-Mesh Gillnets
In March 2002, NMFS published new restrictions for the use of gillnets with larger than 8-inch stretched mesh, in federal waters (3-200 nautical miles) off North Carolina and Virginia. These restrictions were published in an interim final rule under the authority of the ESA (67 FR 13098) and were implemented to reduce the impact of the monkfish and other large-mesh gillnet fisheries on ESA-listed sea turtles in areas where sea turtles are known to concentrate. Following review of public comments submitted on the interim final rule, NMFS published a final rule on December 3, 2002, that established the restrictions on an annual basis. As a result, gillnets with larger than 8-inch stretched mesh were not allowed in federal waters (3-200 nautical miles) in the areas described as

follows: (1) north of the North Carolina/South Carolina border at the coast to Oregon Inlet at all times; (2) north of Oregon Inlet to Currituck Beach Light, North Carolina, from March 16-January 14; (3) north of Currituck Beach Light, North Carolina, to Wachapreague Inlet, Virginia, from April 1-January 14; and (4) north of Wachapreague Inlet, Virginia, to Chincoteague, Virginia, from April 16-January 14. On April 26, 2006, NMFS published a final rule (71 FR 24776) that included modifications to the large-mesh gillnet restrictions. The new final rule revised the gillnet restrictions to apply to stretched mesh that is greater than or equal to 7 inches. Federal waters north of Chincoteague, Virginia, remain unaffected by the large-mesh gillnet restrictions. These measures are in addition to Harbor Porpoise Take Reduction Plan measures that prohibit the use of large-mesh gillnets in southern Mid-Atlantic waters (territorial and federal waters from Delaware through North Carolina out to 72º 30'W longitude) from February 15-March 15, annually.

4.3.2 Other Sea Turtle Conservation Efforts

Sea Turtle Handling and Resuscitation Techniques
NMFS published a final rule (66 FR 67495, December 31, 2001) detailing handling and resuscitation techniques for sea turtles that are incidentally caught during scientific research or fishing activities. Persons participating in fishing activities or scientific research are required to handle and resuscitate (as necessary) sea turtles as prescribed in the final rule. These measures help to prevent mortality of hard-shelled turtles caught in fishing or scientific research gear.

Outreach and Education, Sea Turtle Entanglements, and Rehabilitation
There is an extensive network of Sea Turtle Stranding and Salvage Network participants along the Atlantic and Gulf of Mexico coasts who not only collect data on dead sea turtles, but also rescue and rehabilitate any live stranded sea turtles.

A final rule (70 FR 42508) published on July 25, 2005, allows any agent or employee of NMFS, the USFWS, the U.S. Coast Guard, or any other federal land or water management agency, or any agent or employee of a state agency responsible for fish and wildlife, when acting in the course of his or her official duties, to take endangered sea turtles encountered in the marine environment if such taking is necessary to aid a sick, injured, or entangled endangered sea turtle, or dispose of a dead endangered sea turtle, or salvage a dead endangered sea turtle that may be useful for scientific or educational purposes. NMFS already affords the same protection to sea turtles listed as threatened under the ESA [50 CFR 223.206(b)].

Other Actions
A draft revised recovery plan for the loggerhead sea turtle was published May 30, 2008 (73 FR 31066). The recovery plan for the Kemp's ridley sea turtle is in the process of being updated. Recovery teams comprised of sea turtle experts have been convened and are currently working towards revising these plans based upon the latest and best available information. Five-year status reviews have recently been completed for green, hawksbill, Kemp's ridley, leatherback, and loggerhead sea turtles. These reviews were

conducted to comply with the ESA mandate for periodic status evaluation of listed species to ensure that their threatened or endangered listing status remains accurate. Each review determined that no delisting or reclassification of a species status (i.e., threatened or endangered) was warranted at this time. However, further review of species data for the green, hawksbill, leatherback, and loggerhead sea turtles was recommended, to evaluate whether distinct population segments (DPS) should be established for these species (NMFS and USFWS 2007a-e).

4.4 Factors Affecting *Acropora* within the Action Area

In Section 3 (Status of Species), we described the range-wide status of *Acropora*.[9] Within the action area, *Acropora* occur in two specific areas off southeast Florida and in the Gulf of Mexico, with the majority of colonies located in the Florida Keys. *Acropora* colonies are non-motile and susceptible to relatively localized adverse affects as a result. Localized adverse affects on *Acropora* in the action area have resulted from many of the same stressors affecting *Acropora* throughout its range, namely anthropogenic breakage, disease, and intense weather events (i.e., hurricanes and extreme cold-water disturbances). These stressors have led to abundance declines of *Acropora* in the action area commensurate with the declines seen elsewhere in the species' range (*Acropora* BRT 2005). Therefore, we believe the status of the species described in Section 3 is an accurate reflection of the species status within the action area.

4.4.1 Federal Actions

This is the first formal consultation evaluating the effects of a federal fishery on *Acropora*. As such, there are no other biological opinions to reference regarding the impacts of federal fisheries on these species. Given the morphology and distribution of *Acropora*, it is possible certain types of fishing gear (e.g., bottom trawl, bottom longline, and hook-and-line) will adversely affect these species. However, there is currently little data available to evaluate the impacts of those gear types on these species. NMFS is collecting data to analyze the impacts of federal fisheries and will conduct section 7 consultations as appropriate.

Other federal agencies also authorize actions within the action area with the potential to affect *Acropora*, including:

- The U.S. Army Corps of Engineers (COE) authorizes and carries out construction and dredge and fill activities that may result in direct mortality, injure *Acropora*, or eliminate or impede *Acropora's* access to habitat.
- The COE permits discharges to surface waters. Shoreline and riparian disturbances (whether in the riverine, estuarine, marine, or floodplain environment) resulting in discharges may retard or prevent the reproduction, settlement, reattachment, and development of listed corals (e.g., land development

[9] Throughout the rest of the document we use the term '*Acropora*' to refer to the two listed *Acropora* species (*Acropora cervicornis* and *A. palmata*), unless an individual species is specifically identified.

and run-off, and dredging and disposal activities, result in direct deposition of sediment on corals, shading, and lost substrate for fragment reattachment or larval settlement).

- The U.S. Environmental Protection Agency (EPA) regulates the discharge of pollutants, such as oil, toxic chemicals, radioactivity, carcinogens, mutagens, teratogens, or organic nutrient-laden water, including sewage water, into the waters of the United States. Elevated discharge levels may cause direct mortality, reduced fitness, or habitat destruction/modification.
- The National Marine Sanctuary Program and the National Park Service regulate activities within their boundaries that are conducted in shallow water coral reef areas including collection of coral, alteration of the seabed, discharges, boating, anchoring, fishing, recreational scuba diving, and snorkeling.

As more data becomes available to evaluate the impacts of this suite of activities section 7 consultations will be reinitiated as necessary.

4.4.2 Other Non-Federal Actions Affecting *Acropora*

Poor boating and anchoring practices, poor snorkeling and diving techniques, and destructive fishing practices cause abrasion and breakage to *Acropora*. Nutrients, contaminants, and sediment from point and non-point sources cause direct mortality and the breakdown of normal physiological processes. Additionally, these stressors create an unfavorable environment for reproduction and growth.

Diseases have been identified as the major cause of *Acropora* decline. Although the most severe mortality resulted from an outbreak in the early 1980s, diseases (i.e., white band disease) are still present in *Acropora* populations and continue to cause mortality.

Hurricanes and large coastal storms could also significantly harm *Acropora*. Due to its branching morphology, it is especially susceptible to breakage from extreme wave action and storm surges. Historically, large storms potentially resulted in an asexual reproductive event, if the fragments encountered suitable substrate, attached, and grew into a new colony. However, in the recent past, the amount of suitable substrate is significantly reduced; therefore, many fragments created by storms die.

4.4.3 Conservation and Recovery Actions

On November 26, 2008, NMFS published the final rule designating critical habitat for *Acropora*. This designation included areas in four locations: Florida, St. John/St. Thomas, Puerto Rico, and St. Croix. These areas possess the physical or biological features deemed necessary for the conservation of these species (73 FR 72209).

On October 29, 2008 NMFS published a final rule prohibiting the take of *Acropora*, pursuant to section 4(d) of the ESA (73 FR 64264). Such regulations prohibit many actions pertaining to *Acropora*, including but not limited to: importing or exporting these species from or into the United States; taking of these species from U.S. waters, its territorial sea, or the high seas; or possessing or selling these species.

Other federal regulatory mechanisms and conservation initiatives have focused on addressing physical impacts, including damage from fishing gear, anchoring, and vessel groundings. The Coral Reef Conservation Act and the two Coral and Coral Reef Fishery Management Plans require the protection of corals and prohibit the collection of hard corals. Depending on the specifics of zoning plans and regulations, marine protected areas (MPAs) can help prevent damage from collection, fishing gear, groundings, and anchoring.

4.5 Factors Affecting Smalltooth Sawfish Within the Action Area

In recent years, NMFS has undertaken section 7 consultations to address the effects of federally permitted fisheries and other federal actions on smalltooth sawfish, and when appropriate, has authorized the incidental taking of these species. Each of those consultations sought to minimize the adverse impacts of the action on smalltooth sawfish. The following sections summarize anticipated sources of incidental take of smalltooth sawfish in the Atlantic, and Gulf of Mexico EEZ, which have already concluded formal section 7 consultation.

4.5.1 Fisheries

NMFS has completed a section 7 consultation on the continued authorization of *HMS Atlantic shark fisheries* (NMFS 2008). The commercial fishery uses bottom longline and gillnet gear. The recreational sector of the fishery uses only hook-and-line gear. To protect declining shark stocks the proposed action seeks to greatly reduce the fishing effort in the commercial component of the fishery. These reductions are likely to greatly reduce the interactions between the commercial component of the fishery and smalltooth sawfish. The biological opinion concluded that smalltooth sawfish may be adversely affected by operation of the fishery. However, the proposed action was not expected to jeopardize its continued existence and an ITS was provided.

NMFS recently completed a section 7 consultation on the continued authorization of the *coastal migratory pelagic* fishery in the Gulf of Mexico and South Atlantic (NMFS 2007). In the Gulf of Mexico, hook-and-line, gillnet, and cast net gears are used. Gillnets are the primary gear type used by commercial fishermen in the South Atlantic, while the recreational sector uses hook-and-line gear. The biological opinion concluded that smalltooth sawfish may be adversely affected by operation of the fishery. However, the proposed action was not expected to jeopardize its continued existence and an ITS was provided.

NMFS completed a section 7 consultation on the continued authorization of the *Gulf of Mexico reef fish fishery* on February 15, 2005 (NMFS 2005a). The fishery uses three basic types of gear: spear and powerhead, trap, and hook-and-line gear. Hook-and-line gear used in the fishery includes both commercial bottom longline and commercial and recreational vertical line (e.g., handline, bandit gear, rod-and-reel). The biological opinion concluded that smalltooth sawfish may be adversely affected by the operation of the fishery. However, the proposed action was not expected to jeopardize the continued existence of this species and an ITS has been provided.

A section 7 consultation on the *South Atlantic snapper-grouper fishery* was completed by NMFS on June 7, 2006 (NMFS 2006a). The fishery uses spear and powerhead, black sea bass pot, and hook-and-line gear. Hook-and-line gear used in the fishery includes both commercial bottom longline and commercial and recreational vertical line (e.g., handline, bandit gear, rod-and-reel). The consultation concluded the hook-and-line component of the fishery was likely to adversely affect smalltooth sawfish, but was not likely to jeopardize its continued existence. An ITS was issued for takes in the hook-and-line component of the fishery.

NMFS has also conducted section 7 consultations on the impacts of the *Gulf of Mexico shrimp trawl fishery* (NMFS 2006b) *and the South Atlantic shrimp trawl fishery* (NMFS 2005c) on smalltooth sawfish. Both of these consultations found these fisheries likely to adversely affect smalltooth sawfish, but not likely jeopardize their continued existence. The ITS provided in those biological opinions anticipated the lethal take of up to one smalltooth sawfish annually in each of these two fisheries. In May 2009, NMFS requested reinitiation of section 7 consultations on the impacts of the South Atlantic shrimp trawl fishery because the amount of authorized incidental take for smalltooth sawfish had been exceeded. One lethal take was observed in 2008, and three additional takes (one lethal and two non-lethal) were observed in 2009.

Smalltooth sawfish may infrequently be taken in other South Atlantic and Gulf of Mexico federal fisheries involving trawl, gillnet, bottom longline gear, and hook-and-line gear. However, NMFS has little data to substantiate such takings. NMFS is collecting data to analyze the impacts of these fisheries and will conduct section 7 consultations as appropriate.

4.5.2 ESA Permits

Regulations developed under the ESA allow for the issuance of permits allowing take of certain ESA-listed species for scientific research purposes under section 10(a)(1)(A). Prior to issuance of these permits, the proposal must be reviewed for compliance with section 7 of the ESA. There are currently two active smalltooth sawfish research permits. Permit holders are Dr. John Carlson (SEFSC), and Florida Fish and Wildlife Conservation Commission. Although the permitted research may result in disturbance and injury of smalltooth sawfish, the activities are not expected to affect the reproduction of the individuals that are caught, nor result in mortality.

4.5.3 Conservation and Recovery Actions

Under section 4(f)(1) of the ESA, NMFS is required to develop and implement a recovery plan for the conservation and survival of endangered and threatened species. In

September 2003, NMFS convened a smalltooth sawfish recovery team composed of nine members from federal, state, non-governmental, and non-profit organizations. The team has completed a draft recovery plan. The goal of the recovery plan is to rebuild and assure the long-term viability of the U.S. DPS of smalltooth sawfish in the wild, allowing initially for reclassification from endangered to threatened status (downlisting) and ultimately the recovery and subsequent removal from the List of Endangered and Threatened Wildlife (delisting). NMFS released the final Smalltooth Sawfish Recovery Plan on January 21, 2009 (74 FR 3566).

On November 20, 2008, NMFS proposed to designate critical habitat for smalltooth sawfish (73 FR 70290). The proposed critical habitat would comprise of two units off southwestern Florida – the Charlotte Harbor Estuary and the Ten Thousand Island/Everglades unit – comprising approximately 619,013 acres. These areas contain the physical and biological features deemed essential for the conservation of the species.

5.0 Effects of the Action

In this section of the opinion, we assess the probable effects of the continued operation of the Gulf of Mexico/South Atlantic spiny lobster fishery on ESA-listed species. The analysis in this section forms the foundation for our jeopardy (risk) analysis in section 7. A jeopardy determination is reached if we would reasonably expect the proposed action to cause, either directly or indirectly, reductions in numbers, reproduction, or distribution that would appreciably reduce a listed species' likelihood of surviving and recovering in the wild. The ESA defines an endangered species as "...in danger of extinction throughout all or a significant portion of its range..." and a threatened species as "...likely to become an endangered species within the foreseeable future..." The status of each listed species likely to be adversely affected by the continued authorization of the Gulf of Mexico/South Atlantic spiny lobster fishery is reviewed in Section 3. Sea turtle species are listed because of their global status; a jeopardy determination must therefore find the proposed action will appreciably reduce the likelihood of survival and recovery of each species globally. The *Acropora* species are listed because of their statuses throughout their ranges. Like sea turtles, a jeopardy determination for these species must find the proposed action will appreciably reduce the likelihood of survival and recovery for each species throughout its entire range. Only the U.S. DPS of smalltooth sawfish is listed; a jeopardy determination must therefore find the proposed action will appreciably reduce the likelihood of survival and recovery of the U.S. DPS.

The analyses in this section are based upon the best available commercial and scientific data on sea turtles, *Acropora*, and smalltooth sawfish biology and the effects of the proposed action. Data pertaining to the Gulf of Mexico/South Atlantic spiny lobster fishery, relative to interactions with sea turtles, *Acropora*, and smalltooth sawfish are limited, so we are often forced to make assumptions to overcome the limits in our knowledge. Frequently, different analytical approaches may be applied to the same data sets. In those cases, in keeping with the direction from the U.S. Congress to resolve uncertainty by providing the "benefit of the doubt" to threatened and endangered species [House of Representatives Conference Report No. 697, 96th Congress, Second Session, 12 (1979)], we will generally select the value yielding the most conservative outcome (i.e., would lead to conclusions of higher, rather than lower, risk to endangered or threatened species).

When analyzing any proposed action, it is important to consider not only its immediate effects to ESA-listed species, but also the effects caused by or resulting from it that are reasonably certain to occur later in time. For example, effects from the proposed action occurring later in time could include habitat degradation, reduction of prey/foraging base, etc. No such effects to sea turtles or smalltooth sawfish have been identified because of the operation of the Gulf of Mexico/South Atlantic spiny lobster fishery (i.e., scuba diving, vessel operations, gear deployment and retrieval). Our analysis assumes sea turtles, smalltooth sawfish, and *Acropora* are not likely to be adversely affected by a gear type unless they interact with it. We also assume the potential effects of each gear type are proportional to the number of interactions between the gear and each species.

Approach to Assessment
Our analysis of the effect of the action in this section involved several steps. We began by determining which gear types/techniques (i.e., bully nets, hand harvest gears [e.g., nets and snares], and traps) were likely to adversely affect sea turtles, *Acropora*, and smalltooth sawfish. We then reviewed the range of responses to an individual's exposure to fishing gear and the factors affecting the likelihood of exposure. The focus then shifts to evaluating and quantifying the impacts of spiny lobster fishing on sea turtles, *Acropora*, and smalltooth sawfish under status quo management (see Section 2.1 for more detail). For sea turtles and smalltooth sawfish, we estimated the number of individuals likely to be exposed to the fishery, and the likely fate of those animals. For *Acropora*, we estimated the area likely to have been adversely affected by the fishery. We then consider how the fishery's continued operation would affect future levels of take; i.e., whether the estimated past take would increase or decrease and by how much, or whether the same levels would continue in the future.

There are three basic types of gear used in the directed spiny lobster fishery: bully nets, hand harvest gears (e.g., nets and snares), and traps. Section 2 describes these gears and how recreational or commercial fishermen use them to target spiny lobster. The type of fishing gears, the areas, and the manner in which they are used, all affect the likelihood of sea turtle or smalltooth sawfish interactions. For this reason, each gear type is evaluated separately.

Due to a number of factors, the number of traps issued in the fishery has remained essentially unchanged since the 2003/04 fishing season (see Section 2.1). As a result, when discussing the fishery and its interactions with ESA-listed species, we use the fishing seasons from 2004-2005 through 2006-2007 as the baseline to project the number of individuals by species likely to be exposed to the various components of the fishery. We believe data from this time series best reflect the level fishing effort currently occurring in the fishery, and ultimately the level of ESA-listed species interactions occurring under the current management regime.

5.1 Effects on Sea Turtles, *Acropora,* and Smalltooth Sawfish from Commercial and Recreational Bully Net Gear

We believe commercial and recreational bully net use is not likely to adversely affect sea turtles, *Acropora*, or smalltooth sawfish based on the low likelihood of interactions between these species and this gear type. Bully nets require an active fishing technique that is only effective when target prey can be seen and the net is tended constantly. The reliance upon visual contact with a target species greatly improves a fisher's ability to avoid incidentally taking sea turtles, *Acropora*, and smalltooth sawfish. This makes it extremely unlikely that sea turtles, *Acropora*, or smalltooth sawfish would become entangled in these gears. Fragmentation or abrasion of *Acropora* caused by bully nets is also extremely unlikely. *Acropora* are extremely unlikely to occur on the seagrass and mud flats were the vast majority of bully nets are used. Since the likelihood of any interaction between bully net gear and sea turtles, *Acropora*, and smalltooth sawfish is extremely low, we believe any impact from this fishing gear is discountable.

5.2 Effects on Sea Turtles, *Acropora,* and Smalltooth Sawfish from Commercial and Recreational Diving

Effects on Sea Turtles and Smalltooth Sawfish
We believe commercial and recreational spiny lobster diving is not likely to adversely affect sea turtles or smalltooth sawfish. The distribution of spiny lobster diving effort overlaps spatially with areas known to be inhabited by sea turtles and smalltooth sawfish. However, divers only occasionally encounter sea turtles and rarely encounter smalltooth sawfish, if at all. Anecdotal information from encounters indicates some sea turtles and smalltooth sawfish change their route to avoid coming in close proximity to divers, whereas others appear unaware of their presence. There are no reports of incidental sea turtle or smalltooth sawfish takes by spiny lobster divers. Given the selectivity of the gears used and the visual nature of the hunt and capture of spiny lobsters, spiny lobster divers will easily be able to avoid sea turtles and smalltooth sawfish. Any behavioral effects on sea turtles or smalltooth sawfish from the presence of spiny lobster divers are expected to be insignificant. We therefore conclude that diving for spiny lobster is not likely to adversely affect sea turtles or smalltooth sawfish.

Effects on Acropora
Commercial and recreational diving for spiny lobster is not likely to adversely affect *Acropora* species. *Acropora* occurs only rarely and in discrete locations within the Gulf of Mexico and South Atlantic regions, and is not found in the Gulf of Mexico portion of the Florida Keys. Where they do occur, fisheries could cause fragmentation or abrasion resulting from: (1) fishing gear/marine debris, (2) damaging fishing practices, (3) vessel groundings, (4) anchoring, and (5) diver/snorkeler interactions (*Acropora* BRT 2005). However, no impacts are anticipated to occur because of lawful commercial and recreational spiny lobster diving. From 1996-2006, all commercial and recreational spiny lobster trips that occurred in areas where *Acropora* might be present, were inside the Florida Keys National Marine Sanctuary (FKNMS). The FKNMS has specific regulations protecting corals within the sanctuary. Thus, we believe the rarity of

Acropora in the Gulf of Mexico and South Atlantic, coupled with regulations to protect these corals where they do occur, greatly reduces the likelihood of these impacts occurring at all. Below is a discussion of our rationale for reaching a not likely to adversely affect determination.

Derelict fishing gear/marine debris can destroy benthic organisms especially *Acropora*, due to their branching morphology. However, unlike other fisheries (e.g., hook-and-line fisheries), the propensity of the commercial/recreational spiny lobster dive fishery to produce fishing-related marine debris is extremely unlikely. Fishery-related marine debris is often created by accidental gear loss due to weather or accidental entanglement with submerged benthic features. Commercial/recreational divers targeting spiny lobster primarily use their hands and/or nets to collect lobster and return to surface with those gears when fishing is completed. Since these gears are constantly used by fishers and never intentionally left behind at the cessation of fishing, we believe the likelihood of gear being lost and becoming detrimental marine debris is extremely unlikely, and therefore discountable.

Trawling and other types of fishing gear can be harmful to coral reefs. Trawls can dislodge and abrade corals, and stationary gear such as traps can damage branching corals by breaking branches off as they move across the sea floor or by directly landing on them. This is particularly true in the case of storms that can mobilize traps and often snare buoy lines in branching corals such as *Acropora* (*Acropora* BRT 2005). Trawling and traps are not used by commercial/recreational divers targeting spiny lobster. The use of chemicals (i.e., chlorine, bleach, etc.) to harvest spiny lobster is prohibited (50 CFR 640.22(a)(3)). Since these damaging fishing practices are prohibited, we believe any adverse effects to *Acropora* are extremely unlikely to occur, and therefore discountable.

Vessel groundings are another example of anthropogenic impacts that may harm *Acropora*. A modern large steel ship is a powerful mass and its impact can dislodge and fracture corals, pulverize coral skeletons into small debris-rubble, displace sediment deposits, flatten the topography, and destroy or fracture the reef platform (*Acropora* BRT 2005). However, current regulations governing the operations of vessels within the FKNMS prohibit vessels from striking or otherwise injuring corals (15 CFR 922.163(a)(5)(i)). The presence of navigational aides throughout the FKNMS is also likely to reduce to potential for vessel groundings. Since regulations are currently in place that prohibit vessel groundings, we believe adverse effects to *Acropora* from such events are extremely unlikely to occur, and therefore discountable.

Novice snorkelers/divers may stand on or kick *Acropora* causing breakage, although there are no studies that document the frequency of this damage. FKNMS regulations prohibit damaging, breaking, cutting, or otherwise disturbing *Acropora* inside the sanctuary's boundaries (15 CFR 922.163(a)(2)). Likewise, taking or possessing wildlife protected under the ESA is also prohibited under FKNMS regulations (15 CFR 922.163(a)(10)). Mooring buoys have also been deployed throughout the Sanctuary, reducing boaters' need to anchor. Since FKNMS regulations prohibit the actions that precipitate these effects, we believe they are extremely unlikely to occur and therefore discountable.

5.3 Sea Turtle, *Acropora*, and Smalltooth Sawfish Interactions with Commercial Spiny Lobster Trap Gear

5.3.1 Sea Turtle/Trap Interactions

Commercial lobster traps are known to adversely affect sea turtles via entanglement and forced submergence. Captured sea turtles can be released alive or can be found dead upon retrieval of the gear as a result of forced submergence. Sea turtles released alive may later succumb to injuries sustained at the time of capture. Of the entangled sea turtles that do not die from their wounds, some may suffer impaired swimming or foraging abilities, altered migratory behavior, or altered breeding or reproductive patterns. The following discussion summarizes in detail the available information on how individual sea turtles may respond to interactions with spiny lobster trap gear.

Entanglement
The primary effect on sea turtles from traps is entanglement in buoy lines. Sea turtles are particularly prone to entanglement as a result of their body configuration and behavior. Records of stranded or entangled sea turtles reveal that trap lines can wrap around the neck, flipper, or body of a sea turtle and severely restrict swimming or feeding. If a sea turtle is entangled when young, the line could become tighter and more constricting as the sea turtle grows, cutting off blood flow and causing deep gashes, some severe enough to remove an appendage.

Loggerhead sea turtles may be particularly vulnerable to entanglement in trap lines because of their attraction to, or attempts to feed on, species caught in the traps and epibonts growing on traps, trap lines, and floats NMFS and USFWS 1991b). Due to body configuration, leatherback sea turtles are also thought to be particularly prone to entanglement.

Forcible Submergence
Sea turtles can be forcibly submerged by trap gear. Forcible submergence may occur through an entanglement event, where the sea turtle is unable to reach the surface to breathe. Forced submergence could also occur if a sea turtle becomes entangled in a trap line below the surface and the line is too short and or the trap is too heavy to be brought up to the surface by the swimming sea turtle.

Sea turtles that are forcibly submerged undergo respiratory and metabolic stress that can lead to severe disturbance of their acid-base balance (i.e., pH level of the blood). Most voluntary dives by sea turtles appear to be an aerobic metabolic process, showing little if any increases in blood lactate and only minor changes in acid-base status. In contrast, sea turtles that are stressed as a result of being forcibly submerged due to entanglement eventually consume all their oxygen stores. This oxygen consumption triggers anaerobic glycolysis, which can significantly alter their acid-base balance, sometimes leading to death (Lutcavage and Lutz 1997).

Numerous factors affect the survival rate of forcibly submerged sea turtles. It is likely that the rapidity and extent of the physiological changes that occur during forced submergence are functions of the intensity of struggling, as well as the length of submergence (Lutcavage and Lutz 1997). Other factors influencing the severity of effects from forced submergence include the size, activity level, and condition of the sea turtle; the ambient water temperature, and if multiple forced submergences have recently occurred. Disease factors and hormonal status may also influence survival during forced submergence. Larger sea turtles are capable of longer voluntary dives than small sea turtles, so juveniles may be more vulnerable to the stress from forced submergence. During the warmer months, routine metabolic rates are higher. Increased metabolic rates lead to faster consumption of oxygen stores, which triggers anaerobic glycolysis. Subsequently, the onset of impacts from forced submergence may occur more quickly during these months. With each forced submergence event, lactate levels increase and require a long (up to 20 hours) time to recover to normal levels. Sea turtles are probably more susceptible to lethal metabolic acidosis if they experience multiple forced submergence events in a short period. Recurring submergence does not allow sea turtles sufficient time to process lactic acid loads (Lutcavage and Lutz 1997). Stabenau and Vietti (2003) illustrated that sea turtles given time to stabilize their acid-base balance after being forcibly submerged have a higher survival rate. The rate of acid-base stabilization depends on the physiological condition of the turtle (e.g., overall health, age, size), time of last breath, time of submergence, environmental conditions (e.g., sea surface temperature, wave action, etc.), and the nature of any injuries sustained at the time of submergence (NRC 1990).

5.3.2 *Acropora*/Trap Interactions

Traps and/or trap lines can adversely affect *Acropora* via fragmentation or abrasion. Traps may affect *Acropora* via fragmentation and abrasion if they become mobilized during storm events and collide with colonies.[10] The deployment of spiny lobster traps may adversely affect *Acropora* as traps drop toward the sea floor or when traps are retrieved and pulled to the surface. Abrasion may occur when traps or trap lines contact *Acropora* during storm events or normal fishing activities. However, *Acropora* is only rarely, if ever, observed in the Gulf of Mexico off south Florida where the vast majority of trap fishing occurs, because of relatively poor water quality. For this reason, we believe any adverse affects from abrasion/fragmentation due to interactions with commercial spiny lobster trap gear are only likely to occur in the South Atlantic waters off south Florida. The following discussion summarizes the best available information on how *Acropora* may be impacted by these interactions with lobster trap fishing gear.

[10] Storm events are weather events with sustained winds of 15 knots for 2 days or more (C. Lewis and T. Matthews, FFWCC, pers. comm. 2007).

Fragmentation
Severe fragmentation can adversely affect sexual reproduction by reducing colonial biomass and/or causing a reallocation of energy away from reproduction toward stabilization, lesion repair, and growth (Van Veghel and Bak 1994, Van Veghel and Hoetjes 1995, Hall and Hughes 1996, Lirman 2000). Colony size in cnidarians[11] is directly correlated to survivorship, growth, and reproduction (i.e., the larger the colony, the greater the survivorship, growth, and reproductive potential) (Connell 1973, Loya 1976, Highsmith 1982, Jackson 1985, Karlson 1986, 1988; Hughes and Connell 1987, Lasker 1990, Babcock 1991, Hughes et al. 1992). Thus, fragmentation caused by spiny lobster trap gear could result in smaller colonies, potentially reducing their overall survivorship, and growth and reproduction potential. Mortality of coral fragments may also occur, eliminating entirely the possibility of asexual regeneration or future sexual reproduction by those fragments.

Fragmented coral colonies also frequently stop producing gametes for a period of time, due to the reallocation of energy mentioned above. Gamete production is likely to resume only once a certain level of growth and/or tissue repair/regeneration has occurred (Lirman 2000). Lirman (2000) found that *A. palmata* coral colonies that suffered fragmentation during Hurricane Andrew did not produce gametes fully three years after the event. Similar shifts in energy allocation from reproduction toward regeneration have been noted in *Montastraea annularis* (Van Veghel and Bak 1994) and other hard coral species (Kojis and Quinn 1985, Szmant 1986, Hughes et al. 1992). Thus, even surviving *Acropora* fragments may be removed from the spawning population for at least some period of time.

Lirman (2000) observed that the survivorship of *A. palmata* fragments was influenced by the type of substrate upon which the fragment settled. Fragments landing atop other *A. palmata* colonies showed no signs of mortality, while fragments landing on sand showed a 71 percent loss in tissue after four months. The relative scarcity of *Acropora* colonies in the Florida Keys reduces the likelihood of an *Acropora* fragment landing on another *Acropora* colony. As a result, fragments in isolated colonies may have a lower likelihood of survival (T. Matthews, FFWCC, pers. comm. 2008). Other studies suggest a similar correlation between substrate type and survivorship in other coral species (e.g., Yap and Gomez 1984, 1985; Heyward and Collins 1985, Wallace 1985, Bruno 1998). The benthic habitat of the Florida Keys consists primarily of seagrass (71 percent) and bare substrate (20 percent) (e.g., sand or mud) (FFWCC 2000). Since *Acropora* are highly reliant upon sunlight for nourishment (Porter 1976, Lewis 1977), if fragments are transported into these seagrass areas, their survivorship may be reduced due to shading. Seagrass beds also accrete sediment; any *Acropora* fragments transported into seagrass beds may also be susceptible to burial in sediment.

Abrasion
Abrasion by marine debris or fishing gear (e.g., spiny lobster traps and trap lines) can result in the loss of tissue, or tissue and skeleton. The loss of tissue can be partial or complete and the loss of tissue and skeleton can by superficial or extensive (Woodley et

[11] *Acropora* are members of the phylum cnidaria.

al. 1981, Glynn 1990, Craik et al. 1990, Hall 1997). The extent and severity of abrasion injuries is dependent upon the duration and frequency of the abrasion events.

The adverse affects to *Acropora* resulting from abrasion injuries are similar to those mentioned above for fragmentation. One of the primary impacts is the reallocation of energy away from reproduction and growth, towards regeneration or repair of the injured tissue and skeleton (Kobayashi 1984, Rinkevich and Loya 1989, Meester et al. 1994, Van Veghel and Bak 1994, Van Veghel and Hoetjes 1995, Hall and Hughes 1996, Hall 1997).

Areas injured by abrasion also provide sites for pathogens to enter and create habitable space for settlement of other organisms (e.g., algae, sponges, or other corals) (Bak et al. 1977, Hall 1997). In many coral species, polyps defend the colony by secreting mucus, discharging nematocysts, or through the production of allelochemicals (Hall 1997). The removal of polyps reduces a colony's ability to protect itself, potentially affecting its survivorship. Abrasion injuries also reduce the surface area available to photosynthesize, feed, and reproduce (Jackson and Palumbi 1979, Wahle 1983, Hughes and Jackson 1985, Babcock 1991, Hall and Hughes 1996, Hall 1997).

The type and severity of an abrasion injury (i.e., tissue or skeleton) affects the amount of time required for healing and the amount of energy that must be allocated for regeneration. Hall (1997) states that the time needed to fully recover from tissue injuries was much faster than the time required to completely regenerate fragmented skeleton. This suggests that the loss of tissue from a branch has less impact to the colony as a whole, than the loss of a branch. Hall (1997) hypothesizes that the replacement/regeneration of soft tissue requires the commitment of fewer resources than the regeneration of skeletal material, thus soft tissue can be replaced more quickly. However, Hall (1997) also observed that the area exposed when a branch is fragmented from the colony often healed more quickly than other soft tissue injuries. This suggests that while the regeneration of a fragmented branch may take considerably longer than healing a soft tissue injury, the colony may be exposed to disease and competitors for less time after branch fragmentation than when the colony is repairing a tissue injury.

5.3.3 Smalltooth Sawfish/Trap Interactions

Commercial spiny lobster traps may adversely affect smalltooth sawfish via entanglement. Entangled smalltooth sawfish may suffer impaired swimming or foraging abilities, altered migratory behavior, and altered breeding or reproductive patterns. The following discussion summarizes the available information on how individual smalltooth sawfish may be impacted by spiny lobster trap gear.

Entanglement
Entanglement of a smalltooth sawfish's toothed rostrum in a spiny lobster trap's float line is the primary route of effect between these species and this gear type. While no specific information exists on the effects of spiny lobster trap entanglement on smalltooth sawfish, Seitz and Poulakis (2006) list chafing and irritation of the skin, as well as the loss of rostral teeth, as consequences of entanglement in other types of marine debris.

The loss of rostral teeth could be especially detrimental because, unlike other elasmobranchs, smalltooth sawfish do not replace lost teeth (Slaughter and Springer 1968). Since the smalltooth sawfish's rostrum is its primary means for acquiring food, the loss of rostral teeth may impact an animal's ability to forage and hunt effectively. Entanglement injuries could also impair an animal's ability to swim. All such injuries could affect an individual's growth and reproductive abilities.

5.4 Factors Affecting ESA-Listed Species Interactions with Spiny Lobster Traps

5.4.1 Gear Characteristics and Fishing Technique

Bait

Live, under-sized lobster can legally be used as "bait" in the spiny lobster fishery. Due to spiny lobsters' thigmotactic nature and desire for social aggregations, fishers will often use an under-sized lobster to attract other lobsters. Sub-adult and adult loggerheads are primarily coastal dwelling and typically prey on benthic invertebrates such as mollusks and decapod crustaceans in hardbottom habitats. As such, loggerhead sea turtles may be attracted to spiny lobster traps when lobsters are inside. They are also known to feed on epibionts growing on traps, trap lines, and floats and may be attracted to spiny lobster traps for this reason (NMFS and USFWS 1991b). Smalltooth sawfish feed primarily on fish. Mullet, jacks, and ladyfish are believed to be their primary food resources (Simpfendorfer 2001). There is currently no data available on the attraction of smalltooth sawfish to spiny lobster trap gear.

Spatial/Temporal Overlap Between Fishing Effort and Sea Turtle and Smalltooth Sawfish

Another factor affecting the likelihood of sea turtle and smalltooth sawfish entanglement in spiny lobster trap gear is the spatial and temporal overlap between where they occur and fishing effort. The spatial distribution of sea turtles and smalltooth sawfish influences the rate of interaction with spiny lobster traps. The more abundant sea turtles are in a given area where fishing occurs, the greater the probability a sea turtle or smalltooth sawfish will interact with gear. Aerial survey data suggest that sea turtles are more abundant nearshore (i.e., approximately 0-120 feet) than offshore (L. Garrison, SEFSC, pers. comm. 2009). Spiny lobster trap fishing in both state and federal waters occurs almost exclusively within this depth range.

The temporal distribution of fishing effort and sea turtle and smalltooth sawfish abundance is also a factor. Of the 10 sea turtle stranding records from the Florida Keys with documented entanglement in spiny lobster gear applicable to the 2004-2005 through 2006-2007 fishing seasons, four (40 percent) were recorded in January, two (20 percent) were recorded in August; one (10 percent) was noted for each month of March, June, October, and December. No strandings of sea turtles with spiny lobster gear were documented in February, April, May, July, September or November (NMFS unpublished data).

Soak Time
Spiny lobster gear interactions with sea turtles and smalltooth sawfish also depend on soak time. The longer the soak time, the longer a sea turtle or smalltooth sawfish is exposed to an entanglement threat, increasing the likelihood of such an event occurring. The mortality rate of entangled sea turtles increases with soak time because of the higher potential for extended forced submergence times. Since forced submergence is not a concern for smalltooth sawfish, soak times do not appear to affect morality rates for incidentally caught animals.

5.4.2 Life Stage

Different life stages of sea turtles and smalltooth sawfish are associated with different habitat types and water depths. For example, pelagic stage loggerheads are found offshore; closely associated with *Sargassum* rafts. As loggerheads mature, they begin to live in coastal inshore and nearshore waters foraging over soft- and hardbottom habitats of the continental shelf (Carr 1987, Witzell 2002). Therefore, traps set closer to these areas are more likely to encounter adult loggerheads. Leatherbacks and juvenile loggerheads are more likely to be found further offshore in deeper, colder water. Spiny lobster traps are generally not fished in these areas, thus the fishery is far less likely to interact with these life stages. Ten sea turtle stranding records show evidence of spiny lobster trap gear entanglements during the 2004-2005 through 2006-2007 fishing seasons, three loggerheads, three green, two leatherbacks, one Kemp's ridley, and one unidentified sea turtle. Of those records, size data to estimate animal life stage was available for four animals: two small benthic juvenile loggerheads, one adult green, and one benthic juvenile Kemp's ridley (NMFS unpublished data). Although genetic samples are collected from sea turtles, the number of samples currently available is too small to be able to determine the sub-population origin of individuals.

Juvenile smalltooth sawfish are most commonly associated with shallow-water areas off Florida, close to shore, and typically associated with mangroves (Simpfendorfer and Wiley 2004). Since large animals are also observed in very shallow waters, it is believed that smaller (younger) animals are restricted to shallow waters, while large animals roam over a much larger depth range (Simpfendorfer 2001). Mature animals are known to occur in water depths of 100 m or more (C. Simpfendorfer pers. comm. 2006). Thus, gear deployed in deeper water is more likely to encounter adult age classes.

5.5 Estimating ESA-Listed Species Take in the Commercial Spiny Lobster Trap Fishery

The preceding sections discussed the potential adverse effects to sea turtles, *Acropora*, and smalltooth sawfish that may result from interactions with spiny lobster trap gears. Our discussion now shifts to evaluating and quantifying the impacts of spiny lobster trap fishing on those species. In the following sections, we describe the data used, the processes, and the results of our analyses for estimating the number or amount of sea turtle, *Acropora*, and smalltooth sawfish take that occurred in the commercial spiny lobster trap fishery from 2004-2005 through 2006-2007.

As noted above (Section 2.1), Florida's Lobster Trap Certificate Program has placed a cap on the number of traps available to the fishery since the 1993/94 fishing season. Annual reductions in the number of trap tags[12] available from the FFWCC succeeded in reducing the number of trap tags issued. Since the number of trap tags issued from 2004-2005 through 2006-2007 has remained relatively stable (see Table 2.1 and Figure 2.1), our analysis focuses on the fishery over this period. We believe using this period best represents how the fishery operates today and using effort information before this period would introduce a positive bias that may overestimate the potential for adverse effects. The cap on number of traps available to the fishery also excludes the possibility of the number of traps in the fishery returning to previous levels. As a result, using data from this period will not underestimate effort in the fishery. Since data for the 2007-2008 fishing season is not yet complete, those data are not used in our analysis.

5.5.1 Estimating Sea Turtle Take by Commercial Spiny Lobster Traps

As noted above, sea turtles may be adversely affected by spiny lobster traps via entanglement and forced submergence. The following sections present our process for estimating sea turtle take by commercial spiny lobster traps. When calculating the sea turtle take rate, we used all STSSN stranding and incidental capture records documented during the 2004-2005 through 2006-2007 fishing seasons to increase our sample size (see the following section for more details on those data). We believe this approach is sensible for a number of reasons. Trap construction requirements are very similar in the state and federal fisheries, and the fishing season is the same. The species of sea turtles that occur in the action area are all highly migratory and found in both state and federal waters off Florida. The vast majority of both state and federal fishing effort occurs in the depth range (0-120 ft) where sea turtles are known to occur most frequently; thus, neither fishery is likely to have a disproportionate rate of entanglement of sea turtles. Since the gear, timing, and distribution of effort with respect to sea turtle abundance, are essentially the same in both state and federal waters, we believe the number of traps fished in the state and federal fisheries is the best predictor of sea turtle entanglements.

Our analysis used the best available sea turtle entanglement and commercial trap fishery data to estimate the total number of sea turtles taken by the Gulf of Mexico/South Atlantic spiny lobster fishery during the 2004-2005 through 2006-2007 fishing seasons. We calculated a sea turtle take rate per trap soak day and multiplied this figure by the number of traps in the federal fishery to estimate the number of sea turtles taken. We also estimated the number of mortalities occurring as a result of those takes, and assigned both lethal and non-lethal takes by species. Due to the statistical and mathematical computation used to estimate take and mortality, some of our estimates do not use whole numbers. However, because it is impossible to take only a portion of a sea turtle, we round off our final take estimates.

[12] Trap tags are required and must be attached to each individual spiny lobster trap fished. As a result, trap tags are a reasonable surrogate for estimating the actual number of traps fished. It is possible for a trap tag to be purchased but never actually used. To act conservatively, our analysis assumes all trap tags issued represent actual traps used in the fishery.

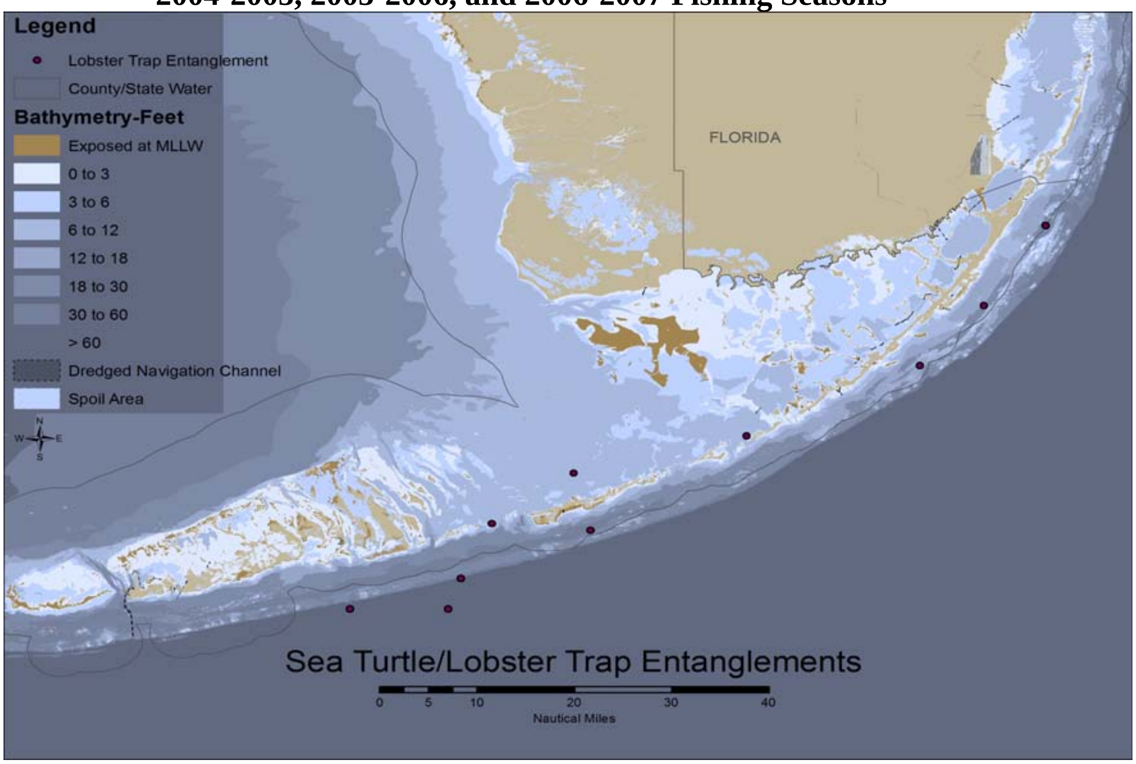
5.5.1.1 Summary of Data Used to Estimate Sea Turtle Takes

Sea Turtle Stranding and Salvage Network Data

The Sea Turtle Stranding and Salvage Network (STSSN) was formally established in 1980 to collect information on and document strandings and incidental captures of sea turtles along the U.S. Gulf of Mexico and Atlantic coasts. The SEFSC currently maintains this database. The network encompasses the coastal areas of eighteen states, including all the states in the Gulf of Mexico and South Atlantic region. Network participants document sea turtle strandings and incidental captures in their respective states, noting any fishing gear or other marine debris associated with the animal. Those data are then entered into a central STSSN database.

The data contained in this database is the best and only available on sea turtle entanglements in spiny lobster trap gear in action area. Querying this database returned 10 records of sea turtle entanglement in spiny lobster trap gear in both state and federal waters (Table 5.2), covering the 2004-2005 through 2006-2007 fishing years. Records indicate entanglements occurred in both state and federal waters (STSSN Database, unpublished data). Two of these records noted the animal was dead when it was found; the remaining seven animals were alive at the time of discovery.

Figure 5.1 Location of Sea Turtle Strandings in Spiny Lobster Trap Gear for the 2004-2005, 2005-2006, and 2006-2007 Fishing Seasons



Individual Spiny Lobster Trap Use and Soak Time by Month

Results from mail surveys showed that from the 1993-94 through the 1999-2000 fishing season, the percentage of total available spiny lobster traps fished each month declined markedly over the course of the fishing season (Matthews 2001). Those data show that, on average, close to 100 percent of traps were fished when the season opened, but only 42 percent were still being fished at the end of the season (Figure 5.2). Table 5.1 summarizes the results.

Matthews (2001) also notes that soak time for each trap varies by month (Figure 5.3). Early in the season, traps were soaked for a relatively short period of time (approximately eight days on average). Soak times then increased as the season progressed, with an average soak time of approximately 27 days by March.

Figure 5.2 Percentage of Traps Used Each Month by Fishing Season

Source: Matthews 2001

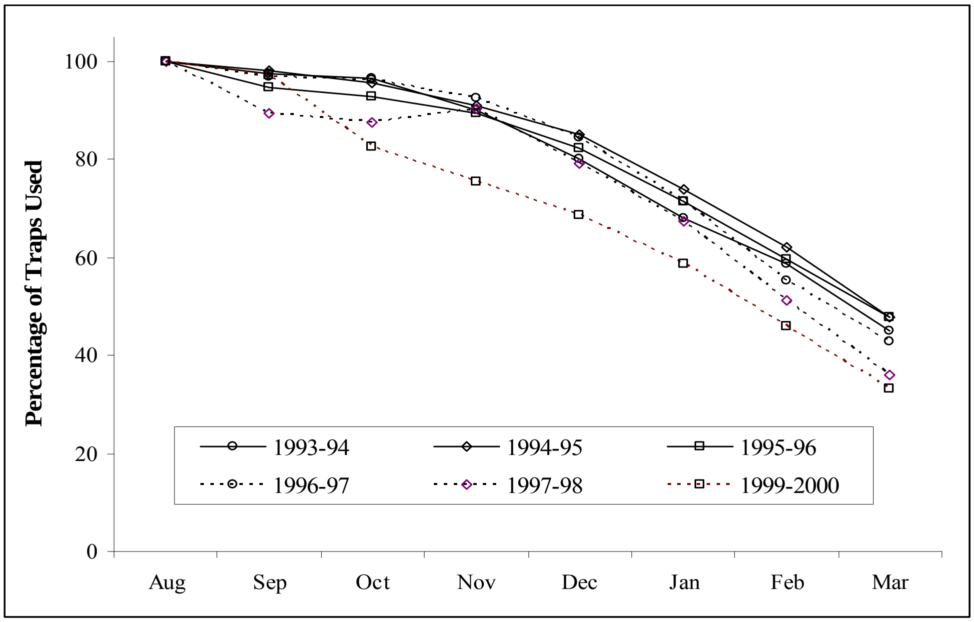
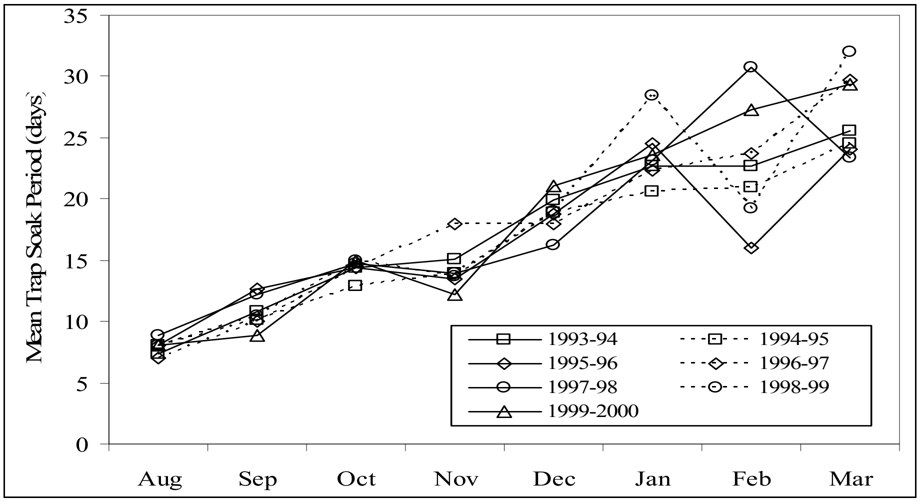


Table 5.1 Percentage of Traps Used Each Month by Fishing Season

Source: Matthews 2001

	1993/94	1994/95	1995/96	1996/97	1997/98	1999/2000	Average by Month
August	100.00	100.00	100.00	100.00	100.00	100.00	100.00
September	97.63	98.18	94.73	96.80	89.34	97.36	95.67
October	96.69	95.83	92.75	96.33	87.52	82.56	91.95
November	90.00	91.11	89.47	92.70	90.35	75.35	88.16
December	80.08	85.04	82.40	84.48	79.18	68.62	79.97
January	68.14	74.09	71.33	71.48	67.50	58.57	68.52
February	58.67	62.06	59.75	55.29	51.25	46.12	55.52
March	45.12	47.79	47.78	42.94	35.90	33.25	42.13
Average by Yr	79.54	81.76	79.78	80.00	75.13	70.23	77.74

Figure 5.3 Mean Soak Time for Spiny Lobster Traps by Month
Source: Matthews 2001



5.5.1.2 Estimating Sea Turtle Take in the Commercial Spiny Lobster Trap Fishery

Estimating Sea Turtle Take Rates Per Fishing Year
We began by assigning the STSSN sea turtle entanglement records to a specific commercial spiny lobster fishing season (August 6-March 31) based on the date the stranding was documented (Table 5.2). One stranding record could not be assigned to a specific fishing season using this method. Since this event was documented as spiny lobster trap gear entanglement, we believe it should be included in our analysis. We also believe it is reasonable to assume this entanglement occurred as a result of fishing in the season immediately preceding the date of the stranding (i.e., the stranding documented on June 3, 2006, was likely the result of fishing that occurred during the 2005-2006 season). Therefore, we assigned it to the 2005-2006 fishing season.

Table 5.2 Sea Turtle Stranding Records Noting Lobster Trap Gear Entanglement

Fishing Season	Month	Day	Species	Area	Condition
2005-2006	December	03	Loggerhead	FL - Gulf of Mexico	Alive
2005-2006	January	16	Leatherback	FL - Gulf of Mexico	Alive
2005-2006	March	17	Unknown	FL - Gulf of Mexico	Alive
2005-2006*	June	03	Green	FL – South Atlantic	Alive
2006-2007	August	08	Green	FL – South Atlantic	Dead
2006-2007	August	08	Green	FL – South Atlantic	Dead
2006-2007	November	07	Kemp’s Ridley	FL - Gulf of Mexico	Alive
2006-2007	January	16	Loggerhead	FL - Gulf of Mexico	Alive
2006-2007	January	16	Loggerhead	FL - Gulf of Mexico	Alive
2006-2007	January	23	Leatherback	FL - Gulf of Mexico	Alive

*This record fell outside of a specific fishing season and was assigned using the process noted above.

While these data are the best available regarding sea turtle interactions with spiny lobster trap gear, determining what proportion of all lobster gear induced strandings these records actually represent is difficult. Because of oceanic conditions (i.e., currents, waves, wind) and the dynamic nature of the marine environment, it is likely that

stranding records actually represent only a small number of the total at-sea entanglements caused by trap/pot gear (Murphy and Hopkins-Murphy 1989, Epperly et al. 1996). Studies of at-sea mortalities indicate stranding data only represent between 5 percent and 28 percent of all moralities occurring at sea (Hopkins-Murphy 1989, Epperly et al 1996, TEWG 1998, Hart et al. 2006). NMFS SEFSC (2001) states that on average, the number of dead sea turtle strandings represent 20 percent, at best, of all at-mortalities. We also believe it is likely that the number of live sea turtle strandings reported is only a small fraction of the total actually occurring. Unfortunately, there are currently no estimates available of what percentage of live sea turtles strandings are actually reported.
We addressed this potential under-representation by dividing the number of sea turtles strandings each year, by 20 percent (Table 5.3).

Table 5.3 Original and Adjusted Estimates of Sea Turtle Strandings

Fishing Year	Number of STSSN Stranding Events	Adjusted Stranding Events
2004-2005	0	0
2005-2006	4	20
2006-2007	6	30
Total	**10**	**50**

Next, we tabulated and calculated the amount of commercial trap fishing effort in the fishery during the 2004-2005, 2005-2006, and 2006-2007 fishing years (Florida Fish and Wildlife Conservation Commission, Marine Fisheries Trip Ticket Program, unpublished data). Effort can be measured in variety of ways, including the traps available, total number of trips, traps fished, sets, hours fished, and soak time. Since we believe the likelihood of sea turtle entanglement is dependent on the amount of time the trap spends in the water, we used trap soak time for calculating entanglements (Table 5.4).

The trap soak time in federal waters was calculated by multiplying the number of traps issued each season, by the percentage of all traps used each month (see Table 5.1) to estimate the total number of times traps were used each month. We then multiplied that figure, by the average soak time of a single trap each month (Figure 5.3) to estimate the total number of trap soak days for each month. By summing the total trap soak day estimates from each month, we estimated the total number of trap soak days for the entire fishery (Table 5.4). This method is conservative because it assumes each trap issued will be used in the fishery. Since each trap can be used more than once during a fishing season, the number of traps used is greater than the number of total traps issued.

Table 5.4 Total Trap Soak Days in Federal and State Waters

Fishing Year	Traps Issued	No. of Traps Fished Each Year	Total Trap Soak Days
2004-2005	498,409	3,099,705	49,552,717
2005-2006	497,042	3,091,204	49,416,807
2006-2007	495,770	3,083,293	49,290,343
Total	1,491,221	9,274,202	148,259,867

Next, we divided our annual adjusted sea turtle stranding estimates by the number of trap soak days for each fishing year, yielding an estimate of sea turtle takes per trap soak day

(Table 5.5). The sea turtle take rates were far less than one. They ranged from a low of 0 interactions in the 2004-2005 fishing years when no sea turtle strandings were reported, to a high of $6x10^{-7}$ takes per trap soak day during the 2006-2007 fishing year.

Table 5.5 Sea Turtle Take Rates Per Trap Soak Day

Fishing Year	Total Trap Soak Days	Sea Turtle Strandings (Adjusted)	Sea Turtle/Soak Day Interaction Rate
2004-2005	49,552,717	0	0.0000000
2005-2006	49,416,807	20	0.0000004
2006-2007	49,290,343	30	0.0000006
Total	148,259,867	50	--

Sea Turtle Takes in the Federal Spiny Lobster Trap Fishery

Since the proposed action is the continued authorization of the federal fishery, we applied the above sea turtle take rates to the effort in the federal fishery only. Using Florida Trip Ticket information, we calculated the percentage of all traps in the fishery that are fished in federal waters. Applying that percentage to the total trap soak days used each year, we estimated the number of trap soak days in the federal fishery. Multiplying those figures by our sea turtle take rate yielded the number of sea turtle takes by spiny lobster traps in federal waters (Table 5.6). We estimate 6.2 sea turtles takes occurred between the 2004-2005 and 2006-2007 fishing years; an average of 2.06 per fishing season.

Table 5.6 Estimated Sea Turtle Takes in Federal Waters

Fishing Year	% of All Traps Pulled	Total Trap Soak Days in Federal Waters	Sea Turtle/Trap Interaction rate	No. of Sea Turtle Takes
2004-2005	18.10%	8,971,140	0.0000000	0.00
2005-2006	16.31%	8,060,826	0.0000004	3.22
2006-2007	10.09%	4,975,731	0.0000006	2.98
Total	--	22,007,697	--	6.20

Estimating Mortality

Next, we estimated how many of these takes may have resulted in mortality. Our sea turtle strandings records indicate that 20 percent of sea turtle entanglements in spiny lobster trap gear result in mortality. However, it is impossible to ascertain what role the entangling gear actually played in causing the mortality of these animals. Likewise, it is impossible to determine how entangling gear would have affected the live sea turtles if the gear had not been removed. While we acknowledge these potential biases exist, we have no way of non-arbitrarily addressing them. Therefore, we use our estimate of 20 percent mortality when calculating the number of lethal takes.

Estimating Sea Turtle Takes by Species

To conduct our jeopardy (risk) analysis and effectively assess the impacts of incidental takes, we must assign take for individual species. We rely on what we know about sea turtle relative abundance and behavior in the action area to arrive at take estimates for each sea turtle species.

We initially produced a sea turtle species composition estimate with the nine sea turtle stranding records returned from our STSSN query (Table 5.7). However, we were concerned that this small sample size might not accurately represent the potential for entanglement of other species. For example, hawksbill sea turtles are known to inhabit the nearshore areas where spiny lobster trap fishing is common and could potentially become entangled. To address these issues we evaluated the suitability of other data sources for estimating sea turtle species composition. Since the federal lobster trap fishing effort is concentrated so close to shore, we believe the STSSN database represents the best available source for estimating sea turtle species composition in the action area.

Between the 2004-2005 and 2006-2007 fishing years, over 80 percent of federally-fished traps were off the Florida Keys and Dade County, Florida. The STSSN regional statistical zones 1, 2, 24, and 25 entirely circumscribe these areas (Figure 5.3 and 5.4). We aggregated all sea turtle stranding data available from these statistical zones to estimate sea turtle composition (Table 5.8). These data suggest loggerheads are the most abundant, followed by green sea turtles.

Table 5.7 Sea Turtle Species Composition Derived from 10-Queried STSSN Records

Species	No. of Strandings	% of Total Strandings
Loggerhead	3	30
Green	3	30
Leatherback	2	20
Kemp's Ridley	1	10
Unknown	1	10
Total	10	--

Table 5.8 Sea Turtle Species Composition Derived from All STSSN Records in Statistical Zones 1, 2, 24, & 25

Species	No. of Strandings	% of Total Strandings
Loggerhead	647	48.3
Green	503	37.5
Leatherback	19	1.4
Hawksbill	106	7.9
Kemp's Ridley	18	1.3
Unknown	46	3.4
Total	1339	--

(STSSN Database, Accessed June 1, 2007)

Figure 5.4 STSSN Statistical Zones for the Gulf of Mexico Region

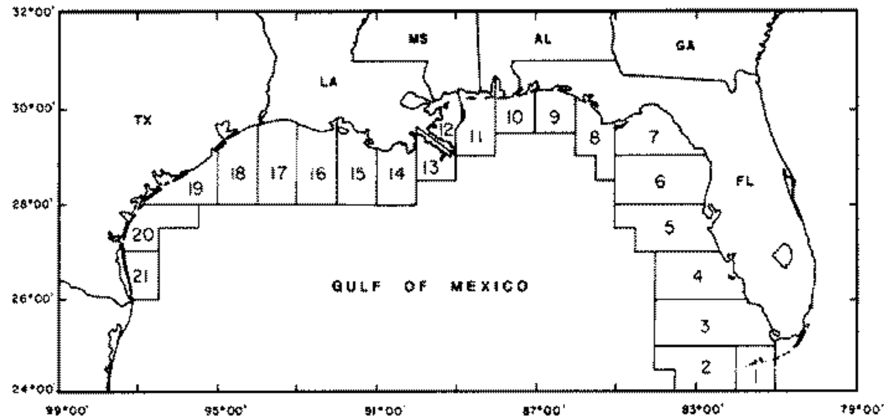
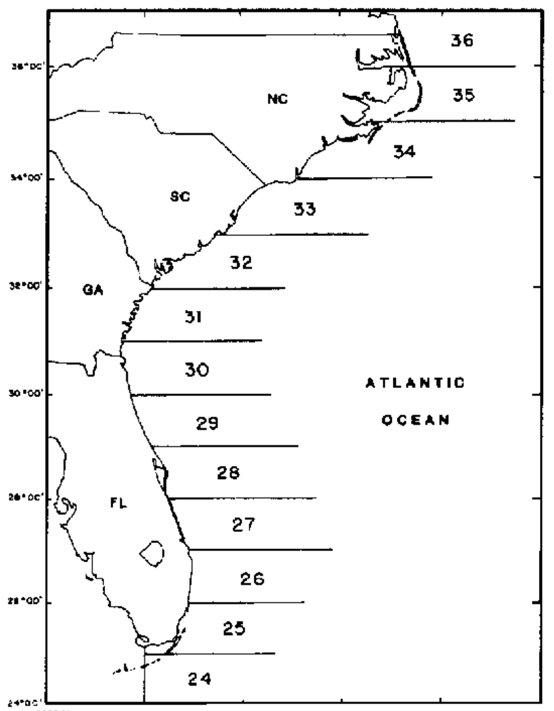


Figure 5.5 STSSN Statistical Zones for the South Atlantic Region



We chose to use the species composition estimate from all STSSN records (Table 5.8) because it represents a much larger sample size. We believe this species composition best represents the species likely to be in area. By multiplying our take estimate by the STSSN species composition estimate listed above (Table 5.8), and using our mortality estimate from above, we estimated non-lethal and lethal takes by species: 2.99 loggerheads (0.59 lethal); 2.33 green (0.47 lethal); 0.09 leatherbacks (0.018 lethal); 0.49 hawksbill (0.10 lethal) and 0.08 Kemp's ridley (0.016 lethal) sea turtles.

Because the take estimates for leatherback, hawksbill, and Kemp's ridley sea turtles were far less than one, we combined these species when calculating take.[13] Since it is not possible to take a partial sea turtle, we rounded our calculations up to the nearest whole number. Likewise, since our estimates of lethal take for each species are less than one, we did not round each individual lethal take up to the nearest whole number. We believe doing so would artificially inflate our take numbers beyond a reasonable characterization of take levels in the fishery. Instead, our estimates reflect take that could be either lethal or non-lethal. Therefore, we estimate that during the 2004-2005 through 2006-2007 fishing years, three loggerhead (lethal or non-lethal), three green (lethal or non-lethal) and one hawksbill, leatherback, or Kemp's ridley sea turtle (lethal or non-lethal) take occurred. Table 5.9 summarizes these estimates.

Table 5.9 Estimated Lethal and Non-Lethal Sea Turtle Takes in the Federal Fishery, 2004-2005 Through 2006-2007 Fishing Years

Species	Number of Takes
	Lethal or Non-Lethal
Loggerhead	3
Green	3
Hawksbill	1*
Leatherback	1*
Kemp's Ridley	1*

*The take for these species is in combination, not one per each species.

5.5.2 Estimating Adverse Affects to *Acropora* from Commercial Spiny Lobster Traps

The preceding sections discussed the potential adverse effects to *Acropora* from interactions with spiny lobster trap gears. Our discussion now shifts to evaluating and quantifying those impacts. *Acropora* may be adversely affected by spiny lobster traps as a result of buoyed[14] and derelict traps moving during storm events.[15,16] Even pulling traps can adversely affect *Acropora* via fragmentation and abrasion.[17] We quantified the adverse affects to *Acropora* by estimating the area likely to be affected. We chose this metric because traps affect an area of the seafloor, and using this parameter made quantification of adverse affects easier. The morphology of the species also makes using an areal metric necessary. Because *Acropora* are branching, colonial species, definition of discrete colonies can be difficult without individual genetic identification. Partially for this reason, coral monitoring (including *Acropora* monitoring) is customarily done by

[13] This means we believe only one take of one of these species occurred. It does not mean one take of each species.
[14] For the purposes of our analysis we assume buoyed traps are being actively fished.
[15] Derelict traps have been lost or abandoned and are no longer being actively fished.
[16] Storm events are weather events with sustained winds of 15 knots for 2 days or more (C. Lewis and T. Matthews, FFWCC, pers. comm. 2007).
[17] We use the term pulled trap to indicate all aspects of trap fishing, including retrieval and deployment. Since an individual trap can be pulled many times during a fishing season, the number of traps pulled may be greater than the number of individual traps used in a fishing season.

evaluating areal metrics. Therefore, quantified adverse affects to *Acropora* by area and our incidental take statement is issued the same way.

Because of *Acropora*'s distribution, we believe these routes of effect are only likely to occur in the South Atlantic waters off south Florida. Approximately 99 percent of all trap fishing occurring in the South Atlantic is conducted in the Florida Keys (Florida Fish and Wildlife Conservation Commission, Marine Fisheries Trip Ticket Program, unpublished data). Therefore, our effects analysis for trap impacts to *Acropora* focuses on the fishing effort in the Florida Keys.

As noted above (Section 2.1), Florida's Lobster Trap Certificate Program has placed a cap on the number of traps available to the fishery. Since the number of trap tags issued from 2004-2005 through 2006-2007 has remained relatively stable (see Table 2.1 and Figure 2.1), our analysis focuses on the fishery over this period. In the following sections, we describe the data used, the processes, and the results of our analyses for estimating the amount of *Acropora* take that occurred in the commercial spiny lobster trap fishery from 2004-2005 through 2006-2007. Then in Section 5.6, we use these estimates to project the level of take likely to occur in the future.

5.5.2.1 Data Used for Estimating Adverse Affects to *Acropora*

Individual Spiny Lobster Trap Use and Soak Time by Month
See Section 5.5.1.1

Wind Driven Trap Mobilization Study
Lewis et al. (in review) evaluated the impacts of trap mobilization on coral reef habitat during storm events. They studied the movement of buoyed and unbuoyed traps at three depths (4, 8, and 12 m). They observed that the mean area of impact from an individual buoyed spiny lobster trap was 4.96 square meters, 2.85 square meters, and 0.78 square meter, at 4, 8, and 12 m depths, respectively. The mean area of impact for an individual unbuoyed trap was 0.75 square meter at both 4 and 8 m depths. Tests at 12 m were not conducted for unbuoyed traps. When estimating the adverse effects of mobilized buoyed traps, we used the average area of mean impact from the 8 m and 12 m trials because the majority of federal waters occur beyond 4 m depth (Lewis et al. in review). The study also noted an annual average of 18 non-tropical storm events. It is worth noting that these estimates of annual storm events do not include the impacts of tropical storms or hurricanes.

Lewis et al. (in review) estimate two to five tropical weather events (i.e., tropical storms and hurricanes) occur annually, and the impacts from trap mobilization during such events are believed to be far greater than the impacts measured in this study. While anecdotal evidence suggests traps may move several miles during tropical weather events, no data exists on the extent of mobilization or the impacts of mobilization (T. Matthews, FFWCC, pers. comm. 2008). Since the impacts of tropical weather events are considerable, we believed it was necessary to include their impacts. Since no data exists on the size of the impacts of these events, we selected the greatest area of impact associated with non-tropical weather events, 4.96 square meters, for our analysis. We recognize this area of observed impact occurred in depths shallower than where the federal fishery is likely to operate. However, given what we know about the impacts of tropical weather events on trap mobilization, we believe this impact estimate is appropriate, and may actually underestimate the impacts from these mobilization events. The number of tropical weather events occurring annually varies greatly. Therefore, we used the annual average of 3.5 tropical weather events from Lewis et al. (in review) in our analysis.

Acropora Population Abundance and Size in the Florida Keys

Miller et al. (2007) surveyed 235 sites in the Florida Keys National Marine Sanctuary (FKNMS) and Biscayne National Park (BNP). The survey evaluated nine unique habitat types for the presence and absence of *Acropora*, recording colonial density and size where found. The areas surveyed included FKNMS no-take zones, as well as areas open to fishing. Since these data are the best available and most comprehensive for the action area, we applied them to each fishing season.

Acropora cervicornis was observed at 55 of the 235 (23 percent) sites surveyed, 508 colonies within eight habitat types. Of these, 113 colonies (22.2 percent) were counted from among 36 mid-channel patch reefs, 246 colonies (48.4 percent) from 42 offshore patch reefs, 15 colonies (3.0 percent) from 25 shallow (< 6 m) low-relief hardbottom sites, 29 colonies (5.7 percent) from eight inner line reef tract spur-and-groove sites, 90 colonies (17.7 percent) from 51 high-relief spur-and-groove sites, one colony (0.2 percent) from 15 deeper (> 6 m) hard-bottom sites, six colonies (1.2 percent) from 21 patchy hardbottom sites, and eight colonies (1.6 percent) from 33 low-relief spur-and-groove sites. The greatest mean (± 1 SE) site level density (no. of colonies per square meter) was 1.217 ± 1.780 on an offshore patch reef north of Looe Key Sanctuary Preservation Area (SPA). Colony size ranged from 42 to 1,312 square centimeters.

Acropora palmata was found at 24 of 235 (10.2 percent) sites surveyed, 403 colonies within three habitat types. The habitat distribution of this coral was much narrower than its congener and was only found on: offshore patch reefs (4.8 percent of 42 sites), inner line reef tract spur and groove reefs (37.5 percent of 8 sites), and high-relief spur-and-groove reefs (27.5 percent of 51 sites). Of these, 15 colonies (3.7 percent of the total) were counted from among 42 offshore patch reefs, 10 colonies (2.5 percent) from eight inner line reef tract spur and groove sites, and 378 colonies (93.8 percent) from 51 high-relief spur and groove sites (Miller et al. 2007). The greatest mean ± 1 SE site level density (no. colonies per m^2) was 1.250 ± 0.959 recorded at high-relief spur and groove reefs at Elbow Reef SPA. Colonial size ranged from 184 cm^2 to 9,959 cm^2 (Miller et al. 2007).

Spiny Lobster Trap Distribution in the Florida Keys

Matthews (2003) conducted a survey of trap distribution in the Florida Keys. Of 2,119 traps observed, 1,697 were identified as spiny lobster traps and used in the analysis. Matthews (2003) identified 15 different habitat types upon which spiny lobster traps could be found and estimated the relative distribution of traps across each. We consolidated five specific habitat types into two broader categories (coral and hardbottom) that we believe represent *Acropora* supporting habitat (ASH)[18] (Table 5.10).

Miller et al. (2007) observed *Acropora cervicornis* in all the habitat types they surveyed, while *Acropora palmata* was more discretely distributed. Therefore, our analysis assumes the traps observed on habitats in both the coral and hardbottom categories may impact *Acropora cervicornis* (15 percent of all traps; Table 5.10), while only those traps observed in the habitats of coral category may impact *Acropora palmata* (4 percent of all traps; Table 5.10).

Table 5.10 Habitat Types Used to Estimate the Total Percentage of Traps Landing on *Acropora* Supporting Habitat (Adapted from Matthews 2003)

Category	Habitat Type	Relative Distribution of Spiny Lobster Traps
Coral	High-Relief Coral	0%
	Low-Relief Coral	3%
	Rubble	1%
	Total Coral Group	4%
Hardbottom	Gorgonians	11%
	Grass and Benthic Fauna	0%
	Mixed Benthic Fauna	0%
	Total Hardbottom Group	11%
Other	Grass and Algae	1%
	Mixed Grass	3%
	Syringodium sp.	11%
	Thalassia sp.	20%
	Halodule sp.	0%
	Sponges	0%
	Attached Algae	13%
	Coarse sediment	19%
	Fine Sediment	16%
	Total Other Group	85%

5.5.2.2 Estimating Adverse Effects to *Acropora* from Storm-Mobilized, Buoyed Spiny Lobster Traps

Traps are frequently moved from their original locations during storm events. The extent of mobilization varies depending on trap depth, and whether they are tethered to buoys. Because of these differences, we bifurcated our analyses to examine the effects from buoyed and non-buoyed ("derelict") traps separately.

In this analysis, we estimate the impacts to *Acropora* from storm-mobilized, buoyed traps. Our analysis makes certain assumptions to overcome gaps in our knowledge. For example, we use number of spiny lobster trap tags as a surrogate for the number of spiny lobster traps. Since every spiny lobster trap must have a single trap tag, we assume that a spiny lobster tag translates to a single spiny lobster trap. It also assumes that traps set

[18] For our analysis of the federal fishery, we considered ASH to be coral or hardbottom areas, from 0 to 30 m depth, occurring in areas open to fishing, in federal waters.

outside areas closed to fishing could migrate into those closed areas; thus, we used average *Acropora* colonial densities estimates for areas both open and closed to fishing. We also assume *Acropora* will be adversely affected (via fragmentation and/or abrasion) each time there is contact with a spiny lobster trap.

To estimate adverse effects to *Acropora*, we conducted six different analyses, one for each species of *Acropora*, in each region of the Florida Keys (i.e., Upper, Middle, and Lower). These estimates are divided regionally (i.e., Upper, Middle, and Lower) to remain consistent with the *Acropora* abundance and density data provided in Miller et al. (2007). As noted in Section 5.5.2.1, because of species distribution, we assume 4 percent of all federally fished traps will affect habitat supporting *A. palmata*, while we believe 15 percent of all federally fished traps will affect habitat supporting *A. cervicornis*. In the interest of brevity, only the narrative of the analysis conducted for *A. cervicornis* during the 2006-2007 fishing year in the Upper Keys, appears below. Table 5.14 summarizes the constants that remained the same across all fishing seasons that were used in the analyses of storm-mobilized buoy traps. Tables 5.15 and 5.16 provide summary results of all six analyses. Appendix 3 provides a more comprehensive review of the steps used in the analyses, as well as the results.

Estimating Buoyed Spiny Lobster Trap Effects to ASH in the Upper Keys During the 2006-2007 Fishing Season

We began by tabulating and calculating the amount of commercial trap fishing effort in the fishery for the 2006-2007 fishing year. Effort can be measured in a variety of ways, including the traps issued, total numbers of trips, traps fished, number of sets, hours fished, and soak time. We measured the effort in the fishery by estimating the number of traps fished during a given year, based on the number of traps issued to fishers reported by FFWCC (FFWCC 2007).[19] To be conservative toward the species, our analysis assumes all traps issued were actually used in the fishery.

We then multiplied the number of traps issued during the season (466,686) by the percentage of traps used each month. Next, we multiplied the number of traps used each month by the percentage of all trap fishing that occurred in federal waters and then multiplied that figure by percentage of federal trap fishing occurring in the region. This yielded an estimate of the number of traps fished each month in the federal waters off the Upper Keys. Multiplying our monthly trap use figures by the percentage of traps that end up on ASH for *A. cervicornis* (15 percent) (Matthews 2003), yielded an estimate of the number of federally fished traps that land on ASH each month. Table 5.11 summarizes this process.

[19] FFWCC defines active traps as spiny lobster trap tags issued, not whether the traps was actually fished.

Table 5.11 Estimating Monthly Federal Trap Impact to ASH in the Upper Keys During the 2006-2007 Fishing Season

Month	% of All Traps Used	No. Traps Used Each Month	% of All Trap Fishing Occurring Federal Waters	No. Traps Used in Federal Waters	% of All Federal Effort Occurring in the Region	Traps Fished in Federal Waters in the Region	No. of Federally Fished Traps Landing on ASH
Aug	100.00	466,686	10.09	47,111	0.124	58.49	8.77
Sep	95.67	446,478	10.09	45,071	0.124	55.96	8.39
Oct	91.95	429,118	10.09	43,318	0.124	53.78	8.07
Nov	88.16	411,430	10.09	41,533	0.124	51.57	7.73
Dec	79.97	373,209	10.09	37,674	0.124	46.78	7.02
Jan	68.52	319,773	10.09	32,280	0.124	40.08	6.01
Feb	55.52	259,104	10.09	26,156	0.124	32.47	4.87
Mar	42.13	196,615	10.09	19,848	0.124	24.64	3.70
Average	77.74	362,802	10.09	36,624	0.124	45.47	6.82
Total	--	2,902,414	--	292,991	--	363.77	54.56

Since the type of weather event (tropical or non-tropical) affects the extent of trap mobilization, we calculated the impacts from both types separately. We estimated 0.875 tropical weather event occurred each month (August-November) and 2.57 non-tropical weather events per month (October-April) [Lewis et al. (in review)]. For each month, we multiplied the number of traps landing on ASH, by the number of tropical or non-tropical weather events likely to affect those traps, and the area of impact associated with each weather event. As mentioned in above, we used 4.96 square meters and 1.815 square meters as the areas of impact resulting from tropical and non-tropical weather events, respectively. For months when both tropical and non-tropical weather events could occur (October and November), we estimated the areas of impact from each event separately, and summed the result. Our analysis showed 317.53 square meters of ASH was affected during the 2006-2007 fishing season due to storm-mobilized, buoyed traps. Table 5.12 summarizes these steps.

Table 5.12 Estimating Monthly and Annual Area of Impact from Storm-Mobilized Buoyed Traps During the 2006-2007 Fishing Season

Month	Traps Fished in Federal Waters in the Region	No. of Federally Fished Traps Landing on ASH	No. Tropical Weather Events (3.5/yr)	Individual Trap Area of Impact from Tropical Weather Events (m^2)	No. Non-Topical Weather Events (18/yr)	Individual Trap Area of Impact from Non-Tropical Weather Events (m^2)	Annual Area of Impact
Aug	58.49	8.77	0.875	4.96	0	0	38.08
Sep	55.96	8.39	0.875	4.96	0	0	36.43
Oct	53.78	8.07	0.875	4.96	2.57	1.815	72.64
Nov	51.57	7.73	0.875	4.96	2.57	1.815	69.65
Dec	46.78	7.02	0	0	2.57	1.815	32.73
Jan	40.08	6.01	0	0	2.57	1.815	28.04
Feb	32.47	4.87	0	0	2.57	1.815	22.72
Mar	24.64	3.70	0	0	2.57	1.815	17.24
Average	45.47	6.82	--	--	--	--	39.69
Total	363.77	54.56	--	--	--	--	317.53

Quantifying Adverse Effects to Acropora cervicornis in the Upper Keys
We estimated an *A. cervicornis* density of 0.0078 colonies/square meter of ASH, in areas open and closed to fishing in the Upper Keys, from Miller et al. (2007). By multiplying this estimate by the area of ASH in the Upper Keys impacted by storm-mobilized traps, we estimated the number of *A. cervicornis* colonies affected during the 2006-2007 fishing season. By multiplying the number of colonies impacted by the average area of each *A. cervicornis* colony, we estimated 0.052 square meter of *A. cervicornis* was adversely impacted by spiny lobster trap mobilization in the Upper Keys, during the 2006-2007 fishing season. Table 5.13 summarizes the analysis for *A. cervicornis* in the Upper Keys.

Table 5.13 Impacts of Storm-Mobilized, Buoyed Traps on *Acropora cervicornis*

Upper Keys	
	Fishing Season
	2006-2007
Total Traps Issued[a]	466,686
% of All (State & Federal) Traps Pulled in Federal Waters for All Regions[b]	10.09
% of Federal Effort by Region	0.124
No. Traps Used in Federal Waters by Region	363.77
No. of Traps Used Landing on ASH	54.56
No. of Traps on ASH Mobilized by Tropical Weather Events	17.17
Area of ASH Impacted by Traps Mobilized During Tropical Weather Events (m^2)	74.51
No. of Traps on ASH Affected by Tropical and Non-Tropical Weather Events	15.80
Area of ASH Impacted by Traps Mobilized During Tropical and Non-Tropical Weather Events (m^2)	142.29
No. of Traps on ASH Mobilized by Non-Tropical Weather Events	21.60
Area of ASH Impacted by Traps Mobilized During Non-Tropical Weather Events (m^2)	100.73
Area of ASH Impacted Annually by Mobilized Traps (m^2)	317.53
No. *A. cervicornis* Colonies Impacted	2.477
Area of *A. cervicornis* Impacted by Mobilized Traps (m^2)	**0.052**

[a]FFWCC 2007; [b]Derived from FFWCC, unpublished data

Adverse Effects to Acropora in the Remaining Regions During the 2004-2005 Through 2006-2007 Fishing Seasons
Throughout all regions of the Florida Keys, we estimate 351.33 square meters of *A. cervicornis* and 6.89 square meters of *A. palmata* were adversely affected by mobilized, buoyed spiny lobster traps during the 2004-2005 through 2006-2007 fishing seasons. Table 5.14 summarizes the constants used in the analyses that remained the same across all fishing seasons. Tables 5.15 and 5.16 summarize the resulting calculations for both species across all regions and all years.

Table 5.14 Constants Used in Storm-Mobilized, Buoyed Trap Impact Analyses

Parameter		Region		
		Upper Keys	Middle Keys	Lower Keys
Avg. Area of Impact Per Trap from Tropical Weather Events (m^2)[a]		4.96	4.96	4.96
Avg. No. of Tropical Storms Occurring Monthly (Aug.-Nov.)		0.875	0.875	0.875
Avg. Area of Impact Per Trap Non-Tropical Weather Events (m^2)[a]		1.815	1.815	1.815
Avg. No. of Non-Tropical Weather Events Occurring Monthly (Oct.-Apr.)[a]		2.57	2.57	2.57
Area of ASH (m^2)[b]		83,712,586	54,579,251	45,989,091
% of Traps Landing on ASH[c]	*A. cervicornis*	15	15	15
	A. palmata	4	4	4
Avg. Colonial Density (no./m^2)[d]	*A. cervicornis*	0.0078	0.0013	0.0394
	A. palmata	0.0094	0.0008	0.0297
Total No. of *Acropora* colonies in ASH[d]	*A. cervicornis*	652,958	70,953	1,811,970
	A. palmata	136,452	112,870	31,372
Avg. Size (Surface Area) of Each Colony (m^2)[d]	*A. cervicornis*	0.021	0.014	0.0186
	A. palmata	0.122	0.101	0.148

[a]Lewis et al. (in review); [b]NMFS unpublished data; [c]Matthews 2003; [d]Derived from Miller et al. 2007

Table 5.15 Storm-Mobilized, Buoyed Trap Impacts to *Acropora cervicornis* in All Regions of the Florida Keys

Total for All Regions				
	Fishing Season			
	2004-2005	2005-2006	2006-2007	2004-2005 through 2006-2007
Total Traps Issued[a]	477,227	479,536	466,686	1,423,449
% of All (State & Federal) Traps Pulled in Federal Waters for All Regions[b]	18.10	16.31	10.09	--
No. Traps Used in Federal Waters by Region	537,328.28	486,475.07	292,991.07	1,316,794.42
No. of Traps Used Landing on ASH	80,599.24	72,971.26	43,948.66	197,519.16
No. of Traps on ASH Mobilized by Tropical Weather Events	25,358.33	22,958.40	13,827.24	62,143.97
Area of ASH Impacted by Traps Mobilized During Tropical Weather Events (m^2)	110,055.16	99,639.45	60,010.20	269,704.81
No. of Traps on ASH Affected by Tropical and Non-Tropical Weather Events	23,341.80	21,132.71	12,727.67	57,202.17
Area of ASH Impacted by Traps Mobilized During Tropical and Non-Tropical Weather Events (m^2)	210,182.37	190,290.53	114,606.95	515,079.84
No. of Traps on ASH Mobilized by Non-Tropical Weather Events	31,899.11	28,880.16	17,393.75	78,173.02
Area of ASH Impacted by Traps Mobilized During Non-Tropical Weather Events (m^2)	148,795.02	134,712.93	81,134.03	364,641.98
Area of ASH Impacted Annually by Mobilized Traps (m^2)	469,032.54	424,642.90	255,751.18	1,149,426.63
No. *A. cervicornis* Colonies Impacted	7,367.34	5,834.21	5,906.28	19,107.83
Area of *A. cervicornis* Impacted by Mobilized Traps (m^2)	**135.29**	**106.83**	**109.21**	**351.33**

[a]FFWCC 2007; [b]Derived from FFWCC, unpublished data

Table 5.16 Storm-Mobilized, Buoyed Trap Impacts to *Acropora palmata* in All Regions of the Florida Keys

Total for All Regions				
	Fishing Season			
	2004-2005	2005-2006	2006-2007	2004-2005 through 2006-2007
Total Traps Issued[a]	477,227	479,536	466,686	1,423,449
% of All (State & Federal) Traps Pulled in Federal Waters for All Regions[b]	18.10	16.31	10.09	--
No. Traps Used in Federal Waters by Region	537,328.28	486,475.07	292,991.07	1,316,794.42
No. of Traps Used Landing on ASH	21,493.13	72,857.20	25,829.13	120,179.45
No. of Traps on ASH Mobilized by Tropical Weather Events	6,762.22	6,122.24	3,687.26	16,571.72
Area of ASH Impacted by Traps Mobilized During Tropical Weather Events (m^2)	29,348.04	26,570.52	16,002.72	71,921.28
No. of Traps on ASH Affected by Tropical and Non-Tropical Weather Events	6,224.48	5,635.39	3,394.05	15,253.91
Area of ASH Impacted by Traps Mobilized During Tropical and Non-Tropical Weather Events (m^2)	56,048.63	50,744.14	30,561.85	137,354.62
No. of Traps on ASH Mobilized by Non-Tropical Weather Events	8,506.43	7,701.37	4,638.33	20,846.14
Area of ASH Impacted by Traps Mobilized During Non-Tropical Weather Events (m^2)	39,678.67	35,923.45	21,635.74	97,237.86
Area of ASH Impacted Annually by Mobilized Traps (m^2)	125,075.34	113,238.11	68,200.32	306,513.77
No. *A. palmata* Colonies Impacted	193.48	183.18	87.26	463.92
Area of *A. palmata* Impacted by Mobilized Traps (m^2)	**2.86**	**2.68**	**1.35**	**6.89**

[a] FFWCC 2007; [b] Derived from FFWCC, unpublished data

5.5.2.3 Estimating Adverse Effects to *Acropora* from Storm-Mobilized, Derelict Spiny Lobster Traps

Since we addressed the impacts of storm-mobilized, buoyed traps in the previous section, our analysis now moves to estimating the impacts of storm-mobilized, unbuoyed traps lost in the environment. A number of traps are lost annually due to storm events, accidental cut-offs, etc., where the buoy is lost and fishers can no longer locate the trap. We refer to these unbuoyed, lost traps as 'derelict traps'. Derelict traps can adversely affect *Acropora* when they mobilize during storm events. Our analysis assumes that after two years a derelict trap will have degraded to a point where storm mobilization is unlikely and the trap no longer poses a threat to *Acropora* (T. Matthews, FFWCC, pers. comm. 2007). This analysis uses the same basic process presented in the previous section. However, it describes the process for estimating the number of traps lost, the number of derelict traps remaining, and how we quantified the impacts of storm-mobilized derelict traps. Table 5.19 summarizes the constants used in the analyses of storm-mobilized, derelict traps that remained the same across all fishing seasons. Tables 5.20 and 5.21 provide summary results of all six analyses. Appendix 3 provides a more comprehensive review of the steps used in the analyses, as well as the results.

Estimating the Derelict Spiny Lobster Trap Impacts to ASH in the Upper Keys During the 2006-2007 Fishing Season

We started by using the same steps listed above to estimate the number of traps fished in the federal waters of the region each month (see Table 5.11). We multiplied these figures by the percentage of traps lost estimated from FFWCC commercial fisheries mail surveys (unpublished data). Next, we multiplied our estimates of derelict traps by the mean percentage of lost traps recovered annually through marine debris recovery programs to estimate derelict traps remaining in the environment. We then reduced this number by half to account for degraded traps.

We then multiplied our estimate of the number of derelict traps remaining in the environment after degradation by percentage of all traps likely to end up on ASH. This produced an estimate of the number of derelict traps that landed on ASH in the Upper Keys, each month during the 2006-2007 fishing season. These values were then substituted into the analysis above in place of the federally fished traps landing on ASH.

When estimating the area of impact from weather events for derelict traps we used the same area of impact for tropical weather events (4.96 square meters). For estimating impacts from non-tropical weather events, we used the area of impact (0.75 square meters) for derelict traps reported in Lewis et al. (in review). Table 5.17 illustrates these changes.

Table 5.17 Estimating Monthly and Annual Area of Impact from Storm-Mobilized Derelict Traps During the 2006-2007 Fishing Season

Month	No. Derelict Traps Remaining After Degradation	No. of Derelict Traps Landing on ASH	No. Tropical Weather Events (3.5/yr)	Individual Trap Area of Impact from Tropical Weather Events (m^2)	No. Non-Topical Weather Events (18/yr)	Individual Trap Area of Impact from Non-Tropical Weather Events (m^2)	Annual Area of Impact
Aug	5.53	0.83	0.875	4.96	0	0	3.60
Sep	5.29	0.79	0.875	4.96	0	0	3.44
Oct	5.08	0.76	0.875	4.96	2.57	0.75	4.78
Nov	4.87	0.73	0.875	4.96	2.57	0.75	4.58
Dec	4.42	0.66	0	0	2.57	0.75	1.28
Jan	3.79	0.57	0	0	2.57	0.75	1.10
Feb	3.07	0.46	0	0	2.57	0.75	0.89
Mar	2.33	0.35	0	0	2.57	0.75	0.67
Average	4.30	0.64	--	--	--	--	2.54
Total	34.38	5.16	--	--	--	--	20.33

Recalculating the area of ASH and number of *A. cervicornis* colonies affected annually with the values in Table 5.17, we estimate 0.014 square meter of *A. cervicornis* was adversely impacted by mobilized, derelict traps off the Upper Keys after the 2006-2007 fishing season. Table 5.18 summarizes the analysis for *A. cervicornis* in the Upper Keys.

Table 5.18 Impacts of Storm-Mobilized, Derelict Traps on *Acropora cervicornis*

Upper Keys	
	Fishing Season
	2006-2007
Total Traps Issued[a]	466,686
% of All (State & Federal) Traps Pulled in Federal Waters for All Regions[b]	10.09
% of Federal Effort by Region	0.124
No. Traps Used in Federal Waters by Region	363.77
No. of Derelict Traps in Federal Waters	72.75
No. of Derelict Traps in Federal Waters Recovered	4.00
No. of Derelict Traps in Federal Waters Remaining	68.75
No. of Derelict Traps in Federal Waters After Degradation	34.38
No. of Derelict Traps in Federal Waters Affecting ASH	5.16
No. of Derelict Traps on ASH Mobilized by Tropical Weather Events	1.62
Area of ASH Impacted by Derelict Traps Mobilized During Tropical Weather Events (m^2)	7.04
No. of Derelict Traps on ASH Affected by Tropical and Non-Tropical Weather Events	1.49
Area of ASH Impacted by Derelict Traps Mobilized During Tropical and Non-Tropical Weather Events (m^2)	9.36
No. of Derelict Traps on ASH Mobilized by Non-Tropical Weather Events	2.04
Area of ASH Impacted by Derelict Traps Mobilized During Non-Tropical Weather Events (m^2)	3.93
Area of ASH Impacted Annually by Mobilized Derelict Traps (m^2)	20.33
No. *A. cervicornis* Colonies Impacted	0.153
Area of *A. cervicornis* Impacted by Mobilized Derelict Traps (m^2)	**0.003**

[a] FFWCC 2007; [b] Derived from FFWCC, unpublished data

Adverse Effects to Acropora in the Remaining Regions During the 2004-2005 Through 2006-2007 Fishing Seasons

Throughout all regions of the Florida Keys, we estimate 6.03 square meters of *A. cervicornis* and 0.46 square meter of *A. palmata* were adversely affected by mobilized, derelict spiny lobster traps over these fishing seasons. Since the steps used to quantify the adverse effects to *Acropora* in the remaining regions of the Florida Keys are identical to the ones above, we do not provide a narrative of those calculations here. Table 5.19 summarizes the constants used in the analyses that remained the same across all fishing seasons. Tables 5.20 and 5.21 summarize the resulting calculations for both species across all regions and all years.

Table 5.19 Constants Used in Storm-Mobilized, Derelict Trap Impact Analyses

Parameter		Region		
		Upper Keys	Middle Keys	Lower Keys
% of Trap Lost Annually[a]		20	20	20
Annual Average Percentage of Lost Trap Recovered[a]		5.5	5.5	5.5
Avg. Per Trap Area of Impact from Tropical Weather Events (m^2)[b]		4.96	4.96	4.96
Avg. No. of Tropical Storms Occurring Monthly (Aug.-Nov.)		0.875	0.875	0.875
Avg. Per Trap Area of Impact One Non-Tropical Weather Events (m^2)[b]		0.75	0.75	0.75
Avg. No. of Non-Tropical Weather Events Occurring Monthly (Oct.-Apr.)[b]		2.57	2.57	2.57
Area of ASH (m^2)[c]		83,712,586	54,579,251	45,989,091
% of Traps Landing on ASH[d]	*A. cervicornis*	15	15	15
	A. palmata	4	4	4
Avg. Colonial Density (no./m^2)[e]	*A. cervicornis*	0.0318	0.0132	0.0589
	A. palmata	0.0495	0.0195	0.0077
Total No. of *Acropora* colonies in ASH	*A. cervicornis*	2,662,060	720,446	2,708,757
	A. palmata	106,482	28,818	108,350
Avg. Size (Surface Area) of Each Colony (m^2)[e]	*A. cervicornis*	0.021	0.014	0.0186
	A. palmata	0.122	0.101	0.148

[a]FDEP 2001; [b]Lewis et al. (in review); [c]NMFS unpublished data; [d]Matthews 2003; [e] Derived from Miller et al. 2007

Table 5.20 Storm-Mobilized, Derelict Trap Impacts to *Acropora cervicornis* in All Regions of the Florida Keys

Total for All Regions				
	Fishing Season			
	2004-2005	2005-2006	2006-2007	2004-2005 through 2006-2007
Total Traps Issued[a]	477,227	479,536	466,686	1,423,449
% of All (State & Federal) Traps Pulled in Federal Waters for All Regions[b]	18.10	16.31	10.09	--
% of Federal Effort by Region	--	--	--	--
No. Traps Used in Federal Waters by Region	537,328.28	486,475.07	292,991.07	1,316,794.42
No. of Derelict Traps in Federal Waters	107,465.66	97,295.01	58,598.21	263,358.88
No. of Derelict Traps in Federal Waters Recovered	5,910.61	5,351.23	3,222.90	14,484.74
No. of Derelict Traps in Federal Waters Remaining	101,555.05	91,943.79	55,375.31	248,874.15
No. of Derelict Traps in Federal Waters After Degradation	50,777.52	45,971.89	27,687.66	124,437.07
No. of Derelict Traps in Federal Waters Affecting ASH	2,031.93	1,849.65	1,111.29	4,992.87
No. of Derelict Traps on ASH Mobilized by Tropical Weather Events	639.29	581.94	349.64	1,570.87
Area of ASH Impacted by Derelict Traps Mobilized During Tropical Weather Events (m^2)	2,774.52	2,525.63	1,517.42	6,817.57
No. of Derelict Traps on ASH Affected by Tropical and Non-Tropical Weather Events	588.45	535.67	321.83	1,445.95
Area of ASH Impacted by Derelict Traps Mobilized During Tropical and Non-Tropical Weather Events (m^2)	3,688.13	3,357.29	2,017.08	9,062.50
No. of Derelict Traps on ASH Mobilized by Non-Tropical Weather Events	804.18	732.05	439.82	1,976.05
Area of ASH Impacted by Derelict Traps Mobilized During Non-Tropical Weather Events (m^2)	1,550.07	2,511.21	847.75	4,909.02
Area of ASH Impacted Yearly by Mobilized Derelict Traps (m^2)	8,012.71	8,394.12	4,382.26	20,789.09
No. *A. cervicornis* Colonies Impacted	125.83	101.41	100.98	328.22
Area of *A. cervicornis* Impacted by Mobilized Derelict Traps	**2.31**	**1.85**	**1.87**	**6.03**

[a] FFWCC 2007; [b] Derived from FFWCC, unpublished data

Table 5.21 Storm-Mobilized, Derelict Trap Impacts to *Acropora palmata* for All Regions of the Florida Keys

Total for All Regions				
	Fishing Season			
	2004-2005	2005-2006	2006-2007	2004-2005 through 2006-2007
Total Traps Issued[a]	477,227	479,536	466,686	1,423,449
% of All (State & Federal) Traps Pulled in Federal Waters for All Regions[b]	18.10	16.31	10.09	--
% of Federal Effort by Region	--	--	--	--
No. Traps Used in Federal Waters by Region	537,328.28	486,475.07	292,991.07	1,316,794.42
No. of Derelict Traps in Federal Waters	107,465.66	97,295.01	58,598.21	263,358.88
No. of Derelict Traps in Federal Waters Recovered	5,910.61	5,351.23	3,222.90	14,484.74
No. of Derelict Traps in Federal Waters Remaining	101,555.05	91,943.79	55,375.31	248,874.15
No. of Derelict Traps in Federal Waters After Degradation	50,777.52	45,971.89	27,687.66	124,437.07
No. of Derelict Traps in Federal Waters Affecting ASH	2,031.10	1,838.88	1,107.51	4,977.48
No. of Derelict Traps on ASH Mobilized by Tropical Weather Events	639.03	578.55	348.45	1,566.03
Area of ASH Impacted by Derelict Traps Mobilized During Tropical Weather Events (m^2)	2,773.39	2,510.91	1,512.26	6,796.56
No. of Derelict Traps on ASH Affected by Tropical and Non-Tropical Weather Events	588.21	532.54	320.74	1,441.49
Area of ASH Impacted by Derelict Traps Mobilized During Tropical and Non-Tropical weather events (m^2)	3,686.63	3,337.72	2,010.22	9,034.57
No. of Derelict Traps on ASH Mobilized by Non-Tropical Weather Events	803.86	727.78	438.32	1,969.96
Area of ASH Impacted by Derelict Traps Mobilized During Non-Tropical Weather Events (m^2)	1,549.44	2,500.98	844.87	4,895.29
Area of ASH Impacted Annually by Mobilized Derelict Traps (m^2)	8,009.45	8,349.62	4,367.34	20,726.42
No. *A. palmata* Colonies Impacted	12.39	13.26	5.59	31.24
Area of *A. palmata* Impacted by Mobilized Derelict Traps (m^2)	**0.18**	**0.19**	**0.09**	**0.46**

[a] FFWCC 2007; [b] Derived from FFWCC, unpublished data

5.5.2.4 Estimating Adverse Impacts to *Acropora* from Routine Spiny Lobster Fishing

In this analysis, we quantify the impacts from traps being deployed during fishing (i.e., the impacts of traps being pulled off of or falling to the seafloor) or “trap pulls”. Our analysis makes certain assumptions to overcome gaps in our knowledge. We use number of spiny lobster trap tags as a surrogate for the number spiny lobster traps. Since every spiny lobster trap must have a single trap tag, we assume that a spiny lobster tag translates to a single spiny lobster trap. To be conservative, we assume that all traps issued in the fishery will be used during the season. Additionally, because an individual trap can be pulled many times during a fishing season, our estimate of the number of traps pulled annually is greater than the number of individual traps issued. We also assume traps were set only in areas open to fishing; therefore, we used the average *Acropora* colonial density and size estimates calculated only for areas open to fishing.

To quantify the extent of adverse affects to *Acropora*, we conducted six different analyses, one for each species of *Acropora*, in each region of the Florida Keys (i.e., Upper, Middle, and Lower). As noted in Section 5.5.2.1, because of species distribution, we assume 4 percent of all federally fished traps will affect habitat supporting *A. palmata*, while we believe 15 percent of all federally fished traps will affect habitat supporting *A. cervicornis*. For consistency with the *Acropora* abundance and density data provided in Miller et al. (2007), our estimates of federal trap fishing effort have been segregated, to the greatest extent possible, to match the regions as they were defined in those reports. In the interest of brevity, only the narrative of the analysis conducted for *A. cervicornis* during the 2006-2007 fishing year in the Upper Keys appears below. The remaining analyses of routine fishing impacts use the same steps outlined below. Tables 5.23 through 5.25 provide the information used and results of the analyses for all fishing years.

Estimating the Spiny Lobster Trap Impacts to ASH in the Upper Keys During the 2006-2007 Fishing Season

We estimate 57.29 square meters of ASH were adversely affected by routine spiny lobster fishing during the 2006-2007 fishing season. We calculated this number by first multiplying the number of traps issued in the fishery by average number of traps fished each month (see Table 5.1 for monthly trap used estimates). Using the average soak time for each trap per month reported in Matthews (2001)(see Figure 5.3), and dividing the number of days in each month by the average soak time for each month, we estimated the number of times an individual trap was pulled each month. By multiplying the average number of times an individual trap was pulled each month, by the number of traps used each month, we calculated the number of trap pulls each month. We then multiplied the number of trap pulls by the percentage of traps used in the federal waters and the percentage of federal fishing occurring the in the Upper Keys. This calculated the number of traps pulls occurring in federal waters off the Upper Keys during the 2006-2007 fishing season. Multiplying this estimate by the percentage of traps that land on ASH, we calculated the number of traps affecting ASH in the region each month and annually. Since the footprint of a spiny lobster trap is 0.49 square meter we multiplied this measurement by our estimate of the number of traps landing on ASH to calculate to their total area of impact.

Quantifying Adverse Effects to Acropora cervicornis in the Upper Keys During the 2006-2007 Fishing Season

We estimated an *A. cervicornis* density of 0.0094 colonies/square meter of ASH [derived from Miller et al. (2007)], in areas open to fishing in the Upper Keys. By multiplying this estimate by the area of ASH in the Upper Keys impacted by routine fishing, we estimated the number of *A. cervicornis* colonies affected during the 2006-2007 fishing season. We then multiplied the number of colonies impacted by the average area of each *A. cervicornis* colony to calculate 0.012 square meter of *A. cervicornis* had been adversely impacted by spiny lobster trap fishing in the Upper Keys, during the 2006-2007 fishing season. Table 5.22 summarizes the analysis for *A. cervicornis* in the Upper Keys.

Table 5.22 Impacts of Routine Spiny Lobster Fishing on *Acropora cervicornis*

Upper Keys	
	Fishing Season
	2006-2007
Total Traps Issued[a]	466,686
Total Traps Pulled During Season	6,434,135
% of All (State & Federal) Traps Pulled in Federal Waters for All Regions	10.09
% of Federal Effort by Region	0.12
No. Traps Pulled in Federal Waters by Region	779.41
No. of Individual Traps Used Landing on ASH	116.91
Area of ASH impacted by traps (m^2)	57.29
No. *A. cervicornis* Colonies Impacted	0.54
Total Area of *A. cervicornis* Adversely Impacted (m^2)	**0.012**

[a] FFWCC 2007

Adverse Effects to Acropora in the Remaining Regions During the 2004-2005 Through 2006-2007 Fishing Seasons

Throughout all regions of the Florida Keys, we estimate 124.73 square meters of *A. cervicornis* and 0.062 square meters of *A. palmata* were adversely affected during routine spiny lobster trap fishing. Since the steps used to quantify the adverse effects to *Acropora* in the remaining regions of the Florida Keys are identical to the ones above, we do not provide a narrative of those calculations here. Table 5.23 summarizes the constants used in the analyses that remained the same across all fishing seasons. Tables 5.24 and 5.25 summarize the resulting calculations for both species across all regions and all years.

Table 5.23 Constants Used in Routine Fishing Impact Analyses

Parameter		**Region**		
		Upper Keys	Middle Keys	Lower Keys
Percentage of Traps Landing on ASH[a]	*A. cervicornis*	15	15	15
	A. palmata	4	4	4
Avg. Colonial Density (no./m^2)[b]	*A. cervicornis*	0.0094	0.0008	0.0297
	A. palmata	0.00031	0	0.00002
Avg. Size (Surface Area) of Each Colony (m^2)[b]	*A. cervicornis*	0.223	0.0054	0.0285
	A. palmata	0.146	0	0.130
Total No. of *Acropora* colonies in ASH[b]	*A. cervicornis*	786,898	43,663	1,365,876
	A. palmata	25,921	0	920
Spiny Lobster Trap Footprint (m^2)		0.49	0.49	0.49
Area of ASH (m^2)[c]		83,712,586	54,579,251	45,989,091

[a]Matthews 2003; [b] Derived from Miller et al. 2007;[c]NMFS unpublished data;

Table 5.24 Routine Spiny Lobster Trap Fishing Impacts to *Acropora cervicornis* in All Regions of the Florida Keys

Total for All Regions				
	Fishing Season			
	2004-2005	2005-2006	2006-2007	2004-2005 through 2006-2007
Total Traps Issued[a]	477,227	479,536	466,686	1,423,449
Total Traps Used During Season	6,579,462	6,611,296	6,434,135	19,624,892
% of All (State & Federal) Traps Pulled in Federal Waters for All Regions	18.10	16.31	10.09	--
No. Traps Pulled in Federal Waters by Region	1,191,042.10	1,078,320.85	649,444.12	2,918,807.07
No. of Individual Traps Used Landing on ASH	178,656.32	161,748.13	97,416.62	437,821.06
Area of ASH impacted by traps (m^2)	87,541.59	79,256.58	47,734.14	166,798.18
No. *A. cervicornis* Colonies Impacted	1,026.78	811.85	827.57	2,666.19
Total Area of *A. cervicornis* Adversely Impacted (m^2)	**28.26**	**23.37**	**73.10**	**124.73**

[a] FFWCC 2007

Table 5.25 Routine Spiny Lobster Trap Fishing Impacts to *Acropora palmata* in All Regions of the Florida Keys

Total for All Regions				
	Fishing Season			
	2004-2005	2005-2006	2006-2007	2004-2005 through 2006-2007
Total Traps Issued[a]	477,227	479,536	466,686	1,423,449
Total Traps Used During Season	6,579,462	6,611,296	6,434,135	19,624,892
% of All (State & Federal) Traps Pulled in Federal Waters for All Regions	18.10	16.31	10.09	--
No. Traps Pulled in Federal Waters by Region	1,191,042.10	1,078,320.85	649,444.12	2,918,807.07
No. of Individual Traps Used Landing on ASH	47,641.68	43,132.83	25,977.76	116,752.28
Area of ASH impacted by traps (m^2)	23,344.43	21,135.09	12,729.10	44,479.51
No. *A. palmata* Colonies Impacted	0.18	0.15	0.15	0.48
Total Area of *A. palmata* Adversely Impacted (m^2)	**0.023**	**0.020**	**0.020**	**0.063**

[a] FFWCC 2007

5.5.3 Estimating Past Smalltooth Sawfish Take by Commercial Spiny Lobster Traps

Smalltooth sawfish can become entangled in spiny lobster trap lines. In the following section, we analyze and quantify the adverse effects to smalltooth sawfish from entanglement in spiny lobster traps.

5.5.3.1 Data Used for Estimating Smalltooth Sawfish Takes

The best available data for estimating smalltooth sawfish takes come from two encounter databases, one maintained by Gregg Poulakis (Florida Fish and Wildlife Commission, Fish and Wildlife Research Institute) and Jason Seitz (Florida Museum of Natural

History) and another maintained by Mote Marine Laboratory (MML). Each of these datasets is discussed below.

Poulakis and Seitz Database
Biologists Gregg Poulakis and Jason Seitz maintain a non-validated database of recent smalltooth sawfish encounters (1990 to present) from Gulf of Mexico and South Atlantic waters off south Florida. At least 2,969 individual animals have been documented in this database. Poulakis and Seitz (2004) document 1,632 sawfish encounters in Florida Bay and the Keys between 1990 and 2002; approximately 89 percent of these occurred between 1998 and 2002. Most sawfish encounters were reported as a single fish caught on hook-and-line or observed in the water by divers/swimmers, but several sawfish were also observed together. Virtually all of the captured sawfish were the bycatch of fishers targeting sharks, tarpon, snook, or red drum.

MML Database
As discussed in Section 3.2.8, MML maintains a statewide database for Florida of validated smalltooth sawfish encounters from 1998 through the present. From January 1998 through May 2006, MML validated 840 observations of smalltooth sawfish (1,177 individuals) (MML unpublished data). The majority of these encounters (66 percent) occurred during fishing. The encounter data presented in Simpfendorfer and Wiley (2004) suggests that outside of its core range, the smalltooth sawfish appears more common on the west coast of Florida and the Florida Keys. Although the overall latitudinal spread of encounters was similar off both coasts, encounters off the east coast were much less common. The majority of the east coast encounters occurred south of 27.2ºN with no east coast areas having encounters rates greater than 0.03 per km (Simpfendorfer and Wiley 2004). Observations are based on sightings densities that have not been corrected for sightings effort, however, so may be somewhat biased by the amount of fishing effort (i.e., more fishing effort in the Gulf of Mexico state waters than off the Atlantic coast).

These datasets note only two smalltooth sawfish entanglements in lobster trap gear within the last 10 years (Seitz and Poulakis 2006, T. Wiley, pers. comm. 2007) and none between 2004-2005 and 2006-2007. Both occurred off the Florida Keys in 2001 and 2002. One animal was released alive; the condition of the other upon release is not known.

5.5.3.2 Estimating Smalltooth Sawfish Trap Takes

The MML and Poulakis and Seitz data represent the best available for estimating smalltooth sawfish interactions with spiny lobster trap gear. As noted above, those data show two smalltooth sawfish entanglements in the last 10 years. Smalltooth sawfish is an easily identifiable species that was not listed under the ESA until 2003. Because they are relatively rare, easily distinguishable, and only recently protected by law, we believe smalltooth sawfish entanglements in spiny lobster trap gear are rare and likely to have been reported when they do occur. Therefore, we believe that the two documented smalltooth sawfish encounters are likely a good representation of the actual number of smalltooth sawfish takes that have occurred in the trap sector of the Gulf of Mexico/South Atlantic spiny lobster fishery.

Estimating Mortality
One of the smalltooth sawfish entanglements records stated the animal was released alive and in good condition. The condition of the other animal at the time of release was not noted in the other record. The records suggest that smalltooth sawfish survive at least some portion of entanglements, if not all. Smalltooth sawfish physiology may help reduce the severity of impacts resulting from entanglement. They naturally lay on the sea floor, using their spiracles to breathe (Simpfendorfer pers. comm. 2003). This adaptation allows them to breathe normally without actively swimming. Thorson (1982) reports examples of largetooth sawfish caught by fishermen at night or when no one was present to tag them, surviving, tethered by their rostrums, in the water for several hours with no apparent harmful affects. This evidence leads us to believe entanglement is extremely unlikely to result in mortality. Therefore, based on this information we believe the smalltooth sawfish takes that occurred in the past were non-lethal.

5.6 Anticipated Future Take Resulting from the Continued Authorization of the Gulf of Mexico/South Atlantic Spiny Lobster Fishery

In the preceding sections, we extrapolated the best available data to estimate the area of *Acropora* affected and the number of sea turtle and smalltooth sawfish takes that occurred in the Gulf of Mexico/South Atlantic spiny lobster fishery from 2004-2005 through 2006-2007. We now must consider what effect, if any, the continued authorization of the fishery would have on future levels of take (i.e., whether the levels of lethal and non-lethal take and the areas of *Acropora* adversely impacted in the past are likely to change in the future). Since the number of traps available to the fishery cannot increase [F.A.C. 68B-24.009(1)], we believe the sea turtle, *Acropora*, and smalltooth sawfish interaction patterns that existed in the recent past are likely to continue into the future. Below is a summary of our projections of actual take by species.

Because of the high degree of variability in takes associated with variabilities in water temperatures, species abundances, and other factors that cannot be predicted, a 3-year take estimate was used for the incidental take statement (ITS). Annual take estimates have high variability because of natural and anthropogenic variation. It is unlikely that all species evaluated in this opinion will be consistently impacted year after year by the fishery. Some years may have no interactions, while others may have several. The latter scenario can cause an annual take level to be exceeded because of a potentially anomalous event. As a result, monitoring fisheries using 1-year estimated take levels is largely impractical. However, too long of a time frame is also problematic. We are electing to authorize take for 3-year time periods because this is consistent with our estimates of take occurring during the 2004-2005 through 2006-2007 fishing seasons. This approach reduces the likelihood of requiring reinitiation unnecessarily, while still allowing for an accurate assessment of how the fishery is performing versus expectations.

Triennial Estimate of Sea Turtle Take
The current cap on the number of traps available to the fishery is extremely unlikely to increase over the next three years [F.A.C. 68B-24.009(1)]. Additionally, an action to increase the number of traps available in the fishery would represent a modification to the proposed action and a section 7 consultation could be reinitiated to evaluate any new risks to protected species not previously considered. For these reasons, we believe it is reasonable to assume the level of take we estimated to have occurred over the last three years is likely to continue into the future.

However, our take estimates account for strandings that are not documented. To monitor future take, we must then estimate the number of sea turtles likely to be documented with spiny lobster trap gear entanglements. Since we increased our estimate of strandings to account for the estimated 80 percent that do not get documented, we must now reduce our take estimates by the same percentage to calculate the number of sea turtle entanglements that go undocumented. However, when we apply that percentage to our take estimates, and round up to nearest whole number, we ultimately end up with the same numbers we began with. Therefore, over any consecutive 3-year period, we believe up to three loggerhead, three green sea turtles, and one hawksbill, Kemp's ridley, or leatherback sea turtle may be documented as lethally or non-lethally taken during spiny lobster trap fishing.

Triennial Estimate of Acropora Take
As noted above, the current trap cap makes an increase in the number of traps extremely unlikely. Therefore, we believe it is reasonable to assume the area of *Acropora* adversely affected in the past (2004-2005 through 2006-2007 fishing seasons) is likely to continue into the future. We estimate 482.09 square meters of *A. cervicornis* and 7.41 square meters of *A. palmata* are likely to be taken over any consecutive 3-year period by continued authorization of the spiny lobster fishery.

Triennial Estimate of Smalltooth Sawfish Take
Since the only documented smalltooth sawfish takes by spiny lobster gear occurred relatively recently, and during the same fishing season (2001-2002), it is unclear if these takes represent an emerging trend of increasing interactions between smalltooth sawfish and spiny lobster trap gear, or if they were anomalous. These records illustrate that smalltooth sawfish entanglements can occur, but their relative frequency is uncertain. Given this uncertainty, we believe it is prudent to acknowledge that entanglements can occur, however, assuming two entanglements occurring in one year is common may be inappropriate. Therefore, we estimate two smalltooth sawfish takes could over a triennial period. This approach also allows for some annual variability in smalltooth sawfish abundance or fishing effort. Fluctuations in abundance or effort can influence smalltooth sawfish/fishery interactions, and could account for the recent increase in documented interactions. Selecting a 3-year period for estimating future takes allows us to acknowledge these potential fluctuations. As noted above (see Section 5.5.3.2), we believe smalltooth sawfish are likely to survive entanglements. Based on this information, we believe the two smalltooth sawfish takes will be non-lethal.

5.7 Summary

Based on our review in this section, Gulf of Mexico/South Atlantic spiny lobster traps have adversely affected sea turtles, *Acropora*, and smalltooth sawfish in the past via entanglement and forced submergence, fragmentation and abrasion, and entanglement, respectively. We believe these adverse effects are also likely to continue at their current levels in the future. The other two gear types used in the Gulf of Mexico/South Atlantic spiny lobster fishery – commercial/recreational bully net and commercial/recreational diving – are unlikely to have adversely affected sea turtles, *Acropora*, or smalltooth sawfish, and are unlikely to do so in the future. We have estimated the level of take we believe is likely to occur every three years in the future; Table 5.26 summarizes those estimates.

Table 5.26 Estimated Future 3-Year Take Estimates

Marine Turtles	Number of Takes		
	Lethal or Non-Lethal		Total
Loggerhead	3		3
Green	3		3
Hawksbill	1*		1*
Leatherback	1*		1*
Kemp's ridley	1*		1*
Marine Fish	**Number of Takes**		
	Lethal	Non-Lethal	Total
Smalltooth sawfish	0	2	2
Corals	**Area Effected**		
Acropora cervicornis	482.09 m^2		
Acropora palmata	7.41 m^2		

*The take for these species is in combination, not one per each species.

6.0 Cumulative Effects

Cumulative effects are the effects of future state, local, or private activities that are reasonably certain to occur within the action area considered in this biological opinion. Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA. Within the action area, major future changes are not anticipated in ongoing human activities described in the environmental baseline. The present, major human uses of the action area, such as commercial fishing, recreational boating and fishing, and shipping of goods through the area, are expected to continue at the present levels of intensity in the near future as are their associated risks of injury or mortality to sea turtles and smalltooth sawfish posed by incidental capture by fishermen, accidental oil spills, vessel collisions, marine debris, chemical discharges, and man-made noises.

Beachfront development, lighting, and beach erosion control are all ongoing activities along the Atlantic and Gulf coasts of the United States. These activities potentially reduce or degrade sea turtle nesting habitats or interfere with hatchling movement to sea.

Nocturnal human activities along nesting beaches may also discourage sea turtles from nesting sites. The extent to which these activities reduce sea turtle nesting and hatchling production is unknown. However, an increasing number of coastal counties have or are adopting more stringent protective measures to protect hatchling sea turtles from the disorienting effects of beach lighting. Some of these measures were drafted in response to lawsuits brought against the counties by concerned citizens who charged the counties with failing to uphold the ESA by allowing unregulated beach lighting that results in takes of hatchlings.

Urbanization in many southeastern coastal states has resulted in substantial loss of coastal habitat through activities such as agricultural and urban development (wetland conversion, flood control and diversion projects, dredge-and-fill operations). Smalltooth sawfish are particularly vulnerable to coastal habitat degradation because of their affinity for shallow, estuarine systems. Marine pollutants and debris may also negatively impact smalltooth sawfish if it gets caught on their saw and interfere with feeding.

Several examples of stressors to *Acropora* are outlined in the Atlantic *Acropora* Status Review (BRT 2005). Abrasion and breakage of *Acropora* induced by divers/snorkelers, improper anchoring, vessel groundings, marine debris, and destructive fishing practices are the primary ways humans impact corals directly. Sedimentation occurring from activities like dredging and nutrient and contaminant loading from both point and non-point source pollution are examples of activities that can indirectly impact these species.

State-regulated commercial and recreational boating and fishing activities in local waters currently result in the incidental take of threatened and endangered species. It is expected that states will continue to license and permit large vessel and thrill-craft operations that do not fall under the purview of a federal agency, and will issue regulations that will affect fishery activities. Recreational hook-and-line fisheries have been known to take sea turtles and smalltooth sawfish. Future cooperation between NMFS and the states on these issues should help decrease take of sea turtles caused by recreational activities. NMFS will continue to work with states to develop ESA section 6 agreements and section 10 permits to enhance programs to quantify and mitigate these takes.

In addition to fisheries, NMFS is not aware of any proposed or anticipated changes in other human-related actions (e.g., habitat degradation, poaching) or natural conditions (e.g., changes in oceanic conditions, etc.) that would substantially change the impacts that each threat has on the sea turtles or smalltooth sawfish covered by this opinion. Therefore, NMFS expects that the levels of take of these species described for each of the fisheries and non-fisheries will continue at similar levels into the foreseeable future.

7.0 Jeopardy Analysis

The analyses conducted in the previous sections of this opinion serve to provide a basis to determine whether the proposed action would be likely to jeopardize the continued existence of any ESA-listed sea turtles, *Acropora*, or smalltooth sawfish. In Section 5, we outlined how the proposed action can affect these species and the extent of those effects in terms of estimates of the numbers of sea turtles and smalltooth sawfish caught and injured or killed and the amount of *Acropora* taken. Now we turn to an assessment of each species' response to this impact. We evaluate the overall population effects from the estimated take, and whether those effects of the proposed action, when considered in the context of the status of the species (Section 3), the environmental baseline (Section 4), and the cumulative effects (Section 6), will jeopardize the continued existence of the affected species.

"To jeopardize the continued existence of" means to engage in an action that reasonably would be expected, directly or indirectly, to appreciably reduce the likelihood of both the survival and the recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species (50 CFR 402.02). Thus, in making this determination for each species, we must look at whether there will be a reduction in the reproduction, numbers, or distribution. Then, if there is a reduction in one or more of these elements, we evaluate whether it will cause an appreciable reduction in the likelihood of both the survival and the recovery of the species.

7.1 Effects of the Action on the Likelihood of Sea Turtles' Survival and Recovery in the Wild

In two steps, this section analyzes if the anticipated take from the proposed action will reduce the likelihood of green, hawksbill, Kemp's ridley, leatherback, and loggerhead sea turtles' survival and recovery in the wild. First, we evaluate how each species' population is likely to respond if takes were non-lethal or lethal. Then we evaluate whether the anticipated take will result in any reduction in distribution, reproduction, or numbers of each species that may appreciably reduce the likelihood of survival. Second, we consider how anticipated take is likely to affect these species' recovery in the wild by considering recovery objectives in the recovery plans of each species. Since incidental take affects individuals, some of which may be reproductively mature, we pay specific attention to those objectives that may be affected by reductions in the numbers or reproduction of resulting from the proposed action.

7.1.1 Hawksbill, Kemp's Ridley, and Leatherback Sea Turtles

Survival in the Wild

The proposed action may result in up to one hawksbill, Kemp's ridley, or leatherback sea turtle take (lethal or non-lethal) during a given 3-year period.

The non-lethal take of up to one hawksbill, Kemp's ridley, or leatherback sea turtle, in combination, over consecutive 3-year periods is not expected to have any measurable impact on the reproduction, numbers, or distribution of these species. That individual is expected to fully recover such that no reductions in reproduction or numbers of these species are anticipated. Since the takes may occur anywhere in the action area and would be released within the general area where caught, no change in the distribution of hawksbill, Kemp's ridley, or leatherback sea turtles is anticipated.

The lethal take of up to one hawksbill, Kemp's ridley, or leatherback sea turtle, in combination, over consecutive 3-year periods would reduce their respective population by one, compared to the number that would have been present in the absence of the proposed action, assuming all other variables remained the same. A lethal take could also result in a reduction in future reproduction, assuming the individual was a female and would have survived to reproduce in the future. For example, an adult hawksbill sea turtle can lay 3-5 clutches of eggs every few years (Meylan and Donnelly 1999, Richardson et al. 1999) with up to 250 eggs/nest (Hirth 1980). The loss of one adult female sea turtle, on average, could preclude the production of thousands of eggs and hatchlings, of which a fractional percentage is expected to survive to sexual maturity. Thus, the death of a female eliminates that individual's contribution to future generations, and the action will result in a reduction in sea turtle reproduction. The anticipated take is expected to occur anywhere in the action area and sea turtles generally have large ranges in which they disperse; thus, no reduction in the distribution of hawksbill, Kemp's ridley, or leatherback sea turtles is expected from the take of an individual.

Whether the reductions in numbers and reproduction of these species attributed to spiny lobster fishery would appreciably reduce their likelihood of survival depends on the probable effect the changes in numbers and reproduction would have relative to current population sizes and trends.

The 5-year status review for hawksbill sea turtles states their populations appear to be increasing or stable at the two principal nesting beaches in the U.S. Caribbean where long-term monitoring has been carried out: Mona Island, Puerto Rico, and Buck Island Reef National Monument (BIRNM), St. Croix, USVI (NMFS and USFWS 2007b). Mona Island hosts between 199-332 nesting females per season, while 56 females nest at BIRNM per season (NMFS and USFWS 2007b). Although today's nesting population is only a fraction of what it was historically (i.e., 20 to 100 years ago), nesting activity in recent years by hawksbills has increased on well-protected beaches in Mexico, Barbados, and Puerto Rico (Caribbean Conservation Corporation 2005). Increasing protections for live coral habitat over the last decade in the Atlantic, Gulf of Mexico, and Caribbean may also increase survival rates of hawksbills in the marine environment.

The total population of Kemp's ridleys is not known, but nesting has been increasing significantly in the past several years (9 to 13 percent per year) with over 15,000 nests recorded in 2007 (Gladys Porter Zoo 2007). Kemp's ridleys mature and nest at an age of 7-15 years, which is earlier than other chelonids. A younger age at maturity may be a factor in the response of this species to recovery actions. A period of steady increase in benthic immature ridleys has been occurring since 1990 and appears to be due to increased hatchling production and an apparent increase in survival rates of immature sea turtles. The increased survivorship of immature sea turtles is largely attributable to the introduction of turtle excluder devices (TEDs) in the U.S. and Mexican shrimping fleets and Mexican beach protection efforts. The TEWG (2000) projected that Kemp's ridleys could reach the Recovery Plan's intermediate recovery goal of 10,000 nesters by the year 2015.

The Leatherback Turtle Expert Working Group estimates there are between 34,000-95,000 total adults (20,000-56,000 adult females; 10,000-21,000 nesting females) in the North Atlantic. Of the five leatherback populations or groups of populations in the North Atlantic, three show an increasing or stable trend (Florida, Northern Caribbean, and Southern Caribbean). This includes the largest nesting population, located in the Southern Caribbean at Suriname and French Guiana. Of the remaining two populations, there is not enough information available on the West African population to conduct a trend analysis, and, for the Western Caribbean, a slight decline in annual population growth rate was detected (TEWG 2007).[20]

Although the anticipated mortalities would result in a reduction in absolute population numbers, it is not likely these small reductions would appreciably reduce the likelihood of survival of any of these sea turtle species. If the hatchling survival rate to maturity is greater than the mortality rate of the population, the loss of breeding individuals would be replaced through recruitment of new breeding individuals from successful reproduction of non-taken sea turtles. Considering that all three species' nesting trends are either stable or increasing, we believe the loss of up to one hawksbill, Kemp's ridley, or leatherback sea turtle every three years will not have any measurable effect on those trends.

Based on the above analysis, we believe the proposed action is not reasonably expected to cause, directly or indirectly, an appreciable reduction in the likelihood of survival of these species of sea turtles in the wild.

Recovery in the Wild

Although no change in distribution was concluded for any species, we concluded lethal takes would result in a reduction in absolute population numbers that may also reduce reproduction, but these reductions are not expected to appreciably reduce the likelihood of survival of any species in the wild. The following analysis considers the effects of the anticipated take on the likelihood of recovery in the wild.

The Recovery Plan for the population of the hawksbill sea turtles (NMFS and USFWS 1993) lists the following relevant recovery objectives over a period of 25 continuous years:

- The adult female population is increasing, as evidenced by a statistically significant trend in the annual number of nests at five index beaches, including Mona Island and Buck Island Reef National Monument;
    - Of the rookeries regularly monitored: Jumby Bay (Antigua/Barbuda), Barbados, Mona Island, and Buck Island Reef National Monument all show increasing trends in the annual number of nests (NMFS and USFWS 2007b).

[20] An annual growth rate of 1.0 is considered a stable population; the growth rates of two nesting populations in the Western Caribbean were 0.98 and 0.96 (TEWG 2007).

- The numbers of adults, subadults, and juveniles are increasing, as evidenced by a statistically significant trend on at least five key foraging areas within Puerto Rico, USVI, and Florida.
  - In-water research projects at Mona Island, Puerto Rico, and the Marquesas, Florida, which involve the observation and capture of juvenile hawksbill turtles, are underway. Although there are 15 years of data for the Mona Island project, abundance indices have not yet been incorporated into a rigorous analysis or a published trend assessment. The time series for the Marquesas project is not long enough to detect a trend (NMFS and USFWS 2007b).

The recovery plan for Kemp's ridley sea turtles (USFWS and NMFS 1992) lists the following relevant recovery objective:

- Attain a population of at least 10,000 females nesting in a season.
  - An estimated 4,047 females nested in 2006, which is a substantial increase from the 247 nesting females estimated during the 1985-nesting season (P. Burchfield, Gladys Porter Zoo, personal communication, 2007, in NMFS and USFWS 2007c).
  - In 2007, an estimated 5,500 females nested in the state of Tamaulipas from May 20-22 (P. Burchfield, Gladys Porter Zoo, personal communication, 2007, in NMFS and USFWS 2007c).
  - 10,000 nesting females in a season = about 30,000 nests (NMFS and USFWS 2007c).

The Atlantic recovery plan for the U.S. population of the leatherback sea turtles (NMFS and USFWS 1992) lists the following relevant recovery objective:

- The adult female population increases over the next 25 years, as evidenced by a statistically significant trend in the number of nests at Culebra, Puerto Rico; St. Croix, USVI; and along the east coast of Florida.
  - In Puerto Rico, the main nesting areas are at Fajardo on the main island of Puerto Rico and on the island of Culebra. Between 1978 and 2005, nesting increased in Puerto Rico from a minimum of 9 nests recorded in 1978 and to a minimum of 469-882 nests recorded each year between 2000 and 2005. Annual growth rate was estimated to be 1.1 with a growth rate interval between 1.04 and 1.12, using nest numbers between 1978 and 2005 (NMFS and USFWS 2007d).
  - In the U.S. Virgin Islands, researchers estimated a population growth of approximately 13 percent per year on Sandy Point National Wildlife Refuge from 1994 through 2001. Between 1990 and 2005, the number of nests recorded has ranged from 143 (1990) to 1,008 (2001). The average annual growth rate was calculated as approximately 1.10 (with an estimated interval of 1.07 to 1.13) (NMFS and USFWS 2007d).
  - In Florida, a Statewide Nesting Beach Survey program has documented an increase in leatherback nesting numbers from 98 (1989) to 800-900 (early

2000s). Based on standardized nest counts made at Index Nesting Beach Survey sites surveyed with constant effort over time, there has been a substantial increase in leatherback nesting in Florida since 1989. The estimated annual growth rate was approximately 1.18 (with an estimated 95 percent interval of 1.1 to 1.21) (NMFS and USFWS 2007d).

The potential lethal take of one hawksbill, Kemp's ridley, or leatherback sea turtle, in combination, over consecutive 3-year periods is not likely to reduce population numbers over time due to current population sizes and expected recruitment. Non-lethal takes of sea turtles would not affect the adult female nesting population or number of nests per nesting season. Additionally, our estimate of future take is based on our belief that the same level of take occurred in the past. It is worth noting that this level of take has already occurred in the past, yet we have still seen positive trends in the status of these species. Thus, we believe the proposed action is not in opposition to the recovery objectives above and will not result in an appreciable reduction in the likelihood of hawksbill, Kemp's ridley, or leatherback sea turtles' recovery in the wild.

7.1.2 Green Sea Turtle

Survival in the Wild

The proposed action may result in two green sea turtle takes (lethal or non-lethal) over consecutive 3-year periods.

The potential non-lethal take of three green sea turtles over consecutive 3-year periods is not expected to have any measurable impact on the reproduction, numbers, or distribution of these species. The individuals are expected to fully recover such that no reductions in reproduction or numbers of green sea turtles are anticipated. Since the takes may occur anywhere in the action area and would be released within the general area where caught, no change in the distribution of green sea turtles is anticipated.

The potential lethal take of three green sea turtles over consecutive 3-year periods would reduce the number of green sea turtles, compared to their numbers in the absence of the proposed action, assuming all other variables remained the same. Lethal takes could also result in a potential reduction in future reproduction, assuming the individuals were females and would have survived to reproduce. For example, an adult green sea turtle can lay 1-7 clutches (usually 2-3) of eggs every 2 to 4 years, with 110-115 eggs/nest. The loss of two adult female sea turtles, on average, could preclude the production of thousands of eggs and hatchlings, of which a fractional percentage are expected to survive to sexual maturity. The anticipated takes are expected to occur anywhere in the action area and sea turtles generally have large ranges in which they disperse; thus, no reduction in the distribution of green sea turtles is expected from these takes.

Whether the reductions in numbers and reproduction of these species attributed to spiny lobster fishery would appreciably reduce their likelihood of survival depends on the probable effect the changes in numbers and reproduction would have relative to current population sizes and trends.

The 5-year status review for green sea turtles states that of the seven green sea turtle nesting concentrations in the Atlantic basin for which abundance trend information is available, all were determined to be either stable or increasing (NMFS and USFWS 2007a). That review also states that the annual nesting female population in the Atlantic basin ranges from 29,243-50,539 individuals. Additionally, the pattern of green sea turtle nesting shows biennial peaks in abundance, with a generally positive trend during the ten years of regular monitoring since establishment of index beaches in Florida in 1989. An average of 5,039 green turtle nests were laid annually in Florida between 2001 and 2006 with a low of 581 in 2001 and a high of 9,644 in 2005 (NMFS and USFWS 2007a).

Although the anticipated mortalities would result in an instantaneous reduction in absolute population numbers, the U.S. populations of green sea turtles would not be appreciably affected. For a population to remain stable, sea turtles must replace themselves through successful reproduction at least once over the course of their reproductive lives, and at least one offspring must survive to reproduce itself. If the hatchling survival rate to maturity is greater than the mortality rate of the population, the loss of breeding individuals would be replaced through recruitment of new breeding individuals from successful reproduction of non-taken sea turtles. Since the abundance trend information for green sea turtles is either stable or increasing, we believe the loss of two green turtles over consecutive 3-year periods will not have any measurable effect on that trend.

Based on the above analysis, we believe the proposed action is not reasonably expected to cause, directly or indirectly, an appreciable reduction in the likelihood of survival of the green sea turtle in the wild.

Recovery in the Wild

Although no change in distribution was concluded for green sea turtles, we concluded lethal takes would result in a reduction in absolute population numbers that may also reduce reproduction, but these reductions are not expected to appreciably reduce the likelihood of survival of green sea turtles in the wild. The following analysis considers the effects of the anticipated take on the likelihood of recovery in the wild.

The Atlantic Recovery Plan for the population of Atlantic green sea turtles (NMFS and USFWS 1991b) lists the following relevant recovery objectives over a period of 25 continuous years:

- The level of nesting in Florida has increased to an average of 5,000 nests per year for at least 6 years;
    - Green turtle nesting in Florida over the past six years has been documented as follows: 2001 – 581 nests, 2002 – 9,201 nests, 2003 – 2,622, 2004 – 3,577 nests, 2005 – 9,644 nests, and 2006 – 4,970 nests. This averages 5,039 nests annually over the past 6 years (NMFS and USFWS 2007a).

- A reduction in stage class mortality is reflected in higher counts of individuals on foraging grounds.
  - Several actions are being taken to address this objective; however, there are currently no estimates available specifically addressing changes in abundance of individuals on foraging grounds.

The potential lethal take of three green sea turtles over consecutive 3-year periods is not likely to reduce population numbers over time due to current population sizes and expected recruitment. Non-lethal takes of sea turtles would not affect the adult female nesting population or number of nests per nesting season. Additionally, our estimate of future take is based on our belief that the same level of take occurred in the past. It is worth noting that this level of take has already occurred in the past, yet we have still seen positive trends in the status of this species. Thus, the proposed action is not in opposition to the recovery objectives above and will not result in an appreciable reduction in the likelihood of green sea turtles' recovery in the wild.

7.1.3 Loggerhead Sea Turtle

Survival in the Wild
The proposed action may result in up to three loggerhead sea turtle takes (lethal or non-lethal) over consecutive 3-year periods.

The potential non-lethal take of three loggerhead sea turtles over consecutive 3-year periods is not expected to have any measurable impact on the reproduction, numbers, or distribution of these species. These individuals are expected to fully recover such that no reductions in reproduction, or numbers of loggerhead sea turtles are anticipated. Since these takes may occur anywhere in the action area and would be released within the general area where caught, no change in the distribution of loggerhead sea turtles is anticipated.

The potential lethal take of three loggerhead sea turtles over consecutive 3-year periods would reduce the number of loggerheads as compared to their numbers in the absence of the proposed action, assuming all other variables remained the same. Lethal takes could also result in a potential reduction in future reproduction, assuming these individuals were female and would have survived to reproduce. For example, an adult female loggerhead sea turtle can lay 3 or 4 clutches of eggs every 2 to 4 years, with 100-130 eggs/clutch. The loss of two adult female sea turtles, on average, could preclude the production of thousands of eggs and hatchlings of which a small percentage are expected to survive to sexual maturity. These anticipated takes are expected to occur anywhere in the action area and sea turtles generally have large ranges in which they disperse; thus, no reduction in the distribution of loggerhead sea turtles is expected from the take of an individual.

Whether the reductions in numbers and reproduction of these species attributed to spiny lobster fishery would appreciably reduce their likelihood of survival depends on the probable effect the changes in numbers and reproduction would have relative to current population sizes and trends.

The TEWG (2000) assessment of the status of the two loggerhead populations about which the most is known, concluded that no population trend for the Northern subpopulation [essentially the Northern Recovery Unit (NRU)] could be determined, and that the South Florida subpopulation (essentially the Peninsular Florida Recovery Unit [PFRU]) was increasing at that time. Annual nest totals from northern beaches, reflective of the NRU, averaged 5,215 nests from 1989-2008. This was a period of near-complete surveys of nesting beaches (GDNR unpublished data, NCWRC unpublished data, SCDNR unpublished data), representing approximately 1,272 nesting females per year (4.1 nests per female, Murphy and Hopkins 1984). Daily beach surveys showed a significant declining trend in nesting of 1.3 percent annually. Nest counts from aerial surveys conducted by SCDNR showed a 1.9 percent annual decline in nesting in South Carolina since 1980. A Georgia DNR analysis of the 40-year time-series trend data shows an overall decline in nesting. However, the shorter comprehensive survey data (20 years) indicates a stable population (SCDNR 2008, GDNR unpublished data, NCWRC unpublished data, SCDNR unpublished data). Overall, there is strong statistical data to suggest the NRU has experienced a long-term decline. Nesting data from 2008 showed a reversal in the annual declining trends, but future nesting years will need to be analyzed to determine if this trend is continuing. In North Carolina, 841 loggerhead nests were observed compared to the 10-year average of 715 nests. South Carolina had the seventh highest year on record since 1980, with 4,500 nests. Georgia beach surveys located 1,648 nests in 2008; surpassing the previous statewide record of 1,504 nests in 2003 (SCDNR 2008, GDNR unpublished data, NCWRC unpublished data, SCDNR unpublished data).

Following the 2000 TEWG assessment, the Florida Wildlife Research Institute conducted a, yet-to-be-published, analysis of PFRU nesting data from 1989-2005. The analysis indicates there is a significant declining trend in nesting at beaches utilized by the PFRU (McRae letter to NMFS, October 25, 2006). Data from the 2006 and 2007 nesting seasons are also consistent with the decline in loggerhead nests. The core index nesting beach nest number only reached 28,074; the lowest total since the index nesting beach monitoring program started in 1989. However, in 2008, 39,789 nests were observed at the index nesting beaches, which is the highest total since 2003, but the overall nesting trend data still indicate a significant declining trend (FWRI Index Nesting Beach website: http://research.myfwc.com/features/view_article.asp?id=10690). It has been unclear if the nesting decline reflects a decline in population, or is indicative of a failure to nest by reproductively mature females due to other factors (resource depletion, nesting beach problems, oceanographic conditions, etc.). However, recent analysis of the data has led to the conclusion that the nesting decline is best explained by an actual decline in the number of adult female loggerheads in the population (Witherington et al. 2009).

The meaning of the nesting decline data is further confounded by various in-water research projects that indicate the abundance of neritic juvenile loggerheads is steady or increasing. Epperly et al. (2007) reported a 13.2 percent per year increase in loggerhead catch per unit effort (CPUE) off North Carolina during sea turtle sampling in 1995-1997 and 2001-2003. Ehrhart et al. (2007) also reported a significant increase in loggerhead CPUE over the last four years in the Indian River Lagoon, Florida. Entrainment of loggerheads at St. Lucie Power Plant on Hutchison Island, Florida, has also increased at an average rate of 11 percent per year from 1998 to 2005 (M. Bersette pers. comm. in Epperly et al. 2007). Epperly et al. (2007) determined the trends of increasing loggerhead catch rates from all the aforementioned studies in combination provide evidence that there has been an increase in neritic juvenile loggerhead abundance in the southeastern United States in the recent past. Whether this increase in abundance represents a true population increase among juveniles or merely a shift in spatial occurrence is not clear. NMFS has convened a new Turtle Expert Working Group for loggerhead sea turtles that will gather available data and examine the potential causes of the nesting decline and what the decline means in terms of population status. A final report by the loggerhead TEWG is expected in 2009.

The remaining three recovery units, the Dry Tortugas (DTRU), Northern Gulf of Mexico (NGMRU), and Greater Caribbean (GCRU) are much smaller subpopulations but remain relevant to the continued existence of the species. Nesting surveys for the DTRU are conducted as part of Florida's statewide survey program. Survey effort has been relatively stable during the 9-year period from 1995-2004 (although the 2002 year was missed). Nest counts ranged from 168-270, with a mean of 246, but with no detectable trend during this period (Florida Fish and Wildlife Conservation Commission, Florida Marine Research Institute, Statewide Nesting Beach Survey Data; NMFS and USFWS 2008). Nest counts for the NGMRU are focused on index beaches rather than all beaches where nesting occurs. The 12-year dataset (1997-2008) of index nesting beaches in the area show a significant declining trend of 4.7 percent annually (NMFS and USFWS 2008). Similarly, nesting survey effort has been inconsistent among the GCRU nesting beaches and no trend can be determined for this subpopulation. Zurita et al. (2003) found a statistically significant increase in the number of nests on seven of the beaches on Quintana Roo, Mexico from 1987-2001, where survey effort was consistent during the period. However, nesting has declined since 2001 and the previously reported increasing trend appears to not have been sustained (NMFS and USFWS 2008).

It is still unclear whether nesting beach trends, in-water abundance trends, or some combination of both, best represents the actual status of loggerhead sea turtle populations in the Northwest Atlantic. Regardless, we do not believe the loss of two individuals over consecutive 3-year periods, even if they are removed from the smallest recovery unit, will have a measurable impact on the likelihood of the loggerhead's survival in the wild. Although the declining annual nest density at major loggerhead sea turtle nesting beaches requires further study and analysis to determine the causes and long-term effects on population dynamics, the likelihood of survival in the wild of loggerheads will not be appreciably reduced because of this action. Therefore, we believe that the lethal or non-lethal take of two loggerhead sea turtles associated with the proposed action is not expected to cause an appreciable reduction in the likelihood of survival of this species of sea turtles in the wild.

Recovery in the Wild

Although no change in distribution was concluded for loggerhead sea turtles, we concluded lethal takes would result in a reduction in absolute population numbers that may also reduce reproduction, but these reductions are not expected to appreciably reduce the likelihood of survival of loggerhead sea turtles in the wild. The following analysis considers the effects of the anticipated take on the likelihood of recovery in the wild.

The second revision of the recovery plan for the Northwest Atlantic population of loggerhead sea turtles (NMFS and USFWS 2008), herein incorporated by reference, lists the following relevant recovery objective:

- Ensure that the number of nests in each recovery unit is increasing and that this increase corresponds to an increase in the number of nesting females
    - Northern Recovery Unit

      (1) There is statistical confidence (95 percent) that the annual rate of increase over a generation time of 50 years is 2 percent or greater resulting in a total annual number of nests of 14,000 or greater for this recovery unit (approximate distribution of nests is NC=14 percent [2,000], SC=66 percent [9,200], and GA=20 percent [2,800]).

      (2) This increase in number of nests must be a result of corresponding increases in number of nesting females (estimated from nests, clutch frequency, and remigration interval).
    - Peninsular Florida Recovery Unit

      (1) There is statistical confidence (95 percent) that the annual rate of increase over a generation time of 50 years is statistically detectable (1 percent), resulting in a total annual number of nests of 106,100 or greater for this recovery unit.

      (2) This increase in number of nests must be a result of corresponding increases in number of nesting females (estimated from nests, clutch frequency, and remigration interval).
    - Dry Tortugas Recovery Unit

      (1) There is statistical confidence (95 percent) that the annual rate of increase over a generation time of 50 years is 3 percent or greater, resulting in a total annual number of nests of 1,100 or greater for this recovery unit.

      (2) This increase in number of nests must be a result of corresponding increases in number of nesting females (estimated from nests, clutch frequency, and remigration interval).
    - Northern Gulf of Mexico Recovery Unit

      (1) There is statistical confidence (95 percent) that the annual rate of increase over a generation time of 50 years is 3 percent or greater resulting in a total annual number of nests of 4,000 or greater for this recovery unit (approximate distribution of nests (2002-2007) is FL=92 percent [3,700] and AL=8 percent [300]).

(2) This increase in number of nests must be a result of corresponding increases in number of nesting females (estimated from nests, clutch frequency, and remigration interval).

- Greater Caribbean Recovery Unit

  (1) The total annual number of nests at a minimum of three nesting assemblages, averaging greater than 100 nests annually (e.g., Yucatán, Mexico; Cay Sal Bank, The Bahamas) has increased over a generation time of 50 years.

  (2) This increase in number of nests must be a result of corresponding increases in number of nesting females (estimated from nests, clutch frequency, and remigration interval).

- Ensure the in-water abundance of juveniles in both neritic and oceanic habitats is increasing and is increasing at a greater rate than strandings of similar age classes.

  - Trends in Abundance on Foraging Grounds:

    A network of in-water sites, both oceanic and neritic, distributed across the foraging range is established and monitoring is implemented to measure abundance. There is statistical confidence (95 percent) that a composite estimate of relative abundance from these sites is increasing for at least one generation.

  - Trends in Neritic Strandings Relative to In-water Abundance:

    Stranding trends are not increasing at a rate greater than the trends in in-water relative abundance for similar age classes for at least one generation.

The potential lethal take of three loggerhead sea turtles over consecutive 3-year periods will result in reduction in numbers when takes occur but it is unlikely to have any detectable influence on the trends noted above. Non-lethal takes of sea turtles would not affect the adult female nesting population or number of nests per nesting season. Thus, the proposed action is not in opposition to the recovery objectives above, and is not likely to result in an appreciable reduction in the likelihood of loggerhead sea turtle recovery in the wild.

7.2 Effects of the Action on the Likelihood of *Acropora* Survival and Recovery in the Wild

As noted in Section 5.6, we believe *Acropora* is likely to be adversely affected by the continued authorization of the spiny lobster fishery. We must now determine if the action would reasonably be expected to appreciably reduce, either directly or indirectly, the likelihood of *Acropora* survival and recovery in the wild. Given what we know about the fishery and the stressors impacting *Acropora* throughout its range, we do not believe the fishery is likely to directly or indirectly reduce the likelihood of *Acropora* survival and recovery in the wild. The fishery has been on going throughout periods of both high and low *Acropora* abundance. Additionally, over the last 15 years the number of traps in the fishery has been declining, further reducing the likelihood of adverse affects from the fishery occurring on *Acropora*.

In two steps, the following sections provide our rationale for why we believe the fishery is not likely to appreciably reduce the likelihood of *Acropora* survival and recovery in the wild. First, we evaluate whether the anticipated take for each species will result in any reduction in distribution, reproduction, or areal coverage that may appreciably reduce the species likelihood of survival in the wild. Second, we consider how the anticipated take is likely to affect these species' recovery in the wild. We believe some of the *Acropora* taken would eventually recover, and regain its functional potential within the population.[21] However, because it is unclear what portion would regain this potential, we err on the side of species conservation and assume all taken *Acropora* will lose its functional potential forever and will be lost from the population.

7.2.1 Acropora cervicornis

Survival in the Wild

The final listing rule for *Acropora* (71 FR 26852; May 9, 2006) provides the following rationale for listing the species as threatened and not endangered: (1) the species geographic range remains intact, (2) there are believed to be a high number of colonies still in existence throughout its range, and (3) asexual reproduction provides a source for new colonies that can buffer natural demographic and environmental variability.

Since *Acropora* are threatened species, we believe an appreciable reduction in the likelihood of survival in the wild can be determined by evaluating if the proposed action is likely to bring the species any closer to an endangered listing. Therefore, if we determine the proposed action had detectable effects range wide on the species' geographic distribution, number of colonies, or the species' ability to asexually reproduce; we would conclude the proposed action is appreciably reducing the likelihood of the species' survival in the wild.

The continued authorization of the spiny lobster fishery will not appreciably reduce the distribution of the *A. cervicornis* throughout its range, leaving its geographic range intact. The proposed action may adversely affect up to 482.09 square meters of *A. cervicornis* over consecutive 3-year periods. We estimated that throughout the action area a minimum of 116,372 square meters of *A. cervicornis* exists. The adverse impact to 482.09 square meters of *A. cervicornis* over consecutive 3-year periods would represent 0.41 percent of the total believed to exist in the action area. The action area represents only a small portion of the species current range. Such a small reduction would have no measurable effect on the distribution of the species throughout its range.

The proposed action is also not likely to appreciably reduce the likelihood of survival via a reduction in numbers. The potential loss of 482.09 square meters of *A. cervicornis* or 22,102 colonies over consecutive 3-year periods would reduce the population by that amount, compared to the population in the absence of the continued authorization of the

[21] We define 'functional potential' to mean the potential for producing viable gametes or clones.

Gulf of Mexico/South Atlantic spiny lobster fishery. However, viewed against the large number of colonies still in existence throughout the range of the species, the effects from the proposed action will not be detectable range wide. Miller et al. (2008), estimate over 13 million *A. cervicornis* colonies likely exist currently in the Florida Keys, and while the absolute number of *Acropora* colonies is unknown, it is estimated that as many as a billion individual colonies may exist range wide (71 FR 26852; May 9, 2006). The loss of 22,102 colonies would represent only 0.17 percent of the colonies believed to exist in the Florida Keys, and would be undetectable range wide. Therefore, the proposed action is not likely to measurably reduce the large number of colonies thought to exist range wide.

Acropora cervicornis is a simultaneously hermaphroditic species.[22] For this reason, our discussion of the impacts on reproduction from the proposed action focuses on colonial sexual maturity. Soong and Lang (1992) estimated that *A. cervicornis* becomes sexually mature when branch lengths reach 17 centimeters. Using *A. cervicornis* branch length records observed in 2007 (Miller et al. unpublished data), we estimated 2.41 percent of *A. cervicornis* colonies occurring in the action area are sexually mature. If we assume 2.41 percent of adversely impacted *A. cervicornis* is sexually mature, the proposed action would remove 11.61 square meters of sexually mature *A. cervicornis* over consecutive 3-year periods. This represents 0.41 percent of the total estimated sexually mature area of *A. cervicornis* in the action area. *Acropora cervicornis* is also a relatively fast growing coral. Given the species morphology, a fast growth rate directly influences how quickly a colony reaches sexual maturity. In the Florida Keys, *A. cervicornis* likely grows 10 to 11.5 cm/year (Shinn 1966, Jaap 1974, Shinn 1976). Such high growth rates suggest a relatively short juvenile period. This means on any given year several size classes (i.e., 7 to 16 cm branch length) considered juveniles the previous years will become sexually mature, assuming all other variable remain the same. This greatly increases *A. cervicornis'* ability to replace sexually mature colonies taken by the proposed action. Additionally, the proposed action is extremely unlikely to impede *A. cervicornis'* ability to reproduce asexually. This reproductive strategy will continue to provide a source of new colonies that can buffer natural demographic and environmental variability.

We believe the proposed action may adversely affect *A. cervicornis*, but is not appreciably reducing its likelihood of survival in the wild. The proposed action will not reduce the species distribution, leaving its geographic range intact. The level of anticipated take will reduce the overall numbers of *A. cervicornis* and will likely remove some sexually mature colonies. However, these amounts are unlikely to even be detectable range wide, given the number of colonies believed to exist, and species' fast growth rate. Since we do not believe the effects of the action will be detectable range wide, we conclude that the continued authorization of spiny lobster fishing is not appreciably reducing the likelihood of the species survival in the wild.

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[22] Simultaneously hermaphroditic refers to colonies with both female and male reproductive parts. Gametes (eggs and sperm) of these colonies are located in different mesenteries of the same polyp (Soong 1991).

Recovery in the Wild
Although no change in distribution was concluded, we concluded the anticipated level of take would result in a reduction of the overall areal coverage, which may also reduce reproduction, but these reductions are not expected to appreciably reduce the likelihood of survival of either species in the wild. The following analysis considers the effects of the anticipated loss of areal coverage on the likelihood of recovery in the wild.

For sea turtles and smalltooth sawfish we evaluate the impacts of the proposed action against the recovery objectives outlined in their respective recovery plans. Recovery plans delineate actions that the available information indicates are necessary for the conservation and survival of listed species. Actions deemed necessary for the conservation and survival of the species are developed after considering the threats and causal listing factors. A recovery plan for *Acropora cervicornis* and *A. palmata* is not yet available; though a list of threats and causal listing factors exists (Table 7.1). We can compare the proposed action to this list, to get a sense of how all fishing (classified as anthropogenic abrasion and breakage, below) ranks as a stressor to these species. Anthropogenic abrasion and breakage is currently considered a moderate threat to *Acropora cervicornis* and *A. palmata*, and is likely less of a threat with protective regulations in place. The proposed action represents only a small fraction of all fishing, and fishing represents only a portion of the larger anthropogenic abrasion and breakage category. Additionally, the proposed action is not likely to reduce the chances of *A. cervicornis'* and *A. palmata's* (see Section 7.2.2) survival in the wild. Therefore, we do not believe the continued authorization of the Gulf of Mexico/South Atlantic spiny lobster fishery will appreciably reduce the likelihood of *Acropora*'s recovery in the wild.

Table 7.1 Rank of stressor severity to *Acropora* without (w/out) and with (w/) prohibition/protection of existing regulatory mechanisms (regs)* (*Acropora* BRT 2005)

Stressor	***A. palmata***		***A. cervicornis***	
	Rank w/o Regs	Rank w/ Regs	Rank w/o Regs	Rank w/ Regs
Disease	5+	5+	5+	5+
Temperature	5	5	5	5
Over-harvest	5*	1	5*	1
Natural abrasion and breakage	4	4	4	4
Anthropogenic abrasion and breakage	3	2	2	1
Competition	3	3	3	3
Predation	3	3	3	3
Sedimentation	3	2	3	2
African Dust	1	1	1	1
CO_2	1	1	1	1
Nutrients	1	1	1	1
Sea level rise	1	1	1	1
Sponge boring	1	1	1	1
Contaminants	U	U	U	U
Loss of genetic diversity	U	U	U	U

*A rank of 5 represents the highest threat, 1 the lowest, and U undetermined/unstudied.

7.2.2 *Acropora palmata*

Survival in the Wild

The final listing rule for *Acropora* (71 FR 26852; May 9, 2006) provides the following rationale for listing the species as threatened and not endangered: (1) the species geographic range remains intact, (2) there are believed to be a high number of colonies still in existence throughout its range, and (3) asexual reproduction provides a source for new colonies that can buffer natural demographic and environmental variability.

Since *Acropora* are threatened species, we believe an appreciable reduction in the likelihood of survival in the wild can be determined by evaluating if the proposed action is likely to bring the species any closer to an endangered listing. Therefore, if we determine the proposed action had detectable effects range wide on the species' geographic distribution, number of colonies, or the species' ability to asexually reproduce, we would conclude the proposed action is appreciably reducing the likelihood of the species' survival in the wild.

The continued authorization of the spiny lobster fishery will not appreciably reduce the distribution of the *A. palmata* throughout its range, leaving its geographic range intact. The proposed action may adversely affect up to 7.41 square meters of *A. palmata* over consecutive 3-year periods. We estimated that throughout the action area a minimum of 134,647 square meters of *A. palmata* exists. The adverse impact to 7.41 square meters of *A. palmata* over consecutive 3-year periods would represent 0.005 percent of the total believed to exist in the action area. The action area represents only a small portion of the species current range. Such a small reduction would have no measurable effect on the distribution of the species throughout its range.

The proposed action is also not likely to appreciably reduce the likelihood of survival via a reduction in numbers. The potential loss of 7.41 square meters of *A. palmata* or 495 colonies over consecutive 3-year periods would reduce the population by that amount, compared to the population in the absence of the continued authorization of the Gulf of Mexico/South Atlantic spiny lobster fishery. However, viewed against the large number of colonies still in existence throughout the range of the species, the effects from the proposed action will not be detectable range wide. Miller et al. (2008), estimate over 1.6 million *A. palmata* colonies likely exist currently in the Florida Keys, and while the absolute number of *Acropora* colonies is unknown, it is estimated that as many as a billion individual colonies may exist range wide (71 FR 26852; May 9, 2006). The loss of 495 colonies would represent only 0.031 percent of the colonies believed to exist in the Florida Keys, and would be undetectable range wide. Therefore, the proposed action is not likely to measurably reduce the large number of colonies thought to exist range wide.

Acropora palmata is a simultaneously hermaphroditic species. For this reason our discussion of the impacts on reproduction from the proposed action focuses on colonial sexual maturity. Soong and Lang (1992) estimated *A. palmata* colonies become sexually mature when they reach a surface area of 1,600 square centimeters. Using the colonial size data from Miller et al. (2007), we estimate 26.3 percent of *A. palmata* colonies in the action area are sexually mature. If we assume 26.3 percent of adversely impacted *A. palmata* is sexually mature, the proposed action would remove 1.94 square meters of sexually mature *A. palmata,* over consecutive 3-year periods. This represents less than one percent of the total estimated sexually mature area of *A. palmata* in the action area. Like *A. cervicornis, A. palmata* also has a relatively fast growth rate, directly influencing how quickly colonies reach sexual maturity. In the Florida Keys, *A. palmata* has a documented growth rate of 10 cm/year (Jaap 1974). Such high growth rates suggest a relatively short juvenile period. This greatly increases *A. palmata's* ability to replace sexually mature colonies taken by the proposed action. Additionally, the proposed action is extremely unlikely to impede *A. palmata's* ability to reproduce asexually. This reproductive strategy will continue to provide a source of new colonies that can buffer natural demographic and environmental variability.

We believe the proposed action may be adversely affecting *A. palmata*, but is not appreciably reducing its likelihood of survival in the wild. The proposed action will not reduce the species distribution, leaving its geographic range intact. The level of anticipated take will reduce the overall numbers of *A. palmata* and will likely remove some sexually mature colonies. However, these amounts are unlikely to even be detectable range wide, given the number of colonies believed to exist, and species' fast growth rate. Since we do not believe the effects of the action will be detectable range wide, we conclude that the continued authorization of spiny lobster fishing is not appreciably reducing the likelihood of the species survival in the wild.

Recovery in the Wild
See Section 7.2.1

7.3 Effects of the Action on the Likelihood of Smalltooth Sawfish Survival and Recovery in the Wild

This section analyzes the effects of the action on the likelihood smalltooth sawfish survival and recovery in the wild, in two steps. First, we evaluate how the population is likely to respond if takes were non-lethal or lethal, then we evaluate whether the anticipated take will result in any reduction in distribution, reproduction, or numbers that may appreciably reduce its likelihood of survival. Second, we consider how anticipated take is likely to affect smalltooth sawfish recovery in the wild by considering recovery objectives in the recovery plan.

Survival in the Wild
The non-lethal take of two smalltooth sawfish over consecutive 3-year periods is not expected to have any measurable impact on the reproduction, numbers, or distribution of these species. The vast majority of smalltooth sawfish released after incidental capture show no apparent signs of any negative sub-lethal effects. Although the range of impacts of non-lethal takes are variable, this take estimate represents only those takes for which all animals are expected to fully recover such that no reductions in reproduction or numbers of smalltooth sawfish are anticipated. Since the takes may occur anywhere in

the action area and would be released within the general area where caught, no change in the distribution of green sea turtles is anticipated.

Recovery in the Wild
Since only non-lethal take is anticipated, we believe there will be no effect to the population of reproductive adults and thus no appreciable reduction in the likelihood of smalltooth sawfish survival or recovery in the wild.

8.0 Conclusion

We have analyzed the best available data, the current status of the species, environmental baseline, effects of the proposed action, and cumulative effects to determine whether the proposed action is likely to jeopardize the continued existence of any sea turtle species, *Acropora*, or smalltooth sawfish.

Green, Hawksbill, Kemp's Ridley, Leatherback, and Loggerhead Sea Turtles
Our sea turtle analyses focused on the impacts to and population response of sea turtles in the Atlantic basin. However, the impact of the effects of the proposed action on the Atlantic populations must be directly linked to the global populations of the species, and the final jeopardy analysis is for the global populations as listed in the ESA. Because the proposed action will not reduce the likelihood of survival and recovery of any Atlantic populations of sea turtles, it is our opinion that the continued operation of the Gulf of Mexico/South Atlantic spiny lobster fishery is also not likely to jeopardize the continued existence of green, hawksbill, Kemp's ridley, leatherback, or loggerhead sea turtles.

Acropora
Our *Acropora* analysis focused on the impacts and population response of *Acropora*. Based on these analyses, it is our opinion that the continued operation of the Gulf of Mexico/South Atlantic spiny lobster fishery is not likely to jeopardize the continued existence of *Acropora cervicornis* or *Acropora palmata*.

Smalltooth Sawfish
The smalltooth sawfish analyses focused on the impacts and population response of the U.S. DPS of smalltooth sawfish. Based on these analyses, it is our opinion that the continued operation of the Gulf of Mexico/South Atlantic spiny lobster fishery is not likely to jeopardize the continued existence of smalltooth sawfish.

9.0 Incidental Take Statement (ITS)

Section 9 of the ESA and protective regulations issued pursuant to Section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or attempt to engage in any such conduct. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of Section 7(b)(4) and Section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the ESA provided that such taking is in compliance with the RPMs and terms and conditions of the ITS.

Section 7(b)(4)(c) of the ESA specifies that to provide an ITS for an endangered or threatened species of marine mammal, the taking must be authorized under Section 101(a)(5) of the MMPA. Since no incidental take of listed marine mammals is expected or has been authorized under Section 101(a)(5) of the MMPA, no statement on incidental take of protected marine mammals is provided and no take is authorized. Nevertheless, F/SER2 must immediately notify (within 24 hours, if communication is possible) NMFS' Office of Protected Resources should a take of a listed marine mammal occur.

9.1 Anticipated Amount or Extent of Incidental Take

NMFS anticipates the following incidental takes may occur in the future as a result of the continued operation of Gulf of Mexico/South Atlantic spiny lobster fishery. As noted in Section 5.5.2, incidental take for *Acropora* is issued as an area because of the species unique morphology, and because of the accepted practice of monitoring coral species using areal parameters.

Table 9.1 3-Year Anticipated Future Take in the Gulf of Mexico/South Atlantic Spiny Lobster Fishery

<table>
<tr><th rowspan="2">Marine Turtles</th><th colspan="3">Number of Takes</th></tr>
<tr><td colspan="2">Lethal or Non-Lethal</td><td>Total</td></tr>
<tr><td>Loggerhead</td><td colspan="2">3</td><td>3</td></tr>
<tr><td>Green</td><td colspan="2">3</td><td>3</td></tr>
<tr><td>Hawksbill</td><td colspan="2">1*</td><td>1*</td></tr>
<tr><td>Leatherback</td><td colspan="2">1*</td><td>1*</td></tr>
<tr><td>Kemp's ridley</td><td colspan="2">1*</td><td>1*</td></tr>
<tr><th rowspan="2">Marine Fish</th><th colspan="3">Number of Takes</th></tr>
<tr><td>Lethal</td><td>Non-Lethal</td><td>Total</td></tr>
<tr><td>Smalltooth sawfish</td><td>0</td><td>2</td><td>2</td></tr>
<tr><th>Corals</th><th colspan="3">Area Effected</th></tr>
<tr><td>Acropora cervicornis</td><td colspan="3">482.09 m^2</td></tr>
<tr><td>Acropora palmata</td><td colspan="3">7.41 m^2</td></tr>
</table>

*I/C: These estimates are for all species in combination, not each species individually.

9.2 Effect of the Take

NMFS has determined the level of anticipated take specified in Section 9.1 is not likely to jeopardize the continued existence of green, hawksbill, Kemp's ridley, leatherback, or loggerhead sea turtles, *Acropora*, or smalltooth sawfish.

9.3 Reasonable and Prudent Measures (RPMs)

Section 7(b)(4) of the ESA requires NMFS to issue to any agency whose proposed action is found to comply with section 7(a)(2) of the ESA, but may incidentally take individuals of listed species, a statement specifying the impact of that taking. It also states that RPMs necessary to minimize the impacts from the agency action, and terms and conditions to implement those measures, must be provided and followed. Only incidental taking that complies with the specified terms and conditions is authorized.

The RPMs and terms and conditions are required, per 50 CFR 402.14 (i)(1)(ii) and (iv), to document the incidental take by the proposed action and to minimize the impact of that take on ESA-listed species. These measures and terms and conditions are non-discretionary, and must be implemented by NMFS for the protection of section 7(o)(2) to apply. NMFS has a continuing duty to regulate the activity covered by this incidental take statement. If it fails to adhere to the terms and conditions of the incidental take statement through enforceable terms, and/or fails to retain oversight to ensure compliance with these terms and conditions, the protective coverage of section 7(o)(2) may lapse. To monitor the impact of the incidental take, F/SER2 must report the progress of the action and its impact on the species to F/SER3 as specified in the incidental take statement [50 CFR 402.14(i)(3)].

We have determined that the following RPMs are necessary and appropriate to minimize the impacts of future takes of sea turtles, *Acropora*, and smalltooth sawfish by the Gulf of Mexico/South Atlantic spiny lobster fishery and to monitor levels of incidental take.

1. Sea Turtle and Smalltooth Sawfish Handling Requirements:
   As noted in Section 5.3.1, spiny lobster trap gear can adversely affect sea turtles and smalltooth sawfish via entanglement and/or forced submergence. Most, if not all, sea turtles and smalltooth sawfish released after entanglement events have experienced some degree of physiological injury from forced submergence and/or abrasions/lacerations caused by trap ropes. Experience with other gear types (i.e., hook-and-line) has shown that the ultimate severity of these events is dependent not only upon actual interaction (i.e., physical trauma from entanglement/forced submergence), but the amount of gear remaining on the animal at the time of release. The handling of an animal also greatly affects its chance of recovery. Therefore, the experience, ability, and willingness of fishers to remove gear, is crucial to the survival of sea turtles and smalltooth sawfish following release, and NMFS shall require that captured sea turtles and smalltooth sawfish are handled in a way that minimizes adverse effects from incidental take and reduces mortality.
2. Minimization of Trap Impacts to *Acropora*:
   As noted in Section 5.3.2, spiny lobster trap gear can affect *Acropora* via fragmentation or abrasion occurring during routine fishing or by storm-mobilized traps. We estimate only 20 percent of all spiny lobster trap fishing occurs in federal waters, on average. All the adverse affects to *Acropora* outlined in this document are also likely to be occurring in state waters, but at a greater magnitude because of the higher level fishing effort. Since we believe that adverse affects are occurring to *Acropora* in areas beyond the scope of this opinion, implementing strong conservation measures in the federal fishery is the best approach to providing protection for these species occurring in federal waters

at this time. Therefore, NMFS must require that federal spiny lobster fishing is conducted in such a manner and area that adverse impacts to *Acropora* are minimized. Further, NMFS must collaborate with the State of Florida to reduce adverse impacts to *Acropora* from state spiny lobster fishing to the greatest extent possible.

3. Monitoring the Frequency and Magnitude of Incidental Take:
   The jeopardy analyses for sea turtles, smalltooth sawfish, and *Acropora* are based on the assumption that the frequency and magnitude of adverse effects that occurred in the past will continue into the future. If our estimates regarding the frequency and magnitude of incidental take prove to be an underestimate, we risk having misjudged the potential adverse effects to the sea turtles, smalltooth sawfish, and *Acropora*. Thus, it is imperative that we monitor and track the level of take occurring specific to the spiny lobster trap fishery. Therefore, NMFS must ensure that monitoring and reporting of any sea turtles or smalltooth sawfish encountered, or any *Acropora* interactions: (1) detects any adverse effects resulting from the Gulf of Mexico/South Atlantic spiny lobster fishery; (2) assess the actual level of incidental take in comparison with the anticipated incidental take documented in that opinion; and (3) detect when the level of anticipated take is exceeded.

9.4 Terms and Conditions

To be exempt from take prohibitions established by section 9 of the ESA, NMFS must comply with the following terms and conditions, which implement the RPMs described above. These terms and conditions are non-discretionary.

The following terms and conditions implement RPM No. 1.

1. NMFS must update careful release protocols and modify release gears as new information becomes available.
2. F/SER2, in cooperation with F/SER3, F/SEC, and the State of Florida, must distribute information to permitted spiny lobster trap tag holders specifying handling and/or resuscitation requirements fishers must undertake for any sea turtles taken, as stated in 50 CFR 223.206(d)(1-3).
3. F/SER2, in cooperation with the State of Florida, shall inform all permitted spiny lobster trap tag holders that disentanglement of sea turtles from trap gear takes priority over transferring catch from traps to vessels. Simply cutting lines and leaving entangled gear on sea turtles is strongly discouraged. If a sea turtle is cut loose with the line attached, the flipper may eventually become occluded, necrotic and infected, and this could lead to mortality.
4. F/SER2, in cooperation with F/SER3, F/SEC, and the State of Florida, must also remind permitted spiny lobster trap tag holders they should take the following actions to safely handle and release an incidentally caught smalltooth sawfish:
    a. Leave the sawfish, especially the gills, in the water as much as possible.

b. Do not remove the saw (rostrum) or injure the animal in any way.
c. Remove as much fishing gear as safely possible, from the body of the animal.
d. If it can be done safely, untangle any line wrapped around the saw.
e. Use extreme caution when handling and releasing sawfish as the saw can thrash violently from side to side.

The following terms and conditions implement RPM No. 2.

5. F/SER2, in cooperation with F/SER3, F/SEC, and the State of Florida, must develop and provide permitted spiny lobster trap certificate holders with outreach material describing the appearance and likely habitat of *Acropora*, to aid fishers in avoiding potential interactions with these species.
6. The spiny lobster fishery in Florida is primarily a state fishery (see fishery discussion in Section 2.1). As such, the greatest conservation value to *Acropora* will come from minimizing adverse impacts from spiny lobster trap fishing occurring in state waters. Therefore, NMFS must work with the State of Florida to develop and implement changes in the state fishery that reduce impacts to ESA-listed species. Specifically, NMFS should encourage the State of Florida to pursue an ESA section 10(a)(1)(B) Incidental Take Permit and develop a Conservation Plan for the state's spiny lobster fishery.
7. NMFS, in cooperation with the Florida Keys National Marine Sanctuary, Gulf of Mexico and South Atlantic Fishery Management Councils, must work to establish new closed areas or expand the size of existing closed areas in waters under their jurisdiction where *Acropora* is present to prohibit spiny lobster trap fishing. This will reduce the likelihood of spiny lobster traps affecting *Acropora*.
8. NMFS, in cooperation with the State of Florida, must work to promote the removal of spiny lobster trap marine debris during the spiny lobster closed (April 1-August 5). Specifically, NMFS should provide funding, to the greatest extent practicable, to marine debris projects targeting spiny lobster trap gear.
9. NMFS, in cooperation with industry and Gulf of Mexico and South Atlantic Fishery Management Councils, should also explore allowing the public or other entities to remove trap line, buoys, and make unfishable, any spiny lobster trap gear found in the environment when the fishery is closed and all traps must be out of the water (April 1-August 5).
10. NMFS must remind spiny lobster trap fishers that a good-faith effort should be made to remove all traps from the water, or move them to a location that minimizes the likelihood of mobilization, 48 hours before a forecasted storm arrives.
11. NMFS must work with NMFS SEFSC Harvesting Systems Branch or fund other projects exploring potential spiny lobster trap gear modifications that reduce adverse impacts from spiny lobster traps. If these efforts produce viable gear modifications, F/SER2 must work with the State of Florida, and the Gulf of Mexico and South

Atlantic Fishery Management Councils to implement these gear modifications as soon as practicable.

The following terms and conditions implement RPM No. 3

12. NMFS will continue to coordinate with the STSSN and states to monitor strandings. If stranding trends show a significant increase in spiny lobster trap gear related strandings, this may represent new information that would require reinitation of section 7 consultation.
13. NMFS must work with the Gulf of Mexico and South Atlantic Fishery Management Councils, and the State of Florida, to implement measures requiring that all spiny lobster trap rope be a specific color or have easily identifiable patterns/markings, not currently in use in other fisheries, along its entire length. This will ensure any trap rope affects can be attributed to the appropriate fishery (e.g., stone crab, spiny lobster, or blue crab fisheries). Easily identifiable ropes must be phased into the federal fishery no later than five years after the finalization of this biological opinion.
14. NMFS, in cooperation with the State of Florida, must develop a module for STSSN volunteers to provide training on identifying spiny lobster trap gear. This effort should be coordinated with the STSSN's existing fishing gear identification program. Since sea turtle strandings data is the primary means for monitoring the level of take within the fishery, this training is necessary to increase the accuracy of sea turtle entanglement reports. Additionally, this training will help ensure that sea turtle entanglements in trap gear are attributed to the appropriate fishery (e.g., stone crab, spiny lobster, or blue crab fisheries).
15. NMFS, in cooperation wit the State of Florida, must ensure, to the greatest extent practicable, that the Florida STSSN remains operational at least at its current level of monitoring. STSSN participants should be reminded to fill out the SEFSC Sea Turtle Life History Form to the greatest extent possible. STSSN participants should also be strongly encouraged to photograph strandings to confirm species identity, release condition, and any fishing gear associated with the animal.
16. F/SER2, in collaboration with the SEFSC, must submit STSSN stranding reports, including the information below, that show evidence of trap entanglements to F/SER3 by May 1 of each year.
    a. The STSSN report must include information on: species, sex, date (day, month, and year), state, the region where the take occurred (Gulf of Mexico or Atlantic Ocean), the NMFS statistical zone, the latitude and longitude, the animal condition and disposition, and the curved and/or straight carapace length (when available).
    b. These reports must be forwarded to the Assistant Regional Administrator for Protected Resources, Southeast Regional Office, Protected Resources Division, 263 13th Avenue South, St. Petersburg, Florida 33701.
17. NMFS will continue to use *Acropora* abundance surveys to monitor *Acropora* in the action area. If these data show a decrease in abundance not easily attributed to non-anthropogenic sources (e.g., an active hurricane season, disease outbreak, etc.) this

may represent new information that would require reinitation of section 7 consultation.

10.0 Conservation Recommendations for Sea Turtles, *Acropora,* and Smalltooth Sawfish

Section 7(a)(1) of the ESA directs federal agencies to utilize their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information.

The following additional measures are recommended. For F/SER3 to be kept informed of actions minimizing or avoiding adverse effects or benefiting listed species or their habitats, F/SER3 requests notification of the implementation of any conservation recommendations.

Sea Turtles:

1. NMFS should work with the State of Florida to evaluate the feasibility of adding ESA-listed species reporting requirements to the Florida Trip Ticket reporting system. This will provide data regarding the incidental capture of ESA-listed species.
2. To better understand sea turtle populations and the impacts of incidental take in Gulf of Mexico/South Atlantic spiny lobster fishery, NMFS should support in-water abundance estimates of sea turtles to achieve more accurate status assessments for these species and improve our ability to monitor them.
3. Once reasonable in-water estimates are obtained, NMFS should support population modeling or other risk analyses of the sea turtle populations affected by the Gulf of Mexico/South Atlantic spiny lobster fishery. This will help improve the accuracy of future assessments of the effects of different levels of take on sea turtle populations.
4. NMFS should encourage the State of Florida to apply for funds available under section 6 of the ESA, to conduct research into the impacts of trap fisheries on sea turtles occurring in state waters.
5. NMFS should encourage the State of Florida to develop and implement programs aimed at helping conserve ESA-listed sea turtles species occurring in state waters.

Acropora:

6. NMFS should encourage the State of Florida to develop and implement programs aimed at helping conserve ESA-listed *Acropora* species occurring in state waters.
7. NMFS should conduct or fund research into identifying and quantifying the impacts of fishing related marine debris, particularly trap rope, on *Acropora*.

8. NMFS should conduct or fund research into the efficacy of marine debris removal programs, for the purpose of identifying potential ways to improve the efficiency of such programs.

9. NMFS should conduct, fund, or otherwise develop educational and outreach materials explaining the impacts of fishing related marine debris on ESA-listed *Acropora* species.

10. NMFS should conduct or fund *Acropora* restoration efforts in the Florida Keys.

11. NMFS should conduct or fund efforts to increase the assessment, monitoring, and modeling of coral reefs in the Florida Keys National Marine Sanctuary to allow for a better understanding of *Acropora* abundance and distribution within the area.

Smalltooth Sawfish:

12. NMFS should conduct or fund research on the distribution, abundance, and migratory behavior of smalltooth sawfish to better understand their occurrence in federal waters and potential for interaction with spiny lobster trap gear.

13. NMFS should conduct or fund reproductive behavioral studies to ensure that the incidental capture of smalltooth sawfish in the Gulf of Mexico/South Atlantic spiny lobster fishery is not disrupting any such activities.

14. NMFS should consider time/area closures to reduce fishery interactions in areas where significant numbers of smalltooth sawfish interactions occur.

15. NMFS should encourage the State of Florida to develop and implement programs aimed at helping conserve smalltooth sawfish occurring in state waters.

16. NMFS should encourage the State of Florida, to develop regulations that prohibit spiny lobster trap fishing in waters three feet or less. This action will help reduce to likelihood of adult smalltooth sawfish becoming entangled in trap lines while using the nearshore areas for breeding. This will also provide protection for younger smalltooth sawfish that use the nearshore environment as nursery habitat.

11.0 Reinitiation of Consultation

This concludes formal consultation on the Gulf of Mexico/South Atlantic spiny lobster fishery. As provided in 50 CFR 402.16, reinitiation of formal consultation is required if discretionary federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) The amount or extent of the taking specified in the incidental take statement is exceeded; (2) new information reveals effects of the action that may affect listed species or critical habitat (when designated) in a manner or to an extent not previously considered; (3) the identified action is subsequently modified in a manner that causes an effect to listed species or critical habitat that was not considered in the biological opinion; or (4) a new species is listed or critical habitat designated that may be affected by the identified action. In instances where the amount or extent of incidental take is exceeded, F/SER2 must immediately request reinitiation of formal consultation.

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Appendix 1 Overview of Management Objectives and Measures for the Gulf of Mexico and South Atlantic Spiny Lobster Fishery

FMP/Amendment	Management Objectives/Measures
Original FMP (GMFMC and SAFMC 1982)	• Protect the long-run yields and prevent depletion of lobster stocks • Increase yield by weight from the fishery • Reduce user group and gear conflicts in the fishery • Acquire the necessary information to manage the fishery • Promote efficiency in the fishery
Amendment 1 (GMFMC and SAFMC 1987)	• Required a commercial permit • Limited the possession of undersized lobsters used as attractants and require a live well for those that are kept on board until placed in traps • Modified the recreational possession and season regulations • Modified closed season regulations • Required the immediate release of egg bearing females • Modified the minimum size limit • Required a permit to separate tails while at sea • Prohibited the possession or stripping of egg bearing slipper lobsters
Amendment 2 (GMFMC and SAFMC 1989)	• Modified optimum yield • Established a procedure and protocol for an enhanced management system • Added additional measures to the vessel safety and habitat sections of the original FMP
Amendment 3 (GMFMC and SAFMC 1990)	• Overfishing was defined • NMFS' right to charge a fee for issuing permits was clarified
Regulatory Amendment 1 (GMFMC and SAFMC 1992)	• Extended the Florida spiny lobster trap certificate system for reducing the number of traps in the commercial fishery to the EEZ off Florida • Revised the FMP commercial permitting requirements • Limited the number of live undersize lobster that could be used as attractants for baiting traps • Specified allowable gear for commercial fishing in the EEZ off Florida • Specified the possession limit of spiny lobsters by persons diving at night • Required lobsters harvested by divers be measured without removing from the water • Specified uniform trap and buoy numbers for the EEZ off Florida
Regulatory Amendment 2 (GMFMC and SAFMC 1993)	• Changed the days for the special recreational season in the EEZ off Florida • Prohibited nighttime harvest off Monroe County, Florida during the special recreational season • Specified allowable gear during the special recreational season • Provided different bag limits during the special recreational season off the Florida Keys and the EEZ off other areas of Florida

Appendix 1 Continued

Amendment 4 (GMFMC and SAFMC 1994)	• Allowed the harvest of two lobsters per person per day for all fishermen year round in the South Atlantic waters north of the Florida/Georgia border
Amendment 5 (SAFMC 1998a)	• Identified Essential Fish Habitat (EFH) and EFH-Habitat Areas of Particular Concern for spiny lobster
Amendment 6 (SAFMC 1998b)	• Amended the original FMP as required to make definitions of MSY, OY, overfishing, and overfished consistent with National Standard Guidelines • Identified and defined fishing communities and addressed bycatch management measures
Amendment 7 (GMFMC 2000)	• Addressed the establishment of the Tortugas Marine Reserves

Appendix 2 The anticipated annual incidental take of loggerhead, leatherback, Kemp's ridley, green, and hawksbill sea turtles as outlined in the most recent opinions on NMFS-authorized federal fisheries.

FISHERY	SEA TURTLE SPECIES				
	LOGGERHEAD	LEATHERBACK	KEMP'S RIDLEY	GREEN	HAWKSBILL
ATLANTIC BLUEFISH	6-No more than 3 lethal	None	6-Lethal or non-lethal	None	None
ATLANTIC MACKEREL/SQUID/ BUTTERFISH	6-No more than 3 lethal	1-Lethal or non-lethal	2-Lethal or non-lethal	2-Lethal or non-lethal	None
ATLANTIC HMS-PELAGIC LONGLINE	635-No more than 113 lethal	588-No more than 28 lethal	35-No more than 6 lethal for these species in combination		
ATLANTIC HMS-SHARK FISHERIES	679-No more than 346 lethal	74-No more than 47 lethal	2 – No more than 1 lethal	2 – No more than 1 lethal	2 – No more than 1 lethal
COASTAL MIGRATORY PELAGICS	11-Lethal takes	2-Lethal takes for leatherbacks, hawksbill, and Kemp's ridley-both lethal take	14-Lethal takes	2-Lethal takes for Leatherbacks, hawksbill, and Kemp's ridley-both lethal take	
DOLPHIN-WAHOO	12-No more than 2 lethal	12-No more than 1 lethal	3-All species in combination; no more than 1 lethal take		
GULF OF MEXICO REEF FISH	68-No more than 26 lethal	7-No more than 3 lethal	1-Lethal or non-lethal	17-No more than 7 lethal	15-No more than 5 lethal
MONKFISH (GILLNET)	3-Loggerhead (No more than 5 lethal loggerhead takes by all monkfish gear over 5 yrs)	1-Leatherback, Kemp's ridley or green			None
MONKFISH (TRAWL)	1-Loggerhead, leatherback, Kemp's ridley or green				None
NORTHEAST MULTISPECIES	1-Lethal or non-lethal	1-Lethal or non-lethal	1-Lethal or non-lethal	1-Lethal or non-lethal	None
SOUTH ATLANTIC SNAPPER-GROUPER	68-No more than 23 lethal	9-No more than 5 lethal	7-No more than 3 lethal	13-No more than 5 lethal	2-No more than 1 lethal

Appendix 2 Continued

SOUTHEASTERN U.S. SHRIMP	163,160-No more than 3,948 lethal	3,090-No more than 80 lethal	155,503-No more than 4,208 lethal	18,757-No more than 514 Lethal	640-All lethal
SPINY DOGFISH	3-No more than 2 lethal	1-Lethal or non-lethal	1-Lethal or non-lethal	1-Lethal or non-lethal	None
SUMMER FLOUNDER/SCUP/ BLACK SEA BASS	19-No more than 5 lethal (total - either loggerheads or Kemp's ridley)	None	See loggerhead entry	2 lethal or non-lethal	None

Appendix 3 Storm-Mobilized Spiny Lobster Trap Effects on *Acropora*

Quantifying Adverse Impacts to *Acropora* from Buoyed Spiny Lobster Traps Over the 2004-2005 Through 2006-2007 Fishing Seasons

The following section illustrates in more detail the analysis of trap mobilization impacts to *Acropora*, conducted in Section 5.5.2.2. Our analysis makes certain assumptions to overcome gaps in our knowledge. We use number of spiny lobster trap tags as a surrogate for the number spiny lobster traps. Since every spiny lobster trap must have a single trap tag, we assume that a spiny lobster tag translates to a single spiny lobster trap. It also assumes that traps set outside areas closed to fishing could migrate into those closed areas; thus, we used average *Acropora* colonial densities estimates for areas both open and closed to fishing. We also assume *Acropora* will be adversely affected (via fragmentation and/or abrasion) each time there is contact with a spiny lobster trap.

To quantify the extent of adverse affects to *Acropora*, we conducted six different analyses, one for each species of *Acropora*, in each region of the Florida Keys (i.e., Upper, Middle, and Lower). As noted in Section 5.5.2.1, because of species distribution, we assume 4 percent of all federally fished traps will affect habitat supporting *A. palmata*, while we believe 15 percent of all federally fished traps will affect habitat supporting *A. cervicornis*. For consistency with the *Acropora* abundance and density data provided in Miller et al. (2007), our estimates of federal trap fishing effort have been segregated, to the greatest extent possible, to match the regions as they were defined in those reports. In the interest of brevity, only the narrative of the analysis conducted for *A. cervicornis* during the 2006-2007 fishing year in the Upper Keys appears below. The remaining analyses of storm-mobilized buoyed trap impacts use the same steps outlined below. Tables A3.3 through A3.5 provide the information used and results of the analyses for both species over the 2004-2005 through 2006-2007 fishing seasons.

Estimating Buoyed Spiny Lobster Trap Effects to ASH in the Upper Keys During the 2006-2007 Fishing Season

We began by tabulating and calculating the amount of commercial trap fishing effort in the fishery for the 2006-2007 fishing year. Effort can be measured in variety of ways, including the traps issued; total number of trips, traps fished, sets, hours fished, and soak time. We measured the effort in the fishery by estimating the number of traps fished during a given year, based on the number of traps issued to fishers reported by FFWCC (FFWCC 2007).[23] To be conservative toward the species, our analysis assumes all trap issued were actually used in the fishery.

The number of traps issued by the FFWCC during the season was 466,686. This number was then multiplied by the percentage of traps used each month to estimate the number of traps pulled monthly. The number of traps pulled each month was then multiplied the percentage of all traps (state and federal waters) used in federal waters. During the 2006-2007 fishing season, traps used in federal waters accounted for 10.09 percent of all traps

[23] FFWCC defines active traps as spiny lobster trap tags issued, not whether the traps was actually fished.

used in the Florida Keys (FFWCC unpublished data).[24] We multiplied this percentage by the number of traps pulled each month to estimate the number of individual traps used each month and annually in federal waters. Using FFWCC Trip Ticket information, we estimated the percentage of total federal fishing effort that occurred in the Upper Keys (0.124 percent) during the 2006-2007 season. By multiplying this percentage by our estimate of the number of traps used each month in federal waters, we estimated the number of individual traps used monthly in federal waters off the Upper Keys. Multiplying our monthly trap use figures by the percentage of traps that end up on ASH for *A. cervicornis* (15 percent) (Matthews 2003), yielded an estimate of the number of federally fished traps that land on ASH each month. Table A3.1 summarizes this process.

Table A3.1 Estimating Monthly Federal Trap Impact to ASH in the Upper Keys

Month	% of All Traps Used	No. Traps Used Each Month	% of All Trap Fishing Occurring Federal Waters	No. Traps Used in Federal Waters	% of All Federal Effort Occurring in the Region	Traps Fished in Federal Waters in the Region	No. of Federally Fished Traps Landing on ASH
Aug	100.00%	466,686	10.09	47,111	0.124	58.49	8.77
Sep	95.67%	446,478	10.09	45,071	0.124	55.96	8.39
Oct	91.95%	429,118	10.09	43,318	0.124	53.78	8.07
Nov	88.16%	411,430	10.09	41,533	0.124	51.57	7.73
Dec	79.97%	373,209	10.09	37,674	0.124	46.78	7.02
Jan	68.52%	319,773	10.09	32,280	0.124	40.08	6.01
Feb	55.52%	259,104	10.09	26,156	0.124	32.47	4.87
Mar	42.13%	196,615	10.09	19,848	0.124	24.64	3.70
Average	77.74%	362,802	10.09	36,624	0.124	45.47	6.82
Total	--	2,902,414	--	292,991	--	363.77	54.56

Since the type of storm (tropical or non-tropical) affects the extent of trap mobilization, we calculated the impacts from both types separately. We estimated the impacts from storm-mobilized buoyed traps landing on ASH, during tropical and non-tropical storm events, by first estimating the type of weather event likely to occur during each month. We assumed 3.5 tropical weather events would occur annually; only during August through November (0.875 tropical events/month). Lewis et al. (in review) observed 18 non-tropical weather events occurring during October through April (2.57 non-tropical weather events/month). For each month, we multiplied the number of traps landing on ASH, by the number of tropical or non-tropical weather events likely to affect those traps, and the area of impact associated with each weather event. As mentioned in Section 5.5.2.1, we used 4.96 square meters and 1.815 square meters as the areas of impact resulting from tropical and non-tropical weather events, respectively. For months when both tropical and non-tropical weather events could occur (October and November), we estimated the areas of impact from each event separately, and summed the result. Our analysis showed 317.53 square meters of ASH was affected during the 2006-2007 fishing season due to storm-mobilized, buoyed traps. Table A3.2 summarizes these steps.

[24] In our analyses, we used percentage of traps pulled in federal waters and region of the Florida Keys, as a proxy for estimating the total number of individual traps used in those areas.

Table A3.2 Estimating Monthly and Annual Area of Impact from Storm-Mobilized Buoyed Traps During the 2006-2007 Fishing Season

Month	Traps Fished in Federal Waters in the Region	No. of Federally Fished Traps Landing on ASH	No. Tropical Storms (3.5/yr)	Individual Trap Area of Impact from Tropical Storms (m^2)	No. Non-Topical Storms (18/yr)	Individual Trap Area of Impact from Tropical Storms (m^2)	Annual Area of Impact
Aug	58.49	8.77	0.875	4.96	0	0	38.08
Sep	55.96	8.39	0.875	4.96	0	0	36.43
Oct	53.78	8.07	0.875	4.96	2.57	1.815	72.64
Nov	51.57	7.73	0.875	4.96	2.57	1.815	69.65
Dec	46.78	7.02	0	0	2.57	1.815	32.73
Jan	40.08	6.01	0	0	2.57	1.815	28.04
Feb	32.47	4.87	0	0	2.57	1.815	22.72
Mar	24.64	3.70	0	0	2.57	1.815	17.24
Average	45.47	6.82	--	--	--	--	39.69
Total	363.77	54.56	--	--	--	--	317.53

Quantifying Adverse Effects to Acropora cervicornis in the Upper Keys

We estimated an *A. cervicornis* density of 0.0078 colonies/square meter of ASH, in areas open and closed to fishing in the Upper Keys, from Miller et al. (2007). By multiplying this estimate by the area of ASH in the Upper Keys impacted by storm-mobilized traps (317.53 square meters), we estimated 2.47 *A. cervicornis* colonies were affected during the 2006-2007 fishing season. By multiplying the number of colonies impacted (2.47) by the average area of each *A. cervicornis* colony [0.021 square meters; derived from Miller et al. (2007)], we estimated 0.052 square meter of *A. cervicornis* was adversely impacted by spiny lobster trap mobilization in the Upper Keys, during the 2006-2007 fishing season.

Adverse Effects to Acropora in the Remaining Regions During the 2004-2005 Through 2006-2007 Fishing Seasons

Throughout all regions of the Florida Keys, we estimate 351.33 square meters of *A. cervicornis* and 6.89 square meters of *A. palmata* were adversely affected by mobilized, buoyed spiny lobster traps during the 2004-2005 through 2006-2007 fishing seasons. Table A3.3 summarizes the constants used in the analyses that remained the same across all fishing seasons. Tables A3.4 and A3.5 summarize the resulting calculations from each analysis.

Table A3.3 Constants Used in Storm-Mobilized, Buoyed Trap Impact Analyses for Both Species

Parameter		Region		
		Upper Keys	Middle Keys	Lower Keys
Avg. Per Trap Area of Impact from Tropical System (m^2)[a]		4.96	4.96	4.96
Avg. No. of Tropical Storms Occurring Monthly (Aug.-Nov.)		0.875	0.875	0.875
Avg. Per Trap Area of Impact One Non-Tropical Weather Events (m^2)[a]		1.815	1.815	1.815
Avg. No. of Non-Tropical Weather Events Occurring Monthly (Oct.-Apr.)[a]		2.57	2.57	2.57
Area of ASH (m^2)[b]		83,712,586	54,579,251	45,989,091
Percentage of Traps Landing on ASH[c]	*A. cervicornis*	15	15	15
	A. palmata	4	4	4
Colonial Density (no./m^2)[d]	*A. cervicornis*	0.0078	0.0013	0.0394
	A. palmata	0.0094	0.0008	0.0297
Total No. of *Acropora* colonies in ASH	*A. cervicornis*	652,958	70,953	1,811,970
	A. palmata	136,452	112,870	31,372
Avg. Size (Surface Area) of Each Colony (m^2)[d]	*A. cervicornis*	0.021	0.014	0.0186
	A. palmata	0.122	0.101	0.148

[a]Lewis et al. (in review); [b]NMFS unpublished data; [c]Matthews 2003; [d]Derived from Miller et al. 2007

Table A3.4 Impacts of Storm-Mobilized, Buoyed Traps on *Acropora cervicornis*

Upper Keys				
	Fishing Season			
	2004-2005	2005-2006	2006-2007	2004-2005 through 2006-2007
Total Traps Issued[a]	477,227	479,536	466,686	1,423,449
% of All (State & Federal) Traps Pulled in Federal Waters for All Regions[b]	18.10	16.31	10.09	--
% of All Federal Effort by Region	0.015	0.213	0.124	--
No. Traps Used in Federal Waters by Region	79.47	1,036.96	363.77	1,480.19
No. of Traps Used Landing on ASH	11.92	155.54	54.56	222.03
No. of Traps on ASH Mobilized by Tropical Weather Events	3.75	48.94	17.17	69.86
Area of ASH Impacted by Traps Mobilized During Tropical Weather Events (m^2)	16.28	212.39	74.51	303.17
No. of Traps on ASH Affected by Tropical and Non-Tropical Weather Events	3.45	45.05	15.80	64.30
Area of ASH Impacted by Traps Mobilized During Tropical and Non-Tropical Weather Events (m^2)	31.09	405.62	142.29	579.00
No. of Traps on ASH Mobilized by Non-Tropical Weather Events	4.72	61.56	21.60	87.87
Area of ASH Impacted by Traps Mobilized During Non-Tropical Weather Events (m^2)	22.01	287.15	100.73	409.89
Area of ASH Impacted Annually by Mobilized Traps (m^2)	69.37	905.16	317.53	1,292.06
No. *A. cervicornis* Colonies Impacted	0.541	7.060	2.477	10.078
Area of *A. cervicornis* Impacted by Mobilized Traps (m^2)	**0.011**	**0.148**	**0.052**	**0.21**

[a] FFWCC 2007; [b] Derived from FFWCC, unpublished data

Table A3.4 Continued

Middle Keys				
	Fishing Season			
	2004-2005	2005-2006	2006-2007	2004-2005 through 2006-2007
Total Traps Issued[a]	477,227	479,536	466,686	1,423,449
% of All (State & Federal) Traps Pulled in Federal Waters for All Regions[b]	18.10	16.31	10.09	--
% of Federal Effort by Region	62.17	67.17	42.70	--
No. Traps Used in Federal Waters by Region	334,071.67	326,787.88	125,093.35	785,952.90
No. of Traps Used Landing on ASH	50,110.75	49,018.18	18,764.00	117,892.94
No. of Traps on ASH Mobilized by Tropical Weather Events	15,765.97	15,422.22	5,903.58	37,091.77
Area of ASH Impacted by Traps Mobilized During Tropical Weather Events (m^2)	68,424.30	66,932.44	25,621.52	160,978.26
No. of Traps on ASH Affected by Tropical and Non-Tropical Weather Events	14,512.23	14,195.82	5,434.11	34,142.17
Area of ASH Impacted by Traps Mobilized During Tropical and Non-Tropical Weather Events (m^2)	130,676.12	127,826.98	48,931.76	307,434.85
No. of Traps on ASH Mobilized by Non-Tropical Weather Events	19,832.55	19,400.14	7,426.31	46,659.00
Area of ASH Impacted by Traps Mobilized During Non-Tropical Weather Events (m^2)	92,509.93	90,492.93	34,640.40	217,643.25
Area of ASH Impacted Annually by Mobilized Traps (m^2)	291,610.34	285,252.34	109,193.68	686,056.37
No. *A. cervicornis* Colonies Impacted	379.09	370.83	141.95	891.87
Area of *A. cervicornis* Impacted by Mobilized Traps (m^2)	**5.31**	**5.19**	**1.99**	**12.49**

Lower Keys				
	Fishing Season			
	2004-2005	2005-2006	2006-2007	2004-2005 through 2006-2007
Total Traps Issued[e]	477,227	479,536	466,686	1,423,449
% of All (State & Federal) Traps Pulled in Federal Waters for All Regions[f]	18.10	16.31	10.09	--
% of Federal Effort by Region	37.81	32.61	57.18	--
No. Traps Used in Federal Waters by Region	203,177.14	158,650.24	167,533.95	529,361.33
No. of Traps Used Landing on ASH	30,476.57	23,797.54	25,130.09	79,404.20
No. of Traps on ASH Mobilized by Tropical Weather Events	9,588.61	7,487.24	7,906.49	24,982.34
Area of ASH Impacted by Traps Mobilized During Tropical Weather Events (m^2)	41,614.58	32,494.62	34,314.17	108,423.37
No. of Traps on ASH Affected by Tropical and Non-Tropical Weather Events	8,826.11	6,891.84	7,277.75	22,995.71
Area of ASH Impacted by Traps Mobilized During Tropical and Non-Tropical Weather Events (m^2)	79,475.16	62,057.93	65,532.90	207,066.00
No. of Traps on ASH Mobilized by Non-Tropical Weather Events	12,061.85	9,418.45	9,945.85	31,426.15
Area of ASH Impacted by Traps Mobilized During Non-Tropical Weather Events (m^2)	56,263.08	43,932.85	46,392.90	146,588.84
Area of ASH Impacted Annually by Mobilized Traps (m^2)	177,352.83	138,485.40	146,239.97	462,078.21
No. *A. cervicornis* Colonies Impacted	6,987.70	5,456.32	5,761.85	18,205.88
Area of *A. cervicornis* Impacted by Mobilized Traps (m^2)	**129.97**	**101.49**	**107.17**	**338.63**

[a] FFWCC 2007; [b] Derived from FFWCC, unpublished data

Table A3.4 Continued

Total for All Regions				
	Fishing Season			
	2004-2005	2005-2006	2006-2007	2004-2005 through 2006-2007
Total Traps Issued[a]	477,227	479,536	466,686	1,423,449
% of All (State & Federal) Traps Pulled in Federal Waters for All Regions[b]	18.10	16.31	10.09	--
No. Traps Used in Federal Waters by Region	537,328.28	486,475.07	292,991.07	1,316,794.42
No. of Traps Used Landing on ASH	80,599.24	72,971.26	43,948.66	197,519.16
No. of Traps on ASH Mobilized by Tropical Weather Events	25,358.33	22,958.40	13,827.24	62,143.97
Area of ASH Impacted by Traps Mobilized During Tropical Weather Events (m^2)	110,055.16	99,639.45	60,010.20	269,704.81
No. of Traps on ASH Affected by Tropical and Non-Tropical Weather Events	23,341.80	21,132.71	12,727.67	57,202.17
Area of ASH Impacted by Traps Mobilized During Tropical and Non-Tropical Weather Events (m^2)	210,182.37	190,290.53	114,606.95	515,079.84
No. of Traps on ASH Mobilized by Non-Tropical Weather Events	31,899.11	28,880.16	17,393.75	78,173.02
Area of ASH Impacted by Traps Mobilized During Non-Tropical Weather Events (m^2)	148,795.02	134,712.93	81,134.03	364,641.98
Area of ASH Impacted Annually by Mobilized Traps (m^2)	469,032.54	424,642.90	255,751.18	1,149,426.63
No. *A. cervicornis* Colonies Impacted	7,367.34	5,834.21	5,906.28	19,107.83
Area of *A. cervicornis* Impacted by Mobilized Traps (m^2)	**135.29**	**106.83**	**109.21**	**351.33**

[a] FFWCC 2007; [b] Derived from FFWCC, unpublished data

Table A3.5 Impacts of Storm-Mobilized Buoyed Traps on *Acropora palmata*

Upper Keys				
	Fishing Season			
	2004-2005	2005-2006	2006-2007	2004-2005 through 2006-2007
Total Traps Issued[a]	477,227	479,536	466,686	1,423,449
% of All (State & Federal) Traps Pulled in Federal Waters for All Regions[b]	18.10	16.31	10.09	--
% of Federal Effort by Region	0.015	0.213	0.124	--
No. Traps Used in Federal Waters by Region	79.47	1,036.96	363.77	1,480.19
No. of Traps Used Landing on ASH	3.18	41.48	363.77	408.42
No. of Traps on ASH Mobilized by Tropical Weather Events	1.00	13.05	4.58	18.63
Area of ASH Impacted by Traps Mobilized During Tropical Weather Events (m^2)	4.34	56.64	19.87	80.85
No. of Traps on ASH Affected by Tropical and Non-Tropical Weather Events	0.92	12.01	4.21	17.15
Area of ASH Impacted by Traps Mobilized During Tropical and Non-Tropical Weather Events (m^2)	8.29	108.16	37.94	154.40
No. of Traps on ASH Mobilized by Non-Tropical Weather Events	1.26	16.42	5.76	23.43
Area of ASH Impacted by Traps Mobilized During Non-Tropical Weather Events (m^2)	5.87	76.57	26.86	109.30
Area of ASH Impacted Annually by Mobilized Traps (m^2)	18.50	241.37	84.67	344.55
No. *A. palmata* Colonies Impacted	0.030	0.393	0.138	0.562
Area of *A. palmata* Impacted by Mobilized Traps (m^2)	**0.0006**	**0.0083**	**0.0029**	**0.0118**
Middle Keys				
	Fishing Season			
	2004-2005	2005-2006	2006-2007	2004-2005 through 2006-2007
Total Traps Issued[a]	477,227	479,536	466,686	1,423,449
% of All (State & Federal) Traps Pulled in Federal Waters for All Regions[b]	18.10	16.31	10.09	--
% of Federal Effort by Region	62.17	67.17	42.70	--
No. Traps Used in Federal Waters by Region	334,071.67	326,787.88	125,093.35	785,952.90
No. of Traps Used Landing on ASH	13,362.87	49,018.18	18,764.00	81,145.05
No. of Traps on ASH Mobilized by Tropical Weather Events	4,204.26	4,112.59	1,574.29	9,891.14
Area of ASH Impacted by Traps Mobilized During Tropical Weather Events (m^2)	18,246.48	17,848.65	6,832.41	42,927.54
No. of Traps on ASH Affected by Tropical and Non-Tropical Weather Events	3,869.93	3,785.55	1,449.10	9,104.58
Area of ASH Impacted by Traps Mobilized During Tropical and Non-Tropical Weather Events (m^2)	34,846.96	34,087.19	13,048.47	81,982.63
No. of Traps on ASH Mobilized by Non-Tropical Weather Events	5,288.68	5,173.37	1,980.35	12,442.40
Area of ASH Impacted by Traps Mobilized During Non-Tropical Weather Events (m^2)	24,669.31	24,131.45	9,237.44	58,038.20
Area of ASH Impacted Annually by Mobilized Traps (m^2)	77,762.76	76,067.29	29,118.31	182,948.36
No. *A. palmata* Colonies Impacted	160.81	157.31	60.22	378.34
Area of *A. palmata* Impacted by Mobilized Traps (m^2)	**2.25**	**2.20**	**0.84**	**5.30**

[a] FFWCC 2007; [b] Derived from FFWCC, unpublished data

Table A3.5 Continued

Lower Keys				
	Fishing Season			
	2004-2005	2005-2006	2006-2007	2004-2005 through 2006-2007
Total Traps Issued[a]	477,227	479,536	466,686	1,423,449
% of All (State & Federal) Traps Pulled in Federal Waters for All Regions[b]	18.10	16.31	10.09	--
% of Federal Effort by Region	37.81	32.61	57.18	--
No. Traps Used in Federal Waters by Region	203,177.14	158,650.24	167,533.95	529,361.33
No. of Traps Used Landing on ASH	8,127.09	23,797.54	6,701.36	38,625.98
No. of Traps on ASH Mobilized by Tropical Weather Events	2,556.96	1,996.60	2,108.40	6,661.96
Area of ASH Impacted by Traps Mobilized During Tropical Weather Events (m^2)	11,097.22	8,665.23	9,150.45	28,912.90
No. of Traps on ASH Affected by Tropical and Non-Tropical Weather Events	2,353.63	1,837.82	1,940.73	6,132.19
Area of ASH Impacted by Traps Mobilized During Tropical and Non-Tropical Weather Events (m^2)	21,193.38	16,548.78	17,475.44	55,217.60
No. of Traps on ASH Mobilized by Non-Tropical Weather Events	3,216.49	2,511.59	2,652.23	8,380.31
Area of ASH Impacted by Traps Mobilized During Non-Tropical Weather Events (m^2)	15,003.49	11,715.43	12,371.44	39,090.36
Area of ASH Impacted Annually by Mobilized Traps (m^2)	47,294.09	36,929.44	38,997.33	123,220.85
No. *A. palmata* Colonies Impacted	32.63	25.48	26.91	85.02
Area of *A. palmata* Impacted by Mobilized Traps (m^2)	**0.61**	**0.47**	**0.50**	**1.58**

Total for All Regions				
	Fishing Season			
	2004-2005	2005-2006	2006-2007	2004-2005 through 2006-2007
Total Traps Issued[a]	477,227	479,536	466,686	1,423,449
% of All (State & Federal) Traps Pulled in Federal Waters for All Regions[b]	18.10	16.31	10.09	--
No. Traps Used in Federal Waters by Region	537,328.28	486,475.07	292,991.07	1,316,794.42
No. of Traps Used Landing on ASH	21,493.13	72,857.20	25,829.13	120,179.45
No. of Traps on ASH Mobilized by Tropical Weather Events	6,762.22	6,122.24	3,687.26	16,571.72
Area of ASH Impacted by Traps Mobilized During Tropical Weather Events (m^2)	29,348.04	26,570.52	16,002.72	71,921.28
No. of Traps on ASH Affected by Tropical and Non-Tropical Weather Events	6,224.48	5,635.39	3,394.05	15,253.91
Area of ASH Impacted by Traps Mobilized During Tropical and Non-Tropical Weather Events (m^2)	56,048.63	50,744.14	30,561.85	137,354.62
No. of Traps on ASH Mobilized by Non-Tropical Weather Events	8,506.43	7,701.37	4,638.33	20,846.14
Area of ASH Impacted by Traps Mobilized During Non-Tropical Weather Events (m^2)	39,678.67	35,923.45	21,635.74	97,237.86
Area of ASH Impacted Annually by Mobilized Traps (m^2)	125,075.34	113,238.11	68,200.32	306,513.77
No. *A. palmata* Colonies Impacted	193.48	183.18	87.26	463.92
Area of *A. palmata* Impacted by Mobilized Traps (m^2)	**2.86**	**2.68**	**1.35**	**6.89**

[a] FFWCC 2007; [b] Derived from FFWCC, unpublished data

Quantifying Adverse Effects to *Acropora* from Storm-Mobilized, Derelict Spiny Lobster Traps Over the 2004-2005 Through 2006-2007 Fishing Seasons

Since we addressed the impacts of storm-mobilized, buoyed traps in the previous section, our analysis now moves to estimating the impacts of storm-mobilized, unbuoyed traps lost in the environment. A number of traps are lost annually due to storm events, accidental cut-offs, etc., where the buoy is lost and fishers can no longer use the trap. We refer to these unbuoyed lost traps as 'derelict'. Derelict traps can adversely affect *Acropora* when they are mobilized by storm events. Our analysis assumes that after two years a derelict trap will have degraded to a point where it no longer poses a threat to *Acropora* (T. Matthews, FFWCC, pers. comm. 2007). This analysis uses the same basic process described in the previous section. However, it describes the process for estimating the number of traps lost, the number of derelict traps remaining, and how we quantified the impacts of storm-mobilized derelict traps. Tables A3.7 through A3.9 provide the information used and results of the analyses for all fishing years.

Estimating the Derelict Spiny Lobster Trap Impacts to ASH in the Upper Keys During the 2006-2007 Fishing Season

We started by using the same steps listed above to estimate the number of traps fished in the federal waters of the region each month (see Table A3.1). To estimate the number of those traps that became derelict, we multiplied those figures by the 20 percent trap loss rate estimated from FFWCC commercial fisheries mail surveys (unpublished data). Next, we multiplied our estimates of derelict traps by the mean percentage of lost traps recovered annually (5.5 percent, [FDEP 2001]) through marine debris recovery programs. Because specific trap degradation rates are unknown, we assumed half of the unrecovered traps degraded to a point where they would not damage *Acropora*. Therefore, we reduced our estimates of unrecovered derelict traps by half.

We multiplied our estimate of the number of derelict traps remaining in the environment by percentage of all traps likely to end up on ASH (15 percent). This produced an estimate of the number of derelict traps that landed on ASH in the Upper Keys, each month during the 2006-2007 fishing season. These values were then substituted into the analysis above in place of the federally fished traps landing on ASH.

Since the impacts of trap mobilization from tropical weather events are thought to be so great, we believe it is reasonable to use the largest area of impact recorded by Lewis et al. (in review) (4.96 square meters) when calculating impacts from these events. However, when evaluating the storm-mobilization impacts from non-tropical weather events we used the area of impact observed by Lewis et al. (in review) (0.75 square meters) for derelict traps. Table A3.6 summarizes these changes.

Table A3.6 Estimating Monthly and Annual Area of Impact from Storm-Mobilized Derelict Traps During the 2006-2007 Fishing Season

Month	No. Derelict Traps Remaining After Degradation	No. of Derelict Traps Landing on ASH	No. Tropical Storms (3.5/yr)	Individual Trap Area of Impact from Tropical Storms (m^2)	No. Non-Topical Storms (18/yr)	Individual Trap Area of Impact from Non-Tropical Storms (m^2)	Annual Area of Impact
Aug	5.53	0.83	0.875	4.96	0	0	3.60
Sep	5.29	0.79	0.875	4.96	0	0	3.44
Oct	5.08	0.76	0.875	4.96	2.57	0.75	4.78
Nov	4.87	0.73	0.875	4.96	2.57	0.75	4.58
Dec	4.42	0.66	0	0	2.57	0.75	1.28
Jan	3.79	0.57	0	0	2.57	0.75	1.10
Feb	3.07	0.46	0	0	2.57	0.75	0.89
Mar	2.33	0.35	0	0	2.57	0.75	0.67
Average	4.30	0.64	--	--	--	--	2.54
Total	34.38	5.16	--	--	--	--	20.33

Recalculating the area of ASH and number of *A. cervicornis* colonies impacted annually, we estimate 0.003 square meter of *A. cervicornis* was adversely impacted by mobilized, derelict traps off the Upper Keys after the 2006-2007 fishing season.

Adverse Effects to Acropora in the Remaining Regions During the 2004-2005 Through 2006-2007 Fishing Seasons

Throughout all regions of the Florida Keys, we estimate 6.03 square meters of *A. cervicornis* and 0.46 square meter of *A. palmata* were adversely affected by mobilized, derelict spiny lobster traps over these fishing seasons. Since the steps used to quantify the adverse effects to *Acropora* in the remaining regions of the Florida Keys are identical to the ones above, we do not provide a narrative of those calculations here. Table A3.7 summarizes the constants used in the analyses that remained the same across all fishing seasons. Tables A3.8 and A3.9 summarize the resulting calculations from each analysis.

Table A3.7 Constants Used in Storm-Mobilized, Derelict Trap Impact Analyses for Both Species

Parameter		Region		
		Upper Keys	Middle Keys	Lower Keys
Percentage of Trap Lost Annually[a]		20	20	20
Annual Average Percentage of Lost Trap Recovered[a]		5.5	5.5	5.5
Avg. Per Trap Area of Impact from Tropical System (m^2)[b]		4.96	4.96	4.96
Avg. No. of Tropical Storms Occurring Monthly (Aug.-Nov.)		0.875	0.875	0.875
Avg. Per Trap Area of Impact One Non-Tropical Weather Events (m^2)[b]		0.75	0.75	0.75
Avg. No. of Non-Tropical Weather Events Occurring Monthly (Oct.-Apr.)[b]		2.57	2.57	2.57
Area of ASH (m^2)[c]		83,712,586	54,579,251	45,989,091
Percentage of Traps Landing on ASH[d]	*A. cervicornis*	15	15	15
	A. palmata	4	4	4
Colonial Density (no./m^2)[e]	*A. cervicornis*	0.0078	0.0013	0.0394
	A. palmata	0.0094	0.0008	0.0297
Total No. of *Acropora* colonies in ASH	*A. cervicornis*	652,958	70,953	1,811,970
	A. palmata	136,452	112,870	31,372
Avg. Size (Surface Area) of Each Colony (m^2)[e]	*A. cervicornis*	0.021	0.014	0.0186
	A. palmata	0.122	0.101	0.148

[a]FDEP 2001; [b]Lewis et al. (in review); [c]NMFS unpublished data; [d]Matthews 2003; [e] Derived from Miller et al. 2007

Table A3.8 Impacts of Storm-Mobilized, Derelict Traps on *Acropora cervicornis*

Upper Keys				
	Fishing Season			
	2004-2005	2005-2006	2006-2007	2004-2005 through 2006-2007
Total Traps Issued[a]	477,227	479,536	466,686	1,423,449
% of All (State & Federal) Traps Pulled in Federal Waters for All Regions[b]	18.10	16.31	10.09	--
% of Federal Effort by Region	0.015	0.213	0.124	--
No. Traps Used in Federal Waters by Region	79.47	1,036.96	363.77	1,480.19
No. of Derelict Traps in Federal Waters	15.89	207.39	72.75	296.04
No. of Derelict Traps in Federal Waters Recovered	0.87	11.41	4.00	16.28
No. of Derelict Traps in Federal Waters Remaining	15.02	195.98	68.75	279.76
No. of Derelict Traps in Federal Waters After Degradation	7.51	97.99	34.38	139.88
No. of Derelict Traps in Federal Waters Affecting ASH	1.13	14.70	5.16	20.98
No. of Derelict Traps on ASH Mobilized by Tropical Weather Events	0.35	4.62	1.62	6.60
Area of ASH Impacted by Derelict Traps Mobilized During Tropical Weather Events (m^2)	1.54	20.07	7.04	28.65
No. of Derelict Traps on ASH Affected by Tropical and Non-Tropical Weather Events	0.33	4.26	1.49	6.08
Area of ASH Impacted by Derelict Traps Mobilized During Tropical and Non-Tropical Weather Events (m^2)	2.04	26.68	9.36	38.08
No. of Derelict Traps on ASH Mobilized by Non-Tropical Weather Events	0.45	5.82	2.04	8.30
Area of ASH Impacted by Derelict Traps Mobilized During Non-Tropical Weather Events (m^2)	0.86	13.94	3.93	18.73
Area of ASH Impacted Annually by Mobilized Derelict Traps (m^2)	4.44	60.69	20.33	85.46
No. *A. cervicornis* Colonies Impacted	0.035	0.473	0.159	0.667
Area of *A. cervicornis* Impacted by Mobilized Derelict Traps (m^2)	**0.001**	**0.010**	**0.003**	**0.014**

[a] FFWCC 2007; [b] Derived from FFWCC, unpublished data

Table A3.8 Continued

Middle Keys				
	Fishing Season			
	2004-2005	2005-2006	2006-2007	2004-2005 through 2006-2007
Total Traps Issued[a]	477,227	479,536	466,686	1,423,449
% of All (State & Federal) Traps Pulled in Federal Waters for All Regions[b]	18.10	16.31	10.09	--
% of Federal Effort by Region	62.17	67.17	42.70	--
No. Traps Used in Federal Waters by Region	334,071.67	326,787.88	125,093.35	785,952.90
No. of Derelict Traps in Federal Waters	66,814.33	65357.58	25,018.67	157,190.58
No. of Derelict Traps in Federal Waters Recovered	3,674.79	3,594.67	1,376.03	8,645.48
No. of Derelict Traps in Federal Waters Remaining	63,139.55	61,762.91	23,642.64	148,545.10
No. of Derelict Traps in Federal Waters After Degradation	31,569.77	30,881.45	11,821.32	74,272.55
No. of Derelict Traps in Federal Waters Affecting ASH	1,262.79	1,235.26	472.85	2,970.90
No. of Derelict Traps on ASH Mobilized by Tropical Weather Events	397.30	388.64	148.77	934.71
Area of ASH Impacted by Derelict Traps Mobilized During Tropical Weather Events (m^2)	1,724.29	1,686.70	645.66	4,056.65
No. of Derelict Traps on ASH Affected by Tropical and Non-Tropical Weather Events	365.71	357.73	136.94	860.38
Area of ASH Impacted by Derelict Traps Mobilized During Tropical and Non-Tropical Weather Events (m^2)	2,292.08	2,242.10	858.27	5,392.45
No. of Derelict Traps on ASH Mobilized by Non-Tropical Weather Events	499.78	488.88	187.14	1,175.81
Area of ASH Impacted by Derelict Traps Mobilized During Non-Tropical Weather Events (m^2)	963.33	2,039.78	360.72	3,363.83
Area of ASH Impacted Annually by Mobilized Derelict Traps (m^2)	4,979.70	5,968.58	1,864.65	12,812.93
No. *A. cervicornis* Colonies Impacted	6.47	7.76	2.42	16.66
Area of *A. cervicornis* Impacted by Mobilized Derelict Traps (m^2)	**0.09**	**0.11**	**0.03**	**0.23**

[a] FFWCC 2007; [b] Derived from FFWCC, unpublished data

Table A3.8 Continued

Lower Keys				
	Fishing Season			
	2004-2005	2005-2006	2006-2007	2004-2005 through 2006-2007
Total Traps Issued[a]	477,227	479,536	466,686	1,423,449
% of All (State & Federal) Traps Pulled in Federal Waters for All Regions[b]	18.10	16.31	10.09	--
% of Federal Effort by Region	37.81	32.61	57.18	--
No. Traps Used in Federal Waters by Region	203,177.14	158,650.24	167,533.95	529,361.33
No. of Derelict Traps in Federal Waters	40,635.43	31,730.05	33,506.79	105,872.27
No. of Derelict Traps in Federal Waters Recovered	2,234.95	1,745.15	1,842.87	5,822.97
No. of Derelict Traps in Federal Waters Remaining	38,400.48	29,984.89	31,663.92	100,049.29
No. of Derelict Traps in Federal Waters After Degradation	19,200.24	14,992.45	15,831.96	50,024.65
No. of Derelict Traps in Federal Waters Affecting ASH	768.01	599.70	633.28	2,000.99
No. of Derelict Traps on ASH Mobilized by Tropical Weather Events	241.63	188.68	199.24	629.56
Area of ASH Impacted by Derelict Traps Mobilized During Tropical Weather Events (m^2)	1,048.69	818.86	864.72	2,732.27
No. of Derelict Traps on ASH Affected by Tropical and Non-Tropical Weather Events	222.42	173.67	183.40	579.49
Area of ASH Impacted by Derelict Traps Mobilized During Tropical and Non-Tropical Weather Events (m^2)	1,394.00	1,088.50	1,149.46	3,631.96
No. of Derelict Traps on ASH Mobilized by Non-Tropical Weather Events	303.96	237.35	250.64	791.94
Area of ASH Impacted by Derelict Traps Mobilized During Non-Tropical Weather Events (m^2)	585.88	457.48	483.10	1,526.46
Area of ASH Impacted Annually by Mobilized Derelict Traps (m^2)	3,028.57	2,364.85	2,497.27	7,890.70
No. *A. cervicornis* Colonies Impacted	119.33	93.18	98.39	310.89
Area of *A. cervicornis* Impacted by Mobilized Derelict Traps (m^2)	**2.22**	**1.73**	**1.83**	**5.78**

[a] FFWCC 2007; [b] Derived from FFWCC, unpublished data

Table A3.8 Continued

Total for All Regions				
	Fishing Season			
	2004-2005	2005-2006	2006-2007	2004-2005 through 2006-2007
Total Traps Issued[a]	477,227	479,536	466,686	1,423,449
% of All (State & Federal) Traps Pulled in Federal Waters for All Regions[b]	18.10	16.31	10.09	--
% of Federal Effort by Region	--	--	--	--
No. Traps Used in Federal Waters by Region	537,328.28	486,475.07	292,991.07	1,316,794.42
No. of Derelict Traps in Federal Waters	107,465.66	97,295.01	58,598.21	263,358.88
No. of Derelict Traps in Federal Waters Recovered	5,910.61	5,351.23	3,222.90	14,484.74
No. of Derelict Traps in Federal Waters Remaining	101,555.05	91,943.79	55,375.31	248,874.15
No. of Derelict Traps in Federal Waters After Degradation	50,777.52	45,971.89	27,687.66	124,437.07
No. of Derelict Traps in Federal Waters Affecting ASH	2,031.93	1,849.65	1,111.29	4,992.87
No. of Derelict Traps on ASH Mobilized by Tropical Weather Events	639.29	581.94	349.64	1,570.87
Area of ASH Impacted by Derelict Traps Mobilized During Tropical Weather Events (m^2)	2,774.52	2,525.63	1,517.42	6,817.57
No. of Derelict Traps on ASH Affected by Tropical and Non-Tropical Weather Events	588.45	535.67	321.83	1,445.95
Area of ASH Impacted by Derelict Traps Mobilized During Tropical and Non-Tropical Weather Events (m^2)	3,688.13	3,357.29	2,017.08	9,062.50
No. of Derelict Traps on ASH Mobilized by Non-Tropical Weather Events	804.18	732.05	439.82	1,976.05
Area of ASH Impacted by Derelict Traps Mobilized During Non-Tropical Weather Events (m^2)	1,550.07	2,511.21	847.75	4,909.02
Area of ASH Impacted Annually by Mobilized Derelict Traps (m^2)	8,012.71	8,394.12	4,382.26	20,789.09
No. *A. cervicornis* Colonies Impacted	125.83	101.41	100.98	328.22
Area of *A. cervicornis* Impacted by Mobilized Derelict Traps (m^2)	**2.31**	**1.85**	**1.87**	**6.03**

[a] FFWCC 2007; [b] Derived from FFWCC, unpublished data

Table A3.9 Impacts of Storm-Mobilized, Derelict Traps on *Acropora palmata*

Upper Keys				
	Fishing Season			
	2004-2005	2005-2006	2006-2007	2004-2005 through 2006-2007
Total Traps Issued[a]	477,227	479,536	466,686	1,423,449
% of All (State & Federal) Traps Pulled in Federal Waters for All Regions[b]	18.10	16.31	10.09	--
% of Federal Effort by Region	0.015	0.213	0.124	--
No. Traps Used in Federal Waters by Region	79.47	1,036.96	363.77	1,480.19
No. of Derelict Traps in Federal Waters	15.89	207.39	72.75	296.04
No. of Derelict Traps in Federal Waters Recovered	0.87	11.41	4.00	16.28
No. of Derelict Traps in Federal Waters Remaining	15.02	195.98	68.75	279.76
No. of Derelict Traps in Federal Waters After Degradation	7.51	97.99	34.38	139.88
No. of Derelict Traps in Federal Waters Affecting ASH	0.30	3.92	1.38	5.60
No. of Derelict Traps on ASH Mobilized by Tropical Weather Events	0.09	1.23	0.43	1.76
Area of ASH Impacted by Derelict Traps Mobilized During Tropical Weather Events (m^2)	0.41	5.35	1.88	7.64
No. of Derelict Traps on ASH Affected by Tropical and Non-Tropical Weather Events	0.09	1.14	0.40	1.62
Area of ASH Impacted by Derelict Traps Mobilized During Tropical and Non-Tropical Weather Events (m^2)	0.55	7.11	2.50	10.16
No. of Derelict Traps on ASH Mobilized by Non-Tropical Weather Events	0.12	1.55	0.54	2.21
Area of ASH Impacted by Derelict Traps Mobilized During Non-Tropical Weather Events (m^2)	0.23	3.72	1.05	5.00
Area of ASH Impacted Annually by Mobilized Derelict Traps (m^2)	1.18	16.18	5.42	22.79
No. *A. palmata* Colonies Impacted	0.002	0.025	0.009	0.036
Area of *A. palmata* Impacted by Mobilized Derelict Traps (m^2)	**0.00004**	**0.00052**	**0.00019**	**0.00075**

[a] FFWCC 2007; [b] Derived from FFWCC, unpublished data

Table A3.9 Continued

Middle Keys				
	Fishing Season			
	2004-2005	2005-2006	2006-2007	2004-2005 through 2006-2007
Total Traps Issued[a]	477,227	479,536	466,686	1,423,449
% of All (State & Federal) Traps Pulled in Federal Waters for All Regions[b]	18.10	16.31	10.09	--
% of Federal Effort by Region	62.17	67.17	42.70	--
No. Traps Used in Federal Waters by Region	334,071.67	326,787.88	125,093.35	785,952.90
No. of Derelict Traps in Federal Waters	66,814.33	65,357.58	25,018.67	157,190.58
No. of Derelict Traps in Federal Waters Recovered	3,674.79	3,594.67	1,376.03	8,645.48
No. of Derelict Traps in Federal Waters Remaining	63,139.55	61,762.91	23,642.64	148,545.10
No. of Derelict Traps in Federal Waters After Degradation	31,569.77	30,881.45	11,821.32	74,272.55
No. of Derelict Traps in Federal Waters Affecting ASH	1,262.79	1,235.26	472.85	2,970.90
No. of Derelict Traps on ASH Mobilized by Tropical Weather Events	397.30	388.64	148.77	934.71
Area of ASH Impacted by Derelict Traps Mobilized During Tropical Weather Events (m^2)	1,724.29	1,686.70	645.66	4,056.65
No. of Derelict Traps on ASH Affected by Tropical and Non-Tropical Weather Events	365.71	357.73	136.94	860.38
Area of ASH Impacted by Derelict Traps Mobilized During Tropical and Non-Tropical Weather Events (m^2)	2,292.08	2,242.10	858.27	5,392.45
No. of Derelict Traps on ASH Mobilized by Non-Tropical Weather Events	499.78	488.88	187.14	1,175.81
Area of ASH Impacted by Derelict Traps Mobilized During Non-Tropical Weather Events (m^2)	963.33	2,039.78	360.72	3,363.83
Area of ASH Impacted Annually by Mobilized Derelict Traps (m^2)	4,979.70	5,968.58	1,864.65	12,812.93
No. *A. palmata* Colonies Impacted	10.30	11.71	3.86	25.86
Area of *A. palmata* Impacted by Mobilized Derelict Traps (m^2)	**0.14**	**0.16**	**0.05**	**0.36**

[a] FFWCC 2007; [b] Derived from FFWCC, unpublished data

Table A3.9 Continued

Lower Keys				
	Fishing Season			
	2004-2005	2005-2006	2006-2007	2004-2005 through 2006-2007
Total Traps Issued[a]	477,227	479,536	466,686	1,423,449
% of All (State & Federal) Traps Pulled in Federal Waters for All Regions[b]	18.10	16.31	10.09	--
% of Federal Effort by Region	37.81	32.61	57.18	--
No. Traps Used in Federal Waters by Region	203,177.14	158,650.24	167,533.95	529,361.33
No. of Derelict Traps in Federal Waters	40,635.43	31,730.05	33,506.79	105,872.27
No. of Derelict Traps in Federal Waters Recovered	2,234.95	1,745.15	1,842.87	5,822.97
No. of Derelict Traps in Federal Waters Remaining	38,400.48	29,984.89	31,663.92	100,049.29
No. of Derelict Traps in Federal Waters After Degradation	19,200.24	14,992.45	15,831.96	50,024.65
No. of Derelict Traps in Federal Waters Affecting ASH	768.01	599.70	633.28	2,000.99
No. of Derelict Traps on ASH Mobilized by Tropical Weather Events	241.63	188.68	199.24	629.56
Area of ASH Impacted by Derelict Traps Mobilized During Tropical Weather Events (m^2)	1,048.69	818.86	864.72	2,732.27
No. of Derelict Traps on ASH Affected by Tropical and Non-Tropical Weather Events	222.42	173.67	183.40	579.49
Area of ASH Impacted by Derelict Traps Mobilized During Tropical and Non-Tropical Weather Events (m^2)	1,394.00	1,088.50	1,149.46	3,631.96
No. of Derelict Traps on ASH Mobilized by Non-Tropical Weather Events	303.96	237.35	250.64	791.94
Area of ASH Impacted by Derelict Traps Mobilized During Non-Tropical Weather Events (m^2)	585.88	457.48	483.10	1,526.46
Area of ASH Impacted Annually by Mobilized Derelict Traps (m^2)	3,028.57	2,364.85	2,497.27	7,890.70
No. *A. palmata* Colonies Impacted	2.09	1.53	1.72	5.34
Area of *A. palmata* Impacted by Mobilized Derelict Traps (m^2)	**0.04**	**0.03**	**0.03**	**0.10**

[a] FFWCC 2007; [b] Derived from FFWCC, unpublished data

Table A3.9 Continued

Total for All Regions				
	Fishing Season			
	2004-2005	2005-2006	2006-2007	2004-2005 through 2006-2007
Total Traps Issued[a]	477,227	479,536	466,686	1,423,449
% of All (State & Federal) Traps Pulled in Federal Waters for All Regions[b]	18.10	16.31	10.09	--
% of Federal Effort by Region	--	--	--	--
No. Traps Used in Federal Waters by Region	537,328.28	486,475.07	292,991.07	1,316,794.42
No. of Derelict Traps in Federal Waters	107,465.66	97,295.01	58,598.21	263,358.88
No. of Derelict Traps in Federal Waters Recovered	5,910.61	5,351.23	3,222.90	14,484.74
No. of Derelict Traps in Federal Waters Remaining	101,555.05	91,943.79	55,375.31	248,874.15
No. of Derelict Traps in Federal Waters After Degradation	50,777.52	45,971.89	27,687.66	124,437.07
No. of Derelict Traps in Federal Waters Affecting ASH	2,031.10	1,838.88	1,107.51	4,977.48
No. of Derelict Traps on ASH Mobilized by Tropical Weather Events	639.03	578.55	348.45	1,566.03
Area of ASH Impacted by Derelict Traps Mobilized During Tropical Weather Events (m^2)	2,773.39	2,510.91	1,512.26	6,796.56
No. of Derelict Traps on ASH Affected by Tropical and Non-Tropical Weather Events	588.21	532.54	320.74	1,441.49
Area of ASH Impacted by Derelict Traps Mobilized During Tropical and Non-Tropical Weather Events (m^2)	3,686.63	3,337.72	2,010.22	9,034.57
No. of Derelict Traps on ASH Mobilized by Non-Tropical Weather Events	803.86	727.78	438.32	1,969.96
Area of ASH Impacted by Derelict Traps Mobilized During Non-Tropical Weather Events (m^2)	1,549.44	2,500.98	844.87	4,895.29
Area of ASH Impacted Annually by Mobilized Derelict Traps (m^2)	8,009.45	8,349.62	4,367.34	20,726.42
No. *A. palmata* Colonies Impacted	12.39	13.26	5.59	31.24
Area of *A. palmata* Impacted by Mobilized Derelict Traps (m^2)	**0.18**	**0.19**	**0.09**	**0.46**

[a] FFWCC 2007; [b] Derived from FFWCC, unpublished data

Appendix 4 Spiny Lobster Trap Effects on *Acropora* from Routine Fishing

Quantifying Adverse Impacts to *Acropora* from Routine Spiny Lobster Fishing Between 2004-2005 Through 2006-2007

The following illustrates in more detail the analysis conducted in section 5.5.2.4 on the impacts of routine spiny lobster fishing to *Acropora*. In this analysis, we quantify the impacts from traps being deployed during fishing (i.e., the impacts of traps being pulled off of or falling to the seafloor) or "trap pulls". Our analysis makes certain assumptions to overcome gaps in our knowledge. We use number of spiny lobster trap tags as a surrogate for the number spiny lobster traps. Since every spiny lobster trap must have a single trap tag, we assume that a spiny lobster tag translates to a single spiny lobster trap. To be conservative, we assume that all traps issued in the fishery will be used during the season. Additionally, because an individual trap can be pulled many times during a fishing season, our estimate of the number of traps pulled annually is greater than the number of individual traps issued. We also assume traps were set only in areas open to fishing; therefore, we used the average *Acropora* colonial density and size estimates calculated only for areas open to fishing.

To quantify the extent of adverse affects to *Acropora*, we conducted six different analyses, one for each species of *Acropora*, in each region of the Florida Keys (i.e., Upper, Middle, and Lower). As noted in Section 5.5.2.1, because of species distribution, we assume 4 percent of all federally fished traps will affect habitat supporting *A. palmata*, while we believe 15 percent of all federally fished traps will affect habitat supporting *A. cervicornis*. For consistency with the *Acropora* abundance and density data provided in Miller et al. (2007), our estimates of federal trap fishing effort have been segregated, to the greatest extent possible, to match the regions as they were defined in those reports. In the interest of brevity, only the narrative of the analysis conducted for *A. cervicornis* during the 2006-2007 fishing year in the Upper Keys appears below. The remaining analyses of routine fishing impacts use the same steps outlined below. Tables A4.2 through A4.4 provide the information used and results of the analyses for all fishing years.

Estimating the Spiny Lobster Trap Impacts to ASH in the Upper Keys During the 2006-2007 Fishing Season

The FFWCC issued 466,686 spiny lobster tags for the 2006-2007 fishing season. By multiplying that figure by the percentage of traps used each month during the fishing season (see Table A4.1) and summing the results, we estimated the total number of traps used each month. Matthews (2001) also reported the average soak time for each trap, in days per month, during an average season (see Figure A4.1.). Dividing the number of days in each month by the average soak time for each month we estimated the number of times an individual trap was pulled each month. By multiplying the average number of times an individual trap was pulled each month, by the number of traps used each month, we calculated the number of trap pulls each month. Summing those monthly values provided an estimate of 6,434,135 individual trap pulls in the entire fishery during the 2006-2007 fishing season. Using FFWCC Trip Ticket information, we estimated that

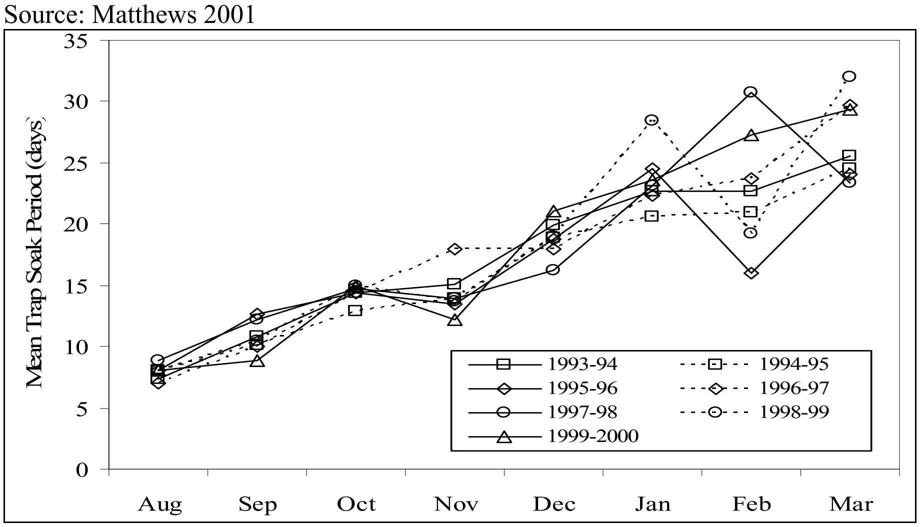
10.09 percent of all traps fished during the 2006-2007 fishing season were used in federal waters. Using that same database, we estimated 0.12 percent of all federally-fished traps were used in the Upper Keys. By multiplying the total number of trap pulls (6,434,135) by the percentage of trap pulls occurring in federal waters (10.09 percent), we estimated 649,204 trap pulls occurred in federal waters. Multiplying that figure by the percent of all federally-fished traps used in the Upper Keys (0.12 percent), we estimated 779.41 trap pulls occurred in the region during the season.

We estimated 116.91 pulled traps landed on ASH during the fishing season by multiplying our estimate of the number of traps pulled (779.41) by the percentage of traps that land on ASH (15 percent; Matthews [2003]). Since the footprint of each trap is approximately 0.49 square meter, the area of ASH impacted by those traps was 57.29 square meters.

Table A4.1 Percentage of Traps Used Each Month by Fishing Season
Source: Matthews 2001

	1993/94	1994/95	1995/96	1996/97	1997/98	1999/2000	Average by Month
August	100.00	100.00	100.00	100.00	100.00	100.00	100.00
September	97.63	98.18	94.73	96.80	89.34	97.36	95.67
October	96.69	95.83	92.75	96.33	87.52	82.56	91.95
November	90.00	91.11	89.47	92.70	90.35	75.35	88.16
December	80.08	85.04	82.40	84.48	79.18	68.62	79.97
January	68.14	74.09	71.33	71.48	67.50	58.57	68.52
February	58.67	62.06	59.75	55.29	51.25	46.12	55.52
March	45.12	47.79	47.78	42.94	35.90	33.25	42.13
Average by Yr	79.54	81.76	79.78	80.00	75.13	70.23	77.74

Figure A4.1 Mean Soak Time for Spiny Lobster Traps by Month
Source: Matthews 2001



Quantifying Adverse Effects to Acropora cervicornis in the Upper Keys
We estimated an *A. cervicornis* density of 0.0094 colonies/square meter of ASH, in areas open to fishing in the Upper Keys, from Miller et al. (2007). By multiplying this estimate by the area of ASH in the Upper Keys impacted by routine fishing (57.29 square meters), we estimated 0.54 *A. cervicornis* colonies were affected during the 2006-2007 fishing

season. By multiplying the number of colonies impacted (0.54) by the average area of each *A. cervicornis* colonies [0.0223 square meter; derived from Miller et al. (2007)], we estimated 0.012 square meter of *A. cervicornis* was adversely impacted by spiny lobster trap fishing in the Upper Keys, during the 2006-2007 fishing season.

Adverse Effects to Acropora in the Remaining Regions During the 2004-2005 Through 2006-2007 Fishing Seasons
Throughout all regions of the Florida Keys, we estimate 124.73 square meters of *A. cervicornis* and 0.062 square meter of *A. palmata* were adversely affected by routine spiny lobster fishing during the 2004-2005 through 2006-2007 fishing seasons. Table A4.2 summarizes the constants used in the analyses that remained the same across all fishing seasons. Tables A4.3 and A4.4 summarize the resulting calculations from each analysis.

Table A4.2 Constants Used in Routine Fishing Impact Analyses for Both Species

Parameter		Region		
		Upper Keys	Middle Keys	Lower Keys
Percentage of Traps Landing on ASH[a]	*A. cervicornis*	15	15	15
	A. palmata	4	4	4
Colonial Density (no./m^2)[b]	*A. cervicornis*	0.0094	0.0008	0.0297
	A. palmata	0.00031	0	0.00002
Avg. Size (Surface Area) of Each Colony (m^2)[b]	*A. cervicornis*	0.223	0.0054	0.0285
	A. palmata	0.1463	0	0.130
Total No. of *Acropora* colonies in ASH	*A. cervicornis*	786,898	43,663	1,365,876
	A. palmata	25,921	0	920
Spiny Lobster Trap Footprint (m^2)		0.49	0.49	0.49
Area of ASH (m^2)[c]		83,712,586	54,579,251	45,989,091

[a]Matthews 2003; [b] Derived from Miller et al. 2007;[c]NMFS unpublished data;

Table A4.3 Impacts of Routine Spiny Lobster Fishing on *Acropora cervicornis*

Upper Keys				
	Fishing Season			
	2004-2005	2005-2006	2006-2007	2004-2005 through 2006-2007
Total Traps Issued[a]	477,227	479,536	466,686	1,423,449
Total Traps Pulled During Season	6,579,462	6,611,296	6,434,135	19,624,892
% of All (State & Federal) Traps Pulled in Federal Waters for All Regions	18.10	16.31	10.09	--
% of Federal Effort by Region	0.01	0.21	0.12	--
No. Traps Pulled in Federal Waters by Region	119.12	2,264.70	779.41	3,163.23
No. of Individual Traps Used Landing on ASH	17.87	339.71	116.91	474.48
Area of ASH impacted by traps (m^2)	8.76	166.46	57.29	232.50
No. *A. cervicornis* Colonies Impacted	0.08	1.56	0.54	2.19
Total Area of *A. cervicornis* Adversely Impacted (m^2)	**0.0018**	**0.0349**	**0.0120**	**0.0487**
Middle Keys				
	Fishing Season			
	2004-2005	2005-2006	2006-2007	2004-2005 through 2006-2007
Total Traps Issued[a]	477,227	479,536	466,686	1,423,449
Total Traps Used During Season	6,579,462	6,611,296	6,434,135	19,624,892
% of All (State & Federal) Traps Pulled in Federal Waters for All Regions[d]	18.10	16.31	10.09	--
% of Federal Effort by Region	62.17	67.17	42.69	--
No. Traps Pulled in Federal Waters by Region	740,544.93	724,380.56	277,275.42	1,742,200.91
No. of Individual Traps Used Landing on ASH	111,081.74	108,657.08	41,591.31	261,330.14
Area of ASH impacted by traps (m^2)	54,430.05	53,241.97	20,379.74	128,051.77
No. *A. cervicornis* Colonies Impacted	43.54	42.59	16.30	102.44
Total Area of *A. cervicornis* Adversely Impacted (m^2)	**0.24**	**0.23**	**0.09**	**0.55**

[a] FFWCC 2007

Table A4.3 Continued

Lower Keys				
	Fishing Season			
	2004-2005	2005-2006	2006-2007	2004-2005 through 2006-2007
Total Traps Issued[a]	477,227	479,536	466,686	1,423,449
Total Traps Used During Season	6,579,462	6,611,296	6,434,135	19,624,892
% of All (State & Federal) Traps Pulled in Federal Waters for All Regions	18.10	16.31	10.09	--
% of Federal Effort by Region	37.81	32.61	57.18	--
No. Traps Pulled in Federal Waters by Region	450,378.06	351,675.60	371,389.29	1,173,442.94
No. of Individual Traps Used Landing on ASH	67,556.71	52,751.34	55,708.39	176,016.44
Area of ASH impacted by traps (m^2)	33,102.79	25,848.16	27,297.11	86,248.06
No. *A. cervicornis* Colonies Impacted	983.15	767.69	810.72	2,561.57
Total Area of *A. cervicornis* Adversely Impacted (m^2)	**28.02**	**21.88**	**23.11**	**73.00**

Total for All Regions				
	Fishing Season			
	2004-2005	2005-2006	2006-2007	2004-2005 through 2006-2007
Total Traps Issued[a]	477,227	479,536	466,686	1,423,449
Total Traps Used During Season	6,579,462	6,611,296	6,434,135	19,624,892
% of All (State & Federal) Traps Pulled in Federal Waters for All Regions	18.10	16.31	10.09	--
No. Traps Pulled in Federal Waters by Region	1,191,042.10	1,078,320.85	649,444.12	2,918,807.07
No. of Individual Traps Used Landing on ASH	178,656.32	161,748.13	97,416.62	437,821.06
Area of ASH impacted by traps (m^2)	87,541.59	79,256.58	47,734.14	166,798.18
No. *A. cervicornis* Colonies Impacted	1,026.78	811.85	827.57	2,666.19
Total Area of *A. cervicornis* Adversely Impacted (m^2)	**28.26**	**23.37**	**73.10**	**124.73**

[a] FFWCC 2007

Table A4.4 Impacts of Routine Spiny Lobster Fishing on *Acropora. palmata*

Upper Keys				
	Fishing Season			
	2004-2005	2005-2006	2006-2007	2004-2005 through 2006-2007
Total Traps Issued[a]	477,227	479,536	466,686	1,423,449
Total Traps Used During Season	6,579,462	6,611,296	6,434,135	19,624,892
% of All (State & Federal) Traps Pulled in Federal Waters for All Regions	18.10	16.31	10.09	--
% of Federal Effort by Region	0.01	0.21	0.12	--
No. Traps Pulled in Federal Waters by Region	119.12	2,264.70	779.41	3,163.23
No. of Individual Traps Used Landing on ASH	4.76	90.59	31.18	126.53
Area of ASH impacted by traps (m^2)	2.33	44.39	15.28	62.00
No. *A. palmata* Colonies Impacted	0.001	0.014	0.005	0.02
Total Area of *A. palmata* Adversely Impacted (m^2)	**0.0001**	**0.0020**	**0.0007**	**0.0028**
Middle Keys*				
	Fishing Season			
	2004-2005	2005-2006	2006-2007	2004-2005 through 2006-2007
Total Traps Issued[a]	477,227	479,536	466,686	1,423,449
Total Traps Used During Season	6,579,462	6,611,296	6,434,135	19,624,892
% of All (State & Federal) Traps Pulled in Federal Waters for All Regions	18.10	16.31	10.09	--
% of Federal Effort by Region	62.17	67.17	42.69	--
No. Traps Pulled in Federal Waters by Region	740,544.93	724,380.56	277,275.42	1,742,200.91
No. of Individual Traps Used Landing on ASH	29,621.80	28,975.22	11,091.02	69,688.04
Area of ASH impacted by traps (m^2)	14,514.68	14,197.86	5,434.60	34,147.14
No. *A. palmata* Colonies Impacted	0.00	0.00	0.00	0.00
Total Area of *A. palmata* Adversely Impacted (m^2)	**0.00**	**0.00**	**0.00**	**0.00**

[a] FFWCC, unpublished data

*Note: No *A. palmata* was found in the Middle Keys in areas open to fishing.

Table A4.4 Continued

Lower Keys				
	Fishing Season			
	2004-2005	2005-2006	2006-2007	2004-2005 through 2006-2007
Total Traps Issued[a]	477,227	479,536	466,686	1,423,449
Total Traps Used During Season	6,579,462	6,611,296	6,434,135	19,624,892
% of All (State & Federal) Traps Pulled in Federal Waters for All Regions	18.10	16.31	10.09	--
% of Federal Effort by Region	37.81	32.61	57.18	--
No. Traps Pulled in Federal Waters by Region	450,378.06	351,675.60	371,389.29	1,173,442.94
No. of Individual Traps Used Landing on ASH	18,015.12	14,067.02	14,855.57	46,937.72
Area of ASH impacted by traps (m^2)	8,827.41	6,892.84	7,279.23	22,999.48
No. *A. palmata* Colonies Impacted	0.18	0.14	0.15	0.46
Total Area of *A. palmata* Adversely Impacted (m^2)	**0.02**	**0.02**	**0.02**	**0.06**

Total for All Regions				
	Fishing Season			
	2004-2005	2005-2006	2006-2007	2004-2005 through 2006-2007
Total Traps Issued[a]	477,227	479,536	466,686	1,423,449
Total Traps Used During Season	6,579,462	6,611,296	6,434,135	19,624,892
% of All (State & Federal) Traps Pulled in Federal Waters for All Regions	18.10	16.31	10.09	--
No. Traps Pulled in Federal Waters by Region	1,191,042.10	1,078,320.85	649,444.12	2,918,807.07
No. of Individual Traps Used Landing on ASH	47,641.68	43,132.83	25,977.76	116,752.28
Area of ASH impacted by traps (m^2)	23,344.43	21,135.09	12,729.10	44,479.51
No. *A. palmata* Colonies Impacted	0.18	0.15	0.15	0.48
Total Area of *A. palmata* Adversely Impacted (m^2)	**0.023**	**0.020**	**0.020**	**0.062**

[a] FFWCC 2007

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 4
ATLANTA FEDERAL CENTER
61 FORSYTH STREET
ATLANTA, GEORGIA 30303-8960

June 1, 2011

Dr. Roy E. Crabtree
Regional Administrator
Southeast Regional Office
National Oceanic and Atmospheric Administration
263 13th Avenue South
St. Petersburg, Florida 33701

Subject: EPA NEPA Review Comments on NOAA's DEIS for "Amendment 10 to the Fishery Management Plan for Spiny Lobster in the Gulf of Mexico and South Atlantic"; CEQ #20110116

Dear Dr. Crabtree:

The U.S. Environmental Protection Agency (EPA) has reviewed the subject National Oceanic and Atmospheric Administration (NOAA) Draft Environmental Impact Statement (DEIS) in accordance with our responsibilities under Section 102(2)(C) of the National Environmental Policy Act (NEPA) and Section 309 of the Clean Air Act. EPA understands that the purpose and need for Amendment 10 is to bring the spiny lobster fishery management plan into compliance with new requirements of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) and to meet requirements of the Endangered Species Act (ESA). EPA also understands that the spiny lobster fishery management plan (FMP) is the jointly managed by the Gulf of Mexico and South Atlantic Fishery Management Councils (Councils).

It is our understanding that NOAA proposes 11 actions within the DEIS which include: 1) removal of lobster species from the FMP; 2) modification of maximum sustainable yield (MSY), overfishing & overfished; 3) establishment of sector allocations; 4) establishment of an acceptable biological catch (ABC) rule, annual catch limits (ACL), annual catch targets (ACT); 5) establishment of accountability measures (AM); 6) update of the framework procedure and protocol for enhanced cooperative management; 7) modification of regulations regarding use of undersized lobster as attractants; 8) modification of regulations regarding tailing permits; 9) closure of areas to protect threatened coral species; 10) requirement of trap line markings; and 11) removal of derelict traps.

The proposed action will impact the management of the following species[1]:

- Caribbean spiny lobster, *Panulirus argus*
- Smoothtail spiny lobster, *Panulirus laevicauda*

[1] P. S-3

- Spotted spiny lobster, *Panulirus guttatus*
- Spanish slipper lobster, *Scyllarides aequinoctialis*
- Ridged slipper lobster, *Scyllarides nodifer*

EPA has a responsibility to review and comment on major Federal actions significantly affecting the quality of the human environment, including FMPs and FMP Amendments (Amendments) as developed, approved, and implemented under the MSA where those Plans and Amendments are subject to the EIS requirement of NEPA, but it should be clear that we defer to NOAA and the Councils as to the development of fishery statistics and the relative importance of the commercial and recreational fisheries for each species.

EPA appreciates that several alternatives for proposed actions were presented and that preferred alternatives were identified in the DEIS. Based on our review, we offer the following comments for the preferred alternatives for the 11 actions covered within the DEIS.

Actions and Alternatives:

Action – 1: Removal of lobster species from the FMP

- It is unclear from the table on page S-6 if all four of the species listed under the preferred alternative are being removed from the FMP, although it is somewhat clarified at the bottom of the page with a small table that has proposed species for removal. EPA notes that the text on page 17 is also unclear regarding how many species are being proposed for removal from the FMP. Later in the DEIS it is stated that **preferred alternative 4** would remove any or all of the other lobster species from the FMP.[2] EPA recommends that the preferred alternative in the FEIS specifically identify which species are being proposed for removal from the FMP.
- It is stated in the summary section of the DEIS that two species are currently managed under the existing FMP, while five species are included in plan. It is unclear in the summary section which species are currently managed in the FMP. EPA recommends clarification in the FEIS.
- EPA recommends additional discussion in the FEIS on why certain species are not managed under the existing FMP.
- It is stated in the DEIS that some of the species proposed for removal may not meet the National Standard 1 guidelines for an ecosystem component species designation. Based on our review of the DEIS it is our understanding that designating species as ecosystem component species as proposed under **alternative 3** would allow for continued data collection. This additional data could be used to determine if future management is needed. EPA recommends additional discussion be provided in the FEIS regarding the "pros and cons" of listing or not listing species as ecosystem component species.

[2] P. 115

Action 2: Modification of MSY, overfishing & overfished

- EPA defers to the Councils in setting the Maximum Sustainable Yields, Overfishing and Overfished Thresholds for the Caribbean Spiny Lobster.
- Under the preferred alternative the Councils propose to use 7.90 million pounds for the MSY proxy, which is the overfishing limit recommended by the Gulf of Mexico Scientific and Statistical Committee (Gulf SSC). The FEIS should provide further discussion on how the MSY proxy value was derived by the Gulf SSC.

Action 3: Establishment of sector allocations

- EPA defers to the Councils in establishment of sector allocations.
- The following statement is made when referring to the potential for ecological, biological, and physical impacts of setting sector allocations under Action 3, "The range of commercial allocations (74-80%) is not sufficient to affect the number of lobster traps used so there would be no change in the impacts from lobster traps."[3] EPA believes that additional background on the potential impacts to the environment from commercial versus recreational fishing for Caribbean Spiny Lobster should provided in the FEIS. This additional information should be presented in a manner to assist the reader in understanding the true environmental impact of setting versus not setting sector allocations.

Action 4: Establishment of ABC, ACL, ACT

- EPA defers to the Councils in setting acceptable biological catch control rules, annual catch limits, and annual catch targets for the Caribbean Spiny Lobster, however EPA does request clarification on **preferred alternative 2 option C**. Specifically, EPA recommends additional information be provided in the FEIS regarding the basis for setting the ACT at 6.0 million pounds.
- Two preferred alternatives are selected for the ACT on page S-11, while only one preferred alternative is selected for the ACT on page 29. The preferred alternative should be clearly defined in the FEIS.
- A description of the relevance of bolding certain values in Table 4.4.2.2 should be provided in the FEIS. EPA notes that the discussion provided on the proceeding page (p.136) does provide some clarification of this table.

Action 5: Establishment of accountability measures

- EPA defers to the Councils in establishment of accountability measures.
- A note provided at the top of page 31 indicates that more than one alternative, option, sub-option, or combination thereof, may be chosen as preferred, yet **alternative 4** is selected as the preferred alternative. EPA suggests clarification in the FEIS regarding the selection of a preferred alternative.

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[3] P. 128

- Under the preferred alternative, **alternative 4**, the Councils propose to use an ACT of 6.0 million pounds as the AM. As stated above, EPA recommends additional information be provided in the FEIS regarding the basis for setting the ACT at 6.0 million pounds.

Action 6: Update of the framework procedure and protocol for enhanced cooperative management

- EPA notes that two preferred alternatives have been selected under Action 6. The first preferred alternative (**alternative 2**) addresses the current Protocol for Enhanced Cooperative Management and the other (**alternative 4: option a**) addresses the current Regulatory Amendment Procedures to develop a Framework Procedure to modify ACLs and AMs. EPA finds the discussion of Action 6 to be somewhat confusing for the reader, since two preferred alternatives have been selected and essentially two actions are being discussed. It may be more appropriate to separate Action 6 into two separate actions with their own alternatives analysis.
- Although EPA does not oppose the selection of **alternative 4: option a** as one of the preferred alternatives under Action 6, we do encourage more robust public involvement/engagement similar to **alternative 4: option c**.
- The preferred alternative should be labeled in table 2.6.2.

Action 7: Modification of regulations regarding use of undersized lobster as attractants

- EPA notes that preferred **alternative 4** tracks the State of Florida regulations and would make enforcement more effective.
- EPA agrees that bringing federal regulations more in line with the State of Florida regulations for the possession and handling of juvenile Caribbean Spiny Lobsters as "undersized attractants" will ease some of the enforcement concerns. However, EPA notes that the preferred alternative is less protective of juvenile Caribbean Spiny Lobsters than the existing regulation, 50CFR 640.21 (c), which allows no more than 50 undersized Caribbean Spiny Lobsters, or one per trap aboard the vessel, whichever is greater. Based on EPA's understanding of the preferred alternative, a fisherman could possess 50 juvenile Caribbean Spiny Lobsters in addition to one per trap. As started in the DEIS, some mortality, although low, would be expected. EPA finds it unclear why fisherman would need more juvenile Caribbean Spiny Lobsters than traps aboard. Please clarify in the FEIS.

Action 8: Modification of regulations regarding tailing permits;

- EPA supports the selection of both preferred **alternatives 3 and 4**, which would result in the greatest biological benefit.
- EPA recommends combining **alternatives 3 and 4** into a fifth alternative, since both have been selected as the preferred alternative. This would allow for the selection of alternative 3, 4, or a combination of the two.

Action 9: Closure of areas to protect threatened coral species

- A note provided at the top of page S-22 indicates that more than one alternative may be chosen as preferred, yet only one alternative is selected as the preferred throughout the DEIS (with one exception on p. 167), **alternative 3: option a**. The preferred alternative should be clearly defined in the FEIS.
- EPA notes that **alternative 2** would provide the greatest biological benefit to the *Acropora* corals but would also have the greatest economic impact because it would close approximately 73 square miles of the EEZ off Florida to trapping. EPA recommends that quantification of economic impacts in the context of all of the alternatives be included in the FEIS. This additional information would assist the reader in understanding the potential economic impact of the proposed alternatives.
- EPA notes the statement: "Alternative 4 differs from Preferred Alternative 3 in that it covers all fishing for spiny lobster, but the economic difference may be small if the waters are sufficiently deep that the lobsters are accessible primarily with traps and not diving."[4] It is unclear why **alternative 4: option a** was not selected as the preferred alternative, due to being more protective of the *Acropora* corals and minimal differences of economic impact between **alternative 3: option a** and **alternative 4: option a**. EPA notes that the Councils' decision may be based on Action 1 – removal of species from the FMP, but this should be made clear in the FEIS. In addition, as stated in the DEIS, "alternative 4 would be easier to enforce because any boat in a closed area with lobster on board would be in violation of regulations."[5] EPA recommends additional clarification in the FEIS regarding why **alternative 3: option a** was selected as the preferred alternative.

Action 10: Requirement of trap line markings

- Action 10 appears to be specific to gear markings for spiny lobster traps used in the EEZ off Florida only. Although EPA notes that the majority of the Caribbean Spiny Lobster fishing takes place off the coast of Florida, it is unclear why a similar action hasn't been proposed for gear markings off waters in other states covered by this DEIS (North Carolina, South Carolina, Georgia, Alabama, Mississippi, Louisiana, and Texas).

Action 11: Removal of derelict traps

- Similar to Action 10, Action 11 appears to be specific to the removal of derelict or abandoned spiny lobster traps found in the EEZ off Florida only. EPA is unclear on why similar action is not being proposed for the removal of traps off waters in other states covered by this DEIS (North Carolina, South Carolina, Georgia, Alabama, Mississippi, Louisiana, and Texas).

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[4] P. 176
[5] P. 178

General Comments:

Demographics/Social Vulnerability - EPA appreciates NOAA's efforts to evaluate potential environmental justice issues posed by Amendment 10 of the Spiny Lobster Fishery Management Plan. The DEIS examines county and state demographics for minority and low-income populations using 2000 and 2007 estimates from the U.S. Census Bureau. According to the DEIS, the demographic information presented includes those South Florida Counties that are most reliant on Spiny Lobster, commercially and recreationally. According to the DEIS, there are two coastal Florida counties (Miami-Dade and Broward Counties) along the proposed Fishery-Management areas that are considered minority and/or low-income. Both counties contain substantial minority populations. Miami-Dade County also has a substantial percentage of residents living below poverty relative to the state (16.1% vs. 12.6%). EPA notes a demographic error on page 108 which indicates that the residents in Miami-Dade are **74.4%** White (77.8% State) and **61.7%** Hispanic populations (20.5% State). We are also unclear why the county demographics in other coastal states affected by this fishery management plan are not included in the DEIS. EPA request clarification on how the fishing port cities and counties were determined to be "representative" of the fisheries of concern.

EPA appreciates the inclusion of the map in the DEIS of South Florida Counties with fishing communities that are geocoded based on their social vulnerability (i.e., unemployment, poverty, education, etc) using 2000 Census data. The social vulnerability map indicates that fishing communities in Miami-Dade, Martin, Palm Beach, Sarasota, St. Lucie, and Charlotte Counties are highly vulnerable to coastal environmental hazards and social disruptions including regulatory changes.[6]

Environmental Justice – Although proposed FMPs/Amendments are implemented for the sake of recovering the fishery, they can have societal effect on fishers. These affects can be equally or unequally distributed among fishers. Section 3.5.1. (Page 112) states that, "it is anticipated that the impacts of this amendment may affect communities with environmental justice concerns..." It is then stated that the impacts of Amendment 10 should not discriminate against any group and implies that the FMP will affect all groups in the same manner. While this may be true, the effect of the impact may vary based on the vulnerability of populations affected. For example, the DEIS documents landings and values for the top fifteen species for several coastal areas in south Florida (Figures 3.5.3 – 3.5.14). According to the DEIS, Caribbean spiny lobster is by far the most valuable species landed in Miami with over 60% of the value of the total landings and accounting for over 30% of the landings (Figure 3.5.12),[7] yet Miami-Dade County has higher than average poverty and is listed as highly vulnerable (Figure 3.5.1) which is not the case for other coastal areas described in the DEIS.

Public Participation – It is important to incorporate and discuss the public participation activities related to EJ associated with the project. There is no discussion of the public participation process related to EJ communities. Given that two coastal counties Miami-

[6] P. 99
[7] P. 108

Dade and Broward have substantial Hispanic populations, the DEIS should include some discussion about the strategies used to meaningfully engage or outreach to these communities in the decision-making and assessment process (i.e., Spanish materials/translators provided during the public involvement process, etc). EPA notes that two public hearing were held to discuss the Spiny Lobster Amendment 10, one in Key West Florida and the other in Marathon Florida (Appendix F). However, it is not clear that representatives of these communities were involved or that any issues they have were identified. EPA recommends more EJ specific outreach efforts for these public participation opportunities.

Section 5 – Fishery Impact Analysis/Social Impact Statement
No information is provided under this section in our copy of the DEIS. Please provide Section 5 in the FEIS.

Color Figures and Tables in DEIS
EPA found figures and tables in the DEIS copies delivered to the Region very difficult to review. Several figures and tables required color copies to interpret. EPA was able to download a pdf version off the Council's website for review. For future documents, please provide color copies of documents that require color to interpret. EPA does note that NOAA provided additional color copies of proposed closure areas which were helpful.

EPA DEIS Rating:

Although some clarification comments were offered for this DEIS, EPA generally supports NOAA and the Councils on Amendment 10 and gives deference to their fishery expertise. Therefore, EPA rates this DEIS as "LO" (Lack of Objections). Nevertheless, we request that NOAA and the Councils directly respond to our comments in a dedicated section of the FEIS.

EPA appreciates the opportunity to review the DEIS. Should NOAA have questions regarding our comments on the Amendment actions, please feel free to contact Dan Holliman at 404/562-9531 or holliman.daniel@epa.gov and for EJ comments please contact Ntale Kajumba at 404/562-9620 or kajumba.ntale@epa.gov of my staff.

Sincerely,

Heinz J. Mueller
Chief, NEPA Program Office
Office of Policy and Management

Appendix K. Response to DEIS Comments

Including comments from the EPA, 6 comments were received from individuals and organizations during the 45-day comment period on the DEIS. The following is a response to these comments. The EPA classified the DEIS and proposed actions as "LO" (Lack of Objections) and will publish these findings in the Federal Register. The following are responses to the public comments received. All comments received were posted to Federal e-Rulemaking Portal (http://www.regulations.gov, docket number: **NOAA-NMFS-2011-0106**).

Comment 1: The Councils and NMFS should be more conservative and set an ACL less than the ten-year mean.

Response: The preferred alternative for Action 4-2 sets ACL at 7.32 mp based on the recommendation for ABC by the Gulf SSC. Based on population genetics and physical transport data, juvenile spiny lobster that settle in south Florida have a high probability of recruiting from several spawning populations throughout the greater Caribbean and are not locally self-recruited. Therefore, landings in south Florida are unlikely to have a substantial effect on future recruitment there. In addition, current effort is limited by the number of trap tags issued by the State of Florida, commercial and recreational bag limits, and the length of the fishing season. Although fishers could fish more often and fish during a longer part of the season to increase effort, they presumably are already fishing at the level they desire because regulations do not prohibit such increased effort. Further, the preferred alternative for Action 4-3 sets an ACT at 90% of the ACL. If the ACT is exceeded in any year, the Council will convene a scientific review panel to consider if changes to the ACL, ACT, or accountability measures are needed to prevent landings from exceeding the ACL.

Comment 2: Tailing and the tailing permit should be eliminated. Law enforcement concerns still exist, especially concerning spearing of lobster and removing the tail to hide it.

Response: Under the preferred alternative, all vessels would be required to have either 1) a federal spiny lobster permit or 2) a Florida Restricted Species Endorsement and a Crawfish Endorsement associated with a Florida Saltwater Products License to obtain a tailing permit. Applications and renewals of the federal tailing permit by state permit holders would require those individuals to submit a copy of their SPL. These requirements would restrict federal tailing permits to only commercial lobster fishermen. Thus recreational divers could not obtain a tailing permit and use that to conceal illegal activity. Commercially permitted lobster divers would still be able to obtain a tailing permit and unscrupulous fishermen could remove evidence of the illegal act of spearing a spiny lobster.

Comment 3: Trap line markings need more discussion before implementation. The requirement is unnecessary and burdensome, fishermen already mark traps and buoys, and entanglements are rare.

Response: The Council chose "no action" as their preferred alternative for Action 10. Additional meetings with fishermen and other stakeholders will take place to determine the least burdensome method for trap line marking.

Comment 4: The Council and NMFS should not implement regulations on lobster before considering regulations to fish for Goliath grouper because Goliath grouper eat lobster.

Response: Many species prey on spiny lobster, particularly juvenile lobster. Gray triggerfish and octopus are considered particularly aggressive predators. The harvest of goliath grouper in the Gulf EEZ was prohibited under Reef Fish Amendment 2. Until a new stock assessment shows this species is no longer overfished, the moratorium is expected to continue.

Comment 5: Amendment 10 is not sufficient to prevent overfishing and keep landings within the ACL. Specifically, the preferred alternative for Action 5 to use the ACT as an accountability measure is not sufficient. Smooth-tailed spiny lobster, spotted spiny lobster, and Spanish slipper lobster should be ecosystem component species to promote ecosystem-based management and provide precautionary protection to the species.

Response: Currently, no quotas constrain harvest of Caribbean spiny lobster; commercial trap fishing for Caribbean spiny lobster is managed by restricting the number of trap tags issued by the State of Florida. Therefore, unless the state increases the number of trap tags it distributes, the number of traps could not increase even if more landings were allowed. Although fishers could fish more often and fish during a longer part of the season to increase effort, they presumably are already fishing at the level they desire because regulations do not prohibit such increased effort.

The preferred alternative for ACT is 90% of the ACL (6.59 mp). If this level of landings is exceeded during any fishing year, the Council would convene a scientific panel to review the ACL, ACT, and accountability measures. Although this would not prevent an overage of the ACL, landings are unlikely to increase so rapidly as to exceed the 10% buffer between the ACT and the ACL. Landings have not been higher than the ACL (7.32 mp) since the 2000/2001 fishing season, and the recent 10-year average is nearly 2 mp less than the ACL.

Based on the current data collection programs, if species were removed from the FMP, but landed and sold to a federal dealer, landings data would still be recorded for these species. This would negate any reason to designate them as ecosystem component species for data collection purposes alone. Further if the Councils chose to establish regulations for these species then they would have to be listed within the FMU which requires a full plan amendment to do so, regardless of if they are currently in the FMP or not.

Comment 6: From the EPA (see Appendix J).

Response: <u>Action 1</u> – All of the comments under this action were addressed in the FEIS in the sections referred to in the EPA comments. However, the team would like to clarify the fourth bullet regarding this action. Our understanding is the Council's designation of species as "ecosystem component species" does not in itself provide better data collection. The current federal recreational system would need to be modified to include invertebrates in addition to finfish. Further any species landed at a federally authorized dealer would be recorded, regardless of whether the species is in a fishery management plan or not. If the Councils chose to leave these species in the FMP and want to establish regulations they would have to place them within the Fishery Management Unit to do so and this action requires a full plan amendment. Therefore, designating species as ecosystem component species for data collection purposes only would not provide any additional benefits under the current system. The team included this information in the FEIS in Section 2.1 and 4.1.

Action 2 – *The discussion of the derivation of the MSY proxy was expanded in the FEIS in Section 2.2.*

Action 3 – *Section 4.9.1 of Amendment 10 includes information on potential commercial trap impacts on the environment. Section 3 of the Biological Opinion includes information on the potential impacts from the commercial and recreational spiny lobster fisheries on Acropora spp. Impacts to targeted and non-targeted species are discussed in the Bycatch Practicability Analysis;a reference to this has been added in Section 4.3. Given that potential impacts from the spiny lobster fishery is at most temporary and insignificant, establishing allocations would not impact the environment and potential commercial allocations of 74-80% would have no affect on the environment either.*

Action 4 – *Subsequent to publication of the DEIS, the Councils changed the preferred alternative for ACT during their June 2011 joint meeting. The ACT is set at 90% of ACL, providing a 10% buffer from ACL. The rationale for this decision is included in the FEIS in Sections 2.4 and 4.4. The other comments were also addressed in the FEIS in the sections referred to in the EPA comments.*

Action 5 - *The note at the top of page 31 has been removed because a single preferred alternative has been chosen. Subsequent to the publication of the DEIS, the Council changed their preferred alternative for ACT to equal a value that is 90% of the ACL or 6.59 million pounds. If the ACT is exceeded it would automatically trigger an AM whereby the Council will convene a review panel to assess whether or not corrective action is needed to prevent the ACL from being exceeded. An expanded discussion of this AM has been incorporated into the document in Sections 2.5 and 4.5.*

Action 6 – *The Councils chose to keep the Protocol and Procedure in one action. The Councils felt the level of public involvement under the Base Procedure (public comment during at least one Council meeting) was sufficient for routine actions that would be developed under the framework. The preferred alternative is indicated in Table 2.6.2*

Action 7 - *The document states the purpose of keeping 50 or more spiny lobsters onboard is to ensure there is an adequate supply of attractants during the baiting process for each trap, i.e., some traps will be onboard being baited while others would be in the water with baits already in them. Sections 2.7 and 4.7 have been updated.*

Action 8 - *Alternatives 3 and 4 were added to the document at separate Gulf and South Atlantic Council meetings and chosen as preferreds at separate Gulf and South Atlantic Council meetings. During the amendment development process neither Council requested the two alternatives be combined to make a new alternative. Choosing multiple preferred alternatives for a single action is a common practice with the Gulf and South Atlantic Councils; keeping the two alternatives separate avoids confusion and redundancy. Both course of action were analyzed in the EIS, and adding a combined alternative would not alter the substance of that analysis.*

Action 9 – *The summary has been updated. The preferred alternative for this action was changed to No Action at the June 2011 joint Council meeting. Closure of areas to protect Acropora spp. will be addressed in Amendment 11, including clarification of the economic impacts and the rationale for the Council preferred.*

Actions 10 and 11 – *Language was added to the beginning of Sections 2.10 and 2.11 explaining that the Biological Opinion only anticipated effects from spiny lobster trapping in federal waters adjacent to Florida, and therefore, actions to minimize those impacts only focus on that area.*

Response to General Comments

Social Environment/Environmental Justice
With regard to comments to the demographics and social vulnerability, it should be pointed out that the error that was noted for Miami-Dade census demographics is not an error. The seemingly contradictory statistic is an artifact of the census questionnaire, as Hispanic is not considered a race and that statistic is derived from a different question on the census form. Therefore, an individual can be both White and considered Hispanic, just as they can be considered any race and Hispanic. The minority threshold that is used for Environmental Justice is the inverse of the White alone, non-Hispanic variable included in the census demographics.

In response to why only Florida Counties where chosen for description of the social environment, the focus on south Florida is due to the nature of the fishery which is prosecuted primarily in Miami-Dade and Monroe Counties. Communities chosen for more detailed description were chosen based upon their ranking within what is called their "regional quota" (rq) the proportion of landings and value of community landings out of total landings for the region. All communities in both regions are located in Florida and as can be seen in the graphics presented for both regions (Figures 3.5.2 & 3.5.10), the communities in the lower portion of the top fifteen communities have less than 1% of landings and value from spiny lobster. Therefore those with fewer landings and value were not considered to be susceptible to impacts from the impending regulations as lobster is not an important part of overall landings. We do not have data refined to the individual or vessel level within communities to be able to analyze such impacts at this time.

Because we do not have demographic data on fishermen within the lobster fishery that would allow us to identify those who live below the poverty level or even those who are Hispanic (the only count would have to be those with Hispanic names), it is difficult to judge how those populations would be affected by actions within this amendment. While it is true that minorities and those below the poverty line do suffer more negative impacts from social disruption, we cannot state with certainty that they will be affected negatively from these actions. Therefore, we attempt to identify where vulnerable populations may be and hope that through public comment any specific issues that may be related to that vulnerability will be identified.
Concerning public participation, after submitting the DEIS to EPA, the summary document for this amendment was translated into Spanish by South Atlantic Council staff. An informational meeting was organized by local Sea Grant agents in Key West and a Spanish translator was brought in to assist with the discussion. Additionally, during public testimony at the Council meeting in Key West, a translator was also present to assist with testimony. In the future, outreach targeted to these populations will continue to ensure that these communities are well informed and have an opportunity to offer comments related to their involvement.

Comment-No information is provided under this section in our copy of the DEIS.
Section 5 – The Fishery Impact Statement is included in the FEIS.

Larval Connectivity and the International Management of Fisheries

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Abstract

Predicting the oceanic dispersal of planktonic larvae that connect scattered marine animal populations is difficult, yet crucial for management of species whose movements transcend international boundaries. Using multi-scale biophysical modeling techniques coupled with empirical estimates of larval behavior and gamete production, we predict and empirically verify spatio-temporal patterns of larval supply and describe the Caribbean-wide pattern of larval connectivity for the Caribbean spiny lobster (Panulirus argus), an iconic coral reef species whose commercial value approaches $1 billion USD annually. Our results provide long sought information needed for international cooperation in the management of marine resources by identifying lobster larval connectivity and dispersal pathways throughout the Caribbean. Moreover, we outline how large-scale fishery management could explicitly recognize metapopulation structure by considering larval transport dynamics and pelagic larval sanctuaries.

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Competing Interests: The authors have declared that no competing interests exist.

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Introduction

The lifecycle of most marine animals includes a dispersive planktonic larval stage lasting hours to months that connects scattered populations. Therefore, knowledge of larval connectivity is crucial for understanding population dynamics and sustainably managing marine taxa whose biogeographic distributions rarely coincide with political boundaries. Recent studies of larval connectivity employing natural or artificial tags [1–3], biophysical modeling [4–6], tracking of larval patches [7], and genetic analysis [8–10] have revealed surprising levels of population self-recruitment, eclipsing the long-held paradigm that marine populations are largely "open" and dependent upon an exogenous supply of larvae [11]. As compelling as these findings are, the ability to predict the actual dispersal of larvae from spawning grounds to nurseries remains a rare exception. Here, we describe how an empirically parameterized biophysical model provides estimates of larval supply and may be used to pinpoint larval origins, destinations, and pathways for one of the Caribbean's most valuable marine species - the spiny lobster, *Panulirus argus*.

The Caribbean spiny lobster is a ubiquitous inhabitant of coral reefs and shallow tropical seas in the tropical West Atlantic. Commercial fishermen and recreational divers in over 30 Caribbean nations harvest lobsters, a resource valued at nearly $1 billion USD annually [12]. Like most marine animals, *P. argus* has a complex life cycle: adults inhabit coral reefs where they spawn, their planktonic larvae (phyllosoma) mature in the open sea and engage in diurnal and ontogenetic vertical migration during dispersal before returning to coastal nurseries in shallow, vegetated habitats [13]. Given the long pelagic larval duration (PLD) of this species (5–9 months) [14], larvae potentially disperse among lobster populations throughout the Caribbean [15]. Genetic analyses support the hypothesis of a single "pan-Caribbean" lobster metapopulation [16–18], indistinguishable within the Caribbean but distinct from a closely related species off the coast of Brazil [19].

Frequent and widespread dispersal of larvae can mask genetically distinct subpopulations, whereas demographic connectivity - the frequent (i.e., weeks to years) exchange of individuals within a metapopulation - is a fundamental ecological process relevant to the management of marine fisheries and protected areas [20]. Studies of demographic connectivity have largely focused on taxa with short PLDs (e.g., bivalves and reef fish) and though valuable scientific contributions, they likely bias our understanding of connectivity at the larger spatial scales most important for marine resource management [21]. Demographic connectivity among distant (>1000 km) populations is virtually undetectable given current tagging methods and genetic techniques [22,23]. For this less tractable circumstance, biophysical modeling is a fast and affordable tool that is unhindered by the PLD of target species; moreover it permits the evaluation of hypothetical management strategies on larval connectivity within marine metapopulations [24].

To identify the origins, destinations, and dispersal corridors of spiny lobster larvae within and among Caribbean nations, we used an open source, multi-scale coupled biophysical larval transport model [25] built from an earlier configuration of a Lagrangian individual-based model [26]. The model has four components: 1) a GIS-based benthic module representing habitat for lobster spawning and recruitment, 2) a physical oceanographic module (Figure 1) containing daily 3-D current velocities from an array of hydrodynamic models, 3) a larval biology module depicting larval life history characteristics, and 4) a Lagrangian stochastic module that tracks the trajectory of individual larvae. We parameterized the model with data on spatio-temporal patterns of spiny lobster spawning and planktonic larval behavior, and then verified the model by comparing simulation results with empirical data on the spatio-temporal patterns of larval supply at four sites in the Caribbean (see Methods). Compared to other larval dispersal models created for spiny lobsters [27–33], our model uses the highest resolution, three-dimensional oceanographic circulation models and also larval behavior, both of which affect dispersal trajectories [34]. Our objectives were to employ this modeling system to investigate: (a) the demographic connectivity of spiny lobster larvae among Caribbean nations, (b) the international patterns of larval imports and exports, and (c) the relevancy of connectivity in designing Caribbean-wide networks of marine protected areas (MPAs). An unanticipated phenomenon also emerged from our modeling results: the predicted existence of pelagic larval nursery areas.

Results

Model Verification

Two independent sets of empirical data on postlarval lobster settlement that were not used in the parameterization of our model [29,35] were subsequently used to evaluate the final coupled system's performance. The model was compared against the monthly patterns of *P. argus* postlarval arrival at two sites in both Mexico and Florida, corresponding to four separate habitat polygons (sites) in the model (Figure 2). The simulated pattern of monthly arrival of postlarval lobsters was significantly correlated ($p<0.05$) with observed postlarval recruitment at two of the four sites and captured the peak in seasonal recruitment at all four sites (Figure 2). The model shows the fall peak in postlarval arrival in the Florida Keys, but does not show the spring peak (Long Key and Big Munson; Figure 2).

Connectivity Matrices

Our simulations reveal distinct flows of long-lived spiny lobster larvae among some regions of the Caribbean and pockets of larval retention within others (Figure 3). Probabilistic imports and exports of larvae from each of 261 sites show that the majority of larval exchanges transcend international boundaries when summarized by country (Figure 4). Nonetheless, domestic connectivity (i.e., self-recruitment of lobsters within a country) still dominates larval recruitment in some areas. For example, lobster populations in the Bahamas, Cuba, Nicaragua, and Venezuela are largely self-recruiting, whereas those in the Cayman Islands, Columbia, Honduras, Jamaica, Panama, and Puerto Rico depend largely on larval subsidies from outside their borders.

Imbalanced International Exchange

Much like international trade, large disparities between larval imports and exports among countries abound in our simulations. We identified imbalances in the international exchange of lobster larvae by removing model predictions of domestic connectivity from the total larval supply and then compared the remaining difference in larval subsidies received and subsidies donated to the pan-Caribbean larval pool (Figure 5). This analysis reveals which countries harbor lobster populations that sustain populations elsewhere. The eastern Bahamas, southern Cuba, Dominican Republic, Nicaragua, and Venezuela export far more lobster larvae than those areas receive from the international community. In contrast, the western Bahamas, Cayman Islands, northern

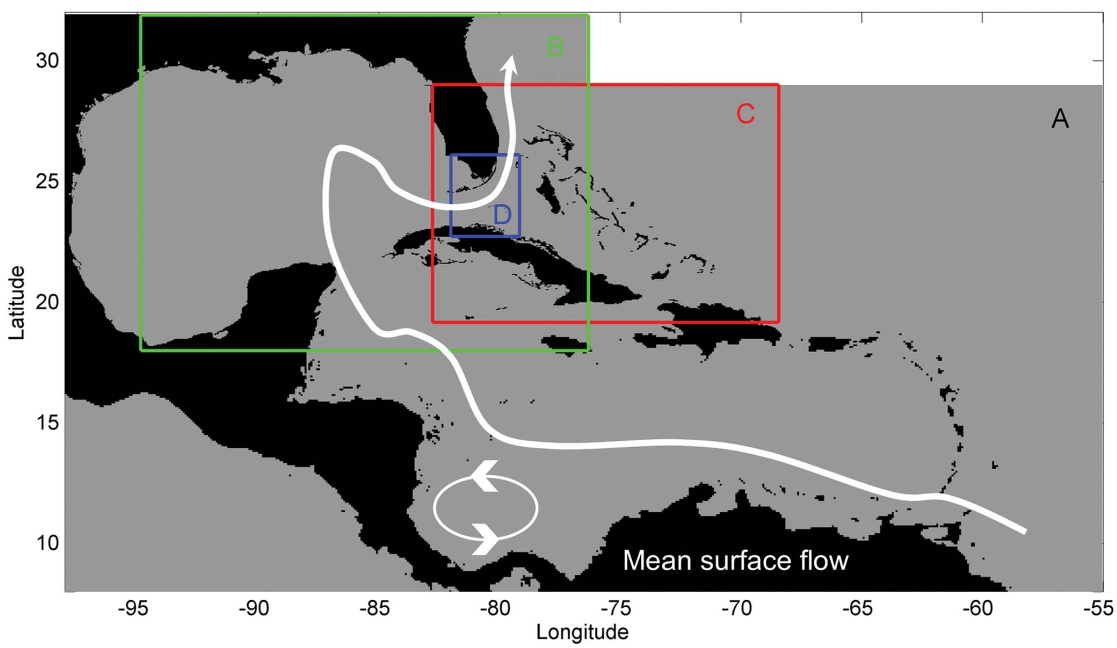

Figure 1. The hierarchy of nested circulation models used in the study and the conceptual mean Caribbean flow. The ocean circulation models used in reverse order of priority for use by the Lagrangian tracking module with their horizontal resolution and vertical depth bins in meters. A) HYCOM Global 1/12 degree: 0, 10, 20, 30, 50, 75, 100; B) GOM-HYCOM 1/25 degree: 0, 5, 10, 15, 20, 25, 30, 40, 50, 60, 70, 80, 90, 100; C) Bahamas ROMS 1/24 degree: 0, 2, 4, 8, 10, 20, 30, 40, 50, 55, 60, 80, 100; D) FLK-HYCOM 1/100 degree: 0, 5, 10, 30, 50, 75, 100. Mean surface flow after Fratantoni [76].
doi:10.1371/journal.pone.0064970.g001

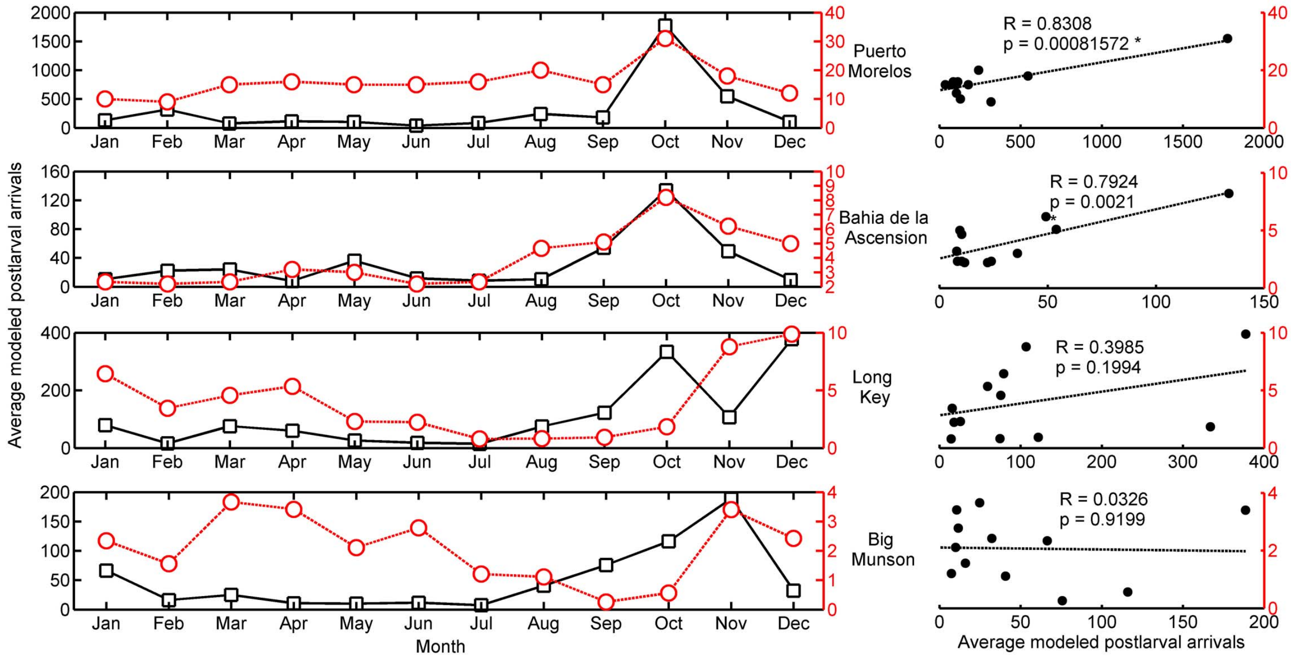

Figure 2. The seasonal pattern of observed postlarval arrival compared to model predictions. A comparison of the actual coastal arrival of *P. argus* postlarvae (red) as compared to model predictions (black) over four years at four different locations (Mexico: Bahia de Ascension, Puerto Morales; Florida: Long Key, Big Munson). The Florida observations [35] are of average postlarval arrivals per collector from 2004–2008. The Mexican observations are averages from Briones-Fourzan [29]. The correlation between the modeled and the observed arrivals was significant ($p<0.05$) for Bahia de Ascension and Puerto Morales. The model also predicted the appropriate peak month of settlement in three locations, suggesting that the model can capture the temporal pattern of arriving larvae.
doi:10.1371/journal.pone.0064970.g002

Cuba, Columbia, Florida Keys, Jamaica, and Panama are regions whose lobster populations receive more larvae from outside their boundaries than they donate to the Caribbean larval pool.

Connectivity and Marine Reserve Networks

Networks of MPAs have been proposed as a solution to ensure that demographic connectivity is maintained among marine animal metapopulations, with a recommendation that on average 20–30% of the coastal seas be set aside as MPAs [36]. We used our model to explore this recommendation specifically for spiny lobster in the Caribbean by designating various model sites as hypothetical MPAs and evaluated different networks of sites as if they were the sole sources of lobster larvae for the Caribbean (Table S1). Five MPA network scenarios were evaluated in simulations in which 40 habitat sites were designated as MPAs and selected in one of five ways: (1) *Random*: 40 sites individually and randomly selected from all those in the Caribbean, (2) *Stratified Random*: two randomly selected sites from each of the 20 countries, (3) *Self-Recruitment:* the top two self-recruiting sites per country, (4) *Long-distance Dispersal*: the top forty sites which successfully export larvae internationally in the Caribbean (5) *Maximum Export*: the top forty sites throughout the Caribbean with export imbalanced exchange (Figure 4). For these simulations the magnitude of larval production from each habitat site was fixed and uniform (unlike the more realistic and variable production used in our first set of simulations), which removed the effect of differences in local population size and focused on the effect of spatial arrangement of MPAs on biophysical connectivity networks. In each of the MPA scenarios, only the larval transport that originated from the 40 selected sites was considered, thus treating the system as a patchwork of MPAs.

The geographical location and connectivity characteristics of sites selected as MPAs altered patterns of spiny lobster larval dispersal and settlement (Table S1). Sites selected at random (scenarios 1 and 2; bootstrapped 1000 times to create averages) produced less successful larval connectivity than sites selected based on their merit as international (scenarios 4 and 5) or domestic (scenario 3) larval exporters. Simulations focusing on preserving domestic connectivity caused a near universal increase in larval recruitment across the Caribbean, although smaller than the ideal internationally managed scenario. Thus, by taking into consideration the complex patterns of connectivity for a species, we can add specificity to the general recommendation that a certain proportion of the sea requires protection to sustain marine fishery resources.

Pelagic Larval Nurseries

An unexpected pattern in larval distribution within the open ocean also appeared in our simulations. When we examined the oceanic pathways travelled (i.e., sum of PLD spent in each oceanic locale) by successfully settling larvae in contrast to the paths taken by larvae that are eventually lost from the system, zones emerged that could be described as "pelagic larval nurseries". That is, regions in the open Caribbean Sea where lobster larvae from around the Caribbean spend much of their planktonic existence before later settling into coastal benthic nurseries. These larval nurseries include relatively large regions offshore of Nicaragua, southern Cuba, and the central Bahamas as well as smaller areas north of Cuba and southeast of Hispaniola (Figure 6). We evaluated the role of larval behavior in creating these pelagic nurseries by conducting an additional simulation without ontogenetic vertical migration (OVM) by larvae, thus simulating passive larval dispersal. The segregation between the regions of concentration was accentuated when larvae drifted passively (Figure 6), indicating that the larval nursery zones were governed primarily

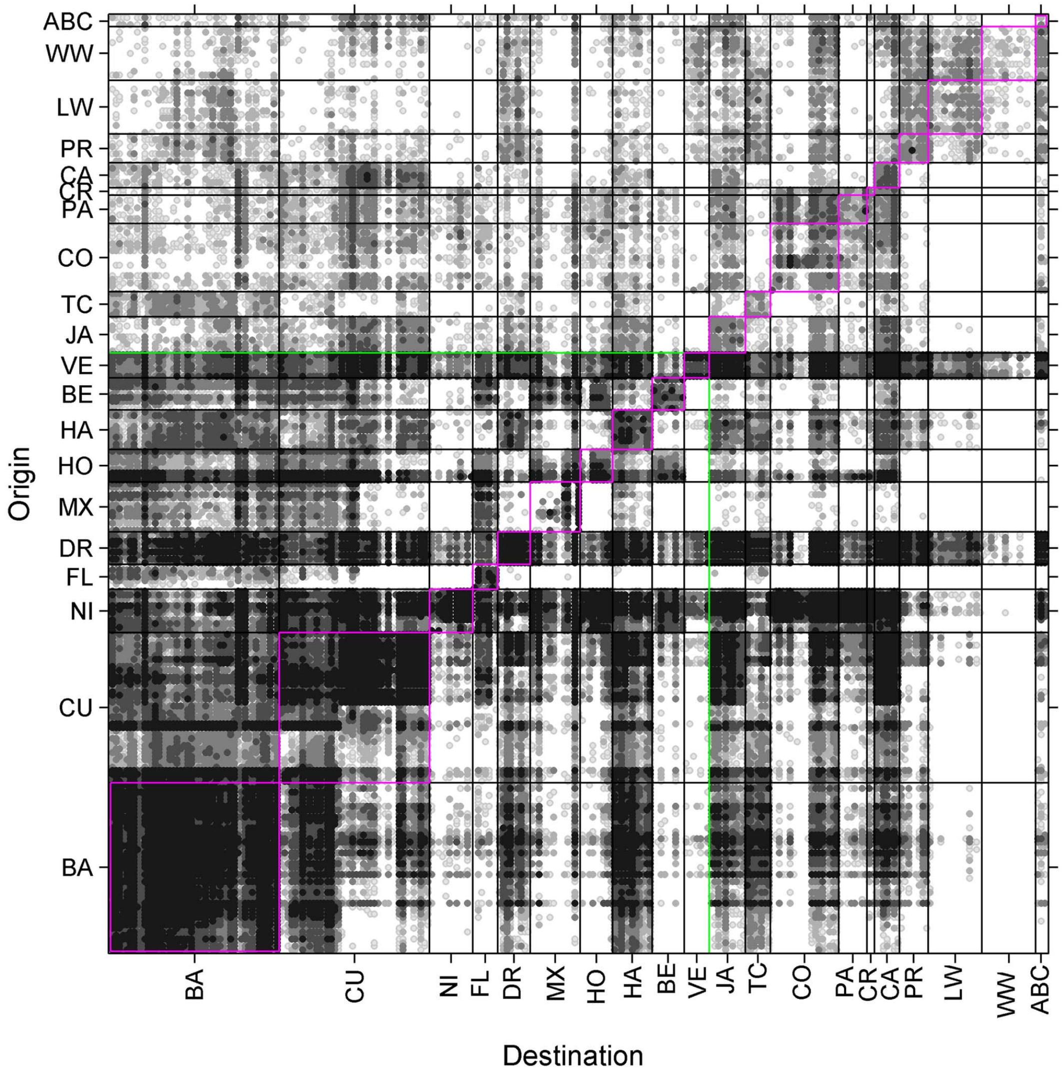

Figure 3. Connectivity matrix of spiny lobster (*P. argus*) larva. A simple matrix showing the number of larva migrating from place to place in a coupled biophysical model. The origin of each larval connection is from the left (rows) and the destination of the larvae is at the bottom (column). Domestic connectivity (recruits that settled into their origin nation) follows the diagonal. The strength of connections among sites is a percentage of the total larval exchanged, and the grey shades represent five quantiles. The top 10 lobster fishery nations are separated by the green box. The results are from four years of Caribbean-wide lobster larval dispersal simulations among 261 habitat sites distributed into 39 countries whose abbreviations are: BA = Bahamas; CU = Cuba; NI = Nicaragua; FL = Florida; DR = Dominican Republic; MX = Mexico; HO = Honduras; HA = Haiti; BE = Belize; VE = Venezuela; JA = Jamaica; TC = Turks and Caicos; CO = Columbia; PA = Panama; CR = Costa Rica; CA = Cayman Islands; PR = Puerto Rico; LW = Leeward Islands (10 countries); WW = Windward Islands (9 countries); ABC = Aruba, Bonaire, and Curacao.
doi:10.1371/journal.pone.0064970.g003

by physical oceanographic features, not OVM behavior specific to spiny lobsters. Thus, these pelagic larval nurseries are potentially relevant to the pelagic retention of other Caribbean species, not just spiny lobster.

Discussion

Managing marine fisheries organisms as if they were constrained within geopolitical boundaries is not working as fisheries worldwide are in decline [37,38]. For example, in regions where the spiny lobster *P. argus* are most abundant and thus heavily fished, adult stocks have declined by 30% or more over the past two decades despite spirited management [39–42]. For many species, an approach to fisheries management that acknowledges dispersal dynamics with estimates of larval connectivity is needed and now possible.

When we used MPAs in our model to "protect" specific locales that tend to export larvae internationally, those simulations yielded the highest successful settlement of lobster larvae throughout the Caribbean. Certain regions contribute disproportionately to the wider Caribbean larval pool, so maintaining the health of spawning stocks in those countries should be an international priority. One strategy for doing so, similar to the trade of "carbon credits" outlined in article 6 of the Kyoto protocol [43], would be to assign each nation "larval credits" based on regional larval export production. Nations that absorb disproportionally more larvae from the international larval pool bear an ethical responsibility and financial incentive to assist in the preservation of spawning stocks in other areas best suited for exporting larvae. Such non-traditional management recommendations are likely to be met with skepticism and their implementation difficult

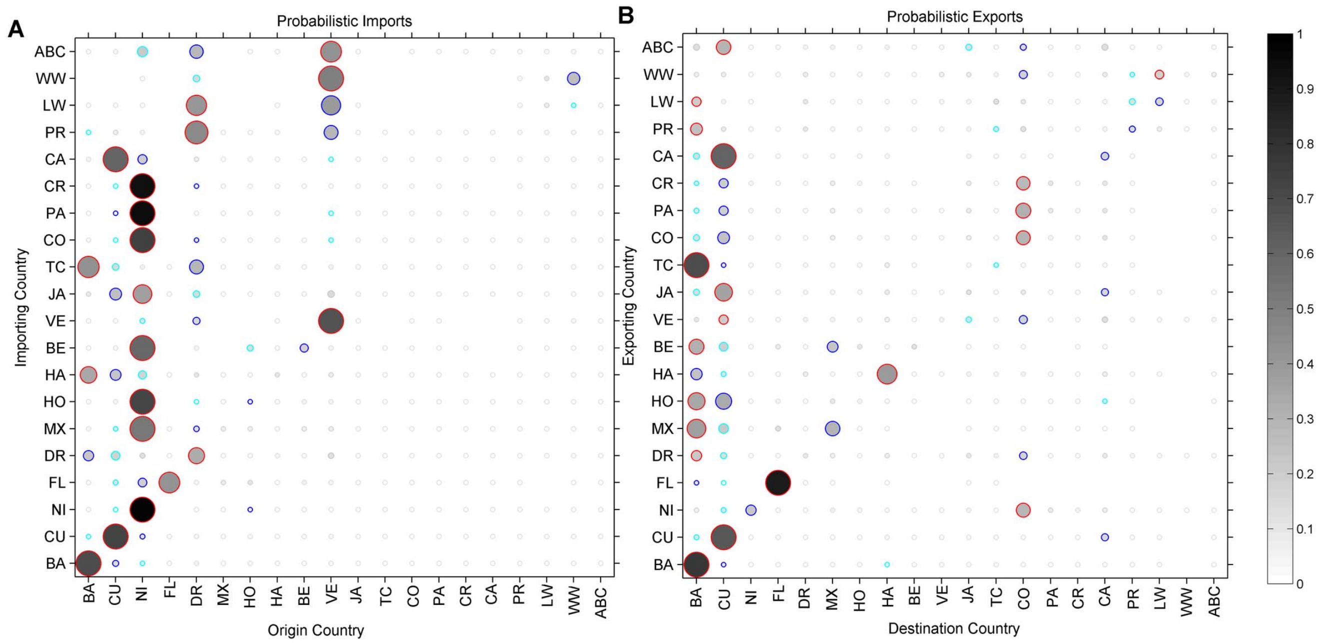

Figure 4. Probabilistic imports (A) and exports (B) of spiny lobster (*P. argus*) larva grouped by political boundaries. The probability for each instance is computed as: $Pij = Pj/\sum_{1}^{n} Pi$ where i = the country importing (A) or exporting (B), j = the origin (A) or the destination (B) country, and n = all countries. The size and shade of grey of the bubble represent the normalized probability, increasing with size and darkness. The three highest probabilities in each scenario are also colored in red, blue, and cyan, respectively.
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considering the political and economic realities of international agreements and the needs of local communities [44]. Yet scientific evidence suggests that populations of many marine animals persist in an intricate web of metapopulations that are often linked across geopolitical boundaries by larval connectivity and should be managed accordingly.

Just as preserving pathways between habitat fragments is essential for sustaining many terrestrial species [45], intact connectivity corridors for marine organisms may be needed. Our results suggest that larval corridors may exist in the open ocean that regularly concentrate and nurture pelagic larvae during their ontogenetic journey to coastal habitats (Figure 6). In contrast, the prevailing Caribbean current that snakes through the Caribbean Basin appears to be a "graveyard" for larval lobsters. Its high mean flows (Figure 1) presumably entrain and then wash larvae into the North Atlantic where few will survive (Figure 6). This stands in contrast to the view that larvae harness strong currents to successfully disperse long distances [11]. Our simulations with and without larval behavior indicated that the pelagic nursery zones we identified were stable and likely maintained by oceanographic features. Thus, our findings for *P. argus* are likely to be robust despite differences in larval origins, destinations, and avenues of dispersal that invariably differ among taxa with dissimilar dispersive traits [46]. If so, then the existence of pelagic nurseries for larvae has implications beyond lobsters and may constitute consideration as oceanic "essential fish habitat" [47]. Protection of these open ocean larval habitats from potentially deleterious processes (e.g., pollution from oil spills, coastal runoff, and vessel discharges) may be considerations for the long-term sustainability of marine species with dispersive larvae.

Although an adequate flow of larvae among sub-populations is crucial for the sustainability of marine resources, the arrival of larvae at a site does not necessarily equate to successful recruitment. Whereas larval supply and later recruitment are correlated for some species of spiny lobster and in some areas [39;48–50], unsuitable nursery habitats decouple the relationship between larval supply and juvenile recruitment in others [51,52]. The transition from pelagic larva to benthic juvenile and on to adulthood is dependent on a variety of post-settlement processes [53], many of which are site-specific and not accounted for in models like ours that assume homogeneous and static habitat quality. Other studies indicate that phenotype-environment mismatches between settlers from one region into another can also contribute to post-settlement mortality and be a barrier to population connectivity [54]. Thus, the integration of biophysical larval dispersal models with spatially-explicit and dynamic depictions of benthic habitat conditions that drive benthic population dynamics [55,56] are a logical next step in the development of predictive large-scale metapopulation models.

Advances in computing, genetics, and oceanographic remote sensing are yielding tools useful in addressing questions about the connectivity of marine metapopulations that were unfathomable only a decade ago. The dispersal of long-lived larvae is a complex function of temporally unstable hydrodynamics and ontogenetically variable larval behavior. Therefore, models that do not capture these essential system traits or whose results are not verified with empirical data will be misleading. Management of marine resources should benefit from new tools such as biophysical modeling that quantify larval connectivity and thus can be used to help guide policy. For example, the establishment of MPA networks in ecologically relevant areas that maximize larval production and connectivity among disparate populations will maximize population viability in both self-recruiting regions as well as regions dependent upon larvae from elsewhere. Our findings with respect to spiny lobster connectivity in the Caribbean suggest that international management agreements that recognize the existence of marine metapopulations, focus on rebuilding and sustaining adequate spawning stocks [57], and protect sensitive

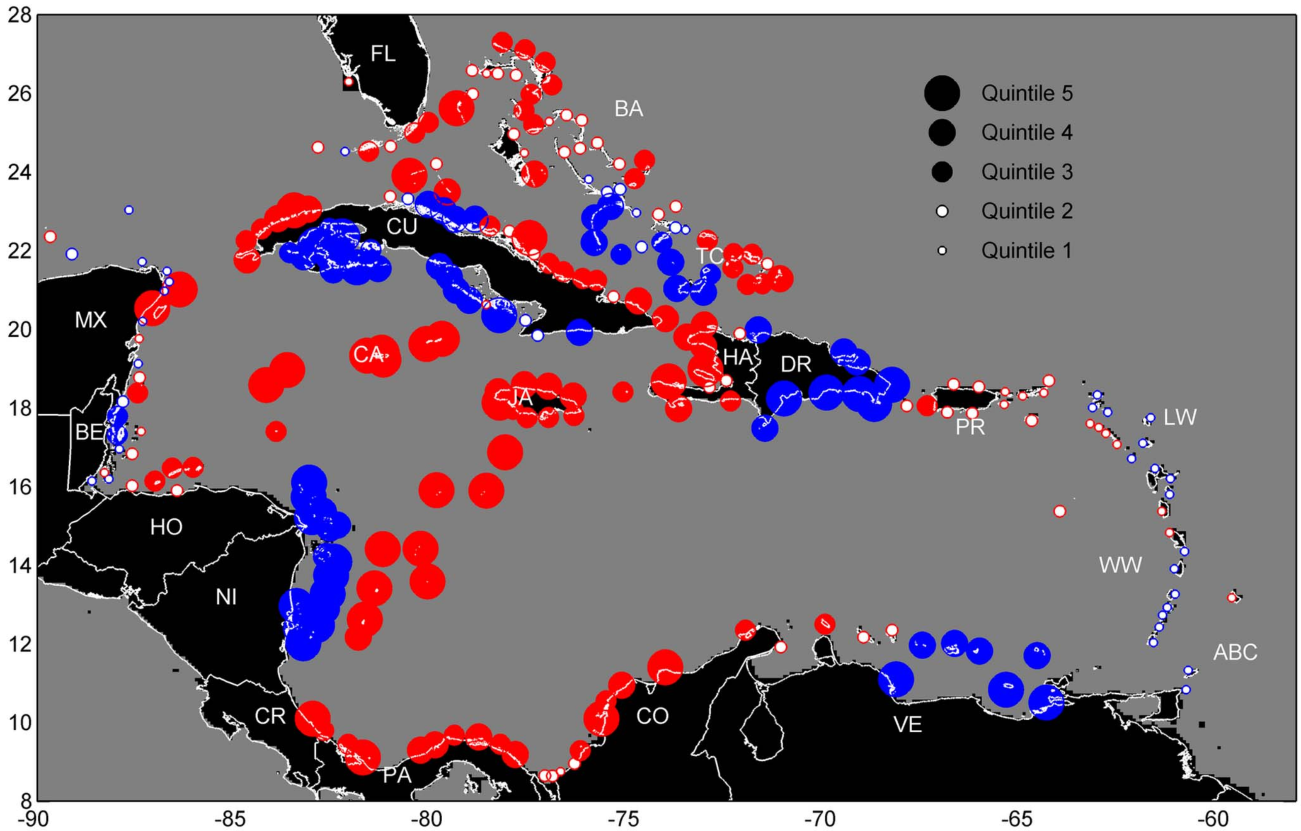

Figure 5. International larval exchange of spiny lobster (*P. argus*) larvae. The difference between larval exports and imports at a site (n = 261), after removing self-recruitment. The size of the circle depicts the relative magnitude of the difference, grouped into 5 quantiles. The direction of the difference is shown as blue for positive (more larval exports) and red for negative (more larval imports). BA = Bahamas; CU = Cuba; NI = Nicaragua; FL = Florida; DR = Dominican Republic; MX = Mexico; HO = Honduras; HA = Haiti; BE = Belize; VE = Venezuela; JA = Jamaica; TC = Turks and Caicos; CO = Columbia; PA = Panama; CR = Costa Rica; CA = Cayman Islands; PR = Puerto Rico; LW = Leeward Islands (10 countries); WW = Windward Islands (9 countries); ABC = Aruba, Bonaire, and Curacao.
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coastal and pelagic nurseries [42] represent a scientifically sound policy for sustainable management of many marine resources.

Methods

Focusing on the Caribbean's most valuable fishery resource as a model system, we investigated larval dispersal through the use of an open-source coupled biophysical larval transport model, specifically parameterized using empirical data collected for *P. argus* (Table S2). Our model adheres to the recommended practices for Lagrangian biophysical modeling laid forth in North *et al* [58], while also incorporating empirical data for biological parameterization. Empirical estimates of spawning population (this study), laboratory and field observations of larval vertical migration in the water column [59], and postlarval sensory behavior [60] were used to parameterize the early life history traits of *P. argus*. Each of four submodules was specifically parameterized for spiny lobster larvae.

The Lagrangian Stochastic Module

The Lagrangian stochastic module drives the coupled biophysical Connectivity Modeling System (CMS). It uses a 4th order Runga-Kutta integration scheme [25] in both time and space to improve the accuracy of simulated larval trajectories as is best practice [61]. For each particle, the next position along the trajectory was calculated during each integration time-step of 2700 seconds, comparable to a previous experiment using spiny lobster that used a time-step of 4500 seconds [59]. The trajectories resulting from the modeled time-step and turbulence are smooth and relatively free of artifacts. Submesoscale turbulent movement was accounted for with stochastic turbulent diffusion during each time-step [25], calculated by multiplying a random number between 0 and 1 by the square root of twice the diffusivity coefficient (0.1 m^2/s) divided by the time-step. We ran simulations starting daily from January 1, 2004 until December 31, 2007, tracking larval flow for over 4 years. Details on the coupled biophysical algorithms and modeling approach can be found in Paris *et al.* [25].

The Physical Oceanographic Module

The physical oceanographic module contains the various oceanographic models that provide the currents with which to move larvae. These currents vary as depth changes from the surface down to 100 m, which is the likely maximum depth utilized by lobster phyllosoma [59]. A hierarchy of ocean circulation models are nested offline in the physical oceanographic module, allowing a Caribbean-wide simulation scale (–100:−55 degrees longitude West and 8:32 degrees latitude North) while not compromising resolution in areas with advanced local circulation models (Figure 1). Four different ocean circulation models were nested together for this study: 1/12 degree HYCOM+NCODA

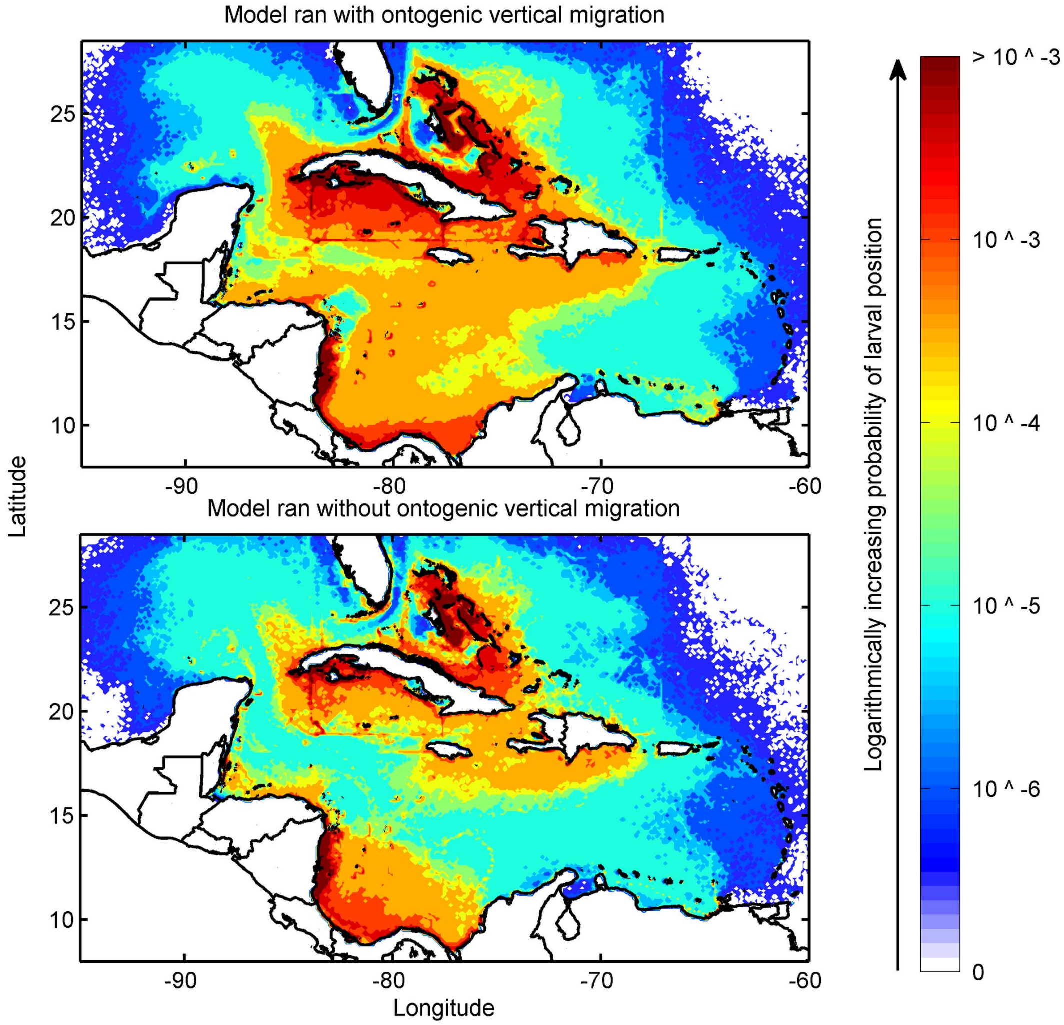

Figure 6. Probabilistic modeled spiny lobster (*P. argus*) larval concentrations. The probability density distributions represent pelagic nursery habitat within the Caribbean Sea for successfully recruiting spiny lobster larvae. The output location was recorded on a ten day frequency and added into a 0.1°×0.1°gridcell. Blue areas were relatively devoid of successfully dispersing larvae; warmer colored regions had more larval trajectories pass through them, increasing logarithmically from blue to red. The most important pelagic nursery zones for larvae are represented in red-orange. The areas of highest mean flow through the Caribbean represent a distinct, inter-linked larval 'graveyard'. Simulations were conducted with (A; n = 54,186,756 larval locations) and without (B; n = 68,675,786 larval locations) ontogenetic vertical migration.
doi:10.1371/journal.pone.0064970.g006

Global Hindcast Analysis [62] provided the base, followed by the higher resolution HYCOM+NCODA Gulf of Mexico 1/25° Analysis (GOMl0.04) [63], a 1/24th degree ROMS model of the Bahamas [64], and the fine scale 900 meter resolution FLKeys-HYCOM [65].

The GIS-based Benthic Module

The GIS-based benthic module determines where larvae can settle and the location, quantity, and timing of larval release. It is directly coupled to the particle tracking module and is accessed during each integration time step. It consists of 261 habitat sites (polygons - vector GIS data) that are a combination of settlement habitat and a sensory envelope reflecting the threshold at which lobster postlarvae can detect and move to settlement habitat (Figures S1–S20 in File S1). Further information on polygon theory is in Paris *et al* [6]. The 18km sensory envelope for this study was constructed based on the sensory abilities of spiny lobster postlarvae [60]. Postlarvae are the highly mobile, non-feeding, settlement stage of spiny lobsters and are capable of detecting nursery habitat cues over similarly long distances [66]. Lobster benthic habitats were delineated based on data from the Millennium Reef Project [67]. Larvae were released from the nearest non-land location to the center of each habitat site.

The daily timing and magnitude of lobster spawning and thus larval release from each habitat site was estimated as a function of lobster density, sex ratio, size, and fecundity. First, the relative abundance of adult lobsters within each Caribbean country was estimated from FAO fishery landing statistics and an independent mail survey. Data was gathered from the top 10 lobster fishing nations that make up ≅95% of the fishery in the Caribbean. We assumed that the FAO [40] fishery landing statistics are an indicator of relative adult lobster abundance due to the overexploited nature of spiny lobster fisheries. However, these are fishery dependent data with unknown bias (e.g., under reporting of total catch) that may well vary among countries in an unpredictable manner. If so, then the magnitude of larval release in our model and our conclusions would be similarly biased. Unfortunately, there are no other data sources available and these data for *P. argus*, the most prized fishery in the Caribbean, are among the very best for any Caribbean species. The data we obtained on the relative abundance of lobsters among nations was then supplemented by a mail survey distributed to lobster scientists and fishery managers around the Caribbean with intimate knowledge of their local jurisdiction [68]. These data sources provided fine-scale resolution of the timing of spawning, the sex ratio, and the size-structure of adult male and female lobsters, which we used to determine fecundity [69] per habitat site.

Using these data, we scaled the larval production per habitat site per day proportional to the total annual egg production in the Caribbean (Figure 7A). These estimates of total *P. argus* egg production per year in the Caribbean were then divided into monthly patterns of spawning for each region based on the FAO and survey data (Figure 7B). The total spawned per month and site was further divided into each day because *P. argus* does not spawn synchronously. Finally, we scaled these empirical estimates so as to restrict the annual release of particles in the model to approximately 40,000,000; of which 38,000,000 were distributed to the 10 countries representing 95% the fishery and the remaining 2,000,000 particles distributed equally throughout the rest of the habitat sites with less accurately known lobster population structure. The annual value of 40,000,000 particles was found *a priori* to saturate movement paths in the model, after accounting for mortality (Figure 8). The end result is a daily release of larvae that varied in magnitude proportional to the total fishery, constructed with the local size, population, and spawning patterns when known for each of the 261 habitat sites.

A modified pattern was used to test for idealized MPA placement, which assumed that each habitat site could hold the same climax population size and have the same reproductive potential. This had timing structured as in the original release, but allocated an equal number of particles to each site, rather than scaling population size based on survey and fishery data.

The Larval Biology Module

The larval biology module accounts for the early life history traits of spiny lobster including PLD, larval competency period, and ontogenetic vertical migration. Lobster larvae display distinct patterns of vertical distribution throughout ontogeny, which greatly alters which currents they are exposed to and therefore

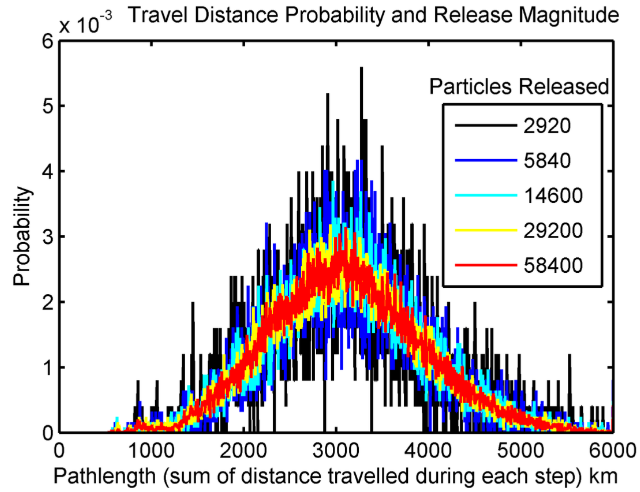

Figure 8. Larval release magnitude and movement pathlength. The probability of dispersal distances for larval releases from a central Caribbean release location (-68°W,14°N). The X-axis is the pathlength (sum of distances moved during each time-step) traveled by each larva binned into 5km increments, and the Y-axis is the probability. The number of larvae released (over 4 years of daily releases) increases in color from black to red and yellow. The smoother curves in red and yellow reflect the stochastic saturation, and suggest the proper number of larvae needed to release daily to probabilistically describe potential lobster larvae dispersal. These values reflect the number of larvae from a single site with no mortality, and had to be multiplied to account for each site and for mortality.
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their dispersal. To reproduce this behavior, CMS assigns larvae probabilistically to different depth bins [25]. In the present simulations, individual larvae may reside during each time-step within one of five depth ranges (0–20 m, 20–40 m, 40–60 m, 60–80 m, and >80 m) with an age-dependent probability. During each time step, the depth bin is assigned randomly from the age-specific distribution [59]. However, larvae are not allowed to travel more than one depth bin per time step. Older larvae (>3 months old) have a higher chance of being deeper than younger larvae. These probabilities were determined through a combination of plankton trawls and laboratory experiments described in

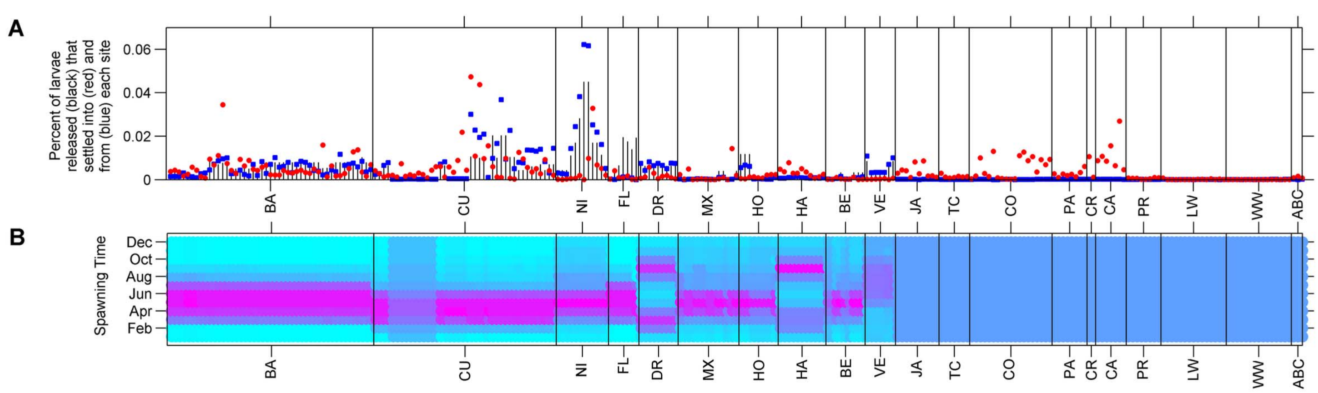

Figure 7. Simulation larval release, settlement, and seasonality. The details of the timing and magnitude of the simulated releases and the larvae received at each habitat site (n = 261). The annual release (black lines), the larvae successfully received (red circles), and larvae donated (blue squares) at each habitat site as a percentage of the total (A). The annual timing of spawning at each site (B). The monthly effort increases from cyan to a peak of spawning occurring in red for locations with dynamic reproductive seasons. A uniform spawning pattern was used in locations that did not have empirical data on spawning time.
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another study [59]. The mean PLD of lobster larvae was observed to be (±1 SD) 174±22 d, based on data from laboratory rearing of *P. argus* from egg to postlarval stage [14]. Larvae in the model metamorphose to postlarvae within a competency period (152 to 196 d) and postlarvae are recorded as 'settled' if they enter a benthic nursery habitat site (habitat module) within this competency period; if suitable habitat was not encountered within the competency period they 'die' and are removed from the simulation.

Mortality is a key parameter in biophysical modeling [70]. There is no evidence that vertebrate plankton mortality rates are similar to that of invertebrate plankton, however there is growing evidence that mortality changes throughout ontogeny for both coral [71] and fish [72]. To impose mortality, we used a half-life function to reflect varying survivorship as a function of larval duration. There are no known mortality rates for *P. argus* phyllosoma, thus we used an estimate for another spiny lobster (*P. cygnus*) used in Feng *et al* [28], based on trawl surveys that had diminishing returns of later stage larva [73], suggesting abundance based mortality of 85–90%. The cumulative mortality imposed on the larva in our model is ≈ *ca*. 90%, including advective mortality resulting from not reaching settlement habitat.

The Verification of Our Model

The verification of our model lends credence to its results. Whereas the backbone of coupled bio-physical models are ocean circulation models whose physical dynamics have been validated and peer reviewed, the biological predictions of larval dispersal models should also be verified [74] but few are. Our verification of the model predictions is based on correlations between model predictions and empirical observations of recruitment into relatively small ca. ≈50km^2 habitat patches following the dispersal of larvae over thousands of kilometers during their 5–9 month PLD (Figure 2). There is precedent for using postlarval collector seasonal settlement trends to verify a Lagrangian model [28], and predictable seasonal patterns are vital for fishery management. Correlating the spatial concentration of observed pelagic larval or juvenile patches with modeled outputs has been done in smaller scale studies [5,7,33,75], but is prohibitively costly and difficult to do at a Caribbean-scale which our model is based on.

Sensitivity analyses of some parameters for which empirical data are lacking or based on laboratory studies (e.g., mortality, PLD, age of competency) could potentially improve the accuracy of our model [6]. Incorporating specific biological traits, for example vertical migrations, into a model alters outputs. For example, Briones-Fourzan *et al* [29] used stochastic perturbations of a particle backtracking simulation to investigate potential origins of postlarvae arriving on the Mexican Quintana Roo coast, without having data on ontogenic vertical migrations. In comparison with their findings, our results suggest diminished larval supply to Mexico from the Lesser Antilles Caribbean Islands and the Venezuelan corridor, while increasing the supply of larva from Central America and Hispaniola (Figure S21 in File S1). This was expected since the vertical migratory behavior of the actively moving larvae increases retention [59]. A simulation that we conducted without larval OVM nor adult population structure did not capture the seasonal recruitment pattern evident in the empirical data (Figure S22 in File S1), and is more similar to the connectivity described in Briones-Fourzan *et al* [29], suggesting that additional biological parameterization could further improve model performance.

Supporting Information

Table S1 Strategies for selecting marine protected areas. Five MPA network scenarios were evaluated in simulations in which 40 habitat sites were designated as MPAs and selected in one of five ways: (1) *Random*: 40 sites individually and randomly selected from all those in the Caribbean, (2) *Stratified Random*: two randomly selected sites from each of the 20 countries, (3) *Self-Recruitment:* the top two self-recruiting sites per country, (4) *Long-distance Dispersal*: the top forty sites which successfully export larvae internationally in the Caribbean (5) *Maximum Export*: the top forty sites throughout the Caribbean with export imbalanced exchange [Fig. 4]. The random sites are the averages of 1000 random selections (Matlab rand function). In each case, an equal number of larvae were released so the difference between scenarios is where the larvae were released from.
(DOC)

Table S2 Parameterization of the Biophysical Model. The data used to parameterize each module of the model, along with specific references to sources.
(DOC)

File S1 Contains Figures S1 to S22.: Figure S1 to S20 in File S1. Habitat maps used for the simulation. For each country the habitat sites are shown. Sites within each country are numbered according to the location on the previous figures (2 and 3) reading from left to right along the X axis. All axes are latitude and longitude. BA = Bahamas; CU = Cuba; NI = Nicaragua; FL = Florida; DR = Dominican Republic; MX = Mexico; HO = Honduras; HA = Haiti; BE = Belize; VE = Venezuela; JA = Jamaica; TC = Turks and Caicos; CO = Columbia; PA = Panama; CR = Costa Rica; CA = Cayman Islands; PR = Puerto Rico; LW = Leeward Islands (10 countries); WW = Windward Islands (9 countries); ABC = Aruba, Bonaire, and Curacao. **Figure S21 in File S1. A comparison of possible larval sources to the Mexican Quintana Roo coast between two Lagrangian individual based models.** The origins of larvae that arrived to habitat on the Quintana Roo coast during April, May, September, and October. Results from Briones-Fourzan are averages between their figures 10 and 11 [29]. Results from our study, using a simulation with passive larvae released equally in magnitude and timing from around the Caribbean (red), and another incorporating vertical migration behavior and larvae released based on reproductive biology (blue). **Figure S22 in File S1. The seasonal pattern of observed postlarval arrival compared to modeled predictions, without considering population structure.** A comparison of the actual coastal arrival of *P. argus* postlarvae (red) as compared to modeled predictions (**black**) over four years at four different locations (Mexico: Bahia de Ascension, Puerto Morales; Florida: Long Key, Big Munson). The Mexican observations are averages from Briones-Fourzan [29]. The Florida FWC observations [35] are of average postlarval arrivals per collector from 2004–2008. The model parameterization ignored seasonal reproductive characteristics and population sizes. There was no significant ($p<0.05$) correlation between the modeled and the observed arrivals for any site, highlighting the importance of using spatially and temporally explicit biological knowledge of reproduction in population modeling.
(ZIP)

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Author Contributions

Conceived and designed the experiments: ASK MJB CBP. Performed the experiments: ASK CBP MJB. Analyzed the data: ASK CBP MJB. Contributed reagents/materials/analysis tools: CBP MJB. Wrote the paper: ASK CBP MJB.

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Hurricanes and the Caribbean Spiny Lobster (*Panulirus argus*) Fisheries

Los Huracanes y las Pesquerías de la Langosta Espinosa *Panulirus argus*

Les Ouragans et les Pêcheries de la Languste *Panulirus argus*

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ABSTRACT

Caribbean spiny lobster fisheries grew, peaked, and declined while affected by at least two hurricanes annually. These atmospheric disturbances can cause significant losses of life and property on land, but their effects on underwater ecosystems seem to be limited to sediment disturbances, runoffs, damage to coastal marine nurseries, and uncertain effects on larval connectivity. During the development of the fisheries the harvested fractions of the populations were small and the parental stocks produced enough recruits to compensate for the combined negative effects of fishery and hurricanes, but when fisheries declined after reaching overdevelopment, the diminished populations could not cope.

This argument of declining landings resulting from a combined negative hurricane-fishery mechanism fails in the self-sustained and isolated Brazilian spiny lobster fishery which also grew, peaked, and declined in total absence of hurricanes. This exception of the second largest Caribbean spiny lobster fishery leaves mismanagement as the fundamental common cause for the present regional condition of all Caribbean spiny lobster fisheries.

Excessive fishing effort, elimination of more than seven million juvenile lobsters annually, and ongoing violations of closed seasons and size limits are the fundamental causes of decline, but recuperation is possible by reducing fishing effort and developing adequate protection measures agreed to and enforced on a regional basis.

KEY WORDS: Mismanagement; overfishing; hurricanes; regulations; recuperation

INTRODUCTION

Spiny lobster *Panulirus argus* populations support commercial fisheries throughout its geographical range (from Rio de Janeiro, Brazil to North Carolina, USA, and Bermuda) with total landings of about 1.6 million metric tons (Mmt) from 1950 to 2008 (FAO 2010). The majority of landings (63% or close to 1 Mmt) came from the Caribbean fishing areas (0.9 Mmt), and Florida. This preeminent role of the Caribbean fisheries of *P. argus* determined using "Caribbean spiny lobster" as its common name in US and international fishing statistics. Each of the regional fisheries evolved at a different rate but most peaked from the mid 1980s to mid 1990s and presently all show signs of decline or even overfishing (Chávez 2009).

The rest of landings (about 0.6 Mmt) correspond to fisheries in Brazil (0.32 Mmt), those from Turks and Caicos Islands to the Bahamas archipelago (0.25Mmt), and Bermuda, all outside the Caribbean and Florida combined region. Recent genetic studies point to the existence of a great regional connectivity resulting in a pan-Caribbean *P. argus* population (Hunt et al. 2009), with the spawning stocks through the Caribbean largely if not wholly responsible for the postlarval recruitment in Florida (Anonymous 2010), although not all scientists share this view (Ehrhardt 2005).

Since the start of historical records, the Caribbean and Florida have suffered the effect of tropical storms and hurricanes some with devastating consequences in losses of life and property. Being atmospheric disturbances, their effect is evident on the water and land surfaces where they can destroy man-made structures, affecting also land flora and fauna. Hurricanes cover areas hundreds of miles wide with thousands of square miles of strong winds and copious rains, but the brunt of their fury is limited to areas usually 20 to 40 miles across corresponding to their eye (NOAA 1999). The maximum winds in the hurricane's eyewall causes the greatest destruction, even obliterating small islands like St. Thomas in the US Virgin Islands that was completely devastated by Hugo, a 1989 "Cape Verde type" category 5 hurricane (Weaver 1994).

The concentrated destructive force of hurricanes winds is easier to appreciate over large landmasses as observed during hurricane Andrew (1992). With an eye of approximately 15 miles across, the South Florida communities of Homestead, Naranja Lakes, Florida City, and Cutler Ridge were devastated but only 18 miles North, even well within its strongest northeastern quadrant, the city of Hialeah escaped any significant damage (Sheets and Williams 2001). This evidences that although some hurricanes can have national and international repercussions like Katrina (2005) in the US, or Mitch (1998) in Central America countries, the maximum destructive effects of hurricanes are localized events.

The obvious effects of hurricanes on fishery activities is mainly limited to the loss of vessels, fishing gears, land facilities, and other infrastructures such as aquaculture installations, but damages to the marine populations seem to be mostly limited to sessile organisms.

After Katrina, American oyster (*Crassostrea virginica*), clam, and mussel beds suffered significant mortality by siltation and contamination caused by runoff (Buck 2005). Damages to the Mangrove oyster (*C. rizhophorae*) are usually larger because hurricanes destroy their substrate (mangrove branches submersed during high tide) and reduce seawater salinity distressing the oyster colonies (Buesa 1997).

Hurricanes runoffs contain chemical fertilizers from agriculture activities. Pesticides and DDT after Mitch (1998) devastated the Pacific shrimp farms in Honduras (Matta et al. 2002) and after Katrina (2005), the levels of nitrate and reactive phosphate in Biscayne Bay, Florida, quintupled and doubled respectively, taking three months to return to normal levels (Zhang et al. 2009).

Hurricane Ivan (2004) made landfall in Pensacola Bay, Florida, as a category 3 hurricane with a 3.5 meters surge that inundated 165 km^2 inland, increasing 2.3 times the water volume of the bay. The subsequent runoff caused a discrete phytoplankton bloom and hypoxia during several days (Hagy et al. 2006).

The destruction of mangrove communities in Florida west coast during Andrew (Doyle et al. 1995), not only affected the nesting areas of various bird species, but probably also damaged the rich underwater nursery communities living amongst their buttressing aerial roots. All these hurricane related events have two similarities; they are coastal and ephemeral.

Marine plants and hurricanes interact differently. Wilma (2005) made landfall over Puerto Morelos, Mexico as a category 4 hurricane, but turtle grass (*Thalassia testudinum*) beds and the calcareous green macroalgae *Halimeda spp.* were unaffected (Tussenbroek et al. 2008).

The impact of hurricanes on seagrass beds is greater on soft bottom areas. Hurricane Georges (1998) caused an immediate 3% density loss of turtle grass, 19% loss of manatee grass (*Syringodium filiforme*), and 24% loss of calcareous green macroalgae *Halimeda spp.* and *Penicillus spp*. in the back reef communities of the Florida Keys. The plants recovered depending on the amount of sediment deposited over them; within one year after moderate deposition, to little recovery after three years if plants buried by 50 cm of sediment (Fourqurean and Rutten 2004).

Hurricane Claudette (2003) suspended about 0.5 kg/m^3 of sediment through the water column near the five-meter isobath on the muddy inner shelf fronting Atchafalaya Bay, Louisiana (Sheremet et al. 2005).

Although hurricanes usually weaken when approaching the coast, its surge can affect turtle eggs nests and disturb the sediments that will end smothering many sponge species before washing onto the beaches (Welch 2006).

The relation between hurricanes and corals is more complex. After category 4 hurricane Keith affected corals in Banco Chinchorro (Mexico) in 2000, there were no significant differences in their components before and after (Beltrán et al. 2003). On the other hand, hurricanes Emily and Wilma passed over the Cozumel corals (Mexico) as categories 4 and 3 respectively, reducing their coverage from 26% to 10%, with recuperation to only 16% two years later (Castillo-Cárdenas et al. 2008).

By contrast, in the Flower Garden Bank coral reefs (northeastern Gulf of Mexico) hurricanes lowered water temperatures reducing bleaching, aided their larval dispersal, and contributed to an 18% increased coverage during the period 1994 - 2004, all of which were positive consequences (Lugo-Fernández and Gravois 2010).

There are no reports of swimming or free moving animals washed onto beaches after hurricanes. Some marine animals can even detect approaching tropical storms, as was the case of 14 tagged blacktip sharks swimming into deeper waters prior to tropical storm Gabriella (2001) made landfall at Terra Ceia Bay, Florida after being downgraded from a category 1 hurricane (Heupel et al. 2003).

Dolphins also move to open water, and Andrew did not affect the Florida manatees (Tiltman et al. 1994). In contrast, the first reported mass stranding of pigmy killer whales for the northeastern Caribbean occurred in the British Virgin Islands, one day after being devastated by hurricane Marilyn. The stranding was associated with this 1995 category 3 hurricane (Mignucci-Giannoni et al. 1999).

In the case of the Caribbean spiny lobster, they migrate to deeper water before the arrival of hurricanes, returning to shallower areas afterwards (Buesa 1970). In spite of the existing evidence indicating low mortality likelihood of free moving marine organisms caused by hurricanes, and their impact mostly limited to shallow coastal areas, some authors suggest hurricanes rather than overfishing caused the spiny lobster landings decline in Cuba (Puga et al. 1991) and in the Caribbean (Ehrhardt et al.). A significant shift of some spiny lobster ecosystems by the 1988 category 5 hurricane Gilbert, and by extension from any other hurricane of similar strength, was suggested also (Ehrhardt 2005).

The analysis of the potential adverse effect of hurricanes on the *P argus* Caribbean fisheries is the subject of this article.

MATERIALS AND METHODS

The analysis is limited to the *P. argus* fisheries of Florida, the Caribbean isles, and bordering continental shelves, *i.e.*, limited to the Caribbean Sea and the Gulf of Mexico. This excludes *P. argus* landings from Brazil, Turks and Caicos, Bahamas, and Bermuda fisheries. In the case of Florida, from 1964 to 1975 east coast landings came mostly from Bahamas, so Millon et al. (1999) made the necessary statistics corrections which are used here. The rest of the regional landings from 1950 thru 2008 come from FAO-FISH-STAT (2010).

The number of years elapsed from the year the hurricane affected the fishing area (y), and the year when landings were equal or higher than the year before the hurricane (y-1) is defined as "landing recuperation time" and is used as indicator of the populations' recovery capacity.

The hurricanes' data and their effects appear in the quoted references, and in NOAA:

(http://www.nhc.noaa.gov/pastall.shtml).

The Gnumeric expansion of Excel 2003 program was used to calculate regressions, correlations, and to prepare the figures.

CARIBBEAN SPINY LOBSTER LANDINGS AND HURRICANES

Landings of Caribbean spiny lobsters were small before the 1950s but grew after the US economic boom during those years increased their export to the US. During the period 1950 to 1959, the annual average landings by the Caribbean and Florida fishers was 4454 mt and more than doubled (11,807 mt) from 1960 to 1965 as a consequence of fishing effort increases in all participating countries. They almost doubled again (23,224 mt) in 1986 to 1990, peaked in 1996 to 2000 (24,357 mt), to start declining thereafter to the present annual levels, similar to those in 1971 to 1975 (Table 1).

From 1960 to 2010 there were 313 hurricanes, 91 of which affected both the Caribbean Sea (CS) and Gulf of Mexico (GM), and 23 the GM alone. Of this total of 114 hurricanes, 40 were categories 4 and 5 in the Saffir-Simpson scale, for a mean of four major hurricanes every five years with a combined frequency of eight in 1960/65, zero in 1981/85, and ten in 2001/05 (Table 1).

Annual landings did not evolve smoothly from 1960 to 2008 for there were frequent landing declines especially after years with large harvests, which could represent the recuperation of the exploited populations, or caused by smaller annual recruitments, a reduction in the fishing effort, or a combination of these factors (Figure 1). The synchronic regression between landings in mt and the number of hurricanes is not statistically significant (R^2 = 0.001; $p > 0.15$), neither are the regressions calculated with a lag of two, three, and four years between the "hurricane year", and the "landing year".

On the other hand, the recovery of the landings after hurricanes was not the same between or within fisheries. Table 2 presents examples of recuperation times for southern Cuba, Florida, and the common fishing areas of Belize and Honduras. Landings recovered after one to eight years (mean of 2.5 ± 2.4 years) when hurricanes impacted the areas before the fishery peaked, and from one to more than twenty years (mean of 4.9 ± 6.4 years) after the fishery peaked.

Six hurricanes affected the southern Cuban fishing areas (Figure 2A) during the 26 years before peaking, with a mean recuperation time of 1.9 years. During the 24 years after peaking, there were seven hurricanes with a mean recuperation time of 7.7 years. A reduction of fishing effort caused by national economic distress and lower catches per unit effort (CPUE), also contributed to the reduction in landings after 1995 (Muñoz-Núñez 2009).

Allen (1980) and Gilbert (1988), two almost identical hurricanes amongst the thirteen in Figure 2A, passed south of Cuba never affecting the fishing areas directly. Nevertheless, landings after them showed very different recuperation times (Table 2) with Gilbert blamed for the spiny lobster landings decline thereafter. Given that the only objective difference between both hurricanes is the year they formed within the development of Cuban fisheries (Table 3), the conclusion that Gilbert alone was responsible for the fishery decline seems untenable.

Two hurricanes made landfall over the common Honduras-Belize fishing areas before they peaked in 1986 (Figure 2B) with a mean recuperation time of 4.5 years. After peaking there were twice as many hurricanes directly striking the fishing areas (two category 4 and two category 5) but the pre-hurricane landings were surpassed after a mean of 3 years only because of increases of the fishing effort and the expansion of the fishing areas to the Nicaraguan shelf (Carcamo 2001, Castellón and Sarmiento 2001).

Table 1. Landings and named hurricanes in the Caribbean Sea (CS) and Gulf of Mexico (GM) .

Period	Average Annual landing (10^3 mt)	Hurricanes within the CS and GM (1960 thru 2010)					Total hurricanes	
		CS + GM	GM only	Total CS+GM	cat. 4	cat. 5	outside CS+GM	in the period
1960/65	12	8	5	13	4	4	18	31
1966/70	15	13	0	13	1	2	21	34
1971/75	16	9	0	9	1	1	14	23
1976/80	20	8	1	9	2	3	20	29
1981/85	21	5	5	10	0	0	17	27
1986/90	23	9	0	9	0	1	19	28
1991/95	22	4	3	7	1	1	19	26
1996/00	24	9	4	13	3	1	25	38
2001/05	21	13	4	17	5	5	26	43
2006/10	17 (*)	13	1	14	3	2	20	34
Total	19	91	23	114	20	20	199	313
Period mean		9	2	11	2	2	20	31
Annual mean		2	<1	2	<1	<1	4	6
% of total		29	7	36	6	6	64	100
% for CS and GM		80	20	100	18	18		

(*) 2006/08 cat. = hurricane strength in the Saffir-Simpson scale

Consequently, the differences in recuperation time of spiny lobster fisheries before and after peaking seem more influenced by the fishery development stage, the fishing effort, and the spiny lobster population condition, rather than by the intensity and frequency of the hurricanes affecting them.

DISCUSSION

For the first time in more than 20 years, on 14 September 1988 hurricane Gilbert made landfall in Cozumel (Mexico) with full category 5 force. Damages on land were considerable, but the effect on the coral reef was minor, the damage to sponges was limited to three delicate species that recuperated rapidly, and there were no signs of damage to fish populations (Fenner 1991).

Gilbert caused limited damage to Jamaican corals but since it struck before they recuperated from larger damages caused by Allen eight years before, the combined events affected the corals severely. Mangroves defoliation and breaking above the buttress roots was greater during Gilbert than during Allen (CEP-UNEP 1989) but Gilbert made landfall in Jamaica as a category 3 hurricane traversing the whole isle east to west while Allen just passed by north of Jamaica.

Gilbert is blamed for the decline of the spiny lobster fishery in the southwestern Cuban shelf that never returned to levels obtained prior to 1988 because of an alleged significant shift in the local spiny lobster ecosystem resulting from that catastrophic event (Ehrhardt 2005). This assertion is difficult to accept because both Allen and Gilbert were of equal strength and similar path, with Allen's course closer (50 - 80 nautical miles) than Gilbert's (120 - 140 nautical miles) south of Cuba. Also fisheries in areas where Gilbert made landfall are in better condition now than those in Cuba so there has to be a better explanation for Cuba's landings decline.

As the effort increases in a developing fishery, larger portions of the population are harvested every year, the fishery becomes more dependent on recruits' survival and growth, and the stocks will remain in good condition only as long as they can sustain the harvests. This equilibrium harvest represents the maximum sustainable yield (MSY) and, although annual harvests may be variable and recruitment dependent, a calculated MSY is a valuable benchmark for fishery managers.

In the case of Cuban fisheries, the two southern shelves had a combined MSY of 8500 mt (Buesa 1972). By 1980, the "year of Allen", the MSY had been exceeded five years, but by 1988, the "year of Gilbert", that limit had been surpassed eight additional years, and it was recognized that the populations were in worse conditions in 1988, than in 1980 (Muñoz-Núñez 2009).

Sometimes Cuban landings were higher during the year of the hurricane than the year before as were the cases of Flora (1963), Dennis (2005), and Ike (2008) in the southeastern shelf; and after Camille (1969), Lili (2002),

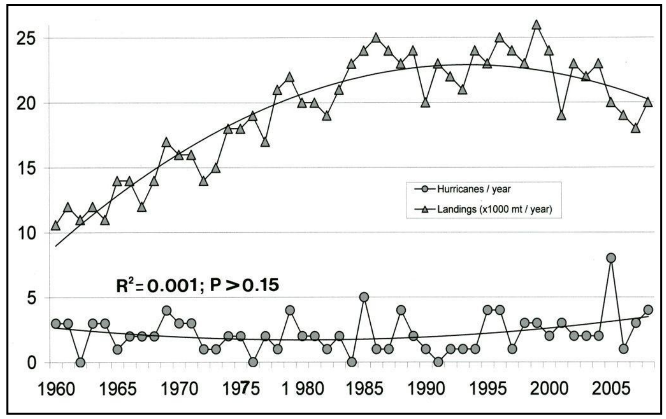

Figure 1. Annual number of hurricanes categories 4 and 5 and landings in thousands of metric tons in the Caribbean Sea and Gulf of Mexico from 1960 thru 2008.

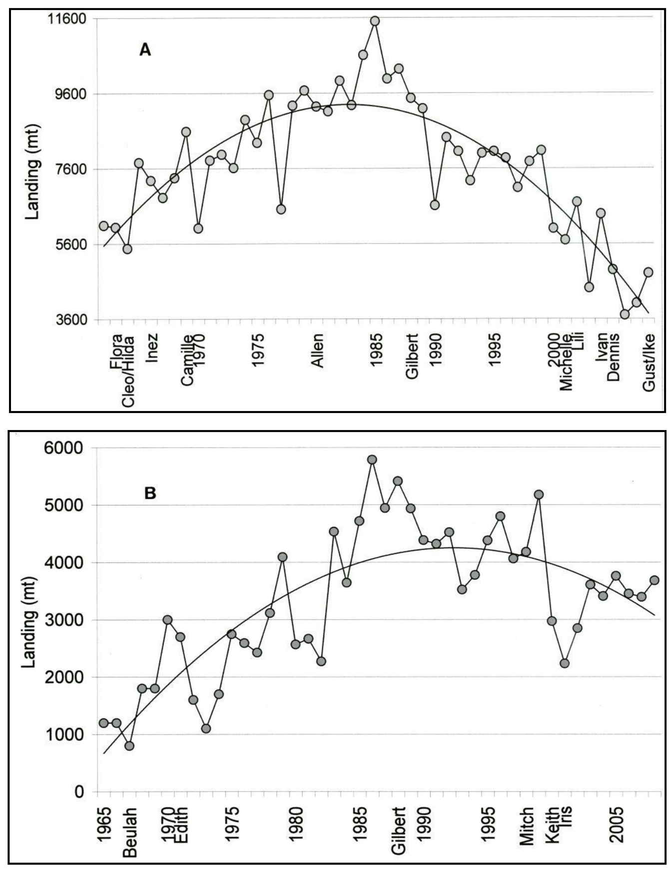

Figure 2. Landings (in metric tons) and number of hurricanes from 1965 thru 2008 affecting the Caribbean spiny lobster fishing areas of:
A - Southern Cuba
B - The common Honduras and Belize fishing areas

and Ivan (2004) in the southwestern shelf.

During 2003 - 2004 south of La Coloma and Zapata, and northeast of "Isla de la Juventud", all in the southwestern Cuban shelf, species diversity and sea grass coverage were reduced by undetermined causes (Arias-Schreiber et al. 2008) but it is worth noting that the diversity data used to make this comparison corresponded to samplings that started in 1981, after hurricane Allen (1980) passed south of Cuba.

In Florida, Andrew (1992) disrupted the recreational fishery (Muller et al. 2000) and hurricane Georges (1998), a category 2 hurricane at landfall, scattered so many traps that it required the State of Florida to authorize 43,886 emergency replacements (NOAA 8 2010). In 1999, Irene

Table 2. Lobster landings (mt) after hurricanes categories 4 and 5.

Year (y)	Hurricane		Hurricane trajectory in relation to the fishing area	Year the landings were ≥ (y - 1)
	Name	category C_{fa} / C_{ms}		
SE Cuban shelf: landings peaked in 1984 (2574 mt)				
1963	Flora	3/4	Eastern half of the shelf	y + 1
1964	Cleo	2/4	Whole shelf	y + 1
1966	Inez	2/4	Whole shelf	y + 1
1980	Allen	4/5	50 miles off South (295º course)	y + 1
1988	Gilbert	4/5	120 miles off South (285º course)	none since
2005	Dennis	4/4	Whole shelf	y + 3
2008	Ike	3/4	Western tip of the shelf (290º course)	nda
SW Cuban shelf: landings peaked in 1985 (9107 mt)				
1964	Hilda	1/4	Whole shelf (290º course)	y + 1
1969	Camille	3/5	W of the shelf (340º course)	y + 3
1980	Allen	4/5	80 miles off South (295º course)	y + 5
1988	Gilbert	4/5	140 miles off South (285º course)	none since
2001	Michelle	4/4	Eastern end of the shelf (50º course)	y + 1
2002	Lili	3/4	Western end of the shelf (315º course)	none since
2004	Ivan	5/5	80 miles off the Western end (325º course)	y + 1
2005	Dennis	4/4	Easternmost part of the shelf (315º course)	none since
2008	Gustav	4/4	Western end of the shelf (320º course)	nda
2008	Ike	2/4	Whole shelf (320º course)	nda
Florida: landings peaked in 1970 (3623 mt) and in 1994 (3420 mt)				
1992	Andrew	4/5	Florida Bay area (280º course)	y + 3
1998	Georges	2/4	Key West (290º course)	y + 1
1999	Irene	1/2	Florida Keys (30º course)	y + 1
2005	Rita	2/5	Key West - Dry Tortugas (270º course)	none since
2005	Wilma	2/5	West coast (70º course)	none since
Honduras, and Belize fishing areas: peaked in 1986 (5787 mt)				
1967	Beulah	2/5		y + 1
1971	Edith	2/5		y + 8
1988	Gilbert	5/5	The whole common area	y + 1
1998	Mitch	5/5	(due West)	y + 1
2000	Keith	4/4		none since
2001	Iris	4/4		y + 2

Category = strength in the Saffir-Simpson scale.
C_{fa} = strength over or near the fishing area. C_{ms} = maximum strength rating.
mt = metric tons. nda = no data available.
y = year of the hurricane.
y + 1 = 1 year after the hurricane; y + 2 = 2 years after…, and so on.
≥ (y - 1) = landings equal or greater than the year before the hurricane affected the area.

affected the fishing areas as a category 1 hurricane, but was credited with the destruction of 105,000 traps (Ehrhardt and Deleveaux 2009). Katrina (2005) entangled or destroyed from one quarter to half of all traps, and caused oil spills from refineries (Buck 2005). In spite of the destruction of traps, the landings recuperated one year after Georges, Irene, and Katrina. The present lower landings in the Florida fishery appear to be the result of the implementation of an effort reduction program (SEDAR 8 2010).

Landings in Florida also exceeded a calculated maximum yield of 2890 mt (Ehrhardt 2005) during six years before Andrew (1992), and three more times before Georges (1998) but, while the recuperation time after Andrew was three years, it was only one year after Georges and this faster recuperation could be caused by a larger recruitment or by an increase of the Catch Per Unit effort (CPUE) resulting from the reduction of traps since 1994 (SEDAR 8 2010).

On the one hand all fisheries, as any exploited animal natural resource, depends on the number, survival, and growth of recruits to the population. On the other hand, it is difficult to accept that such powerful and destructive events as hurricanes do not have at least some impact on the spiny lobster fisheries; perhaps they affect recruitment. Hurricanes destroy mangroves with their complex epiphytic algal communities which are known to release chemical signals that attract the phyllosome stage XI and trigger their metamorphosis to *puerulus* (George 2005). After swimming to the coast, *puerulii* and the initial postlarval stages live within those epiphytic communities, and it can be assumed that if mangroves are destroyed by hurricanes, the survival of postlarval stages could be reduced.

All spiny lobsters have lengthy planktonic periods that for *P. argus* is from six to ten months (Buesa 1970; Hunt 1994) during which the *phyllosome* larvae change their feeding habits and react differently to light. The youngest (phytophagous) *P. argus* larval stages (less than 100 days old) typically dwell in the upper 25 meter or so, and thereafter begin diurnal vertical migration between surface waters and depths over 100 meters (Buesa 1970, Baisre 1976, Yeung and McGowen 1991, Butler et al. 2010)

Hurricanes can mix water layers down to the 70 -100 meter isobaths (Zedler et al. 2002, Spazini et al. 2009), depths where the *P. argus* larvae are especially abundant but it is difficult to know whether water mixing of this magnitude has net positive or negative effects on the larvae and their eventual recruitment onshore. Violent mixing of surface waters associated with hurricanes may damage larvae or redistribute them to depths where their food abundance and predation risk are suboptimal. Yet mixing can also redistribute nutrients and stimulate planktonic growth that in turn can enhance the productivity of the pelagic ecosystem, including lobster larvae (Polovina et al. 1998). So it is difficult to ascertain the effect of hurricanes

Table 3. Hurricanes Allen (1980) and Gilbert (1988): characteristics and associated spiny lobster landings in Cuba and the Caribbean.

Characteristic and landings	Allen, 1980	Gilbert, 1988
Type	Cape Verde	Cape Verde
Formed on	31 July 1980	8 September 1988
Category (Saffir-Simpson)	5	5
Days duration	11	11
Lowest barometric pressure	899 mbar (26.55 inHg)	888 mbar (26.22 inHg)
Strongest sustained winds	190 mph (305 km/h)	185 mph (295 km/h)
Track course South of Cuba	East to West at 295º	East to West at 285º
Distance from Southern Cuba	50-80 nautical miles	120-140 nautical miles
Cuban areas affected	none	none
Southern Cuba landings (y-1)	9671 mt	10,241 mt
Years with landings ≥ MSY of 8500 mt (Buesa, 1972)	5 years from 1965-1979	8 years from 1980-1987 (total of 13 from 1965-1987)
First year with landings ≥(y-1)	y + 2 (9926 mt)	none since
Caribbean areas affected	Windward and Leeward Islands, Puerto Rico, Haiti, Jamaica, Yucatan, northern Mexico, southern Texas	Windward Islands, Venezuela, Hispaniola, Jamaica, Central America, Yucatan, northern Mexico, southern Texas
Landfall	lower Texas coast (cat.3)	Jamaica (cat.3), Cozumel and Cancun (cat.5), Tamaulipas (cat.3)
Direct fatalities	290	433
Damages (in 2011 USD)	$ 4 billion	$13.2 billion (99% in St. Lucia, Jamaica, and Mexico)
Caribbean landings in (y-1)	19,163 mt	22,245 mt
First year with landings ≥(y-1)	y + 3 (19,364 mt)	y + 11 (23,692 mt)

Barometric pressure: mbar = millibar inHg = inches of mercury
MSY = Maximum Sustainable Yield in a fishery
(y -1) = year before the hurricane
(y+1) = 1 year after the hurricane; (y+2) = 2 years after, ….. and so on.

on *P. argus* connectivity although there is evidence that hurricanes are related to increased postlarvae supply in near shore areas of Yucatán (Briones-Fourzán et al. 2008).

Generally speaking it has to be acknowledged that hurricanes of all intensities have affected the Caribbean fishing areas every year, forever, in spite of which all fisheries were able to grow and peak before declining. This fact points to the possible dependence of declining landings on causes other than hurricanes with three concrete examples pointing to the independence between hurricanes and landings.

No strong hurricane in recorded history has ever made direct landfall on the Caribbean coasts of Panama or Costa Rica, in the Gulfs of Darién and Mosquito. During Mitch (1998), the most catastrophic hurricane ever to hit Central America causing 11,000 deaths, the destruction of three million houses, and of 70% of the transportation infrastructure in Honduras, its effect on neighboring Costa Rica was limited to inland runoffs ruining the shrimp culture farms in the Gulf of Fonseca (Pacific coast) (United Nations 1998).

Within this scenario of little influence of hurricanes, Costa Rican Caribbean coast spiny lobster landings peaked in 1993 with 403 mt (Wehrtmann 2004) and declined to only 59 mt in 2008 (FAO 2010).

Something similar occurred to Panamanian spiny lobster fishery in "Bocas del Toro" fishing area. They grew from 300 mt in 1996, to 800 mt in 2001, and declined in 2002 to 650 mt (Guzmán and Tewfik 2004).

The spiny lobster landings in the San Blas archipelago, locally known as "Kuna-Yala", grew from 18 mt in 1998, peaked with 92 mt in 2001 (Castillo and Lessios 2001), and declined to only 5 mt in 2008 (Anonymous 2 2010).

Additionally, both Panama and Costa Rica are influenced by an oceanic closed current circulation were spawned larvae most likely will be recruited locally without contributing to the Caribbean connectivity (Buesa 2007).

Finally, there is the case of Brazil whose landings of 0.32 Mmt from 1950 to 2008 represent 56% of all landings outside the Caribbean Sea and Gulf of Mexico. Brazil's Caribbean spiny lobster fishery grew from 500 mt in 1955, to 5606 mt in 1975, peaked in 1991 with 11,059 mt, and declined to 6480 mt in 2008 (FAO 2010).

Brazilian landings also surpassed a maximum yield of 6446 mt twenty six times from 1970 thru 2007 and presently they have implemented a fishing effort reduction program (Ehrhardt 2005). This is a scenario very similar to Cuba's with a major difference: no hurricane has ever affected Brazilian spiny lobster fishing areas which are south of the southern most limit of the North Atlantic hurricanes paths. Brazilian coasts south of the Equator are in the south Atlantic which is too cold to permit the development of hurricanes (Veiga et al. 2008).

The absence of hurricanes in Brazil is such a known fact, that when in 2004 the weak category one hurricane "Catarina" formed east of Santa Catarina province and made landfall with weak winds and rain for the first time ever, the news was received with disbelief and as a meteorological oddity (Veiga et al. 2008).

The previous discussion indicates that the effects of hurricanes on the Caribbean spiny lobster fisheries could be marginal. The obvious question now is, why have all the Caribbean spiny lobster fisheries declined? The short answer is fisheries mismanagement.

Table 4 summarizes some examples of violations and regulations with negative impact on the populations, especially the case of harvest and commercialization of juvenile individuals. About 2400 mt, or 31% of the combined annual spiny lobster landings of Costa Rica, Florida, Honduras, Jamaica, and Puerto Rico (about 7.4 million spiny lobsters) are juveniles. This total has to be larger because the number of juveniles caught in Belize and other fishing areas is largely unreported and basically unknown. Given their adult potential egg production levels (Buesa and Mota-Alves 1970) had all those juveniles grown to maturity and reproduced, they could have had an output of about 4-5 $x10^{12}$ larvae annually.

Chávez (2009) concluded that the spiny lobster fisheries of Bahamas, Belize, Brazil, Cuba, Honduras, Mexico, and Nicaragua show different levels of overexploitation and that the situation requires several protection measures, especially effort reduction to obtain regional landings of 11,000 mt, instead of the present level of about 17,000 mt. Regional regulations on size, "tail" weights, and closed season are also recommended.

Overfishing and juvenile harvesting in ever-increasing numbers reduce the size of the parental populations and their larvae output, the populations become more vulnerable to the destruction of the postlarva coastal habitat which is one mechanism whereby hurricanes could have a negative impact on a lobster population.

Historically there have always been hurricanes but during the 1960s the parental populations were able to produce enough postlarvae to compensate for any coastal habitat damage caused by the strongest hurricanes and the ever increasing fishing effort. As the harvests increased above sustainable levels, the parental populations and the postlarval output decreased and the year classes became ever smaller. This constant negative feed back cycle ended with the present overexploited stage of populations increasingly more and more vulnerable to the fishing effort and the violation of the existing regulations.

The best argument for this conclusion is that the Caribbean spiny lobster fisheries in Brazil and in the Caribbean region grew and declined similarly, even when Brazil never experienced the effect of any hurricane, its decline resulting from fishing mismanagement alone.

Table 4. Violations and adverse consequences of some regulations.

Country / area	Violation or adverse consequence of regulations
Antigua & Barbuda	From 1992 to 2004, 94 fishery violations recorded included possession of undersized lobsters and berried females (Horsfold and Archibald 2006).
Belize	Unknown but suspected large numbers of juveniles are commercialized (Carcamo 2001)
Costa Rica	Harvested juveniles amounted to 44% of landings in 2004 (about 30 mt) (Wehrtmann 2004)
Cuba	After 12 consecutive years (1978 to 1989) of landings above a MSY of 10,300 mt (Buesa 1972), the situation worsened when the 1999 and 2000 closed seasons were cancelled and the fishery remained open for 33 consecutive months (June 1998 to February 2001) (Muñoz-Núñez 2009)
Dominican Rep.	In 1997, around 70% of lobsters caught in "Parque Jaragua" were below legal size (Nolasco 2001).
Florida	Existing regulations allow using juvenile lobsters as attractants in lobster traps causing the death of 28.32 million from 1978/79 to 2008/09 or close to 1 million juveniles annually (SEDAR 8, 2010). These juveniles amount to 9629 mt or 16% of the total local harvest during the period. The number of undersize lobsters taken or sold illegally continued to be a problem (GMFMC 2002).
Honduras	From 1996-2002, 24.29 million juveniles weighing 2643 mt (12% of the local total harvest in the period) were commercialized. In some areas about 60% of landings are juveniles (Castellón and Sarmiento 2001)
Jamaica	In 2005, 0.2 million juveniles caught amounted to 30% of 221 mt landed. In 2007, immature females were 76% of landings (228mt or 0.67million lobsters). About 0.87 million juveniles are caught annually (CARICOM 2007).
Nicaragua	Between 1990 and 2007 around 30% of landings (18,720 mt) were juveniles (55.06 million). During the early 2000s, juveniles exceeded 40% of annual landings (about 1700 mt) (Ehrhardt 2005). The illegal catch amounts to about 3.06 million juveniles annually (Bernutty 2001).
Puerto Rico	Juveniles were 40% of 174 mt landed from 1985 to 1989 (0.2 million). From 1989 to 1991 juveniles increased to 59% of 107 mt landed (0.19 million), but in 1998 the harvest of juveniles was reduced to 24% of 48 mt (0.03 million). About 0.14 million juveniles are harvested annually (Morris et al. 2004)
St. Lucia	Undersized lobsters represented from 20 to 62% of catches (2 to 12 mt annually) from 1990 to 2005, variable by areas. Local restaurants prefer juveniles (Joseph 2001).
US Virgin Islands	1.3% of landings from 1987 to 1989 in St. Croix, and 2.9% of landings from 1985 to 1989 in St. Thomas and St. John, were juveniles (Morris et al. 2004).

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PaV1 infection in the Florida spiny lobster (*Panulirus argus*) fishery and its effects on trap function and disease transmission

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Abstract: The Caribbean spiny lobster (*Panulirus argus*) supports the most economically valuable fishery in the Caribbean. In Florida, USA, the majority of the catch is landed in traps "baited" with live, sublegal-sized lobsters that attract other lobsters due to their social nature. This species is also commonly infected by the pathogenic virus *Panulirus argus* Virus 1 (PaV1). Here we describe a polymerase chain reaction (PCR) based assessment of the prevalence of PaV1 in the lobster fishery from the Florida Keys. We tested the effect of PaV1-infected lobsters in traps on catch and on transmission to other trapped, uninfected lobsters. We found that 11% of the lobsters caught in commercial traps were positive for the virus by PCR, but none of these animals showed visible signs of disease. We also tested whether healthy lobsters avoid diseased lobsters in traps. Traps into which we introduced an infected lobster caught significantly fewer lobsters than traps containing an uninfected lobster. Moreover, uninfected lobsters confined in traps with infected lobsters acquired significantly more PaV1 infections than those confined with uninfected lobsters. This study demonstrates the indirect effects that pathogens can have on fisheries and the unintended consequences of certain fishery practices on the epidemiology of a marine pathogen.

Résumé : La pêche à la langouste des Caraïbes (*Panulirus argus*) représente une des pêches commerciales les plus importantes du point de vue économique dans les Caraïbes. En Floride, É.-U., la majorité des captures sont faites dans des casiers utilisant comme « appâts » des langoustes vivantes de taille inférieure à la taille légale qui attirent les autres langoustes à cause du caractère social de l'espèce. La langouste est aussi fréquemment infectée par le virus pathogène *Panulirus argus* virus 1 (PaV1). Nous déterminons la prévalence du PaV1 dans la population de langoustes dans les Keys de la Floride à l'aide de la réaction en chaîne par polymérase (PCR). Nous évaluons l'effet des langoustes infectées par PaV1 dans les casiers sur les captures et sur la transmission aux autres langoustes non infectées dans le casier. Dans les casiers commerciaux, 11 % des langoustes capturées affichent une réaction positive au virus à l'analyse PCR, mais aucun de ces animaux ne présente de signes apparents de la maladie. Nous testons aussi si les langoustes en santé évitent les langoustes infectées dans les casiers. Les casiers dans lesquels nous avons placé une langouste infectée capturent significativement moins de langoustes que les casiers contenant une langouste saine. De plus, les langoustes saines confinées dans des casiers contenant des langoustes infectées contractent significativement plus d'infections à PaV1 que celles enfermées avec des langoustes saines. Notre étude démontre les effets indirects que les pathogènes peuvent avoir sur les pêches commerciales et les conséquences imprévues de certaines pratiques de pêche sur l'épidémiologie d'un pathogène marin.

[Traduit par la Rédaction]

Introduction

Pathogens can have significant effects on host populations that support fisheries worldwide (Dobson and May 1987; Patterson 1996; Shields et al. 2005), among them valuable fisheries for decapod crustaceans (e.g., Shields et al. 2007; Shields and Overstreet 2007; Wahle et al. 2009). Several pathogens have impacted commercially important crustacean fisheries in recent decades. For example, parasitic dinoflagellates of the genus *Hematodinium* have caused considerable mortality impacting important crab and lobster fisheries (e.g., snow crabs, *Chionoecetes opilio* (Shields et al. 2005, 2007; Mullowney et al. 2011); velvet crab, *Necora puber*, (Wilhelm and Mialhe 1996); and Norway lobster, *Nephrops norvegicus* (Stentiford et al. 2001)). Epizootic shell disease has had a devastating effect on American lobster (*Homarus americanus*) in southern New England (USA) over the past decade (Castro and Angell 2000; Wahle et al. 2009), prompting the Atlantic States Marine Fisheries Commission – American Lobster Technical Committee to recom-

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mend a 5-year closure of the fishery. Spiny lobsters (Palinuridae) are also afflicted by a range of pathogens (Shields 2011*a*), but they rarely pose a risk to fisheries. An exception may be the PaV1 virus that infects the Caribbean spiny lobster (*Panulirus argus*).

Panulirus argus supports one of the most economically valuable fisheries in the Caribbean, with commercial landings in Florida, USA, valued at over $22M annually (Florida Fish and Wildlife Conservation Commission 2008), and whose value now approaches US$1B Caribbean-wide up from over US$800M five years ago (Food and Agriculture Organization of the United Nations (FAO) 2006). However, over the past decade, commercial landings of lobster in Florida and in several countries in the Caribbean have declined by ~30% and remain below historic levels (Southeast Data, Assessment, and Review 8 (SEDAR 8) 2005; Ehrhardt et al. 2010). The cause of this decline is unknown and difficult to discern because of a lack of time-series data chronicling changes in crucial environmental parameters, lobster population metrics, and fishery effort statistics. Stocks of *P. argus* are overexploited or nearly so in many areas of the Caribbean (Chávez 2009), and the loss of spawning stock may explain the general decline in many fisheries. However, the discovery of the pathogenic virus *Panulirus argus* Virus 1 (PaV1) infecting lobsters in the region is a major concern (Shields and Behringer 2004), and where prevalent, it is of undoubted consequence to lobster stocks and the fisheries they support.

Caribbean spiny lobsters are fished throughout their range using a number of different gear types, including traps, casitas (a flat surface of wood, metal, or cement braced approximately 15 cm off the seafloor), nets, and spears. In Florida, the primary commercial fishing gear is a wood- or plastic-slat trap, no larger than 0.9 m × 0.6 m. Currently, there are about 500 000 traps in the Florida fishery, down from 944 000 in 1992 (Vondruska 2010). There is growing concern over the potential introduction of pathogens from imported or spoiled bait used in fisheries (Hasson et al. 2006; Hervé-Claude et al. 2008), but little or no bait is used in the Florida fishery for *P. argus*. Instead, commercial trap fishermen use sublegal (legal = adult = 76 mm carapace length (CL)) lobsters as live "bait" in traps as a social attractant to legal-sized lobsters and are permitted to possess up to 50 sublegal lobsters ("shorts") and one per trap aboard each boat. Trap confinement of sublegal lobsters results in 29% mortality within four weeks of confinement in a trap, and an estimated 47% of all sublegal lobsters used in traps die during the course of the fishing season (Kennedy 1982; Hunt et al. 1986; Hunt 2000). Traps may also alter PaV1 transmission among spiny lobsters, and the disease may, in turn, alter trap efficiency.

PaV1-diseased lobsters disrupt the normal gregarious behavior of nondiseased lobsters (Behringer et al. 2006), so it is also possible that an infected lobster within a trap could diminish the efficiency of the trap by driving away future inhabitants. Stress induced from confinement and bait-induced malnutrition may also increase disease susceptibility (Tlusty et al. 2008). Transmission of PaV1 among lobsters may also be increased if a diseased lobster enters a trap containing healthy lobsters. The unintentional onboard transport of infected sublegal lobsters from one fishing location to another and potential spread of PaV1 is also a concern. Thus, the use of sublegal lobsters in fishing traps in Florida, combined with the unique changes in social behavior associated with PaV1 infection, creates a situation in which the pathogen and fishery may interact to influence disease dynamics in spiny lobsters.

Therefore, our objectives for this study were to determine (*i*) the prevalence and distribution of PaV1 in lobsters entering the fishery in the Florida Keys using a polymerase chain reaction (PCR) based diagnostic, (*ii*) how the presence of infected lobsters within lobster traps affects the trapping of other lobsters, and (*iii*) if trap confinement enhances PaV1 transmission among lobsters.

Materials and methods

PCR screening for PaV1

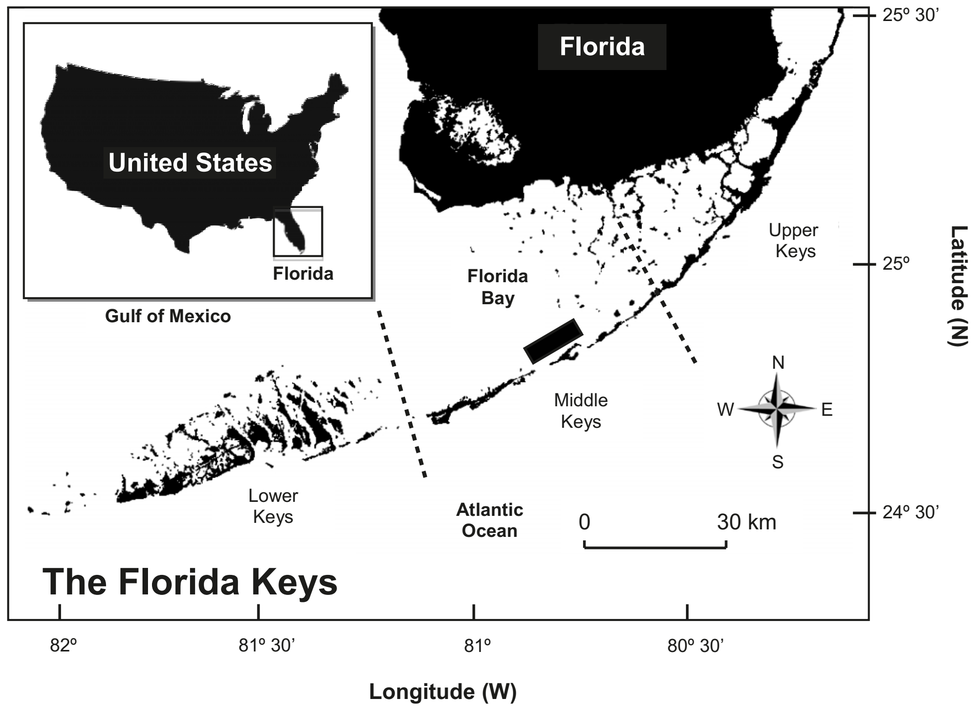
A diagnostic assay for PaV1 infection was used based on the primer set published by Montgomery-Fullerton et al. (2007) with modifications (Moss et al. 2012). In brief, DNA extractions were performed on 100–150 µL of lobster hemolymph using a Qiagen DNeasy (Valencia, California) blood and tissue kit, following the manufacturer's protocol. Lobster genomic DNA was eluted in 150 µL of extraction buffer and stored at 4 °C until assayed. The quality of genomic DNA was assessed by amplifying the small subunit ribosomal RNA (SSU) of the lobster using "universal" SSU primers modified from Medlin et al. (1988) (see Moss et al. 2006). The amplified target DNA fragment was approximately 1800 bp in length. PCR products from the SSU and PaV1 assays were loaded separately onto a 2% agarose gel (*w*/*v*), electrophoresed at 100V, stained with ethidium bromide, and examined under UV light. Images were recorded using the Alpha Innotech FlourChem (San Leandro, California) imaging system.

All lobsters used in experiments were prescreened for PaV1 infections using PCR prior to the start of the experiment, and only uninfected lobsters were included, except when the experimental protocol required the use of infected lobsters, which all had visible signs (milky hemolymph) of disease observed through the dorsal membrane between the abdomen and cephalothorax. Therefore, all infections detected in lobsters at the conclusion of an experiment were new infections or infections that were initially well below the detection limit of the PCR test, which is quite low at 1.2 fg of purified viral DNA per positive test (Montgomery-Fullerton et al. 2007).

PaV1 prevalence among lobsters in the Florida Keys fishery

To determine the prevalence and distribution of PaV1 in the Florida (USA) fishery, we traveled aboard commercial lobster boats throughout the Florida Keys and sampled sublegal and legal lobsters collected in traps. We used a stratified-random sampling design, with the strata being four biogeographic regions in the Florida Keys: (1) middle Keys, Ocean-side, (2) middle Keys, Gulf-side, (3) lower Keys, Ocean-side, and (4) lower Keys, Gulf-side (Fig. 1). Within each stratum, we sampled lobsters from a haphazardly selected subset of traps. We conducted surveys near the beginning (August–November) and end (January–March) of the 2008–2009 fishing season. This seasonal sampling was im-

Fig. 1. Map of the Florida Keys (USA) showing the geographic regions where commercial traps were sampled (Gulf of Mexico, Atlantic Ocean, middle and lower Keys). The solid rectangle represents the region in the middle Keys where experimental traps were deployed.



portant to determine if temporal trends existed in trap catch and disease dynamics that may be associated with lobster density, trap soak times, or environmental correlates such as water temperature. We hypothesized that the effects of trap confinement on PaV1 prevalence, if present, would be more severe late in the fishing season when fishermen pull their traps less frequently.

While on board, we obtained a haphazard sample of lobsters from each trap line, recorded the sex, injuries, and CL of each lobster, and then drew 0.2 mL of hemolymph with a 27-gauge syringe from the juncture between the basis and ischium of the fifth walking leg of each lobster. The hemolymph was stored in labeled microcentrifuge tubes filled with 0.6 mL of anticoagulant, held in an ice bath onboard the vessel, and then transferred to a –40 °C freezer until final shipment for PCR screening. Hemolymph samples were shipped on dry ice to the Virginia Institute of Marine Science for PCR analysis. The relationship between PaV1 prevalence and four independent variables (geographic region, stage of fishing season, sex, and size) was analyzed with logistic regression.

Effect of PaV1 infection on trap catch

To determine the effect of infected lobsters on trap catch, we manipulated the disease state (uninfected or infected) of sublegal lobsters normally used to bait commercial lobster traps and measured the "attractiveness" of those traps to wild lobsters. All experiments were conducted from May–July 2009 when the fishery was closed. The lobsters used in this experiment and the one described below were collected from hard-bottom and coral reef habitat around the middle Florida Keys, Florida, USA (Fig. 1), in the same areas where the traps were later deployed so as not to introduce additional infected lobsters into the wild. The status of infected and uninfected lobsters used in each experiment was determined by PCR prescreening of hemolymph samples for PaV1. All infected lobsters used as experimental bait displayed milky hemolymph, indicative of heavy infection, shown to elicit an avoidance response in conspecifics (Behringer et al. 2006).

Treatments were standard commercial fishing traps containing either a single uninfected (n = 51) or infected experimental lobster (n = 33) that served as "bait" in the trap (i.e., provided a social cue to other lobsters). The mean (± standard deviation, SD) size of infected experimental lobsters was 32.8 ± 9.8 mm, whereas that of uninfected experimental lobsters was 47.7 ± 11.8 mm. The prevalence of PaV1 in the wild is higher among smaller lobsters, hence the lower mean size of infected lobsters in our experiment (Shields and Behringer 2004). However, there is no relationship between the avoidance response of healthy lobsters and the size of either infected lobster or healthy lobsters (Behringer 2003). Each experimental lobster was constrained in a plastic minnow trap placed within the lobster trap to eliminate the possibility of their escape, but the traps were otherwise left unaltered. Traps were deployed in 2–5 m of water and then pulled 7 days later with the assistance of a commercial fisherman. We followed the advice of the fisherman in the haphazard placement of the traps in his normal fishing area. Traps were deployed either 500 m north of Long Key, Florida, or north of the Channel No. 5 bridge east of Long Key (Fig. 1), and at least 100 m apart. The mean number of uninfected lobsters that entered the traps was compared between experimental treatments using a one-way model I analysis of variance (ANOVA).

Fig. 2. Prevalence of PaV1 in Caribbean spiny lobsters (*Panulirus argus*) sampled from traps fished in four geographic regions in the middle and lower Florida Keys. There were no data collected from the Gulf of Mexico side of the lower Keys late in the season because the fishermen had removed their traps from this region. *n* = number of lobsters sampled from each region during the early and late stages of the fishing season.

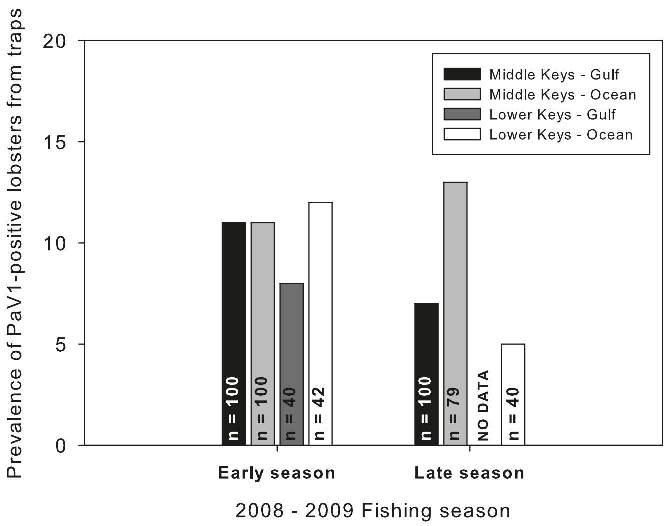


Table 1. Demographic and seasonal distribution of Caribbean spiny lobsters (*Panulirus argus*) infected with PaV1 (PCR positive) and the resulting prevalence during the 2008–2009 fishing season.

Category	PaV1 infected (PCR+)	Uninfected (PCR–)	Total	Prevalence of PaV1 (%)
Sex				
Male	23	208	231	10.0
Female	26	244	270	9.6
Season				
Early	30	252	282	10.6
Late	19	200	219	8.7
Size				
Legal	18	133	151	8.8
Sublegal	31	319	350	11.9

Table 2. Effect of fishing season, geographic location, and sex on PaV1 prevalence in Caribbean spiny lobsters (*Panulirus argus*) caught in the Florida Keys commercial trap fishery.

Overall model evaluation			
Test	df	Likelihood ratio X^2	*P*
Logistic regression	5	2.0417	0.8433
Goodness-of-fit test			
Test	df	Pearson's X^2	*P*
Goodness-of-fit	5	2.042	0.4924
Effect likelihood tests			
Source	df	Likelihood ratio X^2	*P*
Fishing season	1	0.7219	0.3955
Geographic location	3	1.479	0.6871
Sex	1	0.06021	0.8062

Effect of trap confinement with an infected lobster on PaV1 transmission

We determined if confinement, or the stress associated with trap confinement, enhanced PaV1 transmission by sealing three uninfected lobsters in traps with either an uninfected lobster or a visibly infected experimental lobster. Lobsters were all marked with unique color-coded antennae tags for later identification. The mean (± SD) size of infected experimental lobsters was 37.2 ± 9.0 mm, whereas that of uninfected experimental lobsters was 43.3 ± 9.6 mm. After the experimental lobsters were added to standard wood-slat commercial lobster traps, we sealed the traps by covering the entire trap with 5 mm plastic mesh secured with stainless-steel staples. This prevented the experimental lobsters from escaping and also prevented any wild lobsters from entering the trap. Traps containing infected or uninfected experimental lobsters were haphazardly deployed at least 100 m apart from May–July 2009 using a commercial lobster boat in the middle Florida Keys (Fig. 1) as described above, and deployment periods alternated between 7 and 14 days. These durations spanned the range of soak times used in the fishery. Soak times are typically extended as the lobster season progresses and the legal lobster abundance decreases. The frequency with which uninfected lobsters became infected with PaV1, relative to experimental treatment and soak time, was analyzed using a logistic regression.

Results

PaV1 prevalence among lobsters in the Florida Keys fishery

Of the 502 lobsters sampled from commercial lobster traps throughout the Florida Keys, none had visible signs (milky hemolymph) of infection of PaV1, but 11% tested positive by PCR for the presence of PaV1 viral DNA in their hemolymph. The prevalence of infected lobsters varied little among geographic regions or between the early- and late-season samples (Fig. 2; Table 1). There was no significant relationship between region, season, sex, and prevalence of PaV1 (Table 2). For logistical reasons, no samples were acquired from the Gulf side of the lower Keys late in the fishing season.

The mean CL (±1SD) of lobsters sampled from traps was 75.9 ± 6.0 mm (maximum = 95.3 mm) for infected lobsters and 73.9 ± 6.2 mm (maximum = 109.3 mm) for uninfected lobsters. Because smaller lobsters are more susceptible to PaV1 (Shields and Behringer 2004; Butler et al. 2008), we analyzed the effect of size (CL) on the number of infected lobsters sampled from traps. There was a weak ($P = 0.0508$) negative relationship between lobster CL and prevalence of PaV1 (Table 3). When lobsters were grouped into legal (≥76 mm CL) or sublegal (<76 mm CL) sizes, there was no significant difference in the number infected (Fisher's exact test, likelihood $X^2 = 1.086$, df = 1, $P = 0.3256$).

Effect of PaV1 infection on trap catch

Traps deployed with an uninfected or PaV1-infected lobster all caught wild lobsters, but not equally (Fig. 3). The

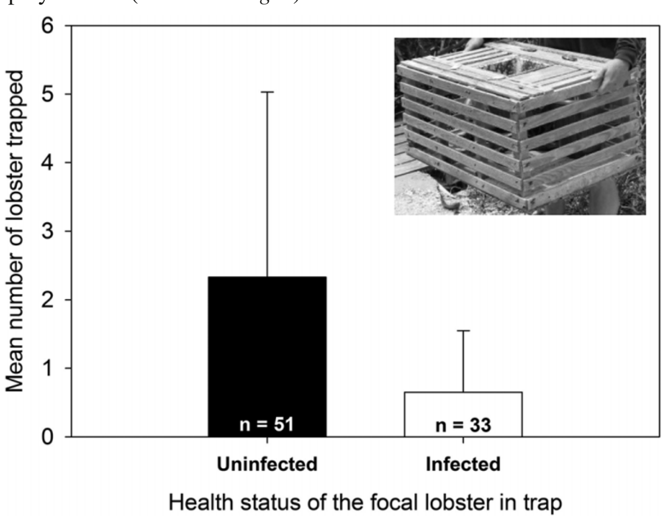
Table 3. Effects of lobster carapace length and fishing season on prevalence of PaV1 in Caribbean spiny lobsters (*Panulirus argus*) in the commercial trap fishery in the Florida Keys.

Overall model evaluation			
Test	df	Likelihood ratio X^2	*P*
Logistic regression	2	4.377	0.1120
Goodness-of-fit test			
Test	df	Pearson's X^2	*P*
Goodness-of-fit	2	206.64	0.9975
Effect likelihood tests			
Source	df	Likelihood ratio X^2	*P*
Carapace length	1	4.354	0.0508
Fishing season	1	0.02396	0.8770

Table 4. Effect of experimental Caribbean spiny lobster (*Panulirus argus*) health status and trap soak time on PaV1 transmission within experimental lobster traps.

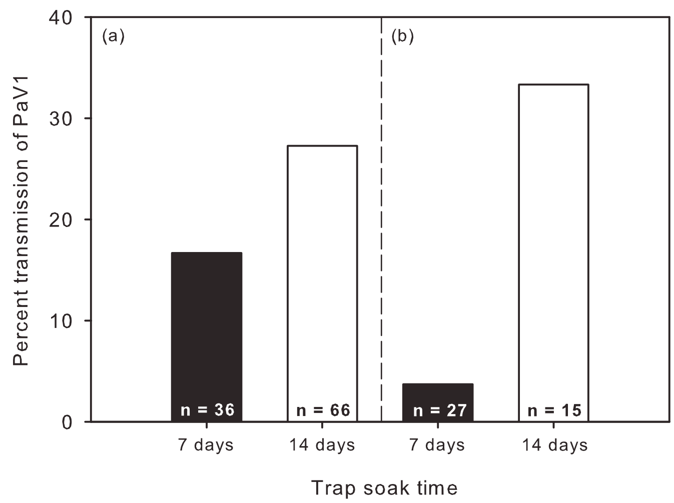
Overall model evaluation			
Test	df	Likelihood ratio X^2	*P*
Logistic regression	2	9.448	0.009
Goodness-of-fit test			
Test	df	Pearson's X^2	*P*
Goodness-of-fit	2	0.750	0.3863
Effect likelihood tests			
Source	df	Likelihood ratio X^2	*P*
Experimental lobster status	1	5.753	0.0165
Trap soak time	1	1.0156	0.3136

Fig. 3. Difference in catch in relation to the presence of an uninfected or infected experimental lobster. The mean (±1 standard deviation, SD) number of lobsters captured in traps baited with an uninfected lobster was significantly higher than that baited with a PaV1-infected juvenile lobster (one-way model I analysis of variance (ANOVA): $F = 4.2375$, df = 1,83, $P = 0.0427$). *n* = number of trap deployments within each treatment. Inset: Picture of a standard wood slat lobster trap used in the Florida fishery for Caribbean spiny lobster (*Panulirus argus*).



data were natural log transformed to meet the ANOVA assumption of normality, and the Welch ANOVA statistic was used because the variances were not homogeneous. The mean (± SD) number of lobsters captured by traps baited with an uninfected lobster was significantly greater (2.33 ± 2.7) than that for traps baited with a visibly PaV1-infected lobster (0.65 ± 0.9) (one-way model I Welch ANOVA: $F = 4.6621$, df = 1,78; $P = 0.0339$). That is, the traps with an infected juvenile lobster caught 72% fewer lobsters than those using uninfected bait animals. The mean (± SD) size of lobsters captured in the traps was 66.0 ± 10.0 mm for traps baited with an uninfected lobster and 62.6 ± 10.4 mm for traps baited with an infected lobster.

Fig. 4. Incidence of Caribbean spiny lobsters (*Panulirus argus*) newly infected with PaV1 when confined in traps with (*a*) a PaV1-infected experimental lobster or (*b*) an uninfected experimental lobster. *n* = number of lobsters within each treatment.



Effect of trap confinement with an infected lobster on PaV1 transmission

Transmission of the virus occurred within the traps. Significantly more uninfected lobsters became infected when confined with a PaV1-infected lobster than those confined with an uninfected lobster (Table 4; Fig. 4). Transmission that occurred during the 7-day trap soak time largely drove this difference, because after a 14-day soak, there was little difference in transmission between the infected or uninfected lobster treatments. In the control treatment, only one (<5%) of the 27 uninfected lobsters became infected with PaV1 after 7 days in a trap with another uninfected lobster, but after 14 days, 33% of the 15 control lobsters tested positive for PaV1 infection.

Discussion

PaV1 may have a profound effect on the Florida trap fishery for Caribbean spiny lobsters. The prevalence of PaV1 was 9% in legal-sized adult lobsters and 11% among all trapped lobsters. This finding is much higher than previously thought, but confirms findings of Shields and Behringer (2004) and Huchin-Mian et al. (2009) that adult lobsters can harbor infections. Traps baited with infected lobsters had lower catches than those baited with uninfected lobsters, which can be explained by the avoidance behavior of healthy lobsters towards diseased animals (Behringer et al. 2006). This has important consequences to the fishery, because in years or locales with high prevalence, catches may be lower if diseased lobsters enter them. We also found that infected lobsters can transmit PaV1 to uninfected lobsters in traps, although background infections were also high. This has important implications to the lobster fishery because it suggests that certain fishery practices could exacerbate the spread of the PaV1 virus.

Lobsters collected that were PCR-positive for PaV1 showed no visible signs of infection, but they were not removed from the fishery for histological examination to detect active infection. Visible infections with PaV1 are most commonly observed in small juveniles (Shields and Behringer 2004), and it is possible that these individuals escaped the traps as they were brought to the fishing boat. The PCR-positive individuals may also have had latent infections, or disease may manifest differently in the adult segment of the population resulting in infected animals that are not visibly diseased.

Avoidance by uninfected lobsters of infected lobsters is an effective means of reducing transmission of PaV1 (Behringer 2003; Behringer et al. 2006; Dolan 2011); thus uninfected lobsters may avoid traps containing infected lobsters. In the Florida fishery, traps are typically baited with sublegal lobsters, not food, thereby representing shelter in this shelter-limited system (Butler and Herrnkind 1997), and shelters containing conspecifics are attractive to other lobsters (Eggleston and Lipcius 1992; Ratchford and Eggleston 1998; Behringer and Butler 2006). However, not all uninfected lobsters avoided traps with visibly infected lobsters; they may be making a trade-off between avoiding disease versus avoiding predation (Lozano-Álvarez et al. 2008). Occasional observations of cohabitation by infected and uninfected lobsters in large, artificial shelters ("casitas") used by fisherman in Mexico were attributed to the large size of the casita relative to most natural crevice shelters within which lobsters are more closely spaced (Lozano-Álvarez et al. 2008). This may allow the lobsters to cohabitate with limited physical contact and may also apply to traps used in Florida. Perhaps more important to the interactions between infected and uninfected lobsters is the status and progression of disease in infected individuals and thus the timing and presence of signals that they produce and to which uninfected lobsters respond.

The interaction between fishery and pathogen has precedence in both crustacean and finfish fisheries (for several examples in crustacean fisheries, see Shields 2011*b*). Many reports of disease are associated with the holding of wild-caught organisms in impoundments. Pacific herring (*Clupea pallasi*) have a much greater prevalence (60%–87%) of viral hemorrhagic septicemia virus (VHSV) following their introduction to net pens in Prince William Sound, Alaska, presumably from exposure to free viral particles released from infected fish in the pen (Hershberger et al. 1999). Gaffkemia, caused by the bacteria *Aerococcus viridans* var. *homari* and Bumper Car Disease, caused by the ciliate *Anophryoides haemophila*, cause mortality of the American lobster *Homarus americanus* in impoundments (Snieszko and Taylor 1947; Stewart 1993; Greenwood and Cawthorn 2005). Some researchers have suggested that the baitfish used to trap *H. americanus* is of insufficient nutritional quality but is used so extensively (70%–80% of the lobster diet; Grabowski et al. 2005) that lobsters may be predisposed to chitinoclastic shell disease due to malnutrition and stress (Tlusty et al. 2008). Sablefish (*Anoplopoma fimbria*), often released as bycatch in the North Pacific, show impaired immune system function when subject to "experimental capture" in the laboratory (Lupes et al. 2006), potentially increasing the risk of infection and bycatch mortality. Fisheries and disease can also interact via the catchability of the host. Many parasites affect the behaviors of their host, altering predation susceptibility (Minchella and Scott 1991; Bakker et al. 1997; Hall et al. 2005). For example, when the Norway lobster (*N. norvegicus*) are heavily infected with the pathogenic dinoflagellate *Hematodinium* sp., they have a much reduced escape response and are more apt to be captured in trawls relative to healthy lobsters (Stentiford et al. 2001). However, differences in trap and trawl efficiency or entry can vary markedly in other hosts infected by *Hematodinium* sp. (Wilhelm and Mialhe 1996; Pestal et al. 2003; Shields et al. 2005). Fisheries and disease can also have indirect effects on populations as shown in the California spiny lobster (*Panulirus interruptus*) fishery in California (USA). In marine reserves, where lobster fishing is prohibited, density-dependent disease from *Vibrio* sp. is rare among lobster prey, the purple urchin (*Strongylocentrotus purpuratus*), but in fished areas, urchin density grows unchecked and epizootics are frequent (Behrens and Lafferty 2004).

Our results show that fishery practices also have a direct effect on disease dynamics in *P. argus*. The use of sublegal lobsters in traps greatly increases their mortality (Kennedy 1982; Hunt et al. 1986; Hunt 2000), and our study shows that trap confinement can also result in PaV1 transmission. Stress increases susceptibility to disease in finfish (Davis et al. 2002; Huntingford et al. 2006), so stress-induced confinement could potentially increase the risk of PaV1 infection in spiny lobsters. Transmission of PaV1 by contact and ingestion of infected food (i.e., via cannibalism) (Butler et al. 2008) may also be enhanced among lobsters confined in traps with limited food. Moreover, even without an infected lobster within the trap, infection is possible from an endemic source of PaV1, and this may increase with longer soak times.

This source is unidentified, but it could well be the presence of diseased lobsters in the surrounding habitat from which the trapped lobsters cannot escape. If true, it may be that waterborne transmission is more efficient than initially determined from histological examination of experimental lobsters (Butler et al. 2008). It is unlikely that transmission occurred between our experimental traps containing infected lobsters and those containing only uninfected lobsters because we never placed more than a single infected lobster in each trap and traps were far from one another (>100 m). Thus, a more plausible source of infection was natural "background" sources from other infected lobsters in the area or perhaps an unidentified prey item acting as a pathogen reservoir. Regardless of the source, sublegal lobsters used in traps and released by fishermen after use are more likely to be infected with PaV1 if confined with infected lobsters.

Managing PaV1 in the fishery

Managing disease in fisheries is notoriously difficult because the disease dynamics often occur outside the act of capture. Typical solutions include reducing crowding in impoundments, careful handling of sublegal organisms or bycatch, and prohibiting the discard of diseased individuals back into the water (Shields 2003; Shields and Overstreet 2007). In the Florida trap fishery, more careful use of sublegal bait lobsters may reduce the spread of PaV1. Lobstermen should (*i*) remove from the water and destroy any lobsters with obvious signs of infection (i.e., milky hemolymph observed between the abdomen and cephalothorax), (*ii*) keep trap soak times to a minimum (<7 days), (*iii*) not move sublegal lobsters from one region to another, and (*iv*) not hold sublegal lobsters under crowded conditions in tanks or cages. Reducing the confinement time of sublegal lobsters in traps will reduce their mortality and perhaps their stress and risk of infection by PaV1. The use of alternative methods or gear should also be evaluated. For example, dive-based fisheries that do not include the use of artificial habitats (e.g., casitas) may minimize the risk of PaV1 infection if they do not artificially concentrate lobsters. Alternatively, leg and antennae injuries are more common in dive-based fisheries and that may increase the risk of infection.

Fishery trends and PaV1

The drivers of fishery stock dynamics are often multifaceted or unknown, and such is the situation with *P. argus*. Although there is no doubt that PaV1 can be a major source of juvenile lobster mortality where the disease is prevalent, there are no data prior to 2000 with which to determine the time of its emergence. Along the Yucatan coast of Mexico, prevalence of PaV1 in juveniles has increased from 2.7% in 2001 to 10.9% in 2006 (Lozano-Álvarez et al. 2008). However, annual surveys conducted since 2000 in the Florida Keys indicate that prevalence of visibly infected juveniles has changed little, fluctuating between 2% and 8% (Behringer et al. 2011). During the same period, lobster landings plummeted ~30% and have remained low (SEDAR8 2010).

Indeed, recent commercial fishery landings of *P. argus* have declined in most Caribbean nations, and most stocks are considered overexploited (Chávez 2009; Ehrhardt et al. 2010). Although the importance of overfishing on postlarval production is obvious, in Florida, there are a number of environmental perturbations that could further impact the fishery in ways similar to PaV1, including harmful algal blooms (Phlips et al. 1999), seagrass die-offs (Rudnick et al. (2005) and references therein), sponge die-offs (Butler et al. 1995; Peterson et al. 2006), and declining water quality (Boyer and Briceño 2005). However, they do not correspond with the discovery of PaV1 or the local decline in fishery landings and do not explain similar downturns elsewhere in the Caribbean. Given our findings, additional studies on the prevalence of the virus in populations of the Caribbean spiny lobster are warranted.

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REVIEW

Review of Panulirus argus virus 1 — a decade after its discovery

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ABSTRACT: In 2000, a pathogenic virus was discovered in juvenile Caribbean spiny lobsters *Panulirus argus* from the Florida Keys, USA. Panulirus argus virus 1 (PaV1) is the first naturally occurring pathogenic virus reported from lobsters, and it profoundly affects their ecology and physiology. PaV1 is widespread in the Caribbean with infections reported in Florida (USA), St. Croix, St. Kitts, Yucatan (Mexico), Belize, and Cuba. It is most prevalent and nearly always lethal in the smallest juvenile lobsters, but this declines with increasing lobster size; adults harbor the virus, but do not present the characteristic signs of the disease. No other PaV1 hosts are known. The prevalence of PaV1 in juvenile lobsters from the Florida Keys has been stable since 1999, but has risen to nearly 11 % in the eastern Yucatan since 2001. Heavily infected lobsters become sedentary, cease feeding, and die of metabolic exhaustion. Experimental routes of viral transmission include ingestion, contact, and for newly settled juveniles, free virus particles in seawater. Prior to infectiousness, healthy lobsters tend to avoid diseased lobsters and so infected juvenile lobsters mostly dwell alone, which appears to reduce disease transmission. However, avoidance of diseased individuals may result in increased shelter competition between healthy and diseased lobsters, and greater predation on infected lobsters. Little is known about PaV1 outside of Mexico and the USA, but it poses a potential threat to *P. argus* fisheries throughout the Caribbean.

KEY WORDS: *Panulirus argus* · Disease · Epidemiology · Ecology · Behavior · Prevalence · Transmission

INTRODUCTION

Until the discovery of Panulirus argus virus 1 (PaV1) (Shields & Behringer 2004), naturally occurring viral infections were unknown in lobsters. Other than PaV1, spiny lobsters are afflicted by non-viral pathogens (Shields et al. 2006, Shields 2011), and like other decapod crustaceans (i.e. lobsters, crabs, and shrimp) that are subject to a variety of microbial and parasitic diseases (Brock et al. 1990, Shields et al. 2006, Shields & Overstreet 2007), they sometimes cause epizootics with potential impacts on fisheries. The prevalence of PaV1 throughout the Caribbean range of *Panulirus argus* is unknown, but reports of infections are mounting (Huchin-Mian et al. 2009, Cruz-Quintana et al. 2011). Caribbean spiny lobsters are the target of the most economically valuable fishery in the Caribbean, where populations are considered fully or over-exploited (FAO 2006). Hence, the discovery of PaV1 is of concern and several countries are now taking steps to determine impacts of the virus on this valuable resource.

Since the initial description of PaV1 much has been done to understand its pathology, epidemiology, ecology, and possible fishery implications. A suite of techniques to assess and study PaV1 infection have also been developed. We review the current knowledge of

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PaV1; much has been learned about it, but there are many gaps that remain to be filled.

DETECTION AND PATHOLOGY

Detection

PaV1 pathology and virus particles were initially observed in tissues of lethargic juvenile Panulirus argus using light microscopy (Fig. 1) and transmission electron microscopy (TEM) (Fig. 2), respectively. TEM revealed icosahedral nucleocapsids ~182 ± 9 nm (± SD) in infected cells with hypertrophied nuclei containing emarginated chromatin (Shields & Behringer 2004). Virions assemble in the nucleus and large aggregations of virions can be found free in the hemolymph. This double-stranded DNA virus currently remains unclassified, but it shares characteristics with both the Iridioviridae and the Herpesviridae. Gross signs of juvenile lobsters heavily infected by PaV1 include lethargy, chalky-white hemolymph (Fig. 3), and sometimes a discolored, heavily fouled carapace (Shields & Behringer 2004). Adult lobsters infected with the virus, along with juveniles with light infections, present no obvious gross signs. Histological detection of pathology is sensitive but destructive (Shields & Behringer 2004). In 2006, a molecular PCR assay was developed with a reported sensitivity to 1.2 fg of purified viral DNA (Montgomery-Fullerton et al. 2007). The PCR was later modified (the primer annealing temperature was increased from 51 to 63°C) and used to confirm PaV1 infection in P. argus from Puerto Morelos, Mexico (Huchin-Mian et al. 2008). The PCR has since been optimized to improve sensitivity to 0.05 fg of viral DNA (J. Moss et al. unpubl. data). A sensitive and specific

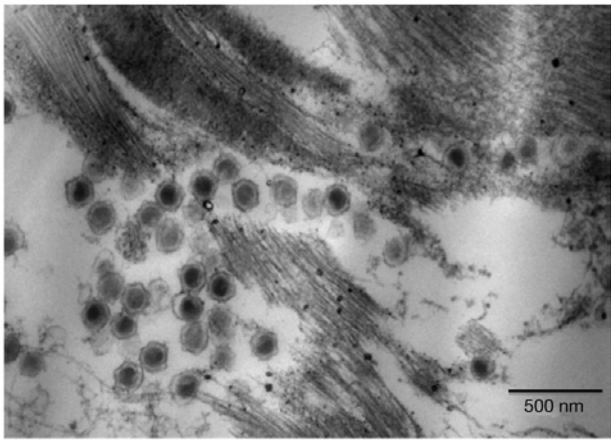

Fig. 2. Panulirus argus virus 1 (PaV1) infecting P. argus. Transmission electron microscopy (TEM) image showing PaV1 virions loose within the hemolymph and among the abdominal muscle fibers of a heavily infected juvenile lobster

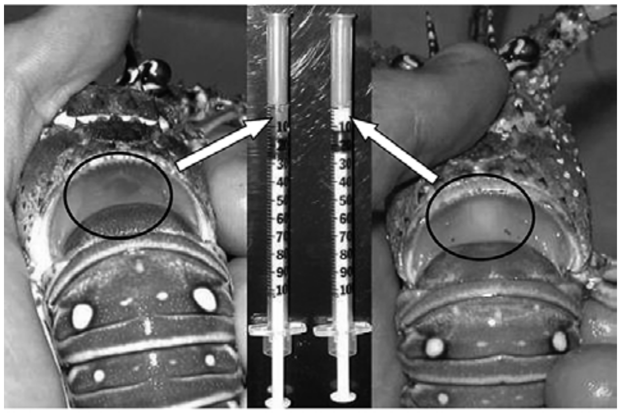

Fig. 3. Panulirus argus virus 1 (PaV1) infecting P. argus. Comparison of hemolymph color between healthy (left syringe: clear hemolymph) and PaV1-infected (right syringe: chalky-white hemolymph) lobsters

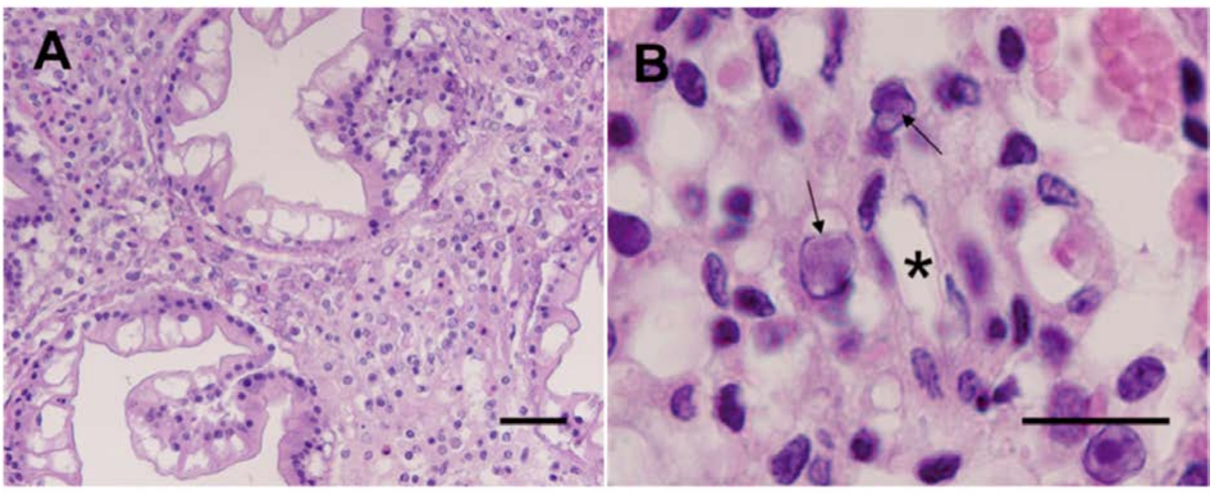

Fig. 1. Panulirus argus virus 1 (PaV1) infecting P. argus. (A) Atrophied hepatopancreas showing infiltration of hemocytes into the spongy connective tissues as a result of infection by PaV1. Scale bar = 50 µm. (B) PaV1 infection in the fixed phagocytes (arrows) surrounding an arteriole in the hepatopancreas. *: lumen of the arteriole. Scale bar = 50 µm

fluorescent in situ hybridization (FISH) assay has also been developed to visualize PaV1-infected lobster tissues (Li et al. 2006). The use of FISH confirmed that connective tissues of the hepatopancreas are the primary site of infection. Continuous cell cultures are not available for crustaceans. However, a primary cell culture method using semigranulocytes and hyalinocytes has been developed to quantify PaV1 in hemolymph samples (Li & Shields 2007). The quantal assay was based on virus-induced cytopathic effects in cell cultures infected in 10-fold serial dilutions of inocula. The assay could be used to calculate the tissue-culture infectious dose 50 % ($TCID_{50}$) of the virus. These techniques now allow for more sensitive and accurate assessments of PaV1 in wild stocks and laboratory experiments.

Genetic information

Little genetic data currently exists for PaV1. The primers for the diagnostic PCR assay target a 500 bp fragment within a 892 bp fragment deposited in GenBank (accession number EF206313) (Montgomery-Fullerton et al. 2007). This DNA fragment appears to be an open reading frame with no other published viral homologs. The other sequenced piece of PaV1 DNA is a partial fragment of a DNA-directed polymerase (GenBank accession number DQ465025), to which the FISH probe was targeted (Li et al. 2006).

Pathology

PaV1 initially infects the fixed phagocytes of the hepatopancreas (i.e. digestive gland) and connective tissue cells surrounding the hepatopancreas (Li et al. 2008) (Fig. 1). Certain circulating hemocytes, specifically hyalinocytes and semi-granulocytes, are also infected (Shields & Behringer 2004). In heavily infected lobsters, virus-infected cells can be found in the spongy connective tissues surrounding most organs, with the hepatopancreas showing marked atrophy (Li et al. 2008). Heavily infected lobsters have a notable lack of reserve inclusions, indicative of a lack of glycogen reserves, supporting the hypothesis that mortality results from metabolic exhaustion (Shields & Behringer 2004). Several hemolymph constituents (glucose, phosphorus, triglycerides, and lipase A) were altered by infection, lending further support to this hypothesis (Li et al. 2008). Indeed heavily infected lobsters have a significantly lower mean hemolymph refractive index, indicative of poor nutritional condition resulting from cessation of feeding, and display a marked atrophy in the hepatopancreas (Behringer et al. 2008, Li et al. 2008, Briones-Fourzán et al. 2009). However, poor nutritional condition does not appear to increase their initial risk of contracting PaV1 (Behringer et al. 2008). The lethargy observed in heavy infections is likely an end stage of the disease due to poor nutritional condition and organ pathology.

EPIDEMIOLOGY

Juvenile lobsters

The prevalence of PaV1 in juvenile Caribbean spiny lobsters (ca. 20 to 55 mm carapace length, CL), as identified visually in long-term field surveys in the Florida Keys, has remained relatively constant, fluctuating between 2 and 8% (Fig. 4). However, prevalence varies both spatially and temporally among sites, with some localities reaching > 40 % infection in a given year. In 2002, a more comprehensive survey was undertaken of PaV1 prevalence in juvenile and subadult lobsters at 120 hard-bottom nursery sites throughout the Florida Keys from Key Largo to the Marquesas, west of Key West. Using histology to screen for PaV1, a mean prevalence of 5% was detected with no obvious spatial patterns (D. C. Behringer, M. J. Butler & J. D. Shields unpubl. data).

The prevalence of PaV1 is highest among the smallest (< 20 mm CL) early benthic juveniles (EBJs) (Butler et al. 2008) and declines with lobster size (Fig. 5). This pattern, observed in Florida, is similar to that observed in Puerto Morelos and Chinchorro Bank (Mexico)

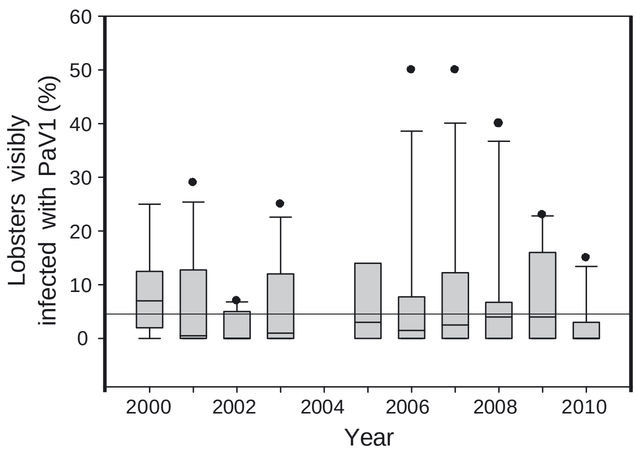

Fig. 4. Panulirus argus virus 1 (PaV1) infecting P. argus. Box plots of visually detected PaV1 prevalence among all sizes of juvenile spiny lobsters from 12 sites in the middle and lower Florida Keys in 2000 to 2010. Individual box plots show the yearly geographic variability between the 12 sites. Dashed line represents the overall mean prevalence of 5%; black dots are outliers; whiskers represent 5th and 95th percentiles; solid line in box is median value for that size class

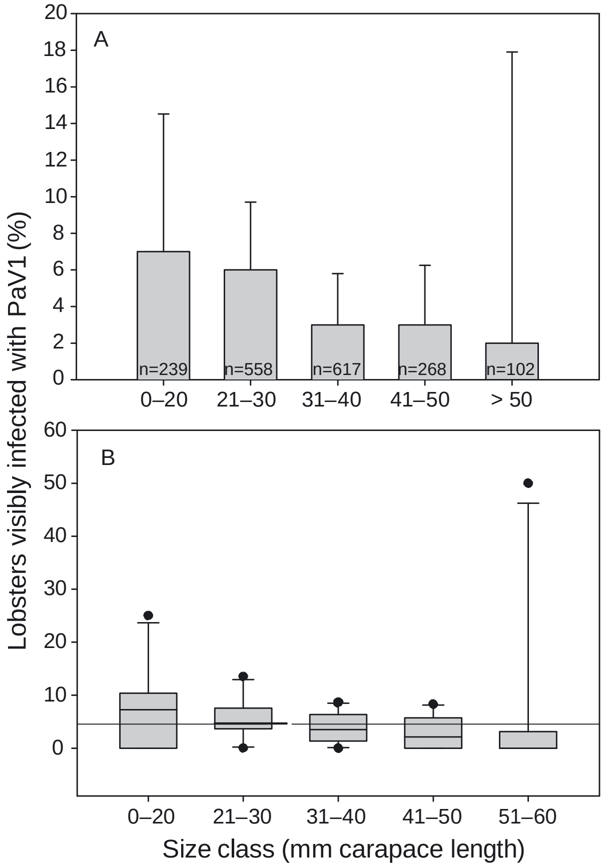

Fig. 5. Panulirus argus virus 1 (PaV1) infecting Panulirus argus. (A) Prevalence of late-stage visible PaV1 by size class for juvenile spiny lobsters from 12 sites in the middle and lower Florida Keys from 2000 to 2010. Error bars represent 1 SD and are based on the inter-annual variability. (B) Box plots of prevalence by size class. Dashed line represents the overall mean prevalence of 5%; black dots are outliers; whiskers represent 5th and 95th percentiles; solid line in box is median value for that size class

(Lozano-Álvarez et al. 2008). The inverse relationship between PaV1 prevalence and lobster size may result from the combined effects of decreasingly effective waterborne transmission with size (Butler et al. 2008) and the ability for healthy lobsters to detect infected conspecifics (Behringer et al. 2006). However, recent PCR-based surveys of juveniles in Florida Bay in 2008 and 2010 show that surveys based on visual signs grossly underestimate the prevalence of PaV1 infection in juveniles (Table 1). Whether disease would develop in all of these PCR-positive individuals is under investigation but, regardless, PaV1 is more prevalent in juvenile lobsters in the Florida Keys than determined previously by visual or histological means (Shields & Behringer 2004).

PaV1 prevalence in lobsters occupying artificial and natural shelters has also been examined by visual means along the Yucatan coast of Mexico (Lozano-Álvarez et al. 2008). In 2001, PaV1 prevalence in the Mexican reef lagoon near Puerto Morelos was 2.7 %, but increased to 7% in 2005 and to 10.9 % in 2006; prevalence at the oceanic atoll-reef of Chinchorro Bank in 2006 was 7.4 %. PaV1 has also been detected in wild lobster populations in St. Croix, St. Kitts, Belize, and Cuba, with anecdotal evidence of PaV1 infections

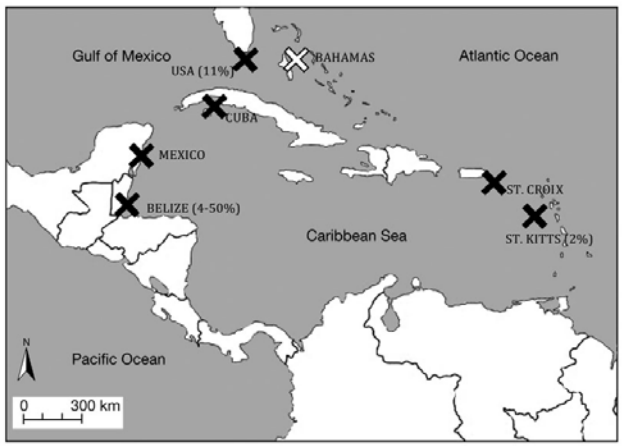

Fig. 6. Panulirus argus virus 1 (PaV1) infecting P. argus. Map of the Caribbean showing the locations where PaV1 infection has been reported anecdotally (☒) and confirmed (✖), along with the prevalence in adult lobsters (in parentheses). Background map is courtesy of the University of Alabama Cartographic Research Laboratory

Table 1. Panulirus argus virus 1 (PaV1) infecting P. argus. Prevalence of PaV1 in the juvenile spiny lobster population from the Gulf of Mexico side of the middle Florida Keys from surveys in the summers of 2008 and 2010. CL: carapace length

Size class (mm CL)	June–August 2008				June–August 2010			
	Total lobsters	PCR+	Visibly diseased	PCR prevalence (%)	Total lobsters	PCR+	Visibly diseased	PCR prevalence (%)
0–20	28	11	0	39	13	8	0	62
21–30	52	20	0	38	23	7	0	30
31–40	63	16	0	25	70	27	1	39
41–50	43	8	0	19	34	15	0	44
>50	14	1	0	7	16	4	0	25
Total	200	56	0	28	156	61	1	39

being reported throughout the Caribbean (Butler et al. 2008, Huchin-Mian et al. 2008, 2009, Cruz-Quintana et al. 2011) (Fig. 6). Prevalence is also suspected to have caused mass mortalities of juvenile lobsters in aquaculture facilities in Florida (Matthews & Maxwell 2007) and Belize (Staine & Dahlgren 2005).

Adult lobsters

Although PaV1 has its greatest impact on small juvenile Caribbean spiny lobsters, it also occurs in adults. In 2001, diver-based visual surveys of adult lobsters throughout the Florida Keys indicated a prevalence of < 1% (n = 4 of 1531; Shields & Behringer 2004). However, in 2008 to 2009 more sensitive PCR-based screening of adult lobsters from commercial traps throughout the Florida Keys detected PaV1 in 11% of the lobsters (authors' unpubl. data). Similarly, PaV1 was detected by PCR in 50% (n = 11 of 22) of the subadult/adult frozen lobster tails imported in Mexico from Belize (Huchin-Mian et al. 2009). Prevalence of 4% was detected by PCR (n = 101) among tissues from adult lobsters (75–160 mm CL) recently collected in Belize. This discrepancy may have arisen due to cross-contamination of the exported tails prior to receipt in Mexico or from temporal and geographic variability in PaV1 prevalence within Belize.

TRANSMISSION

Transmission of PaV1 may occur via several pathways, although not all are equally likely or efficient (Table 2). Transmission routes tested include hemolymph inoculation, ingestion, contact, and waterborne routes (Butler et al. 2008). The latter 2 are the most likely natural modes of transmission (Butler et al. 2008). Waterborne transmission has only been demonstrated for EBJ and small juvenile lobsters (< 25 mm CL) over distances of 2 m or less, which may partially explain the high prevalence of PaV1 infection among the smallest lobsters in the wild. Ingestion of infected tissue remains a possible mode of natural transmission, but cannibalism is probably uncommon outside of laboratory settings, and prey species that could serve as PaV1 reservoirs have not been identified. Transmission of PaV1 via infected hemolymph inoculation in other potential host decapods (channel crab Mithrax spinosissimus, stone crab Menippe mercenaria, spotted lobster Panulirus guttatus) that co-occur with P. argus have been unsuccessful based on histological examination of tissues 80 d post-inoculation, although tissues were not tested by PCR (Butler et al. 2008).

The nutritional condition of juvenile lobsters has no effect on their susceptibility to PaV1 infection (Behringer et al. 2008), nor does exposure to seawater differing in salinity (D. C. Behringer et al. unpubl. data). No seasonal patterns of prevalence are apparent in Florida lobster populations (Behringer 2003). However, laboratory studies indicate that high seawater temperatures increase the susceptibility of EBJ lobsters to PaV1 infection, but not larger juveniles (D. C. Behringer et al. unpubl. data). Susceptibility to infection and the progression of infection are also partially dependent on lobster size (Butler et al. 2008), with the smallest lobsters being most susceptible and dying the fastest.

ECOLOGY AND BEHAVIOR

Avoidance of disease

Panulirus argus are naturally gregarious and den together for protection under structure such as sponges, corals, and solution holes. Yet in the wild, infected lobsters occur alone (94% solitary) whereas healthy lobsters often co-occupy dens with other lobsters (46% solitary) (Behringer et al. 2006). Laboratory experi-

Table 2. Panulirus argus virus 1 (PaV1) infecting P. argus. Experimental transmission of PaV1 to juvenile spiny lobsters. All infections were detected using histological examination (data from Butler et al. 2008). CL: carapace length

Mode[a]	Lobster size range (mm CL)	Sample size	Trial duration (d)	Percent transmission (%)	Transmission coefficient
Inoculation	30–55	21	80	95	0.135
Ingestion	19–34	28	80	42	0.005
Contact	20–30	15	80	63	0.115
	30–40	15	80	33	0.044
	40–50	15	80	11	0.013
Waterborne	22–37	21	120	10	0.026
	5–16	43	120	52	0.004

[a]Note: not all lobsters exposed to PaV1 survived to the end of the trials

ments revealed that healthy individuals detect and avoid diseased lobsters, whereas infected lobsters continue to be attracted to both healthy and diseased lobsters. The onset of avoidance behavior by healthy lobsters occurs just prior to the onset of infectiousness (Behringer et al. 2006), and computer simulations (Dolan 2010) and field studies (M. J. Butler et al. unpubl. data) indicate that this behavior is effective at reducing transmission in this normally gregarious species.

PaV1 prevalence in nature is independent of lobster density over the small spatial scales in which lobsters interact (i.e. 10s of meters) (Behringer 2003, Lozano-Álvarez et al. 2008). However, the size and dimensions of a shelter may affect the frequency of shelter cohabitation as healthy lobsters co-occur more frequently with diseased lobsters in large casitas (21.7 to 29.4 %) than in smaller natural shelters (3.5 %) (Lozano-Álvarez et al. 2008). Computer simulations using a spatially explicit, individual-based lobster recruitment model (Butler 2003, Butler et al. 2005, Dolan & Butler 2006) altered for modeling benthic disease dynamics in the Florida Keys have also indicated that the avoidance of infected lobsters by healthy lobsters is effective in dampening the prevalence of PaV1 in the population modeled (Dolan 2010).

Movement and predation

Heavily infected Panulirus argus appear lethargic in the wild, and this moribund behavior has been replicated in a laboratory movement assay (Behringer et al. 2008). As infection progressed, PaV1-infected juvenile lobsters moved less, ultimately becoming sedentary. However, lobsters in the early stages of infection moved at rates similar to healthy lobsters, highlighting their potential to spread the disease to new locations. In the wild, lobsters were recaptured significantly less often after 5 d than healthy lobsters, indicating that they were either emigrating in greater numbers or suffering greater mortality (Behringer et al. 2008). Recent tethering experiments comparing the relative predation susceptibility between similar-sized healthy and infected lobsters has confirmed that visibly diseased lobsters indeed experience higher predation than healthy lobsters regardless of the presence of shelter (Behringer & Butler 2010).

Shelter competition

The avoidance of diseased lobsters by healthy conspecifics has implications for lobster shelter acquisition and refuge from predation, especially when shelter is limited (Behringer & Butler 2010). The latter may occur in locations where structure for juveniles is naturally sparse, or when shelter (e.g. large sponges) is eliminated by catastrophic events such as harmful algal blooms or disease outbreaks (Butler et al. 1995, Herrnkind et al. 1997). Shelter competition trials performed in shelter-limited mesocosms have revealed that neither healthy nor diseased lobsters are dominant competitors for shelter, but the presence of a diseased lobster reduces cohabitation and thus increases the chance that one lobster is excluded from shelter (Behringer & Butler 2010). Shelter exclusion has more dire consequences for diseased lobsters, which suffer higher rates of predation. However, cohabitation between diseased and healthy lobsters appears to occur more frequently in areas where shelter is scarce than in areas where shelter is abundant (Lozano-Álvarez et al. 2008). Perhaps some healthy lobsters make a trade-off between infection and predation risk in low shelter environments, as is thought to occur in the eastern Yucatan.

Fishery

The Panulirus argus fishery is the most economically valuable in the Caribbean (FAO 2006). However, in the 2000–2001 season fishery landings in Florida plummeted 30 % from those reported the decade before and subsequently remained at these low levels, with the lowest landings ever reported occurring in 2005–2006; and similar declines have occurred elsewhere in the Caribbean (Ehrhardt et al. 2010). Many factors affect fishery recruitment including the loss of habitat for juveniles or adults, changes in spawning stocks and larval supply, changes in water quality, or environmental events that influence population dynamics (e.g. hurricanes, harmful algal blooms, and changes in oceanographic conditions or currents). Thus, pinpointing the cause of fishery declines is difficult, but some lobster fisheries have been severely impacted by other diseases (Wahle et al. 2009). Recent studies show that healthy lobsters can acquire PaV1 when confined in commercial fishing traps with infected lobsters for as little as 7 d, with even higher transmission when lobsters were held together for 14 d (D. C. Behringer et al. unpubl. data). Although the PaV1 disease was not described until 2004 (Shields & Behringer 2004), there are anecdotal reports from fishermen and scientists in Florida and elsewhere in the Caribbean of lobsters with characteristic PaV1 infections observed over 25 yr ago. Thus, it is unlikely that PaV1 is a newly emergent pathogen. However, the presence of a lethal, pathogenic virus infecting the Caribbean's most important fishery resource is of concern to resource managers in the region.

CONCLUSIONS

In the 10 yr since PaV1 was discovered, we now have a better understanding of the nature of this pathogen and how it affects Caribbean spiny lobsters Panulirus argus. However, much remains to be done in unstudied regions of the Caribbean to determine the prevalence and impact of PaV1 on lobster populations, fisheries, and fishing communities that are so dependent on this ecologically and economically important species. Although its prevalence in Florida has remained relatively stable since its discovery, its prevalence in the eastern Yucatan has increased sharply since 2001. It is unknown whether the latter pattern is a harbinger for other regions in the Caribbean, because so little is known of its impact or prevalence outside of Florida and Mexico. Marine diseases in general appear to be emerging at an accelerated rate (Harvell et al. 1999, 2002, 2004); therefore, the tools and knowledge on PaV1 gathered to date will be invaluable in addressing potential future epizootics.

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Spiny Lobster Update Assessment Review Workshop Report

GMFMC/SAFMC/SEDAR Update Assessment Workshop

November 18-19, 2010

Key West, FL

Executive Summary

The stock assessment presented by the 2010 Spiny Lobster Assessment Workshop provided the Review Panel with outputs and results from two statistical assessment models. The primary assessment model was the Integrated Catch-at-Age (ICA) model, while a Modified DeLury model was considered secondary and used to provide a comparison of model results. After careful review and discussion the Review Panel concluded that there were sufficient concerns with the performance of the two assessment models to reject the assessment results and that the stock status of spiny lobster in the southeastern US was unknown. More importantly, new evidence indicating the southeastern US stock largely depends on external recruitment from upstream Caribbean populations precludes reliable estimation of management reference points. The US stock cannot be assessed in isolation and is not the appropriate geographical and biological scale needed to capture population-wide dynamics.

Introduction

The Southeast Data and Assessment Review (SEDAR) Spiny Lobster Update Assessment Review Workshop (RW) was held in Key West, November 18-19, 2010 to review the "Stock assessment of spiny lobster, *Panulirus argus*, in the southeast United States: Update Assessment Report" prepared by the Florida Fish and Wildlife Research Institute team of Drs. Robert Muller and Joseph Munyandorero, who incorporated alternative model scenario requests and advice from the SEDAR Lobster Update Assessment Workshop (AW) held in September, 2010 (Appendix A).

The Assessment Report was presented by Dr. Joseph Munyandorero, Florida Fish and Wildlife Research Institute. The Review participants included two Scientific and Statistical Committee (SSC) reviewers from each Council (Dr. Walter Keithly and Mr. Doug Gregory (Chair) from the Gulf of Mexico Fishery Management Council and Drs. John Hoenig and Luiz Barbieri from the South Atlantic Fishery Management Council) and one observer SSC member from the Gulf of Mexico Fishery Management Council (Dr. Rene Buesa). There were no specific Terms of Reference for the Lobster Update Review Workshop.

The AW Report discussed new genetics data documenting that the southeast US lobster population is largely if not wholly dependent on recruitment of post larval lobsters from spawning stocks throughout the Caribbean (Appendix A: Pages 14 and 27). Due to the importance of this new information relative to the critical issue of population structure, a more detailed summary of the new documentation available since SEDAR 8 was requested to be provided to the RW. Subsequently, a report on the most recent genetics study of *Panulirus argus* was provided (Hunt et al., 2009) and two presentations were arranged for the RW. Doctor Mark Butler of Old Dominion University presented a summary of physical and biological oceanographic information on the potential connectivity of the various lobster stocks in the

Western Central Atlantic, including an overview of the PaV1 lobster virus discovered in 1999. Also, Dr. Mike Tringali of the Florida Fish and Wildlife Research Institute presented microsatellite DNA analyses indicating that the Florida lobster stock represents a genetic mixture of a minimum of four different parental populations with little to no indication of self-sustaining recruitment. These presentations were influential in the subsequent evaluation of the population models presented from the AW and the final conclusions reached by the RW.

The Lobster Update Assessment, under existing SEDAR procedures for update assessments, was constrained to use the same population assessment models that were used in the last benchmark assessment, SEDAR 8, in 2005. The requirement to use the same models as in the last benchmark assessment (five years earlier) prevented the assessment team from employing more sophisticated modeling techniques developed in the interim. Qualitatively, the results from the update assessment were consistent with the original benchmark assessment. The major differences affecting interpretation of the 2010 update assessment were that the retrospective patterns worsened as more years of data were included and the genetic information indicated a predominant to total dependence of the southeastern US spiny lobster population recruitment on foreign sources.

The stock assessment review panel in 2005 concluded that overfishing was not occurring because the estimated current fishing mortality rate was below the $F_{20\%}$ SPR (spawning stock ratio) definition of overfishing established in Amendment 6 to the Fishery Management Plan. The 2005 panel also noted the inability to determine a stock-recruit relationship due to an unknown but potentially large proportion of recruitment coming from external sources and not from the South Florida lobster stock proper.

The new annual catch limit requirements had an obvious impact on interpretation of the Update Assessment results. Similar to the results of SEDAR 8, the population models indicated declining fishing mortality since 2000 (Appendix A: Figure 3.2.2.6.1; Page 110). The main difference between the update and the earlier benchmark assessments is that the observed retrospective patterns that emerged after 1999 worsened with time making the model results even more questionable (see Appendix A: Figure 3.2.2.9.1; Page 112). Also, given the requirement to base ABC (acceptable biological catch) on an estimated OFL (overfishing limit), the combination of retrospective patterns and the now well documented external recruitment phenomenon makes determination of the status of the South Florida lobster stock relative to standard population benchmarks even more problematic.

Assessment Review

The RW noted that there were sufficient concerns with the performance of the two assessment models used (i.e., the Modified DeLury and Integrated Catch-at-Age models) for spiny lobster to reject the assessment results, concluding the stock status of spiny lobster in the southeast US is essentially unknown. Furthermore, the magnitude of the dependency of the US stock recruitment on unknown upstream Caribbean population sources indicates that this and previous assessments were not conducted with the appropriate geographical and biological scales.

Diagnostically, the models exhibit clear lack-of-fit patterns to the residuals of the indices used (Appendix A: Figures 3.1.2.1; Page 92 and 3.2.2.1.2; Page 106) and retrospective inconsistencies in model outputs were extreme (Appendix A: Figures 3.1.2.9.1; Page 98 and

3.2.2.9.1; Page 112) despite various attempts to identify the source of the retrospective inconsistencies using modified inputs (Appendix A: Figures 3.2.2.9.4-3.2.2.9.5; Pages 115-116).

Conceptually, there are at least three main areas of uncertainty. First, there is uncertainty in the mortality effects that the PaV1 lobster virus might be having on juvenile lobster recruitment. This mortality occurs between the time the post-larvae recruitment index is obtained (at settlement) and the time the lobsters recruit to the fishery and may explain why the post-larvae recruitment index does not appear to be well estimated by the model. Alternatively, the lack-of-fit could be due to the limited geographic range of the larval samples. Indeed all the indices were very spatially limited. To date there is no evidence that the virus has increased in prevalence or virulence since its discovery; thus virus mortality may already be included in the estimated natural mortality rate.

Second, the age-length key used in the assessment is not year-specific and thus tends to preserve the estimated age composition from year to year, potentially invalidating total mortality values as well as masking more dynamic changes that may be occurring in the population.

Third, as the assessment team and AW acknowledged, there is a fundamental problem with determining biological reference points based on spawning biomass when an unknown but large fraction of the recruitment derives from upstream spawning biomasses, also of unknown magnitude. Thus, although a Beverton-Holt stock-recruitment curve is presented in the report it was rejected by the assessment team and AW as being invalid. The Panel heard strong genetic evidence that the southeast US lobster stock is dependent on at least four different external spawning stock sources. It is questionable how preserving the spawning biomass in the southeast US stock would benefit either the local stock or the broader Pan-Caribbean population since the southeast US is at the downstream end of the pertinent oceanographic regime responsible for larval distribution. It is conceivable that conservation of spawning biomass in the southeast US could provide recruitment to other possible downstream areas such as North Carolina and Bermuda, but, current genetic data is not robust enough to provide any such evidence (Tringali, personal communications).

The RW noted that, although theoretically possible, computing a value of F20% as a proxy for F_{MSY} using existing models would be impractical given the strong retrospective patterns.

The RW discussed using results from the Integrated Catch-at-Age model from the range of years for which the model had converged as an attempt at estimating biological reference points. This would assume that the converged portion is, in fact, giving correct answers (thus, it assumes for example that errors in catch-at-age and natural mortality may be minimal). Also, very little contrast occurred in the estimated biomass and recruitment (age-1 lobsters) over most of the years so that the stock-recruit relationship was not well determined. Therefore, it was not clear to the Panel how useful these results would be. This approach could be investigated with respect to uncertainty in the stock-recruit relationship. But, more fundamentally, since recruitment to the southeast US lobster stock appears to be largely derived from stocks outside of US waters, a stock-recruitment relationship based solely on southeast US data is meaningless. Thus, while the RW discussed the logic to constraining fishing mortality to achieve some larger (Pan-Caribbean) management objective or to achieve yield-per-recruit goals, it is not clear that a minimum spawning biomass in the southeast US can be specified in a meaningful manner.

Landings and fishing effort seem to be highly correlated and thus, the decline in landings during the last ten fishing seasons appears to be the result of a similar decline in overall fishing effort (see Tables 2.1.1 and 2.1.2; Appendix A).

The SSC should consider the spiny lobster fishery a “special case” given the Caribbean wide distribution of the stock and the extent of externally derived recruitment. Therefore, OFL is unknown or undetermined at this time.

Research Recommendations

The Update Review Panel endorses and recommends the following research recommendations, some of which were proposed by the Update Assessment Workshop.

1. Conduct fishery-independent surveys for juvenile lobsters in lobster nursery areas (e.g., Gulf of Mexico side of Florida Keys such as Great White Heron National Wildlife Refuge). This would lead to more accurate estimates of age-1 lobsters instead of applying the post-larvae index in assessment models.

2. Evaluate the methods used to estimate the number of “shorts’ and legal lobsters used as attractants and their mortality in trap fisheries.

3. Integrate additional long-term post-larvae collector data from “second site” and only use data for first quarter of lunar phase (i.e., Day 7 of each lunar phase). The update included this item as a sensitivity run.

4. Conduct statistical research regarding the generation of the catch-at-age matrices used as input to the catch-at-age stock assessment algorithm. Specifically, several growth equations available for this purpose should be statistically assessed on the basis of their biological growth attributes and on how they might portray different mortality frames. In addition, an overall evaluation of the age-length key, including consideration of inverse age-length keys needs to be conducted.

5. Continue to evaluate the utility of developing either local or Pan-Caribbean spawner-recruit relationships where applicable.

6. Attempt to estimate natural mortality from tagging studies.

7. Evaluate all available maturity data to estimate size and age of maturity for both female and male lobsters, including maturity estimates for combined sexes.

8. Evaluate the utility of a commercial fishery-dependent index derived from the Florida trip ticket system and diver surveys to develop an index derived from the fullest extent of the fishery possible. The use of a trap based index is needed since traps provide more than 80% of the landings. Fishing trips alone are not the best measure of fishing effort because it does not account for more specific measures of effort such as the number of traps worked.

9. Evaluate the selectivity curve further, including what may be causing the observed dome-shaped pattern in fully recruited ages.

10. Conduct a full benchmark assessment at the appropriate geographic and biological scale for the southeastern US-Caribbean spiny lobster population.

11. Continue the oceanographic and genetic studies to identify the origin of spiny lobster recruitment to the southeast United States with one of the goals to develop an estimate of the proportion of recruitment that could derive from the local stock/fishery.

12. Evaluate the impact of recreational harvest, especially the 2-day mini-season, on lobster growth and discard mortality rates.

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Southeast Spiny Lobster

Update Stock Assessment

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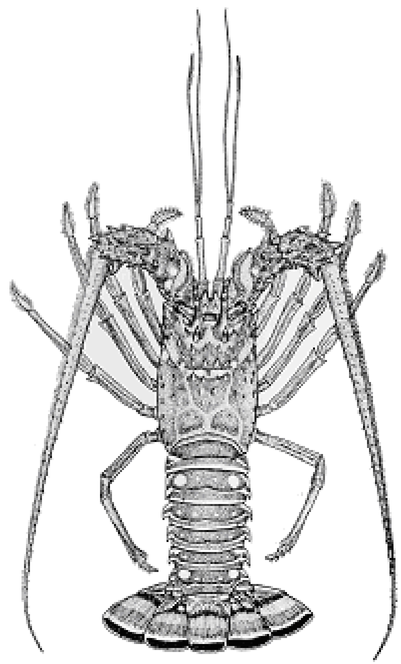
January 2, 2011

APPENDIX A

Stock assessment of spiny lobster, *Panulirus argus*, in the Southeast United States

SEDAR 8 Update Assessment Workshop Report



Prepared by

SEDAR 8 Update Stock Assessment Panel

2010

Key West, Florida

1. Introduction

The condition of spiny lobsters in the Southeast US was previously assessed during SEDAR08 in 2005. Spiny lobsters are fished throughout the Caribbean and Mexico as well as in the southeastern United States (SE US). According to the FAO Fisheries and Aquaculture Statistics and Information Service (2010), the combined western Atlantic landings of the species were 62 million lb in 2008 (the most recent year available, Fig. 1). The US landings of spiny lobster comprised 5.6% of the regional landings. The 2005 assessment found that the spiny lobster fishery was not overfishing in the 2003-04 fishing year but was unable to evaluate the condition of the spawning stock of spiny lobsters without an international Caribbean-wide assessment, because of the potential influx of settling post-larvae from Caribbean and Mexican waters.

The key biological management measures in the SE US are a minimum size (3 inches or 76.2 mm carapace length), a closed season (April 1 – August 5) during most of the reproductive season, a prohibition on the taking of egg-bearing females, and various measures designed to reduce discard mortality (use of live wells on vessels transporting sub-legal lobsters; prohibition of spearing, etc). Commercial traps have to be removed from the water by April 5. The commercial fishery is also regulated through an effort management program designed to reduce the total number of traps used in the fishery to a total of 400,000 traps. Trap numbers have declined from more than 900,000 in 1991-92, just prior to the implementation of this program, to 481,000 in 2009-10. However, the commercial dive fishery expanded until a commercial dive license was required in 2003 and commercial dive vessels were subject to a 250 lobster limit. In addition, a moratorium on new commercial dive licenses was implemented from January 1 2005 until July 1 2010 which was extended in 2010 to July 1 2015. The recreational fishery has a special 2-day sport season that occurs on the last full weekend prior to August 1 each year and a regular season that occurs from August 6 through March 31. Recreational fishers have a 6-lobster daily bag limit in Monroe County (Florida Keys) and Biscayne National Park and a 12 lobster daily bag limit elsewhere in Florida.

The purpose of this assessment update is to determine the condition of the spiny lobster in the SE US using the landings, indices of abundance, and relevant biological information available up through the 2009-10 fishing year.

1.1 Workshop Time and Place

The SEDAR 8 Spiny lobster update stock assessment was conducted via a series of webinars between March and August 2010 and an in-person workshop held in Key West, Florida at the Key West Marriott Hotel from September 28-30, 2010.

1.2 Terms of Reference

1. Update the SEDAR 8 assessment of Southeastern US spiny lobster with

data through 2009-2010. Prepare a continuity scenario and consider

additional sensitivity runs to address assessment concerns raised since the benchmark.

2. Evaluate any relevant data and parameters to be included into the stock assessment model. This evaluation should be conducted with all relevant scientific input. Include life history, indices of abundance, and fishery data.

3. Evaluate the relative reliability of fishery dependent and independent data sources and adjust model input appropriately.

4. Update the approved SEDAR 8 Southeastern spiny lobster model base configuration with data through 2008-09 [the update assessment includes data through 2009-10]. Employ the SEDAR 8 SAR 3 statistical catch-at-age model (Integrated Catch-at-Age) as the base and the DeLury model as a check for consistency. The DeLury model used numbers of lobster and effort by fishing year extended back to the 1978-79 fishing year. Both models used fishery-dependent (observer and Biscayne National Park creel survey) and fishery-independent (puerulus and adult monitoring) tuning indices. Sensitivity runs included running the age-structured model with two lipofuscin growth curves and with two alternative natural mortality rates. Retrospective analysis compared patterns in fishing mortality rates, recruitment, and population sizes in terminal years from 1997-98 to 2002-03 to the base run results. Document any changes in assessment methodology incorporated in the update.

5. Document any changes or corrections made to input datasets, all additional data added for the update, and any modifications applied to the additional data. Tabulate complete updated input datasets. Provide tables of commercial and recreational landings and discards in the units used in SEDAR 8, SAR 3. Specify units of measurement in all tables.

6. Estimate and provide complete updated tables of stock parameters.

7. Update measures of uncertainty and provide representative measures of precision for stock parameter estimates. If time, resources, and available information permit, conduct a P* analysis as needed to determine ABC.

8. Update estimates of stock status and SFA parameters; provide declarations of stock status relative to current SFA criteria. Provide clear statements of stock status relative to ‘overfishing’ and ‘overfished’. If a status of ‘overfished’ or ‘overfishing’ is determined, run the standard range of projections.

9. Specify OFL, and may recommend a range of ABC for review by the SSC in compliance with ACL guidelines.

10. Evaluate and project future conditions for eleven years (2009-10

through 2019-20 inclusive) beyond the terminal year of the update (2008-2009). Run at least these three projection scenarios:

$F = F_{current}$, $F = F_{msy}$, and $F = F_{oy}$

11. Review the research recommendations from SEDAR 8 SAR 3 (2005), note any which have been completed, and make any necessary additions or clarifications. Focus on those items which will improve future assessment efforts. Provide details regarding sampling design, sampling strata and sampling intensity under current exploitation allowances that will facilitate collection of data that will resolve identified deficiencies and impediments in the 2005 assessment. Recommend sampling intensity in terms of the number of sampling events and appropriate elements in order to complete the ACCSP sampling design matrix.

12. Develop an update stock assessment workshop report in SEDAR outline to fully document the input data, methods, and results of the stock assessment update. Address these Terms of Reference. Submit the report to SEDAR no later than October 1, 2010. The report shall be provided to the GMFMC and the SAFMC no later than October 18, 2010.

1.3 List of Participants

See Appendix A for names and affiliation information

2. Data Issues and Deviations from Data Workshop Recommendations

Since there was not another Data Workshop associated with this update and the areas that were discussed in Section2 of the SEDAR08 Assessment Report are still relevant, i.e., the development of the catch–at-length (CAL) and catch-at-age (CAA) information, this section will present updated landings, age-length keys, CAL, CAA, and indices.

2.1 Landings

As noted in SEDAR08, both commercial and recreational gears are used to harvest and land spiny lobster in the SE US. Commercial landings were aggregated into three gear categories: traps, diving, and other (Table 2.1.1, Fig. 2.1.1). The other category includes spiny lobsters that were reported as coming from bully nets, shrimp trawls, and other gears reported on trip tickets. The recreational landings came from mail surveys to divers with lobster permits on their Saltwater Fishing licenses (Table 2.1.2, Fig. 2.1.2). In 1994, the Marine Fisheries Commission instituted a Special Recreational License that allowed those license holders to exceed the six-lobster bag limit and those landings are also included in the recreational landings in Table 2.1.2. The 1999-00 had the highest combined landings of commercial and recreational at 10.5 million lb and 2005-06 had the lowest at

4.2 million lb (Table 2.1.3). It should be noted that the Florida Keys were disrupted by two hurricanes in 2005: Katrina in August and Wilma in October.

2.2 Catch-at-length

The catches-at-length were developed by calculating raising factors (Gulland 1969) with landings and length frequencies from the NMFS's Trip Interview Program, Biscayne National Park's creel survey, FWC's observer program, and FWC's recreational creel survey. There were a total of 243,277 carapace measurements for spiny lobsters. The length frequencies were matched with landings by gear, region, fishing year, and season (Jul-Oct, Nov-Jan, and Feb-Mar; Table 2.2.1). For the purposes of matching lengths to landings, there were six geographic regions: Northeast (North Carolina to St. Lucie County Florida), Southeast (Martin-Dade Counties), the Upper Keys (Dade-Monroe County line to Marathon Key), Lower Keys (Marathon to Marquesas), Tortugas (West of the Marquesas), West Coast (Collier County to Texas) (Fig. 2.2.1). In the regional summaries, we combined the three Florida Keys' regions. More than 92% of the landings had direct matches by stratum with lengths. Most of those landings strata without matching lengths were from either regions other than the Florida Keys or from gears other than traps. We used the same strategy for estimating the lengths for those landings strata without these data that we used in SEDAR08; substituting lengths from other seasons and, for those landings still without matches, combining lengths across fishing years.

2.3 Catch-at-age

A challenge with assigning ages to spiny lobsters is that lobsters lack structures that record age in a manner similar to otoliths in bony fishes. The age-length keys for spiny lobsters from tagging that were presented at the SEDAR08 Data Workshop also were used in the update assessment. The keys were constructed from the original tagging growth trajectories. The age-length keys developed from the lipofuscin data and applied to lobsters collected from the fishery and from the Dry Tortugas were revised because of refinements in the lipofuscin analyses (Maxwell et al. 2007). Briefly, the age-length keys were developed from 1000 trajectories of growth for 15 years by month. We used Fogarty and Idoine's (1992) method to create a trajectory of growth for a spiny lobster that started at one year after settlement at a size of 46 mm carapace length (CL, SD = 5.0) and molted with a probability based on current size, sex, and season (summer or winter); if the lobster molted, then the growth increment was determined based on the same variables. The size at one year after settlement came from coded-wire tagging of post-larvae. The process was repeated each month until the lobster completed 180 months of growth. These growth trajectories were estimated for 1000 male spiny lobsters and 1000 female spiny lobsters. However, before one can assign ages based on these outcomes, mortality has to be included because for the same sized lobster there will be more two-year old lobsters than three year old lobsters. For the SEDAR08 assessment, we used trial total instantaneous mortality values of 0.34, 0.70, 1.00, and 1.30 per year to generate age-length keys that were applied to the catches-at-age and found the best fit to the assessment model, ICA, was with a total mortality rate of 1.0 per year. We used that rate in developing the tagging growth age-length keys and for the updated lipofuscin age-length keys from the fishery. The update AW decided that it would be inappropriate to use the lipofuscin ages from the Dry Tortugas to age the lobsters caught in the fishery because that fast growth pattern reflected more the potential growth rate of lobsters and not the rate that lobsters in the main part of the fishery experienced, where injuries and high mortality occurred.

Ages were assigned to catches-at-length by gear and sex using age-length keys (Table 2.3.1) and then combined into a single catch-at-age because the assessment program specified in Term of Reference (TOR) #4, Integrated Catch-at-Age (ICA), can only accommodate a single catch-at-age table (Table 2.3.2)..

The AW discussed whether to use the age data from the fishery derived from lipofuscin information as the base case but the decision of the group was to stay with the tag-based aging because, while the lipofuscin aging has potential, the fishery samples were only collected in one fishing season (2001-02) and the known-age lobsters from the laboratory did not include animals older than four years. The group included a sensitivity run using the lipofuscin aging method. Another aging method based on tagging was described by Ehrhardt (2008); this method used Munro's inter-molt period approach instead of the probability of molting in a given time interval and his method produced age estimates that were similar to the lipofuscin values. However, due to Dr. Ehrhardt's field work in Central America during the summer of 2010, he was unable to provide the necessary parameters and their precision for us to develop age-length keys. His method should be considered in future assessments.

Other data issues stemmed from discussions during the Stock Assessment webinars. For example, concern was expressed about the validity of the Biscayne National Park creel survey index because the increase in the catch rate coincided with the change in the allowable bag limit from 6 lobsters per person per day to 12 lobsters per person per day. The AW decided to calculate the fishing power under the different bag limits and standardize the catches to the catch rate when there was no bag limit (prior to July 1987). As was recommended at the 2004 AW, the post-larval index only used collectors from the Big Munson site and the response variable was the number of post-larvae per collector. Soak time was grouped into four categories: 1-7 days, 8-14 days, 15-28 days, and more than 28 days and used as a potential explanatory variable. Again, the two pre-recruitment indices included spiny lobsters down to 47 mm carapace length, CL (Table 2.3.3) because, when multiple molts were considered, these lobsters could molt into the fishery during the year. The procedure for estimating the sizes of spiny lobsters that could molt into the legal size class during a year was presented in the SEDAR08 Assessment Report. This procedure essentially used the probability of molting by carapace length and the cumulative probability of the growth increment and the growth was projected for each month. To corroborate this modeling exercise, we extracted all lobsters less than legal size from the tagging data that were free more than 180 days and were recaptured at a size larger than at tagging. Twenty-two of the 28 sub-legal lobsters were recaptured at legal sizes. The smallest lobster was tagged at 46 mm CL and recaptured at 76 mm CL, 288 days later, and there were two 51 mm CL lobsters, one was recaptured after 288 days with a carapace length of 79 mm CL and other lobster was 94 mm CL after 318 days. The values of the tuning indices that were used in subsequent analyses are shown in Table 2.3.4 and Figure 2.3.4. The associated coefficients of variation and number of observations are in Table 2.3.5.

3. Stock Assessment Models and Results

In the SEDAR08 assessment, a variety of models were presented and for the update two models were chosen (TOR #4): the modified DeLury model (Rosenburg et al 1990) and Integrated Catch-at-Age (Patterson 1998). The first model uses catch in numbers by sector, effort, indices, and natural mortality to estimate population sizes, recruitment, and fishing mortality rates while the second model uses the catch-at-age, indices, and natural mortality to estimate the population sizes at age, selectivity by age, fishing mortality rates by age, and spawning biomass.

3.1 Modified DeLury model.

3.1.1 Modified DeLury methods.

3.1.1.1 Overview

The Modified DeLury model (Rosenberg *et al*. 1990, Basson et al. 1996) is similar to a surplus production model except that the units are in numbers of lobsters instead of biomass and the population only increases by recruitment and is decremented by total mortality. The Modified DeLury was promoted at the FAO Caribbean spiny lobster workshops in 1997 and 1998 in the Western Atlantic (Restrepo 2001) and recently has been used for spiny lobster in Mexico (Sosa-Cordero, 2003), Cuba (González-Yáñez et al. 2006), and for Florida pompano (Muller et al. 2002). The model estimated population sizes and fishing mortality rates of the recreational and commercial sectors and for the bait used in traps by fishing year.

3.1.1.2 Data Sources

We used commercial and recreational landings and effort. However because the DeLury model uses the landings expressed in numbers of fish, we had to convert the commercial landings in biomass to numbers using the catches-at-length by fishing year and gear. The recreational landings in number were extended back to the 1978-79 fishing year using the August commercial landings.

The numbers of lobsters that were used as attractants were summarized in the Data Workshop Table 3.1.2 (1). The attractant usage in numbers was estimated in two steps. First we estimated the monthly number of trap hauls by combining monthly trap landings, and the monthly landings per trap from those trip tickets that included the number of traps back to July 1985. We then applied the average number of sub-legal sized lobsters and legal-sized lobsters used as attractants per trap hauled from the 1993-2001 observer data by month to the corresponding estimated monthly trap hauls. We used the average soak time by month from trip tickets and an attractant mortality rate of 26% per four weeks of confinement in traps (Hunt et al. 1986) for months prior to July 1987 when the live-well requirement was implemented and 10% per four weeks afterwards Matthews (2001). Since almost all of the commercial landings prior to the 1985-86 came from traps, we extended these estimates back to 1978-79 by regressing monthly trap hauls on landings which allowed us to calculate the trap hauls by month for the earlier period and to which we applied the same monthly average number of sub-legal and legal sized lobster per trap haul and the 26% mortality rate. This method of attractant estimation is biased high because it assumes that each short or legal lobster used as an attractants put into a traps was unique when fishers used the attractants from before if the shorts were still lively. The landings and effort data are shown in Table 3.1.1.2.

The goal of the extrapolations is to provide a historical perspective for the estimates of the later years when there are data, and to account for levels of removals from the population that otherwise would not have been included in the assessment. The extrapolated values were not included in fitting the model.

Data Workshop (DW) members identified six tuning indices for stock assessment: the number of legal-sized (CL > 76.2 mm) lobsters per trap from FWC's Observer program, the number of pre-recruit sized (47-75 mm CL) lobsters from the Observer program, the number of legal-sized (CL > 76.2 mm) lobsters per trap from FWC's Adult Monitoring program (timed surveys), the number of pre-recruit sized (47-75 mm CL) lobsters from FWC's Adult Monitoring program (timed surveys), the number of lobsters per recreational trip in Biscayne National Park, and the number of post-larvae per collector. The FWC Adult Monitoring program changed sampling protocols from timed underwater surveys (1997-2006) to transect surveys (2004 and later) and the update AW recommended including the transect indices as potential tuning indices. As noted above, the Biscayne National Park index was modified to account for the different bag limits in effect explicitly by year. The specifications of the eight final tuning indices are shown in Tables 2.3.4 and 2.3.5.

The DW and update AW concluded that the natural mortality rate for spiny lobster in southeastern U.S. should be between 0.3 and 0.4 per year. For consistency with SEDAR08 and previous assessments (Muller et al 1997), we used 0.34 per year for natural mortality.

3.1.1.3 Model Configuration and Equations

In the DeLury model, the number of fish at time *t+1* (N_{t+1}) is:

$$N_{t+1} = N_t \exp(-Z_t) + R_t \qquad (1)$$

where Z_t is the total instantaneous mortality rate during time *t* ($Z_t = F_t + M_t$) and R_t is the recruitment at the beginning of time *t*. Many spiny lobsters molt into legal sizes during the closed season. Thus, recruitment is considered to occur at the beginning of the fishing year, i.e. July. The predicted catch for a given sector is:

$$C_{s,t} = q_s E_{s,t} \overline{N_t} \qquad (2)$$

where $C_{s,t}$ is the catch during time, *t,* from sector *s;* q_s is the catchability coefficient that relates the mortality expended by one unit of effort in sector *s*; $E_{s,t}$ is the effort expended by sector, *s*, during time, *t;* and $\overline{N_t}$ is the average number of lobsters in the population during time, *t,* and the equation for $\overline{N_t}$ is :

$$\overline{N_t} = \frac{N_t}{Z_t}(1 - \exp(-Z_t)) \, . \qquad (3)$$

To prevent the model from attempting to use negative recruitment values, the model solves for relative recruitment anomalies (Ra_t) in log space that are scaled by the recruitment in the first fishing year (R_1). The equation is:

$$R_t = R_1 \exp(Ra_t - 1) \qquad (4)$$

and R_1 is approximated by the number of lobsters dying during the first fishing year ($N_1(1\text{-}\exp(-Z_1))$).

Predicted index values, $\hat{I}$, for the legal-sized population were fit to either the beginning population size or the average population size during a fishing year depending upon whether the survey was only conducted in July and/or August or throughout the year:

$$\hat{I}_{j,t} = q_j \overline{N}_t \qquad (5)$$

where *j* refers to the index. These indices of legal-sized lobsters were from 1993-04 to 2000-01, the FWC adult monitoring number of lobsters per dive from 1997 to 2006 with timed surveys, the FWC adult monitoring number of lobsters per dive from 2004 through 2009 with transect surveys, and the number of lobsters per trip from Biscayne National Park's creel survey (1978 – 2009). The observer catch per trap was fit to the average population size (Eq. 5) because the observer program operated throughout the fishing year while the other surveys for legal-sized lobsters operated in July and/or August (Eq. 6).

$$\hat{I}_{j,t} = q_j N_t \,. \tag{6}$$

We potentially used four indices to tune recruitment: the post-larvae index offset two years, the pre-recruit index from the observer program, and the pre-recruit indices from FWC's adult monitoring surveys. The predicted recruitment index values were calculated from:

$$\hat{I}_{j,t} = q_j R_t \tag{7}$$

where *j* refers to the index and *t* refers to the fishing year.

The objective function was the sum of the lognormal likelihood terms for the landings by sector, the tuning indices, and the recruitment anomalies (Hilborn and Mangel 1997, Walters and Martell 2004). We used the full log-likelihood (*LL*) for each component:

$$LL_j = n(\ln(\sigma) + \frac{1}{2}\ln(2\Pi)) + \frac{1}{2\sigma^2}\sum_{i=1}^{n}(\ln(I_{j,i}) - \ln(\hat{I}_{j,i}))^2 \tag{8}$$

where σ^2 is the variance of the log transformed values of the index or landings by fishery sector and these values were input to the model, *n* is the number of observations, $I_{j,i}$, is either the sector landings or index, *j*, and *i* refers to the fishing year. However since the $\frac{1}{2}\ln(2\Pi)$ term in Eq. 8 is constant for each component, this term was omitted in the minimization. In the case of the recruitment anomalies, σ^2 was set to 0.5 and the sum of squares for relative recruitment anomaly, SS_r, portion of equation (8) was

$$SS_r = \frac{\sum_{i=1}^{32}(Ra_i - 1)^2}{2\sigma^2} \,. \tag{9}$$

3.1.1.4 Parameters Estimated

The DeLury model was developed and run using AD Model Builder (ADMB) software (ADMB Project, 2010). This software is a tool for developing and implementing nonlinear statistical models. The model parameters were the initial number of lobsters in the population, N_1, the catchability coefficients by sector or tuning index, and the annual recruitment deviations applied to the recruitment in the first year. Therefore, in this configuration, the model solves for a potential total of 44 parameters: N_1 (1 parameter); the fishery catchability coefficients for recreational (1), commercial (1), and attractant usage (1); coefficients for each of the eight tuning indices (8 parameters); and the recruitment anomalies by fishing year (32 parameters).

3.1.1.5 Uncertainty and Measures of Precision

We evaluated uncertainty with the modified DeLury model with: (1) likelihood profiles for the initial population size, the fishing mortality rate by sector in the final year, and the population size in the final year; and (2) re-running the model with alternative natural mortality rates of 0.25 and 0.43 per year as recommended by the AW. To simplify the results, we plotted relative likelihoods (along with relative normal approximations) which were the likelihood (or normal approximations) values divided by the maximum likelihood (normal) value We also reran the model using terminal fishing years back to 2003-04 to investigate any retrospective bias as a source of uncertainty that is not captured by the precision estimates.

3.1.2 Modified DeLury Results

3.1.2.1. Measures of Overall Model Fit

The fit of the DeLury model to the data was evaluated through the visual inspection of agreement between the observed and predicted values (Fig. 3.1.2.1) and by calculating the components of the objective function, along with the associated statistics (i.e., sum of squares, SS, mean sum of squares, MS = SS / number of degrees of freedoms; Table 3.1.2.1). These calculations were based on the log-transformed observed and predicted harvests and indices. Note that all components had the same weight (i.e., lambda = 1).

Visual inspections of the plots coupled with the magnitude of the MS values indicate that, of the components included in the objective function, the index for legal-sized lobsters generated from the FWC adult monitoring program with transect design, and indices for sub-legal lobsters developed from the FWC Adult Monitoring program with both timed and transect designs were generally poorly fitted. Note that the components which contributed most to the total likelihood (i.e., 96.3%) were the commercial (55%) and recreational (28.5%) sectors, the Biscayne National Park index component (8.9%), and the post-larval settlement index component (3.8%).

3.1.2.2. Parameter estimates

In the base run of the DeLury model (M = 0.34 year^{-1}), the initial population size (1978-79) was 11.5 million lobsters and the number at the beginning of the 2009-10 fishing year was estimated at 9.7 million lobsters with a biomass of 10.7 million lb.

3.1.2.3. Stock Abundance and Recruitment

The number of spiny lobsters and the recruitment at the beginning of each fishing year are shown in Table 3.1.2.3 and Fig. 3.1.2.3. The number of lobsters peaked in 1979-80, 88-90, and in the late 1990s. The marked decline in 1998-99 fishing year was consistent with low catch rates in August 1998 but was confounded by the scattering of traps and disruption of the fishery by Hurricane Georges in September 1998. The number of lobsters declined after the 1999-00 fishing year but remained generally stable at the levels similar to the earlier decline following the 1979-80 fishing year. In the 2000-01 fishing year, however, an unknown, regional environmental perturbation, possibly the juvenile lobster virus (Behringer and Butler IV, 2009), may have been responsible of the decline in the regional stock size that resulted in low landings throughout the region (Fig. 1). In the 2005-06 fishing year, the population size also declined but Hurricanes Katrina and Wilma produced the confounding effects similar to those observed in the 1998-99 fishing year. Recruitment did not help us answer this question because recruits comprise a large portion of the lobsters available to the fishery and so the pattern of recruitment mirrored that of abundance.

3.1.2.4. Stock Biomass (total and spawning stock)

The DeLury model does not distinguish between spawning lobsters and non-spawning. Biomass was estimated as the number of lobsters at the beginning of the fishing year times the average weight in that fishing year and so showed a pattern (Fig. 3.1.2.4) similar to the plot for numbers (Fig. 3.1.2.3.

3.1.2.5. Fishery Selectivity

Selectivity is not applicable in the DeLury model because the model is not age-structured and only estimates a single population value per year.

3.1.2.6. Fishing Mortality

Fishing mortality rates across gears have been variable over this period (Table 3.1.2.6, Fig. 3.1.2.6). After 1986-87, fishing mortality rates increased to a peak in the 1991-92 fishing year, the impacts of Hurricane Andrew on infrastructure in August 1992 lowered fishing mortality that year and then the Trap Reduction Program was implemented in July 1993 such that fishing mortality rates were generally declining after the 1991-92 fishing year. Initial catch rates in the 1998-99 were sluggish as evidenced by the drop in recreational fishing mortality rates and then Hurricane Georges in September 1998 disrupted the fishery by scattering traps. The fishing mortality rate in 2009-10 fishing year was 0.72 per year (recreational F was 0.21 per year, the commercial F was 0.46 per year and the bait mortality was 0.04 per year).

3.1.2.7. Stock-Recruitment Parameters

The scatter in the Stock-Recruit plot precludes identifying a unique curve (Fig. 3.1.2.7.1). The poor relationship between biomass and the resulting recruitment in Caribbean spiny lobster was expected because spiny lobsters have an extensive (six to nine months or longer) planktonic phase prior to settlement. Lyons et al. (1981) argued that the low variability in recruitment in Florida suggested that recruitment here was supplemented from sources outside of Florida. Spiny lobsters occur in many areas of the Caribbean and currents flow from the Caribbean Sea through the Yucatan Straits and form either the Loop Current going into the Gulf of Mexico or the Florida Current (Fig.3.1.2.7.2). The Loop current eventually recombines with the Florida Current to form the Gulf Stream. Morrison and Smith (1990) monitoring current flow in the Caribbean Sea observed a transport maximum in the eastern Caribbean (Aves Ridge) and detected a transport maximum in the Florida Straits approximately 90-100 days later. Florida's downstream location means that Florida could receive recruits from the Caribbean, Mexico, Cuba, or local sub-stock. Yeung and McGowan (1991) sampled lobster larvae off southern Florida and found that *Panulirus* was found further offshore in the Florida Current and concluded that the later stages of phyllosomes most likely came from foreign upstream sources. Silberman et al. (1994) collected a total of 259 lobsters from nine areas extending from Antigua and Martinique in the eastern Caribbean to Florida and Bermuda. They used mtDNA to examine genetic diversity and found 187 unique haplotypes and of those haplotypes, 168 were unique to single lobsters. They concluded that *P. argus* is a single genetic stock shared by many countries. Using micro satellite DNA on samples from Brazil to Bermuda and thought the Caribbean, a similar conclusion was reached by Hunt et al. (2009) who showed that (1) cohorts of spiny lobster that recruit in Florida Keys are admixtures of migrants from at least four different genetic sources; and (2) adult lobsters exhibit wide range with little evidence of isolation-by-distance over the range; this is due to very high gene flow/dispersal distances and, therefore, high connectivity. Sarver et al. (2000) found two specimens of the Brazilian sub-species of spiny lobster off Miami, Florida. Ehrhardt and Fitchett (2010) argue that recruitment in the SE US come from local production but that is based on their post-larval index which was the number of post-larvae per 29 day soak time and the researchers who collect the post-larval data recommend not standardizing the catch rates by soak time. . Therefore, we think that self-recruitment is indeterminate.

3.1.2.8. Measures of Parameter Uncertainty

As mentioned in Section 3.1.1.5, uncertainty was examined by developing likelihood profiles of the initial number, the fishing mortality rate by sector in 2009-10 and the stock size in 2009-10. All these likelihood profiles were dome-shaped (Fig. 3.1.2.8). The likelihood profile for the initial number of spiny lobsters in July 1978 indicated that there was very low likelihood that the number of lobsters was less than 4.2 million; however, while the maximum likelihood was at about 11.5 million, the likelihood declined slowly at higher initial numbers, just slightly at above 40 millions lobsters. The likelihood profile for the fishing mortality rate in 2009-10 had defined peaks at 0.21 per year for the recreational fishery, 0.46 for the commercial fishery, and 0.04 for the commercial bait fishery, which corresponded to the point estimates. There were low likelihoods that these fishing mortalities be less than 0.02, 0.04, and 0.004, respectively. After they peaked, the fishing mortality by sector declined with very low likelihoods that they could reach as high values as 2.23 for the recreational fishery, 4.79 for the commercial fishery, and 0.41 for the lobsters used as attractants. Concerning the likelihood values for the stock size in 2009-10, they peaked at 8.83 million lobsters, with low likelihoods to be less than 54 thousands and more than 25.8 millions. Note that the likelihood profiles are superimposed with the normal approximations and both statistics generally indicated similar distributions of the aforementioned parameters.

3.1.2.9. Retrospective and Sensitivity Analyses

Retrospective analyses of population numbers, recruitment, and fishing mortality rates were conducted by running the DeLury model with terminal fishing years of 2003-04 through 2009-10 (Fig. 3.1.2.9.1 and Fig. 3.1.2.9.2). The FWC Adult Monitoring Transect Survey index was omitted from the retrospective runs because it began in 2004 and we wanted to have the runs as comparable as possible. When necessary, we truncated the indices based on the terminal fishing year. We compared the results beginning with 2003-04 with those of 2009-10 using the average percent difference between the runs. The average populations estimated in 2009-10 were, on average, 17.8% higher when they were the terminal year and conversely for the recruitment estimates in 2009-10, which were on average 29% lower. At the same time, the 2009-10 recreational, commercial, attractant, and total fishing mortality rates were on average 30%, 19%, 24%, and 22 % lower when they were in the terminal year. Two-tailed, paired-t tests showed that these differences were significantly different from zero (P-value < 0.05), except for the recruitment (P-value = 0.086). This is indicative of a retrospective issue such that the estimated fishing mortality will be too high in the last year. Finally, note that the population was particularly high throughout the study timeframe when the terminal years were 2006-07 and 2009-10.

The SAW members recommended running the model with two alternate natural mortality rates, 0.25 per year and 0.43 per year as sensitivity runs. As expected, the population and recruitment estimates were higher as the natural mortality rate was increased and the fishing mortality rates were lower. The total mortality (Z) values for any fishing year were different. Differences ranged between 0.15 and 0.95 per year against an overall average magnitude of 1.64 per fishing year (Fig. 3.1.2.9.3 and Fig. 3.1.2.9.4; Table 3.1.2.3).

3.2 Age-structured models

Growth in spiny lobsters was estimated from two sources: tag returns and rate of accumulation of eye stalk lipofuscin. The lipofuscin technique has potential to provide ages but in this case the aging was based on 51 laboratory-raised spiny lobsters that spanned only four years. In addition to increase its utility, we need to identify the sources of variability in lipofuscin concentrations with the sex and habitat of spiny lobsters. For example, female lobsters had lower lipofuscin concentrations than did males of the same age and animals from the Dry Tortugas had lower concentrations than did lobsters from the Florida Keys. We ran the age-structured models with catches-at-age developed using both sources but chose to use the ages based on tagging for the base run.

3.2.1. Integrated Catch-at-Age

3.2.1.1. Integrated Catch-at-Age Overview

Integrated Catch-at-Age (ICA) is a statistical catch-at-age (CAA) model that solves for the numbers at age in the most recent year, in this case the 2009-10 fishing year, the numbers in the oldest age before the plus group, the age-specific selectivities, and the catchability coefficients for the tuning indices. The program has been evaluated and meets the International Council for the Exploration of the Sea (ICES) Quality Control specifications and is available from ICES. The two things that make this model different from other statistical catch-at-age models are: 1) the model runs backward from the oldest ages in the most recent years instead of solving for recruitment directly and 2) the model allows for the selectivities to be applied only to a portion of the catch history. As a result ICA is a hybrid between statistical catch-at-age models and tuned virtual population assessment (VPA) models such as ADAPT. However, like the traditional VPA approaches, ICA uses a combined CAA, i.e., a CAA aggregated across all sexes and all available fisheries. ICA model assumes separability of the fishing mortality at age between an annual effect (fully selected fishing mortality) and an age effect (selectivity schedule) over the most recent fifteen years (an ICA limit), in this case across the 1995-06 and 2009-10 fishing years. The model solves for the numbers and fishing mortality rates for the earlier fishing years in a manner similar to ADAPT using the information from the 1994-95 fishing year as the starting point for those earlier years.

3.2.1.2. Data Sources

As noted in the SEDAR08 Data Workshop section on age and growth (pages 7-24), growth was estimated from tagging studies and from the relationship of lipofuscin concentrations to known ages of laboratory raised spiny lobsters. ICA used a single, combined gears CAA matrix based on tagging growth model in the base run (Table 3.2.1.2.1), average weights at age and fishing year in the harvest that came from converting the catches-at-length using Matthews et al.'s (2003) length-weight equation (Table 3.2.1.2.2), average weight at age and fishing year in the population that we approximated with the mean size at age from the growth trajectories converted to biomass with the same equation (Table 3.2.1.2.3). All lobsters that were 12 years old and older were combined into a single group (age-12+). Inputs on age-specific life history information are shown in Table 3.2.1.2.4. The program allows for natural mortality rates by age and year although, due to lack of specific information, we used 0.34 per year for all ages and fishing years in the base run. The maturity schedule by age was approximated as 0.0 at age-1, 0.5 at age-2, 0.75 at age-3, and 1.0 for ages 4+ (J. Hunt, personal communication). An alternate maturity schedule was developed for female lobsters spawning in the fishery area (Upper Keys, Middle Keys, Lower Keys, and West of Key West) using biological samples collected by MARFIN program during the months of April-June. This process consisted of two steps. First, females of different CL classes (with 5 mm class intervals) with eggs, spermatophores, or both were considered mature, otherwise immature. The proportions of mature females were then calculated and fitted with a logistic function:

$$M_i = \frac{1}{1+e^{\alpha(l_i - l_{50})}} \quad (1)$$

where M_i is the probability mature for females in CL length class i; l_i is mid length class; and α and l_{50} are parameters. This model led to values of -0.179 and 66.7 mm for α and l_{50}, respectively (Fig. 3.2.1.2.1a). Second, a probabilistic aging method was applied to assign ages after settlement to lobsters based on the carapace lengths and the probabilities of age by length from the tagging growth trajectories (Fig. 3.2.1.2.1b). The estimated maturity schedule by age suggests that its assumed counterpart underestimates the contribution of age-1 to age-3 female lobsters to the overall spawning potential.

The spiny lobster fishery begins in late July with the recreational two-day Sport Season and ends on March 31 of the following year; therefore, all of the fishing occurs before the spawning season (spring and summer with the peak in late May in the Florida Keys (Bertelsen and Matthews 2001)) while only eight months of natural mortality have occurred before the spawning season. In addition to the fishery data, we used the same eight tuning indices that were used in the DeLury model: observer pre-recruit (Age-2) and legal-sized (Age-3 and older) numbers per trap, FWC Adult Monitoring pre-recruit (Age-2) and legal-sized (Age-3 and older) numbers per dive (timed sampling design), the number of post-larvae per collector offset one year and applied to Age-1, and the number of lobsters per trip from Biscayne National Park's creel survey (Age-2 and older). Again, the update AW recommended including the transect indices as potential tuning indices, namely the FWC Adult Monitoring pre-recruit (Age-2) and legal-sized (Age-3 and older) from the transect survey protocol.

3.2.1.3. Model Configuration and Equations

Integrated Catch-at-Age uses a backward projection instead of the more familiar forward projection method; thus, ICA solves for the population numbers in the most recent fishing year (2009-10) and the number of age-11 lobsters which together with the selectivity and annual fishing mortality rates allows the calculation of the numbers of lobsters by age and year and the corresponding predicted catch-at-age.

In a separable model, the fishing mortality on any age and year, $F_{a,y}$, is:

$$F_{a,y} = Sel_a F\_full_y \quad (1)$$

where Sel_a is the selectivity for a given age, *a*, and $F\ full_y$ is the fishing mortality on fully recruited ages for a given fishing year, *y*. The number of lobsters at age and year, $N_{a,y}$, is solved backward from the most recent year using the fishing mortality by age and year, $F_{a,y}$, and the natural mortality rate, $M_{a,y}$, from

$$N_{a-1,y-1} = N_{a,y} \exp(F_{a-1,y-1} + M_{a-1,y-1}) \quad (2)$$

and the average population during the fishing year , $\overline{N_{a,y}}$, is given by

$$\overline{N_{a,y}} = \frac{N_{a,y}}{(F_{a,y} + M_{a,y})}(1 - \exp(-F_{a,y} - M_{a,y})) . \quad (3)$$

Therefore, the predicted catch-at-age, $\hat{C}_{a,y}$, is

$$\hat{C}_{a,y} = F_{a,y} \overline{N_{a,y}} . \quad (4)$$

Predicted index values are calculated from the estimated number of lobsters of the appropriate ages and the catchability coefficient, q_j. For an aged index, I_j, the number of lobsters at age is summed across the ages that the index applies to and the catchability, q_j, or

$$\hat{I}_{a,y,j} = q_j \sum_a N_{a,y} \exp(Fraction_j(-F_{a,y} - M_{a,y})) \quad (5)$$

where $Fraction_j$ accounts when the survey is conducted during the fishing year.

The objective function minimized the differences between the observed and predicted catches-at-age and between the observed and predicted indices. Assuming that the errors in the catch-at-age and in the indices had lognormal distributions, the objective function, *SS*, was

$$SS = \sum_a \sum_y \lambda_{a,y} \ln(\frac{C_{a,y}}{\hat{C}_{a,y}})^2 + \sum_a \sum_y \sum_j \lambda_j \ln(\frac{I_{a,y,j}}{\hat{I}_{a,y,j}})^2 \qquad (6)$$

where the first term minimizes the differences between the catches at age and year and λ is the age-year weight. The second term in equation (6) minimizes the differences between the indices based on numbers and the appropriate ages and λ_j is the weight given to index, I_j. In the case of spiny lobsters, all of the components were weighted equally at 1.0.

3.2.1.4. Parameters Estimated

Given the inputs, the model solved for 56 parameters including the fishing mortality rates on reference age-3 (the earliest age believed to be fully recruited) for 1995-06 through 2009-10 (15 parameters), the selectivities by age for this same period (9 parameters, the reference age of age-3 was fixed as 1.0 and the selectivity in the last age before the plus group (1.0) was specified during the run), the 2009-10 population size in numbers (11 parameters), the number of lobsters at age-11 for the other fishing years in the constant selectivity period (14 parameters), and the catchability coefficients for each of the tuning indices (7 parameters in the base run).

3.2.1.5. Uncertainty and Measures of Precision

This model initially evaluated uncertainty as follows. First, the model used a Monte Carlo process involving 1000 reruns with random draws for the parameters from the covariance matrix. From the 1000 solutions, we developed box-and-whisker plots of spawning biomass, recruitment and fishing mortality rates by fishing year. Second, the model was rerun with alternative natural mortality rates of 0.25 and 0.43 per year as recommended by the AW. Finally, retrospective analyses were conducted over a range of terminal fishing years (2003-04 to 2009-10) by starting with the final run configuration of ICA and sequentially removing the terminal year's data from the catch-at-age and tuning indices. As with the retrospective analysis for the DeLury model, the FWC Adult Monitoring Transect Survey index was omitted from the retrospective runs

3.2.2. Integrated Catch-at-age Results

3.2.2.1. Measures of Overall Model Fit

The measures of fit for ICA are the fit to the catches-at-age (Fig. 3.2.2.1.1) and the fits to the tuning indices (Fig. 3.2.2.1.2). An analysis of variance table with the sources, sum of the squared residuals, numbers of data points, degrees of freedom, and the mean squares is included as Table 3.2.2.1). Except the component for the legal-sized lobster index developed from the FWC Adult Monitoring program, transect sampling design, the components for other indices were significant; so, only the FWC Adult Monitoring Transect age 3+ index was excluded from the final base model run.

3.2.2.2. Parameter estimates

For each of the 56 parameters that ICA solved for, the program presents the maximum likelihood value, the coefficient of variation, the 95% confidence interval, and the mean estimate. The parameters are listed in Table 3.2.2.2. As expected the CV values are higher in the recent fishing years and in the population estimates.

3.2.2.3. Stock Abundance and Recruitment

The estimated number of lobsters by fishing year varied from 37.7 million in 1985-86 to 25.9 million in 2003-04 and, for 2009-10, the estimate at 53.8 million lobsters was the highest (Fig. 3.2.2.3.a). The estimated numbers of spiny lobsters by fishing year and age are included in Table 3.2.2.3. Recruitment expressed as age-1 lobsters was bimodal during 1985-2003 with an early increase in 1987-88 (19 million) and then a decline and another increase in 1993-94 (14.6 million) through 1998-99 then dropped reaching lows in early 2000s (11-12 million) and then a gradual increase afterward with 28 million in 2009-10 (Fig. 3.2.2.3b).

3.2.2.4. Stock Biomass (total and spawning stock)

Total biomass generally showed trends similar to those of estimated numbers (Fig. 3.2.2.4a). The total biomass ranged from 27.3 million pounds in 1985-86 to 18 million pounds in 2003-04 and was 37 million pounds at the beginning of 2009-10. Spawning biomass generally showed trends similar to those of the total biomass and number of lobsters. Spawning biomass has peaked at 10.4 million pounds in 1988-89, declined thereafter at lowest levels in the early 2000s, and rebounded since then to reach a level of 12.4 million pounds in 2009-10 (Fig. 3.2.2.4b). Note that the small error bars in the years prior to 1995-96 reflect that the covariance matrix was determined only for the fishing years 1995-96 and later and the decreasing variability in the early years illustrates that VPAs converge.

3.2.2.5. Fishery Selectivity

Selectivity in spiny lobsters is dome-shaped with fewer age-1 lobsters available to the fishery, many of which were used as attractants, lobsters became fully available at age-3 and then fewer at older ages (Fig. 3.2.2.5). Note that the selectivity of ages 2 through 5 is above 0.8 and these ages comprise and average of 73% of the total kill (age-1 comprises an average 24% of the total kill). A possible explanation for the decreasing availability of older lobsters could be movement away from the areas where the fishery is concentrated.

3.2.2.6. Fishing Mortality

Fishing mortality rates on age-3 (fully recruited) by fishing year have been variable but without trend prior to 1996-97; they then increased to a peak of 0.8 per year in 2000-01 and declined steadily thereafter (Fig. 3.2.2.6.1; Table 3.2.2.6). ICA also calculates the average fishing mortality rate of selected ages, in this case, we chose ages 1 through 5. The pattern of the average fishing mortality rates is similar to that on the fully recruited but lower because of the dome-shaped selectivity (Figure 3.2.2.6.2).

3.2.2.7. Stock-Recruitment Parameters

The comments made in Section 3.1.2.7 are valid here. Thus, given the possible pan-Caribbean nature of recruitment with the unknown spawning biomass, we would not expect to see a tight relationship between the spawning biomass in US waters and subsequent recruitment and, if we do, it would rather be a statistical artifact. To account for the age at settlement in the stock-recruit plot, we plotted the spawning stock (in terms of eggs and biomass weighed by the sex-ratio for females and the average number of broods by female and spawning season) versus the number of age-1 lobsters offset by two years from the spawning biomass instead of one year (Fig. 3.2.2.7). Two years is the same offset that we used in the DeLury model. The issue is not whether we can identify a unique curve but rather defining the spawning biomass that contributes to the spiny lobster populations in the SE U.S.; we know that the spawning biomass is greater than what occurs in Florida but we have no idea how much greater.

3.2.2.8. Measures of Parameter Uncertainty

Measures of parameter uncertainty were presented in Table 3.2.2.2 that includes the maximum likelihood estimate, the coefficient of variation, the 95% confidence interval, and the mean estimate. However, see the following retrospective section below for uncertainty that exceeds these usual measures of precision. As will be shown below in Section 6.4, the fishery is not overfishing and, therefore, a P* analysis was not conducted (TOR #7).

3.2.2.9. Retrospective and Sensitivity Analyses

The retrospective analyses indicate that the model underestimates fishing mortality (Fig. 3.2.2.9.1). For example, running the model with the data through 2007-08, the fishing mortality rate in 2007-08 was estimated at 0.147 per year but when the 2007-08 fishing mortality rate was estimated using data through 2009-10, the value was 0.323 per year (120% higher) and when we average the differences across the terminal years in the retrospective runs then fishing mortality rates were on average 139% (CV = 28%) lower. For example, if we look at the precision of the 2007-08 fishing mortality rate estimate in Table 3.2.2.2, the 95% confidence interval of the

0.32 per year extends from 0.24 to 0.44 per year and does not include the estimate with the terminal year of 2007-08 (0.147 per year). Recruitment was overestimated by an average of 92% (CV = 8%) and the spawning biomass was overestimated by an average of 82% (CV = 10%). As with the DeLury model, we tested the significance of these differences with two-tailed, paired t-tests and all of the differences were significant at α=0.05. Mohn (1999) noted that the retrospective bias stems from the changing catchability coefficients and spiny lobster is consistent with his conclusion (Fig. 3.2.2.9.2). The catchability was estimated by standardizing the recreational effort with the commercial effort using the DeLury fleet catchabilities to get the combined effort, E_y, and then the annual catchability, q_y, is:

$$q_y = \frac{F\_full_y}{E_y} \tag{7}$$

where F_full_y is the fishing mortality on fully recruited ages for a given fishing year, y. The drop in catchability in the most recent three years probably reflects the retrospective bias in F. The AW decided not to make any catchability-related adjustment but rather to note that a retrospective bias presents another source of uncertainty in the assessment that is not incorporated into the precision estimates.

Initially, sensitivity runs included runs with higher (0.43 per year) and lower (0.25 per year) natural mortality rates. These runs yielded predictable results (Fig. 3.2.2.9.3; Table 3.2.2.9.1): lower natural mortality resulted in higher fishing mortality and lower population size and recruitment, and conversely for higher natural mortality. Additional sensitivity runs included repeating the entire analyses with the lipofuscin based age-length keys (LALK) developed for the Florida Keys, where fishing takes place (i.e., LALK developed for the Dry Tortugas were not considered). The using LALK led to slightly lower fishing mortality rates during 2000-2007 (Fig. 3.2.2.9.4a) and slightly higher recruitment (Fig. 3.2.2.9.4c) during the entire timeframe, but these parameters were generally comparable for the two aging methods. The main difference between the two aging methods was the magnitude of the spawning biomass: the LALK yielded higher spawning biomass (Fig. 3.2.2.9.4b) and this was apparently due to different selectivity patterns estimated from the tagging age-length keys and LALK (Fig. 3.2.2.9.4d). Even though the selectivity estimates from both aging-based analyses were dome-shaped, they were similar up to age-2 lobsters, then selectivity declined markedly for older lobsters with the LALK based analyses.

Behringer and Butler (2009) suggested that the marked decrease in landings after 2000 was related to the PAV1 lobster virus that primarily attacked juvenile spiny lobsters. In the ICA model, the post-larvae index is offset by one year and assigned to age-1 lobsters because we considered the recruitment to occur one year after settlement because we have no information on natural mortality on post-larvae. Because the virus attacks juveniles and the index reflects post-larval settlement, AW members asked for some additional sensitivity runs using variations to the post-larval index. The requested runs included 1) deleting the index, 2) using the index only for the years 1988-1998 (in order to exclude the post-virus years), 3) creating a different index using the settlement data from both Big Munson and Long Key but only including the years from 1993-2009 because of the standardized sampling protocols, and 4) increasing the natural mortality rate (M) on age-1 lobsters to account for an average of 36% decrease in landings after the 2000-01 fishing year. The latter request translated into an M value on age-1 lobsters of 0.8 per year; the run involving this M value is henceforth referred to as "base-virus run".

The results from these runs are summarized in Table 3.2.2.9.2 and Fig. 3.2.2.9.5., along with those from base run for comparison, i.e., using original indices and M = 0.34 by year and age. The estimates from all these runs were similar over specific time-windows: 1985-1998 for the total biomass and recruitment; 1985-2002 for the spawning biomass and fishing mortality, especially for base run and base-virus run. After these periods, total biomass, spawning biomass, and recruitment estimated without the post-larvae index or with this index over 1988-1998 increased sharply, with higher and nearly equal values that increasingly and positively diverged over time from those estimated using base run. Recruitment estimates from base-virus run were similar to those derived from runs using the previous index configuration until 2003-04; they then declined gently but at levels still higher than those of the recruitment from base run. Except for the spawning biomass, the base run yielded the lowest total biomass and recruitment estimates after those derived from the run that included the post-larvae index based on data from Big Munson and Long Key sites during 1993-2009. The estimates from the latter ICA configuration also diverged from base run values, increasingly and negatively over time. As usual, the fishing mortality rates had opposite trends to those of the biomass and recruitment estimates.

Three aspects are worth noticing about the ICA sensitivity runs following the treatment of the post-larvae index and the values of M on age-1 lobsters. First, including or ignoring the index in question had no effects on ICA behavior and estimates prior to1995-96, because separability for the ICA model operated only from the 1995-96 fishing year onward. Without any guidance in the last ten years, recruitment became higher because there was no guidance from any other index. This is probably the reason why ICA particularly handled quasi-equivalently the fact of deleting the index or keeping it with values from 1988 through 1998, whereby the effects of the 1996-1998 index values were minimal. Second, the aforementioned configurations of the post-larvae index and base-virus run acted like input guesses of the terminal F in standard VPA runs, upon which the resulting estimates converge backward in time starting from a given year. Finally, ICA runs based on the post-larvae index over 1993-2009 also showed retrospective patterns.

4. Models Comparison

4.1. Compare and Contrast Models Considered

The two models retained for this assessment update used the same landings converted to numbers and the same tuning indices. Differences between the models were that the DeLury model used fishery effort in addition to the tuning indices while the age-structured model, ICA, used the numbers of lobsters landed by age and fishing year to gain additional insights into the stock dynamics. Both models showed little trend in fishing mortality rates until the late-1990s and these rates generally declined simultaneously afterwards. The fishing mortality rates in the DeLury were on average 2.8 times higher than those estimated from ICA (Fig. 4.1); however, one of the Stock Assessment Workshop members pointed out that the lower rates from ICA probably reflected the dome-shaped selectivity curve (Fig. 3.2.2.5) estimated in the age-structured model. The dome-shaped selectivity curve reduced the number of lobsters available to the fishery while the DeLury model assumed that the harvests were comprised of homogeneous lobsters that are all equally available to fishers. Another possible reason is that the DeLury model considers a blended recruitment, consisting of animals of any ages that become available to fishermen instead of only age-1 lobsters. Finally, both models showed significant retrospective patterns.

4.2. Preferred Model Recommendation

Term of reference number 4 states: "Update the approved SEDAR 8 Southeastern spiny lobster model base configuration with data through 2008-09. Employ the SEDAR 8 SAR 3 statistical catch-at-age model (Integrated Catch-at-Age) as the base and the DeLury model as a check for consistency." The AW decided in an initial conference call in February 2010, that the 2009-10 landings data would be available and to extend the analyses through the 2009-2010 fishing year. The AW members concurred with the model recommendations.

5. Population Modeling

5.1. Yield per Recruit Models

5.1.1. Methods

We calculated the yield-per-recruit (YPR) empirically with the natural mortality rate of 0.34 per year across ages, the selectivity from the ICA model, and the average catch weight by age. The values of these inputs by age are shown in Table 5.1.1 (along with inputs specific to the computation of the spawning potential ratio, SPR)

5.1.2. Results

With the life history parameters of spiny lobster, the yield-per-recruit curve did not reach a maximum at a realistic fishing mortality rate but the maximum yield would be about 0.72 lbs per recruit; the YPR at the current fishing mortality of 0.21 per year (geometric mean of the last three years' fishing mortality on fully recruited lobsters) was 0.36 lb; in 2009-10, YPR was 0.28 lbs at a fishing mortality rate on fully recruited lobsters (age-3) of 0.15 per year (Figure 5.1.2). The YPR at the $F_{20\%}$ MSY proxy discussed below was 0.50 lbs at a fishing mortality rate of 0.42 per year.

5.2. Stock-Recruitment Models

As noted in Sections 3.1.2.7 and 3.2.2.7, the spawning stock occurs in the Caribbean as well as in the SE US but we have no idea how much of SE US's recruitment comes from outside spawning activity and, without estimates of the spawning stock in the western Atlantic, we were unable to determine a valid stock-recruit relationship. The Beverton-Holt Stock-recruit figure shown earlier (Fig. 3.2.2.7) only included the spawning biomass in the number of eggs from SE US lobsters and ignored any contribution of post-larvae from upstream in the Caribbean.

6. Biological Reference Points (SFA Parameters)

6.1. Existing Definitions and Standards

The existing definition for overfishing was defined in Amendment 6 of the Spiny Lobster FMP (SAFMC 1998) as a fishing mortality rate (F) in excess of the fishing mortality rate at 20% static SPR ($F_{20\%}$). Static SPR is the equilibrium value associated with any particular fishing and natural mortality rates, selectivity, maturity, and biomass (Mace et al. 1996). Optimum Yield (OY) was defined in Amendment 6 of the spiny lobster FMP as the amount of harvest taken by U.S. fishers while maintaining the Spawning Potential Ratio at or above 30% static SPR. While Maximum Sustainable Yield (MSY) is unknown in this fishery, the Council concluded that the best available data supports using 20% static SPR as a proxy for MSY.

6.2. Estimation Methods

The estimation of Static SPR in terms of eggs per recruit ratio follows the procedures in Gabriel et al. (1989) for calculating spawning stock biomass per recruit with the substitution of the number of eggs per spawning as a function of age for average weight-at-age. Bertelsen and Matthews (2001) gave an expression for the number of eggs as a function of carapace length:

$$E = 91.88 * CL^2 - 231212 \qquad (1)$$

Here, CL is the female's mean carapace length at age (in mm) obtained from the tagging growth model. Thus, under equilibrium conditions, the egg per recruit is:

$$EPR = \sum_{a=1}^{15} Ns_a E_a B_a Mat_a SR_a \quad (2)$$

where E_a is the fecundity or number of eggs produced by a female at age, *a;* B_a is the average number of broods per female by age in a spawning season, one brood for less than 80 mm CL and two for larger female lobsters (Lipcius 1985; Cruz and Bertelsen, 2008); Mat_a represents the assumed maturity schedule as described in Section (3.1.1.2); SR_a is the sex-ratio for reproducing females (i.e., length ≥ 76 mm CL), approximated to be 0.5; and Ns_a is the number of lobsters at age expected at the beginning of the spawning season the following March, from a number at-age, N_a, expected at the onset of the fishing year. $Ns_a = N_a e^{-Z_a * O}$, where $N_a = N_{a-1} e^{-Z_{a-1}}$, Z is the total mortality rate, and o is the spawning offset (August – March) with a value of 0.67 (note that N_1.was set to 1 female lobster). The egg per recruit ratio, *ER*, for a given fishing mortality, *F*, is then:

$$ER = \frac{EPR_F}{EPR_{F=0}} . \quad (3)$$

The previous calculations relate to base Static SPR estimation. They were repeated for sensitivity analysis using the estimated maturity schedule (see section (3.1.1.2). The inputs by age specifically used to calculate the static SPR (average number of eggs, number of broods, proportion mature, average weight in the population from the tagging growth model, and proportion of females) are given along with those used in YPR analyses (natural mortality, and selectivity from ICA model run) in Table 5.1.1.

6.3. Results

Using eggs per recruit as the basis for calculating the static SPR values associated with the estimated fishing mortality rates since 1985-86, the fishing mortality rates exceeded the $F_{20\%}$ in 1989-90 through 1991-92, 1994-95 through 1997-98, 1999-00 through 2004-05, and in 2006-07; touched $F_{20\%}$ in 1998-99; and have been lower in other years (Table 6.3.1, Fig. 6.3). Lower values of fishing mortality estimated during the 2008-09 and 2009-10 fishing years were associated with static SPR greater than 40%. However, the most recent years are the most uncertain as this has been particularly revealed by the retrospective analyses. In fact, ICA tends to underestimate the fishing mortality rates especially since the 1999-00 fishing year and with such fishing mortality rates the static SPR would most likely be lower than their estimated values. Note that, even though the estimated maturity schedule suggests that younger female lobsters can significantly contribute to the spawning potential (Fig. 3.2.1.2.1b), the resulting static SPR only increased by 4% relative to the static SPR obtained using the assumed maturity schedule.

For management perspectives, various benchmarks derived from the previous SPR analyses are summarized in Table 6.3.2. These benchmarks generally were insensitive to the maturity schedule used, except for the current spawning stock biomass, and the ratios $F_{current}/F_{20SPR}$ and $SSB_{current}/SSB_{F20SPR}$.

6.3.1. Overfishing Definitions and Recommendations

The existing overfishing definition is that fishing mortality rates should be no higher than the fishing mortality rate associated with a 20% static SPR ($F_{20\%}$). The fishing mortality rate corresponding to 20% static SPR was 0.45 per year for fully selected lobsters and this rate was similar to the 0.49 per year in SEDAR08. The full fishing mortality rate since 2005-06 has only exceeded 0.45 per year one time and that value was 0.46 per year and the fishing mortality rates on the fully selected lobsters was less than 0.45 per year for 11 out of the 25 fishing years included in the ICA analyses. The geometric mean for the fully selected fishing rate for the past three fishing years, 2007-08 through 2009-10, was 0.21 per year and the stock is considered to not be undergoing overfishing. However, these results illustrate a difficulty with a limit that is close to the long term average in that the limit will be exceeded frequently.

6.3.2. Overfished Definitions and Recommendations

The estimation of conservation and management benchmarks for whether the stock of spiny lobster is overfished in SE US cannot be done reliably using only the data from the stock assessment, alone. The reason for this is threefold:

1) Estimation of long term productivity measures such as maximum sustainable yield requires some understanding of the relationship of future recruitment levels with spawning stock biomass, i.e. the stock-recruitment relationship. In particular one needs to know the curvature of this relationship and at what stock levels recruitment declines. Unfortunately, in this assessment there are no indications of much variation in recruitment trends from the data. Therefore, we cannot estimate benchmarks such as spawning biomass at MSY (SSB_{msy}) or the fishing mortality rate that produces SSB_{msy} (F_{msy}) directly from the data.

2) Even if we could estimate SSB_{msy} from the data, the question remains whether this is appropriate because cohorts of spiny lobster that recruit in the SE US partly come from other areas throughout the Caribbean (Hunt et al., 2009) and, indeed, SE US may contribute recruitment to other areas. Due to high connectivity between spiny lobsters inhabiting various

areas in the Caribbean, self-recruitment is indeterminate; therefore, the SE US population may not be considered as a separate breeding population.

3) The degree of "leakage" of lobsters outside of the traditional fishery caused by migration, behavior, gear selection or some combination makes the estimates of fishing mortality rates and, subsequently, F_{msy}, to be somewhat uncertain.

Note that by using $F_{20\%}$ as a surrogate to F_{msy}, the AW, following SEDAR08, is avoiding the debate on whether recruitment arises from within or without the SE US area. We only are assuming that there is a breeding population of spiny lobsters of which the lobsters in the SE US are part. Then if fishing occurs at F_{msy} throughout the stock, including the SE US component, then it is expected that SSB_{msy} for the entire breeding stock would be achieved. While current management only controls the U. S. component of the fishery, a F_{msy} strategy for this component would be consistent with overall MSY goals for the stock wherever it occurs. This discussion concurs with Amendment 6 of the spiny lobster FMP that states that MSY is unknown for this species.

6.3.3. Control Rule and Recommendations

A control rule based on spawning stock cannot be developed until the spawning biomass of the stock is assessed.

6.4. Status of Stock Declarations

The fishing mortality rates on fully recruited spiny lobsters during the last ten years only have been less than $F_{20\%}$ (i.e., 0.45 per year) in 2005-06 and from 2007-08 through 2009-10, when they ranged between 0.15 and 0.38 per year with associated static SPR of 23% -53%. In these years, especially in 2009-10, these values suggest that the U.S. fishery is not overfishing. However, the retrospective results from ICA model runs with various configurations call for cautions and prudent management options because fishing mortality rates were probably underestimated in recent years (the DeLury has the opposite retrospective bias).

As noted in Sections 6.3.2, a Caribbean-wide stock assessment is needed. This assessment would weigh various local, biological and technical interactions, and perhaps help better understand and determine the exploitation and stock conditions for the Caribbean spiny lobster.

7. Projections and Management Impacts

Term of Reference #10 states "Evaluate and project future conditions for eleven years (2010-11 through 2020-21 inclusive) beyond the terminal year of the update (2009-10). Run at least these three projection scenarios: $F = F_{current}$, $F = F_{msy}$, and $F = F_{oy}$"

To provide a context for the projection duration, the initial step was to determine the mean generation times. A simple equation for average generation time, *GT*, is to weight age by the eggs per recruit (Section 6.2, Equation 2; Krebs 1972), and the equation is:

$$GT = \frac{\sum_{a=1}^{15} a Ns_a E_a B_a Mat_a SR_a}{\sum_{a=1}^{15} Ns_a E_a B_a Mat_a SR_a}. \quad (1)$$

Equation (1) predicts a mean generation time of 4.43 years but that is time after post-larval settlement so including the time while in the plankton as a phyllosome, the mean generation time would be 5.26 years (4.43 + 0.83) and 1.5 times the mean generation time would be 7.9 years; hence the 10 year projection horizon.

The stochastic projections used variation of the model developed for black grouper (SEDAR19 2010) and incorporates the geometric mean of the number of fish by age in 2007-08 through 2009-10 and the standard errors of the numbers of fish by age from the ICA run, the average weight of spawning females by age, the maturity schedule by age, the number of broods by age, and the sex ratio by age, the fishing mortality rates for 2007-08 through 2009-10 from the 1000 bootstraps to estimate $F_{current}$, the recruitment for 2007-08 through 2009-10 from the 1000 bootstraps to estimate recruitment deviations, and the estimates of $F_{20\%SPR}$ and $F_{30\%SPR}$. This model also used the assumption that the combined selectivities for the directed fishery and the attractants would remain the same over the projection period.

For the purposes of developing projections, we fit a Beverton-Holt stock-recruit relationship (Fig. 3.2.2.7) with a two year offset to the spawning biomass in southeast US waters expressed in eggs at time, *t* (SSB_t)and the number of recruits two years later (R_{t+2}). The equation was:

$$R_{t+2} = \frac{1.64*10^7 * SSB_t}{7.29*10^{10} + SSB_t} \quad (2)$$

The corresponding steepness for the stock-recruit curve was 0.97 which means that only at very low spawning biomass would recruitment decrease as indicated by the β term in the equation is approximately 3% of the geometric mean of the 2007-08 through 2009-10 spawning biomass ($2.24x10^{12}$ eggs). The geometric mean fishing mortality rate from 2007-08 through 2009-10 fishing years or 0.21 per year for $F_{current}$. As noted in Section 6.3.1, the F_{msy} proxy ($F_{20\%}$) was equal to 0.42 per year, and Amendment 6 specified $F_{30\%}$ for optimum yield and that translates to a fishing mortality rate of 0.30 per year. The trajectories of spawning biomass and landings for the three fishing mortality scenarios are shown in Figure 7.1. It must be noted that at the beginning of the 2010-11 fishing year, the age-structure was not in equilibrium with the fishing mortality rates because the fishing mortality rates were higher previously. For example, the current geometric mean spawning biomass expressed in eggs was 1,980 billion eggs but the equilibrium biomass associated with $F_{current}$ was approximately 4,000 billion eggs. The projections indicate that this level would be reached by the 2015-16 fishing year. The peak in landings in 2011-12 results from the mean recruitment in the last three fishing years being higher than the asymptotic recruitment.

Fishing at either $F_{20\%SPR}$ or $F_{30\%SPR}$ would be expected to achieve lower spawning biomass ten years out because both of those rates are higher than $F_{current}$. Given the retrospective bias such that $F_{current}$ could be as high as 0.41 per year, the fishery would still be operating below F_{msy} but possibly at a higher rate than F_{oy}.

8. Research Recommendations

Participants in the 2010 spiny lobster assessment update workshop expressed a variety of research and data needs including fishery-independent surveys for age-1 lobsters, attractant or "short" mortality, proper use of the post-larvae index, the development of the catch at age matrices, and controls on fishing mortality. Specifically, they recommended:

8.1. Conduct fishery-independent surveys for juvenile lobsters in lobster nursery areas (e.g., Gulf of Mexico side of Florida Keys such as Great White Heron National Wildlife Refuge). This would lead to more accurate estimates of age-1 lobsters instead of applying the post-larvae index in assessment models.

8.2. Critically evaluating the methods used to estimate the number of "shorts' and legal lobsters used as attractants and their mortality in trap fisheries.

8.3. Integrating additional long-term post-larvae collector data from "second site" and only use data for first quarter of lunar phase (i.e., Day 7 of each lunar phase). The update included this item as a sensitivity run.

8.4. Conducting statistical research regarding the generation of the catch-at-age matrices used as input to the catch-at-age stock assessment algorithm. Specifically, several growth equations available for this purpose should be statistically assessed on the basis of their biological growth attributes and on how they might portray different mortality frames.

8.5 Given a spawning-recruit relationship that has already been suggested by Ehrhardt and Fitchett (2010), research regarding controls of fishing mortality should be considered based on SPR, other mortality reference points, or both.

In SEDAR08, the AW panel members expressed the need for geographically robust adult and juvenile monitoring programs that could provide tuning indices that can be connected to each other and the fishery. Towards this end, FWC has re-examined their Adult Monitoring Survey and changed the sampling protocols from timed surveys to transect surveys. That index is short only beginning in 2004 but with time it will become a valuable index. The weakness of that index now is that it is only conducted in the lower Keys and additional funding is necessary to expand the geographical scope of the survey.

The other main research recommendation in SEDAR08 concerned age and growth of spiny lobsters in the SE US. Discussions of the AW, focused on the lack of growth data from larger (>100 mm CL) lobsters and that the lipofuscin aging only included known age animals up to four years. What is needed is to develop a tag-recapture program in the Dry Tortugas where larger animals are available and also in the Florida Keys which is the center of the fishery. This program will require the cooperation of the industry and recreational divers, Any such studies will require refining existing tagging techniques.

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Table 2.1.1. Commercial landings in pounds by gear, attractants, and the total number trips by fishing year.

Fishing Year	Traps	Diving	Other	Total Directed	Attractants	Total Pounds	Trips
85-86	5,145,623	149,866	67,581	5,363,070	645,646	6,008,716	32,307
86-87	5,149,983	130,441	89,742	5,370,166	783,945	6,154,111	31,064
87-88	5,329,820	76,694	21,665	5,428,179	392,035	5,820,214	34,406
88-89	7,001,015	124,820	36,897	7,162,732	350,768	7,513,500	36,396
89-90	7,616,620	156,695	66,026	7,839,341	525,680	8,365,021	40,276
90-91	5,898,611	97,896	49,484	6,045,991	743,936	6,789,927	40,536
91-92	6,601,749	191,536	42,529	6,835,814	427,430	7,263,244	45,777
92-93	5,124,870	223,277	20,038	5,368,185	351,664	5,719,849	35,821
93-94	5,109,472	175,991	22,202	5,307,665	237,050	5,544,715	31,568
94-95	6,895,235	252,931	27,320	7,175,486	309,951	7,485,437	32,554
95-96	6,681,978	307,682	24,996	7,014,656	306,119	7,320,775	32,830
96-97	7,363,065	333,905	45,095	7,742,065	360,302	8,102,367	32,848
97-98	7,184,737	393,764	57,292	7,635,793	405,152	8,040,945	34,088
98-99	5,002,650	351,243	86,655	5,440,548	187,863	5,628,411	26,198
99-00	7,024,265	582,153	40,250	7,646,668	367,572	8,014,240	28,141
00-01	4,934,255	569,395	55,417	5,559,067	287,605	5,846,672	26,249
01-02	2,606,418	441,997	29,065	3,077,480	234,030	3,311,510	19,670
02-03	3,988,225	547,499	29,131	4,564,855	258,588	4,823,443	24,131
03-04	3,727,484	391,876	29,744	4,149,104	231,342	4,380,446	22,196
04-05	5,096,404	304,936	38,758	5,440,098	244,197	5,684,295	20,369
05-06	2,644,214	258,536	54,668	2,957,418	146,627	3,104,045	14,990
06-07	4,494,587	243,484	53,324	4,791,395	159,627	4,951,022	18,247
07-08	3,449,322	286,182	40,270	3,775,774	185,125	3,960,899	18,987
08-09	2,987,879	240,955	35,974	3,264,808	97,860	3,362,668	15,273
09-10	4,084,450	151,707	67,481	4,303,638	138,774	4,442,412	14,335

Table 2.1.2. Recreational and Special Recreational License landings in pounds and numbers and the number of person-days by fishing year. The effort for the Special Recreational License is expressed in person-day equivalents. Note that the shaded cells in the table are not observations but estimated values.

	Recreational			Special Recreational License			Total recreational landings		
Fishing Year	Pounds	Number	Person Days	Pounds	Number	Eq. Person Days	Pounds	Number	Person Days
85-86	1,432,438	1,296,276	339,625				1,432,438	1,296,276	339,625
86-87	1,453,954	1,315,747	317,518				1,453,954	1,315,747	317,518
87-88	1,797,036	1,626,217	377,255				1,797,036	1,626,217	377,255
88-89	2,032,970	1,839,724	505,243				2,032,970	1,839,724	505,243
89-90	2,060,736	1,864,851	497,125				2,060,736	1,864,851	497,125
90-91	1,820,800	1,647,722	433,092				1,820,800	1,647,722	433,092
91-92	1,476,571	1,336,214	578,003				1,476,571	1,336,214	578,003
92-93	1,352,400	1,203,309	477,756				1,352,400	1,203,309	477,756
93-94	1,883,199	1,746,451	515,006				1,883,199	1,746,451	515,006
94-95	1,831,140	1,682,413	544,438	74,980	68,809	22,267	1,906,120	1,751,222	566,705
95-96	1,863,545	1,615,134	467,265	67,145	58,194	16,836	1,930,690	1,673,328	484,101
96-97	1,868,021	1,728,370	541,729	54,612	50,530	15,838	1,922,633	1,778,900	557,567
97-98	2,254,165	2,138,068	624,074	50,096	47,517	13,870	2,304,261	2,185,585	637,944
98-99	1,253,186	1,139,986	332,391	49,493	45,022	13,127	1,302,679	1,185,008	345,518
99-00	2,400,461	2,235,278	554,953	61,449	57,219	14,206	2,461,910	2,292,497	569,159
00-01	1,910,957	1,803,471	477,776	38,096	35,953	9,525	1,949,053	1,839,424	487,301
01-02	1,218,734	1,111,874	387,570	32,291	28,702	10,005	1,251,025	1,140,576	397,575
02-03	1,410,893	1,262,318	367,089	44,466	39,785	11,570	1,455,359	1,302,103	378,659
03-04	1,372,518	1,203,645	385,656	38,981	34,185	10,953	1,411,499	1,237,830	396,609
04-05	1,238,561	1,124,806	413,005	34,136	32,108	11,789	1,272,697	1,156,914	424,794
05-06	1,104,603	1,045,966	440,354	26,427	25,025	10,536	1,131,030	1,070,991	450,890
06-07	1,277,592	1,113,758	376,722	26,974	23,516	7,954	1,304,566	1,137,274	384,676
07-08	1,194,191	1,068,435	432,148	20,929	18,726	7,574	1,215,120	1,087,161	439,722
08-09	1,246,951	1,130,507	373,115	16,612	15,061	4,971	1,263,563	1,145,568	378,086
09-10	1,116,033	998,510	373,863	10,727	9,598	3,594	1,126,760	1,008,108	377,457

Table 2.1.3. Commercial, recreational, total landings, and percent recreation landings by fishing year.

Fishing Year	Recreational	Commercial	Total Pounds	% rec
85-86	1,432,438	6,008,716	7,441,153	19%
86-87	1,453,954	6,154,111	7,608,065	19%
87-88	1,797,036	5,820,214	7,617,250	24%
88-89	2,032,970	7,513,500	9,546,470	21%
89-90	2,060,736	8,365,021	10,425,756	20%
90-91	1,820,800	6,789,927	8,610,727	21%
91-92	1,476,571	7,263,244	8,739,815	17%
92-93	1,352,400	5,719,849	7,072,249	19%
93-94	1,883,199	5,544,715	7,427,914	25%
94-95	1,906,120	7,485,437	9,391,557	20%
95-96	1,930,690	7,320,775	9,251,465	21%
96-97	1,922,633	8,102,367	10,025,000	19%
97-98	2,304,261	8,040,945	10,345,206	22%
98-99	1,302,679	5,628,411	6,931,090	19%
99-00	2,461,910	8,014,240	10,476,150	24%
00-01	1,949,053	5,846,672	7,795,725	25%
01-02	1,251,025	3,311,510	4,562,535	27%
02-03	1,455,359	4,823,443	6,278,802	23%
03-04	1,411,499	4,380,446	5,791,945	24%
04-05	1,272,697	5,684,295	6,956,991	18%
05-06	1,131,030	3,104,045	4,235,075	27%
06-07	1,304,566	4,951,022	6,255,588	21%
07-08	1,215,120	3,960,899	5,176,019	23%
08-09	1,263,563	3,362,668	4,626,231	27%
09-10	1,126,760	4,442,412	5,569,172	20%

Table 2.2.1. Numbers of spiny lobster by gear, sex, carapace length, and fishing year.

Traps Females

Len cat	Fishing year																							
(mm)	85-86	86-87	87-88	88-89	89-90	90-91	91-92	92-93	93-94	94-95	95-96	96-97	97-98	98-99	99-00	00-01	01-02	02-03	03-04	04-05	05-06	06-07	07-08	08-09	09-10
51	0	0	0	0	0	0	0	7,191	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
56	0	0	0	0	0	0	0	18,216	0	865	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
61	0	0	0	1,426	0	0	0	18,216	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
66	4,780	2,243	5,015	1,646	1,230	1,918	3,170	47,234	23	1,390	1,197	5,498	1,206	1,455	676	0	212	531	194	744	0	6,295	1,055	0	1,042
71	93,129	126,377	82,467	79,307	48,558	41,040	39,877	62,329	22,900	22,768	25,061	42,576	29,484	14,247	23,693	9,310	7,085	6,077	7,295	14,007	18,534	58,534	18,635	10,951	16,263
76	617,945	608,328	686,030	1,013,295	982,804	750,517	760,000	447,710	680,418	888,394	797,036	1,151,785	1,120,962	655,891	938,933	628,573	281,114	418,195	483,113	796,478	609,214	577,531	560,403	543,067	660,652
81	597,887	500,603	521,588	925,597	854,669	607,297	717,625	451,474	539,300	679,279	699,306	912,597	713,380	549,263	789,074	539,614	295,263	484,629	471,114	634,880	382,727	534,902	435,354	365,091	495,961
86	344,716	380,936	407,045	475,026	641,364	389,170	412,196	296,248	337,105	457,549	500,953	446,280	356,382	343,983	441,105	260,376	170,954	258,000	263,498	311,953	166,198	308,352	217,394	169,039	223,081
91	208,826	181,578	229,319	205,016	287,055	248,898	211,560	139,035	138,162	236,591	205,290	212,106	170,922	158,405	207,945	151,176	98,926	156,315	133,976	164,115	63,676	139,453	99,925	59,702	111,950
96	85,505	109,186	121,340	101,487	143,743	91,218	110,264	91,694	64,803	112,921	121,921	98,903	71,670	82,205	133,680	85,124	55,519	76,627	65,953	82,956	33,428	56,720	44,396	28,575	37,917
101	21,650	31,065	55,538	35,707	58,781	36,888	43,039	77,113	24,936	62,790	46,640	52,941	49,344	23,571	51,843	45,990	31,695	35,435	32,487	41,942	17,516	21,558	19,476	8,364	9,984
106	7,624	17,261	12,638	13,245	23,080	24,761	29,850	59,163	6,536	31,099	41,755	39,364	35,807	16,305	21,693	35,725	16,623	20,654	13,395	18,443	4,787	8,312	7,760	3,256	4,602
111	2,591	5,041	8,682	1,372	4,845	36,982	20,236	42,280	11,258	15,467	23,470	15,336	26,643	9,606	5,751	20,589	11,800	11,969	4,139	4,489	2,966	3,661	5,708	1,027	2,770
116	4,273	1,888	8,092	290	2,459	14,878	23,234	20,002	13,336	13,346	12,753	10,309	16,584	7,091	10,293	17,315	5,110	9,625	1,971	3,458	1,718	1,386	1,362	1,043	0
121	275	147	4,078	177	191	10,977	14,478	19,809	2,260	10,302	13,858	7,567	6,658	4,617	3,724	13,418	4,205	5,773	908	377	1,172	0	0	155	0
126	447	0	138	125	121	6,354	8,120	11,550	4,388	5,573	7,275	4,968	3,914	4,164	2,058	8,106	3,578	4,132	160	0	0	0	0	0	0
131	238	1,197	74	1,492	65	7,869	4,992	3,626	719	5,516	2,042	1,619	4,501	905	3,551	6,365	3,678	3,614	514	753	0	0	0	0	0
136	760	1,197	234	212	1,185	5,066	2,826	4,503	195	2,366	4,986	1,045	3,283	1,358	111	4,337	2,850	2,479	0	377	0	490	412	155	0
141	447	0	138	125	121	1,408	804	2,740	1,676	125	4,333	0	1,310	905	65	3,803	1,082	1,110	0	0	0	0	0	0	0
146	89	0	28	25	24	711	1,283	756	23	835	4,084	0	2	1,177	13	1,598	579	814	0	0	0	0	0	0	0
151	0	0	0	0	0	0	615	697	0	718	0	0	1,302	0	0	935	508	284	0	0	0	0	0	0	0
156	0	0	0	0	0	0	0	0	0	0	0	0	0	453	0	0	0	0	0	0	0	0	0	0	0
161	89	0	28	25	24	24	51	62	23	743	0	0	2	0	13	128	0	0	0	0	0	0	0	0	0
166	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
171	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
176	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	0	0	0	0	0	0	0
181	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
186	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
191	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
196	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
201	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
206	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	1,991,271	1,967,047	2,142,472	2,855,595	3,050,319	2,275,976	2,404,220	1,821,648	1,848,061	2,548,637	2,511,960	3,002,894	2,613,356	1,875,601	2,634,221	1,832,482	990,781	1,496,358	1,478,717	2,074,972	1,301,936	1,717,194	1,411,880	1,190,425	1,564,222

Table 2.2.1 (continued). Numbers of spiny lobster by gear, sex, carapace length, and fishing year.

Traps Males

Len cat	Fishing year																							
(mm)	85-86	86-87	87-88	88-89	89-90	90-91	91-92	92-93	93-94	94-95	95-96	96-97	97-98	98-99	99-00	00-01	01-02	02-03	03-04	04-05	05-06	06-07	07-08	08-09	09-10
51	0	0	0	0	0	0	0	14,381	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
56	0	0	0	0	0	0	0	14,381	0	718	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
61	0	0	0	0	0	0	0	28,320	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
66	312	1,322	292	1,713	317	317	508	28,624	23	356	290	320	1,181	725	676	0	212	177	0	0	328	1,908	0	138	1,042
71	21,369	37,058	15,231	43,730	24,441	21,496	9,792	49,001	7,552	15,443	7,655	13,701	21,834	7,658	5,864	2,839	5,390	3,635	3,353	3,685	10,822	33,278	6,858	4,381	13,983
76	469,910	465,963	427,423	861,035	683,135	593,728	511,496	351,965	627,250	708,149	496,451	696,090	881,279	478,808	740,053	418,909	219,551	300,538	353,350	569,774	546,730	418,736	476,888	528,517	692,973
81	611,094	505,358	428,300	933,262	731,157	586,117	641,531	376,968	668,510	731,521	562,659	844,000	894,520	543,215	842,417	498,449	244,891	438,894	426,419	590,912	463,745	487,902	463,226	477,239	581,934
86	495,695	460,488	440,371	629,105	614,166	446,484	580,609	297,299	463,837	532,076	510,235	672,255	654,542	446,560	663,623	368,670	179,384	334,871	322,588	447,570	268,279	421,232	312,866	265,421	389,747
91	335,101	326,744	378,677	427,591	518,970	344,245	416,512	230,535	305,575	344,141	364,789	461,568	389,984	321,258	411,904	250,420	138,920	238,453	235,548	268,343	150,178	305,364	183,425	140,512	214,234
96	216,307	217,106	293,198	243,305	311,646	179,167	242,007	149,069	139,914	238,863	216,791	226,362	233,124	168,527	238,044	157,967	84,482	148,383	139,076	190,640	79,905	203,078	83,821	73,157	119,601
101	94,860	123,792	125,092	83,411	181,065	116,148	146,124	85,752	63,588	150,901	131,653	111,460	120,187	86,287	140,028	117,224	56,320	70,784	83,636	113,567	41,489	101,995	51,005	27,484	57,264
106	66,668	84,623	42,953	46,340	102,008	57,122	72,096	51,776	30,388	92,215	75,500	42,267	66,753	58,027	81,378	51,349	22,247	37,001	36,346	39,543	21,451	54,375	27,483	14,950	22,259
111	17,887	23,661	21,553	21,982	38,133	35,352	35,744	38,126	24,056	45,431	53,295	31,410	29,993	23,173	33,917	30,370	18,667	25,037	20,302	27,781	8,604	27,630	13,676	7,660	11,095
116	11,187	8,275	11,232	9,806	14,431	16,773	16,353	34,349	14,199	22,695	21,245	30,153	23,511	16,914	27,509	24,705	9,895	11,054	8,157	13,973	6,166	10,563	6,248	3,952	1,850
121	774	12,518	7,482	2,042	9,710	16,407	11,360	24,488	16,601	21,909	18,386	13,043	17,347	11,802	13,562	14,268	5,693	7,289	2,867	10,117	2,121	5,087	4,377	1,645	920
126	4,114	1,418	3,242	1,232	4,399	12,762	12,537	25,256	11,061	19,244	22,134	5,674	11,940	12,647	9,137	15,273	6,173	6,039	1,291	2,588	1,854	2,627	2,462	1,668	0
131	305	3,740	192	1,451	2,213	10,985	7,526	20,853	6,450	11,141	14,759	7,432	10,784	2,624	5,248	9,345	3,499	6,225	868	3,361	1,023	1,386	0	2,076	0
136	454	2,542	3,199	227	2,197	7,452	14,667	16,792	3,479	8,973	13,803	5,705	9,265	7,936	2,055	9,815	3,946	4,526	514	1,613	366	1,517	0	1,392	0
141	313	1,197	96	1,469	1,064	5,072	14,067	13,128	4,538	5,446	12,812	1,045	10,641	3,168	709	5,383	4,376	5,545	583	0	0	0	0	309	0
146	358	1,197	110	100	1,076	3,795	6,159	11,117	2,557	4,593	5,850	2,196	6,544	1,358	715	2,264	2,041	2,775	354	744	0	0	0	464	0
151	648	1,345	298	281	1,271	2,181	5,323	7,783	2,111	1,180	9,804	2,821	4,062	3,832	2,260	3,497	1,378	1,854	194	0	0	0	264	309	0
156	164	0	51	46	44	730	4,202	10,822	5,793	2,584	5,233	1,213	890	2,263	876	2,139	1,523	1,583	388	0	0	0	0	0	0
161	179	1,197	55	50	48	48	3,533	6,694	3,959	770	3,192	1,045	3	905	1,363	1,863	1,764	921	160	0	0	0	0	0	0
166	0	0	0	0	0	0	615	4,838	4,160	811	3,495	1,045	0	0	0	1,668	551	189	0	0	0	0	0	0	0
171	0	0	0	0	0	0	551	1,050	658	1,674	3,192	1,045	887	905	0	342	508	271	0	0	0	0	0	0	0
176	89	0	28	25	24	24	51	2,325	23	24	2,042	2,661	2	0	13	66	382	95	0	0	0	0	0	0	0
181	0	0	0	0	0	0	0	3	0	1,528	589	0	0	0	0	195	325	95	0	0	0	0	0	0	0
186	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	113	95	0	0	0	0	0	0	0
191	89	0	28	25	24	24	51	62	23	24	0	0	2	0	13	0	0	19	0	0	0	0	0	0	0
196	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
201	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
206	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	2,347,877	2,279,544	2,199,103	3,308,228	3,241,539	2,456,429	2,753,414	1,895,757	2,406,305	2,962,410	2,555,854	3,174,511	3,389,275	2,198,592	3,221,364	1,987,020	1,012,231	1,646,348	1,635,994	2,284,211	1,603,061	2,076,678	1,632,599	1,551,274	2,106,902

Table 2.2.1 (continued). Numbers of spiny lobster by gear, sex, carapace length, and fishing year.

Diving Females

Len cat (mm)	85-86	86-87	87-88	88-89	89-90	90-91	91-92	92-93	93-94	94-95	95-96	96-97	97-98	98-99	99-00	00-01	01-02	02-03	03-04	04-05	05-06	06-07	07-08	08-09	09-10
	Fishing year																								
51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
56	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
61	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
66	45	68	60	61	39	66	204	403	314	63	293	419	448	395	382	605	84	545	365	229	287	385	339	255	213
71	13,717	1,967	829	992	978	933	1,379	2,230	1,455	993	488	2,372	3,559	1,884	5,958	2,030	1,762	2,087	1,411	6,080	1,107	1,336	2,017	963	1,229
76	12,546	15,434	6,790	11,801	15,514	8,895	17,948	19,751	12,232	28,696	20,967	41,347	49,186	35,114	71,884	51,269	16,491	39,084	26,280	111,165	18,774	80,927	24,505	23,819	12,425
81	16,396	12,115	7,006	11,000	13,646	8,765	20,751	17,540	11,873	13,081	45,088	37,622	34,000	36,777	51,932	47,766	22,244	51,916	29,656	22,963	17,452	29,655	21,786	21,986	11,493
86	8,872	6,190	4,801	7,296	8,866	5,922	10,745	14,992	8,371	10,008	21,211	16,305	20,569	23,557	31,731	29,460	18,985	23,101	21,511	199	16,590	8,029	14,251	14,164	7,628
91	4,656	9,964	3,290	5,498	7,069	4,236	6,533	5,881	6,244	5,434	5,163	7,403	10,786	11,094	11,333	17,721	16,426	24,876	15,057	3,043	9,500	2,550	11,403	10,902	5,883
96	810	4,622	1,661	2,551	3,102	2,061	4,840	3,263	3,318	2,186	5,912	5,303	8,775	3,391	13,036	14,981	15,283	17,831	12,562	401	3,563	1,833	5,373	4,215	2,890
101	264	1,489	819	1,620	2,242	1,148	785	1,398	1,156	1,568	1,410	1,642	2,673	2,061	4,994	13,612	10,062	7,484	7,188	498	3,240	1,074	4,089	2,800	2,052
106	153	230	380	689	902	514	550	1,039	598	1,354	1,388	1,040	1,533	1,039	3,634	3,431	5,746	2,888	4,781	496	1,624	911	2,003	1,412	1,058
111	101	162	172	230	240	205	372	691	976	595	404	686	1,155	721	663	1,031	1,619	2,069	1,059	313	586	590	757	515	443
116	105	174	179	235	245	211	346	618	734	700	1,036	593	590	396	384	606	1,442	1,050	1,002	229	481	483	666	421	391
121	46	70	62	63	40	69	217	432	660	578	322	452	486	435	420	666	888	600	614	252	315	419	368	280	230
126	47	70	75	96	91	89	222	442	616	492	332	463	498	448	432	686	1,634	618	626	259	389	430	455	344	271
131	18	20	24	29	14	31	173	383	298	601	376	431	490	513	494	786	1,508	708	474	297	372	437	378	331	229
136	42	65	56	56	37	61	173	334	379	406	226	341	360	303	293	464	730	675	280	175	220	307	271	195	172
141	8	9	11	13	6	14	80	177	298	172	173	199	226	237	228	363	196	327	219	137	172	202	175	153	106
146	6	7	8	10	5	10	58	128	181	258	125	144	163	171	165	262	267	236	158	99	124	146	126	110	76
151	7	8	10	12	6	13	71	157	248	86	154	177	201	210	203	323	339	291	195	122	153	179	155	136	94
156	5	5	6	7	4	8	44	98	50	258	96	110	126	132	127	202	196	182	122	76	95	112	97	85	59
161	5	6	7	9	4	10	53	118	99	0	116	133	151	158	152	242	0	218	146	91	114	134	116	102	71
166	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
171	3	3	4	4	2	5	27	59	0	86	58	66	75	79	76	121	0	109	73	46	57	67	58	51	35
176	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
181	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
186	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
191	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
196	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
201	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
206	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	57,852	52,678	26,250	42,272	53,052	33,266	65,571	70,134	50,100	67,615	105,338	117,248	136,050	119,115	198,521	186,627	115,902	176,895	123,779	147,170	75,215	130,206	89,388	83,239	47,048

Table 2.2.1 (continued). Numbers of spiny lobster by gear, sex, carapace length, and fishing year.

Diving Males

Len cat (mm)	Fishing year 85-86	86-87	87-88	88-89	89-90	90-91	91-92	92-93	93-94	94-95	95-96	96-97	97-98	98-99	99-00	00-01	01-02	02-03	03-04	04-05	05-06	06-07	07-08	08-09	09-10
51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
56	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
61	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
66	31	53	42	39	29	43	71	108	66	63	4	87	72	1	2	0	0	120	0	0	1	49	48	0	36
71	3,646	614	540	601	555	589	856	1,308	801	705	75	1,393	1,797	315	4,179	1,360	421	1,290	1,995	2,848	1,200	634	960	301	617
76	24,830	8,358	4,535	8,068	10,734	6,006	17,066	20,675	7,865	34,716	13,094	33,968	31,582	16,907	51,820	37,606	14,612	24,311	16,405	76,846	14,539	6,887	16,940	13,729	8,520
81	22,290	6,455	6,446	11,330	14,980	8,489	17,382	19,111	15,245	36,361	31,599	35,015	45,630	34,601	67,476	57,679	19,758	46,682	26,670	39,931	21,730	16,257	23,675	20,767	11,959
86	12,323	5,337	5,454	8,732	10,964	6,882	14,194	15,370	9,651	24,464	31,064	24,548	27,517	29,490	54,645	39,492	16,663	35,761	24,350	14,353	22,459	16,183	17,423	16,662	9,114
91	2,842	6,180	5,934	8,851	10,628	7,260	13,243	17,808	10,325	12,368	30,423	18,895	19,163	27,219	28,893	32,768	18,313	29,241	18,625	8,624	18,016	4,871	16,953	13,477	9,141
96	11,362	6,882	3,532	5,926	7,638	4,554	7,726	6,136	5,345	10,817	7,128	13,323	14,503	12,931	26,853	23,498	15,122	19,925	19,374	174	9,190	10,655	12,213	9,455	6,283
101	1,066	4,040	2,023	2,834	3,249	2,411	3,320	4,032	3,469	3,464	4,593	5,842	7,299	6,324	12,614	11,896	13,577	16,209	11,996	180	3,982	1,987	5,376	3,073	2,995
106	457	1,843	1,427	2,765	3,823	1,971	2,508	1,762	1,804	1,231	1,030	2,617	8,067	3,769	4,478	13,007	10,212	14,060	8,577	186	5,508	962	6,190	4,005	3,049
111	286	2,638	742	1,333	1,776	989	1,405	1,132	1,792	722	1,698	1,286	2,215	1,194	6,922	1,666	5,602	6,839	4,203	147	2,155	643	2,954	1,854	1,496
116	185	2,472	447	767	990	585	1,052	909	1,009	429	328	834	1,245	1,413	484	3,434	3,609	2,616	3,839	245	1,373	629	1,846	1,187	965
121	130	198	256	397	462	326	546	1,063	1,388	705	737	1,404	1,157	1,850	1,350	2,369	3,663	1,637	1,807	572	1,169	988	1,411	1,025	795
126	52	74	102	164	192	132	240	483	519	410	374	508	551	501	485	767	2,601	811	462	290	557	476	648	489	365
131	88	132	162	244	275	204	364	709	947	729	492	728	772	745	638	1,009	3,034	1,029	608	381	737	659	890	647	507
136	32	27	66	132	168	96	205	457	410	955	455	510	583	607	588	929	2,244	837	560	351	634	518	679	557	376
141	59	78	93	137	145	117	267	544	473	585	436	575	628	581	562	888	2,913	801	535	336	551	544	630	485	365
146	24	24	40	65	66	55	195	434	350	347	428	487	554	579	559	887	2,350	800	535	335	485	494	505	429	294
151	10	11	13	15	8	17	93	206	368	172	202	232	264	276	266	423	854	381	255	160	200	235	204	178	123
156	12	13	16	19	9	21	115	256	488	172	251	287	326	342	329	524	854	472	316	198	248	291	252	221	153
161	18	20	24	29	14	31	173	383	298	429	376	431	490	513	494	786	281	708	474	297	372	437	378	331	229
166	3	4	4	5	3	6	31	69	187	0	67	77	88	92	89	141	267	127	85	53	67	78	68	59	41
171	8	6	19	40	54	28	45	100	322	4	100	111	127	132	128	202	570	182	122	76	161	113	175	140	94
176	5	5	6	7	4	8	44	98	198	0	96	110	126	132	127	202	196	182	122	76	95	112	97	85	59
181	5	6	7	9	4	10	53	118	99	86	116	133	151	158	152	242	141	218	146	91	114	134	116	102	71
186	4	5	6	7	3	7	40	88	111	0	87	99	113	118	114	181	88	163	109	69	86	101	87	76	53
191	3	3	4	4	2	5	27	59	50	0	58	66	75	79	76	121	141	109	73	46	57	67	58	51	35
196	3	3	4	4	2	5	27	59	0	0	58	66	75	79	76	121	141	109	73	46	57	67	58	51	35
201																									
206	3	3	4	4	2	5	27	59	50	0	58	66	75	79	76	121	0	109	73	46	57	67	58	51	35
Total	79,777	45,484	31,948	52,528	66,779	40,852	81,315	93,536	63,630	129,934	125,427	143,698	165,245	141,027	264,475	232,319	138,227	205,729	142,389	146,957	105,800	65,138	110,892	89,487	57,805

Table 2.2.1 (continued). Numbers of spiny lobster by gear, sex, carapace length, and fishing year.

Other Females

Len cat	Fishing year																							
(mm)	**85-86**	**86-87**	**87-88**	**88-89**	**89-90**	**90-91**	**91-92**	**92-93**	**93-94**	**94-95**	**95-96**	**96-97**	**97-98**	**98-99**	**99-00**	**00-01**	**01-02**	**02-03**	**03-04**	**04-05**	**05-06**	**06-07**	**07-08**	**08-09**	**09-10**
51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
56	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
61	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
66	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
71	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
76	8,311	11,075	2,691	4,544	8,132	6,095	7,625	2,393	2,703	2,485	3,170	5,632	7,286	5,890	5,480	7,224	3,762	2,869	3,057	4,999	8,491	7,366	5,354	4,814	8,715
81	7,903	10,643	2,654	4,308	7,709	5,777	8,239	2,460	2,966	2,563	3,566	5,778	8,060	9,174	7,704	8,551	4,313	5,130	5,638	5,667	15,351	10,313	6,803	6,242	9,958
86	6,117	8,122	1,956	3,347	5,991	4,491	3,731	1,714	1,887	2,208	2,191	4,035	5,070	7,981	3,390	4,883	2,578	1,722	3,141	3,444	4,372	4,568	3,499	3,114	5,983
91	1,115	1,462	347	601	1,075	805	366	423	450	1,594	405	727	890	68	541	784	415	23	54	559	339	620	545	478	975
96	446	585	139	240	430	322	281	169	180	26	162	291	356	27	216	314	166	9	425	224	136	248	218	191	390
101	1,103	1,451	345	599	1,072	803	319	358	381	1,190	380	710	861	45	493	773	414	679	36	557	326	611	530	463	967
106	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
111	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
116	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
121	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
126	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
131	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
136	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
141	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
146	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
151	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
156	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
161	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
166	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
171	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
176	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
181	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
186	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
191	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
196	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
201	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
206	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	24,995	33,338	8,132	13,639	24,409	18,293	20,561	7,517	8,567	10,066	9,874	17,173	22,523	23,185	17,824	22,529	11,648	10,432	12,351	15,450	29,015	23,726	16,949	15,302	26,988

Table 2.2.1 (continued). Numbers of spiny lobster by gear, sex, carapace length, and fishing year.

Other Males

Len cat	Fishing year																							
(mm)	85-86	86-87	87-88	88-89	89-90	90-91	91-92	92-93	93-94	94-95	95-96	96-97	97-98	98-99	99-00	00-01	01-02	02-03	03-04	04-05	05-06	06-07	07-08	08-09	09-10
51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
56	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
61	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
66	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
71	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
76	5,892	7,798	1,863	3,227	5,776	4,330	2,384	1,609	1,728	1,321	1,985	3,791	4,627	10,305	2,701	4,322	2,317	4,143	2,591	3,110	2,563	3,650	2,982	2,623	5,384
81	8,315	11,093	2,704	4,544	8,132	6,096	5,035	2,417	2,751	2,926	3,237	5,685	7,424	16,074	5,780	7,428	3,851	5,643	4,744	5,110	9,364	7,764	5,561	5,015	8,918
86	7,855	10,391	2,479	4,303	7,701	5,773	3,592	2,138	2,288	1,360	2,625	5,037	6,123	7,824	3,501	5,695	3,059	4,821	4,239	4,110	3,126	4,734	3,907	3,430	7,111
91	4,383	5,827	1,410	2,393	4,282	3,209	3,250	1,303	1,453	1,811	1,645	2,944	3,767	400	2,723	3,672	1,920	1,717	2,321	2,557	3,883	3,612	2,691	2,410	4,455
96	3,509	4,627	1,100	1,915	3,427	2,568	1,574	1,043	1,107	2,015	1,176	2,243	2,707	10,195	1,500	2,458	1,322	37	490	1,780	1,022	1,941	1,670	1,458	3,083
101	662	871	207	360	643	482	281	215	228	408	228	426	516	2,549	296	464	248	9	22	334	196	367	318	278	580
106	1,103	1,451	345	599	1,072	803	543	358	381	808	380	710	861	2,567	493	773	414	15	36	557	326	611	530	463	967
111	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
116	446	585	139	240	430	322	56	169	180	408	162	291	356	27	216	314	166	9	22	224	136	248	218	191	390
121	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
126	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
131	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
136	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
141	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
146	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
151	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
156	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
161	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
166	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
171	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
176	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
181	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
186	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
191	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
196	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
201	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
206	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	32,165	42,643	10,247	17,581	31,463	23,583	16,715	9,252	10,116	11,057	11,438	21,127	26,381	49,941	17,210	25,126	13,297	16,394	14,465	17,782	20,616	22,927	17,877	15,868	30,888

Table 2.2.1 (continued). Numbers of spiny lobster by gear, sex, carapace length, and fishing year.

Attractants Females

Len cat (mm)	85-86	86-87	87-88	88-89	89-90	90-91	91-92	92-93	93-94	94-95	95-96	96-97	97-98	98-99	99-00	00-01	01-02	02-03	03-04	04-05	05-06	06-07	07-08	08-09	09-10
	Fishing year																								
51	25,274	31,799	15,649	14,231	21,313	29,849	17,133	14,146	10,030	10,475	17,267	14,800	10,919	12,575	16,252	11,521	0	2,457	642	680	409	442	513	269	378
56	45,168	56,829	27,967	25,433	38,089	53,345	30,620	25,282	18,425	20,965	23,930	26,218	24,684	20,945	32,198	23,789	16,199	4,913	12,846	13,598	8,189	8,848	10,269	5,380	7,569
61	87,792	110,458	54,359	49,433	74,033	103,685	59,515	49,139	35,056	42,575	41,551	52,724	51,677	32,722	64,014	44,768	58,495	14,739	45,604	48,272	29,070	31,411	36,455	19,100	26,872
66	161,862	203,650	100,221	91,139	136,494	191,163	109,727	90,597	60,802	79,315	74,114	90,300	113,751	46,515	101,833	78,279	71,994	73,697	70,654	74,787	45,039	48,665	56,480	29,592	41,632
71	252,469	317,649	156,322	142,157	212,900	298,173	171,150	141,312	92,289	121,953	125,773	128,800	186,310	61,035	118,773	113,676	57,595	93,349	65,515	69,348	41,763	45,125	52,373	27,440	38,604
76	11,860	8,772	5,668	3,911	5,934	9,979	5,818	4,533	1,946	4,585	3,648	7,779	3,821	2,474	3,471	3,271	1,208	1,216	766	725	382	564	636	443	762
81	6,609	4,888	3,158	2,179	3,307	5,561	3,242	2,526	1,047	2,754	2,174	4,403	1,916	1,518	1,536	1,577	931	645	508	481	253	374	422	294	506
86	3,646	2,697	1,743	1,202	1,824	3,068	1,789	1,394	497	1,721	1,459	2,409	839	742	895	676	772	223	334	316	167	246	278	193	333
91	1,717	1,270	821	566	859	1,445	842	656	210	871	772	1,087	338	284	416	317	436	74	174	165	87	128	145	101	173
96	711	526	340	235	356	599	349	272	67	378	373	390	138	131	183	151	277	0	97	92	49	72	81	56	97
101	278	205	133	92	139	234	136	106	29	128	152	171	47	34	74	37	40	0	14	13	7	10	12	8	14
106	96	71	46	32	48	81	47	37	11	24	62	76	12	13	16	19	20	0	7	7	3	5	6	4	7
111	46	34	22	15	23	39	23	18	4	15	27	52	3	2	16	3	0	0	0	0	0	0	0	0	0
116	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
121	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
126	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
131	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
136	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
141	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
146	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
151	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
156	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
161	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
166	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
171	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
176	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
181	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
186	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
191	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
196	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
201	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
206	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	597,528	738,848	366,449	330,625	495,319	697,221	400,391	330,018	220,413	285,759	291,302	329,209	394,455	178,990	339,677	278,084	207,967	191,313	197,161	208,484	125,418	135,890	157,670	82,880	116,947

Table 2.2.1 (continued). Numbers of spiny lobster by gear, sex, carapace length, and fishing year.

Attractants Males

Len cat (mm)	Fishing year 85-86	86-87	87-88	88-89	89-90	90-91	91-92	92-93	93-94	94-95	95-96	96-97	97-98	98-99	99-00	00-01	01-02	02-03	03-04	04-05	05-06	06-07	07-08	08-09	09-10
51	22,528	28,344	13,949	12,685	18,998	26,607	15,272	12,610	9,422	8,619	16,019	11,813	10,276	10,570	12,657	10,270	900	4,913	1,927	2,040	1,228	1,327	1,540	807	1,135
56	36,958	46,499	22,883	20,810	31,165	43,648	25,054	20,686	15,668	17,017	21,222	20,638	17,966	17,691	24,512	17,161	13,499	22,109	15,415	16,317	9,827	10,618	12,323	6,456	9,083
61	61,504	77,383	38,082	34,631	51,865	72,638	41,694	34,425	26,290	29,222	29,246	36,984	32,842	25,601	42,026	28,968	48,596	24,566	41,108	43,513	26,204	28,314	32,861	17,217	24,222
66	101,218	127,350	62,672	56,992	85,355	119,541	68,616	56,654	41,240	48,788	45,931	59,123	62,422	31,658	74,224	49,070	54,895	51,588	52,669	55,751	33,574	36,277	42,103	22,059	31,035
71	154,963	194,970	95,949	87,254	130,676	183,016	105,050	86,736	61,829	78,136	72,881	84,265	98,666	40,458	91,470	66,099	50,396	93,349	60,377	63,909	38,487	41,586	48,265	25,288	35,576
76	8,611	6,369	4,115	2,839	4,308	7,245	4,224	3,291	1,547	3,469	2,169	5,922	2,808	1,867	3,740	2,415	654	1,936	773	731	385	569	642	447	769
81	6,069	4,489	2,900	2,001	3,037	5,107	2,977	2,320	999	2,408	1,779	4,050	1,972	1,442	2,215	1,745	436	2,135	752	711	375	553	625	435	748
86	4,289	3,172	2,050	1,414	2,146	3,609	2,104	1,639	614	1,782	1,406	3,029	1,303	1,063	1,399	1,200	574	918	460	435	229	338	382	266	457
91	2,851	2,109	1,363	940	1,426	2,399	1,399	1,090	360	1,342	1,081	2,021	715	653	849	644	594	546	362	343	180	266	301	210	360
96	1,576	1,166	753	520	788	1,326	773	602	163	812	733	1,006	330	356	531	374	1,030	521	508	481	253	374	422	294	506
101	904	669	432	298	452	761	444	346	81	454	488	473	194	141	244	216	535	347	286	270	142	210	237	165	284
106	451	334	216	149	226	380	221	173	39	221	273	184	94	78	162	135	634	472	355	336	177	261	295	206	353
111	202	149	96	66	101	170	99	77	15	87	134	99	35	41	85	37	257	273	167	158	83	123	139	97	166
116	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
121	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
126	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
131	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
136	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
141	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
146	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
151	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
156	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
161	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
166	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
171	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
176	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
181	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
186	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
191	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
196	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
201	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
206	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	402,124	493,003	245,460	220,599	330,543	466,447	267,927	220,649	158,267	192,357	193,362	229,607	229,623	131,619	254,114	178,334	173,000	203,673	175,159	184,995	111,144	120,816	140,135	73,947	104,694

Table 2.2.1 (continued). Numbers of spiny lobster by gear, sex, carapace length, and fishing year.

Recreational Females

Len cat	Fishing year																								
(mm)	85-86	86-87	87-88	88-89	89-90	90-91	91-92	92-93	93-94	94-95	95-96	96-97	97-98	98-99	99-00	00-01	01-02	02-03	03-04	04-05	05-06	06-07	07-08	08-09	09-10
51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
56	0	0	0	0	0	0	0	0	0	617	0	0	0	0	0	0	0	15	0	0	0	0	0	0	0
61	1,581	1,605	1,959	2,271	4,224	949	0	0	1,059	0	0	0	0	0	0	0	967	132	0	0	0	0	0	0	0
66	3,162	3,209	3,919	4,543	0	1,898	457	0	2,119	1,850	0	479	0	615	969	0	483	409	0	0	0	1,408	626	0	777
71	30,036	30,487	29,389	52,239	21,119	22,780	19,174	4,962	3,178	5,550	3,810	10,064	7,706	3,692	6,785	8,412	4,351	8,190	10,667	7,955	5,658	3,660	3,756	2,405	12,177
76	211,040	214,210	240,993	327,062	295,673	243,931	202,235	162,509	234,661	250,967	238,775	288,017	324,611	187,042	332,485	261,707	166,324	181,154	156,596	147,361	110,337	126,708	137,421	132,863	126,953
81	154,921	157,248	182,215	233,940	268,218	241,084	171,649	160,028	249,493	213,970	228,614	219,008	330,390	203,039	311,159	196,280	152,302	172,923	173,236	154,558	120,710	128,961	141,491	164,726	128,507
86	60,862	61,776	90,128	70,409	109,821	130,033	68,020	81,875	90,051	94,344	92,716	77,635	111,736	85,522	104,689	78,512	64,789	70,859	85,765	74,627	53,754	48,994	60,728	85,369	69,435
91	17,389	17,650	29,389	15,899	38,015	41,763	15,978	38,456	19,599	21,582	15,876	17,252	26,007	24,611	33,927	15,889	13,054	20,311	23,895	21,593	30,806	19,710	26,295	17,435	23,577
96	5,533	5,616	11,756	2,271	16,896	10,441	5,935	7,443	5,827	8,016	3,810	3,355	6,743	7,383	7,755	5,608	2,417	5,724	8,107	6,061	6,916	6,195	10,643	6,914	6,995
101	2,371	2,407	3,919	2,271	2,112	4,746	1,826	3,722	3,708	1,233	635	958	0	1,846	5,816	3,739	0	1,992	1,280	1,136	1,886	2,253	2,504	2,705	2,591
106	0	0	0	0	0	949	913	1,241	530	617	635	479	963	615	0	935	0	615	0	1,515	629	282	2,817	301	518
111	0	0	0	0	0	949	457	0	1,059	1,233	0	0	0	0	0	0	0	469	853	379	1,572	282	313	902	259
116	1,581	1,605	1,959	2,271	0	0	0	0	0	0	0	0	0	0	0	0	0	73	0	0	314	0	313	0	259
121	0	0	0	0	0	0	457	1,241	0	0	0	0	0	0	0	0	0	44	0	379	0	0	0	0	0
126	0	0	0	0	0	0	0	0	0	0	0	0	0	615	0	0	0	15	0	0	0	0	0	0	0
131	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
136	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
141	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
146	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
151	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
156	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
161	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
166	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
171	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
176	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
181	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
186	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
191	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
196	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
201	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
206	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	488,476	495,813	595,626	713,176	756,078	699,523	487,101	461,477	611,284	599,979	584,871	617,247	808,156	514,980	803,585	571,082	404,687	462,925	460,399	415,564	332,582	338,453	386,907	413,620	372,048

Table 2.2.1 (continued). Numbers of spiny lobster by gear, sex, carapace length, and fishing year.

Recreational Males

Len cat	Fishing year																								
(mm)	85-86	86-87	87-88	88-89	89-90	90-91	91-92	92-93	93-94	94-95	95-96	96-97	97-98	98-99	99-00	00-01	01-02	02-03	03-04	04-05	05-06	06-07	07-08	08-09	09-10
51	0	0	0	0	0	949	0	0	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	0
56	0	0	0	0	0	949	0	1,241	0	0	0	0	963	0	0	935	0	58	0	0	0	0	0	0	0
61	790	802	0	2,271	2,112	1,898	0	0	2,119	0	0	0	0	0	0	0	0	132	0	379	0	0	0	0	0
66	6,323	6,418	0	18,170	0	4,746	0	0	3,708	617	0	479	963	1,846	0	0	0	776	427	0	943	1,689	313	1,202	0
71	25,293	25,673	25,471	43,154	16,896	21,830	14,152	3,722	7,946	7,400	1,270	9,105	2,890	7,383	1,939	4,673	1,934	7,340	8,534	4,167	8,802	3,097	6,574	2,405	10,104
76	275,063	279,195	329,162	408,828	283,001	180,338	186,714	96,761	262,736	280,565	168,920	307,665	288,008	108,287	330,546	309,375	155,687	181,524	131,421	135,617	148,688	130,087	161,838	117,833	112,962
81	244,237	247,906	307,610	345,232	259,770	203,118	237,387	212,130	339,014	343,461	349,271	381,467	435,383	173,506	485,641	411,253	221,926	252,616	224,013	216,306	208,729	222,443	215,679	217,931	172,293
86	150,178	152,434	219,441	177,159	270,329	245,829	230,083	203,446	260,617	271,316	286,403	265,014	345,802	185,196	371,258	282,269	192,433	206,148	193,718	183,727	168,492	192,596	161,838	194,786	144,052
91	56,910	57,765	78,372	72,680	173,180	157,559	110,933	132,736	153,616	159,707	184,796	132,747	197,464	113,825	176,420	159,828	96,700	116,600	128,434	111,752	100,278	139,660	84,832	117,232	112,703
96	28,455	28,882	31,349	45,425	63,358	78,779	41,086	55,824	68,332	58,580	66,679	44,568	77,059	48,606	71,731	71,969	48,350	46,718	58,883	52,656	48,724	68,985	40,068	47,795	54,667
101	13,437	13,639	27,430	6,814	27,455	32,271	15,065	17,367	22,777	17,882	22,861	14,377	16,375	19,689	28,111	19,628	12,087	16,952	21,335	20,835	25,462	28,157	14,713	19,839	19,172
106	4,742	4,814	7,837	4,543	6,336	11,390	5,478	7,443	7,416	3,700	3,810	3,355	9,632	3,076	11,632	5,608	3,868	5,533	7,254	6,819	12,574	8,166	8,139	4,208	6,477
111	790	802	1,959	0	6,336	5,695	3,652	4,962	3,708	3,700	1,270	958	0	7,383	5,816	2,804	967	2,633	2,133	4,925	8,487	2,816	4,695	4,208	2,591
116	790	802	0	2,271	0	1,898	1,826	1,241	1,589	1,233	1,905	958	963	0	3,877	0	483	966	853	1,894	2,829	1,126	0	2,405	518
121	0	0	0	0	0	0	1,370	0	1,589	1,233	0	958	963	615	969	0	483	497	0	1,894	2,515	0	313	1,503	259
126	790	802	1,959	0	0	0	913	1,241	0	617	1,270	0	963	0	969	0	483	278	427	0	1,257	0	939	301	0
131	0	0	0	0	0	0	457	0	0	617	0	0	0	615	0	0	483	102	0	379	629	0	0	0	0
136	0	0	0	0	0	949	0	0	0	617	0	0	0	0	0	0	0	44	0	0	0	0	313	0	0
141	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	259
146	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	301	0
151	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	177	0	0	0	0	0	0	0
156	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
161	0	0	0	0	0	0	0	1,241	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	0
166	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
171	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
176	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
181	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
186	0	0	0	0	0	0	0	1,241	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	0
191	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
196	0	0	0	0	0	0	0	1,241	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	0
201	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
206	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	807,798	819,934	1,030,590	1,126,547	1,108,773	948,198	849,116	741,837	1,135,167	1,151,245	1,088,455	1,161,651	1,377,428	670,027	1,488,909	1,268,342	735,884	839,184	777,432	741,350	738,409	798,822	700,254	731,949	636,057

Table 2.3.1. Numbers of spiny lobster by gear, sex, age, and fishing year.

Traps Female

Fishing							Ages											
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Aged	Unaged	Total
85-86	201,134	789,973	563,217	260,664	104,874	40,169	16,881	6,941	2,806	1,269	905	423	215	117	59	1,989,648	1,623	1,991,271
86-87	208,309	758,496	543,643	260,824	111,637	46,492	20,110	8,563	3,643	1,621	731	329	154	70	32	1,964,653	2,394	1,967,047
87-88	206,029	805,731	593,506	296,140	131,412	55,767	26,830	12,326	5,386	3,565	2,182	1,240	942	585	330	2,141,970	502	2,142,472
88-89	288,566	1,193,433	812,874	346,191	130,646	49,820	19,440	7,583	2,965	1,221	568	227	104	52	25	2,853,716	1,879	2,855,595
89-90	262,702	1,182,960	885,142	421,037	174,308	70,920	29,996	12,548	5,201	2,237	1,047	453	207	97	44	3,048,900	1,419	3,050,319
90-91	201,001	860,967	622,811	301,590	132,486	56,249	32,241	17,627	9,071	7,767	8,841	4,409	2,906	1,883	1,046	2,260,898	15,078	2,275,976
91-92	208,776	920,235	665,738	312,268	133,655	57,495	35,322	18,777	9,122	8,721	10,716	5,392	3,669	2,412	1,351	2,393,649	10,571	2,404,220
92-93	218,680	601,912	442,470	234,398	121,133	63,945	43,588	25,135	13,118	12,398	15,004	7,406	4,969	3,275	1,832	1,809,264	12,384	1,821,648
93-94	173,521	752,825	522,639	228,545	88,638	34,016	19,127	9,844	4,659	2,933	4,480	2,054	1,094	688	363	1,845,425	2,636	1,848,061
94-95	223,804	980,202	706,336	336,004	145,786	63,698	34,161	16,986	7,959	6,753	7,636	3,797	2,575	1,690	946	2,538,334	10,303	2,548,637
95-96	206,672	947,449	703,992	336,146	145,908	64,390	35,223	18,074	8,858	8,359	9,779	4,866	3,344	2,212	1,244	2,496,515	15,445	2,511,960
96-97	299,727	1,241,691	825,395	354,036	142,664	61,239	32,207	15,988	7,609	5,846	6,556	3,169	2,041	1,326	735	3,000,230	2,664	3,002,894
97-98	274,143	1,093,259	694,218	290,983	118,940	52,453	32,290	17,759	8,999	6,463	6,334	3,172	2,005	1,253	684	2,602,956	10,400	2,613,356
98-99	166,090	744,996	533,066	242,251	98,457	39,823	19,599	9,332	4,317	3,382	4,621	2,171	1,337	878	484	1,870,803	4,798	1,875,601
99-00	238,396	1,053,290	742,672	337,278	140,359	59,004	29,164	13,452	5,884	3,730	3,409	1,690	1,085	681	374	2,630,468	3,753	2,634,221
00-01	156,684	699,920	489,625	229,414	103,877	48,850	31,184	17,006	8,468	8,115	10,224	5,055	3,396	2,243	1,255	1,815,316	17,166	1,832,482
01-02	74,307	358,667	274,379	138,895	64,715	30,023	16,588	8,574	4,186	3,238	4,143	1,948	1,202	786	433	982,084	8,697	990,781
02-03	110,830	555,456	425,157	209,043	92,506	40,668	22,410	11,338	5,395	4,270	5,168	2,503	1,600	1,041	576	1,487,962	8,396	1,496,358
03-04	123,439	583,938	426,961	198,241	82,341	34,444	15,540	6,886	2,993	1,573	891	438	273	159	85	1,478,203	514	1,478,717
04-05	197,739	856,151	581,254	254,950	103,602	43,478	20,147	9,037	3,940	1,849	884	423	224	111	55	2,073,842	1,130	2,074,972
05-06	149,437	581,750	353,663	134,723	48,035	18,331	8,185	3,680	1,616	1,054	605	342	262	162	92	1,301,936	0	1,301,936
06-07	174,593	703,511	488,937	214,320	82,056	31,214	12,780	5,331	2,241	961	432	194	84	35	15	1,716,704	490	1,717,194
07-08	143,165	598,316	396,209	166,054	63,310	24,721	10,808	4,862	2,192	991	469	218	96	41	17	1,411,468	412	1,411,880
08-09	131,740	533,385	331,635	125,728	42,638	14,978	5,910	2,382	967	453	223	112	65	35	18	1,190,270	155	1,190,425
09-10	165,040	684,910	440,850	175,871	62,180	22,004	8,086	3,119	1,265	525	222	93	37	14	6	1,564,222	0	1,564,222

Table 2.3.1 (continued). Numbers of spiny lobster by gear, sex, age, and fishing year.

Traps Male

Fishing							Ages											
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Aged	Unaged	Total
85-86	556,508	984,427	479,989	193,109	76,728	30,772	13,303	5,844	2,652	1,204	583	518	223	125	54	2,346,037	1,840	2,347,877
86-87	531,289	905,524	469,351	205,093	88,222	38,668	16,533	7,496	3,393	2,219	2,171	2,486	1,153	695	315	2,274,608	4,936	2,279,544
87-88	464,409	869,323	496,440	216,008	86,800	35,087	14,738	6,642	3,094	1,448	698	2,177	830	528	215	2,198,437	666	2,199,103
88-89	932,093	1,424,879	605,054	214,890	77,943	29,337	11,798	4,960	2,118	1,146	930	547	294	162	79	3,306,232	1,996	3,308,228
89-90	744,431	1,296,041	679,587	295,505	124,124	52,767	22,752	10,173	4,614	2,453	1,754	2,077	919	549	242	3,237,988	3,551	3,241,539
90-91	619,958	982,950	464,433	191,587	82,369	40,696	21,087	11,345	6,104	5,031	5,712	7,042	3,308	2,014	918	2,444,555	11,874	2,456,429
91-92	593,591	1,104,917	569,062	239,243	99,965	45,579	22,217	11,217	5,803	4,171	4,206	10,529	4,378	2,790	1,196	2,718,862	34,552	2,753,414
92-93	492,718	648,466	326,832	149,302	73,686	44,706	28,064	17,054	9,947	8,908	10,571	14,795	6,806	4,189	1,890	1,837,935	57,822	1,895,757
93-94	655,245	1,020,466	424,468	149,587	58,471	29,306	15,890	9,103	5,118	3,797	3,768	3,817	1,845	1,096	506	2,382,483	23,822	2,406,305
94-95	740,194	1,167,315	552,400	238,401	108,317	55,335	29,324	15,884	8,601	6,314	6,339	8,229	3,782	2,304	1,038	2,943,776	18,634	2,962,410
95-96	549,268	987,349	509,204	222,440	100,268	51,930	28,433	15,637	8,616	6,997	7,758	11,721	5,291	3,271	1,462	2,509,645	46,209	2,555,854
96-97	783,313	1,348,849	615,585	229,795	89,740	40,447	20,030	10,514	5,403	3,928	4,091	5,223	2,400	1,462	660	3,161,440	13,071	3,174,511
97-98	916,485	1,406,123	606,567	230,478	94,330	44,742	22,832	12,227	6,520	5,175	5,715	8,089	3,680	2,264	1,016	3,366,244	23,031	3,389,275
98-99	524,771	902,757	430,542	172,793	71,863	34,507	18,189	9,877	5,387	3,163	2,245	5,688	2,304	1,459	615	2,186,161	12,431	2,198,592
99-00	801,773	1,341,387	618,289	247,166	103,706	48,146	23,835	12,230	6,244	3,929	3,393	2,772	1,378	795	372	3,215,415	5,949	3,221,364
00-01	459,325	781,556	382,568	166,050	75,140	39,118	21,727	12,128	6,703	5,045	5,193	8,171	3,633	2,249	997	1,969,603	17,417	1,987,020
01-02	237,731	396,320	196,319	84,625	37,488	18,694	9,911	5,324	2,859	2,040	2,006	3,245	1,430	886	391	999,270	12,961	1,012,231
02-03	365,025	677,408	334,930	136,162	56,808	26,174	12,838	6,540	3,356	2,742	3,170	4,126	1,919	1,175	533	1,632,906	13,442	1,646,348
03-04	391,903	679,526	330,640	135,131	55,066	23,050	9,897	4,363	1,934	991	690	607	282	162	74	1,634,315	1,679	1,635,994
04-05	590,330	945,185	435,226	174,571	72,502	32,447	14,783	7,144	3,440	2,211	2,046	1,885	913	536	248	2,283,467	744	2,284,211
05-06	520,660	688,121	252,107	84,889	31,595	13,085	5,932	2,820	1,364	811	673	522	262	150	70	1,603,061	0	1,603,061
06-07	489,506	842,399	429,118	180,679	74,977	31,849	13,914	6,278	2,858	1,516	1,085	1,374	602	362	159	2,076,678	0	2,076,678
07-08	479,732	703,536	280,425	99,013	38,154	16,657	7,695	3,744	1,837	863	383	173	76	33	14	1,632,335	264	1,632,599
08-09	507,642	680,084	239,803	74,589	25,841	10,215	4,526	2,136	1,038	856	1,025	1,290	606	371	169	1,550,192	1,082	1,551,274
09-10	665,030	911,400	348,731	116,919	41,062	14,957	5,503	2,058	771	292	112	43	16	6	2	2,106,902	0	2,106,902

Table 2.3.1 (continued). Numbers of spiny lobster by gear, sex, age, and fishing year.

Diving Females

Fishing							Ages										
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Aged	Unaged	Total
85-86	42,229	12,450	2,299	471	157	72	46	26	13	19	18	10	8	6	3	57,826	26	57,852
86-87	30,111	15,365	5,005	1,390	404	147	75	39	20	28	25	14	12	8	5	52,649	29	52,678
87-88	15,284	7,350	2,201	734	292	130	75	41	21	26	24	14	11	7	4	26,215	35	26,250
88-89	24,621	11,805	3,644	1,232	465	191	100	52	26	29	27	15	12	8	4	42,230	42	42,272
89-90	30,995	14,825	4,637	1,564	565	216	98	48	23	21	17	10	8	5	3	53,031	21	53,052
90-91	19,348	9,294	2,827	953	373	161	91	49	25	30	28	16	12	8	5	33,220	46	33,266
91-92	40,033	17,617	4,680	1,401	559	272	220	134	70	86	108	55	40	27	15	65,318	253	65,571
92-93	42,004	18,150	4,772	1,744	896	487	435	270	143	171	225	114	80	53	30	69,574	560	70,134
93-94	27,072	13,197	4,142	1,704	993	596	490	305	165	196	313	149	97	65	37	49,522	578	50,100
94-95	42,441	15,214	4,087	1,747	977	553	565	357	187	216	254	133	96	63	36	66,927	688	67,615
95-96	65,396	27,967	6,394	2,139	993	517	438	264	134	133	195	95	61	41	23	104,789	549	105,338
96-97	77,727	27,428	6,302	2,080	965	502	460	287	152	178	244	122	84	56	31	116,618	630	117,248
97-98	85,945	33,327	9,146	3,117	1,343	643	537	325	169	192	269	134	91	60	34	135,334	716	136,050
98-99	75,168	31,021	7,051	2,092	926	466	466	294	156	170	261	127	82	55	30	118,365	750	119,115
99-00	127,714	48,064	13,262	4,616	1,762	705	518	301	154	165	252	123	79	53	29	197,798	723	198,521
00-01	102,972	50,433	18,566	7,170	2,676	1,048	790	468	242	261	400	195	126	84	47	185,477	1,150	186,627
01-02	46,568	35,081	16,629	7,564	3,432	1,552	1,414	892	474	462	435	241	177	113	64	115,100	802	115,902
02-03	93,903	50,821	18,132	6,517	2,569	1,115	820	473	239	317	421	215	155	104	59	175,859	1,036	176,895
03-04	61,661	35,969	14,085	5,824	2,461	1,066	701	397	202	184	254	123	78	51	28	123,085	694	123,779
04-05	122,872	19,733	1,927	651	392	229	258	167	89	98	151	73	48	32	18	146,736	434	147,170
05-06	41,369	21,409	6,626	2,426	1,055	485	398	242	126	129	192	94	60	40	22	74,672	543	75,215
06-07	100,516	21,817	3,283	1,273	740	421	425	270	144	165	236	117	78	52	29	129,568	638	130,206
07-08	50,056	24,174	8,063	3,100	1,342	613	463	276	143	152	210	104	69	46	26	88,836	552	89,388
08-09	48,299	22,821	6,773	2,321	956	430	353	214	112	115	171	83	53	35	20	82,755	484	83,239
09-10	26,184	12,678	4,221	1,645	737	348	274	165	86	94	129	64	43	29	16	46,713	335	47,048

Table 2.3.1 (continued). Numbers of spiny lobster by gear, sex, age, and fishing year.

Diving Males

Fishing Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Aged	Unaged	Total
85-86	26,507	32,459	12,952	4,713	1,785	644	248	106	48	38	45	39	20	12	6	79,620	157	79,777
86-87	8,401	13,947	9,704	5,875	3,325	1,824	1,032	553	275	147	104	61	31	17	8	45,303	181	45,484
87-88	5,982	11,744	7,096	3,452	1,625	797	396	203	101	77	85	78	39	23	11	31,708	240	31,948
88-89	10,129	19,368	11,350	5,581	2,706	1,344	675	344	170	124	131	138	66	40	18	52,183	345	52,528
89-90	13,128	24,739	14,235	7,039	3,464	1,724	865	437	214	149	152	168	79	48	22	66,463	316	66,779
90-91	7,742	15,019	8,952	4,377	2,090	1,033	517	265	132	99	108	106	52	31	14	40,537	315	40,852
91-92	18,463	31,294	16,300	7,163	3,205	1,563	798	422	216	169	190	208	100	60	28	80,178	1,137	81,315
92-93	21,851	35,879	18,060	7,423	3,128	1,625	876	505	281	273	347	431	204	124	57	91,063	2,473	93,536
93-94	11,523	22,568	12,476	5,783	2,906	1,762	1,006	597	334	344	455	454	227	136	64	60,636	2,994	63,630
94-95	36,119	54,221	22,471	7,931	2,994	1,337	651	352	193	231	334	715	309	196	86	128,139	1,795	129,934
95-96	21,946	54,434	28,640	10,399	3,649	1,572	733	382	202	191	241	379	171	106	48	123,094	2,333	125,427
96-97	35,988	56,751	26,961	10,897	4,562	2,216	1,101	604	327	299	367	471	220	135	61	140,958	2,740	143,698
97-98	38,410	64,168	31,212	14,031	6,596	3,232	1,589	806	404	333	391	523	242	148	67	162,153	3,092	165,245
98-99	25,151	56,591	30,963	12,830	5,378	2,672	1,358	763	414	346	395	540	247	151	68	137,867	3,160	141,027
99-00	62,647	106,310	52,042	21,634	9,442	4,401	1,990	932	437	318	342	503	226	139	62	261,427	3,048	264,475
00-01	47,030	87,619	47,214	22,299	10,589	5,283	2,687	1,431	739	541	563	803	361	222	99	227,480	4,839	232,319
01-02	17,654	37,473	27,689	17,079	9,896	6,180	3,671	2,152	1,212	1,169	1,482	2,009	933	574	260	129,431	8,796	138,227
02-03	35,043	72,793	44,099	23,368	12,065	6,186	3,078	1,527	740	528	555	745	340	208	94	201,368	4,361	205,729
03-04	23,003	47,540	31,383	17,305	9,112	4,832	2,532	1,344	679	431	385	503	225	137	61	139,471	2,918	142,389
04-05	63,608	61,606	14,491	2,847	721	416	272	189	119	135	182	291	132	82	37	145,128	1,829	146,957
05-06	19,479	40,017	22,172	10,102	4,791	2,519	1,339	730	385	322	377	546	248	153	69	103,250	2,550	105,800
06-07	11,678	25,241	13,534	5,541	2,401	1,258	689	409	235	243	319	453	209	129	58	62,398	2,740	65,138
07-08	20,816	39,271	22,771	11,395	5,782	3,118	1,670	911	478	395	457	610	281	173	78	108,206	2,686	110,892
08-09	17,208	33,788	18,301	8,314	3,960	2,090	1,119	617	328	280	330	480	218	135	60	87,228	2,259	89,487
09-10	10,658	20,307	11,928	5,954	3,003	1,631	880	485	257	219	258	340	158	97	44	56,218	1,587	57,805

Table 2.3.1 (continued). Numbers of spiny lobster by gear, sex, age, and fishing year.

Other Females

Fishing							Ages										
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Aged	Unaged	Total
85-86	2,051	10,147	7,466	3,277	1,220	487	206	89	35	12	4	1	0	0	0	24,995	0	24,995
86-87	2,739	13,564	9,964	4,356	1,615	642	271	117	46	16	5	2	1	0	0	33,338	0	33,338
87-88	669	3,323	2,433	1,056	388	154	65	28	11	4	1	0	0	0	0	8,132	0	8,132
88-89	1,121	5,541	4,075	1,786	663	264	112	48	19	7	2	1	0	0	0	13,639	0	13,639
89-90	2,006	9,916	7,293	3,196	1,187	473	200	86	34	12	4	1	0	0	0	24,409	0	24,409
90-91	1,503	7,432	5,466	2,395	890	354	150	64	25	9	3	1	0	0	0	18,293	0	18,293
91-92	1,931	9,205	6,122	2,263	687	224	81	31	12	4	1	0	0	0	0	20,561	0	20,561
92-93	600	3,011	2,236	1,006	389	160	68	29	12	4	1	0	0	0	0	7,517	0	7,517
93-94	687	3,474	2,556	1,127	427	172	73	31	12	4	1	0	0	0	0	8,567	0	8,567
94-95	623	3,390	2,881	1,667	800	384	184	85	34	12	4	1	0	0	0	10,066	0	10,066
95-96	810	4,095	2,965	1,256	451	175	73	31	12	4	1	0	0	0	0	9,874	0	9,874
96-97	1,411	7,046	5,143	2,218	811	319	134	57	22	8	3	1	0	0	0	17,173	0	17,173
97-98	1,854	9,349	6,767	2,860	1,022	395	164	70	27	10	3	1	0	0	0	22,523	0	22,523
98-99	1,631	9,761	7,679	3,036	823	198	43	10	3	1	0	0	0	0	0	23,185	0	23,185
99-00	1,476	7,691	5,410	2,133	699	250	99	41	16	6	2	1	0	0	0	17,824	0	17,824
00-01	1,866	9,487	6,795	2,800	968	364	149	63	25	9	3	1	0	0	0	22,529	0	22,529
01-02	965	4,884	3,509	1,457	508	193	79	34	13	5	2	1	0	0	0	11,648	0	11,648
02-03	827	4,504	3,121	1,214	419	183	91	44	18	7	2	1	0	0	0	10,432	0	10,432
03-04	890	5,230	3,969	1,568	481	147	45	14	5	1	0	0	0	0	0	12,351	0	12,351
04-05	1,279	6,465	4,652	1,939	679	258	106	45	18	6	2	1	0	0	0	15,450	0	15,450
05-06	2,457	13,257	8,949	3,139	846	242	80	30	11	4	1	0	0	0	0	29,015	0	29,015
06-07	1,982	10,307	7,216	2,807	897	314	122	51	20	7	2	1	0	0	0	23,726	0	23,726
07-08	1,406	7,218	5,127	2,070	698	257	103	43	17	6	2	1	0	0	0	16,949	0	16,949
08-09	1,271	6,540	4,633	1,858	621	227	91	38	15	5	2	1	0	0	0	15,302	0	15,302
09-10	2,234	11,302	8,128	3,382	1,183	449	185	78	31	11	4	1	0	0	0	26,988	0	26,988

Table 2.3.1 (continued). Numbers of spiny lobster by gear, sex, age, and fishing year.

Other Males

Fishing							Ages											
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Aged	Unaged	Total
85-86	7,144	13,809	6,749	2,650	1,046	413	191	91	42	18	7	3	1	0	0	32,165	0	32,165
86-87	9,482	18,329	8,942	3,502	1,380	544	251	120	55	23	9	3	1	0	0	42,643	0	42,643
87-88	2,282	4,413	2,146	837	329	130	60	28	13	6	2	1	0	0	0	10,247	0	10,247
88-89	3,909	7,553	3,688	1,445	570	225	103	49	23	10	4	1	1	0	0	17,581	0	17,581
89-90	6,997	13,518	6,600	2,586	1,019	402	185	88	41	17	7	2	1	0	0	31,463	0	31,463
90-91	5,245	10,133	4,946	1,938	764	301	139	66	30	13	5	2	1	0	0	23,583	0	23,583
91-92	3,481	7,401	3,685	1,380	494	171	64	24	9	4	1	0	0	0	0	16,715	0	16,715
92-93	1,997	3,913	1,957	799	328	135	65	32	15	7	3	1	0	0	0	9,252	0	9,252
93-94	2,193	4,303	2,132	861	351	144	70	34	16	7	3	1	0	0	0	10,116	0	10,116
94-95	1,901	4,072	2,556	1,325	636	284	146	75	36	15	6	2	1	0	0	11,057	0	11,057
95-96	2,541	4,952	2,386	926	364	144	67	32	15	6	3	1	0	0	0	11,438	0	11,438
96-97	4,700	9,110	4,420	1,723	677	267	124	59	27	12	5	2	1	0	0	21,127	0	21,127
97-98	5,886	11,441	5,499	2,123	828	326	151	72	33	14	6	2	1	0	0	26,381	0	26,381
98-99	12,134	19,526	10,021	4,814	2,182	826	295	98	31	10	3	1	0	0	0	49,941	0	49,941
99-00	3,882	7,644	3,530	1,305	493	191	89	43	20	8	3	1	0	0	0	17,210	0	17,210
00-01	5,649	10,996	5,208	1,973	757	294	135	64	30	12	5	2	1	0	0	25,126	0	25,126
01-02	2,988	5,806	2,760	1,050	404	157	72	34	16	7	3	1	0	0	0	13,297	0	13,297
02-03	4,851	8,098	2,724	587	105	21	5	2	1	0	0	0	0	0	0	16,394	0	16,394
03-04	3,570	7,058	2,838	755	178	44	13	5	2	1	0	0	0	0	0	14,465	0	14,465
04-05	3,993	7,755	3,694	1,408	543	211	97	46	21	9	4	1	0	0	0	17,782	0	17,782
05-06	4,877	9,754	4,045	1,280	411	141	60	28	13	5	2	1	0	0	0	20,616	0	20,616
06-07	5,230	10,257	4,683	1,697	626	238	107	51	23	10	4	1	1	0	0	22,927	0	22,927
07-08	4,032	7,877	3,688	1,380	525	203	93	44	20	9	4	1	0	0	0	17,877	0	17,877
08-09	3,585	7,009	3,268	1,217	461	178	81	39	18	8	3	1	0	0	0	15,868	0	15,868
09-10	6,934	13,476	6,415	2,445	942	367	168	80	37	15	6	2	1	0	0	30,888	0	30,888

Table 2.3.1 (continued). Numbers of spiny lobster by gear, sex, age, and fishing year.

Attractants Females

Fishing							Ages											
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Aged	Unaged	Total
85-86	393,998	170,735	27,121	3,965	1,065	387	152	61	25	11	4	2	1	0	0	597,528	0	597,528
86-87	494,319	209,146	30,549	3,550	807	286	112	45	19	8	3	1	1	0	0	738,848	0	738,848
87-88	243,573	104,171	15,819	2,064	515	185	73	29	12	5	2	1	0	0	0	366,449	0	366,449
88-89	221,219	93,585	13,663	1,585	360	128	50	20	8	3	1	1	0	0	0	330,625	0	330,625
89-90	331,324	140,228	20,507	2,392	546	194	76	31	13	5	2	1	0	0	0	495,319	0	495,319
90-91	464,407	197,931	29,691	3,741	909	326	128	52	21	9	4	2	1	0	0	697,221	0	697,221
91-92	266,588	113,694	17,094	2,168	530	190	74	30	12	5	2	1	0	0	0	400,391	0	400,391
92-93	220,050	93,624	13,957	1,727	414	148	58	24	10	4	2	1	0	0	0	330,018	0	330,018
93-94	149,995	60,910	8,469	822	144	45	17	7	3	1	0	0	0	0	0	220,413	0	220,413
94-95	188,539	81,846	12,734	1,838	505	184	70	27	10	4	2	1	0	0	0	285,759	0	285,759
95-96	194,847	81,576	12,411	1,680	469	185	78	33	14	6	3	1	0	0	0	291,302	0	291,302
96-97	219,318	91,418	14,968	2,410	675	246	99	42	19	8	4	2	1	0	0	329,209	0	329,209
97-98	257,608	118,186	16,725	1,562	253	77	28	10	4	1	1	0	0	0	0	394,455	0	394,455
98-99	127,130	44,235	6,478	844	199	66	24	9	3	1	0	0	0	0	0	178,990	0	178,990
99-00	239,610	86,668	11,703	1,264	273	96	38	15	6	3	1	0	0	0	0	339,677	0	339,677
00-01	189,184	76,619	10,816	1,128	220	73	27	10	4	2	1	0	0	0	0	278,084	0	278,084
01-02	150,532	49,925	6,277	832	247	96	37	13	5	2	1	0	0	0	0	207,967	0	207,967
02-03	121,667	60,775	8,165	628	62	12	3	1	0	0	0	0	0	0	0	191,313	0	191,313
03-04	139,152	51,045	6,234	564	107	37	14	5	2	1	0	0	0	0	0	197,161	0	197,161
04-05	147,274	53,944	6,538	569	103	35	13	5	2	1	0	0	0	0	0	208,484	0	208,484
05-06	88,678	32,431	3,899	326	55	18	7	2	1	0	0	0	0	0	0	125,418	0	125,418
06-07	95,853	35,196	4,320	400	78	27	10	4	1	0	0	0	0	0	0	135,890	0	135,890
07-08	111,242	40,830	5,001	459	89	31	11	4	1	1	0	0	0	0	0	157,670	0	157,670
08-09	58,309	21,504	2,698	275	60	21	8	3	1	0	0	0	0	0	0	82,880	0	82,880
09-10	82,066	30,394	3,895	431	103	37	14	5	2	1	0	0	0	0	0	116,947	0	116,947

Table 2.3.1 (continued). Numbers of spiny lobster by gear, sex, age, and fishing year.

Attractants Males

Fishing Year	Ages 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Aged	Unaged	Total
85-86	346,204	47,899	5,436	1,621	606	229	84	30	10	3	1	0	0	0	0	402,124	0	402,124
86-87	431,592	54,854	4,628	1,215	449	169	62	22	7	2	1	0	0	0	0	493,003	0	493,003
87-88	213,273	28,184	2,763	779	290	109	40	14	5	2	1	0	0	0	0	245,460	0	245,460
88-89	193,139	24,535	2,066	542	200	75	28	10	3	1	0	0	0	0	0	220,599	0	220,599
89-90	289,305	36,813	3,121	821	303	115	42	15	5	2	1	0	0	0	0	330,543	0	330,543
90-91	406,262	53,026	4,972	1,375	510	193	71	25	8	3	1	0	0	0	0	466,447	0	466,447
91-92	233,251	30,516	2,886	801	298	112	41	15	5	2	1	0	0	0	0	267,927	0	267,927
92-93	192,411	24,958	2,286	625	232	88	32	11	4	1	0	0	0	0	0	220,649	0	220,649
93-94	140,239	16,705	1,037	193	61	21	7	3	1	0	0	0	0	0	0	158,267	0	158,267
94-95	165,600	23,014	2,502	773	296	111	40	14	5	2	1	0	0	0	0	192,357	0	192,357
95-96	169,265	20,722	2,145	724	306	125	48	18	6	2	1	0	0	0	0	193,362	0	193,362
96-97	196,674	27,911	3,487	1,005	346	122	42	14	5	2	1	0	0	0	0	229,607	0	229,607
97-98	200,403	26,709	1,904	400	133	48	17	6	2	1	0	0	0	0	0	229,623	0	229,623
98-99	116,921	12,886	1,279	345	120	43	16	5	2	1	0	0	0	0	0	131,619	0	131,619
99-00	224,054	27,101	2,113	527	197	77	29	11	4	1	0	0	0	0	0	254,114	0	254,114
00-01	156,754	19,335	1,602	406	149	56	20	7	2	1	0	0	0	0	0	178,334	0	178,334
01-02	153,914	15,882	1,605	823	442	202	84	32	11	4	1	0	0	0	0	173,000	0	173,000
02-03	176,229	24,297	1,927	630	324	156	68	27	10	4	1	0	0	0	0	203,673	0	203,673
03-04	155,746	17,270	1,235	469	246	115	49	19	7	2	1	0	0	0	0	175,159	0	175,159
04-05	164,773	18,142	1,220	445	233	108	46	18	6	2	1	0	0	0	0	184,995	0	184,995
05-06	99,174	10,837	679	235	123	57	24	9	3	1	0	0	0	0	0	111,144	0	111,144
06-07	107,310	11,953	886	345	181	84	36	14	5	2	1	0	0	0	0	120,816	0	120,816
07-08	124,526	13,844	1,011	389	205	95	40	16	6	2	1	0	0	0	0	140,135	0	140,135
08-09	65,353	7,430	640	270	143	66	28	11	4	1	0	0	0	0	0	73,947	0	73,947
09-10	92,081	10,675	1,040	462	245	114	48	19	7	2	1	0	0	0	0	104,694	0	104,694

Table 2.3.1 (continued). Numbers of spiny lobster by gear, sex, age, and fishing year.

Recreational Females

Fishing							Ages											
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Aged	Unaged	Total
85-86	67,976	223,867	130,130	45,368	13,527	4,111	1,907	856	355	163	100	60	33	16	7	488,476	0	488,476
86-87	68,997	227,230	132,085	46,050	13,731	4,173	1,936	869	360	166	102	61	33	16	8	495,813	0	495,813
87-88	75,916	262,743	162,781	61,928	20,335	6,666	2,963	1,276	513	226	132	77	41	20	9	595,626	0	595,626
88-89	107,324	338,707	185,231	58,579	15,298	4,085	2,044	980	424	207	135	83	46	22	11	713,176	0	713,176
89-90	86,146	336,303	214,413	81,089	26,098	8,267	2,592	810	251	76	23	7	2	1	0	756,078	0	756,078
90-91	73,823	301,091	202,938	81,269	26,879	8,747	2,966	1,094	428	171	71	29	12	5	2	699,523	0	699,523
91-92	58,387	223,064	135,816	48,127	14,375	4,447	1,494	554	222	224	141	86	79	53	31	487,101	0	487,101
92-93	42,746	195,526	135,578	56,529	19,627	6,667	2,295	808	291	465	316	202	203	139	83	461,477	0	461,477
93-94	63,301	277,918	178,249	64,035	18,840	5,703	1,928	754	318	135	60	26	11	4	2	611,284	0	611,284
94-95	65,378	272,244	172,291	62,532	18,817	5,662	1,837	690	293	129	60	27	11	5	2	599,979	0	599,979
95-96	60,823	270,094	171,269	59,920	16,499	4,471	1,240	368	120	43	15	5	2	1	0	584,871	0	584,871
96-97	73,528	291,950	172,615	57,571	15,606	4,244	1,196	359	117	40	14	5	2	1	0	617,247	0	617,247
97-98	84,866	374,552	235,336	81,893	22,759	6,243	1,747	509	162	58	21	7	3	1	0	808,156	0	808,156
98-99	49,644	228,488	152,445	57,849	17,897	5,485	1,715	556	187	65	394	145	53	38	19	514,980	0	514,980
99-00	85,788	368,693	230,498	82,648	24,732	7,561	2,431	825	278	90	29	9	3	1	0	803,585	0	803,585
00-01	65,992	265,687	160,070	55,439	16,194	5,025	1,697	615	229	86	31	11	4	1	0	571,082	0	571,082
01-02	44,060	186,093	117,644	41,452	11,441	2,993	751	188	48	12	3	1	0	0	0	404,687	0	404,687
02-03	49,094	208,366	133,570	49,424	15,179	4,697	1,572	576	226	105	59	28	16	9	5	462,925	0	462,925
03-04	44,945	200,272	136,531	53,637	17,133	5,263	1,657	580	224	90	40	18	7	3	1	460,399	0	460,399
04-05	40,880	181,755	122,297	47,549	15,185	4,861	1,644	599	240	212	128	75	67	45	26	415,564	0	415,564
05-06	30,714	139,699	97,312	41,304	14,862	5,119	1,992	853	385	177	90	45	20	9	4	332,582	0	332,582
06-07	34,519	149,471	97,983	37,823	12,402	4,072	1,388	498	185	69	27	11	4	2	1	338,453	0	338,453
07-08	36,724	165,249	112,294	45,927	16,419	6,060	2,467	1,009	423	187	84	37	16	7	3	386,907	0	386,907
08-09	35,842	178,380	125,964	49,821	15,843	4,988	1,679	642	265	111	49	21	9	4	1	413,620	0	413,620
09-10	38,126	158,911	108,311	44,047	14,865	4,922	1,766	663	254	101	46	21	10	4	2	372,048	0	372,048

Table 2.3.1 (continued). Numbers of spiny lobster by gear, sex, age, and fishing year.

Recreational Males

Fishing Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Aged	Unaged	Total
85-86	289,083	354,554	116,129	32,444	9,825	3,359	1,340	572	274	125	51	24	11	5	2	807,798	0	807,798
86-87	293,426	359,880	117,874	32,932	9,973	3,409	1,360	581	278	127	52	24	11	5	2	819,934	0	819,934
87-88	343,436	458,803	158,158	46,277	14,539	5,300	2,214	964	485	231	95	47	24	11	5	1,030,590	0	1,030,590
88-89	432,571	486,964	150,359	39,584	11,379	3,508	1,283	526	224	91	37	13	5	2	1	1,126,547	0	1,126,547
89-90	303,403	489,163	212,940	70,349	22,154	7,209	2,378	790	259	86	28	10	3	1	0	1,108,773	0	1,108,773
90-91	229,903	405,749	199,474	73,093	25,256	8,772	3,160	1,164	432	158	57	573	211	140	56	948,198	0	948,198
91-92	227,088	388,271	159,404	48,772	15,082	5,537	2,346	1,119	557	349	299	140	83	44	22	849,116	0	849,116
92-93	154,351	337,512	162,191	55,296	18,012	6,284	2,513	1,073	498	223	90	41	19	9	4	738,114	3,723	741,837
93-94	309,824	512,018	212,421	67,605	21,410	7,334	2,657	1,085	460	200	90	39	15	6	3	1,135,167	0	1,135,167
94-95	318,118	526,699	212,143	63,894	18,832	6,202	2,297	987	458	324	338	518	231	143	63	1,151,245	0	1,151,245
95-96	247,893	510,682	227,268	71,294	20,768	6,398	2,338	974	466	213	88	40	19	9	4	1,088,455	0	1,088,455
96-97	346,326	539,950	198,510	54,805	14,980	4,546	1,503	589	248	109	50	22	9	4	1	1,161,651	0	1,161,651
97-98	357,586	642,074	264,583	79,302	22,735	6,934	2,407	979	451	210	92	43	20	9	4	1,377,428	0	1,377,428
98-99	150,620	301,077	143,387	49,106	16,225	5,725	2,041	760	285	222	287	133	86	48	25	670,027	0	670,027
99-00	398,837	690,552	273,731	83,172	26,192	9,410	3,866	1,727	802	358	151	65	28	12	5	1,488,909	0	1,488,909
00-01	355,935	583,329	230,585	69,349	20,399	6,088	1,844	564	172	53	16	5	2	1	0	1,268,342	0	1,268,342
01-02	188,870	340,190	142,745	43,982	13,075	4,104	1,424	561	249	200	239	112	72	40	21	735,884	0	735,884
02-03	221,435	383,548	159,934	50,165	15,467	5,131	1,847	729	306	149	94	68	32	18	8	838,932	252	839,184
03-04	181,185	350,684	162,884	55,623	17,934	5,849	2,035	746	296	118	45	19	8	3	1	777,432	0	777,432
04-05	176,352	333,107	150,782	51,612	17,708	6,687	2,637	1,159	515	300	254	116	67	35	18	741,350	0	741,350
05-06	184,380	320,454	143,669	52,510	20,218	8,801	4,028	1,954	957	565	449	209	121	63	32	738,409	0	738,409
06-07	176,807	354,882	173,330	62,338	20,939	6,933	2,345	810	286	101	35	12	4	1	0	798,822	0	798,822
07-08	191,108	315,779	128,771	41,656	13,945	5,116	2,039	849	381	170	69	215	82	52	21	700,254	0	700,254
08-09	166,589	335,080	152,340	50,508	16,513	6,083	2,461	1,122	525	241	108	47	20	8	3	731,648	301	731,949
09-10	149,000	279,467	134,787	48,252	16,155	5,353	1,800	628	224	82	31	12	4	2	1	635,798	259	636,057

Table 2.3.2. Numbers of spiny lobster (sexes and gears combined) by age after settlement and fishing year.

Fishing	Ages																
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Aged	Unaged	Total
85-86	1,932,834	2,640,320	1,351,488	548,283	210,833	80,643	34,356	14,616	6,260	2,862	1,718	1,080	513	281	131	6,826,217	3,646	6,829,863
86-87	2,078,664	2,576,336	1,331,745	564,788	231,542	96,355	41,741	18,405	8,095	4,357	3,203	2,981	1,398	812	370	6,960,792	7,540	6,968,332
87-88	1,570,852	2,555,784	1,443,344	629,275	256,525	104,324	47,454	21,552	9,640	5,589	3,222	3,635	1,888	1,175	574	6,654,834	1,443	6,656,277
88-89	2,214,692	3,606,371	1,792,004	671,415	240,231	88,978	35,632	14,573	5,980	2,839	1,836	1,026	528	286	138	8,676,528	4,262	8,680,790
89-90	2,070,435	3,544,506	2,048,474	885,578	353,768	142,286	59,184	25,026	10,656	5,058	3,034	2,729	1,220	701	312	9,152,967	5,307	9,158,274
90-91	2,029,193	2,843,592	1,546,510	662,318	272,526	116,833	60,548	31,751	16,278	13,289	14,831	12,180	6,502	4,082	2,041	7,632,475	27,313	7,659,788
91-92	1,651,590	2,846,214	1,580,788	663,587	268,849	115,590	62,657	32,322	16,029	13,735	15,666	16,411	8,350	5,386	2,644	7,299,818	46,513	7,346,331
92-93	1,387,408	1,962,950	1,110,338	508,849	237,846	124,245	77,996	44,941	24,320	22,453	26,560	22,990	12,281	7,790	3,896	5,574,863	76,962	5,651,825
93-94	1,533,599	2,684,384	1,368,590	520,263	192,242	79,100	41,266	21,763	11,086	7,617	9,170	6,540	3,289	1,997	973	6,481,880	30,030	6,511,910
94-95	1,782,718	3,128,216	1,690,402	716,113	297,959	133,750	69,275	35,456	17,778	14,000	14,973	13,423	7,005	4,400	2,171	7,927,639	31,420	7,959,059
95-96	1,519,461	2,909,321	1,666,674	706,925	289,674	129,906	68,671	35,812	18,444	15,956	18,083	17,110	8,889	5,640	2,780	7,413,345	64,536	7,477,881
96-97	2,038,711	3,642,103	1,873,387	716,540	271,025	114,149	56,896	28,514	13,929	10,430	11,332	9,016	4,757	2,984	1,489	8,795,260	19,105	8,814,365
97-98	2,223,186	3,779,188	1,871,957	706,748	268,938	115,092	61,761	32,763	16,773	12,457	12,832	11,972	6,041	3,736	1,806	9,125,253	37,239	9,162,492
98-99	1,249,259	2,351,336	1,322,911	545,960	214,070	89,813	43,746	21,705	10,785	7,362	8,207	8,804	4,110	2,630	1,242	5,881,938	21,139	5,903,077
99-00	2,184,176	3,737,401	1,953,248	781,743	307,856	129,841	62,058	29,577	13,846	8,608	7,583	5,165	2,800	1,682	843	9,226,427	13,473	9,239,900
00-01	1,541,393	2,584,980	1,353,049	556,030	230,968	106,199	60,260	32,356	16,613	14,125	16,437	14,243	7,523	4,800	2,399	6,541,373	40,572	6,581,945
01-02	917,589	1,430,320	789,554	337,759	141,647	64,194	34,031	17,805	9,074	7,138	8,314	7,558	3,815	2,400	1,169	3,772,368	31,256	3,803,624
02-03	1,178,904	2,046,067	1,131,760	477,738	195,504	84,343	42,731	21,256	10,291	8,121	9,471	7,687	4,062	2,555	1,275	5,221,764	27,487	5,249,251
03-04	1,125,495	1,978,532	1,116,760	469,117	185,060	74,846	32,483	14,359	6,344	3,392	2,306	1,708	874	515	251	5,012,041	5,805	5,017,846
04-05	1,509,099	2,483,842	1,322,082	536,542	211,667	88,731	40,002	18,409	8,390	4,822	3,651	2,867	1,451	842	401	6,232,798	4,137	6,236,935
05-06	1,141,225	1,857,727	893,122	330,934	121,988	48,798	22,043	10,348	4,860	3,069	2,390	1,759	974	578	289	4,440,103	3,093	4,443,196
06-07	1,197,993	2,165,033	1,223,290	507,221	195,298	76,411	31,816	13,715	5,998	3,073	2,142	2,164	982	582	263	5,425,982	3,868	5,429,850
07-08	1,162,809	1,916,096	963,360	371,443	140,468	56,870	25,391	11,757	5,499	2,774	1,678	1,359	622	352	159	4,660,637	3,914	4,664,551
08-09	1,035,838	1,826,021	886,056	314,902	107,035	39,277	16,256	7,204	3,273	2,070	1,911	2,035	972	588	272	4,243,710	4,281	4,247,991
09-10	1,237,353	2,133,521	1,068,304	399,407	140,474	50,182	18,724	7,300	2,934	1,343	809	576	269	152	70	5,061,418	2,181	5,063,599

Table 2.3.3. Carapace lengths, number of lobsters that molted, mean growth increments, standard deviations of growth increments, and the number of molts per year for pre-recruit sized spiny lobsters.

CL (mm)	N	Mean Increment (mm)	St. dev.	Molts
47	5	6.20	1.10	5
48	8	6.88	2.90	5
49	6	7.93	3.09	4
50	5	7.76	4.00	4
51	16	6.28	1.68	4
52	8	6.10	1.16	4
53	13	6.31	1.52	4
54	15	6.30	1.58	4
55	15	6.19	1.94	4
56	18	6.99	2.65	4
57	17	6.84	2.66	4
58	16	6.59	1.67	4
59	18	6.47	2.54	4
60	29	6.86	1.76	4
61	22	7.07	2.37	4
62	21	6.60	2.12	4
63	40	6.55	2.14	4
64	19	7.12	2.40	4
65	35	6.10	2.23	3
66	35	6.55	1.88	3
67	39	7.58	1.84	3
68	29	6.86	2.06	3
69	35	6.76	1.77	3
70	39	6.62	2.05	3
71	29	6.38	2.16	3
72	37	6.22	1.81	3
73	40	6.44	2.67	3
74	38	6.37	2.76	3
75	41	6.80	2.56	3

Table 2.3.4. Tuning indices and the ages that they were applied to in the age-structured models used in assessment analyses. The Biscayne National Park creel survey and post-larvae indices were recalculated based on recommendations from the webinar discussions and the Stock Assessment Workshop.

	Estimated indices								Indices scaled to their means							
Fishing	Post-larvae	FWC Adult	FWC Adult			Biscayne	Observer	Observer	Post-larvae	FWC Adul	FWC Adult			Biscayne	Observer	Observer
year	Age-1	Age-2	Ages 3+	Age-2	Ages 3+	Ages 2+	Age-2	Ages 3+	Age-1	Age-2	Ages 3+			Ages 2+	Age-2	Ages 3+
1978-79						30.35								1.64		
1979-80						24.25								1.31		
1980-81						23.86								1.29		
1981-82						17.51								0.94		
1982-83						13.85								0.75		
1983-84						15.92								0.86		
1984-85						13.20								0.71		
1985-86						7.13								0.38		
1986-87						6.48								0.35		
1987-88	10.20					15.86			0.64					0.85		
1988-89	10.89					15.40			0.69					0.83		
1989-90	15.07					15.71			0.95					0.85		
1990-91	11.91					14.86			0.75					0.80		
1991-92	12.80					23.05			0.81					1.24		
1992-93	13.59					11.62			0.86					0.63		
1993-94	17.79					20.73	2.11	0.70	1.12					1.12	0.85	0.69
1994-95	20.08					15.70	2.24	1.14	1.27					0.85	0.90	1.13
1995-96	17.97					19.87	2.16	1.00	1.14					1.07	0.87	0.99
1996-97	11.35					17.65	2.60	1.08	0.72					0.95	1.05	1.07
1997-98	17.79	11.86	23.28			26.95	2.71	1.29	1.12	1.14	0.77			1.45	1.09	1.27
1998-99	23.02	5.36	16.60			20.87	3.15	1.09	1.46	0.52	0.55			1.12	1.27	1.07
1999-00	15.71	15.20	36.75			35.06	2.60	0.93	0.99	1.46	1.22			1.89	1.05	0.92
2000-01	19.22	11.95	35.15			19.72	2.31	0.85	1.21	1.15	1.16			1.06	0.93	0.85
2001-02	14.30	5.54	22.54			14.47			0.90	0.53	0.75			0.78		
2002-03	16.65	6.37	20.89			20.24			1.05	0.61	0.69			1.09		
2003-04	11.61	5.43	24.70			16.10			0.73	0.52	0.82			0.87		
2004-05	15.74	8.15	28.54	0.47	2.13	19.73			0.99	0.78	0.94	0.47	0.68	1.06		
2005-06	15.79	16.55	47.10	1.05	5.94	17.74			1.00	1.59	1.56	1.04	1.89	0.96		
2006-07	17.50	17.73	46.81	1.68	5.02	16.79			1.11	1.70	1.55	1.66	1.60	0.90		
2007-08	16.78			1.49	4.14	13.29			1.06			1.47	1.32	0.72		
2008-09	19.88			0.69	1.69	22.04			1.26			0.68	0.54	1.19		
2009-10	14.92			0.75	1.58	14.14			0.94			0.74	0.50	0.76		

Table 2.3.5. Coefficients of variation and number of observations associated with the tuning indices

Fishing	CVs								Number of observations							
	Post-larvae	FWC Adult	FWC Adult			Biscayne	Observer	Observer	Post-larvae	FWC Adult	FWC Adult			Biscayne	Observer	Observer
year	Age-1	Age-2	Ages 3+			Ages 2+	Age-2	Ages 3+	Age-1	Age-2	Ages 3+			Ages 2+	Age-2	Ages 3+
1978-79						0.04								159		
1979-80						0.06								96		
1980-81						0.05								124		
1981-82						0.07								144		
1982-83						0.09								152		
1983-84						0.11								94		
1984-85						0.13								97		
1985-86						0.50								20		
1986-87						0.24								134		
1987-88	0.04					0.10			43					91		
1988-89	0.05					0.12			36					81		
1989-90	0.03					0.11			46					88		
1990-91	0.06					0.08			39					200		
1991-92	0.06					0.04			31					241		
1992-93	0.07					0.13			19					97		
1993-94	0.03					0.06	0.00	0.01	44					208	22282	22282
1994-95	0.04					0.06	0.01	0.01	44					236	11499	11499
1995-96	0.03					0.06	0.01	0.01	50					175	13760	16526
1996-97	0.06					0.05	0.01	0.01	40					299	11810	12346
1997-98	0.03	0.06	0.03			0.04	0.01	0.01	36	18	18			268	11499	11499
1998-99	0.04	0.14	0.05			0.04	0.01	0.01	43	18	18			262	9627	9627
1999-00	0.04	0.04	0.04			0.04	0.01	0.02	51	18	18			154	4539	4726
2000-01	0.03	0.07	0.03			0.05	0.01	0.01	52	18	18			288	8203	8257
2001-02	0.04	0.10	0.05			0.07			46	18	18			250		
2002-03	0.04	0.08	0.05			0.06			49	18	18			202		
2003-04	0.04	0.10	0.05			0.06			52	18	18			256		
2004-05	0.04	0.09	0.04	0.24	0.13	0.06			50	18	18	40	40	199		
2005-06	0.04	0.05	0.03	0.16	0.08	0.05			31	18	18	39	39	245		
2006-07	0.05	0.05	0.03	0.16	0.09	0.06			49	18	18	40	40	289		
2007-08	0.09			0.10	0.06	0.07			18			70	70	300		
2008-09	0.03			0.18	0.10	0.04			41			60	60	205		
2009-10	0.05			0.12	0.10	0.07			27			80	80	297		

Table 3.1.1.2. The landings, in numbers, and effort by sector and fishing year that were used in the DeLury model.

	Observed Catch (numbers)				Effort	
Fishing year	Recreational	Commercial	Attractants	Total	Rec person days	Commercial trips
78-79	1,032,818	4,712,160	1,489,053	7,234,031	298,427	32,833
79-80	1,332,146	6,384,958	1,766,902	9,484,006	384,930	44,488
80-81	1,653,054	5,074,434	1,450,653	8,178,141	479,513	35,357
81-82	1,438,200	4,673,563	1,389,579	7,501,342	416,247	32,564
82-83	1,487,598	5,192,189	1,440,506	8,120,293	430,799	36,177
83-84	1,114,641	3,516,013	1,205,460	5,836,114	322,088	24,498
84-85	1,218,015	5,077,610	1,458,513	7,754,138	350,689	35,379
85-86	1,296,274	4,533,937	999,652	6,829,863	339,625	32,351
86-87	1,315,747	4,420,734	1,231,851	6,968,332	317,518	31,082
87-88	1,626,216	4,418,152	611,909	6,656,277	377,255	34,406
88-89	1,839,723	6,289,843	551,224	8,680,790	505,243	36,431
89-90	1,864,851	6,467,561	825,862	9,158,274	497,125	40,276
90-91	1,647,721	4,848,399	1,163,668	7,659,788	433,092	40,537
91-92	1,336,217	5,341,796	668,318	7,346,331	578,003	45,777
92-93	1,203,314	3,897,844	550,667	5,651,825	477,756	35,821
93-94	1,746,451	4,386,779	378,680	6,511,910	515,006	31,568
94-95	1,751,224	5,729,719	478,116	7,959,059	544,438	32,554
95-96	1,673,326	5,319,891	484,664	7,477,881	467,265	32,830
96-97	1,778,898	6,476,651	558,816	8,814,365	541,729	32,848
97-98	2,185,584	6,352,830	624,078	9,162,492	624,074	34,088
98-99	1,185,007	4,407,461	310,609	5,903,077	332,391	26,198
99-00	2,292,494	6,353,615	593,791	9,239,900	554,953	28,141
00-01	1,839,424	4,286,103	456,418	6,581,945	477,776	26,249
01-02	1,140,571	2,282,086	380,967	3,803,624	387,570	19,670
02-03	1,302,106	3,552,156	394,986	5,249,248	367,089	24,131
03-04	1,237,831	3,407,695	372,320	5,017,846	385,656	22,196
04-05	1,156,914	4,686,542	393,479	6,236,935	413,005	20,369
05-06	1,070,991	3,135,643	236,562	4,443,196	440,354	14,990
06-07	1,137,275	4,035,869	256,706	5,429,850	376,722	18,247
07-08	1,087,161	3,279,585	297,805	4,664,551	432,148	18,987
08-09	1,145,569	2,945,595	156,827	4,247,991	373,115	15,273
09-10	1,008,105	3,833,853	221,641	5,063,599	373,863	14,335

Table 3.1.2.1. Components of the objective function from the ADMB run of the DeLury model for spiny lobster off the SE US. All statistics were calculated on log-transformed values.

Components	Residual SS	DF	MS	Likelihood	%
Recreational	0.37	17	0.02	-4511.02	28.48%
Commercial	0.41	24	0.02	-8726.33	55.09%
Commercial bait	0.13	7	0.02	-88.54	0.56%
Observer legal-sized	0.21	7	0.03	-87.93	0.56%
FWCtimedadults	0.93	9	0.10	-132.49	0.84%
FWCtransectadult	1.81	5	0.36	-35.64	0.22%
Bayscane National Park	2.44	31	0.08	-1415.06	8.93%
Post-larvae	2.06	21	0.10	-601.10	3.79%
Obsever pre-recruits	0.33	7	0.05	-86.96	0.55%
FWC timed pre-recruits	2.80	9	0.31	-117.09	0.74%
FWC transect pre-recruits	1.12	5	0.22	-41.13	0.26%
Recruitment anomalies	2.07	31	0.07	2.06	-0.01%
TOTAL	14.67			-15840.70	100.00%

Table 3.1.2.3. Runs of the DeLury model with alternative natural mortality rates of 0.25 per year and 0.43 per year as well as the final run value of 0.34 for comparison.

	M = 0.25			M = 0.34			M = 0.43		
Fishing year	Population	Recruitment	Fishing mortality	Population	Recruitment	Fishing mortality	Population	Recruitment	Fishing mortality
1978-79	9,724,200	13,269,782	1.74	11,471,000	14,403,762	1.32	19,619,000	16,207,749	0.99
1979-80	14,606,000	11,911,323	2.34	16,588,000	12,994,022	1.77	17,976,000	14,606,833	1.33
1980-81	13,012,000	8,016,400	1.99	14,996,000	8,632,114	1.51	13,368,000	9,597,373	1.13
1981-82	9,398,200	6,927,434	1.81	10,989,000	7,452,052	1.38	11,403,000	8,301,942	1.03
1982-83	8,123,000	6,635,868	1.99	9,428,300	7,496,899	1.51	11,133,000	8,745,064	1.13
1983-84	7,500,300	6,107,328	1.37	8,976,200	6,602,771	1.04	10,753,000	7,429,729	0.78
1984-85	7,591,600	6,280,750	1.89	8,860,700	6,899,779	1.44	10,235,000	7,849,811	1.08
1985-86	7,170,100	6,058,665	1.75	8,402,500	6,689,168	1.32	10,132,000	7,663,658	0.99
1986-87	7,031,800	6,401,225	1.67	8,281,300	6,983,076	1.27	10,460,000	7,912,861	0.95
1987-88	7,432,800	9,388,537	1.87	8,646,200	10,334,517	1.42	14,146,000	11,792,803	1.06
1988-89	10,284,000	9,202,631	2.06	11,823,000	9,899,551	1.56	13,843,000	10,995,537	1.17
1989-90	10,223,000	6,602,771	2.23	11,663,000	7,025,100	1.69	10,228,000	7,694,374	1.27
1990-91	7,461,800	7,702,072	2.19	8,556,100	8,227,560	1.66	10,988,000	9,074,692	1.25
1991-92	8,347,600	6,858,505	2.54	9,383,500	7,542,015	1.93	10,234,000	8,554,774	1.45
1992-93	7,368,600	8,170,168	2.01	8,510,300	9,101,957	1.52	12,628,000	10,501,199	1.14
1993-94	8,942,400	8,868,356	1.84	10,420,000	9,732,681	1.40	13,966,000	11,083,854	1.05
1994-95	9,970,800	8,877,229	1.91	11,570,000	9,732,681	1.45	14,119,000	11,050,652	1.09
1995-96	10,023,000	9,578,198	1.86	11,664,000	10,490,703	1.41	15,082,000	11,899,417	1.06
1996-97	10,785,000	10,282,973	1.92	12,505,000	11,184,059	1.46	15,879,000	12,597,387	1.09
1997-98	11,511,000	7,834,127	2.04	13,251,000	8,797,692	1.55	13,452,000	10,221,460	1.16
1998-99	9,002,100	9,879,772	1.46	10,802,000	10,907,923	1.11	16,313,000	12,497,010	0.83
1999-00	11,513,000	8,048,530	1.71	13,448,000	8,815,305	1.30	14,024,000	10,029,086	0.98
2000-01	9,658,500	5,277,695	1.57	11,417,000	5,944,637	1.19	10,700,000	6,962,158	0.89
2001-02	6,845,900	6,388,436	1.20	8,416,000	7,181,365	0.91	11,926,000	8,410,572	0.68
2002-03	7,998,900	6,230,705	1.39	9,593,600	7,039,164	1.05	11,804,000	8,285,355	0.79
2003-04	7,782,500	6,649,153	1.31	9,418,200	7,557,115	1.00	12,582,000	8,948,532	0.75
2004-05	8,280,000	5,509,586	1.25	10,032,000	6,299,621	0.95	11,528,000	7,511,908	0.71
2005-06	7,355,500	6,556,713	1.02	9,063,200	7,504,399	0.78	13,166,000	8,975,417	0.58
2006-07	8,618,900	5,632,140	1.12	10,476,000	6,394,827	0.85	12,115,000	7,602,594	0.64
2007-08	7,809,500	5,832,755	1.20	9,570,300	6,769,921	0.91	12,176,000	8,194,715	0.68
2008-09	7,661,500	5,576,099	0.99	9,510,200	6,484,985	0.75	12,399,000	7,873,396	0.56
2009-10	7,805,900	6,218,256	0.94	9,693,300	7,025,100	0.72	12,399,000	8,260,536	0.54

Table 3.1.2.6. Total and sector-specific fishing mortality by fishing year obtained from the Delury model base run (M = 0.34 $year^{-1}$)

Fishing year	Recreational	Commercial	Bait	Total
1978-79	0.17	1.06	0.09	1.32
1979-80	0.22	1.43	0.12	1.77
1980-81	0.28	1.14	0.10	1.51
1981-82	0.24	1.05	0.09	1.38
1982-83	0.25	1.16	0.10	1.51
1983-84	0.19	0.79	0.07	1.04
1984-85	0.20	1.14	0.10	1.44
1985-86	0.20	1.04	0.09	1.32
1986-87	0.18	1.00	0.08	1.27
1987-88	0.22	1.11	0.09	1.42
1988-89	0.29	1.17	0.10	1.56
1989-90	0.29	1.30	0.11	1.69
1990-91	0.25	1.30	0.11	1.66
1991-92	0.33	1.47	0.13	1.93
1992-93	0.27	1.15	0.10	1.52
1993-94	0.30	1.02	0.09	1.40
1994-95	0.31	1.05	0.09	1.45
1995-96	0.27	1.06	0.09	1.41
1996-97	0.31	1.06	0.09	1.46
1997-98	0.36	1.10	0.09	1.55
1998-99	0.19	0.84	0.07	1.11
1999-00	0.32	0.91	0.08	1.30
2000-01	0.27	0.84	0.07	1.19
2001-02	0.22	0.63	0.05	0.91
2002-03	0.21	0.78	0.07	1.05
2003-04	0.22	0.71	0.06	1.00
2004-05	0.24	0.66	0.06	0.95
2005-06	0.25	0.48	0.04	0.78
2006-07	0.22	0.59	0.05	0.85
2007-08	0.25	0.61	0.05	0.91
2008-09	0.21	0.49	0.04	0.75
2009-10	0.21	0.46	0.04	0.72

Table 3.2.1.2.1. Catch-at-age, in numbers of fish, by fishing year of both sexes and all gears.

Fishing	Age after settlement											
Year	1	2	3	4	5	6	7	8	9	10	11	12+
1985	1932834	2640320	1351488	548283	210833	80643	34356	14616	6260	2862	1718	5651
1986	2078664	2576336	1331745	564788	231542	96355	41741	18405	8095	4357	3203	13101
1987	1570852	2555784	1443344	629275	256525	104324	47454	21552	9640	5589	3222	8715
1988	2214692	3606371	1792004	671415	240231	88978	35632	14573	5980	2839	1836	6239
1989	2070435	3544506	2048474	885578	353768	142286	59184	25026	10656	5058	3034	10269
1990	2029193	2843592	1546510	662318	272526	116833	60548	31751	16278	13289	14831	52119
1991	1651590	2846214	1580788	663587	268849	115590	62657	32322	16029	13735	15666	79304
1992	1387408	1962950	1110338	508849	237846	124245	77996	44941	24320	22453	26560	123919
1993	1533599	2684384	1368590	520263	192242	79100	41266	21763	11086	7617	9170	42829
1994	1782718	3128216	1690402	716113	297959	133750	69275	35456	17778	14000	14973	58420
1995	1519461	2909321	1666674	706925	289674	129906	68671	35812	18444	15956	18083	98954
1996	2038711	3642103	1873387	716540	271025	114149	56896	28514	13929	10430	11332	37350
1997	2223186	3779188	1871957	706748	268938	115092	61761	32763	16773	12457	12832	60794
1998	1249259	2351336	1322911	545960	214070	89813	43746	21705	10785	7362	8207	37924
1999	2184176	3737401	1953248	781743	307856	129841	62058	29577	13846	8608	7583	23963
2000	1541393	2584980	1353049	556030	230968	106199	60260	32356	16613	14125	16437	69536
2001	917589	1430320	789554	337759	141647	64194	34031	17805	9074	7138	8314	46198
2002	1178904	2046067	1131760	477738	195504	84343	42731	21256	10291	8121	9471	43066
2003	1125495	1978532	1116760	469117	185060	74846	32483	14359	6344	3392	2306	9152
2004	1509099	2483842	1322082	536542	211667	88731	40002	18409	8390	4822	3651	9697
2005	1141225	1857727	893122	330934	121988	48798	22043	10348	4860	3069	2390	6692
2006	1197993	2165033	1223290	507221	195298	76411	31816	13715	5998	3073	2142	7859
2007	1162809	1916096	963360	371443	140468	56870	25391	11757	5499	2774	1678	6406
2008	1035838	1826021	886056	314902	107035	39277	16256	7204	3273	2070	1911	8148
2009	1237353	2133521	1068304	399407	140474	50182	18724	7300	2934	1343	809	3249

Table 3.2.1.2.2. Average weight (lb) of harvested spiny lobsters by age after settlement and fishing year.

Fishing	Age after settlement											
Year	1	2	3	4	5	6	7	8	9	10	11	12+
1985	0.805	1.058	1.246	1.438	1.616	1.784	2.046	2.255	2.433	2.628	2.989	3.370
1986	0.780	1.050	1.260	1.471	1.672	1.867	2.071	2.255	2.402	2.736	3.198	3.740
1987	0.839	1.078	1.274	1.464	1.643	1.821	2.088	2.292	2.449	2.752	2.959	3.610
1988	0.868	1.059	1.217	1.392	1.578	1.759	1.968	2.140	2.277	2.561	3.059	3.412
1989	0.842	1.085	1.270	1.458	1.645	1.829	2.022	2.193	2.341	2.590	3.010	3.670
1990	0.794	1.066	1.258	1.463	1.685	1.931	2.265	2.482	2.621	3.023	3.417	3.688
1991	0.848	1.086	1.263	1.464	1.683	1.922	2.284	2.494	2.630	3.034	3.418	3.763
1992	0.787	1.079	1.276	1.517	1.795	2.096	2.412	2.579	2.688	3.094	3.463	3.729
1993	0.883	1.077	1.232	1.412	1.638	1.935	2.328	2.567	2.719	3.041	3.463	3.683
1994	0.881	1.079	1.260	1.472	1.701	1.968	2.281	2.492	2.646	3.046	3.434	3.739
1995	0.873	1.095	1.264	1.462	1.695	1.974	2.306	2.517	2.666	3.081	3.457	3.765
1996	0.880	1.073	1.225	1.416	1.649	1.909	2.206	2.403	2.530	2.939	3.394	3.681
1997	0.881	1.068	1.228	1.432	1.679	1.957	2.298	2.502	2.631	2.993	3.392	3.743
1998	0.880	1.094	1.258	1.445	1.658	1.920	2.244	2.478	2.650	2.971	3.417	3.814
1999	0.877	1.081	1.247	1.450	1.671	1.905	2.181	2.382	2.536	2.879	3.313	3.581
2000	0.873	1.079	1.256	1.480	1.727	1.993	2.317	2.506	2.633	3.030	3.432	3.711
2001	0.830	1.085	1.270	1.484	1.718	1.973	2.265	2.458	2.598	3.005	3.464	3.759
2002	0.875	1.093	1.268	1.469	1.687	1.913	2.207	2.404	2.542	2.977	3.428	3.700
2003	0.863	1.093	1.268	1.459	1.658	1.852	2.066	2.237	2.370	2.668	3.121	3.517
2004	0.875	1.073	1.242	1.441	1.658	1.886	2.116	2.305	2.446	2.792	3.231	3.651
2005	0.879	1.060	1.221	1.420	1.645	1.884	2.153	2.364	2.524	2.889	3.283	3.592
2006	0.871	1.093	1.268	1.455	1.649	1.847	2.068	2.263	2.424	2.724	3.191	3.754
2007	0.866	1.066	1.228	1.423	1.640	1.869	2.121	2.324	2.484	2.689	3.058	3.551
2008	0.880	1.065	1.211	1.380	1.580	1.811	2.083	2.313	2.492	2.927	3.400	3.834
2009	0.880	1.069	1.228	1.401	1.578	1.747	1.928	2.100	2.247	2.503	3.009	3.495

Table 3.2.1.2.3. Estimated average weight (lb) in the population from the tagging growth trajectories of spiny lobsters.

Fishing	Age after settlement										
Year	1	2	3	4	5	6	7	8	9	10	11	12+
1985	0.381	0.780	1.097	1.349	1.575	1.745	1.904	2.050	2.190	2.296	2.395	2.579
1986	0.381	0.780	1.097	1.349	1.575	1.745	1.904	2.050	2.190	2.296	2.395	2.579
1987	0.381	0.780	1.097	1.349	1.575	1.745	1.904	2.050	2.190	2.296	2.395	2.579
1988	0.381	0.780	1.097	1.349	1.575	1.745	1.904	2.050	2.190	2.296	2.395	2.579
1989	0.381	0.780	1.097	1.349	1.575	1.745	1.904	2.050	2.190	2.296	2.395	2.579
1990	0.381	0.780	1.097	1.349	1.575	1.745	1.904	2.050	2.190	2.296	2.395	2.579
1991	0.381	0.780	1.097	1.349	1.575	1.745	1.904	2.050	2.190	2.296	2.395	2.579
1992	0.381	0.780	1.097	1.349	1.575	1.745	1.904	2.050	2.190	2.296	2.395	2.579
1993	0.381	0.780	1.097	1.349	1.575	1.745	1.904	2.050	2.190	2.296	2.395	2.579
1994	0.381	0.780	1.097	1.349	1.575	1.745	1.904	2.050	2.190	2.296	2.395	2.579
1995	0.381	0.780	1.097	1.349	1.575	1.745	1.904	2.050	2.190	2.296	2.395	2.579
1996	0.381	0.780	1.097	1.349	1.575	1.745	1.904	2.050	2.190	2.296	2.395	2.579
1997	0.381	0.780	1.097	1.349	1.575	1.745	1.904	2.050	2.190	2.296	2.395	2.579
1998	0.381	0.780	1.097	1.349	1.575	1.745	1.904	2.050	2.190	2.296	2.395	2.579
1999	0.381	0.780	1.097	1.349	1.575	1.745	1.904	2.050	2.190	2.296	2.395	2.579
2000	0.381	0.780	1.097	1.349	1.575	1.745	1.904	2.050	2.190	2.296	2.395	2.579
2001	0.381	0.780	1.097	1.349	1.575	1.745	1.904	2.050	2.190	2.296	2.395	2.579
2002	0.381	0.780	1.097	1.349	1.575	1.745	1.904	2.050	2.190	2.296	2.395	2.579
2003	0.381	0.780	1.097	1.349	1.575	1.745	1.904	2.050	2.190	2.296	2.395	2.579
2004	0.381	0.780	1.097	1.349	1.575	1.745	1.904	2.050	2.190	2.296	2.395	2.579
2005	0.381	0.780	1.097	1.349	1.575	1.745	1.904	2.050	2.190	2.296	2.395	2.579
2006	0.381	0.780	1.097	1.349	1.575	1.745	1.904	2.050	2.190	2.296	2.395	2.579
2007	0.381	0.780	1.097	1.349	1.575	1.745	1.904	2.050	2.190	2.296	2.395	2.579
2008	0.381	0.780	1.097	1.349	1.575	1.745	1.904	2.050	2.190	2.296	2.395	2.579
2009	0.381	0.780	1.097	1.349	1.575	1.745	1.904	2.050	2.190	2.296	2.395	2.579

Table 3.2.1.2.4. Age-specific life history information used in ICA model (M = natural mortality; wt = weight; Mat = maturity) for the spiny lobster population off SE-US.

		Tagging ages		Lipofuscin ages	
Age	M ($year^{-1}$)	Wt (lbs)	Mat	Wt (lbs)	Mat
1	0.34	0.381	0	0.418	0
2	0.34	0.780	0.5	1.096	0.5
3	0.34	1.097	0.75	1.513	0.75
4	0.34	1.349	1	1.726	1
5	0.34	1.575	1	1.829	1
6	0.34	1.745	1	1.878	1
7	0.34	1.904	1	1.909	1
8	0.34	2.050	1	1.924	1
9	0.34	2.190	1	1.940	1
10	0.34	2.296	1	1.946	1
11	0.34	2.395	1	1.940	1
12+	0.34	2.579	1	1.948	1

Table 3.2.2.1. Analysis of variances from components in the objective function for ICA model.

a) ICA run with all indices included

SOURCES	SSQ	Data	Parameters	d.f.	Variance	Chi-sq	Prob Ho
Total for model	19.0392	260	57	203	0.0938		
Catches at age	5.7027	165	49	116	0.0492	2.7847	0.0000
Obs Pre-recruit Age 2	0.2415	8	1	7	0.0345	0.2694	0.0001
Obs Adult Age 3+	0.4270	8	1	7	0.0610	0.1790	0.0000
Puerulus 1988-2009	1.5096	22	1	21	0.0719	0.5539	0.0000
FWC Adult Mon Pre-recruit Timed	1.3915	10	1	9	0.1546	0.6202	0.0001
FWC Adult Mon Legal Timed	1.5568	10	1	9	0.1730	0.4574	0.0000
Biscayne National Park	4.5673	25	1	24	0.1903	1.5913	0.0000
FWC Adult Mon Pre-recruit Transect	1.1825	6	1	5	0.2365	0.5350	0.0092
FWC Adult Mon Legal Transect	2.4603	6	1	5	0.4921	2.2269	0.1831

b) Final ICA base run without the component for FWC Adult Monitoring Legal sizes Transect, which was not significant

SOURCES	SSQ	Data	Parameters	d.f.	Variance	Chi-sq	Prob Ho
Total for model	16.1104	254	56	198	0.0814		
Catches at age	5.6143	165	49	116	0.0484	2.7788	0.0000
Obs Pre-recruit Age 2	0.2285	8	1	7	0.0326	0.2545	0.0001
Obs Adult Age 2+	0.4165	8	1	7	0.0595	0.1746	0.0000
Puerulus 1988-2009	1.4938	22	1	21	0.0711	0.5517	0.0000
FWC Adult Mon Pre-recruit Timed	1.2778	10	1	9	0.1420	0.5688	0.0001
FWC Adult Mon Legal Timed	1.3895	10	1	9	0.1544	0.4085	0.0000
Biscayne National Park	4.5450	25	1	24	0.1894	1.6001	0.0000
FWC Adult Mon Pre-recruit Transect	1.1450	6	1	5	0.2290	0.5111	0.0083

Table 3.2.2.2. The parameters in the ICA model with their maximum likelihood values, CV, 95% confidence intervals, and the mean estimate.

Fishing mortality on age-3 spiny lobsters					
Fishing year	Max like	CV	Low 95%	Upper 95%	Mean
1995	0.4879	10	0.3966	0.6003	0.4907
1996	0.4903	10	0.4007	0.5999	0.4929
1997	0.6039	9	0.4978	0.7326	0.6069
1998	0.4236	10	0.3458	0.5188	0.4258
1999	0.6547	9	0.5413	0.7918	0.6578
2000	0.7846	9	0.6529	0.9429	0.788
2001	0.4745	10	0.3875	0.5811	0.4771
2002	0.6407	9	0.5269	0.779	0.6439
2003	0.4793	10	0.3886	0.5913	0.4821
2004	0.6228	10	0.5037	0.77	0.6265
2005	0.3816	12	0.2993	0.4866	0.3846
2006	0.4603	13	0.3513	0.6032	0.4647
2007	0.3231	15	0.2361	0.442	0.3272
2008	0.1975	17	0.14	0.2785	0.2005
2009	0.1462	18	0.1018	0.2101	0.1488

Population at age 11 (numbers in thousands)					
Fishing year	Max like	CV	Low 95%	Upper 95%	Mean
1995	53	30	29	96	55
1996	36	22	23	57	37
1997	28	19	19	41	29
1998	23	17	16	33	23
1999	20	16	14	27	20
2000	18	15	13	25	18
2001	15	15	11	20	15
2002	14	14	10	19	14
2003	10	15	7	14	10
2004	10	15	7	13	10
2005	9	16	6	12	9
2006	9	16	6	13	9
2007	8	18	5	12	8
2008	10	19	7	16	11

Table 3.2.2.2 (continued). The parameters in the ICA model with their maximum likelihood values, CV, 95% confidence intervals, and the mean estimate.

Selectivity by age

Age	Max like	CV	Low 95%	Upper 95%	Mean
1	0.2474	10	0.2008	0.3047	0.2488
2	0.8825	9	0.7263	1.0725	0.8869
3	1	**Fixed : Reference age**			
4	0.9743	9	0.8092	1.1732	0.9787
5	0.8279	9	0.6931	0.989	0.8313
6	0.7119	8	0.599	0.8461	0.7146
7	0.6683	8	0.5639	0.7919	0.6708
8	0.6021	8	0.5086	0.7127	0.6043
9	0.5063	8	0.4256	0.6024	0.5083
10	0.569	9	0.4747	0.6819	0.5714
11	1	**Fixed : Last true age (INPUT)**			

Population (number in thousands) in 2009-10 fishing year by age

Age	Max like	CV	Low 95%	Upper 95%	Mean
1	28368	22	18141	44360	29115
2	12665	16	9114	17600	12845
3	6838	16	4938	9469	6933
4	3267	17	2312	4616	3318
5	1527	18	1064	2191	1553
6	638	19	437	929	649
7	250	19	169	369	255
8	108	20	73	160	110
9	52	20	35	77	53
10	23	20	16	35	24
11	12	20	8	19	13

Catchability coefficients for the tuning indices

Index	Max like	CV	Low 95%	Upper 95%	Mean
Obs Pre-recruit (age-2)	3.71E-04	10	3.35E-04	5.07E-04	4.15E-04
Obs legal sizes (age 3+)	1.71E-03	10	1.55E-03	2.33E-03	1.91E-03
Puerulus (age-1)	1.22E-03	6	1.15E-03	1.50E-03	1.32E-03
FWC pre-recruits (age-2; timed)	1.31E-03	0	1.31E-03	1.31E-03	1.31E-03
FWC legal sizes (age 3+; timed)	4.13E-03	9	3.78E-03	5.43E-03	4.55E-03
BNP (age 2+)	9.54E-04	6	8.98E-04	1.15E-03	1.02E-03
FWCpre-recruits (age-2; transect)	9.81E-04	14	8.58E-04	1.49E-03	1.14E-03

Table 3.2.2.3. Estimated number (in thousands) of lobsters at the beginning of the fishing year and age from Integrated Catch-at-Age.

	Age after settlement											
Fishing year	1	2	3	4	5	6	7	8	9	10	11	12+
1985-86	17682	10319	4935	2704	1162	586	150	68	38	20	7	22
1986-87	18388	10969	5150	2390	1468	651	350	78	36	22	12	49
1987-88	18940	11349	5664	2559	1231	852	383	214	40	19	12	32
1988-89	18088	12166	5951	2832	1298	663	519	233	134	21	9	31
1989-90	16132	11023	5667	2749	1457	724	397	340	154	91	12	42
1990-91	15626	9752	4909	2340	1223	743	396	233	221	100	60	212
1991-92	14942	9426	4581	2212	1116	644	431	232	140	143	60	305
1992-93	16430	9254	4348	1952	1024	570	362	254	138	86	91	423
1993-94	16223	10533	4952	2172	967	531	303	192	144	78	43	199
1994-95	15915	10264	5265	2388	1113	528	312	181	119	93	49	191
1995-96	16151	9837	4711	2347	1106	545	265	164	99	70	54	298
1996-97	16357	10189	4552	2058	1038	525	274	136	87	55	38	112
1997-98	14630	10312	4705	1984	909	493	264	141	72	48	30	156
1998-99	16994	8968	4308	1831	784	392	228	125	70	38	24	128
1999-00	15171	10893	4392	2007	862	393	207	122	69	40	21	58
2000-01	11938	9184	4351	1624	755	357	176	95	59	35	20	148
2001-02	12635	6998	3271	1413	538	281	145	74	42	28	16	142
2002-03	12033	7997	3277	1448	633	259	143	75	40	24	15	105
2003-04	13018	7309	3234	1229	552	265	117	66	36	20	12	28
2004-05	14609	8230	3408	1425	548	264	134	60	35	20	11	24
2005-06	16446	8913	3381	1301	553	233	121	63	29	18	10	25
2006-07	16455	10651	4530	1643	639	287	126	67	36	17	10	25
2007-08	17407	10452	5050	2035	747	310	147	66	36	20	9	27
2008-09	18687	11438	5594	2602	1057	407	176	84	39	22	12	53
2009-10	28369	12667	6839	3268	1528	639	252	110	53	25	14	28

Table 3.2.2.6. Estimated fishing mortality per year by fishing year and age from Integrated Catch-at-Age.

	Age after settlement											
Fishing year	1	2	3	4	5	6	7	8	9	10	11	12+
1985-86	0.14	0.35	0.39	0.27	0.24	0.18	0.31	0.29	0.21	0.18	0.37	0.37
1986-87	0.14	0.32	0.36	0.32	0.20	0.19	0.15	0.32	0.30	0.27	0.38	0.38
1987-88	0.10	0.31	0.35	0.34	0.28	0.16	0.16	0.13	0.33	0.42	0.38	0.38
1988-89	0.16	0.42	0.43	0.32	0.24	0.17	0.08	0.08	0.05	0.18	0.27	0.27
1989-90	0.16	0.47	0.54	0.47	0.33	0.26	0.19	0.09	0.09	0.07	0.34	0.34
1990-91	0.17	0.42	0.46	0.40	0.30	0.20	0.20	0.17	0.09	0.17	0.34	0.34
1991-92	0.14	0.43	0.51	0.43	0.33	0.24	0.19	0.18	0.14	0.12	0.36	0.36
1992-93	0.10	0.29	0.35	0.36	0.32	0.29	0.29	0.23	0.23	0.36	0.42	0.42
1993-94	0.12	0.35	0.39	0.33	0.27	0.19	0.17	0.14	0.10	0.12	0.29	0.29
1994-95	0.14	0.44	0.47	0.43	0.37	0.35	0.30	0.26	0.19	0.19	0.44	0.44
1995-96	0.12	0.43	0.49	0.48	0.40	0.35	0.33	0.29	0.25	0.28	0.49	0.49
1996-97	0.12	0.43	0.49	0.48	0.41	0.35	0.33	0.30	0.25	0.28	0.49	0.49
1997-98	0.15	0.53	0.60	0.59	0.50	0.43	0.40	0.36	0.31	0.34	0.60	0.60
1998-99	0.10	0.37	0.42	0.41	0.35	0.30	0.28	0.26	0.21	0.24	0.42	0.42
1999-00	0.16	0.58	0.65	0.64	0.54	0.47	0.44	0.39	0.33	0.37	0.65	0.65
2000-01	0.19	0.69	0.78	0.76	0.65	0.56	0.52	0.47	0.40	0.45	0.78	0.78
2001-02	0.12	0.42	0.47	0.46	0.39	0.34	0.32	0.29	0.24	0.27	0.47	0.47
2002-03	0.16	0.57	0.64	0.62	0.53	0.46	0.43	0.39	0.32	0.36	0.64	0.64
2003-04	0.12	0.42	0.48	0.47	0.40	0.34	0.32	0.29	0.24	0.27	0.48	0.48
2004-05	0.15	0.55	0.62	0.61	0.52	0.44	0.42	0.37	0.32	0.35	0.62	0.62
2005-06	0.09	0.34	0.38	0.37	0.32	0.27	0.26	0.23	0.19	0.22	0.38	0.38
2006-07	0.11	0.41	0.46	0.45	0.38	0.33	0.31	0.28	0.23	0.26	0.46	0.46
2007-08	0.08	0.29	0.32	0.31	0.27	0.23	0.22	0.19	0.16	0.18	0.32	0.32
2008-09	0.05	0.17	0.20	0.19	0.16	0.14	0.13	0.12	0.10	0.11	0.20	0.20
2009-10	0.04	0.13	0.15	0.14	0.12	0.10	0.10	0.09	0.07	0.08	0.15	0.15

Table 3.2.2.9.1. Comparison of total biomass, spawning biomass, recruitment, and fishing mortality per year on the fully recruited ages estimated with three natural mortality rates: 0.25, 0.34, and 0.43 per year.

	M = 0.25				M = 0.34				M = 0.43			
	Biomass (millions lbs)		Recruitment	Fishing	Biomass (millions lbs)		Recruitment	Fishing	Biomass (millions lbs)		Recruitment	Fishing
Fishing year	Total	Spawning	Millions	mortality	Total	Spawning	Millions	mortality	Total	Spawning	Millions	mortality
1985-86	20.33	6.14	13.075	0.51	27.33	8.87	17.682	0.39	41.33	14.45	26.513	0.26
1986-87	21.73	6.78	13.914	0.47	28.99	9.64	18.388	0.36	43.01	15.31	26.395	0.25
1987-88	23.31	7.40	14.603	0.46	30.57	10.28	18.94	0.35	44.05	15.78	26.367	0.24
1988-89	24.91	7.89	14.12	0.54	31.84	10.64	18.088	0.43	44.34	15.76	24.859	0.32
1989-90	24.02	7.19	12.573	0.68	30.36	9.71	16.132	0.54	41.62	14.30	22.129	0.40
1990-91	22.00	7.07	12.077	0.57	27.96	9.41	15.626	0.46	38.43	13.60	21.675	0.34
1991-92	21.07	6.60	11.334	0.64	26.80	8.77	14.942	0.51	36.75	12.61	21.06	0.38
1992-93	20.76	6.76	12.624	0.44	26.51	8.87	16.43	0.35	36.29	12.53	22.695	0.26
1993-94	21.80	7.14	12.716	0.48	27.29	9.09	16.223	0.39	36.43	12.43	21.867	0.30
1994-95	22.61	6.78	12.48	0.57	27.79	8.56	15.915	0.47	36.36	11.61	21.468	0.36
1995-96	21.96	6.43	12.583	0.59	26.97	8.07	16.151	0.49	35.26	10.90	21.929	0.38
1996-97	21.25	6.01	12.761	0.59	26.00	7.48	16.357	0.49	33.89	10.04	22.193	0.38
1997-98	20.80	5.30	11.447	0.72	25.28	6.67	14.63	0.60	32.76	9.12	19.721	0.47
1998-99	19.54	5.66	13.421	0.50	23.90	6.94	16.994	0.42	31.19	9.26	22.631	0.33
1999-00	20.83	4.91	12.089	0.77	24.93	6.06	15.171	0.65	31.86	8.24	20.136	0.51
2000-01	18.04	3.76	9.428	0.94	21.65	4.84	11.938	0.78	28.07	7.00	16.224	0.59
2001-02	14.66	3.93	9.911	0.58	18.10	5.00	12.635	0.47	24.51	7.21	17.446	0.34
2002-03	15.26	3.45	9.422	0.79	18.70	4.50	12.033	0.64	25.32	6.79	16.863	0.45
2003-04	14.23	3.58	10.058	0.60	17.78	4.69	13.018	0.48	24.94	7.13	18.699	0.33
2004-05	15.54	3.22	11.111	0.81	19.56	4.46	14.609	0.62	27.89	7.27	21.564	0.41
2005-06	15.67	3.98	12.16	0.52	20.51	5.55	16.446	0.38	30.68	8.97	25.044	0.24
2006-07	17.96	4.26	11.767	0.67	23.85	6.38	16.455	0.46	36.00	10.75	25.771	0.27
2007-08	18.15	5.14	12.183	0.49	25.42	7.90	17.407	0.32	39.66	13.22	27.385	0.19
2008-09	20.33	7.08	13.124	0.29	28.87	10.48	18.687	0.20	44.64	16.59	28.793	0.12
2009-10	26.83	9.77	20.342	0.21	37.11	13.58	28.369	0.15	54.90	20.02	41.967	0.10

Table 3.2.2.9.2. Comparison of total biomass, spawning biomass, recruitment, and fishing mortality per year on the fully recruited age estimated with a natural mortality rate (M) of 0.34 per year. Results relate to base run, runs with variations of the post-larvae index (i.e., 1988-98 time series; excluded; and 1993-2009 time series with data from both Big Munson and Long Key sites), and base run with M = 0.8 per year on age-1 lobsters over 1999-09.

	Base (with full post-larvae)				Post-larvae: 1988 - 1998				No post-larvae				Post-larvae: 1993-2009 (Long Key and Big Munson sites)				Base run with M = $0.8*year^{-1}$ on age-1 lobsters , 1999-09			
	Biomass (millions lbs)		Recruitment	Fishing	Biomass (millions lbs)		Recruitment	Fishing	Biomass (millions lbs)		Recruitment	Fishing	Biomass (millions lbs)		Recruitment	Fishing	Biomass (millions lbs)		Recruitment	Fishing
Fishing year	Total	Spawning	Thousands	mortality	Total	Spawning	Thousands	mortality	Total	Spawning	Thousands	mortality	Total	Spawning	Thousands	mortality	Total	Spawning	Thousands	mortality
1985-86	27.33	8.87	17682	0.39	27.28	8.84	17660	0.39	27.29	8.85	17660	0.39	27.31	8.85	17670	0.39	27.30	8.85	17660	0.39
1986-87	28.99	9.64	18388	0.36	28.95	9.61	18370	0.36	28.96	9.62	18380	0.36	28.97	9.63	18370	0.36	28.97	9.63	18370	0.36
1987-88	30.57	10.28	18940	0.35	30.53	10.25	18930	0.35	30.54	10.26	18930	0.35	30.55	10.27	18930	0.35	30.54	10.26	18920	0.35
1988-89	31.84	10.64	18088	0.43	31.80	10.62	18080	0.43	31.81	10.62	18080	0.43	31.81	10.63	18070	0.43	31.80	10.62	18070	0.43
1989-90	30.36	9.71	16132	0.54	30.32	9.68	16120	0.55	30.34	9.69	16130	0.54	30.33	9.69	16120	0.55	30.32	9.68	16120	0.55
1990-91	27.96	9.41	15626	0.46	27.93	9.38	15630	0.46	27.94	9.39	15630	0.46	27.93	9.39	15620	0.46	27.93	9.38	15620	0.46
1991-92	26.80	8.77	14942	0.51	26.79	8.75	14980	0.51	26.80	8.76	14970	0.51	26.77	8.75	14930	0.51	26.78	8.75	14960	0.51
1992-93	26.51	8.87	16430	0.35	26.55	8.86	16530	0.35	26.55	8.87	16520	0.35	26.47	8.85	16400	0.35	26.52	8.85	16490	0.35
1993-94	27.29	9.09	16223	0.39	27.44	9.12	16430	0.39	27.42	9.12	16390	0.39	27.23	9.07	16170	0.39	27.37	9.10	16350	0.39
1994-95	27.79	8.56	15915	0.47	28.14	8.65	16340	0.46	28.08	8.64	16230	0.46	27.64	8.53	15660	0.47	27.98	8.61	16120	0.46
1995-96	26.97	8.07	16151	0.49	27.58	8.15	16660	0.50	27.27	8.13	16070	0.50	26.57	8.02	15600	0.49	27.27	8.10	16370	0.49
1996-97	26.00	7.48	16357	0.49	26.74	7.60	16840	0.50	26.24	7.53	16410	0.49	25.36	7.39	15590	0.49	26.37	7.52	16490	0.50
1997-98	25.28	6.67	14630	0.60	26.02	6.79	14880	0.61	25.65	6.73	14920	0.61	24.74	6.58	14630	0.60	25.61	6.69	14620	0.62
1998-99	23.90	6.94	16994	0.42	24.54	7.07	17310	0.43	24.30	7.03	16950	0.43	23.57	6.86	16610	0.43	24.12	6.94	16990	0.43
1999-00	24.93	6.06	15171	0.65	28.34	6.21	22690	0.66	28.05	6.18	22520	0.65	24.36	5.97	14390	0.67	28.06	6.08	22920	0.66
2000-01	21.65	4.84	11938	0.78	23.95	4.97	17870	0.76	23.79	4.96	17780	0.76	21.08	4.71	11780	0.80	23.81	4.81	17880	0.79
2001-02	18.10	5.00	12635	0.47	20.51	5.14	18920	0.45	20.41	5.12	18820	0.45	17.48	4.83	11850	0.49	20.34	4.94	19090	0.48
2002-03	18.70	4.50	12033	0.64	21.07	4.71	18450	0.60	20.97	4.69	18360	0.60	18.02	4.27	11930	0.66	20.68	4.42	18060	0.64
2003-04	17.78	4.69	13018	0.48	20.82	5.00	20390	0.44	20.71	4.97	20260	0.44	16.94	4.41	12010	0.51	19.96	4.58	19560	0.48
2004-05	19.56	4.46	14609	0.62	23.86	5.00	24530	0.55	23.70	4.95	24360	0.55	18.55	4.03	14360	0.67	21.90	4.34	21790	0.62
2005-06	20.51	5.55	16446	0.38	26.52	6.49	28250	0.32	26.28	6.41	27990	0.33	19.17	4.96	15280	0.43	23.15	5.36	24580	0.39
2006-07	23.85	6.38	16455	0.46	31.36	7.98	29630	0.37	31.02	7.86	29310	0.37	21.71	5.39	14840	0.55	26.13	6.09	24220	0.47
2007-08	25.42	7.90	17407	0.32	35.09	10.37	32270	0.25	34.64	10.20	31880	0.25	21.64	6.35	14060	0.40	27.53	7.44	25420	0.33
2008-09	28.87	10.48	18687	0.20	41.43	14.00	36840	0.15	40.82	13.75	36320	0.15	23.55	8.01	15930	0.26	30.65	9.74	26970	0.21
2009-10	37.11	13.58	28369	0.15	66.50	18.49	85060	0.10	65.11	18.15	82860	0.10	27.39	10.16	17160	0.20	39.02	12.46	38680	0.16

Table 5.1.1. Age specific natural mortality rates, selectivities, average female weight, proportion mature, number of broods per spawning season, average number of eggs produced per spawn; and sex-ratio for females. See section3.2.1.2 for estimated proportion mature-at-age.

			Catch (both sexes)	Female population	Proportion mature				
Age	M	Selectivity	Weight (lbs)	Weight (lbs)	Assumed	Estimated	Broods	Eggs	Sex ratio
1	0.34	0.247	0.890	0.381	0.00	0.54	1	70983	0.50
2	0.34	0.883	1.073	0.780	0.50	0.80	1	270292	0.50
3	0.34	1.000	1.232	1.097	0.75	0.93	1	406946	0.50
4	0.34	0.974	1.416	1.349	1.00	0.98	1	507239	0.50
5	0.34	0.828	1.619	1.575	1.00	0.99	1	592776	0.50
6	0.34	0.712	1.832	1.745	1.00	1.00	1	654809	0.50
7	0.34	0.668	2.071	1.904	1.00	1.00	2	711260	0.50
8	0.34	0.602	2.272	2.050	1.00	1.00	2	761798	0.50
9	0.34	0.506	2.434	2.190	1.00	1.00	2	809349	0.50
10	0.34	0.569	2.746	2.296	1.00	1.00	2	844449	0.50
11	0.34	1.000	3.188	2.395	1.00	1.00	2	877102	0.50
12	0.34	1.000	3.636	2.483	1.00	1.00	2	905947	0.50
13	0.34	1.000	3.615	2.583	1.00	1.00	2	938062	0.50
14	0.34	1.000	3.704	2.655	1.00	1.00	2	960976	0.50
15+	0.34	1.000	3.692	2.732	1.00	1.00	2	985381	0.50

Table 6.3.1. Fishing mortality rates on fully recruited spiny lobsters (Age-3) and static SPR values based on eggs per recruit by fishing year. Static SPR was calculated using assumed and estimated maturity schedules (mat_a).

Fishing year	Fishing mortality (yr^{-1})	Static SPR eggs assumed mat_a	estimated mat_a
1985	0.385	24%	28%
1986	0.3595	26%	30%
1987	0.3533	26%	30%
1988	0.4322	21%	25%
1989	0.5446	16%	20%
1990	0.4571	19%	24%
1991	0.5129	17%	21%
1992	0.3541	26%	30%
1993	0.3893	24%	28%
1994	0.468	19%	23%
1995	0.4879	18%	22%
1996	0.4903	18%	22%
1997	0.6039	13%	18%
1998	0.4236	21%	26%
1999	0.6547	12%	16%
2000	0.7846	9%	13%
2001	0.4745	19%	23%
2002	0.6407	12%	17%
2003	0.4793	18%	23%
2004	0.6228	13%	17%
2005	0.3816	24%	28%
2006	0.4603	19%	24%
2007	0.3231	29%	33%
2008	0.1975	44%	48%
2009	0.1462	54%	57%

Table 6.3.2. Management benchmarks for the spiny lobster off SE US calculated using assumed (a) and estimated (b) maturity schedules.

a

Criterion	Description	Definition	Value from Assessment
MSST	Minimum Spawning Stock Threshold	Bmsy*(1-M) or 0.5Bmsy	1.150 x 10^{12} eggs
MFMT	Maximum Fishing Mortality Threshold	Fmsy = F20%SPR	0.45 per year
MSY	Maximum Sustainable Yield	Yield @ F20%SPR	7,950,000 lb
BMSY	Biomass at MSY	Biomass @ F20%SPR	1.743 x 10^{12} eggs
FOY	Fishing Mortality at Optimum Yield	F30%SPR	0.31 per year
OY	Optimum Yield	Yield @ F30%SPR	6,940,000 lb
	Fcurrent	GM 2007-2009	0.21 per year
	Fcurrent/F20%SPR		0.47
	SSBcurrent	GM 2007-2009	2.240 x 10^{12} eggs
	SSBcurrent/SSB F20%SPR		1.29

b

Criterion	Description	Definition	Value from Assessment
MSST	Minimum Spawning Stock Threshold	Bmsy*(1-M) or 0.5Bmsy	1.190 x 10^{12} eggs
MFMT	Maximum Fishing Mortality Threshold	Fmsy = F20%SPR	0.54 per year
MSY	Maximum Sustainable Yield	Yield @ F20%SPR	8,020,000 lb
BMSY	Biomass at MSY	Biomass @ F20%SPR	1.803 x 10^{12} eggs
FOY	Fishing Mortality at Optimum Yield	F30%SPR	0.36 per year
OY	Optimum Yield	Yield @ F30%SPR	7,260,000 lb
	Fcurrent	GM 2007-2009	0.21 per year
	Fcurrent/F20%SPR		0.39
	SSBcurrent	GM 2007-2009	3.110 x 10^{12} eggs
	SSBcurrent/SSB F20%SPR		1.72

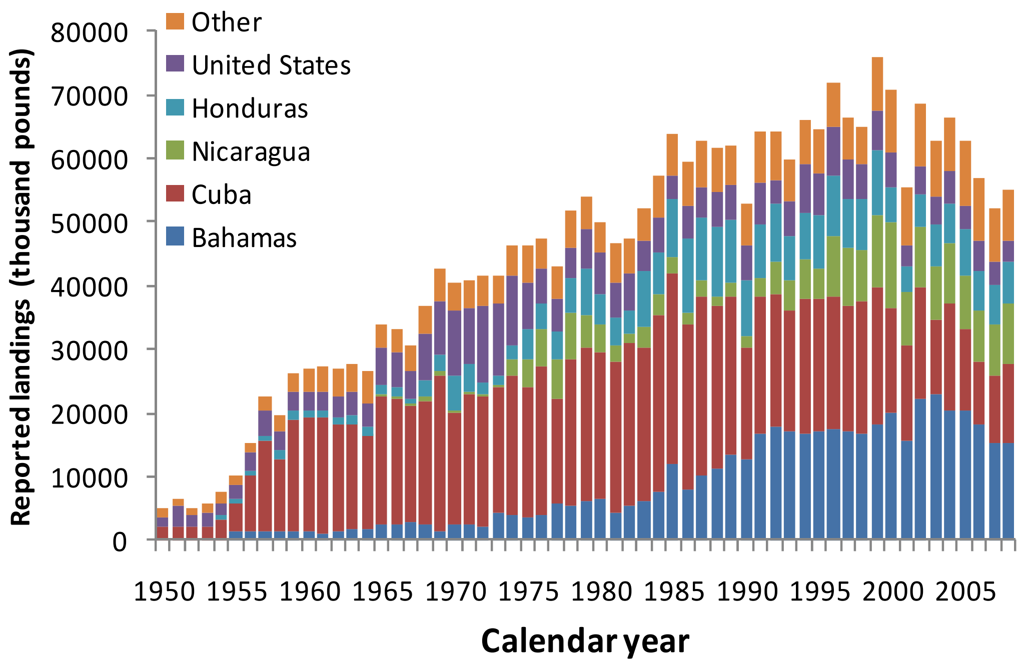


Figure 1. Reported landings (thousand pounds) of the Caribbean spiny lobster in the western central Atlantic, 1950 – 2008 (Source: FAO Fisheries and Aquaculture Statistics and Information Service. 2010).

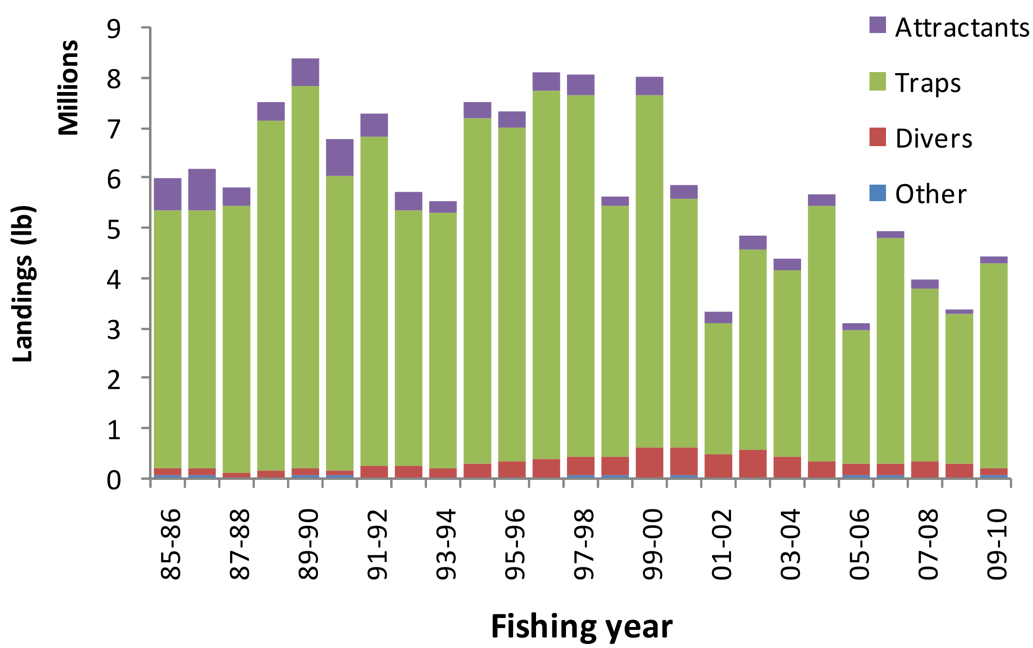
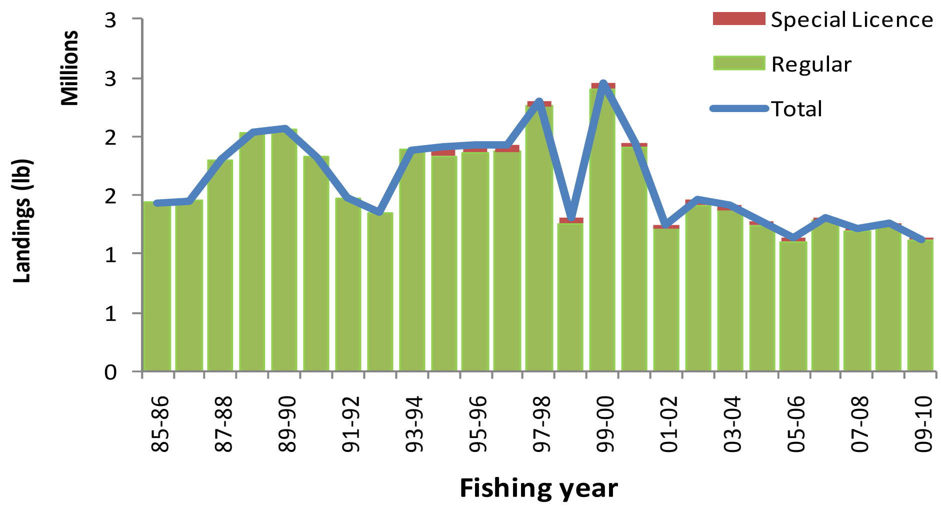
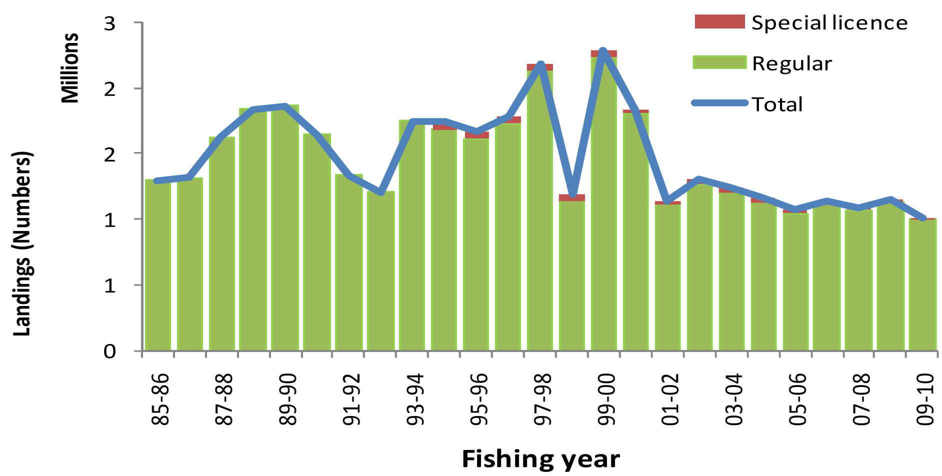


Figure 2.1.1. Commercial landings in pounds by gear and fishing year for spiny lobster off the Southeastern Unites States.





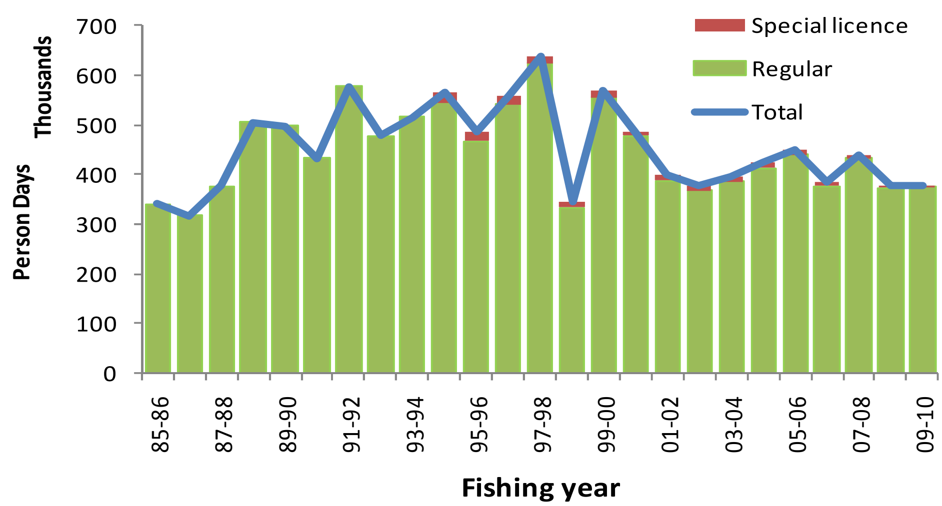


Figure 2.1.2. Recreational and Special Recreational License landings in pounds (top) and numbers (middle) and the number person-days (bottom) by fishing year. The effort for the Special Recreational License is expressed in person-day equivalents. Note that values prior to 1992-93 fishing year were not observations but rather estimates.

Figure 2.2.1. Geographic regions for spiny lobster in the southeastern U.S.

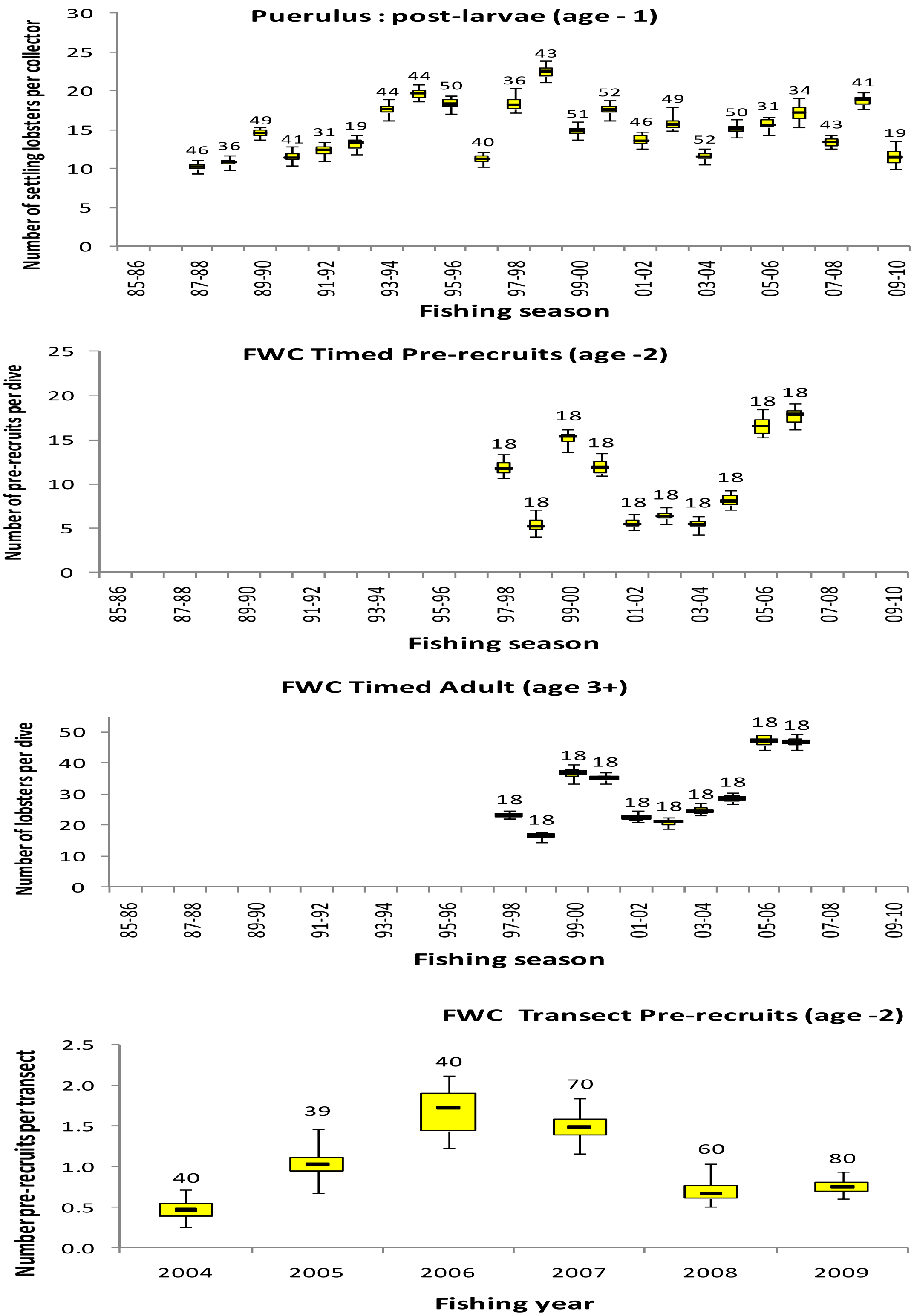


Figure 2.3.4 . Tuning indices by fishing year. The vertical line is the 95% confidence interval, the box is the inter-quartiles (25 to 75 percentiles) and the horizontal line is the median.

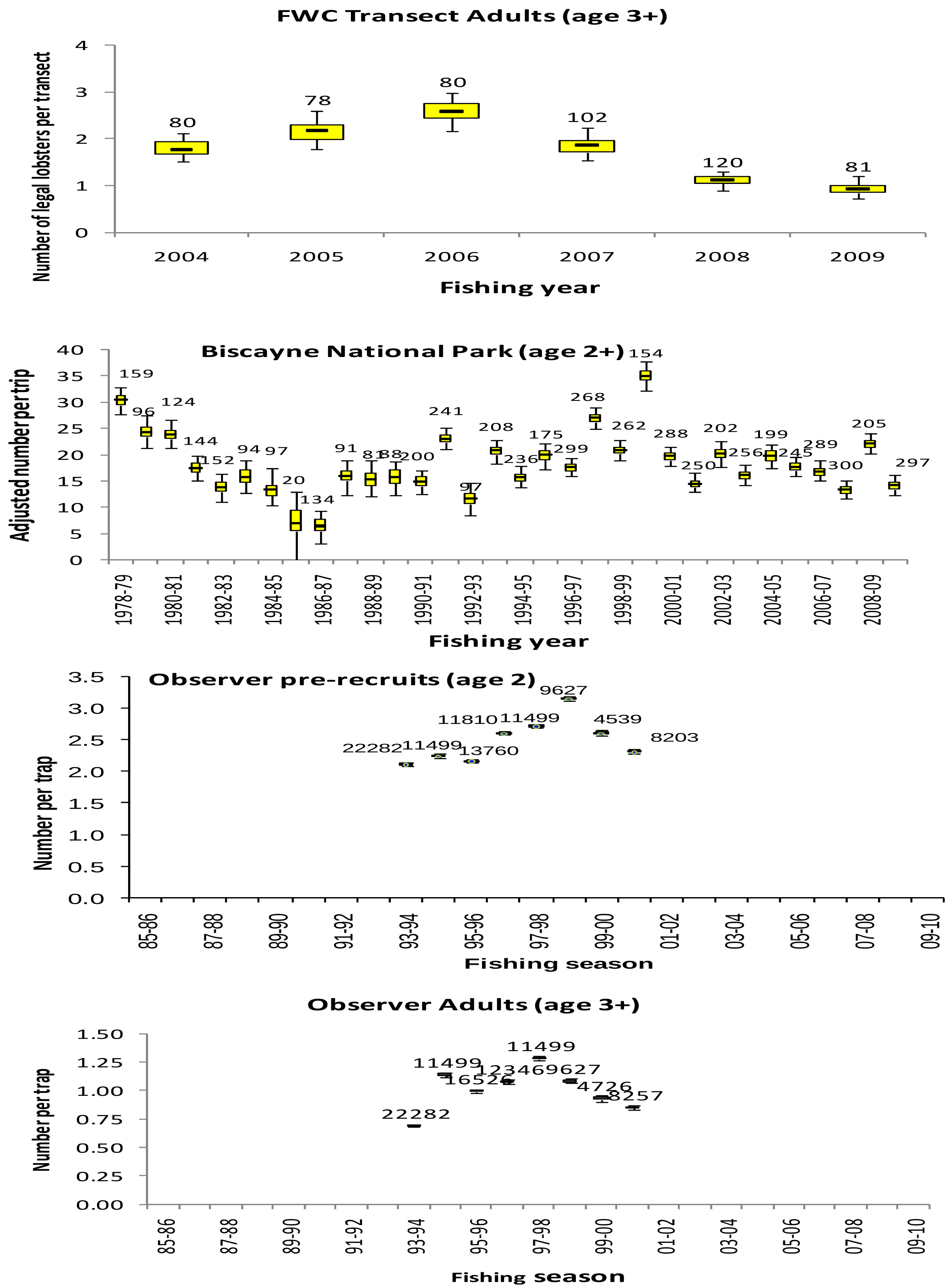


Figure 2.3.4 (Continued). Tuning indices by fishing year. The vertical line is the 95% confidence interval, the box is the inter-quartiles (25 to 75 percentiles) and the horizontal line is the median.

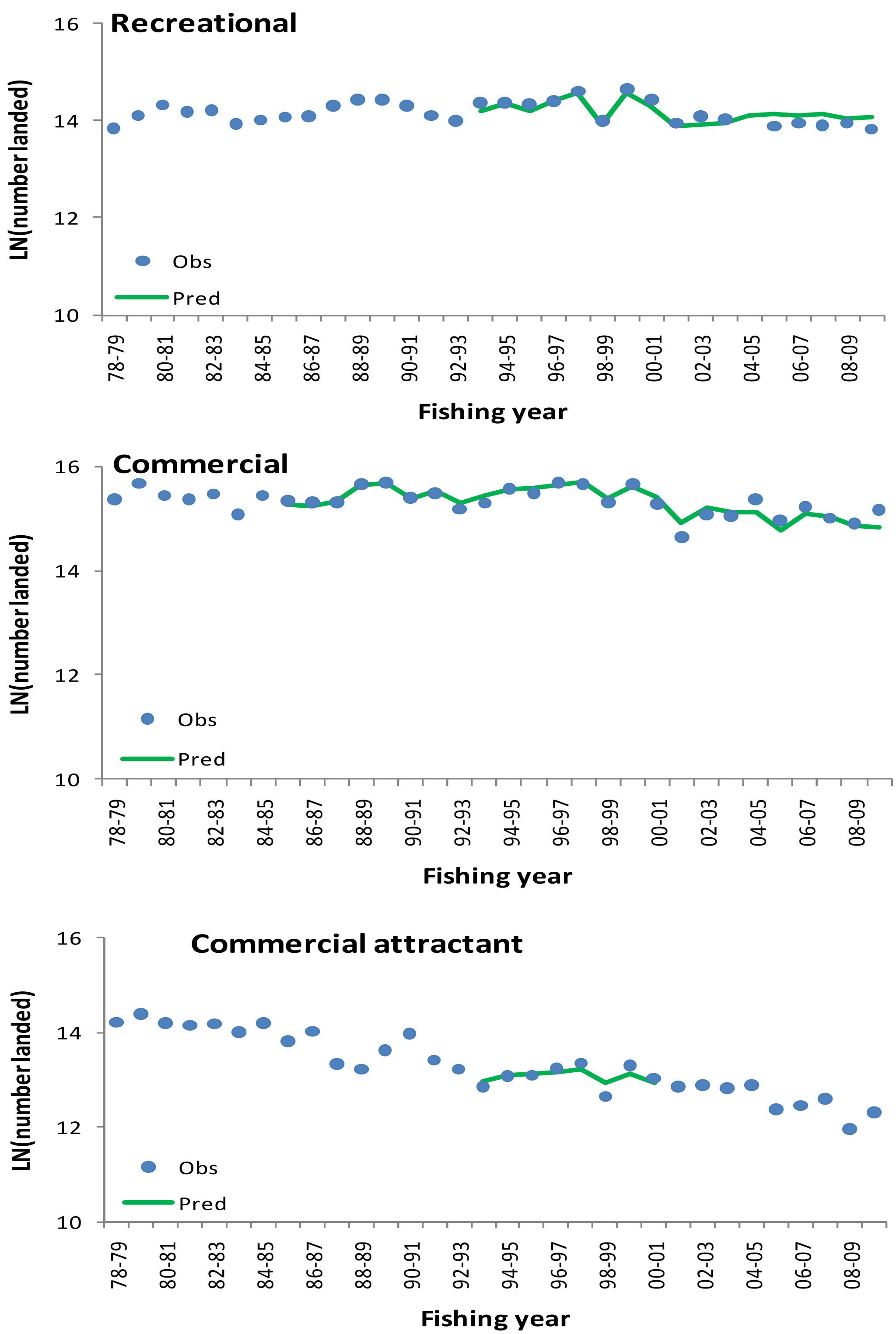


Figure 3.1.2.1. Fit of DeLury model run to harvests by fishery sector. Estimated values of landings were not considered in the model fit.

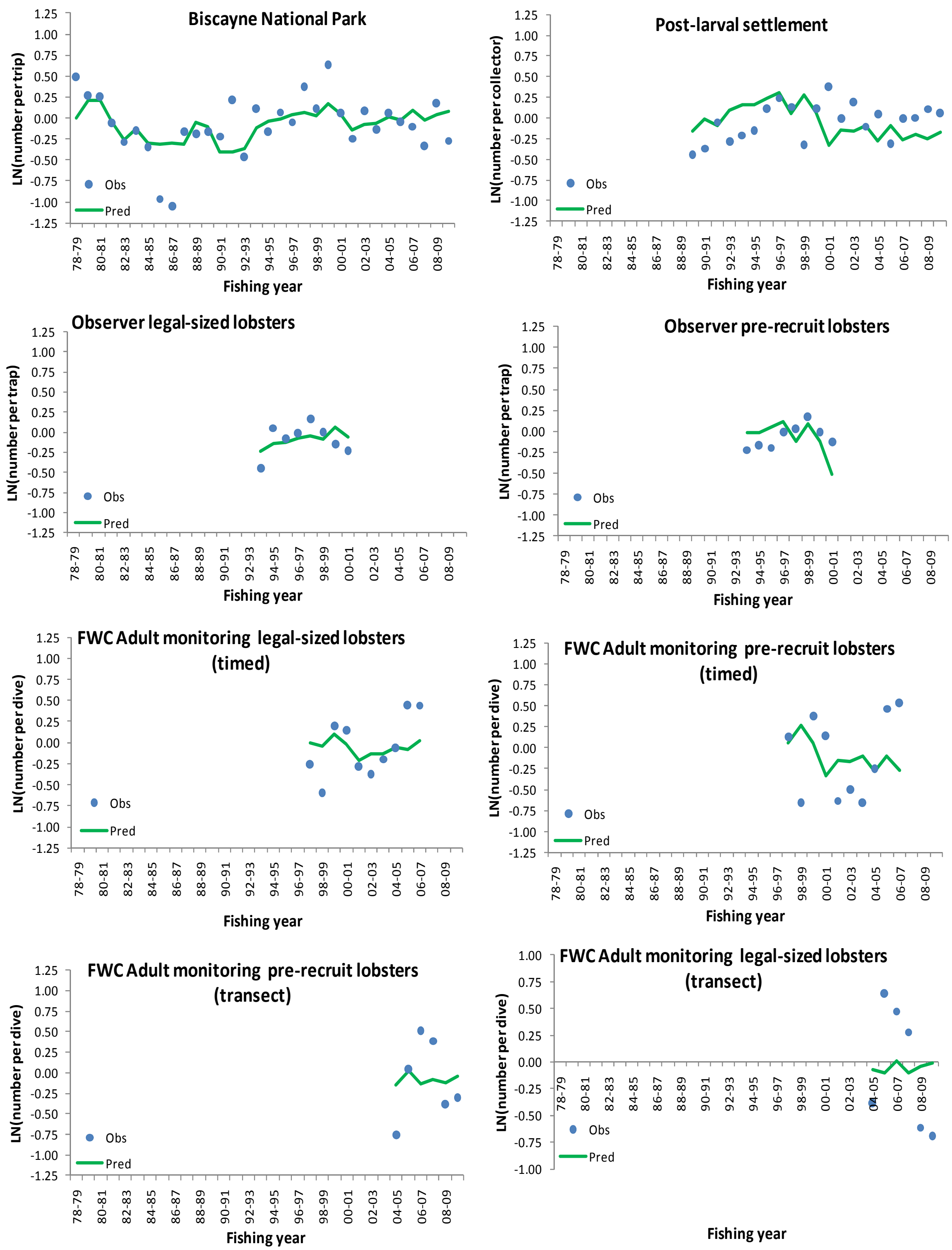
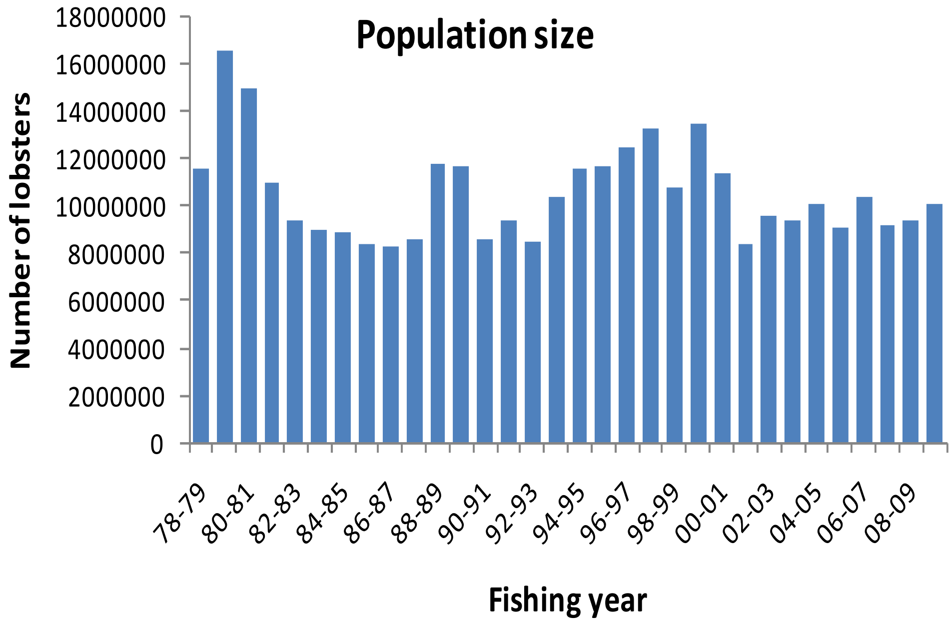


Figure 3.1.2.1 (continued). Fit of DeLury model run to indices. See their designations in the corresponding plots.



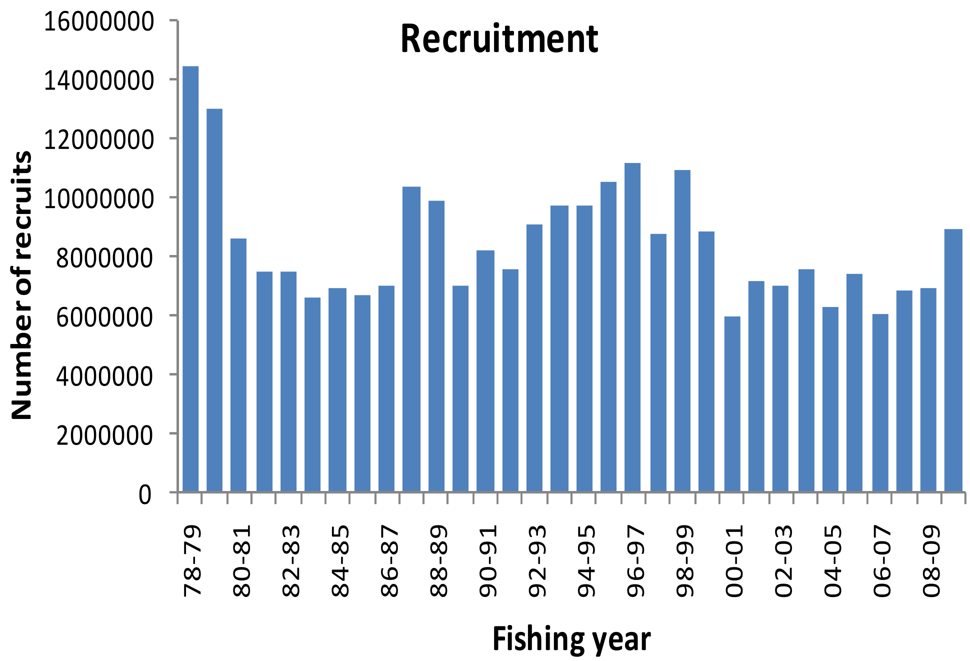


Figure 3.1.2.3. Estimated number of lobsters and recruitment at the beginning of the fishing year from the DeLury model.

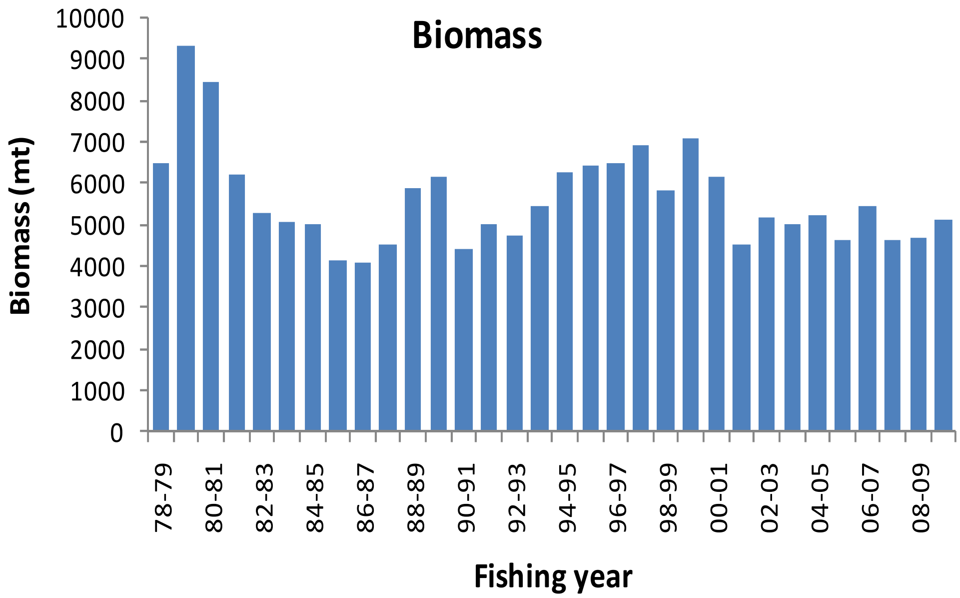


Figure 3.1.2.4. Biomass of lobsters at the beginning of the fishing year.

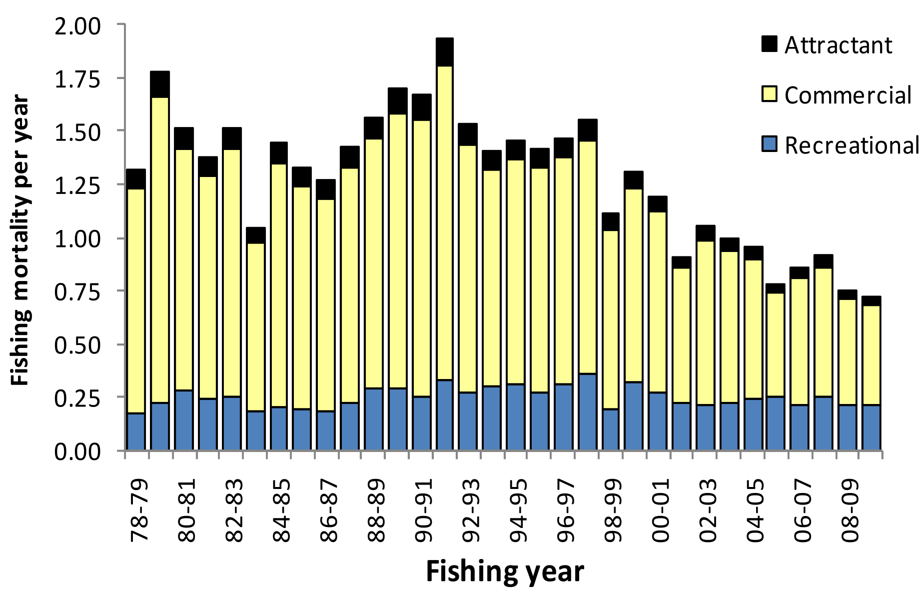


Figure 3.1.2.6. Fishing mortality per year by fishing year for the recreational fishery (blue bars), commercial fishery (yellow bars), and attractant fishery (black bars).

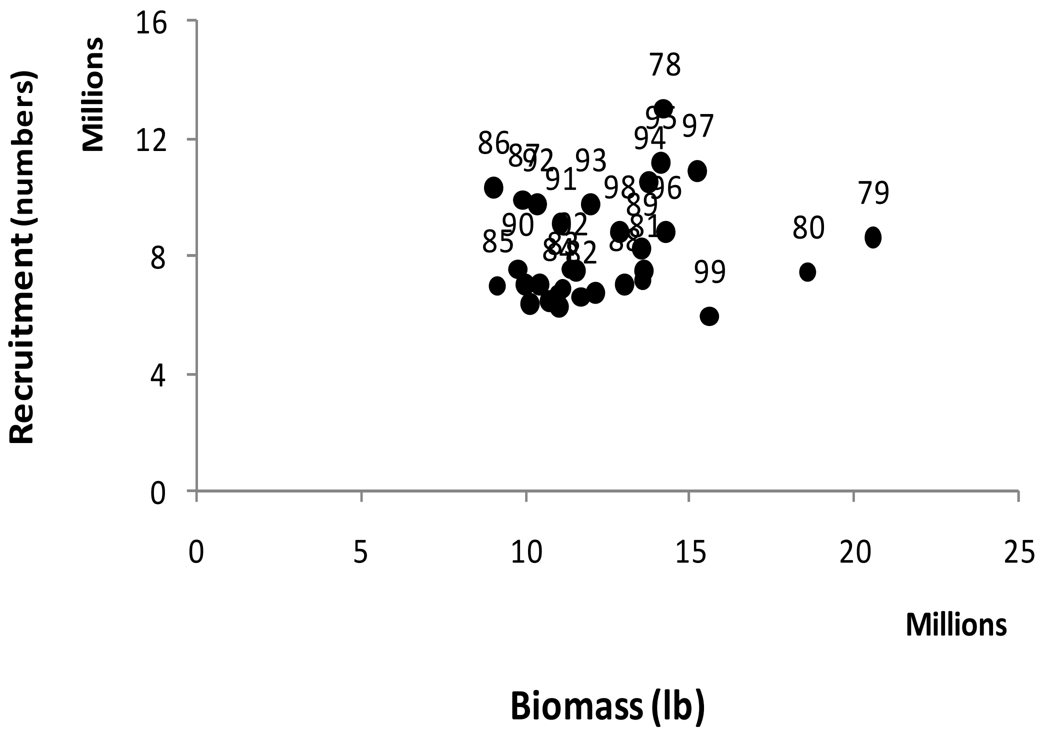
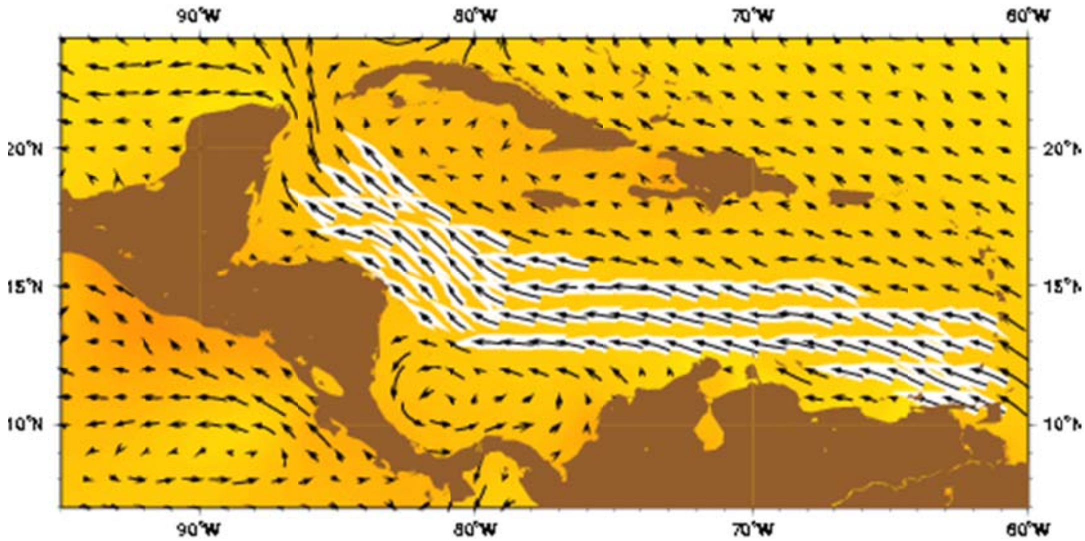


Figure 3.1.2.7.1. Stock in biomass and recruitment two years later. Some numbers above the points are some of the biomass years (78-07), the other years were too close to each other to be distinguished.

a. Caribbean Current



b. Loop Current

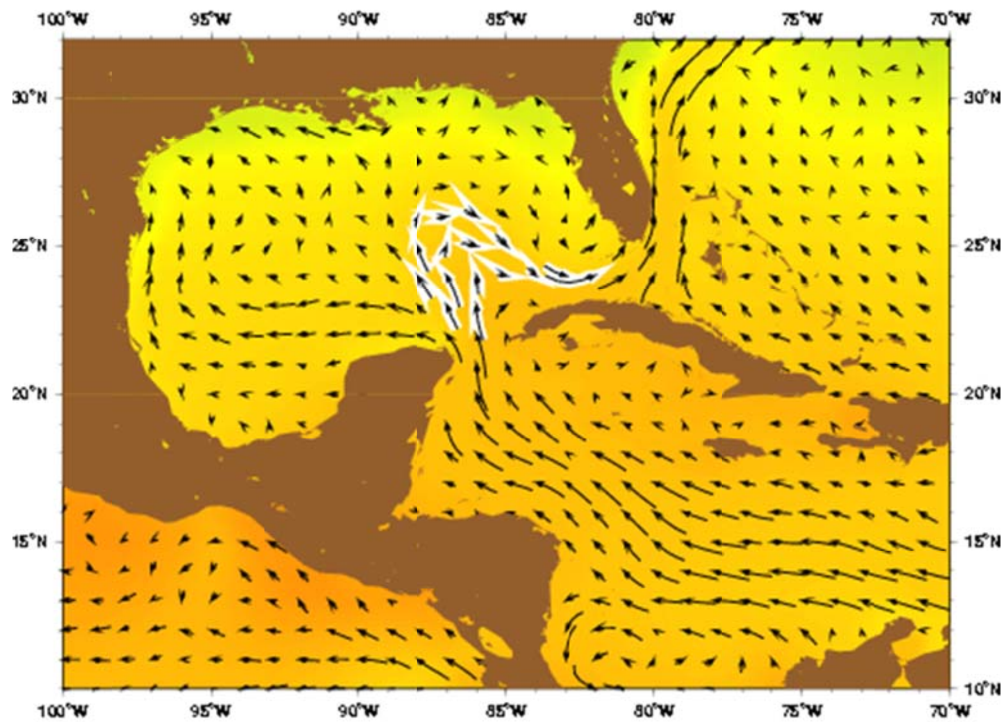


Figure 3.1.2.7.2. The Caribbean Current (a, Gyory et al. undated a) and the Loop Current b, Gyory et al. undated b)
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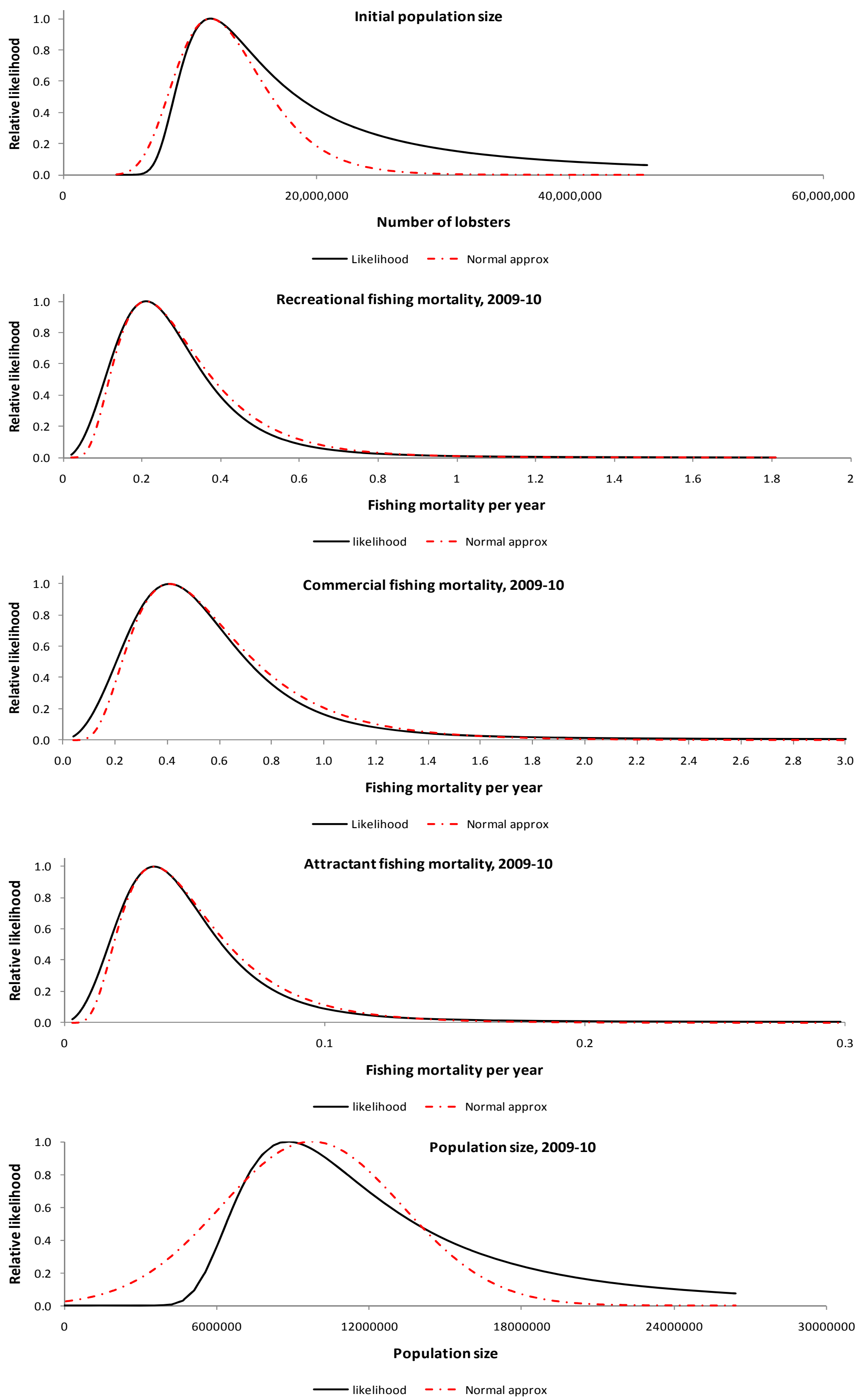


Figure 3.1.2.8. Likelihood profiles and normal approximation for the DeLury model about the initial population size, fishing mortality by sector, and current population size.

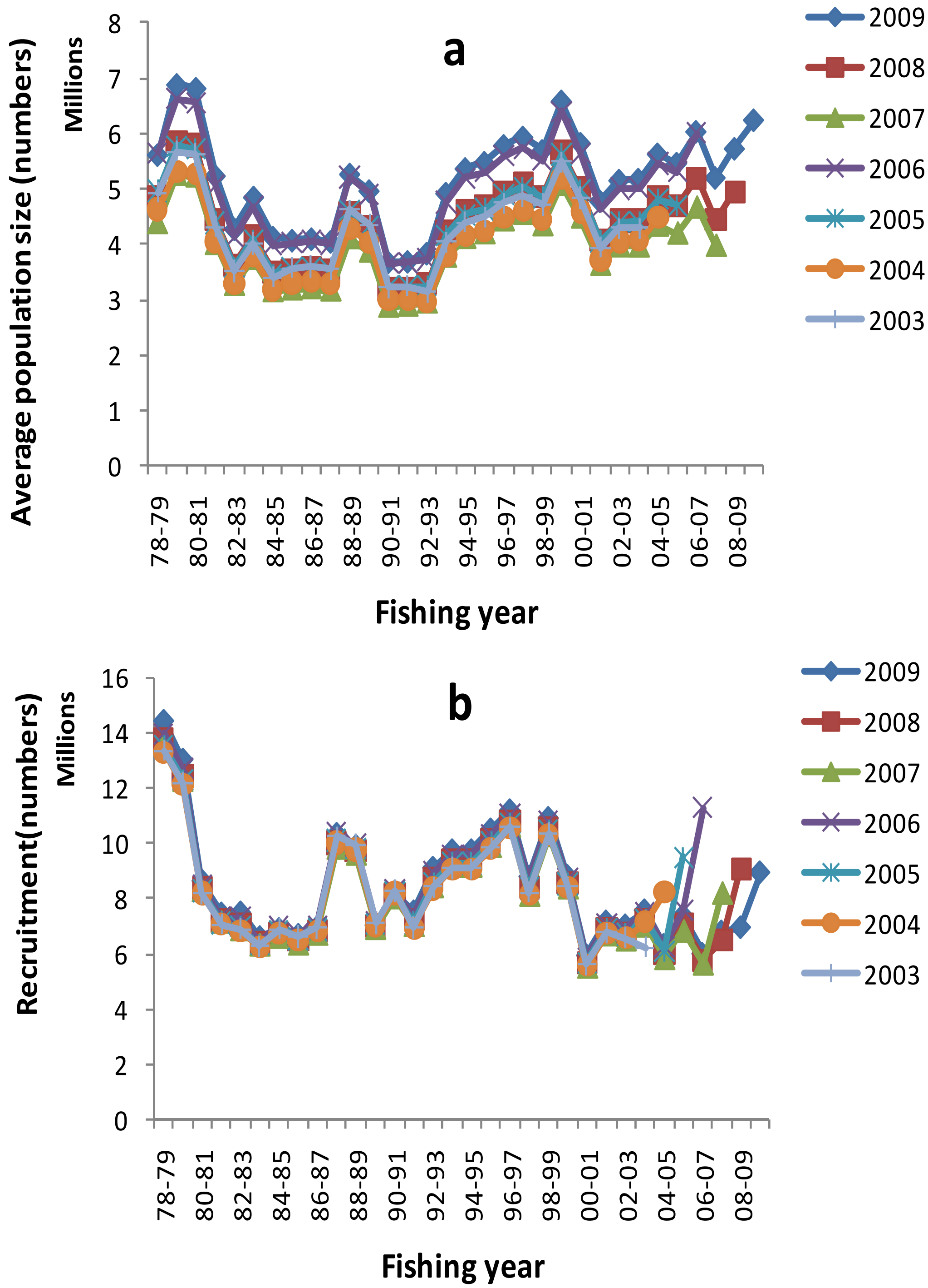


Figure 3.1.2.9.1 Retrospective analyses of average population size (a) and recruitment (b) from the DeLury model with ending fishing years 2003-04 through 2009-10.

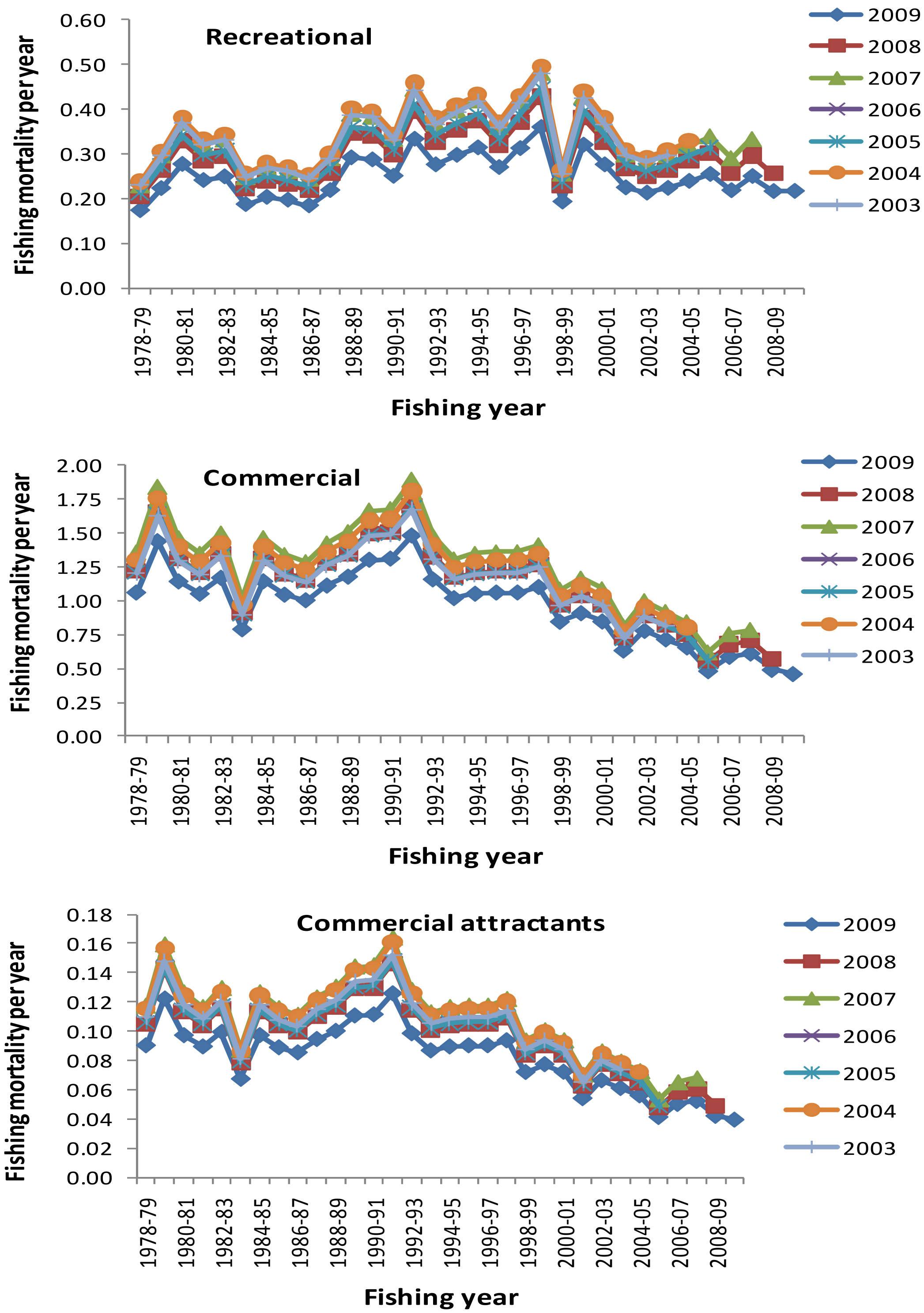


Figure 3.1.2.9.2. Retrospective analyses of fishing mortality by sector from the DeLury model with ending fishing years 2003-04 through 2009-10

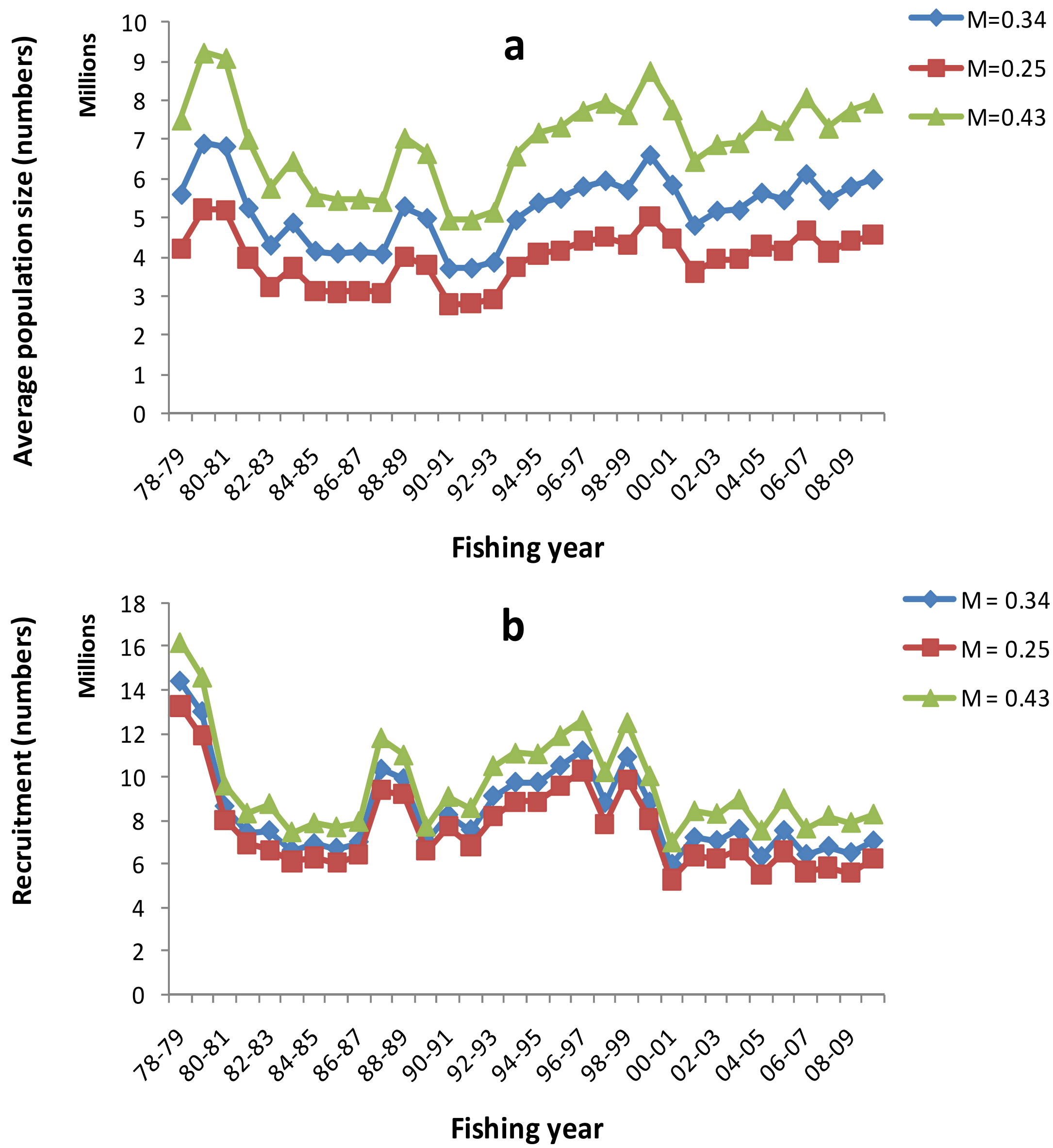


Figure 3.1.2.9.3. Average population size (a) and recruitment trajectories from the DeLury model runs with alternative natural mortality rates of 0.25 per year and 0.43 per year as well as the final run value of 0.34 per year for comparison

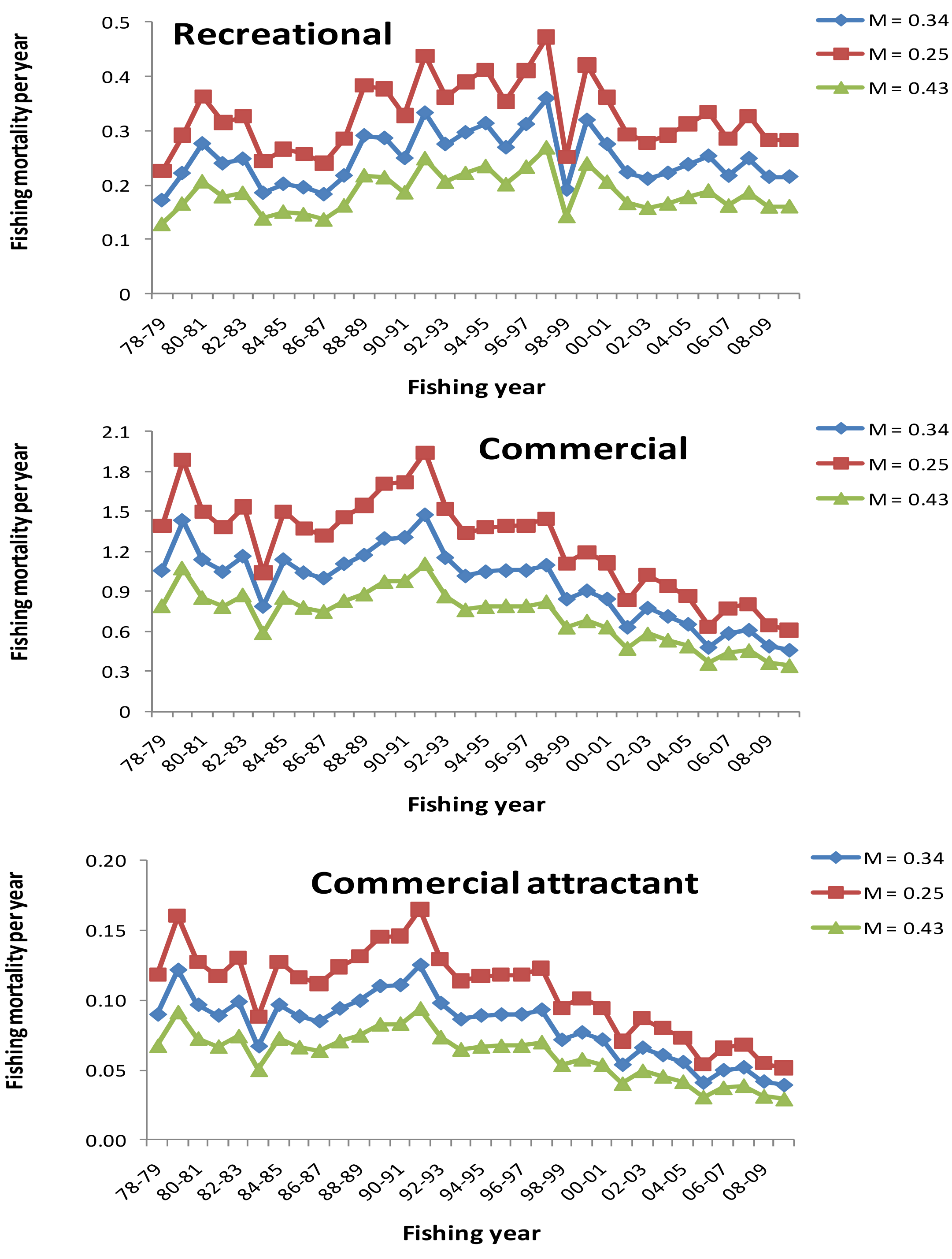


Figure 3.1.2.9.4. Fishing mortality by sector from the DeLury model runs with alternative natural mortality rates of 0.25 per year and 0.43 per year as well as the final run value of 0.34 per year for comparison

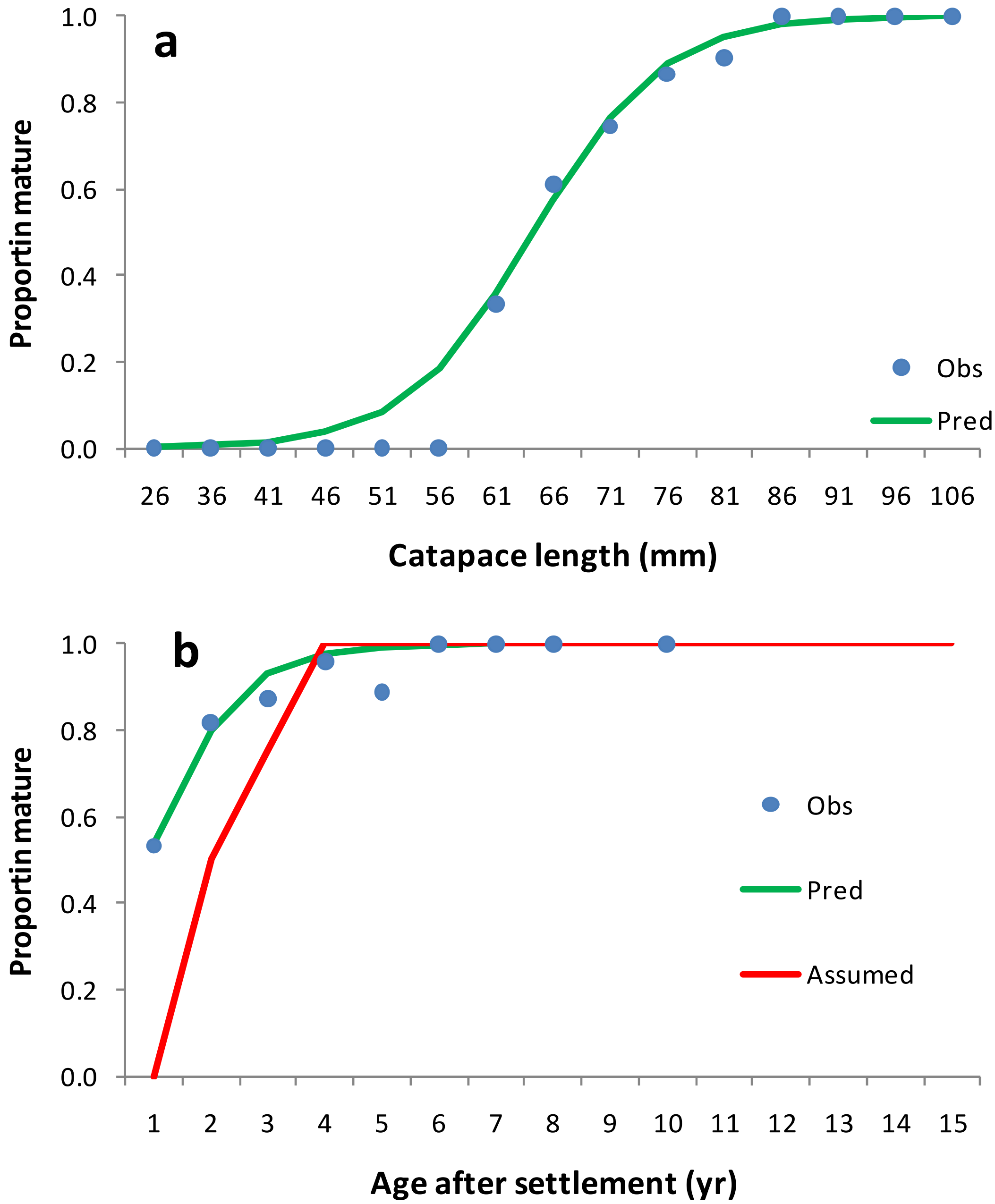


Figure 3.2.1.2.1 - Maturity-at-length (a) and maturity-at-age (b) for female lobsters in the fishery area (Florida Keys) off the Southeastern US. The estimated maturity-at-age is superimposed with the assumed maturity schedule for comparison (the latter was used as a base case scenario while the estimated maturity schedule was used for sensitivity in spawning biomass-per-recruit analyses). .

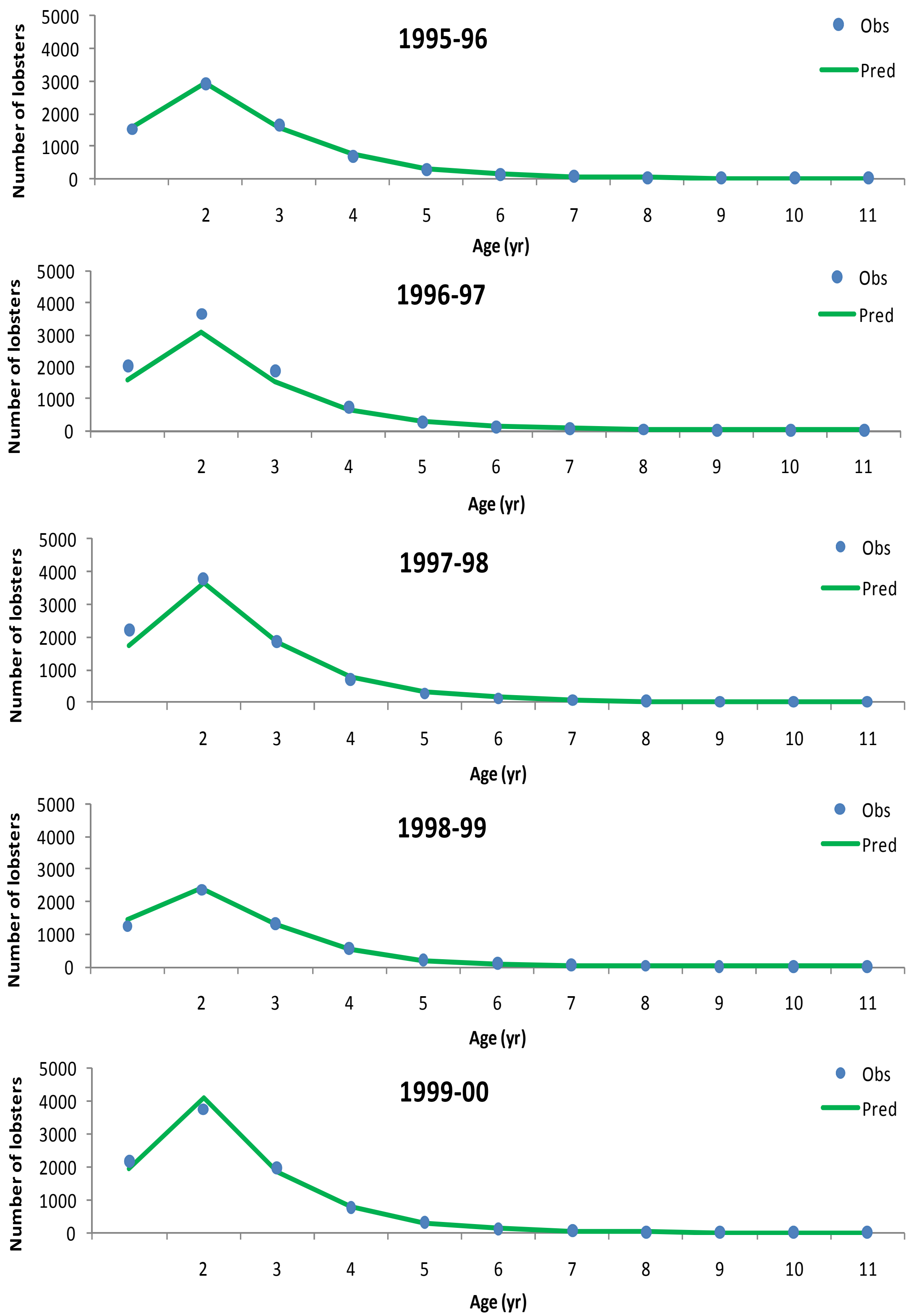


Figure 3.2.2.1.1. Fits of the catches-at-age in the ICA model by fishing year.

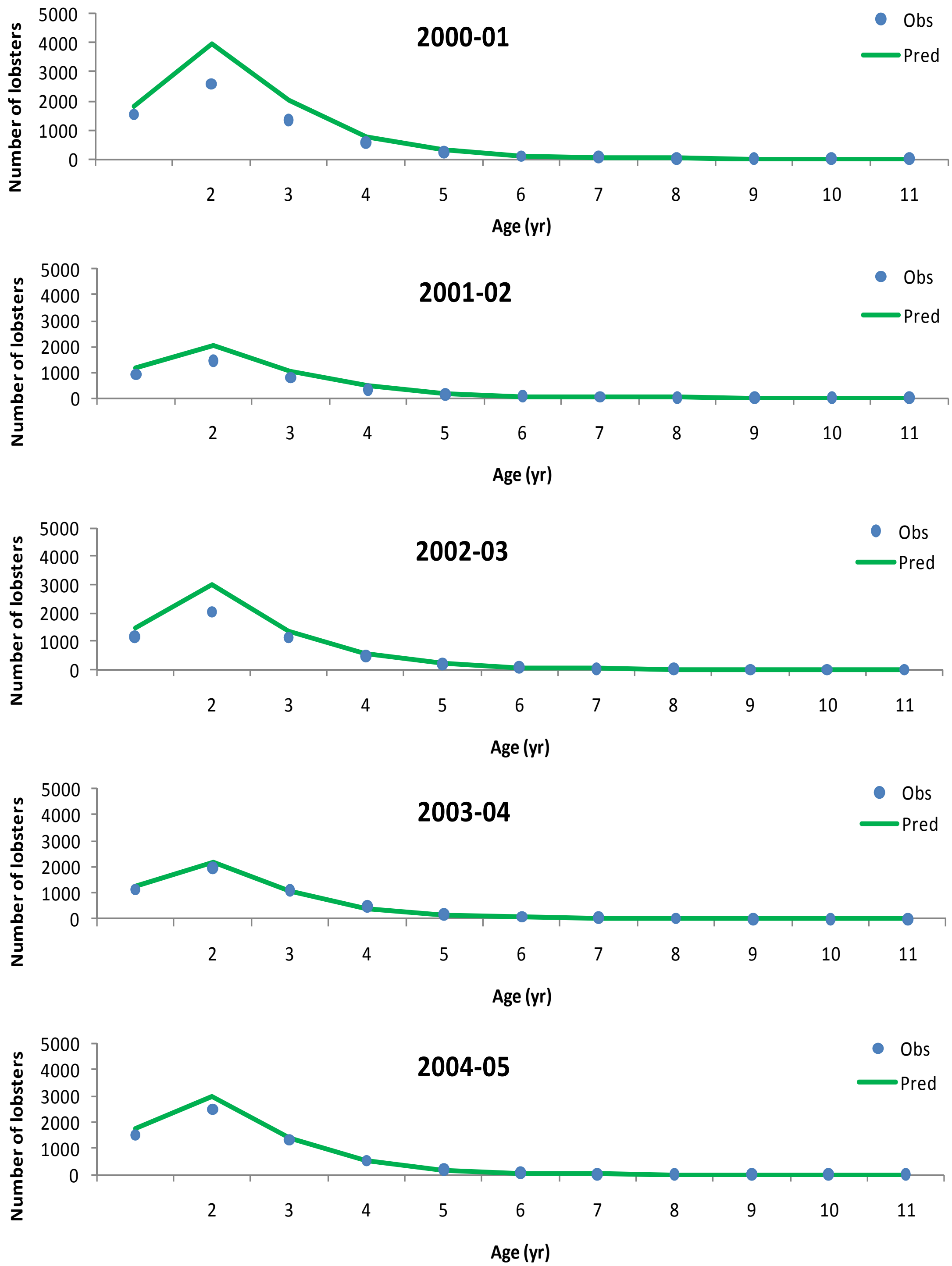


Figure 3.2.2.1.1 (continued). Fits of the catches-at-age in the ICA model by fishing year.

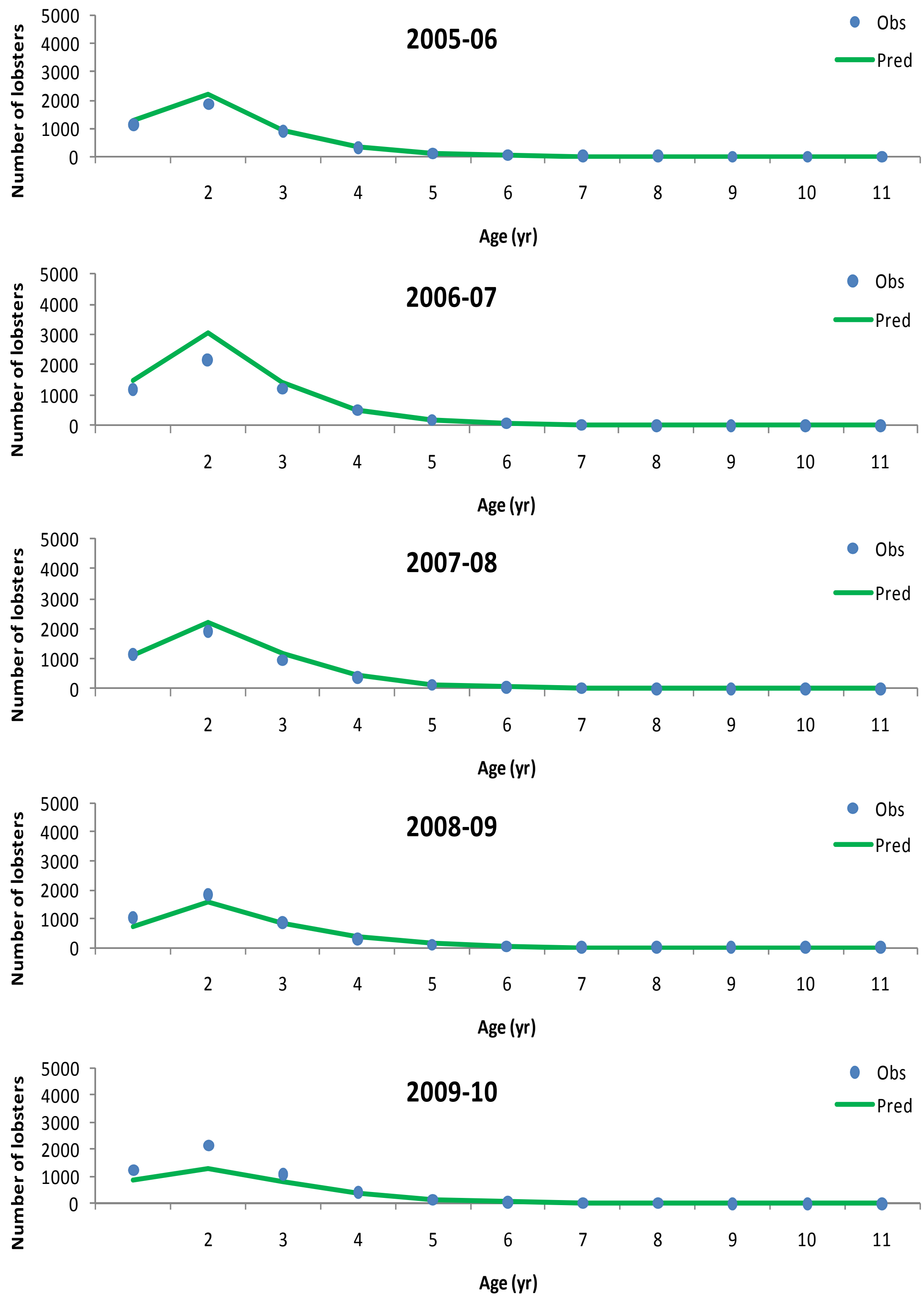


Figure 3.2.2.1.1 (continued). Fits of the catches-at-age in the ICA model by fishing year.

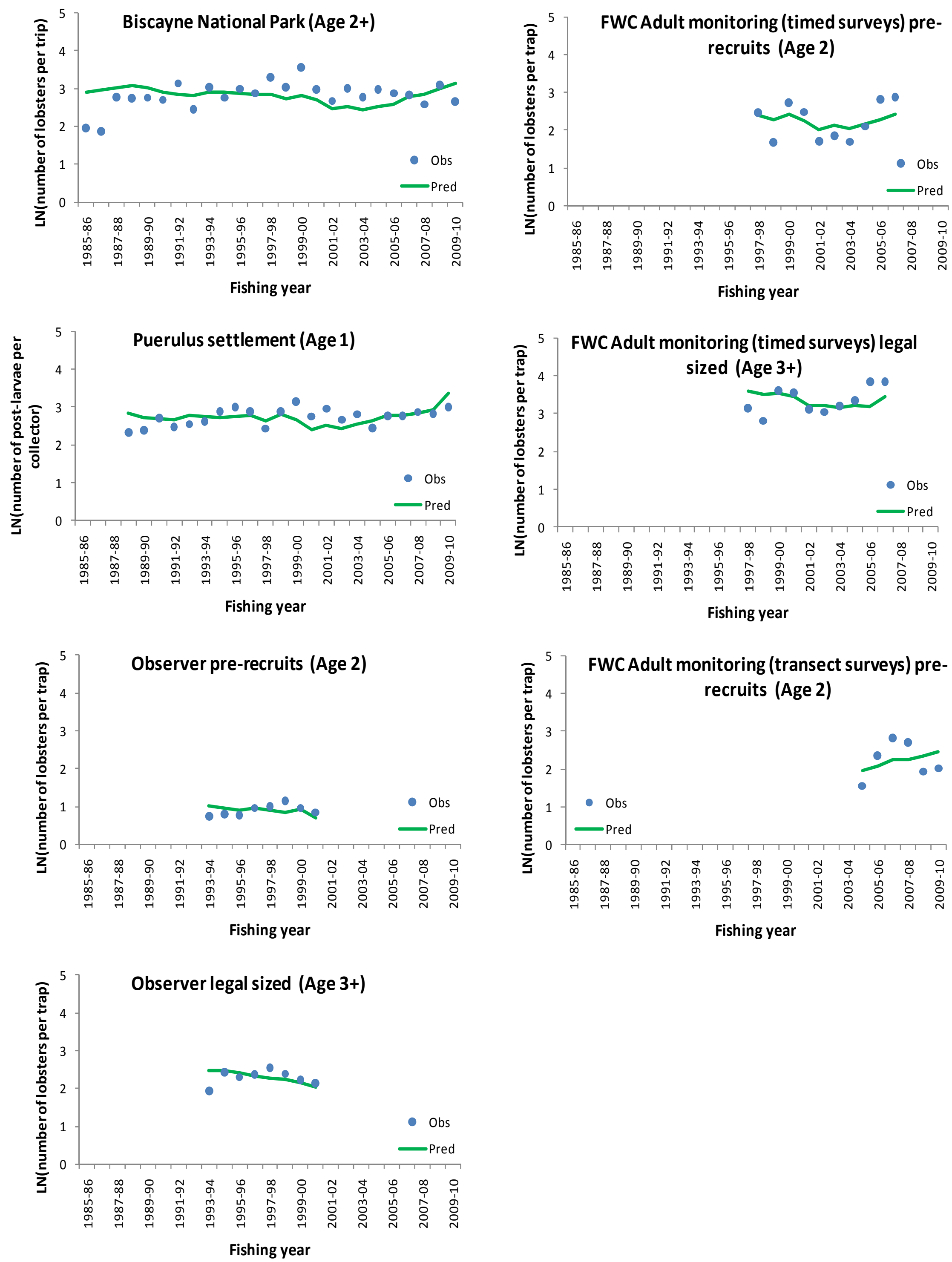
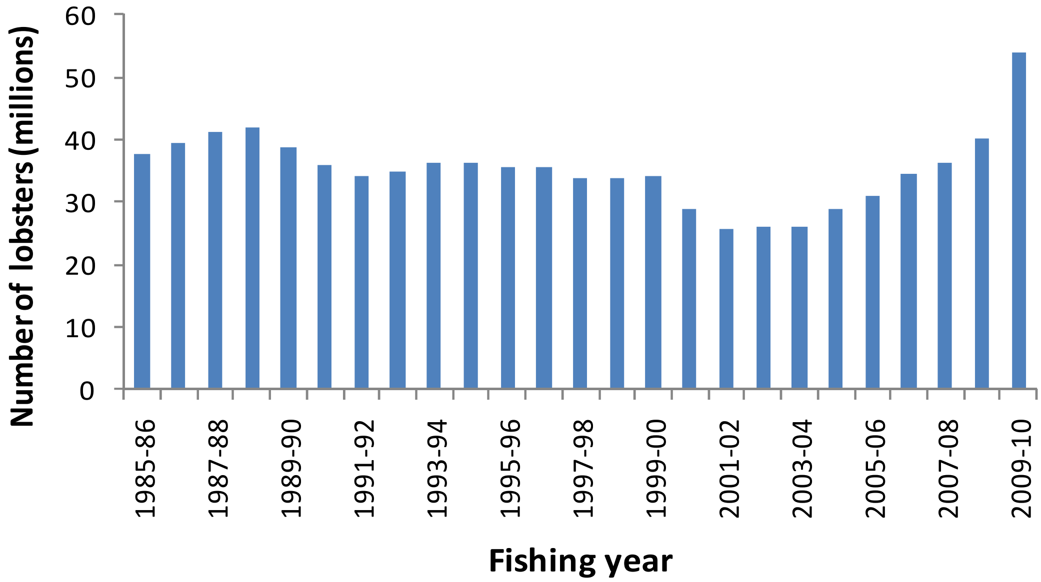


Figure 3.2.2.1.2. Fits of the tuning indices to ICA model.

a. Population



b. Recruitment of Age-1 lobsters

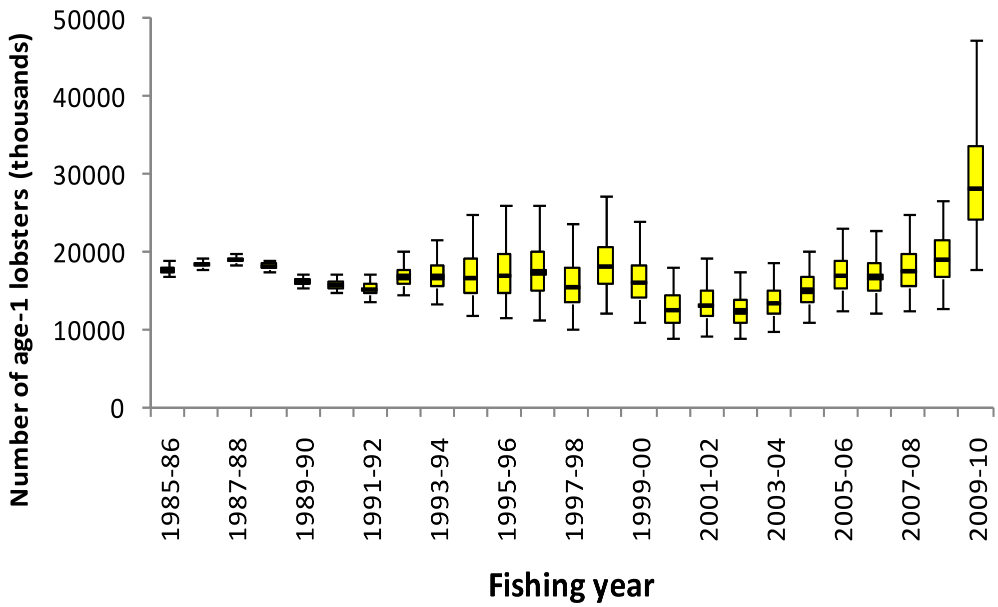
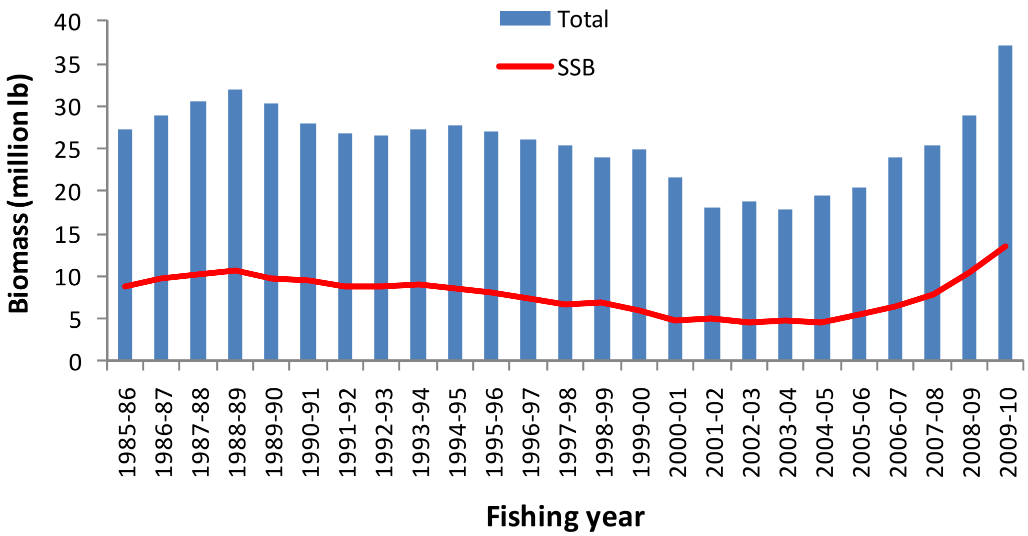


Figure 3.2.2.3. The total number of lobsters by fishing year (a) and the number of age-1 recruits based on 1000 Monte Carlo runs using the covariance matrix (b). The vertical line is the 95% confidence interval, the box is the inter-quartiles (25 to 75 percentiles) and the horizontal line is the median.

a. **Total biomass**



b. **Spawning biomass in Florida**

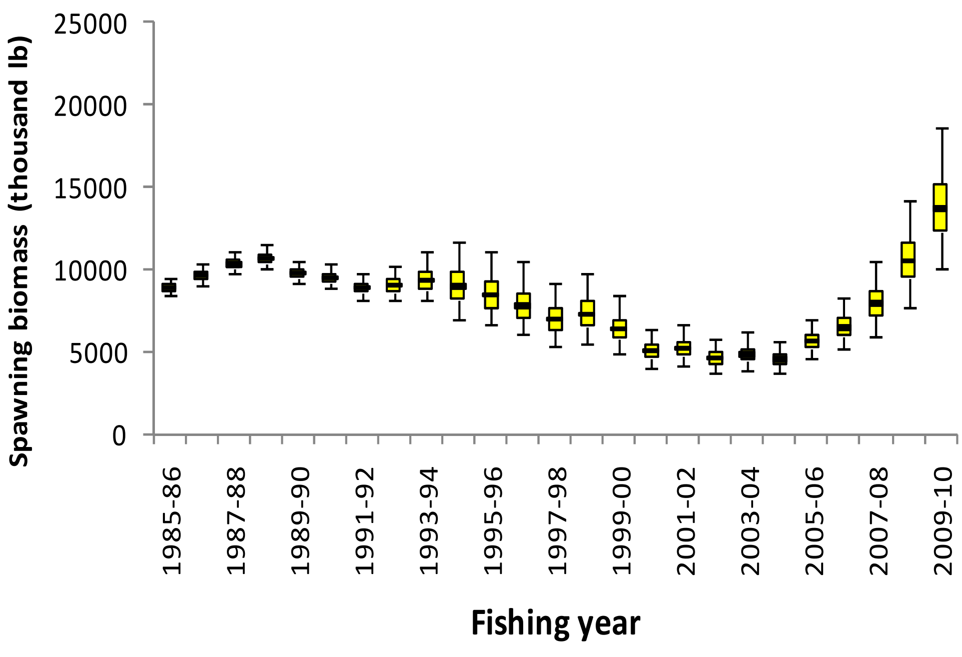


Figure 3.2.2.4. Total biomass and spawning biomass in SE US by fishing year. The vertical line is the 95% confidence interval, the box is the inter-quartiles (25 to 75 percentiles) and the horizontal line is the median.

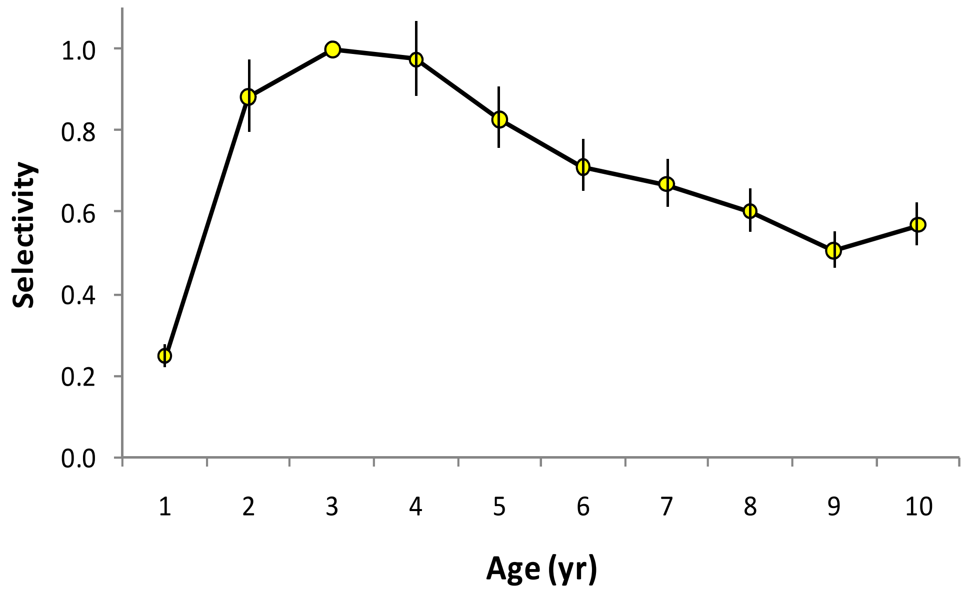


Figure 3.2.2.5. Selectivity by age for the period 1995-96 and later. The vertical lines are the 95% confidence intervals and the horizontal line is the maximum likelihood point estimate.

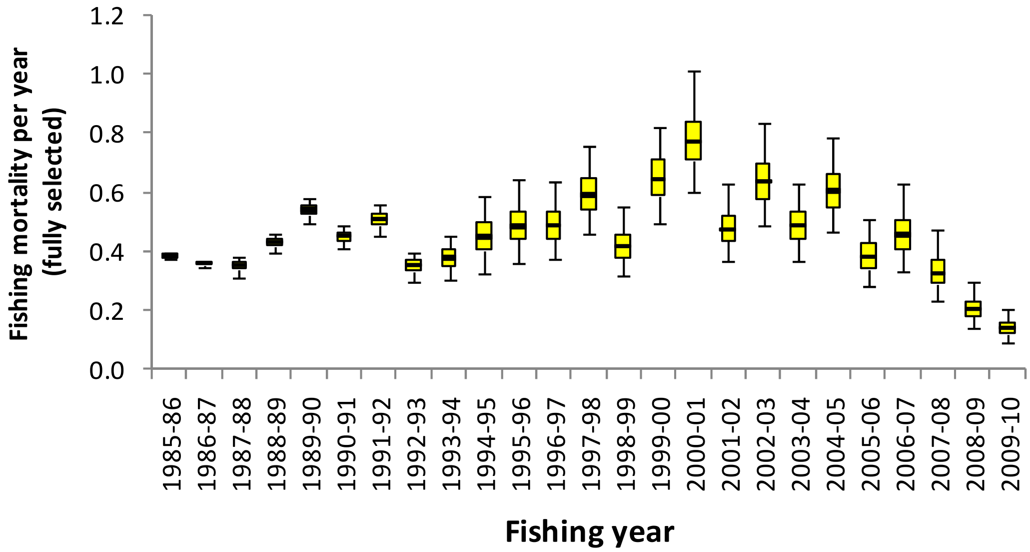


Figure 3.2.2.6.1. Fishing mortality rates on age-3 (fully selected) lobsters estimated by ICA. The uncertainty in the average fishing mortality rates is based on 1000 Monte Carlo runs using the covariance matrix. The vertical line is the 95% confidence interval, the box is the inter-quartiles (25 to 75 percentiles) and the horizontal line is the median.

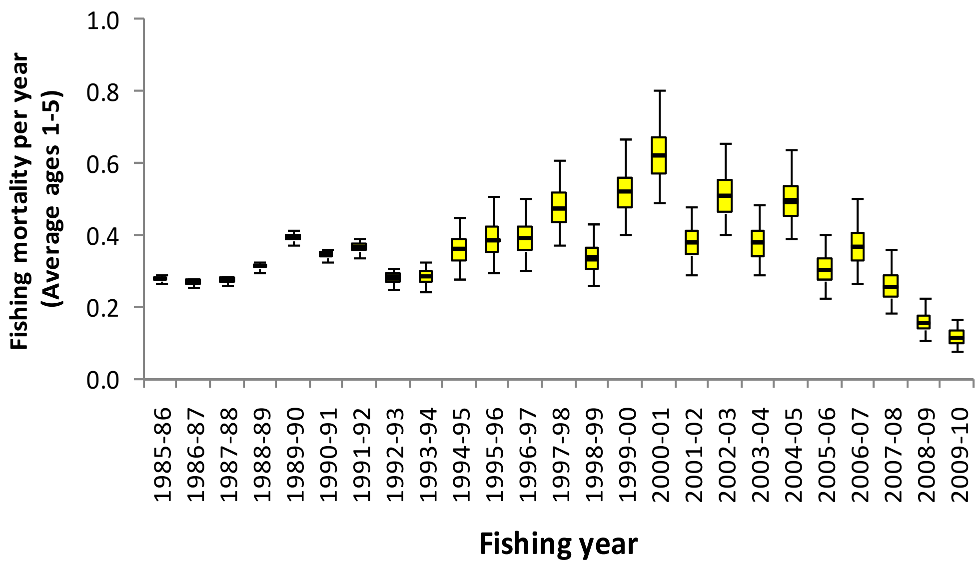


Figure 3.2.2.6.2. Average fishing mortality rates (ages 1 – 5) estimated by ICA. The uncertainty in the average fishing mortality rates is based on 1000 Monte Carlo runs using the covariance matrix. The vertical line is the 95% confidence interval, the box is the inter-quartiles (25 to 75 percentiles) and the horizontal line is the median.

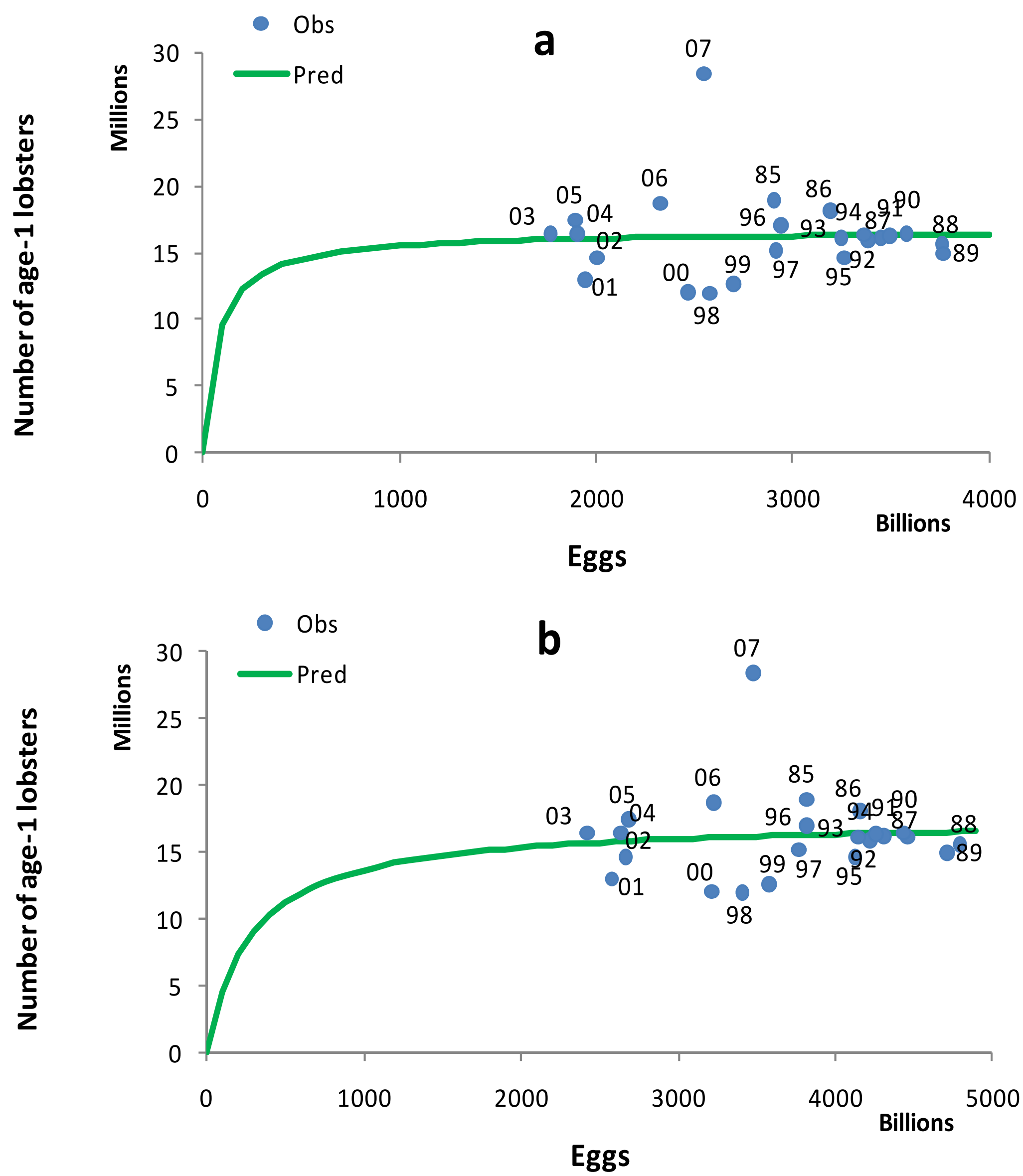


Figure 3.2.2.7. Relationships between spawning biomass, expressed as the number of eggs (a and b, using assumed and estimated maturity schedules, respectively) and the number of age-1 lobsters two years later. The spawning biomass accounted for the sex-ratio for females and the average number of broods by female in a spawning season. Ages are the time after settlement which occurs when lobsters are about ten months old so that an age-1 lobster actually is almost two years old.

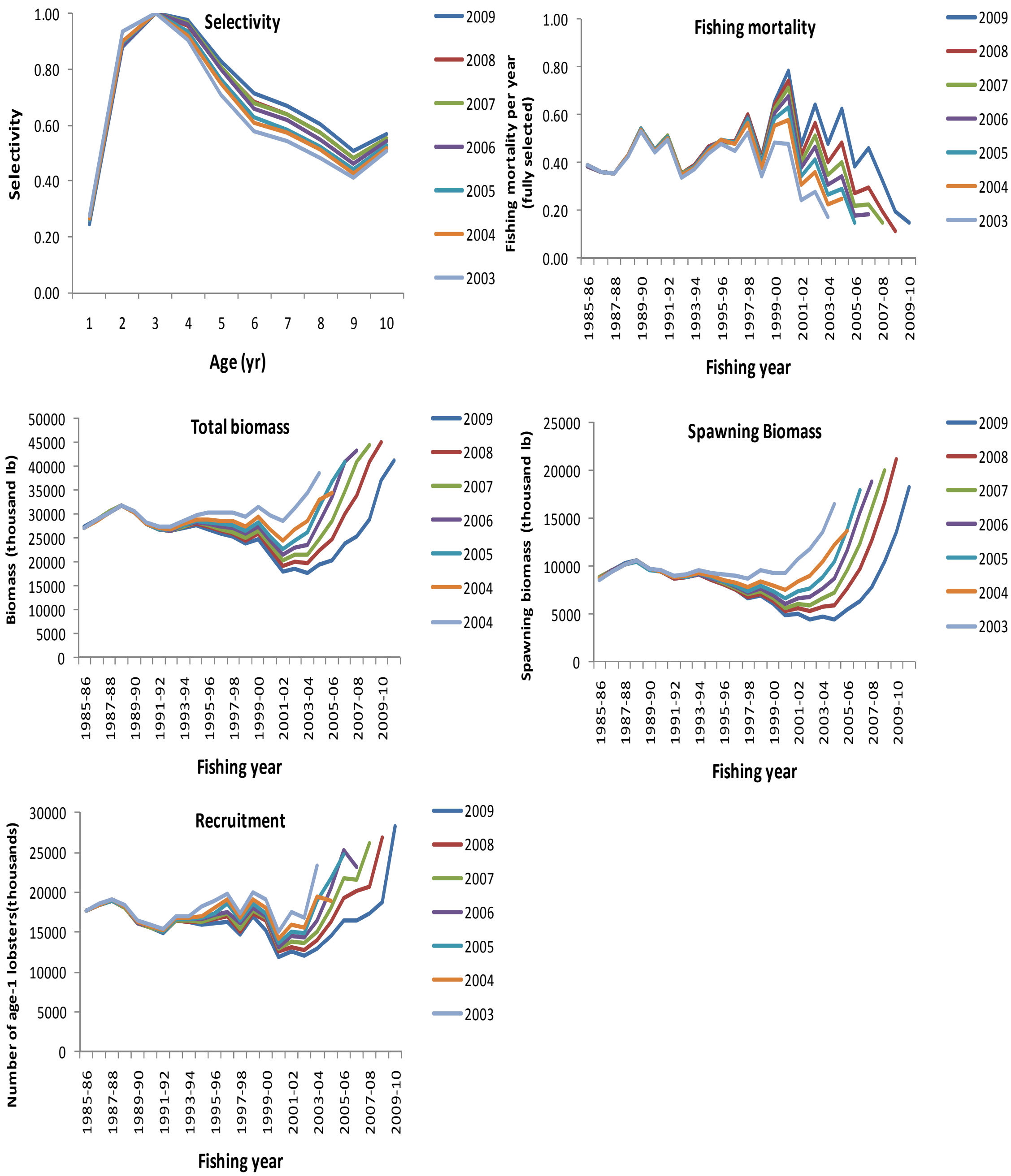


Figure 3.2.2.9.1. Retrospective analyses for the 1997-98 fishing year and later of different population parameters.

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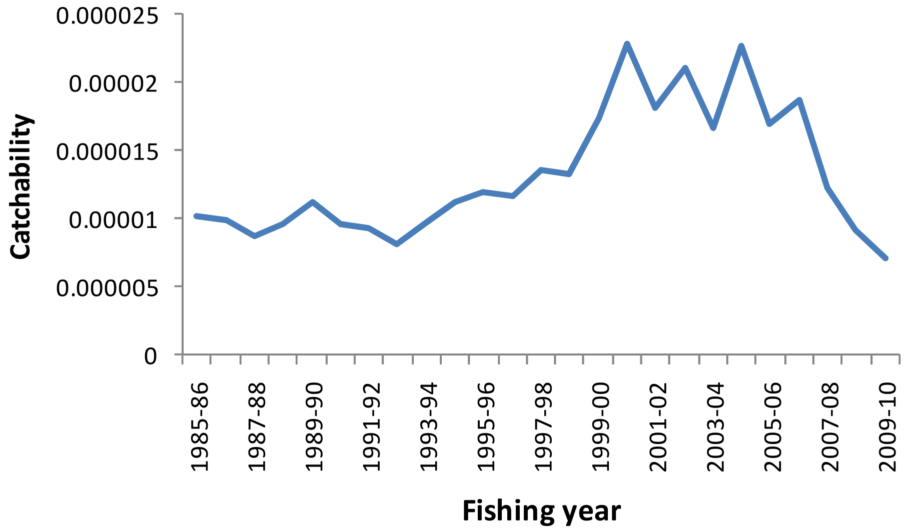

Figure 3.2.2.9.2. Annual variations in the estimates of catchability coefficients for the spiny lobster fishery off the SE U.S., 1985 -2009.
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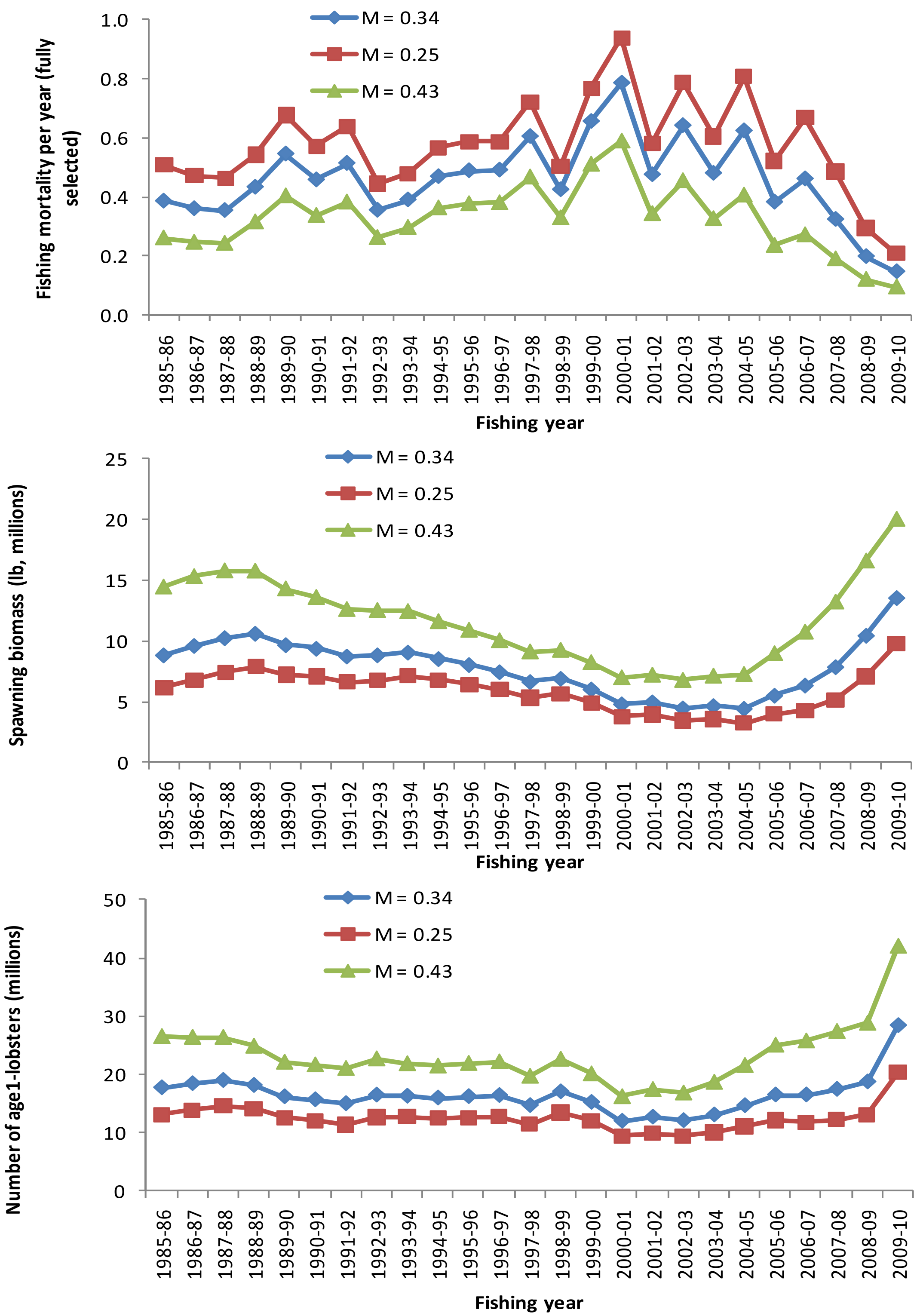


Figure 3.2.2.9.3. Comparison of fishing mortality per year on the fully recruited ages, spawning biomass, and recruitment estimated with three natural mortality rates: 0.25, 0.34, and 0.43 per year.

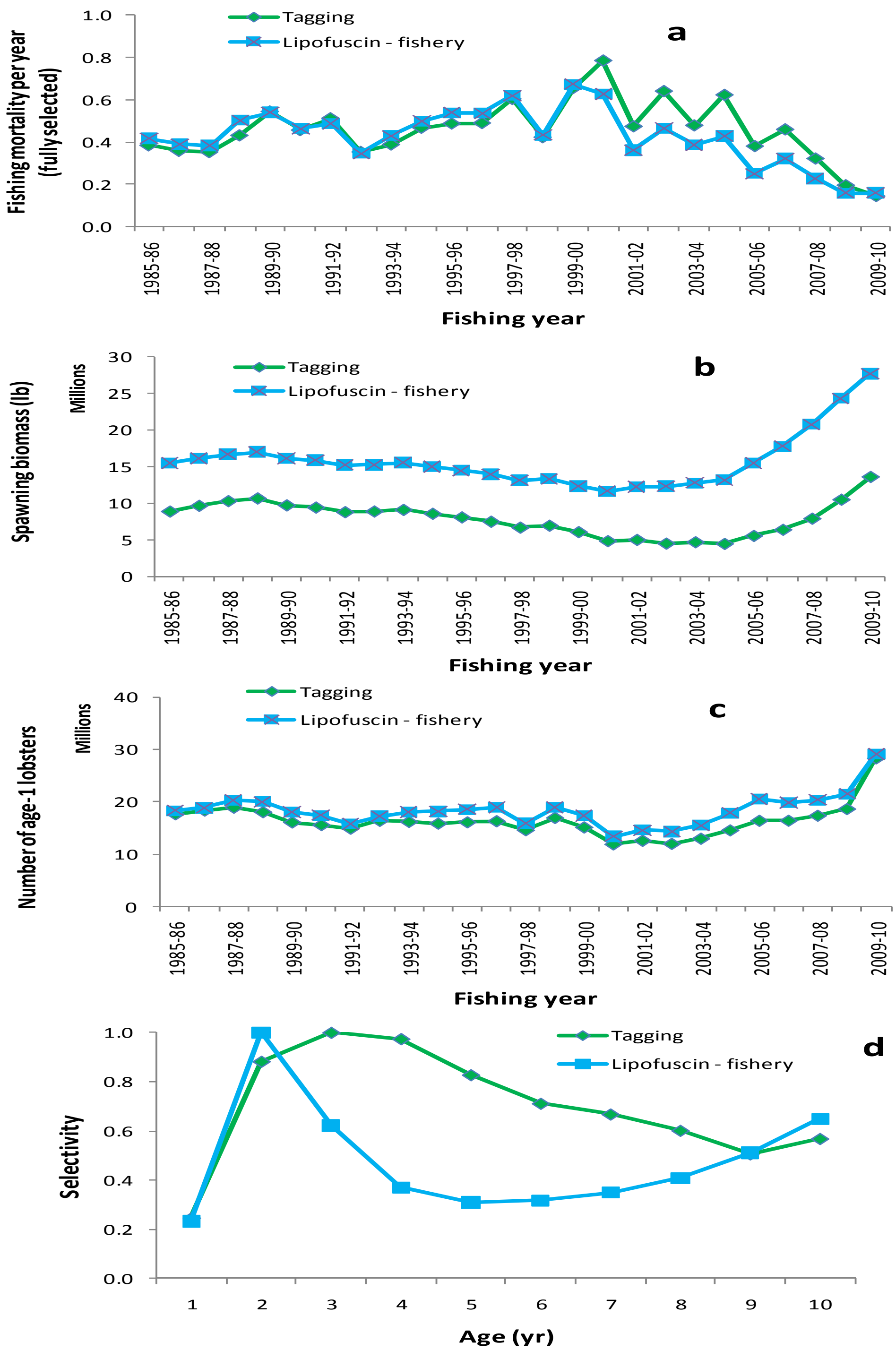


Figure 3.2.2.9.4. Comparison of fishing mortality per year on the fully recruited ages (a), spawning biomass (b), recruitment (c), and selectivity (d) estimated by ICA base run using tagging based age-length keys and lipofuscin based age-length keys that were developed for Florida Keys (i.e., for the fishery)

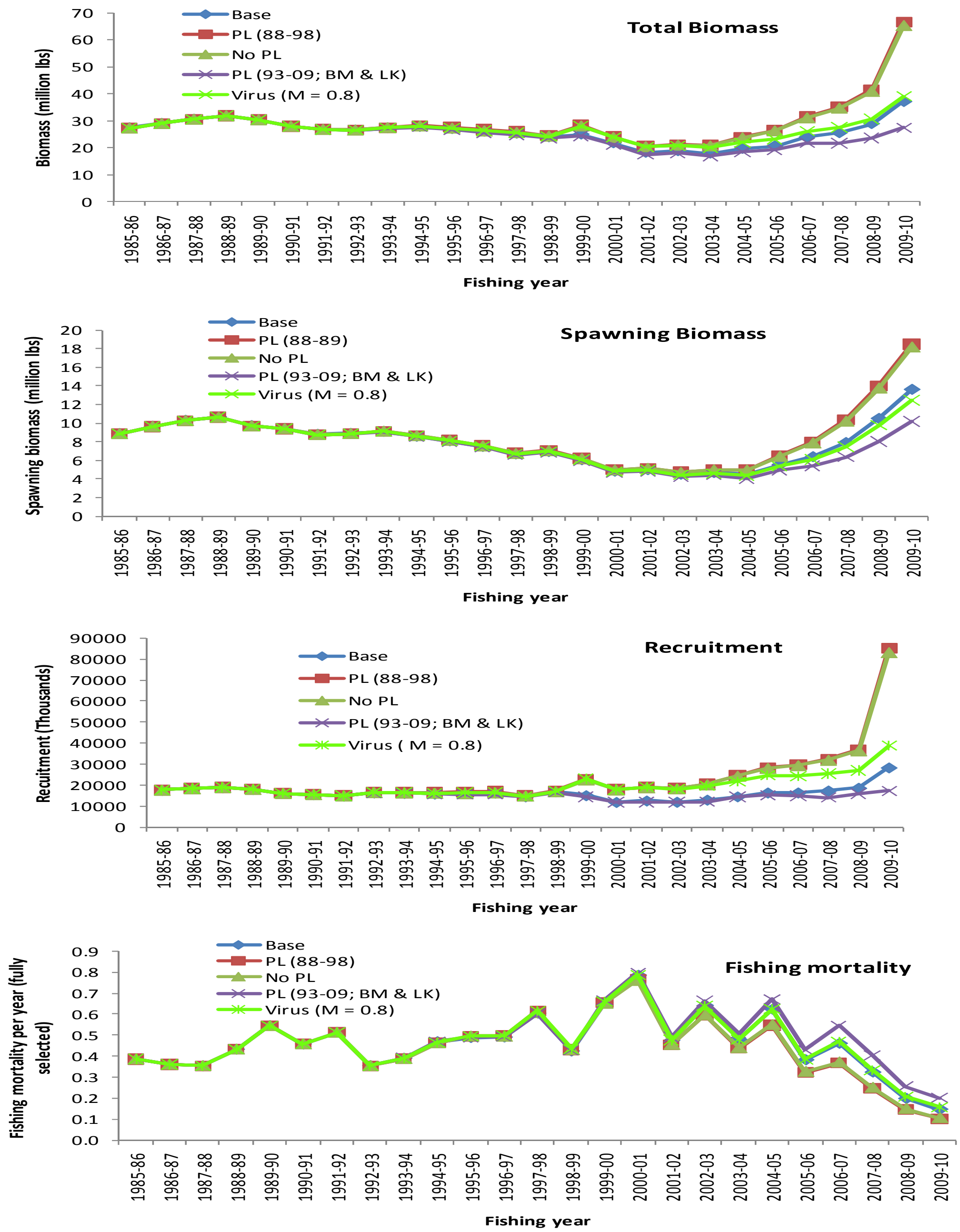


Figure 3.2.2.9.5. Comparison of total biomass, spawning biomass, recruitment, and fishing mortality per year on the fully recruited age of lobsters, estimated with a natural mortality rate of 0.34 per year in base run and runs with variations of the post-larvae index: 1988-98 time series (PL (88-89)), excluded (No PL), and 1993-2009 time series with data from both Big Munson and Long Keys sites (PL (93-09; BM & LK)); and with a natural mortality of 0.8 per year in base run, adjusted to account for an average of 36% decline in landings over 1999-09.

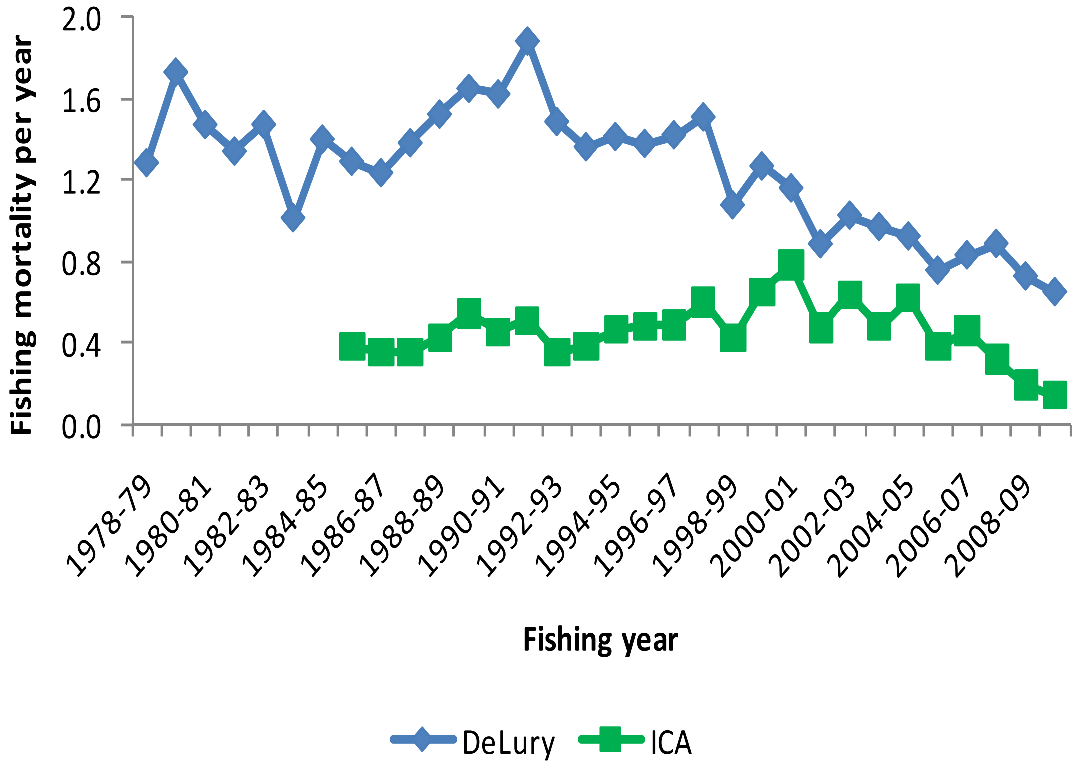


Figure 4.1. Comparison of the fishing mortality rates from the selectivity adjusted DeLury model and the age-structured model ICA.

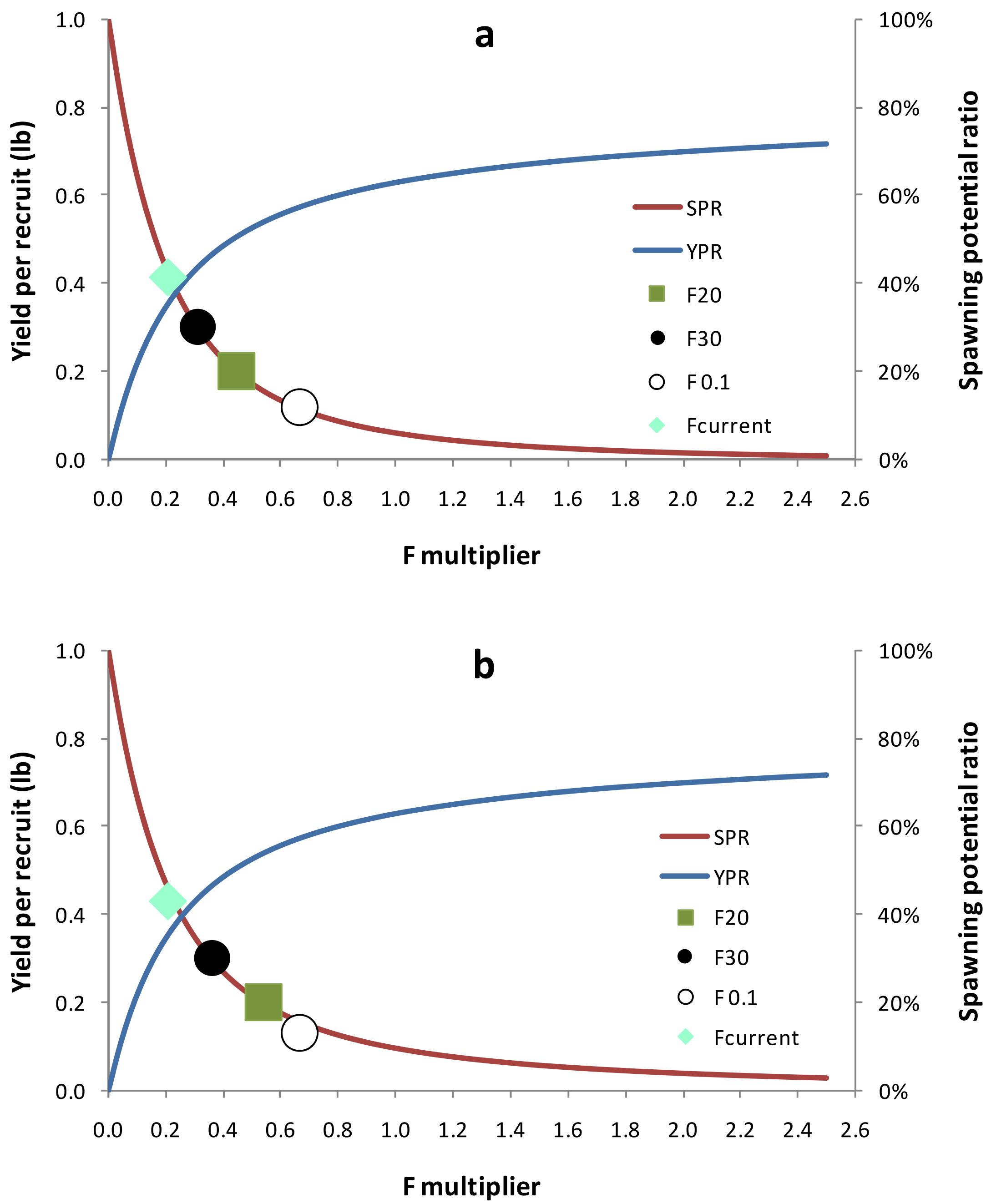


Figure 5.1.2. Yield-per-recruit and Spawning potential ratio (SPR; Static eggs per recruit) by fishing mortality rates on fully recruited spiny lobsters off SE US. Various reference points are also included. The SPR was calculated using assumed (a) and estimated (b) maturity schedules.

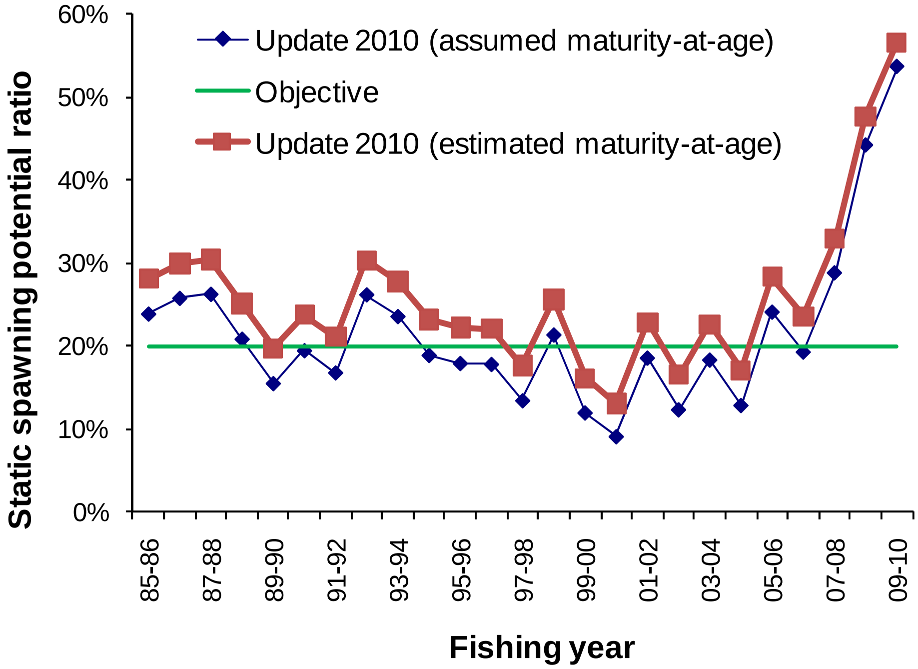
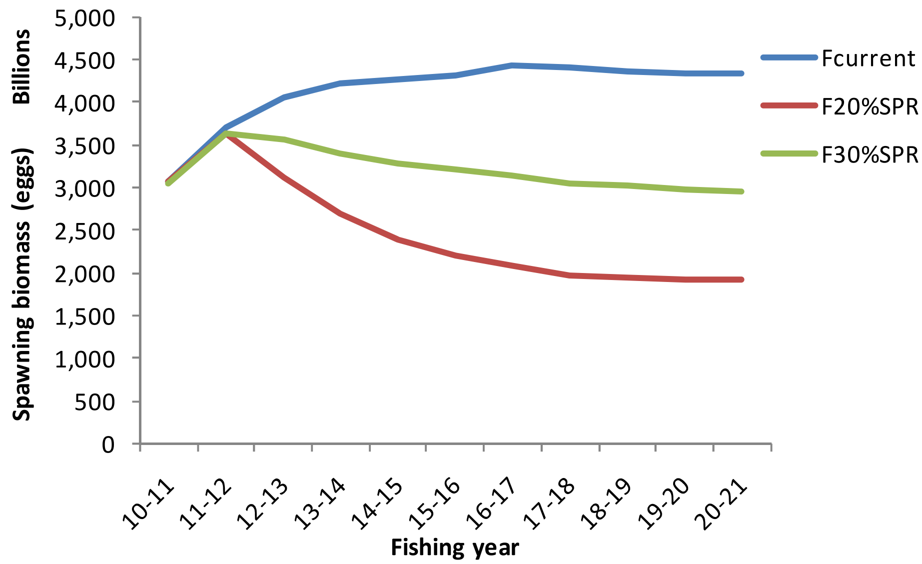


Figure 6.3. Static spawning potential ratios by fishing year (established using the assumed and estimated maturity schedules) and the current management objective of 20%.

a. Spawning biomass



b. Landings

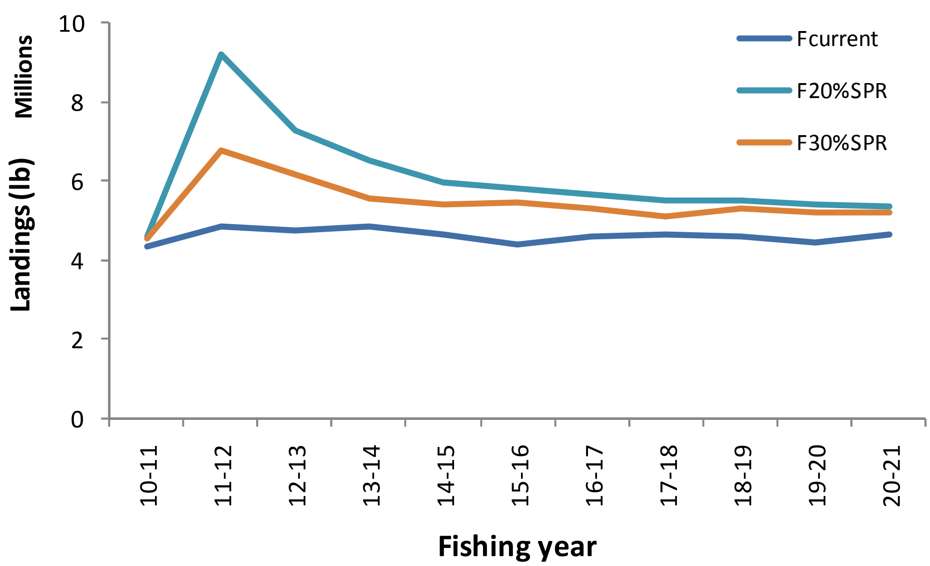
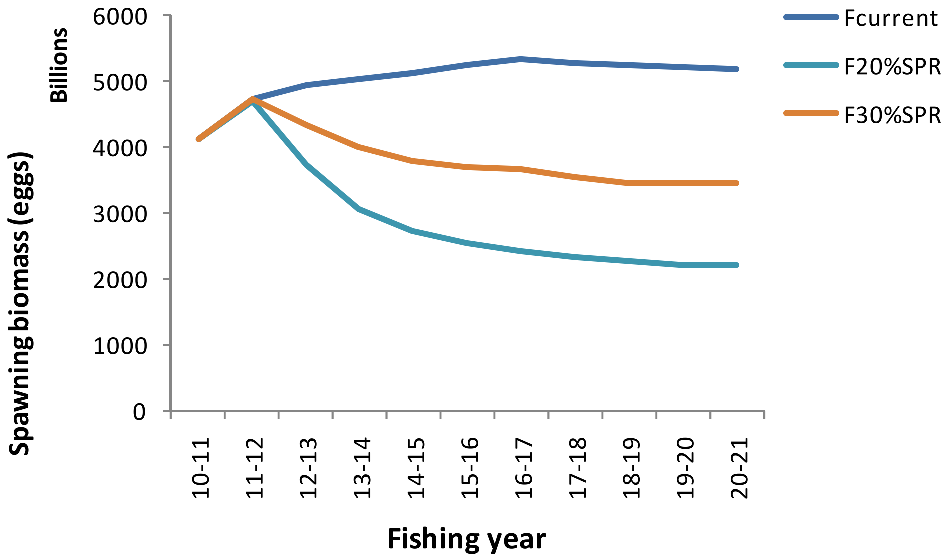


Figure 7.1.1. Projected biomass levels (a) and landings (b) for various fishing mortality rates including $F_{current}$, $F_{20\%SPR}$, and F_{oy} ($F_{30\%SPR}$), when the maturity schedule is assumed.

a. Spawning biomass



b. Landings

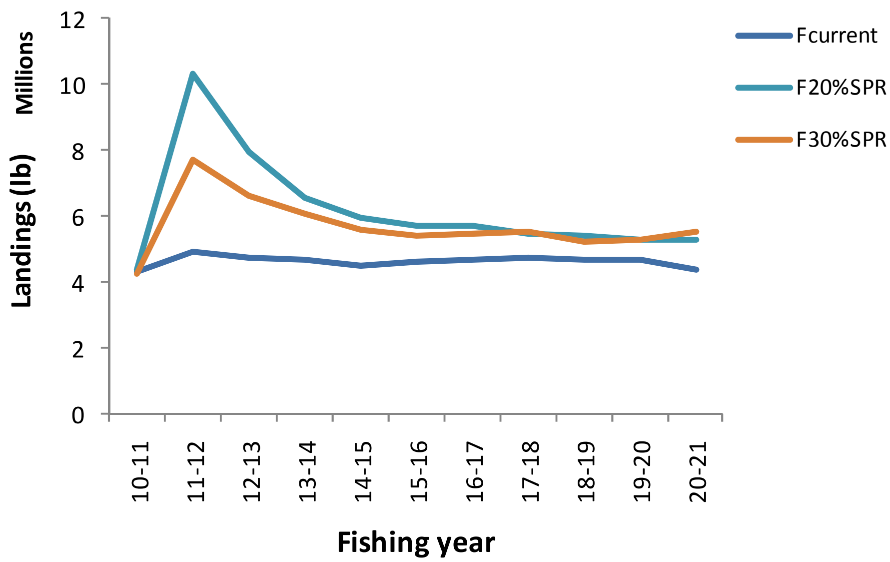


Figure 7.1.2. Projected biomass levels (a) and landings (b) for various fishing mortality rates including $F_{current}$, $F_{20\%SPR}$, and F_{oy} ($F_{30\%SPR}$), when the maturity schedule is estimated.

Appendix A – Southeast Spiny Lobster Update Stock Assessment Participants

Assessment Panel	
Doug Gregory	GMFMC SSC
John Hunt	GMFMC SL SSC
Anne Lange	SAFMC SSC
David Eggleston	SA, Researcher
Jerry Sansom	GMFMC SL AP
Simon Stafford	GMFMC SL AP
Nelson Ehrhardt	RSMAS
Analytic Team[†]	
Robert Muller, Lead Analyst	FWRI
Joseph Munyandorero, Analyst	FWRI
Appointed Observers	
Mark Robson	SAFMC Council Member
Bill Teehan	GMFMC Council Member
Sue Gerhart	SERO
Kate Michie	SERO
Staff	
Carrie Simmons	GMFMC Staff
Gregg Waugh	SAFMC Staff
John Froeschke	GMFMC Staff
Julie A Neer	SEDAR
Tina O'Hern	GMFMC Staff
Patrick Gilles	NOAA/NMFS/SEFSC
Observers	
Tom Matthews	FWC/FWRI
Bill Sharp	FWC/FWRI
Bill Kelly	FKCFA
Ken Blackburn	NOAA Enforcement
Dennis O'Hern	FRA
Edward Little	NOAA/NMFS
Dave Hawtof	FWC Volunteer
Jesus Diaz	Commercial fisherman
Richard Diaz	Commercial fisherman
Manuel Ravels	Commercial fisherman
Ruben Ravels	Commercial fisherman
Mimi Stafford	FKCFA
George Geiger	SAFMC
Aaron Podey	FWC
Rodney Bertelsen	FWC

REVISED DRAFT Standing, Special Spiny Lobster and Special Reef Fish Scientific and Statistical Committee
Committee Summary
Tampa Florida
January 18-21, 2011

The agenda was adopted with the addition of several items under Other Business: Proposed revisions to the SEDAR process, Issues regarding the ABC control rule, Location for next meeting, Template for species biological information, and Information needs to complete ABCs. The summary minutes of the December 13-15, 2010 meeting were approved with an editorial correction to the last line on page 10, change :whole weight" to "gutted weight" on the motion on page 11, and a correction to the Attachment 2 ABC control rule Tier 3b conditions for use.

Spiny Lobster Update Assessment

Doug Gregory, chair of the Spiny Lobster Review Panel gave an overview of the stock assessment review to the Standing and Special Spiny Lobster SSC. The Review Panel concluded after careful consideration that there were sufficient concerns with the performance of the two assessment models to reject the assessment results and that the stock status of spiny lobster in the southeastern United States was unknown. In addition, Mike Tringali, from the Florida Fish and Wildlife Conservation Commission gave a presentation that found new evidence indicating the southeastern United States spiny lobster stock largely depends on external recruitment from upstream Caribbean populations. The Assessment Review Panel concluded that the United States spiny lobster stock cannot be assessed in isolation and is not the appropriate geographical and biological scale needed to capture population-wide dynamics. Rene Buesa, on the Special Spiny Lobster SSC also gave a brief overview on his written considerations which the Review Panel concluded and SSC agreed would be better utilized during the next Benchmark assessment.

After extensive discussion the SSC concluded that, for purposes of setting OFL and ABC, Tier 3a from the Generic Annual Catch Limits/Accountability Measures Amendment was appropriate to use with the spiny lobster stock. However, there were no recreational landings estimates for 2004/05 in the landings data supplied to the SSC by Florida FWC and updated January 13, 2011 (Table 1). Multiple hurricanes over that time period resulted in undue bias in the survey attempts. Consequently, the landings for that year had to be estimated. In addition, the SSC agreed that spiny lobster stock was a special case where ABC could be set at the mean of the recent landings plus 1.5 standard deviations rather than the default of the mean plus 1 standard deviation. The methodology for estimating 2004/05 landings and the rationale for using 1.5 rather than 1 standard deviation are provided below.

> **The SSC recommends that spiny lobster be considered as a special case fishery and set using Tier 3a in table 2.3.1 (ABC Control Rule) at:**

- **OFL is set as the mean of the most recent 10 years, (2000-2010) with data that does not include attractants, with landings plus 2 standard deviations at 7.90 million pounds and**
- **ABC set at the mean of the landings plus a 1.5 standard deviation at 7.32 million pounds.**

Motion passed unanimously.

Table 1. STATEWIDE landings provided by Florida FWC and updated January 13, 2011. Calculations for recreational and combined landings during the 2004/05 fishing year are outlined below and indicated in italics within the table.

Fishing Season	Commercial Landings	Recreational Landings	Combined Landings
2000/01	5,568,707	1,949,033	7,517,740
2001/02	3,079,263	1,251,081	4,330,343
2002/03	4,577,392	1,455,298	6,032,690
2003/04	4,161,589	1,411,509	5,573,097
2004/05	5,472,994	*1,657,535*	*7,201,308*
2005/06	2,963,160	1,131,014	4,094,174
2006/07	4,799,493	1,304,511	6,104,004
2007/08	3,778,037	1,215,069	4,993,105
2008/09	3,269,397	1,263,509	4,532,906
2009/10	4,343,305	1,126,714	5,470,019

Rationale:

Two aspects of the SSC's accepted OFL and ABC for spiny lobster may need further clarification. First, no estimate of recreational landings for the 2004/05 fishing year were provided in the landings data presented to the SSC. The mean percentage of total landings taken by the recreational fishery during the ten-year times series (2000/01 to 2009/10) over which mean landings and its standard deviation were computed was 24%. Therefore, recreational landings for the 2004/05 fishing year was estimated by first dividing the 2004/05 commercial landings by 0.76 to compute estimated total landings, with that quotient then multiplied by 0.24 to estimate recreational landings.

The second aspect of setting spiny lobster OFL/ABC that needs further clarification is the rationale for deviating from the default method for setting ABC under Tier 3a of the SSC's ABC control rule. The default under Tier 3a is to set ABC as the mean of a landings time series plus 1 standard deviation, but the maximum level ABC could be set is the mean of landings plus 1.5 standard deviations. This latter approach was chosen by the SSC. The rationale for this choice was the SSC's conclusion, based on population genetics and physical transport data presented, that there was a high probability that juvenile spiny lobster that settle in south Florida recruit from several spawning populations throughout the greater Caribbean and are not locally self-recruited. Therefore, there is a low probability that landings in south Florida will have a substantial effect on future recruitment there.

After further discussion, the SSC passed the following motion supporting the research recommendations in the assessment review workshop report.

> **The SSC fully supports the research recommendations of the Spiny Lobster Update Assessment Review Workshop Report. Additionally, the SSC recommends that monitoring and research be supported to produce a Pan-Caribbean population-wide assessment as recommended by that panel.**

Motion passed unanimously.

SEDAR 15 Mutton Snapper Benchmark Assessment

The mutton snapper assessment was completed in 2008 by FWC but had not been previously reviewed by the Gulf Council or the SSC. Joe O'Hop gave a presentation summarizing the assessment. The stock straddles the Gulf Council and South Atlantic Council jurisdictions. It was assessed using a statistical catch-at-age program (ASAP), and 71 sensitivity runs in addition to the base case model were run to evaluate the effect of using different data inputs or modifying parameters such as the steepness of the spawner-recruit curve. The results were that 29 out of 72 runs including the base case model had spawning biomass estimates at or above minimum stock size threshold (not overfished), and 51 out of 72 runs including the base case model had fishing mortality rates that were less than the maximum fishing mortality threshold (not undergoing overfishing). Consequently, the stock is neither overfished nor undergoing overfishing. One concern expressed by the SEDAR Review Panel was that the overfishing threshold of $F_{30\%\ SPR}$ (as a proxy for F_{MSY}) was risk-prone given the life history of mutton snapper.

Following the assessment presentation Luiz Barbieri summarized the OFL and ABC recommendations of the South Atlantic SSC. The South Atlantic SSC recommended that the OFL be set equal to the equilibrium maximum sustainable yield proxy, which is the yield at $F_{30\%\ SPR}$ = 688 metric tons (1.52 million pounds).The South Atlantic SSC also recommended that the ABC be set equal to the equilibrium optimum yield, which is the yield at $F_{40\%\ SPR}$ = 524 metric tons (1.16 million pounds).

The SSC noted that the above recommendations were in terms of total removals, i.e., landed catch plus dead discards. Steven Atran advised the SSC that under the National Standard 1 guidelines, ABC could be designated either in terms of total removals or landed catch, as long as the dead discards were accounted for. He also noted that the other ABCs have been in terms of landed catch. After discussion, the SSC decided to recommend an OFL and ABC that was consistent with the South Atlantic SSC recommendation, except that the Gulf SSC recommendation would be in terms of landed weight with the estimated dead discards stated separately.

> **The SSC recommends that the directed landings for ABC and OFL for Mutton Snapper be consistent with the SAFMC SSC recommendations with the following adjustments to reflect landed weight:**

- **ABC = 512 metric tons (1.13 million pounds) landed whole weight,**
- **Yield at the MSY proxy = OFL = 672 metric tons (1.48 million pounds) landed whole weight.**

This assumes additional dead discards of 12 metric tons (26,500 pounds) for ABC and 16 metric tons (35,300 pounds) for OFL.

Motion passed unanimously.

Re-run of Gag Update Assessment

Brian Linton gave a presentation describing the methodology for the re-run of the gag update assessment. Two changes were made to the original 2009 update assessment run for the Fall 2010 re-run. 1) The size distribution of released fish in the charter and private recreational fisheries was revised to provide a better estimate of the size distribution. In the original run the size distributions were truncated at just below the minimum size limit in several cases. The revisions were made by using Mote data from 2006-2007 to adjust the private vessel size distribution, and by applying the headboat observer data from 2000-2008 to the charterboat sector. In addition, landed undersized gag were excluded from the discard data to avoid biasing the size distribution, but were included in the landed size distributions. 2) Observer based commercial discard estimates were used in place of the previous estimates that were based on logbook records of depth fished along with estimates of size at depth and release mortality at depth. The terminal year of the assessment model remains at 2008. And $F_{current}$ remains as the average of 2005-2007.

The results of the re-run produced higher estimates of the number of discards in the commercial handline fishery, but lower estimates of discards in the commercial longline fishery. Spawning stock biomass was lower in the re-run but only slightly (Figure 1). The fishing mortality estimates were nearly unchanged except for the terminal year of 2008, but the terminal year is not used in the calculation of $F_{current}$ (Figure 2). The end result was that the yield streams for OFL, $F_{rebuild}$ and OY increased slightly for each year, but the stock remains overfished and undergoing overfishing (Figure 3 and Attachment 1).

Figure 1.

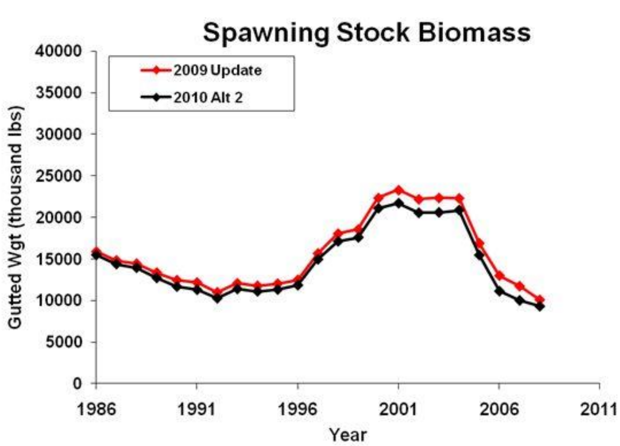


Figure 2.

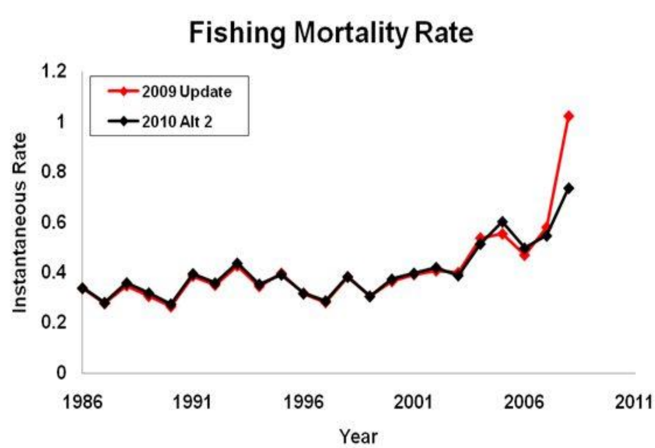
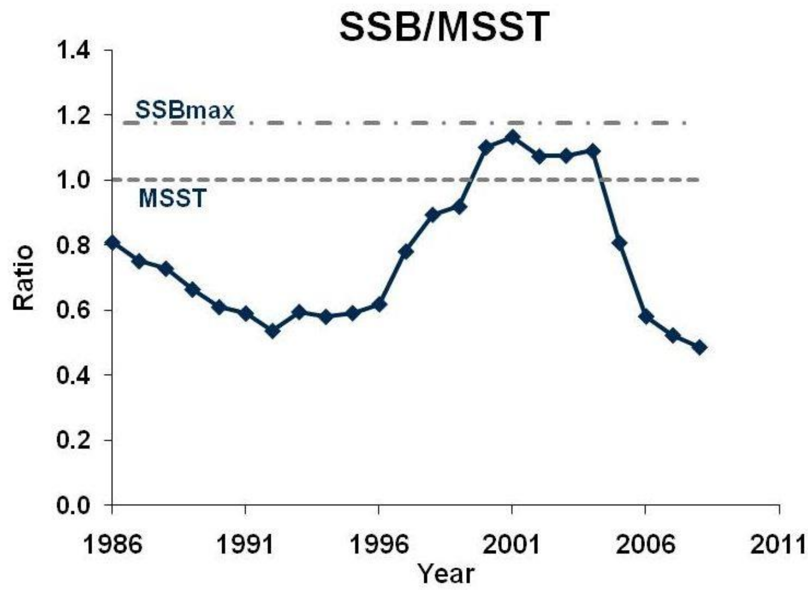


Figure 3.



Following the review and discussion of the re-run, the SSC passes the following motions regarding acceptance of the re-run and revised OFL and ABC.

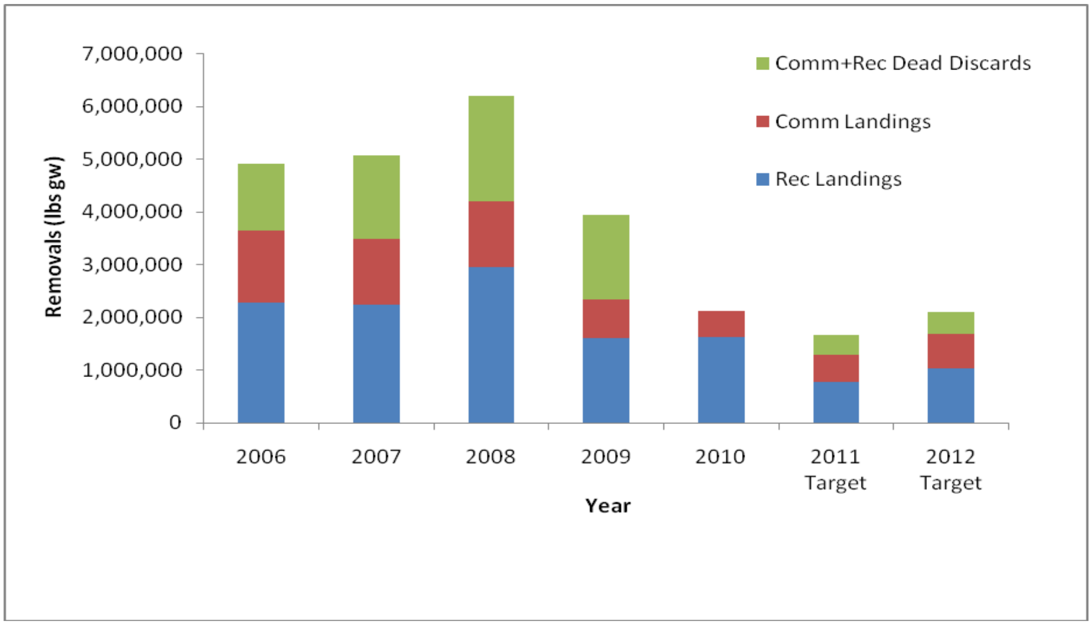
> **The SSC moves to accept the revised Gag assessment, with updated discarding and dead discard estimates, as the best scientific information available.**
>
> Motion passed unanimously.
>
> **The SSC moves to recommend the ABC for gag based on $F_{rebuild}$ to SSB_{max}:**
> **2011 = 1.58 mp gw**
> **2012 = 2.02 mp gw**
> **2013 = 2.45 mp gw**
> **2014 = 2.82 mp gw**
> **2015 = 3.12 mp gw**
>
> Motion passed unanimously.
>
> **The SSC moves to recommend the OFL for gag based on yield at F_{max}:**
> **2011 = 1.67 mp gw**
> **2012 = 2.11 mp gw**
> **2013 = 2.54 mp gw**
> **2014 = 2.91 mp gw**
> **2015 = 3.19 mp gw**
>
> Motion passed unanimously.

During discussion of the gag assessment re-run, the SSC began to discuss the proposed SEDAR procedure revisions and updated SEDAR schedule (Tab A, No. 7). Those comments are summarized later in this report. However, noting that the SEDAR 10 gag benchmark assessment was conducted in 2005, the SSC felt that the time between full assessments is too long, and passed the following motion regarding the next gag assessment.

> **The SSC moves to request that the next assessment for gag be a benchmark assessment to be completed by the end of 2013, or sooner if possible.**
>
> Motion passed unanimously.

Andy Strelcheck presented a graph of total removals of gag in recent years (Figure 4). The management decision spreadsheet that he is preparing to help the Council decide on a strategy for reducing recreational gag harvest. The needed percent reduction to achieve the 2011 target catch level is currently determined from the baseline years of 2006-2008 (last three years of the assessment). However, there was an obvious decline in removals in 2009-2010 (2010 is preliminary). Since there is currently no effort or age-composition data available for 2009-2010, the reason for this decline cannot be determined, nor whether the decline is persistent or temporary. For purposes of presenting management advice to the Council, Dr. Strelcheck proposed presenting the Council with management scenarios based on reductions from both the 2006-2008 baseline and a 2009 (or 2009-2010) baseline, and letting the Council decide which to use. He asked if the SSC felt that this was a reasonable approach. The SSC did not vote on the request, but individual comments were that this was a reasonable approach, and that it would be conjecture for the SSC to recommend one baseline over the other.

Figure 4.



Impact of Observer Discard Estimates on Red Grouper Stock Assessment

Brian Linton presented a PowerPoint presentation prepared by John Walter on an analyses of the effect of using observer based commercial discard estimates on the red grouper update assessment. Before analyzing the results of the observer discard data, an analysis was conducted on the effect of lowering the commercial minimum size limit from 20" to 18" in 2009. This resulted in 12% more fish retained for age 4 and 9% more for age 5. Even without including the observer based discards, this resulted in higher yield streams for F_{MSY} and F_{OY} (Attachment 2, middle column). When the observer data is used, the estimated discards from the commercial handline fishery are about double the previous estimates. However, the handline fishery has only about 10% discard mortality rate, so the impact on dead discards is not very great. The longline fishery has a 45% discard mortality rate, but the discard estimates using the observer data are almost identical to the earlier discard estimates. The resulting fishing mortality rate relative to F_{MSY} is slightly lower when the observer based data is used (Figure 5), and the biomass estimate relative to B_{MSY} is slightly higher (Figure 6).

Figure 5.

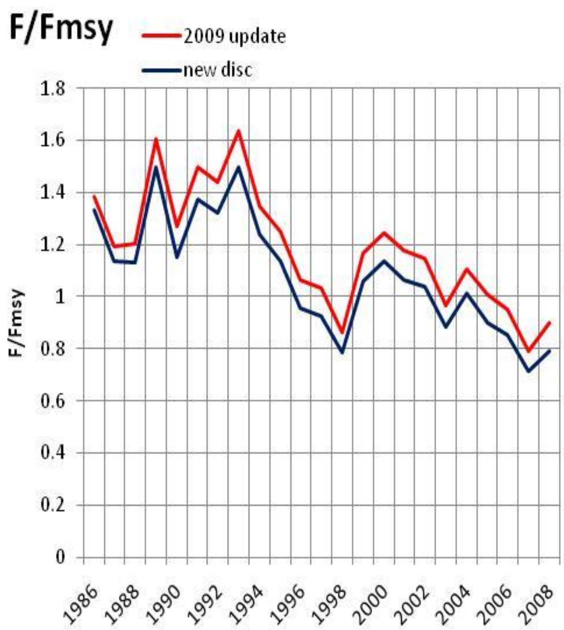
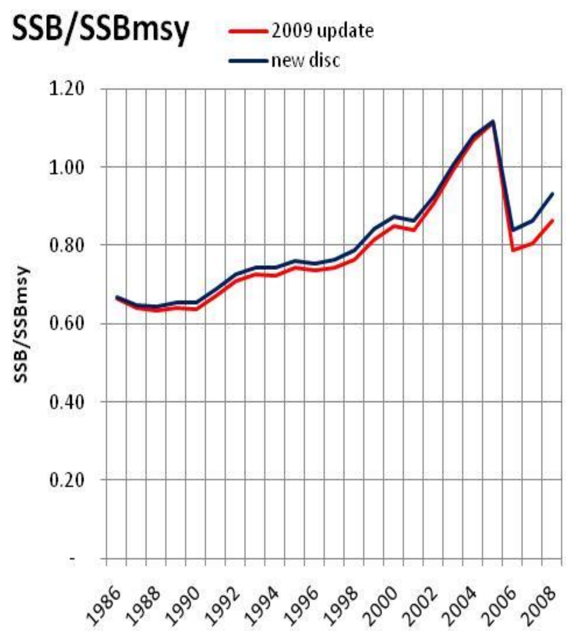


Figure 6.



Attachment 2 shows the results of both the impact of the 18 inch size limit and the additional impact of using observer based discards. Since the Council did not re-convene the red grouper assessment workgroup, and only asked that the Science Center evaluate the observer discard information with regard to red grouper and determine the magnitude of impact to the stock assessment, the SSC did not revise its previous OFL and ABC recommendations. However, the SSC noted that the analyses extended the projections for OFL and OY by an additional two years, although the assessment itself ended with 2008 data. SSC members expressed concern about the increased uncertainty with long term projections in light of factors such as the low level of observer coverage on vessels (less than 2 percent) and changing regulations such as the

Amendment 31 change in the reef fish longline boundary off Florida. The SSC passed the following motion.

> **The SSC moves to accept the red grouper 2010 revised update with benchmarks recomputed accounting for the 18" size limit as the best scientific information available. However, the SSC also stresses that there is inherent risk in extending the timeframe of assessments by simply extending landings time series without also extending time series for CPUE indices and incorporating age composition estimates for the additional years.**
>
> Motion passed unanimously.

SEDAR 23 Goliath Grouper Benchmark Assessment

Joe O'Hop reviewed the SEDAR 23 goliath grouper benchmark assessment. Because there are few catches outside of Florida, the assessment was restricted to south Florida. There were several issues with the available catch data. Since the stock has been under a moratorium since 1992, there are no recent landings. Furthermore, in the commercial landings data available from the 1960s to the 1980s, a dealer in south Florida appears to have overstated his goliath grouper landings. There are some recreational landings available in numbers of fish, but few lengths and weights were taken, so converting the numbers of fish to pounds is problematic. The maximum known age of goliath grouper is 37 years, but in an overfished stock the age distribution can be truncated, so this may be an underestimate. Given that goliath grouper occur throughout the Gulf of Mexico and Caribbean, SSC members also expressed concern about the spatial distribution of the available data. Because of the lack of landings data, a catch-free model that was used in the 2004 SEDAR 6 assessment was chosen for this assessment. This model provides relative benchmarks of population status, but does not give absolute estimates of MSY or other benchmark reference points. A total of 17 sensitivity runs were made at various levels of moratorium effectiveness, and at maximum ages of 37 to 80 years. Under the base case (maximum age = 37, moratorium produces 91% reduction in fishing mortality), the model estimated that the goliath grouper stock is at 96% of its $SSB_{50\%\ SPR}$ relative biomass level. The range of results from the sensitivity runs ranged from 29% to 116% of $SSB_{50\%\ SPR}$, with 45% of the runs below the minimum stock size threshold. However, the SEDAR Review Panel rejected the assessment as not rising to a level where it could be used for management. While the Panel felt that the assessment was done properly for the model selected and the available data, they concluded that the assessment did not meet the Terms of Reference, and could not provide the necessary management benchmarks.

An SSC member who participated in the review workshop felt that the SEDAR Review Panel had been too strict in interpreting the Terms of Reference, but also felt that the Terms of Reference were inappropriate for data poor stocks. Steven Atran pointed out that the available data is not known until the Data Workshop is conducted, which is part of the assessment. Another SSC member who attended the workshop felt that the Center of Independent Expert (CIE) reviewers were concerned about the use of a non-traditional catch-free model, and also felt that an attendee at the review had inappropriately lobbied the CIE reviewers to reject the assessment. The SSC disagreed with the SEDAR Review Panel, and felt that the use of the catch-free model was appropriate for the assessment. The SSC passed the following motion and provided the rationale below for the motion.

The SSC accepts the contents of the Goliath Grouper Stock Assessment Report as best available science.

Motion passed unanimously.

Rationale:

1) The stock assessment report contains results that are consistent with the SSC's expectations for data-poor species, particularly those for which a reliable time-series of removals is not available. These results include a trajectory of SSB relative to SSB_{SPR50} (a proxy for MSY) and CPUE series.

2) The choice of the stock assessment model (Catch-Free Model, Porch et al. 2006) was appropriate given that a reliable time-series of removals is not available to date, nor is it likely to become available. The SSC also notes that this peer-reviewed model was used, reviewed and accepted during the previous assessment of goliath grouper (SEDAR 6), which has since been applied to assessments of other species (e.g. blue shark, dusky shark, and shortfin mako).

3) Indices of CPUE indicate an increasing Goliath grouper population in inshore and offshore waters of southwestern Florida, but the SSC expressed concerns as to the lack of information on Goliath grouper stock status in the greater Gulf of Mexico and southern US Atlantic. A focus of future analyses should be attempting to understand stock dynamics in other areas of US waters in addition to continuing to monitor the population off southwestern Florida.

Although the SSC accepted the assessment, they felt that due to the limited spatial range of the assessment, uncertainty about model inputs, and results that suggest that the stock is still below its $SSB_{50\%\ SPR}$ (as a proxy for B_{MSY}) level, they could not recommend an acceptable biological catch level for the directed fishery. The SSC passed the following motion and provided the rationale below for the motion.

The SSC recommends that the status quo (moratorium on directed landings) for Goliath grouper be continued for 2011-2015.

Motion passed unanimously

Rationale: The SSC recognizes that the stock appears to be increasing Florida. However:

1) The U.S. stock represents a small proportion of the species' range which, at unfished condition, was distributed across the Caribbean.

2) Abundance trends (and other data inputs) from the northern and western Gulf of Mexico were not available. Therefore, it is not clear that the stock has recovered across a meaningful proportion of its former U.S. range.

3) Given the uncertainly in the model inputs, the SEDAR RW and the SSC was unable to make conclusions about the current status of Goliath grouper relative to the proposed management benchmark (SPR50%). Furthermore, the SSC recognizes that the median outcome of the base model proposed by the SEDAR AW suggests that the spawning stock remains below the SSB at SPR50%.

The SSC intent was that the next goliath grouper assessment be conducted within the next 3 to 5 years, and that it have sufficient data to address the uncertainties identified in the current assessment. The SSC has previously recommended a limited scientific kill as a way to collect the data needed for a traditional assessment, but no such data collection program has been implemented. The SSC therefore made the following request to the Council.

The SSC requests the Council to convene a workshop to gather scientists and assessment biologists familiar with Goliath grouper population biology and the species' recent assessment. The goals of the workshop would be to gather all available biological information on the species, identify critical data needed to decrease uncertainty in Goliath grouper's stock status, and produce a coordinated scientific sampling plan to address those needs in the next 3-5 years, where possible.

Motion passed unanimously.

Other Business – Modification to ABC Control Rule

During discussion of the goliath grouper assessment, SSC members noted that even the lowest tiers in the ABC control rule required that stocks have a reliable time series of landings. Stocks such as goliath grouper or stock without a reliable landings history are not covered by any of the control rule tiers. In addition to goliath grouper, red drum is another stock that has been closed for an extended time but may eventually be reopened. To deal with such stocks, the SSC initially considered a motion to augment the ABC control rule to allow for changing OFL and ABC for closed fisheries. That motion was tabled until the SSC was finished with the goliath grouper assessment. Under Other Business, the motion was replaced with a broader motion to add a note to the bottom of the control rule to allow any fishery without reliable landings to be considered on a case by case basis.

Tabled motion: The SSC moves that the ABC Control Rules be augmented to include a strategy to decide whether or not to change the OFL and ABC for closed fisheries and, if warranted, to determine a revised ABC.
Motion tabled until Other Business.

The SSC moves that the following text be added at the bottom of the ABC Control Rule:

Note: There may be situations in which reliable landings estimates do not exist for a given data-poor stock. The approach and methodology for setting OFL and ABC will be determined on a case-by-case basis, based on expert opinion and the best scientific information available.

Motion passed unanimously.

See Attachment 3 for the control rule with this change.

Other Business – Scheduling of SEDAR Assessments and Ecosystem Stocks

The SSC reviewed the latest schedule of SEDAR projects through 2015, but felt that they should have input into which assessments should be given priority. The SSC asked that the SEDAR schedule be put on the agenda for the next SSC meeting so that they could review it and provide recommendations to the SEDAR Steering Committee on changes.

The SSC also discussed whether some of the minor stocks could be declared ecosystem component stocks under the National Standard 1 guidelines. Council staff informed the SSC that the Council had decided not to declare any ecosystem component stocks based on advice from legal Counsel and a determination that no stocks fully met the criteria. However, the SSC asked that the guidelines for determining ecosystem stocks be reviewed at the next SSC meeting.

Other Business – Revisions to the SEDAR Process (no quorum)

The current proposed revisions to the SEDAR process would create three types of assessments.

- A benchmark assessment would be the first assessment done on a stock, and would be similar to current benchmark assessments. It is expected to take 12 months.
- A standard assessment could be done at variable intervals, but would be triggered if an update interval exceeds 5 years. It is similar to the current update assessment, but has more flexibility in that it can consider new models to address new data (e.g., add a survey, age info, discard info to the prior framework). It is expected to take 4 to 6 months.
- An update assessment would be a strict update, only new data added. No method changes. It would be conducted at 1 to 5 year intervals, and is expected to take one month.

Overall, the SSC voiced concern over the frequency of stock assessments. Problems with balancing assessment needs for all species were mentioned, as was the creation of new methods to expedite the assessment process. Committee members agreed that assessments were overly time consuming, and expressed interest in the SEDAR Steering Committee's efforts to further examine the SEDAR process and how it might be improved.

There was no quorum by the time of this discussion, and no motions were made by the SSC, but some of the points raised during discussion by SSC members were as follows:

Benchmark vs. standard vs. update assessments

- Need to have Benchmark assessments rather than updates when big changes in management have occurred or are occurring
- Should minimize the number of updates wherever/whenever possible
- Update assessments are taking 6-10 months, sometimes longer. Benchmarks can be done in the same amount of time it is currently taking to conduct update assessments
- Problems arise with update assessments, including no thorough review due to data restrictions and time constraints
- The Standard assessment process may be overburdened with tasks to be completed within the time period specified (4-6 months)

Standardization of assessments

- Changing software affects data quality. There is a need to standardize the methodology when conducting all assessments in order to streamline the process and increase efficiency
- Varying and changing stock histories make standardization difficult, but possible
- Need to be able to change the model if necessary, since modeling capabilities and data quantity/quality change with time
- Need to standardize species data collection methods as well
- Consider having the Gulf Council pursue its own approach when conducting stock assessments?
- Update assessments are frustrating because you cannot change methodology, even if you need to do so
- All Update assessments seem to become Standard assessments eventually, and time between assessments is too long as it is

Data Issues

- States have much of the data for some assessments; without data summaries available or prepared prior to workshops- data should be prepared ahead of time and presented at the data workshop [note: for this to be feasible, an adequate template needs to be provided to the data holders prior to the data workshop. If analyses are needed to extract the pertinent information, adequate lead time must be included for those analyses.

- Need data sets well in advance of workshops in order to examine and analyze prior to the workshop- preferably, data would be available for review and comment by a certain date prior to the workshop, and any revisions would have to be submitted by a given date after the workshop

Scheduling of Assessments

- Need to investigate the possibility of a triage approach to species selection for assessment, apply simpler models where applicable, etc in order to expedite the assessment process. Triage example: FWC to do yellowtail snapper assessment in-house, and introduce results to SAFMC SEDAR in Fall 2011

- Perhaps more economically and ecologically important species ought to receive priority over others when determining the order and frequency of stock assessments, similar to the concept of triage

- Perhaps the Council should outsource some stock assessment duties to other entities, especially for those species deemed to be at a lower priority level compared with economically/ecologically important species like red and gag grouper

- GSMFC has some stock assessment capabilities of its own, as does NMFS

Role of SEDAR Coordinator

- SEDAR Coordinator needs to work with analysts to identify data 6-12 months prior to scheduled data workshops, giving analysts time to work on data prior to the workshop

- Each player in the process needs to know their respective duties- currently there are no set responsibilities for SEDAR Coordinators

- SEDAR Coordinator duties need to be clearly defined- should task duties and encourage SEDAR staff to meet deadlines

Use of Webinars

- Need to pool people involved in the assessment to streamline the process, rather than via current email, conference call, or webinar efforts

- People are often unavailable for webinars, and meeting in person is much more efficient

- Webinars suffer in the continuity of ideas, whereas in-person meetings keep everyone focused until the purpose of the meeting is achieved

- Webinars are probably best used for sharing information, but not for making decisions

General/Procedural

- A desire to increase transparency, amongst other objectives, has not yet been achieved

- Separate working groups limit transparency but may improve productivity of the workshop

- Need to have participants commit to the entire SEDAR process ahead of time

- Reports need to be started prior to the conclusion of each workshop

- Having a reviewer available to help guide the process could prove very helpful in terms of keeping the discussion on track and would make analysis and report generation more timely.

- One source of complexity is coming from the peer-review process being incorporated into the assessment process

- Deadlines ought to be met

- SEDAR needs simple, strict guidelines and schedules, and for deadlines to be established far in advance to increase the likelihood that said deadlines will be met

- SEDAR staff needs to meet with SEFSC staff to discuss ways to increase efficiency and thereby streamline the assessment process.

- SSC definitely needs to be involved in the SEDAR process and provide input on the development and review of the Terms of Reference

- Need guidance document to specify when SEDAR process is not needed, and what species do not require the SEDAR stock assessment method

Other Business – Unassigned ABCs (no quorum)

The SSC reviewed the list of stocks and stock complexes that still need to have ABC recommendations, and stocks with ABC recommendations that the SSC may want to revisit in light of changes to the ABC control rule. These stocks include scamp, yellowtail snapper, deep-water grouper complex, mid-water snapper complex, shallow-water snapper complex, jacks complex, tilefishes complex, hogfish, and lane snapper. For each of these stocks, the SSC discussed having a summary sheet of available biological information to assist them in determining whether the stock should be assigned to Tier 3a or Tier 3b. At a previous meeting, Joe Powers had offered to develop a template for an information sheet. However, Dr. Powers was not present at this meeting. Harry Blanchet distributed a spreadsheet as a possible alternative starting point for a biological info template (Attachment 4). It was suggested that the Stephens and MacCall (2004) approach might be used for estimating CPUE for some of these stocks.

Stephens, A., and A. MacCall. 2004. A multispecies approach to subsetting logbook data for purposes of estimating CPUE. Fisheries Research 70:299-310

Standing Scientific and Statistical
Committee members in attendance
Harry Blanchet, Chair
Sean Powers, V. Chair
Luiz Barbieri *(Tu-We-Th only)*
Shannon Cass-Calay
Jim Cowan *(Tu-We only)*
Richard Fulford
Douglas Gregory
William Patterson
Stephen Szedlmayer
Elbert Whorton *(Tu-We-Th only)*

Special Spiny Lobster
SSC in attendance
Rene Buesa *(Tu only)*
John Hunt *(Tu only)*
William Sharp *(Tu only)*

Special Reef Fish
SSC in attendance
Barbara Dorf
Bill Lindberg
John Mareska

Others Present
Bob Gill, Council member
Steven Atran, Council staff
Charlotte Schiaffo, Council staff
Steve Bortone, Council staff
Karen Burns, Council staff
John Froeschke, Council staff
Richard Leard, Council staff
Ryan Rindone, Council staff
Carrie Simmons, Council staff

Steve Branstetter, NMFS/SERO
Roy Crabtree, NMFS/SERO
Nick Farmer, NMFS/SERO
Sue Gerhardt, NMFS/SERO
Peter Hood, NMFS/SERO
Rich Malinowski, NMFS/SERO
Andy Strelcheck, NMFS/SERO
Joseph Munyandonero, FWC/FWRI
Joe O'Hop, FWC/FWRI
Mike Tringali, FWC/FWRI

Tom Coppedge (OFF)
Claudia Friess (OC)
Bill Kelly (FKCFA)
TJ Marshall (OC)
Dennis O'Hern (FRA)
Jerry Sansom (OFF)

ATTACHMENT 1. Required SFA and MSRA evaluations for the 2010 rerun of the Gulf of Mexico gag update assessment. 2009 assessment update values come from the Gulf of Mexico gag 2009 update assessment report, except where otherwise noted. Assessment rerun values come from alternative model run 2 for the 2010 rerun of the Gulf of Mexico gag update assessment.

Criteria	Definition	2009 Assessment Update Value Table 9.3 except as noted	Assessment rerun revisions
	Mortality Rate Criteria		
$F_{MSY\ or\ proxy}$	F_{MAX}	0.22	0.22
MFMT	F_{MAX}	0.22	0.22
F_{OY}	75% of F_{MAX}	0.16	0.17
$F_{CURRENT}$	Geometric mean 2005-2007	0.53	0.55
$F_{CURRENT}$/MFMT	Geometric mean 2005-2007	2.47	2.50
Base M		0.15	0.15
	Biomass Criteria		
SSB_{MAX}	Equilibrium SSB @ F_{MAX}	24.02 mp gw	22.51 mp gw
MSST	(1-M)*SSB_{MAX} M=0.15	20.41 mp gw	19.14 mp gw
$SSB_{CURRENT}$	current = 2008	9.58 mp gw	9.30 mp gw
$SSB_{CURRENT}$/MSST	current = 2008	0.47	0.49
Equilibrium MSY	Equilibrium Yield @ F_{MSY}	4.28 mp gw	4.19 mp gw
Equilibrium OY	Equilibrium Yield @ F_{OY}	4.17 mp gw	4.08 mp gw
OFL	Annual Yield @ F_{MAX}		
(June 10, 2010 e-mail	2011	1.32 mp gw	1.67 mp gw
From Clay Porch & Brian Linton)	2012	1.81 mp gw	2.11 mp gw
	2013	2.30 mp gw	2.54 mp gw
	2014	2.74 mp gw	2.91 mp gw
	2015	3.08 mp gw	3.19 mp gw
	2016	3.34 mp gw	3.40 mp gw
10-yr rebuild yield (ABC)	Annual Yield @ $F_{Rebuild}$		
(March 22, 2010 revised	2011	1.17 mp gw	1.58 mp gw
assessment with 2009 landings)	2012	1.64 mp gw	2.02 mp gw
	2013	2.12 mp gw	2.45 mp gw
	2014	2.57 mp gw	2.82 mp gw
	2015	2.93 mp gw	3.12 mp gw
	2016	3.20 mp gw	3.34 mp gw
Annual OY (ACT)	Annual Yield @ F_{OY}		
(March 22, 2010 revised	2011	1.01 mp gw	1.28 mp gw
assessment with 2009 landings)	2012	1.44 mp gw	1.69 mp gw
	2013	1.90 mp gw	2.11 mp gw
	2014	2.34 mp gw	2.49 mp gw
	2015	2.70 mp gw	2.80 mp gw
	2016	2.98 mp gw	3.04 mp gw

ATTACHMENT 2. Required SFA and MSRA evaluations for Gulf of Mexico red grouper. The central model was not projected for the 2010 re-run with observer discards and the 18 inch commercial size limit. Yields are mil. pounds, gutted weight, spawning stock measures (SSB, MSST) are in million grams of mature female gonad weight. Yields come from the deterministic run of the projection model. Gray values are the actual estimated landings for 2009 and 2010 used in the current projections. Blue values are 2011 TAC.

Criteria	Definition	Red Tide	ReRun 2010	ReRun 2010, with diff benchmarks
Mortality Rate Criteria				
$F_{MSY\ or\ proxy}$	Fmsy	0.1865	0.1853	0.1922
MFMT	Fmsy	0.1865	0.1853	0.1922
F_{OY}	75% OF F_{MSY}	0.1399	0.1389	0.1441
$F_{CURRENT}$	Geom mean 2005-2007	0.1610	0.1563	0.1563
$F_{CURRENT}$/MFMT	Geom mean 2005-2007	0.8633	0.8439	0.8135
Base M		0.140	0.140	0.140
Biomass Criteria				
SSB_{msy}	Equilibrium SSB @ Fmsy	712.700	713.49	696.255
MSST	(1-M)*SSB_{Msy} M=0.14	612.922	613.601	598.779
$SSB_{CURRENT}$	SSB_{2008}	615.524	650.50	650.50
$SS_{CURRENT}$/MSST	SSB_{2008}	1.004	1.060	1.086
Equilibrium MSY	Equilibrium Yield @ F_{MSY}	7.670	7.818	8.10
Equilibrium OY	Equilibrium Yield @ F_{OY}	7.498	7.875	7.927
OFL	Annual Yield @ FMFMT			
	2009	4.69 ~~7.498~~	4.635	4.635
	2010	4.69 ~~6.425~~	3.481	3.481
	2011	7.42 ~~6.626~~	5.680	5.680
	2012	7.43 ~~6.737~~	9.132	9.434
	2013	7.53 ~~6.940~~	9.040	9.289
	2014	7.54 ~~7.053~~	8.859	9.060
	2015		8.704	8.864
	2016		8.592	8.720
Annual OY (ACT)	Annual Yield @ F_{OY}			
	2009	4.69 ~~7.570~~	4.635	4.635
	2010	4.69 ~~4.913~~	3.481	3.481
	2011	5.68 ~~5.260~~	5.680	5.68
	2012	5.90 ~~5.528~~	6.982	7.218
	2013	6.19 ~~5.859~~	7.176	7.389
	2014	6.38 ~~6.099~~	7.274	7.463
	2015		7.358	7.525
	2016		7.442	7.59
	Annual Yield (2012) @ 65% FMFMT		6.098	6.306
	Annual Yield (2012) @ 75% FMFMT		6.982	7.218
	Annual Yield (2012) @ 85% FMFMT		7.852	8.115

Note: The column containing the base case reported yield projections based on the initial update assessment results. The assessment projections were re-run in March 2010 once 2009 landings data was available. Council actions in the August 2010 regulatory amendment to reduce red grouper TAC were based on the March 2010 re-run.

Note: For OFL and ACT under the Red Tide base run, the struck-out values were from the original 2009 update assessment. These values have been corrected to reflect the March 2010 results that were used for the August 2010 red grouper regulatory amendment.

ATTACHMENT 3. Acceptable Biological Catch control rule – As Accepted by Scientific and Statistical Committee January 2011

Tier 1 Acceptable Biological Catch Control Rule	
Condition for Use	A quantitative assessment provides both an estimate of overfishing limit based on MSY or its proxy and a probability density function of overfishing limit that reflects scientific uncertainty. Specific components of scientific uncertainty can be evaluated through a risk determination table.
OFL	OFL = yield resulting from applying F_{MSY} or its proxy to estimated biomass.
ABC	The Council with advice from the SSC will set an appropriate level of risk (P*) using a risk determination table that calculates a P* based on the level of information and uncertainty in the stock assessment. ABC = yield at P*.
Tier 2 Acceptable Biological Catch Control Rule	
Condition for Use*	An assessment exists but does not provide an estimate of MSY or its proxy. Instead, the assessment provides a measure of overfishing limit based on alternative methodology. Additionally, a probability density function can be calculated to estimate scientific uncertainty in the model-derived overfishing limit measure. This density function can be used to approximate the probability of exceeding the overfishing limit, thus providing a buffer between the overfishing limit and acceptable biological catch.
OFL	An overfishing limit measure is available from alternative methodology.
ABC	Calculate a probability density function around the overfishing limit measure that accounts for scientific uncertainty. The buffer between the overfishing limit and acceptable biological catch will be based on that probability density function and the level of risk of exceeding the overfishing limit selected by the Council. a. Risk of exceeding OFL = 45% b. Risk of exceeding OFL = 35% c. Risk of exceeding OFL = 25% (default level for unassigned stocks) d. Risk of exceeding OFL = 15% Set ABC = OFL – buffer at risk of exceeding OFL
Tier 3a Acceptable Biological Catch Control Rule	
Condition for Use*	No assessment is available, but landings data exist. The probability of exceeding the overfishing limit in a given year can be approximated from the variance about the mean of recent landings to produce a buffer between the overfishing limit and acceptable biological catch. Based on expert evaluation of the best scientific information available, recent historical landings are without trend, landings are small relative to stock biomass, or the stock is unlikely to undergo overfishing if future landings are equal to or moderately higher than the mean of recent landings. For stock complexes, the determination of whether a stock complex is in Tier 3a or 3b will be made using all the information available, including stock specific catch trends.
OFL	Set the overfishing limit equal to the mean of recent landings plus two standard deviations. A time series of at least ten years is recommended to compute the mean of recent landings, but a different number of years may be used to attain a representative level of variance in the landings.
ABC	Set acceptable biological catch using a buffer from the overfishing limit that represents an acceptable level of risk due to scientific uncertainty. The buffer will be predetermined for each stock or stock complex by the Council with advice from the SSC as: a. ABC = mean of the landings plus 1.5 * standard deviation (risk of exceeding OFL = 31%) b. ABC = mean of the landings plus 1.0 * standard deviation (default)(risk of exceeding OFL = 16%) c. ABC = mean of the landings plus 0.5 * standard deviation (risk of exceeding OFL = 7%) d. ABC = mean of the landings (risk of exceeding OFL = 2.3%)
Tier 3b Acceptable Biological Catch Control Rule	
Condition for Use*	No assessment is available, but landings data exist. Based on expert evaluation of the best scientific information available, recent landings may be unsustainable.
OFL	Set the overfishing limit equal to the mean of landings. A time series of at least ten years is recommended to compute the mean of recent landings, but a different number of years may be used to attain a representative level of variance in the landings.
ABC	Set acceptable biological catch using a buffer from the overfishing limit that represents an acceptable level of risk due to scientific uncertainty. The buffer will be predetermined for each stock or stock complex by the Council with advice from its SSC as: e. ABC = 100% of OFL f. ABC = 85% of OFL g. ABC = 75% of OFL (default level for unassigned stocks) h. ABC = 65% of OFL

*Changes in the trend of a stock's landings or a stock complex's landings in three consecutive years shall trigger a reevaluation of their acceptable biological catch control rule determination under Tiers 2, 3a, or 3b.

Note: There may be situations in which reliable landings estimates do not exist for a given data-poor stock. The approach and methodology for setting OFL and ABC will be determined on a case-by-case basis, based on expert opinion and the best scientific information available.

ATTACHMENT 4. Draft Biological Information Template.

Beginnings of an outline on information suggested for inclusion in biological summaries

Schooling	Year-round?
	Spawning aggregations?
	fidelity?
Migrations	Seasonal?
	Spawning?
Growth	
	Linf
	k
	T0
	number of samples
	number of studies
	location of studies
Maturity	
	age
	age at sex change
Fecundity	batch?
	protect young?
	Hermaphroditism / gonochorism?
	egg size?
	elasmobranch?
Longevity	
	max age
	number of studies
	location of studies
	age of studies
Biogeography	
	range
	depth strata
	substrate characteristics
	habitats
History of Fishery	known/estimated landings
	geographic distribution in US
	worldwide distribution

FINAL REPORT

PROJECT NUMBER: R/LR-B-57

PROJECT TITLE: "Assessment of regional Spiny Lobster stock dynamics and linkages to explain Florida stock abundance trends"

PRINCIPAL INVESTIGATORS: Drs. Nelson M. Ehrhardt and Donald Olson

INSTITUTION: University of Miami
Rosenstiel School of Marine and Atmospheric Science

DATE: 30 June 2006

1. INTRODUCTION

The important commercial fishing industry of Monroe County, in southwest Florida, generates approximately 20 percent of the total Florida landings and is leader for several high-valued species (40% of the stone crab, 90% of the spiny lobster, 25% of the snapper, and 40% of the king mackerel landed in Florida). Management issues such as overfishing, excessive gear deployed (overcapitalization), and significant interactions and competition for finite resources among users characterize each of the main species and their fisheries. Efforts to address management issues in these congested fisheries have historically been approached on a single-species basis, with management strategies traditionally used in open-access fisheries. The need to consider restricted access management measures is reflected in the Florida spiny lobster trap reduction program established in 1992. This program was implemented based on the fact that catch per trap (CPUE) should increase if fewer traps were used because landings until then varied with no trend within the 250000-930000-trap range. Hence, the management objective under the goal of the spiny lobster trap certificate program was to improve CPUE for the spiny lobster fishery as a whole and to reduce the confrontation among fishers and other users of the waterways (sport fishing, pleasure boating, etc.). Lobster traps were reduced from about 930,000 at the start of the program to about 450,000 in 2000. Ehrhardt (2001) concluded that the spiny lobster fishery in Florida is one where break-even economic conditions prevailed during the 1999/2000 fishing season, while an unintended effect of the program was the re-direction of spiny lobster non-regulated effort to the stone crab fishery. The economic outcome deteriorated significantly as landings in the Florida spiny lobster trap fishery decreased 57.8% in the last 3 fishing seasons and the causes of such great decrease are not presently known.

The economic impact generated by lower productivity created stiff economic hardships to the industry and a workshop organized by Florida Sea Grant and held on 6 June 2003 in Key West, Florida discussed the potential causes that might be responsible for the observed drop in landings. An indication of regional signals affecting common trends in lobster landings was presented by Ehrhardt (invited speaker) and the talk generated a promising line of new research discussed at the workshop. The Monroe County Commercial Fishermen, Inc., reacted immediately to the general regional dynamic production concept and the importance of the more holistic approach to plan fisheries management in the Florida fishery.

The drastic decrease in landings in the Florida trap fishery that reached 2.6 million pounds in the 2001/2002 fishing season contrast well with the results emerging from the September 2002 Food and Agriculture Organization of the United Nations (FAO) Second Workshop on the Management of Caribbean Spiny Lobster in the Western Central Atlantic Region. Analyses carried out at the Workshop showed that landings in the last 3 fishing seasons decreased 26% in the Bahamas, 30% in Cuba and 35% in Nicaragua (the 3 largest spiny lobster producing countries in the Western Caribbean region). These trends were identified with a decrease in stock abundance estimated for the above fisheries; however, no conclusions were reached regarding the origin of these common decreasing trends. Hence, the observed conditions in the Florida fishery are suspected to be regional in its origin given the common decreasing slopes and variances observed in the landings of the two most important fisheries in the region – the Cuban and Brazilian fisheries (Figure 1), which are also two of the farthest apart fisheries. The unknown causes of such declines need to be investigated to better dimension the Florida fishery within a more reasonable long-term sustainability strategy.

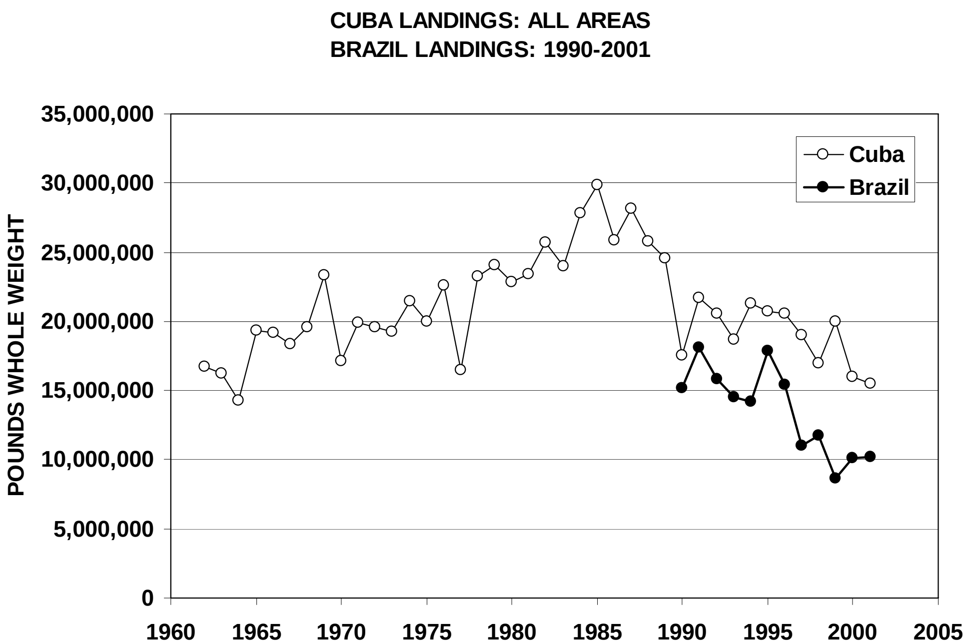


Figure 1. Cuban and Brazilian spiny lobster landings indicating downward trends and variances in the last 12 years.

The Caribbean spiny lobster possesses larvae that may remain in the water column for 6 to 12 months (Lewis, 1951; Lyons, 1980) before settling in a suitable juvenile habitat. That condition coupled with the strong ocean currents dominating the general larval environment throughout the Caribbean Sea, makes colonization far downstream plausible by those larvae from far upstream -- thus the Pan-Caribbean theory of spiny lobster populations. The likelihood that spiny lobster stocks may originate from a single gene pool in the Caribbean Sea was postulated by Menzies and Kerrigan (1980) and Lyons (1981). Caribbean-wide genetic studies provide conclusive evidences that sustain the above statement by showing a consistent lack of major geographical differentiation in adults (Silberman, et al. 1994.a) and a lack of seasonal variation in genetics of pueruli arriving in the Florida Keys (Silberman, et al. 1994.b). These two conditions are indications of high levels of mixing and of the constancy of the mixing. Furthermore, there are clear signals of trends and variances associated with spiny lobster landings in Brazil and Florida (Figure 2) that show the importance of potential regional linkages in spiny lobster population dynamics. Thus, regional genetic mixing and similitude in stock productions appear as unquestionable regarding the local Florida fishery dynamics. These aspects have not been incorporated in the analyses of the present day spiny lobster crisis in Florida. This project addresses the regional stock connectivity to local Florida stock dynamics and the impact on the Florida fishery.

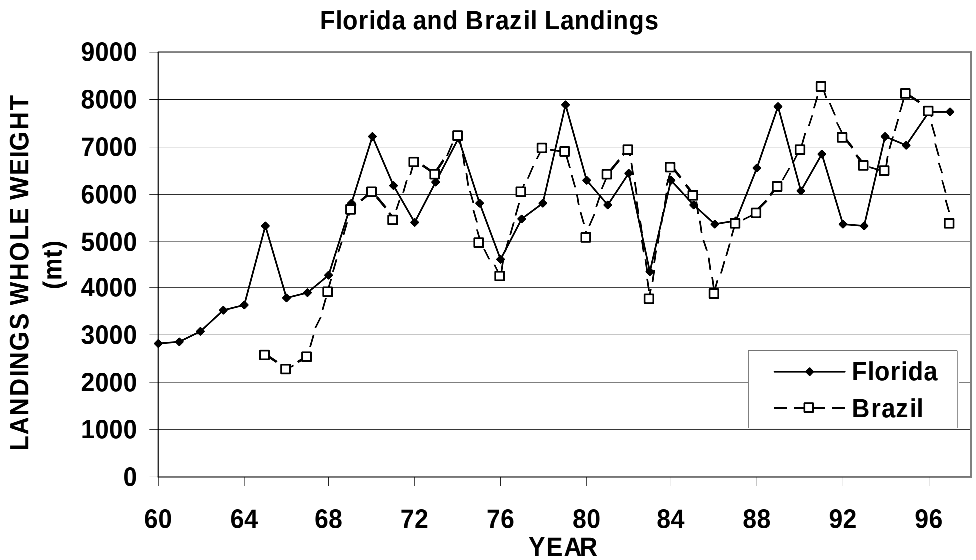


Figure 2. Florida and Brazil historic landings showing similitude in trends and variance.

In summary, complex spiny lobster population dynamics inhabiting complex ecosystems in the wider Caribbean dominated by strong ocean currents affect spiny lobster production in southwest Florida. It appears, therefore, that simple local single-species conceptual frameworks are not sufficient to properly manage the Florida spiny lobster fishery. Surprisingly, however, existing theoretical and empirical fishery management models do not provide a comprehensive framework to evaluate the long-term impacts of these regional effects on the management of the Florida fishery. This research project provides an assessment of the likelihood of Pan Caribbean larval supply to Florida through advanced ocean circulation models coupled to local spiny lobster population dynamics in Brazil, Honduras+Nicaragua, and Florida. The project examines for the first time a complex management problem affecting the most important fishery in the State of Florida through an integrated regional environmental and population dynamic analysis.

2. GOALS AND OBJECTIVES:

The goals of this project were to identify the origins and to resolve the uncertainties and variance of the fundamental causes that until now create unexpected and significant negative inter annual changes in abundance experienced by the Florida spiny lobster stock. An evaluation of the regional dynamics of spiny lobster stocks provided the necessary understanding to reduce the risk of over investing in this fishery characterized by eras of lower production, thus enhancing the economics of the fishery, while ensuring long-range sustainability of the most economically important fishery in South Florida.

In order to accomplish the above goal, the following project objectives were included:

1) To assess and compare the dynamic regional character of population age structures and of parent stock-recruitment functions for spiny lobster stocks in the region and their relevance to local and regional production.
2) To assess the dynamic bio-physical linkages among stocks in the region.
3) To evaluate the environmental variables that impact recruitment and production variability observed in the region, and
4) To assess long-term economic risks associated with regional and local factors affecting spiny lobster production in Florida.

3. RESULTS

Objective 1. To assess and compare the dynamic regional character of population age structures and of parent stock-recruitment functions for spiny lobster stocks in the region and their relevance to local and regional production.

Spiny lobster abundance at age was obtained through a standardized stock assessment algorithm of strategically located fisheries in the Honduras+Nicaragua and Brazil while the Florida information was obtained from stock assessments by Muller et al. (2000) using a similar stock assessment algorithm. The algorithm is explained below. The assessments were carried out using catch-at-age matrices constructed from catch-at-size matrices made available to the project from the Governments of Brazil, Honduras, and Nicaragua, and applied to sequential population modeling algorithms. The data on annual tail length composition in the landings were converted to seasonal age compositions in the landings by a simple slicing of length frequencies using growth functions specified by sex. These data were used in a calibrated age-structured sequential population analysis (ADAPT) following a least squares statistical reasoning. The conceptual algorithm minimizes a specific objective function given initial mortality rates at age for the last year in the data sets and for the oldest age classes in every year. The objective function used in the minimization procedure was defined as

$$\min \sum_{i}^{m} (CPUE_i - q_i \overline{N_i})^2$$

where i is year, $CPUE_i$ is the catch in numbers per fishing effort for specified year i, q_i is the catchability coefficient in year i, and N_i is the average abundance of specified ages estimated by the least square algorithm in year i. The seasonal catchability coefficient (q) that is necessary in the computations was estimated as

$$q_i = \frac{\sum_{j=3}^{n} CPUE_{i,j} * \overline{N_{i,j}}}{\sum_{j=3}^{n} \left(\overline{N_{i,j}}\right)^2}$$

where j refers to the specified ages used in the calibration. The algorithm was calibrated with standardized catch per unit of effort in each fishery.

Similar sequential population analysis was employed by Muller et al. (2000) for the Florida fishery and their results are used here.

Matrices of abundance from age 0 to the maximum ages observed in the fisheries are used to portray comparative seasonal abundance variability and the likely synchronic character of the annual abundance available in the different fisheries. The results are presented in figure 3 for the longest data series corresponding to Brazil and the restricted period covering 1990-2002 for the Brazil, Honduras+Nicaragua and Florida are presented in figure 4.

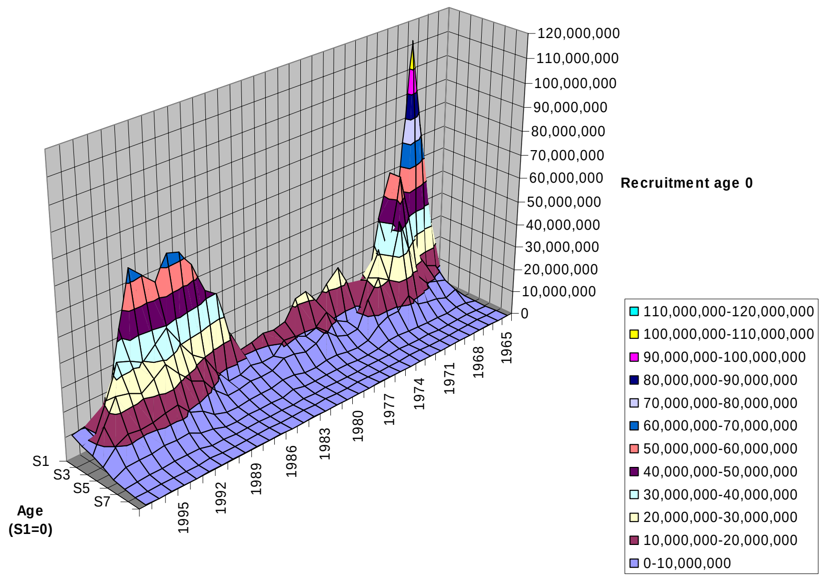
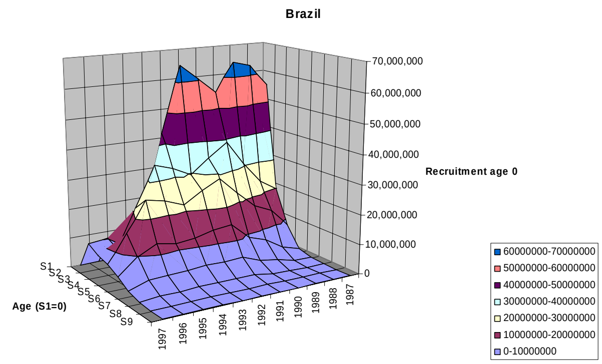
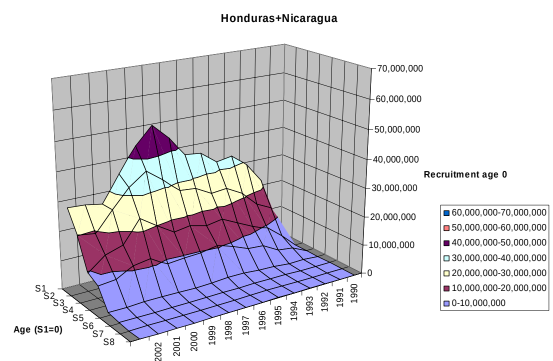


Figure 3. Abundance at age for the Brazilian spiny lobster covering the period 1965-1997.

The recruitment dynamics in the Brazil spiny lobster fishery show two very large abundance peaks (1966-1970 and 1984-1992), and prolonged periods of significant low recruitment abundance (for example 1971-1983). As we explain in Objective 3, the later variability in recruitment may be attributed to changes in wind patterns and strength. These winds are known to be related to ENSO events in the Pacific.

Recruitment abundance at age 0 and the abundance at ages of the recruited stock for a comparative time period (1987-2002) in Brazil, Honduras+Nicaragua and Florida fisheries are shown in figure 4. In this figure is evident that the Brazil *Panulirus argus* stock exhibits a much larger abundance than in Florida for all age classes and during all the years shown. In fact, the lowest levels of abundance in Brazil during 1971-1983 (Fig. 3) are approximately similar to those observed at peak abundance in the Florida fishery. The Honduras+Nicaragua stock shows intermediate abundance at age levels that fall between those of the other two fisheries. An aspect that is worrisome is the significantly declining trend in recruitment at age that started in 1993 in Brazil and 1999 in Honduras+Nicaragua, which is not clearly observed in the Florida fishery data series. However, an important lower recruitment is observed in 1997. In order to explore for trends in recruitment in the Florida fishery for years later than 2000, we implemented a deletion model similar to the one used by Ehrhardt and Deleveaux (2004). This model





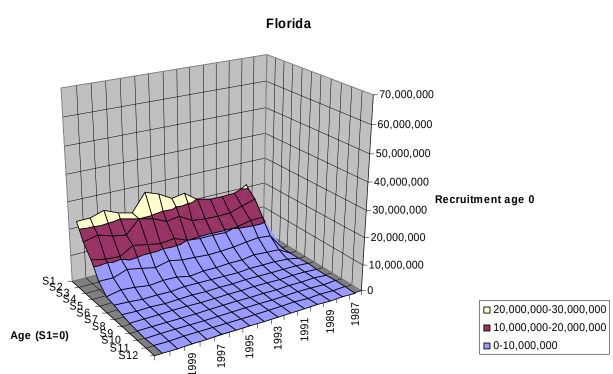


Figure 4. Abundance at age for the Brazilian, Honduras+Nicaragua and Florida spiny lobster covering the period 1987-2002.

estimates the seasonal catchability coefficient, q, and recruitment to the fishery at age 2.

The model is similar to those used in the scientific literature concerning fishery assessments (Leslie and Davis, 1939; DeLury, 1947; Chien and Condrey, 1985; Sanders, 1988; Rosemberg, et al., 1990) but uses Pope's (1972) approximation to Baranov's catch equation. This approximation assumes that total catch (C_t) realized in a given time unit (t) will be taken instantaneously at the middle of the time unit. Such an approximation will generate unbiased estimates of population abundance at the beginning (N_t) and end (N_{t+1}) of the time units given that the natural mortality (M) and fishing mortality rates are not greater than 0.3 and 1.2 for each of the time units, respectively. Hence, the basic population equation is expressed as

$$N_{t+1} = (N_t e^{-M/2} - C_t)e^{-M/2} \qquad (1)$$

and the average population abundance is expressed as

$$\overline{N_t} = N_t e^{-M/2} - \frac{C_t}{2} \qquad (2)$$

Also, the relative stock abundance expressed as the catch in numbers per unit of effort in the time period t is assumed directly proportional to the average abundance. Hence,

$$CPUE_t = q * \overline{N_t} \qquad (3)$$

and therefore,

$$q = \frac{CPUE_t}{\overline{N_t}} \qquad (4)$$

Application of equation (1) to express seasonal depletion in the spiny lobster fishery requires that N_t varies with fishing and natural mortality under the time schedule assumed by the model. However, at the beginning of the fishing season (August) the stock abundance is composed of the last season's remnant of stock abundance that escaped natural and fishing mortality until that period, and the new recruits that accumulated during the closed season. In this manner, the seasonal depletion population model adopted here estimates the seasonal population abundance with which to estimate average population abundance in equation 2 and subsequently estimate catchability by equation (4) is for the month of August ($t+1$)

$$N_{t+1} = (N_t e^{-M/2} - C_t)e^{-M/2} + R_{t+1} \qquad (5)$$

where C_t is zero. For the remaining months until March (last month of the seasonal fishery) the recruitment (R_{t+1}) is assumed equal to zero and the C_t takes its observed monthly value.

The seasonal depletion model expressed by equation (5) was fitted to the monthly catch in numbers per unit of effort data for the period including the 1991/1992 through the 2002/2003 fishing seasons. For this purpose the catch in pounds per unit of effort estimated from the trip-ticket database provided by the FWCC (FMRI)-Marathon was divided by the corresponding average individual weight in the landings with data provided by the same source. The catchability coefficient was assumed to vary among the seasons following a random walk model of the type:

$$q_i = q_{i-1}e^{\varepsilon_i}$$

where the ε_i are annual, and normally distributed with mean zero and variance σ_ε^2. The model was fitted by minimizing the negative log-likelihood objective function

$$\frac{n}{2}\sum_t(\ln(U_t)-\ln(\hat{U}_t))^2+\frac{\sum_t \varepsilon_i^2}{\sigma_\varepsilon^2}, \qquad (6)$$

where U_t represents CPUE in month t and σ_ε^2 was fixed to achieve a coefficient of variation of 20% in log space -- a percent that was adopted to represent the likely response of the q change to trap reductions. Allowing for a random walk in q should accommodate situations such as the one observed in the Florida fishery in which gear efficiency changed smoothly over time (1992-2002) as a consequence of the trap reduction program implemented in 1992.

The recruitment index estimated by the above model corresponds to cohorts at age 2 and the results compare well with the recruitment estimates in numbers at age 2 by Muller et al. (2000) (Fig. 5). The declining trend in the recruitment index at age 2 starting in 1998 corroborates the lower recruitment observed at age 0 starting in 1997 and the following years (Fig. 4). Furthermore, data on a puerulus larval index (from Muller, personal communication) matches very significantly the trend in recruitment at age 0 estimated from data of Muller et al. (2000)(Fig. 6). In the figure we observe a steep decrease in the puerulus larval index in the later years supporting the most likely negative trend in the recruitment trend estimated by the depletion model during those years (Fig. 5).

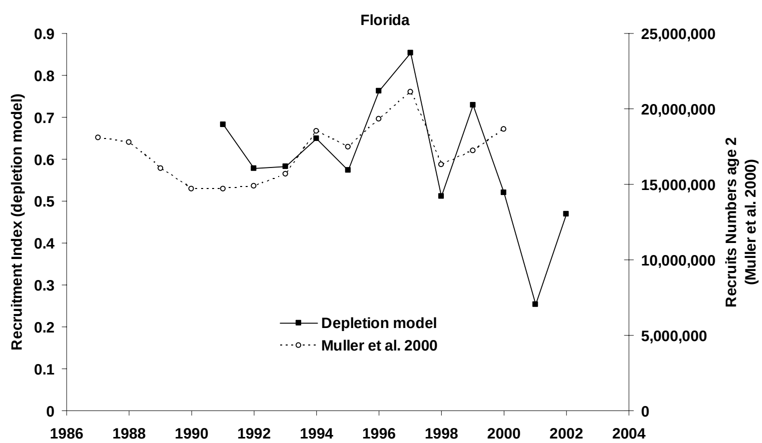


Figure 5. Recruitment index at age 2 estimated from a depletion model and recruitment at age 2 estimated from an age-structured model by Muller et al. (2000).

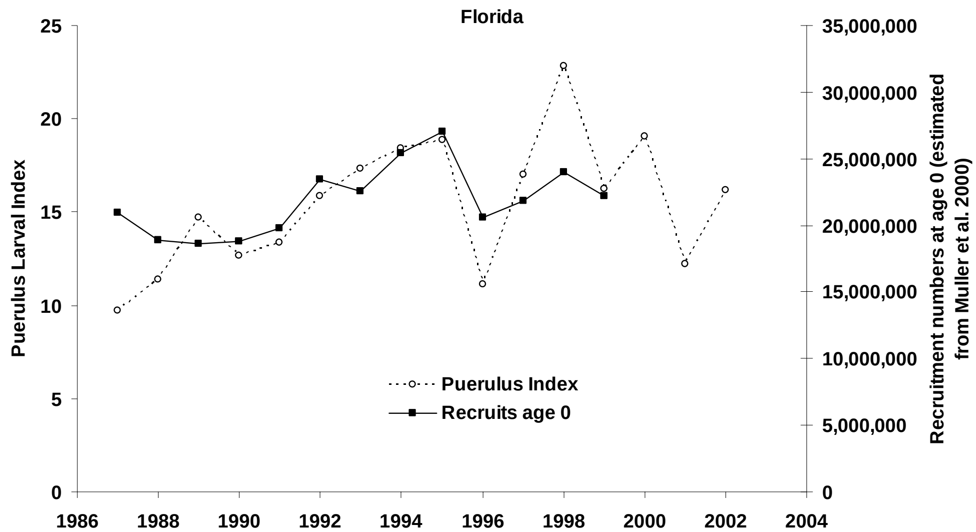


Figure 6. Puerulus larval index and recruitment at age 0 estimated from data in Muller et al. (2000).

The previous results are indicative that the Florida fishery may be enetering a declining recruitment trend similar to those found in this study for the Brazil and Honduras+Nicaragua fisheries. These results also suggest the potential for a delayed recruitment and spawning biomass effects between the Brazil, Honduras+Nicaragua and Florida fisheries. In figure 7 we observe that recruitment abundance trends in Brazil are followed by a 3-year delayed peak in spawning abundance. In fact, there is highly correlated (R^2=0.84) relationship between these two delayed variables (Fig. 8). When the historic trend in spawning biomass abundance for the Brazil fishery is compared with a similar trend estimated for the Honduras+Nicaragua fishery (Fig. 9), we found also a highly correlated (R^2=0.94) 3-year delayed matching trend between the two variables (Fig. 10).

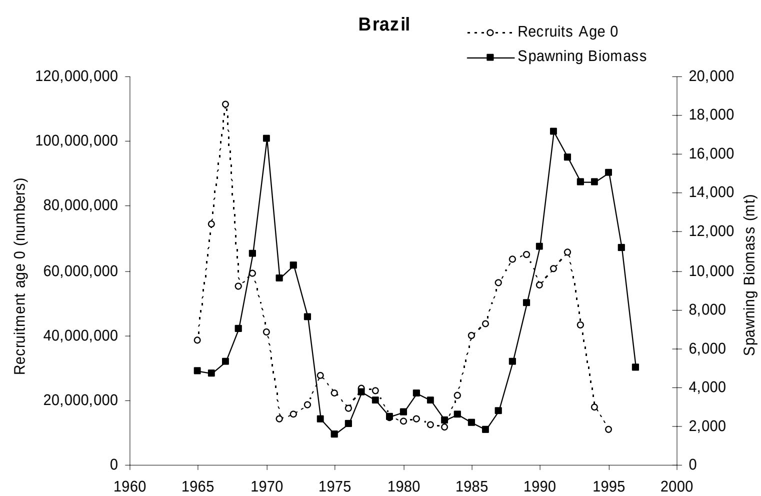


Figure 7. Historic recruitment and spawning stock abundance trends for the Brazil fishery.

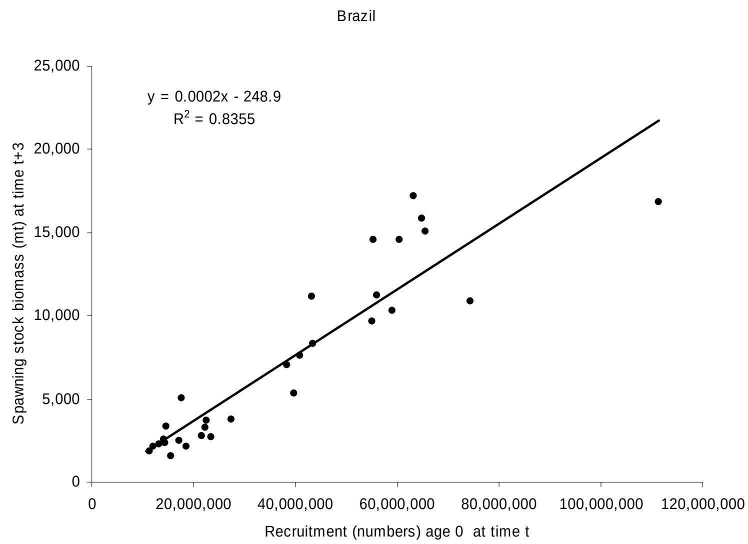


Figure 8. Functional 3-year delayed relationship between recruitment and spawning stock biomass in the Brazil fishery.

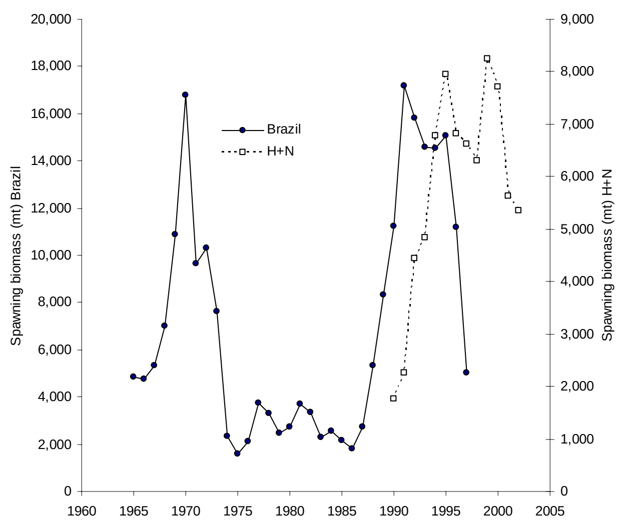


Figure 9. Spawning stock biomass trends for the Brazil and Honduras+Nicaragua fisheries.

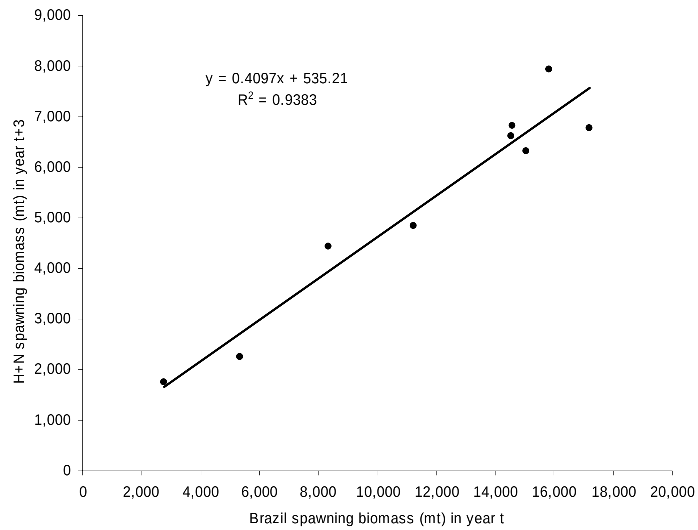


Figure 10. Three year delayed spawning stock abundance in Brazil and in Honduras+Nicaragua.

However, when we compare the spawning stock abundance of the Honduras+Nicaragua with that estimated for the Florida fishery we find that they are significantly correlated but with the same time scale (Figs. 11 and 12).

Given that the general habitat for spiny lobsters in Brazil, Honduras+Nicaragua and Florida do not have commonly occurring environmental and nursery area characteristics we observe that the previous trends follow source/sink metapopulation dynamics characteristics.

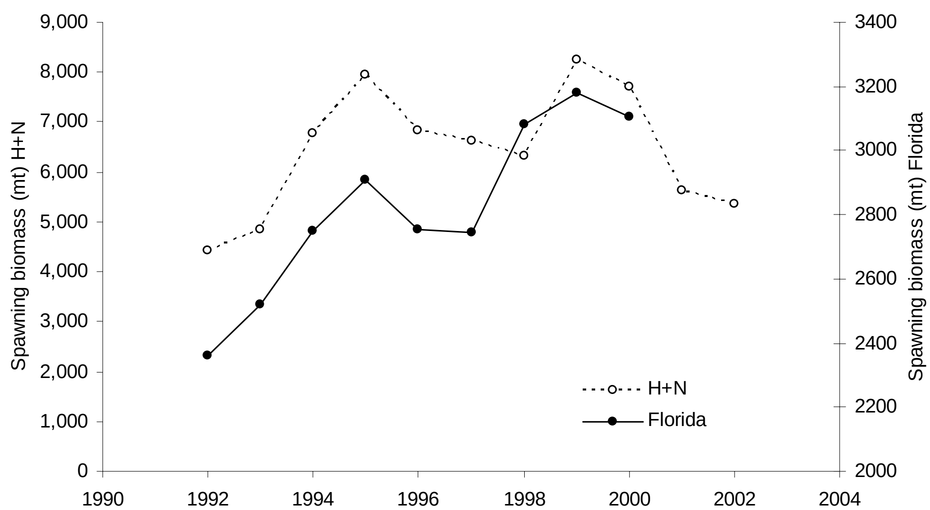


Figure 11. Spawning biomass trends for the Honduras+Nicaragua and Florida fisheries.

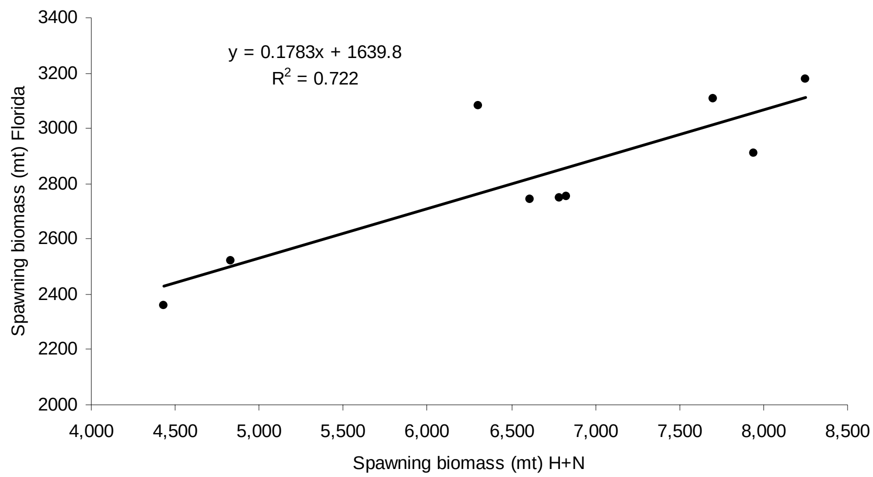


Figure 12. Spawning stock abundance relationship between Honduras+Nicaragua and Florida.

The abundance at age 0 in every year as estimated by sequential population analysis and the abundance of females and males older than 2 years of age defined as mature stock abundance (measured as spawning stock biomass in metric tons) were utilized in the stock recruitment analysis. We used a generalized recruit-parent stock model (Shepherd 1982) expressed as

$$R_t = \frac{\alpha * S_t}{(1+(\frac{S_t}{K})^{\beta})}$$

where R is recruitment and S is parent stock in year t. This model provides different levels of compensation that are needed to assess the comparative recruitment analysis of spiny lobster fisheries. The parameters in the above model are: α - the slope at the origin of the curve, β measures the power of the density-dependent to compensate for changes in spawning stock biomass, and K measures the spawning stock biomass above which density dependent effects come to dominate the density independent effects. The parameters (θ) were estimated using a negative log-likelihood estimator defined as

$$-\log L(\theta / data) = \sum_t (-\frac{1}{2} * \ln(2 * \pi)) - (\frac{1}{2} * \ln(\sigma^2 - \frac{(\ln R_{t,observed} - \ln R_{t,expected})^2}{2 * \sigma^2})$$

We used the analytical solution for σ as proposed by Hilborn and Walters (1992)

$$\sigma = \sqrt{\frac{1}{n} \sum_t (\ln R_{t,observed} - \ln R_{t,expected})}$$

where n is the number of years in the data series.

The parameters for the recruit-parent stock relationships for each fishery are given below and the likelihood fitted curves to the observed data in figure 13.

Parameters	Brazil	Honduras+Nicaragua	Florida	Pooled
Alpha	0.350	0.313	0.201	0.456
Beta	1.808	2.102	1.629	1.700
K	7,807	6,000	2,906	7,000

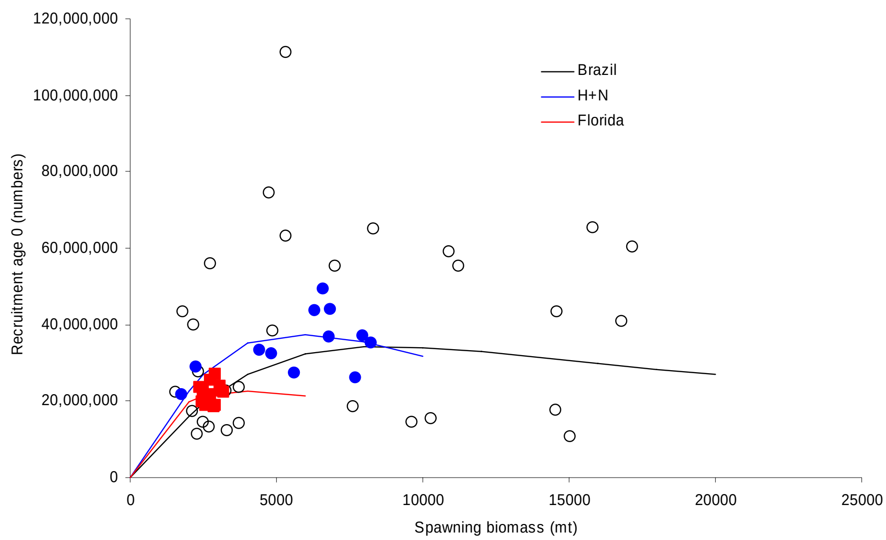


Figure 13. Recruitment-spawning stock relationships for the Brazil, Honduras+Nicaragua and Florida fisheries.

A comparative analysis of these recruit-spawner relationships show that the downstream fisheries exhibit much lower variance in recruitment and spawning stock biomass than the upstream stocks. This may be in part due to the differences in regressional ranges observed in the available data. That is, the fisheries in Florida and Honduras+Nicaragua data sets cover years with strong recruitment classes (or cohorts) passing through the fisheries and only in the later years of the data series they show significant decreases both in recruitment as well as parent stock biomass. Contrarily, the Brazilian database cover a long time period in which large changes in recruitment abundance and spawning biomass occurred. In spite of the above, the observed data appear to fit well within a common recruit-spawning stock envelope (Fig. 13) and the functional relationships provide some indication of the most plausible differences that may exists in the recruitment dynamics among these fisheries. In the table below we present a relative measure of the compensatory character of the functional relationships. For this purpose we estimated two ratios: the recruitment at maximum spawning stock biomass and the recruitment when the spawning stock abundance starts having an affect on density-dependent compensation (K).

	Smax	Rmax	Rmax/Sbmax	K	Rmax/K
Brazil	10,000	34,013,101	3,401	7,807	4,357
H+N	6,000	37,527,500	6,255	6,000	6,255
Florida	3,107	22,659,304	7,293	2,906	7,797

R in numbers; S in metric tons; K in metric tons

The results of these ratios show that the upstream fisheries always generate more recruits per unit of parent stock biomass than those upstream, which could be taken as a significant feature attributable to downstream fisheries that may receive larger contributions of larvae from upstream stocks. The above conclusion is based on the fundamental assumption that the individual fecundity of spiny lobsters in each fishery remains relatively similar.

Objective 2. To assess the dynamic bio-physical linkages among stocks in the region.

The effort to simulate the transport of lobster larvae across the greater Caribbean makes use of a state of the art ocean circulation model to estimate the regional dispersal of larvae and the connectivity of the regions benthic habitat. These calculations are verified against physical observations and genetic analyses. The resulting connectivity matrices are then used to create a 20 node “stepping stone” model which can be used to explore the population dynamics and genetics of the spiny lobster. The latter is used rather than the original connectivity matrices in order to accommodate the long planktonic phase observed in lobster.

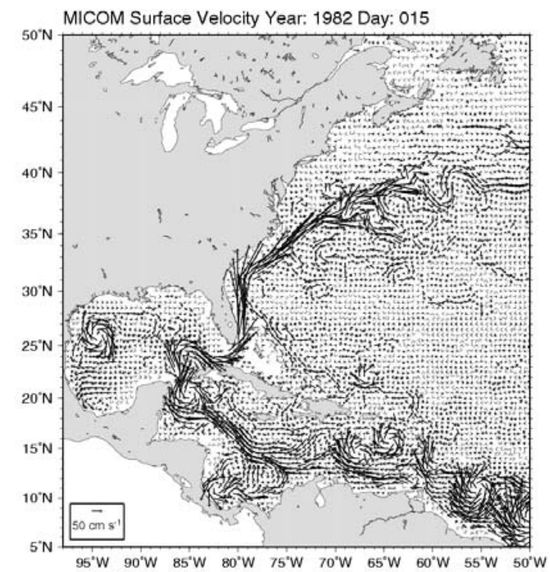


Fig. 14 Velocity field for a single day from the MICOM model. This is an example of the daily velocity fields used in the Lagrangian simulations that result in the connectivity matrices.

The model fields used to represent the ocean circulation are from a set of simulations using the Miami Isopycnal Coordinate Ocean Model (MICOM) North Atlantic simulations of Paiva et al. (1999). A full discussion of the model and its application to tracing the spread of biological populations in the sea is given in Olson (2006). The drift simulations are completed using an updated version of the particle following or Lagrangian model used in Cowen et al. (2000) to consider connectivity issues in the eastern Caribbean. The model makes use of daily velocity fields from five years of a MICOM simulation forced by European Center for Medium Range Forecasting (ECMWF) six hourly winds (Fig. 14). The MICOM model is a numerical model of the Atlantic Ocean between 24º S and approximately 70º N. It has a horizontal grid of 1/12 of a degree and 19 layers in the vertical. More details on the model can be found in Paiva et al. (1999). The Lagrangian model uses the MICOM velocity field to provide the deterministic portion of a particles trajectory. To this a stochastic velocity component is added to represent subgrid scale mixing (Dutkeiwitz et al., 1993; Griffa, 1996). The subgird diffusion is chosen based on the 1/12 degree grid scale and the compilation of scale dependent Lagrangian diffusivities based on the dye studies of Murty (1976). The turbulence model of Dutkeiwitz et al. (1993) involves an autocorrelated random walk, i.e. a random walk with a memory time scale T and a diffusivity, κ, from the Murty (1976) relationships. A simplified version of the model was used in the dispersal calculations in Cowen et al. (2000) and Olson et al. (2001). The current simulations use the original Dutkeiwitz code with its 4 th order Runga-Kutta integration and a new random number generator (Kloeden and Platen, 1995). The MICOM velocities have been interpolated to a carthesian grid while maintaining the 1/12º velocity patterns. Arrival codes are those originally developed by Cowen et al. (2003). The model is similar to the one used in Cowen et al. (2006).

The runs involve 1000 particles launched at order of 100 randomly chosen points around the outside of the Caribbean from Barbados to Cuba. Simulations are run for 24 day and 42 days periods in three different seasons (Julian days 15-57; 135-177; 205-247) and for each of five years from the early 1980 ECMWF wind-driven MICOM runs (1982-1986). Run durations correspond the average larval duration and the upper range for the Caribbean (Hood and Zastrow, 1993). While it would be naïve to expect any of these years to correspond to the actual ocean on those dates, it is reasonable to believe that the model captures the magnitude and basic structure of the mean circulation and the mesoscale eddy field and some aspects of their interannual variability. Since the goal is to explore a full set of possibilities the behavior of the particles are not correlated. See Griffa et al. (2004) for methods for individual simulations that maintain subgrid scale connections for application in oilspill tracking and other applications that demand simulation of individual events as opposed to computation of dispersal probabilities. Here the goal is to estimate the total set of possible outcomes given the MICOM velocity fields (Fig. 14). To test the assumption that the combination of the MICOM simulations and the sub-grid scale turbulence code actually approximate the real system the results are compared with observed drifters in the region.

The basic information available to verify the MICOM model are the degree to which the model reproduces the surface salinity field, the transport through various straits in the IAS, and the surface velocity patterns measured by drifters deployed across the region. The surface drifter data involves all of the available World Ocean Circulation Experiment style surface drifters deployed in the region between 1988 and 1999 (Fig. 15). The drifters have a 10 m tall 3D holey-sock set at a mean depth of 15 m and have been carefully tested to validate their water following capabilities (see Niiler, 2001). The transport estimates are based on studies involving a variety of shipboard and mooring work described in Wilson and Johns (1997) in the straits and passages. The salinity field comparison involves comparing the T/S observations described in Hansel et al. (2004) with those produced in the model. The detailed description of the inter-comparison between the model and observations will appear in a manuscript in preparation. Here the conclusions of the reliability of the reconstruction of possible trajectories and their use to consider the connectivity of different sub-regions in the IAS.

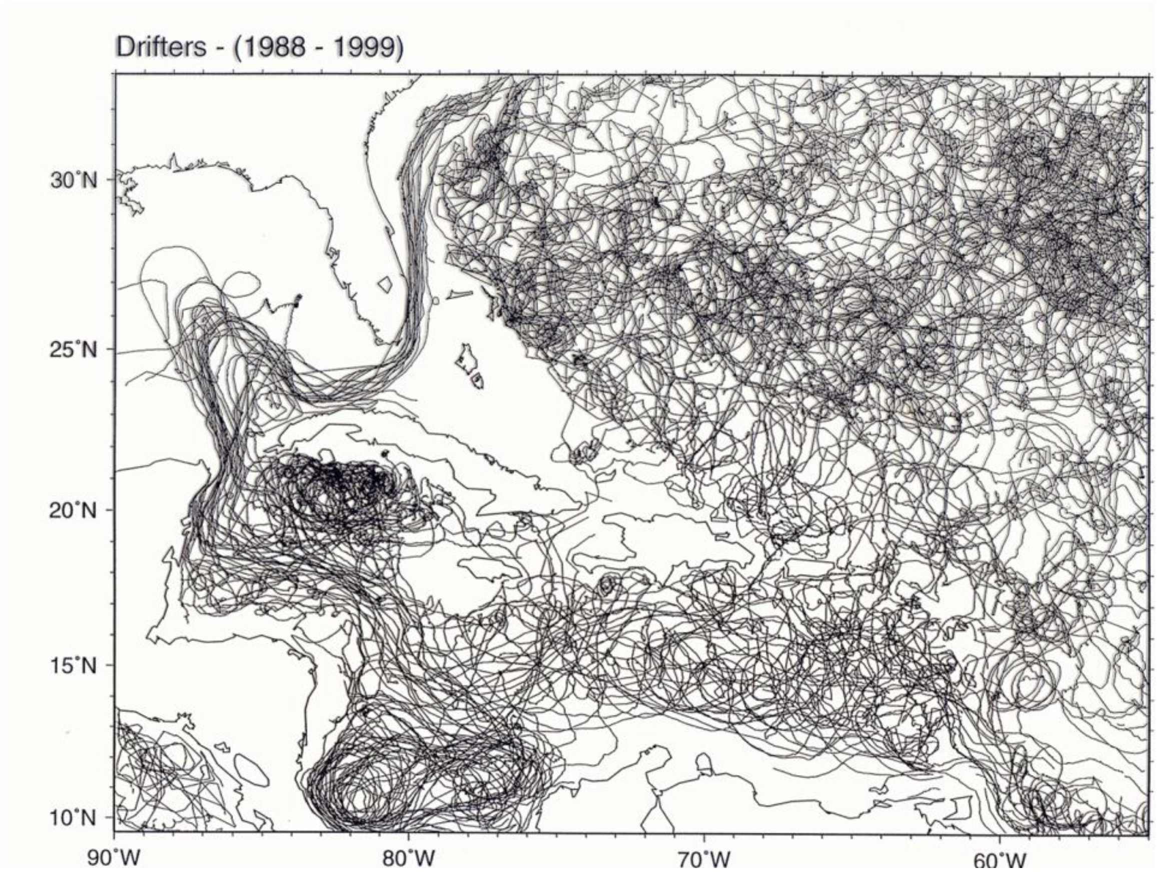


Fig. 15 Trajectories from WOCE surface drifters deployed in the western Atlantic. Note the looping trajectories indicating a strong mesoscale eddy field across the region. Closed gyres off Panama and the coherent trajectories in the Gulf Stream are also evident.

As an example of using Lagrangian methods to explore the biology of an area, the problem of the connections between various portions of the Greater Caribbean or Inter-American Sea (IAS) is considered. The Bahamas, for example, sit at the outer edge of the IAS and share many, if not all of the marine benthic species with the region. The Bahamas and the east coast of Florida represent the northernmost range of many of these species with the exception of the small island of Bermuda. These three regions can be connected to the rest of the Caribbean through the western boundary current, the Gulf Stream or by flows to the north of the Greater Antilles and into the Bahamas from the east. Within the Caribbean itself there is a broad flow from east to west that is driven by the North Equatorial Current (Mooers and Maul, 1998) and an additional component from the south brought across the equator as part of the North Brazil Current and its rings (Johns et al} 1990 Frantantoni et al. 1995). Most of this flow goes on to form the boundary current although a portion is entrained into the semi-closed Columbian gyre (Fig. 15). This gyre is connected to the rest of the Caribbean by a septrix point connecting elliptical trajectories in the gyre to the cross Caribbean flow off the coast of Nicaragua. North and west of this point the flow is variable as it crosses the Cayman basin and intensifies along the Belize and Mexican coast to form the Gulf Stream. This current sweeps through the Straits of Yucatan and forms a loop in the Gulf of Mexico before coursing through the Straits of Florida and back into the North Atlantic (Fig. 14, 15). The other route to the Bahamas is from the east on the northern side of the Greater Antilles (Puerto Rico, Hispanola, and Cuba). One question is the degree that these waters are from the open subtropical gyre or from the south where Caribbean fauna can be introduced. The flow through the passages separating these islands is also of interest in terms of regional connections. The historical view (see Nof and Olson, 1983) is that the Mona passage between Puerto Rico and Hispanola is shallow and unimportant, with the major connection is a flow from the Atlantic into the Caribbean through the Windward Passage between the latter island and Cuba. Here a set of Lagrangian simulations within the MICOM model will be used to consider the features that make up oceanographic connectivity for the surface layer plankton in the Caribbean.

The species distributions between the Greater Caribbean differs somewhat but all of the region hosts populations of conch (*Stombus gigas)*, spiny lobster (*Panulirus argus*), and a large number of tropical fish. Morphological and genetic studies available on many of these can be used to test the model predictions. The cleaner goby (*Gobiosoma evelynae*) studied by Taylor and Hellberg (2003) has a short meroplanktonic stage with time scales (~ 20 days) similar to conch. There work details several color morphs that form subpopulations around the Caribbean. These populations also demonstrate genetic differentiation in their mitochondrial DNA. A break in connectivity at Mona Passage and the partial isolation of the Bahamas are two features found in both the goby study and the simulations. A more recent study of coral genetics in comparison to a genetic model run using the connectivity matrices from the simulations (Galindo et al., in press) also confirms the general applicability of the model. In considering the simulations below the differences between long and short planktonic periods in possible connections and the possible disconnections for some species across the Caribbean are the points of interest. Spiny lobsters provide a challenge to the model because of the length of time they spend in the plankton (up to a year).

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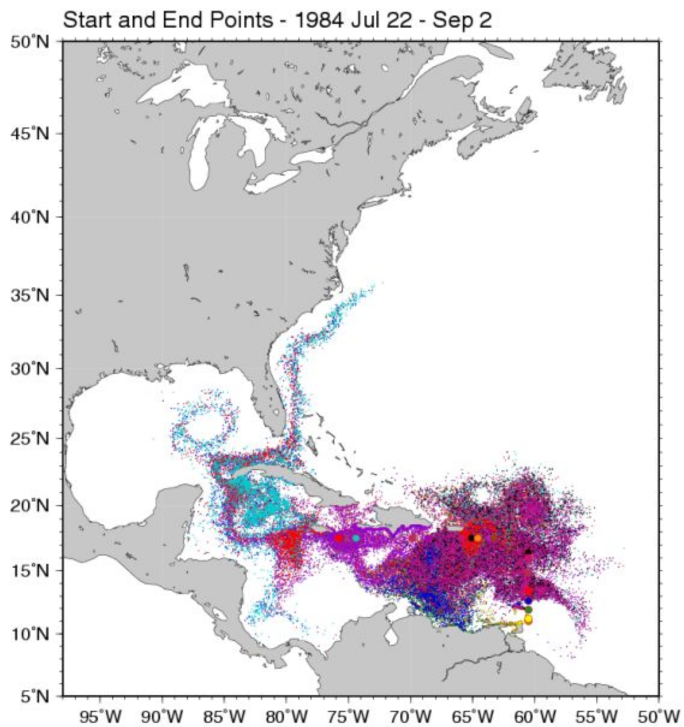

Fig. 16 Drift simulations for late summer with 1984 winds driving the MICOM model. Color codes indicate launch points. The simulation involves 42 days worth of trajectory. Each launch involves 1000 particles.

Simulations for Lagrangian drift across the Caribbean in the MICOM model are shown in Figs. 16 . An inter-comparison with actual drifter trajectories is given in Fig. 17. Figure 18 by comparison shows the out come of similar simulations, but in different years to highlight the inter-annual variations in drift outcomes. Notice that breaks in all years occur at the inferred barriers in observed populations (Taylor and Hellberg, 2003; Baums et al., 2005; Galindo et al., in press). Interconnections to the western boundary are more variable with good connection between the Jamaica area and the coast of Mexico and even Florida occurring in one year and not the others. The difference between these two years involves the nature of the fronts and eddy fields in the Cayman basin. In the first case there is a coherent front across the basin that provides trajectories liking the central Caribbean to the Mexican and Florida coasts within weeks. In the other year the Cayman basin is dominated by eddies that make the transport to these western areas diffusive and slow. These factors create variability in the connectivity, defined by the probability of a successful arrival of meroplanktonic larvae across portions of the domain, with time. This addition of temporal variability broadens the debate between Roberts (1997) and Cowen et al. (2000) over recruitment across ocean spaces. Here recruitment is defined in the traditional fisheries sense as successful arrival to our ability to catch (sense) the animal.

The scenario in the simulations show some years are consistent with Roberts' picture of well connected regimes, while the other years renders dispersion patterns that amplify the Cowen et al. (2000, 2006) conclusions.

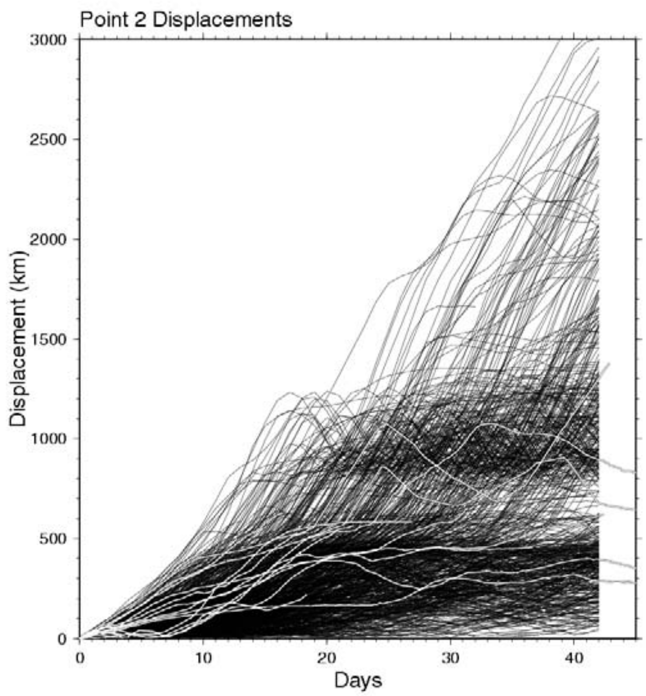

Fig. 17 Dispersion diagram for actual drifters in the western Caribbean (light lines) and for simulated drifters (dark lines).

The simulations of the Caribbean only provide a starting place for understanding the workings of its marine ecosystem. The overall results suggest that the details of the mesoscale eddy field are important determinants of initial eddy spread. There is evidence of local retention in most of the sites considered and in most areas a small but significant chance of making a coherent transit in an oceanic front across a wide expanse of space. This is especially true in the western Caribbean where the Gulf Stream provides some very long pathways out into the North Atlantic (Fig. 18). The inter-annual differences in the simulations are larger than the seasonal ones over most of the area. In particular this is evident in changes in the western Caribbean where there are large differences in dispersion across the Cayman Sea between Jamaica and the Mexican coast and between

Jamaica and the Bahamas through the Windward Passage. Finally, the reader is reminded that probabilities of arrival from these simulations provide only one of the probabilities needed to estimate the probability of recruitment. The probability of successful settlement involves details of population dynamics at a local scale.

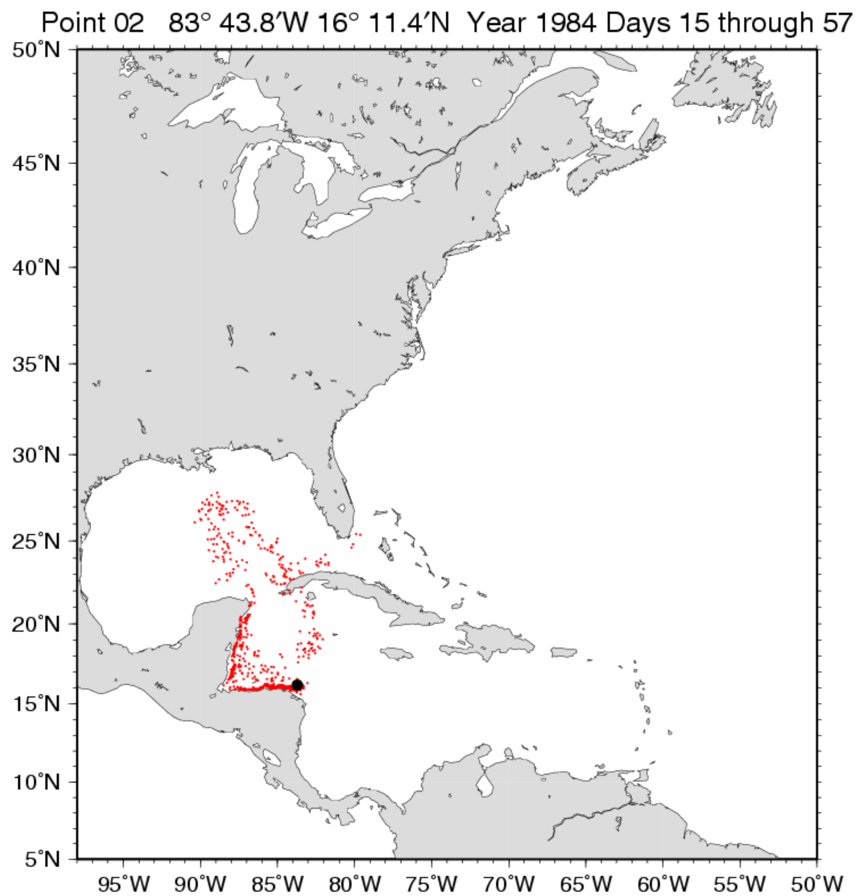

Fig. 18. Example of a simulated particle dispersal from the Nicaragua shelf. Simulation includes 1000 particles. Note in this case a small probability of reaching Florida waters. In other years particles are dispersed all the way to Cape Hatteras.

To understand the dynamics of population connectivity it is necessary to consider the probability of transport from one breeding population to another. To accomplish this the results of the simulations have been combined to provide overall probability of connection. An example of a probability cloud combining all of the runs is shown in Fig. 19. These are then converted to probabilities and then averaged into larger habitat regions to produce the "stepping stone" model. For the variable length drifts expected in lobster the probability of transport between nodes is used to estimate the number of individuals that are transported at different times. By comparing probabilities for different years it is possible to infer actual mechanisms that may account for the observed population dynamics under objective 1. For example, the results in the western Caribbean suggest strong connections between Nicaragua and Florida in some years and very low connectivity in others. While the simulations only contain NAO signals (see objective 3) to the extent that they are manifest in the ECMWF product, it is possible to consider the regional manifestations that do occur in both the model and the observed changes in the western Caribbean. This is currently being considered using satellite data to consider variations over the region.

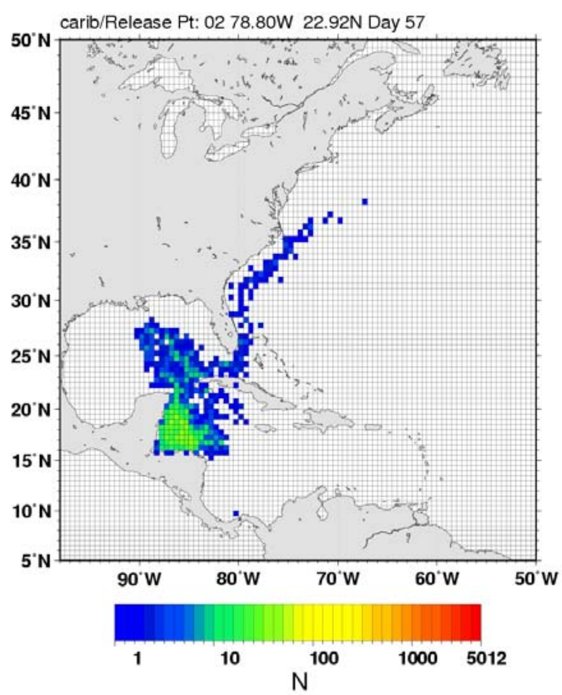

Fig. 19 Total particale density for all five years of runs from the Nicaragua shelf for the winter simulations. Compare to Fig. 18 for a single year. Numbers have now been binned into a matrix. Dividing the number of particles in a box yields the probability of arrival at this point in the simulations.

Objective 3. To evaluate the environmental variables that impact recruitment and production variability observed in the region.

In the Brazilian spiny lobster fishery we found negatively correlated trends between the residuals of recruitment at age 0 about the recruit-spawning model in figure 13 and the wind intensity in the coastal regions of the State of Ceara, Brazil (Fig. 20). This condition may be the result of significant changes in the spiny lobster larval retention mechanisms at times when winds relax their strength and changes toward a more NW direction from a prevailing SE direction. From figure 20, we observe that eras of wind shifts predominate in the 20-year observational window and that recruitment of age 0 spiny lobsters is significantly impacted by such changes.

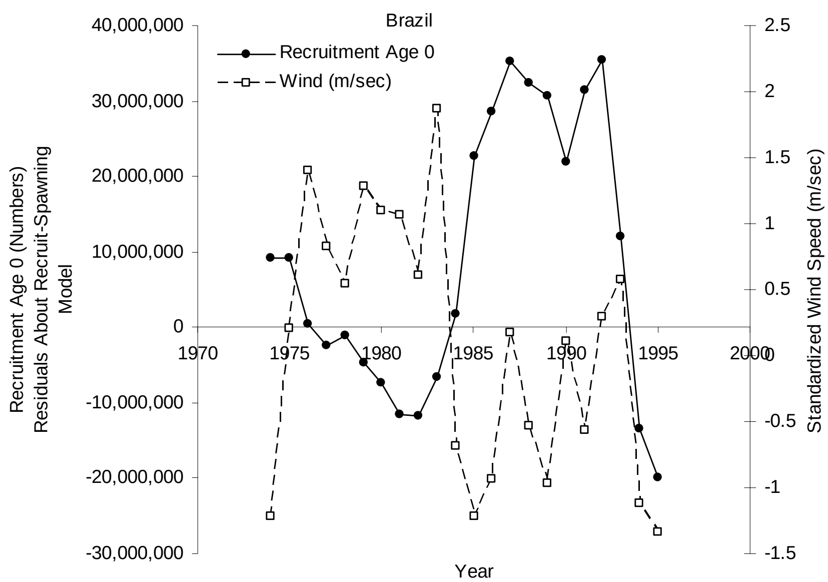

Figure 20. Residuals of recruitment at age 0 in numbers about the recruit-spawner model for the Brazil fishery and standardized wind speeds in the Ceara State, Brazil.

The North Atlantic Oscillation (NAO) tropical index was shown by Ehrhardt (6 June 2003 Key West lobster workshop) as a highly correlated 2-year delayed environmental variable potentially driving Florida landings (Fig. 21). The North Atlantic Oscillation, although not accepted as such in some scientific forum, is primarily defined as shifts in relative intensity in atmospheric pressure between the Iceland area and the eastern subtropical Atlantic (Hurrell, 1995; Hurrell et al., 2003). While these atmospheric variations extend into the region of interest it is the relationship between these atmospheric anomalies, the subtropical ocean, and the dynamics of the tropical Atlantic that may be key to understanding the larval linkages discussed in Objective 2 in the context of this study. The linkages of NAO pressure anomalies to Sea Surface temperature (SST) anomalies in the latitude belt that includes the Caribbean and the linkage to the cross equatorial ocean transports are highly significant (Xie and Tanimoto, 1998; Sutton et al., 2001; Visbeck et al., 2003). The SST linkage reaches its strongest correlations just to the East of the Caribbean and along the South American coast where the Brazil lobster population linkage to the West is established. The SST anomalies in this region lag the atmospheric signal by 0-2 years (Visbeck et al., 2003). This is similar to the lag in lobster production expressed by Ehrhardt (Workshop 6 June 2003), but the processes still need to be carefully considered. It is hard to suggest that SST anomalies that are typically less than the daily temperature cycle directly affect lobster population dynamics. Rather the hypothesis that the relationship between lobster recruitment and NAO and related tropical Atlantic climate variations involves elements of the surface circulation response to the atmospheric forcing. Therefore, the suggestion is that the modification of the mean and mesoscale eddy field is responsible in part for both the SST and the lobster signal.

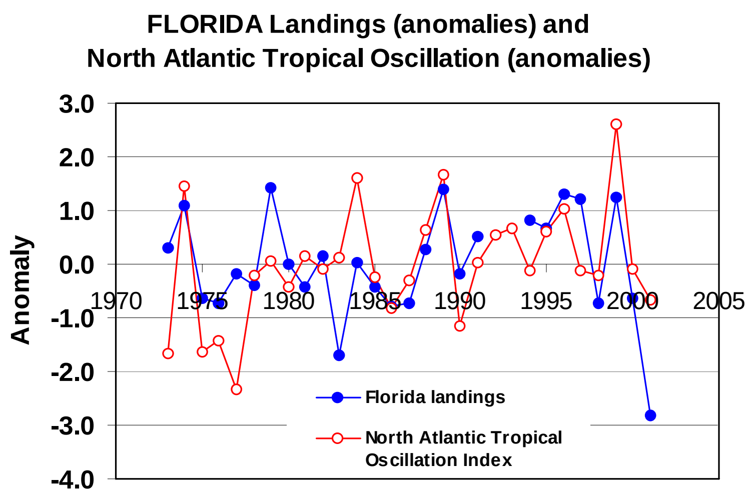

Figure 21. Florida landing anomalies and NAO Index anomalies.

Of significance in the attempt to elucidate recruitment variability in Florida is the unknown reason for the persistence of the NAO signal at the puerulus larval stages (Muller, personal communication and figure 22) that is also reflected in the similarity between NAO index and landings trends presented in figure 21. The later can be explained by the intermediate linkage between the puerulus index and the recruitment (Fig. 6). Therefore, it appears that the NAO signal is strong enough as to reflect such signal at all cohort stages (from the puerulus to the landings of adults). Moreover, such signal also appear in the short recruitment data series from Honduras+Nicaragua and in the longer relative abundance index of the spiny lobster in the later fishery (Figs. 23 and 24).

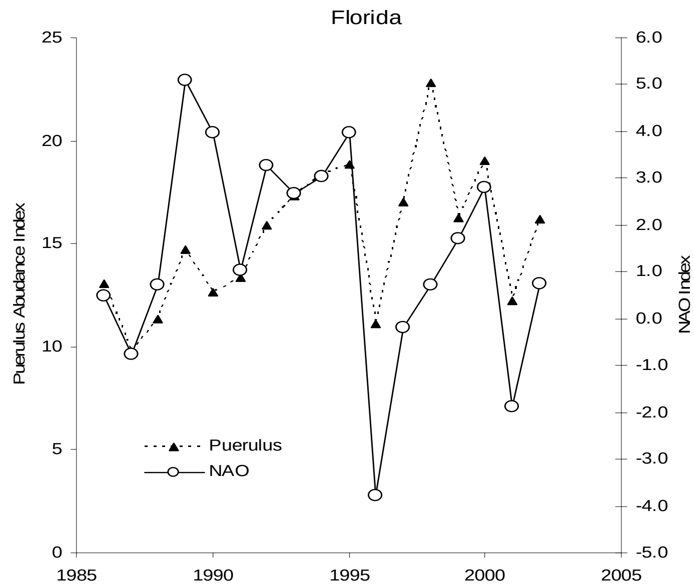

Figure 22. Puerulus larval index for the Florida spiny lobster and the NAO Index (Robert Muller, personal communication).

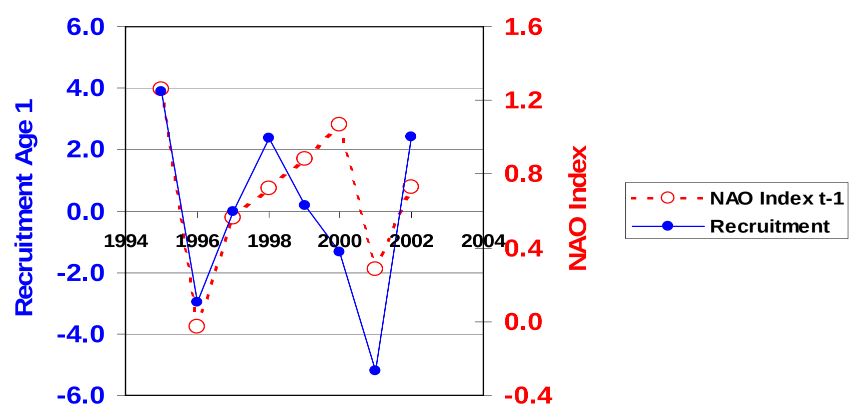

Figure 23. Recruitment at age 1 spiny lobster in Honduras+Nicaragua and NAO index.

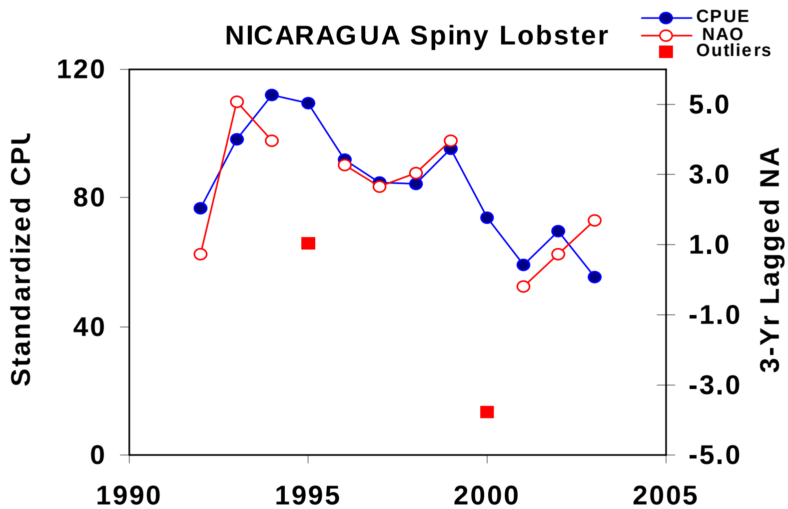

Figure 24. Relative abundance spiny lobster in Honduras+Nicaragua and 3-year delayed NAO index.

Objective 4. To assess long-term economic risks associated with regional and local factors affecting spiny lobster production in Florida.

Results in the previous objectives demonstrate that spiny lobster recruitment variability appears closely related to some key environmental signals as well as to their spawning stock biomass. However, in our regional analysis we found out that in the Brazil and Honduras+Nicaragua fisheries there are significant landings and commercialization of juvenile spiny lobsters. These account between 40% and 55% of the landings in weight. In fact, we found that there is a fully developed black market for illegal lobster tails with very significant economics and social consequences in the entire Caribbean region. The US Department of Commerce has stepped up the control of the illegal imports of these lobsters into the United States market. In the Florida fishery there is a minimum size restriction on the landings but there are no restrictions on the use of sub-legal size lobster as attractants in the traps. These may suffer some mortality due to handling and starvation. In summary then, there is a very high probability that spawning stock abundance may be significantly impacted by these fishing practices in all main spiny lobster fisheries in the region. Consequently, it is highly likely that the decreasing trends observed in recruitment in Brazil and Honduras+Nicaragua may be due to decreased population fecundity, but this fundamental aspect could not be finalized during this project. We completed however some preliminary analyses on the economic consequences of exploiting undersized lobsters in the Nicaraguan fishery. Similar analyses should be undertaken in Honduras, Brazil and Florida before definite conclusion may be drawn regarding spawning stock abundance depletion.

In general, recruitment and spawning stock abundance variability in the Florida fishery is much reduced relative to the variability observed in that abundance in upstream fisheries, especially in the Brazil fishery. What is of extraordinary concern regarding economic risks in the Florida fishery is the unknown probability that the Florida fishery may undergo a sudden decreasing trend in recruitment as already observed in Brazil and in the Honduras+Nicaragua fisheries. This can only happen if a significant connectivy exists among those fisheries upstream.

EXPECTED RESULTS, APPLICATIONS AND BENEFITS

This research project generated a thorough assessment of regional spiny lobster fisheries in Honduras+Nicaragua and Brazil and the effects of recruitment dynamics in those fisheries were linked to possible effects on the characteristics of the Florida spiny lobster fishery. For this purpose we used environmental frameworks and standard fishery data to assess cohort abundance and to account for natural stock abundance variability and regional stock connectivity. Results will be integrated into two scientific papers that are presently in preparation. One paper will deal with the biophysical characteristics that dominate recruitment variability and the second paper will deal with the conceptual economic consequences of over exploiting sub-legal size spiny lobsters and their impact on the overall regional fecundity of the stocks. These publications will provide fishery managers in Florida as well as in Brazil, Nicaragua and Honduras with a platform regarding production anomalies (trends and variances) based on knowledge about larval origin and regional exploited population dynamic causes.

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Project Final Report

I. Report Title, Author, Organization, Grant Number, Date

Project Title: Meta population stock assessment methods incorporating climatic and ecosystem effects for the Florida spiny lobster fishery

Author: Nelson M. Ehrhardt

Organization: Division of Marine Biology and Fisheries, Rosenstiel School of Marine and Atmospheric Science, University of Miami.

Grant Number: NA05NMF4331081

Date: 31 August 2007

II. Abstract

New segmented growth functions by gender were estimated from a large tagging program. The functions were used to develop catch-at-age matrices that were input to an age-structured stock assessment algorithm. Contrary to the optimistic SEDAR 08 stock assessment results, the analyses in this project show a persistent and significant decreasing trend in the spawning stock abundance. Such decline is highly correlated with post larval abundance estimates also obtained by the project. This constitutes the first demonstration that larval recruitment to the Florida fishery is highly dependent on local spawning stock. It is concluded that lower landings observed since 2000 are due to low stock abundance, lower post larval abundance and subsequent lower recruitment. Fishing mortality rates follow an increasing trend reaching values that are twice as large as the natural mortality rate assumed for the species. Apical fishing mortality rate is more than 4 times the natural mortality rate. Regional ecosystem shifts may cause the lower recruitment success estimated for the last seasons in the time series analyzed.

III. Executive Summary

This project responded to the needs of research recommended by the SEDAR 08 process. A new analysis of growth using a large tagging database provided segmented growth trends by gender that differ considerably from other segmented growth patterns obtained for the species as well as from von Bertalanffy growth trends usually adopted in Caribbean spiny lobster assessments (Appendix I). These new segmented growth patterns cover most of the size of individuals historically observed in the landings. Females reach a Carapace Length (CL) of 151 mm at the maximum simulated age of 30 years, while males reach 220 mm CL at that age (Fig. 1). The use of these growth patterns in the slicing of ages from size frequencies resulted in a much younger exploited stock than previously estimated (SEDAR 08, 2005). The consequences to stock assessment estimates are therefore significant.

The age-structured stock assessment algorithm adopted in this research shows a *P. argus* stock that is undergoing considerable over exploitation. Of significant concern is the conspicuous decreasing trend in the spawning stock (Appendix II) while this abundance is very much similar in trend and variance when compared with the new estimates of puerulus abundance (Appendix III)(Fig. 2). The resulting fishing mortality estimates follow a generally increasing trend (Fig. 3), which is opposite to the fishing mortality estimates obtained in the SEDAR 08 process. The decrease in landings observed in after 1999 may be due to the lower abundance resulting from this analysis.

Analysis of the Florida spiny lobster recruitment dynamics (Appendix III) resulted in a significant positive correlation between the puerulus post larval abundance and the spawning stock generating it; however, the time path in such correlation is pointing conspicuously toward the origin. Also, it was found that recruitment success for individuals at age 1 from the puerulus abundance is well correlated to spawning stock but a significant shift in the recruitment success is observed during 1999-2002 (Fig. 4). Two immediate conclusions may be drawn from the above findings: 1) *P. argus* recruitment to the Florida fishery is significantly dependent on local spawning stock abundance, and 2) regional ecosystem conditions may be responsible for the shift in lower recruitment success observed in Florida. The consequences of these findings to management may be of importance given that the Florida spiny lobster fishery has been managed under the paradigm of a Pan Caribbean origin of the recruitment. Under the new paradigm, the fishery should be managed much more conservatively to prevent depletion of the parent stock.

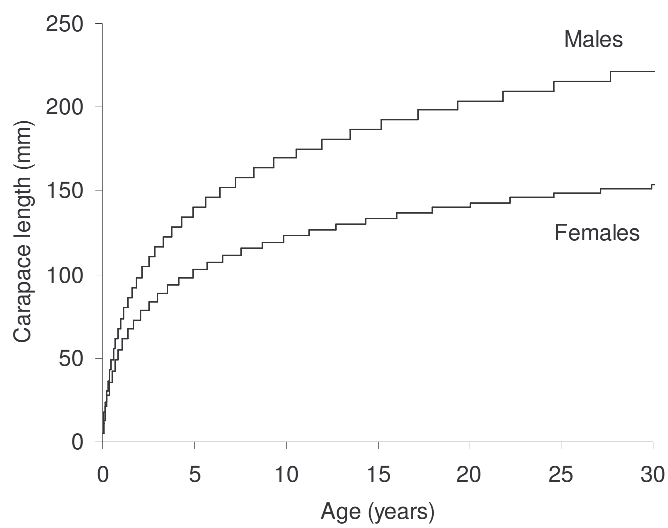

Figure 1. Segmented growth trends for female and male *P. argus*.

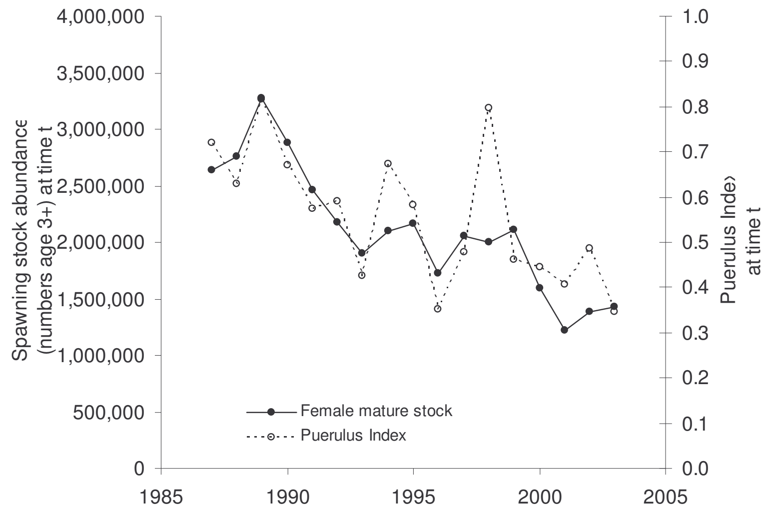

Figure 2. Trends of estimated female spawning abundance and puerulus index.

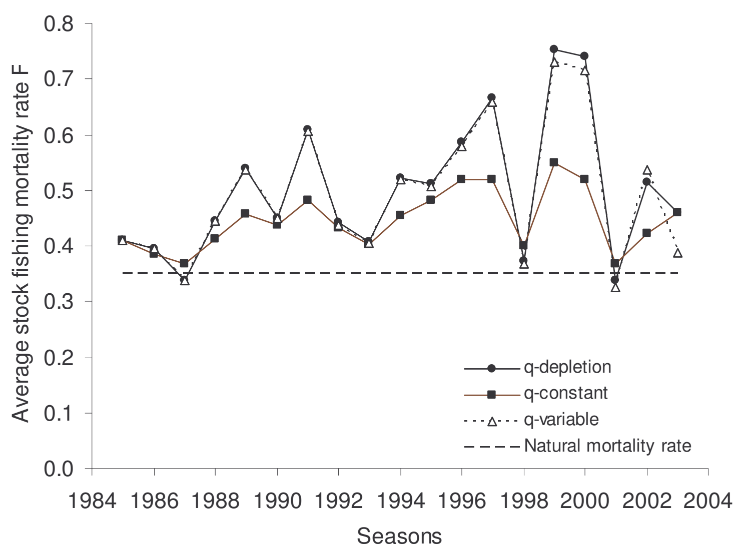

Figure 3. Average fishing mortality rates for sexes combined and for three tuning procedures.

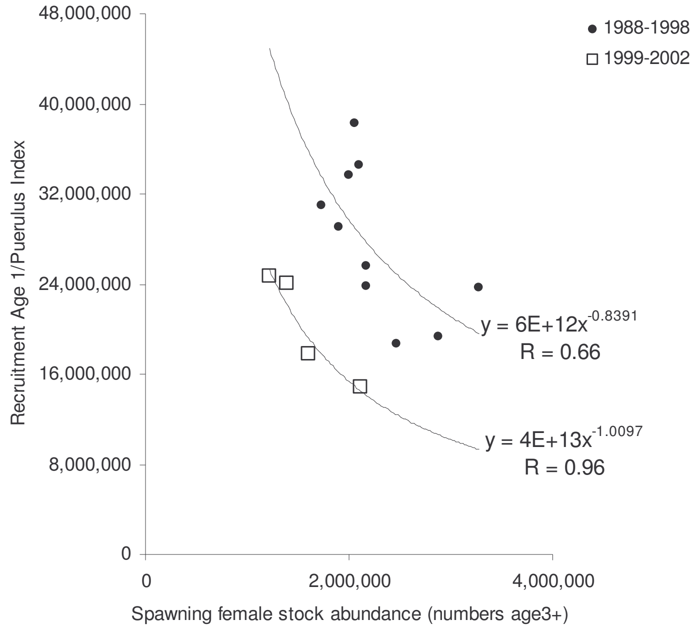

Figure 4. Recruitment success measured as the ratio of recruitment at age 1 and post larval abundance index on spawning stock delayed 1 year.

IV. Purpose

A. Detailed description of problem or impediment of fishing industry that was addressed.

The species and fishery selected for research in this proposal is strategic and fundamental to the fishery management process in the Gulf of Mexico. The Florida spiny lobster is one of the most economically important fisheries in the Southeastern US that has been managed under the consideration of a Pan Caribbean or up-stream recruitment sources. The species exhibit larval recruitment that is significantly driven by environmental factors and landings are explained by recruitment variability. The consequences of such effects on the assessment algorithms are not understood and research in this area has never been attempted for this fishery in the Gulf of Mexico. Hence, this proposal represented a unique and innovative opportunity to research the consequences of dynamic ecosystem factors in the usual fishery dependent management process. At the same time, the regional origin of the spiny larval sources is indicative of the need to understand the Florida spiny lobster abundance trends as part of what it may constitute a Meta population process.

This proposal addressed several of the specific priorities in the 2005 MARFIN solicitation:

B. Reef Fish and other Fishery Resources Associated with Reef Environments.

1. Collection of basic biological data for species in commercially and recreationally important fisheries.
   (c) Recruitment of reef fish and other fishery resources associated with reef environments.
      (1) **Source of recruitment** in Gulf and South Atlantic waters, especially for snappers, groupers, amberjacks, other reef fish and **spiny lobster**.
2. **Population assessment** of reef fish and other fishery resources associated with reef **environments**.
   (e) **Stock assessment** to establish the status of **major recreational and commercial** species.
   (f) **Assessment of spiny lobster** resources in Florida waters.

The important commercial spiny lobster fishing industry of Monroe County, in southwest Florida, generates approximately 20% of the total Florida landings and is leader for several high-valued species. The fishery is fundamentally a trap fishery although in the last few seasons a sizeable 10% of the landings were generated by commercial diving. There is an important recreational fishery supported by this stock as well. Management issues such as overfishing, excessive gear deployed (overcapitalization), and significant interactions and competition for finite resources among users characterize this fishery. The need to consider restricted access management measures is reflected by the Florida spiny lobster trap reduction program established in 1992. The economic merits of the program are demonstrated by a significant increase in catchability as a function of the number of traps reduced. However, and spite of the fishery management actions implemented in this fishery, the economic outcome deteriorated significantly as landings in the Florida spiny lobster trap fishery decreased by about 57% in the last 5 fishing seasons and the causes of such great decrease are not known.

The drastic decreases in landings in the Florida trap fishery contrast well with the results emerging from the September 2006 Food and Agriculture Organization of the United Nations (FAO) Third Workshop on the Management of Caribbean Spiny Lobster in the Western Central Atlantic Region. Analyses carried out at the Workshop showed that recent landings decreased 26% in the Bahamas, 30% in Cuba and 35% in Nicaragua (the 3 largest spiny lobster producing countries in the Western Caribbean region). These trends were identified with a decrease in stock abundance estimated for the above fisheries; however, no conclusions were reached regarding the origin of these common decreasing trends.

The economic impact generated by lower productivity created stiff economic hardships to the Florida industry and a workshop sponsored by the Florida Sea Grant and held on 6 June 2003 in Key West, Florida, discussed the status of scientific knowledge of the Florida spiny lobster fishery. The SEDAR 08 stock assessment process conducted in 2005 concluded that abundance follows an apparent stable trend while fishing mortality is decreasing concomitant with the decreasing trend in landings. Therefore, there was a general concern that sources other than those included in the assessments may be affecting the Florida fishery. It was argued that exit of fishing effort from the fishery may be one plausible cause; however, the drop in catch per trap does not explain such condition.

The Caribbean spiny lobster possesses larvae that may remain in the water column for extended periods of time before settling in a suitable juvenile habitat. That condition coupled with the strong ocean currents dominating the general larval environment throughout the Caribbean Sea, makes colonization far downstream plausible by those larvae from far upstream -- thus the Pan-Caribbean theory of spiny lobster populations. The likelihood that spiny lobster stocks may originate from a single gene pool in the Caribbean Sea has been variously postulated and Caribbean-wide genetic studies provide preliminary evidences that may sustain the above statement.

Signals of the potential coupling of the environment and the abundance of the spiny lobster puerulus arriving in Florida and the potential linkage to the recruitment to the fishery are aspects that have not been incorporated in the analyses of the present day spiny lobster assessments in Florida. This proposal addressed the effects of regional environmental effects on local Florida stock dynamics and it pointed to elucidate the nature of the trends observed in the available fishery data.

In summary, environmentally driven population dynamics of an economically important species inhabiting complex ecosystems in the Gulf of Mexico and the Caribbean Sea was considered in this proposal. The simple single-species environmentally disconnected conceptual frameworks presently used may not be sufficient to properly assess and manage this type of fisheries. Surprisingly, however, existing theoretical and empirical stock assessment and fishery management models do not provide a comprehensive framework to evaluate the long-term impacts of the regional effects on the management of local fisheries. The research work proposed in this project provided an assessment of the likelihood of environmental changes on the stock abundance estimates. The work proposed to elucidate the status of decreased productivity of the Florida fishery, which required multidisciplinary research and the integration of large databases. This work could not be accomplished by the fishing industry and as such research funding was required to elucidate fundamental pending issues regarding the status of exploitation of one of the most important fishery resources in the State of Florida.

B. Objectives of the project.

The goal of this project was to contribute new knowledge to avoid overexploitation and overcapitalization of the spiny lobster fishery through a better understanding of the highly variable population dynamics of the species. The contribution to this MARFIN high priority species is by providing a better understanding of climate change and ecosystem dynamic effects on population abundance and exploitation rates.

To accomplish this goal the following objectives were proposed:

1) To develop a stock assessment algorithm that includes environmental variables in stock recruitment prediction.

2) To apply the algorithm to assess the spiny lobster fishery in the Gulf of Mexico considering Meta population abundance estimated for lobster stocks in Brazil, Nicaragua-Honduras and Bahamas.

3) Develop a forecasting capability for the fishery.

V. Approach

A. Detailed description of the work that was performed.

The work performed by the project is contained in the three Appendices attached to this final report. A summary of the work is described here. Large databases were made available by the Florida Fish and Wildlife Conservation Commission (FFWCC). These consisted of a 1967-2003 tagging database containing 6811 useable tag-recapture observations; 1987-2006 monthly catch per trap, number of trips and soak-time by regions of the Florida Keys trap fishery; seasonal landings by size frequencies for all gears and bait; total seasonal landings in pounds whole weight by all gear. A puerulus database consisting of catch per day soaking of puerulus collectors set in two places in the Florida Keys covering the period 1987-2007. The Food and Agriculture Organization of the United Nations (FAO) made available to the project databases with biological parameters for *P. argus* compiled in the Caribbean region and including growth, natural mortality and reproductive parameters. Oceanographic and meteorological databases from NOAA sources consisting in historic mean sea level for the Caribbean Sea and Gulf of Mexico, mean sea level data collected in the Florida Keys on an hourly basis from 1988 to 2007 by the National Buoy Data Center (www.nbdc.noaa.gov), and sea surface temperature, oxygen, salinity, and conductivity from the Sombrero Key oceanographic station were a made available.

Segmented growth modeling was approached by stratifying the tagging database by gender, by measurement error and by seasons. Functional relationships for pre-molt and post-molt were obtained and molting frequencies estimated following an algorithm adapted from Munro (1974) to estimate molt intervals (Fig. 5). Inter-molt periods were correlated to carapace length and functional relationships obtained. With these functions and the pre-molt post-molt functions a segmented growth path was built starting with age at post larval settling. The segmented growth path by gender differed significantly from von Bertalanffy growth functions adopted for *P. argus* throughout the Caribbean.

The segmented growth paths were used to slice age frequencies from size frequencies found in the FFWCC size frequency database. The resulting catch-at-age matrices expressed in number of individuals were used in a gender specific tuned catch-at-age stock assessment algorithm. Tuning was accomplished by utilizing catch per unit of effort standardized to trap-trip corrected by soaking time. Three different procedures were used in the tuning: 1) q-constant estimated internally by groups of years that portrayed the trap reduction program implementation, 2) q-variable estimated internally for each fishing season, and 3) q externally estimated from a depletion model fitted to the monthly soak-time standardized catch per trap-trip. The adequacy of the tuning procedures was judged from the overall variance of the fitting of the objective functions and by an ad hoc analysis of the comparison of the recruitment at age 1 from the age-structured model and the recruitment index estimated from the seasonal depletion model. The resulting information consisted of recruitment abundance at age 1 for males and females, overall stock abundance (all ages), spawning stock according to maturity at age (age 3+), and stock fecundity according to fecundity at size translated to age by the segmented growth path. Fishing mortality rates at age by season and gender as well as an exploitation pattern were also obtained.

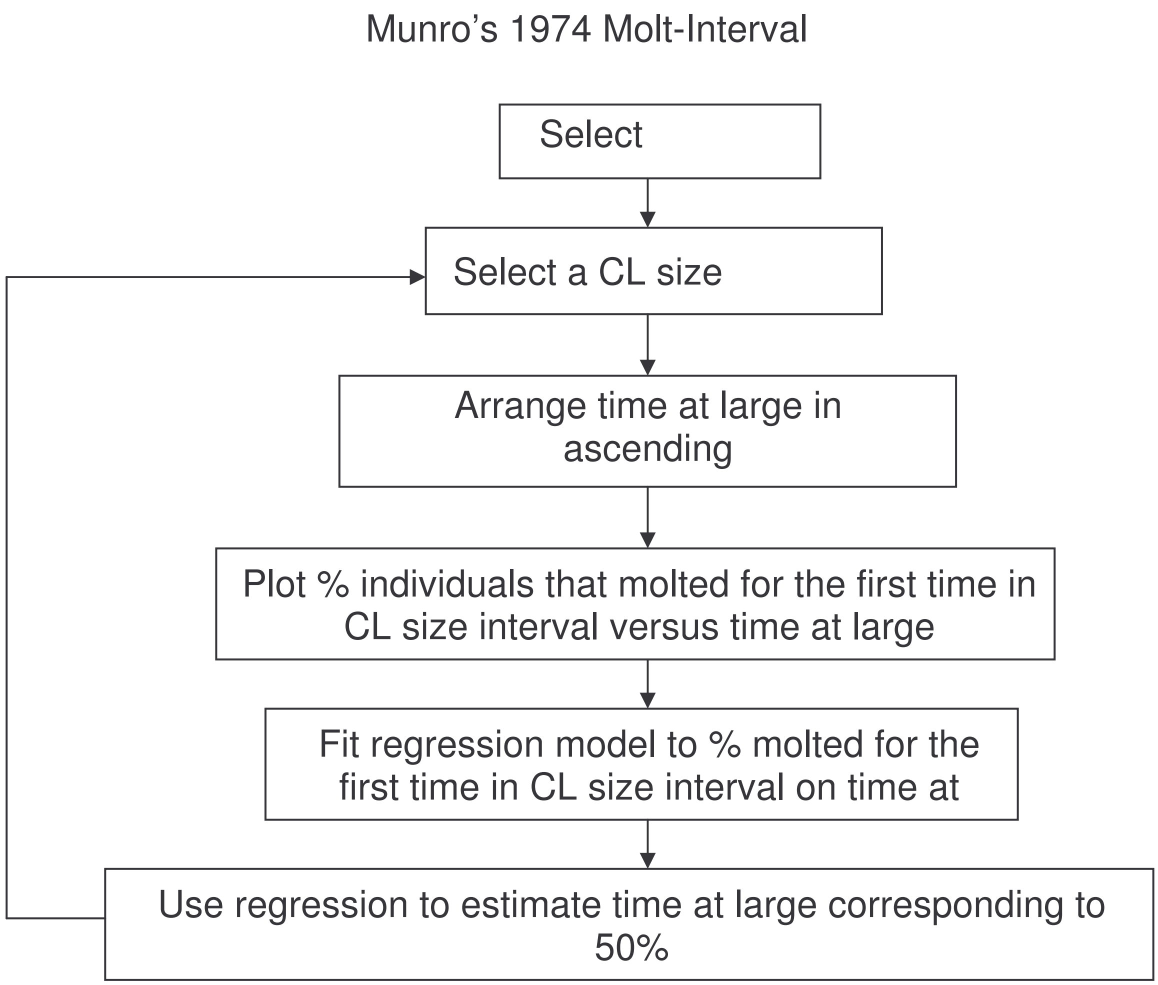

Figure 5. Algorithm for estimating inter-molt periods following Munro's (1974) procedure.

A puerulus abundance index was estimated from the nominal CPUE expressed as number of post larva per soak-time by means of a Generalized Linear Model (GLM) where years, seasons, and Florida Keys mean sea level corresponding to each soak-time were used as sources of variance. The annual puerulus estimate obtained by the GLM procedure was centered on the seasonal fishery (August to April), such that estimates could be used in further analyses relative to the recruitment and parent stock abundance previously estimated from the catch at age stock assessment algorithm.

Statistical tests and model fitted to the data generated from the above procedures were used to draw conclusions on the Florida *P. argus* exploited dynamics.

B. Project management: List individuals and/or organizations actually performing the work and how it was done.

All the work was performed by Dr. Nelson Ehrhardt with the participation of one Graduate Research Assistant (Mr. Mark Fitchett) who collaborated in data integration and statistical analyses. All the work was performed in the laboratory of the Principal Investigator at the Rosenstiel School of Marine and Atmospheric Science, University of Miami.

VI. Findings

A. Actual accomplishments and findings.

All objectives were met. A new set of segmented growth paths for males and females was obtained from the extensive Florida spiny lobster tagging database. These paths are given in Figure 1. Size at age obtained from these growth patterns are significantly different that the von Bertalanffy growth patterns usually adopted in *P. argus* assessments in the Caribbean region.

The abundance trend of the spiny lobster resource in Florida shows a significant and persistent decrease that should be of concern to fishery management. Such a decline is explained by lower recruitment generated by a decreased spawning stock abundance as shown in figure 2. A considerable shift in recruitment success is observed in during 1999-2002 and it may be originated in the mean sea level trends observed in the Caribbean. (Fig. 4). These trends may be pointing to climate change conditions and research in this specific topic should be developed with certain degree of urgency.

The results obtained in this project differ considerably from stock abundance results by the SEDAR 08 process. The main reason for such discrepancy in results is the very different segmented growth pattern estimated in this research. Previous growth patterns are for individuals that reach rather small sizes at very old ages; therefore, distributing individuals more evenly into age frequencies. In order words, the previous growth trends tend to express an older stock while the new segmented patterns show a younger stock that portrays better the actual conditions of the post larval abundance and explains the decrease in landings observed in the 2000's.

B. If significant problems development which resulted in less than satisfactory or negative results, they should be discussed.

No significant problems were encountered in the implementation of the research project.

C. Description of need, if any, for additional work.

There is a need to continue the research regarding the effects of regional environmental shifts on the recruitment success of the spiny lobster, *Panulirus argus*, in Florida. This research project demonstrated the importance of recruitment abundance to forecast landings; however, there is a need to expand the knowledge that will elucidate the consequences of the environmental variables on recruitment.

VII. Evaluation

A. Describe the extent to which the project goals and objectives were attained. This description should address the following:

1. Were the goals and objectives attained? How? If not, why?

The goals and objectives of this project were fully attained. This is demonstrated by the analyses and results obtained.

2. Were modifications made to the goals and objectives? If so, explain.

No modifications were made to the goals and objectives of the project.

B. Dissemination of Project results:

The project generated 3 papers concerning: 1) growth, 2) abundance and exploitation, and 3) recruitment dynamics. These three documents will be circulated for review and opinions and then submitted to the peer review literature for archiving.

APPENDIX I

Growth Estimation of the Florida Spiny Lobster, *Panulirus argus*, Based on Tagging Experiments.

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Rosenstiel School of Marine and Atmospheric Science
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31 August 2007

Introduction

The process of determining age and growth of exploitable aquatic species is fundamental for determining lifespan, age at recruitment and first capture, age at first maturity, and cohort identification. In stock assessment work age and growth are the bases for yield per recruit estimation, sequential population analyses, definition of management bench mark, etc. Age determination in crustaceans is conspicuously difficult by the fact that historic discontinuities in the seasonal growth (metabolism) found in hard parts, that are usually used to determine age among fish and some mollusk species, are loss with each molt of the individual exoskeletons. Most of the spiny lobster, *Panulirus argus*, age and growth estimates available in the scientific literature have been obtained from indirect methods (FAO 2001). Indirect methods identify groups of individuals of approximately similar size in a size frequency distribution under the assumption that such groupings should represent animals of the same age that portray a unimodal size distribution. Several problems associated with such methods exist such as 1) age cannot be assigned to the youngest age, 2) slowdown of growth with age creates significant overlap of unimodal size-age distributions at older ages; therefore, precluding separation of the age groups, 3) in the tropics continuous recruitment and growth creates homogenous size distributions that significantly difficult identification of the potential unimodal age distributions or cohorts, and 4) exploitation patterns mar the true nature of the unimodal distributions through seasonal differences in size availability and selectivity.

While fish species grow continuously towards an asymptotic size, crustacean growth is the product of two distinct biological processes: 1) molt period or its inverse the probability of molt and 2) growth per molt. These two seemingly separated processes are correlated to age in that intermolt periods and growth per molt decrease with age and more conspicuously so starting at the age or size of first maturity. Therefore, crustacean growth is characterized by segmented or piecewise growth that may or may not be modeled by standard size at age models adopted for fish and some mollusk species (e.g. von Bertalanffy growth function).

Crustacean segmented growth can be studied by either direct observation of animals in captivity or by means of tagging studies. Both avenues are time consuming and expensive to implement and are potentially subjected to loss of natural characterizations of growth due to captivity or tagging effects. Lewis et al. (1952), Travis (1954) and Sweat (1968) provided growth per molt stages of *P. argus* in captivity for larval and juvenile stages. Additionally, Sweat (1968) provided estimates of intermolt periods by size through 17 molt stages starting with the first post larval stage. Munro (1974, 1983) estimated intermolt periods from tagging studies of immature and mature *P. argus* in the Caribbean by assuming that if at the time of tagging, individuals of the same size or in a given size group are uniformly randomly distributed throughout their molting periods at all times, 50% of them should have molted when half of the intermolt period has elapsed. Munro's procedure is statistically robust (Restrepo and Hoenig, 1988) but has not been widely used because it is data intensive when considering the needs of stratifying the data to include sexual dimorphism, size classes or groups, and season characterizations. Hoenig and Restrepo (1989) provide methods for finding maximum likelihood estimates of the size specific intermolt period when tag-recapture data is available; however, the method has been rarely used mostly due to computer programming expertise requirements that is not always readily available while the methods may provide similar results as Munro's (1974) algorithm. Hunt and Lyons (1986) estimated intermolt periods of *P. argus* for different size of tagged *P. argus* in Florida following Munro's procedure and obtained the growth per intermolt period for those size groups. However, no formal growth models were developed from the segmented growth information thus obtained. Muller et al. (1997) developed segmented growth trends for tagged male and female *P. argus* in Florida following Fogarty and Idoine's (1988) logistic regression procedure to estimate intermolt periods and used multiple regression to estimate molt increment as a function of length at release, time at large, and dummy variables to account for season, zone and sex variants. The resulting female and male segmented growth trends, however, portray carapace lengths at 15 years of age that do not exceed 120 mm in males and 100 mm among females. These values appear to under estimate considerably the observed male and female sizes in the length frequency data available from landings. Also, the above size estimates fall well below the asymptotic sizes (L_∞) found in the *P. argus* scientific literature (FAO 2001).

Assessment of the Florida spiny lobster fishery requires generation of catch-at-age matrices separated by sex. This is usually accomplished among fish species by transforming the total length frequency distributions by sex in the annual landings to age distributions in the landings by means of age-length keys that are the probability age distributions at length. Lacking hard parts to determine age, age-length keys cannot be developed in the case of crustaceans, in which case a growth function is used to slice age compositions from the length composition data. For this reason, this project put a major effort to elucidate the growth of *P. argus* in the Florida fishery and use the new information in the assessments.

Materials and Methods

Tagging data were provided by Robert Muller of the Florida Marine Conservation Commission. These data consisted of a composite database with recapture information generated from several tagging studies carried by the State of Florida, and by the University of Florida (data kindly provided by Douglas Gregory). The integrated database consists of 3481 females and 3330 males recovered from tagged individuals released throughout the Florida Keys between 1967 and 2003. Female lobsters ranged in size from 32 to 111.7 mm CL while males ranged between 35 and 118 mm CL. Each individual record consisted of size at the time of tagging and release, days at large and size at recapture. Additional information on capture-recapture location and injury status was recorded. Details of the protocols of the tagging experiments are found in Hunt and Lyons (1986) and Muller et al. (1999).

Additionally, data on time and size corresponding to the first 17 intermolt events of 169 out of 321 post larval lobsters captured in the Florida Keys and kept in the laboratory by Sweat (1968) were added to the intermolt data obtained from the tagging data. These data were used in the development of intermolt period-premolt size functions for female and male spiny lobsters. According to Sweat (1968) the laboratory data was consistent with the growth obtained in the laboratory by Lewis et al. (1952). The 169 post larval lobster that molted ranged from an average size of 8 mm CL corresponding to the first post larval stage at the start of the experiment to an average of 50 mm CL at the end of the 17th molting event. On the other hand, data on molting interval of juvenile lobsters kept under laboratory observation by Travis (1954) consisted of 159 individuals ranging from 20 to 89 mm CL. These were not integrated to the database because the growth experiment did not initiate at the start of the first post larval stage and the data was representative of only 7 molting stages that cannot be properly matched with the molting stages identified by Sweat (1968) that started with the first molt after reaching the post larval stage.

Sample sizes in the combined 1967-2003 tagging data varied widely within size groups with most samples falling between 70, 80, and 90 mm CL categories for sexes combined. Significantly fewer lobsters were tagged and recaptured in size categories below 70 mm CL and above 100 mm CL (Fig. 1). Therefore, the tag-recapture data is the outcome of an unbalanced sample design that has consequences to the study of growth especially regarding the larger or older individuals that usually define asymptotic sizes.

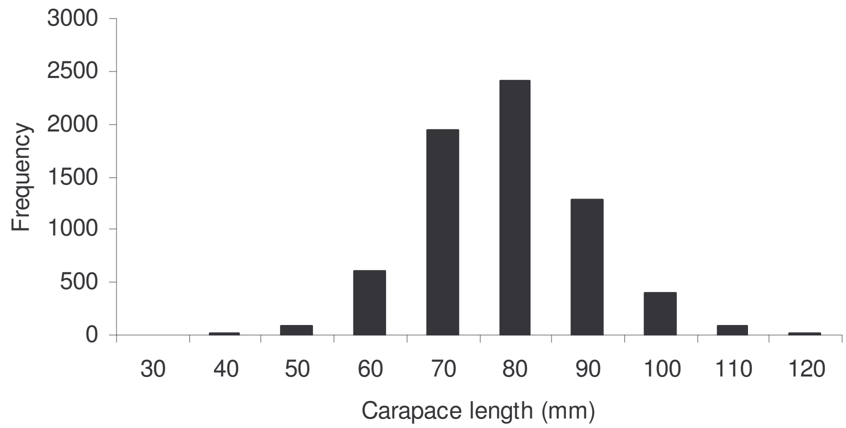

Figure 1. Size frequency distribution of male and female *P. argus* recapture from all tagging experiments between 1967 and 2003.

Also, due to the very high fishing intensity exerted in the areas where the tagged lobsters were released, a very significant number of the tag returns show extremely short times at large; therefore, preventing the observation of growth (Fig. 2). In figure 2 the frequency of recaptured female and male lobsters from all tagging experiments plotted as a function of time at large show that most tags (97-98%) were recaptured before 120 days at large while 96% of them were recaptured before 100 days at large.

Under the condition of short times at large measurement error plays a significant role on growth estimation. This initial measurement error was analyzed separately by sex by grouping length at recapture minus length at release for all tag returned within 5 days of tag release. The error distribution centers significantly about 0 for either sex (Fig 3, males upper panel, females lower panel). The error does not appear to propagate 2 mm above or below zero mm CL. The distributions are very approximately similar between sexes. This finding is similar to that of Hunt and Lyons (1986) regarding measurement errors. Consequently, only those recaptured individuals showing a CL increment larger than 2 mm were considered in the analyses of growth.

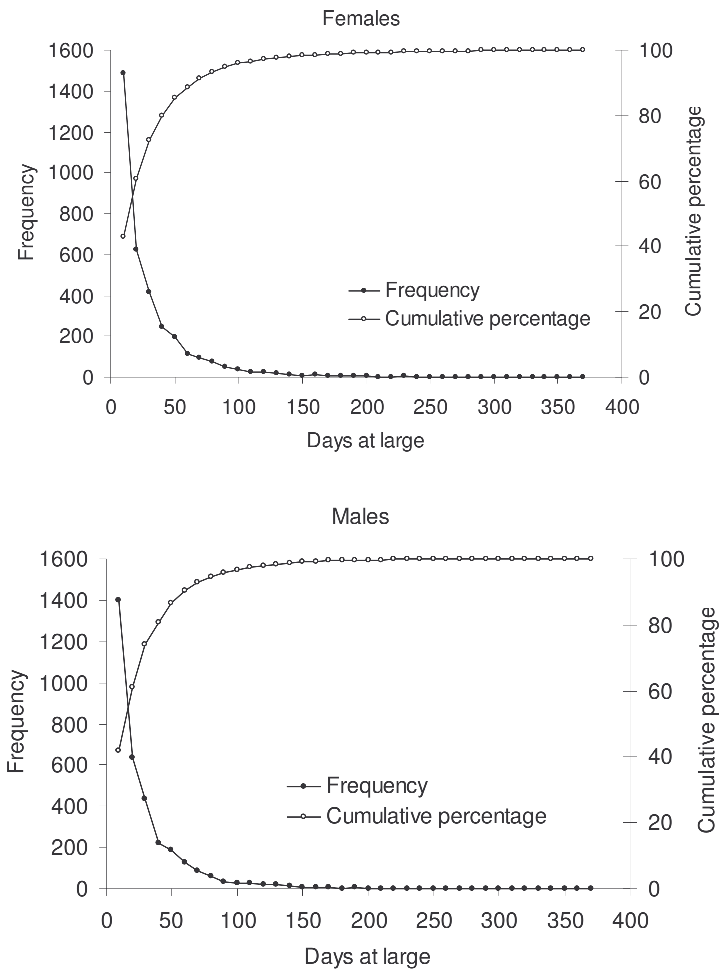

Figure 2. Frequency and cumulative percentage of males and females recaptured after given times at large from all tagging experiments.

Intermolt periods were estimated separately by sex and by 10 mm CL intervals starting with a size category <40 mm CL and then every 10 mm above 40 mm CL until the largest individuals tagged in each sex. The data was organized in EXCEL templates following an algorithm that functionally follows Munro's (1974) procedure (Fig. 4). In the few cases when the size increment within a CL interval was conspicuously large (outlier) and the time at large was also large, then this increment was judged as a multiple molt individual and discarded from the estimation of the percentage of individuals that molted for the first time within the CL interval for any time at large available for such interval.

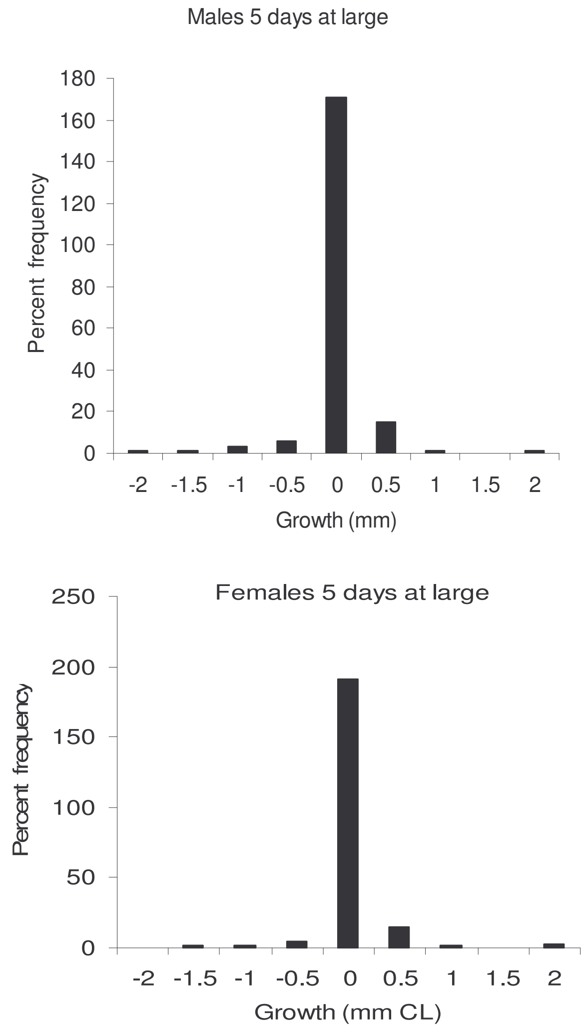

Figure 3. Percent frequency of growth (difference between CL at recapture and CL at release) of males and females recaptured during the first 5 days at large from all tagging experiments.

The intermolt period premolt carapace length function was expressed as

$$IP = ae^{bL_{pr}} \qquad (1)$$

where IP is the intermolt period, L_{pr} is the premolt carapace length, and *a* and *b* are parameters of the function estimated by non linear least squares procedures.

Pre-post molt relationships necessary to express the change in size at molt were developed for male and female spiny lobster based on the condition that such changes are expected among those individuals that have molted only once at any given size. An apparent linear relationship should be evident from such plots although it may change upon attainment of maturity (Hiatt, 1948; Kurata, 1962; Mauchline, 1977; Somerton 1980; Caddy, 1987).

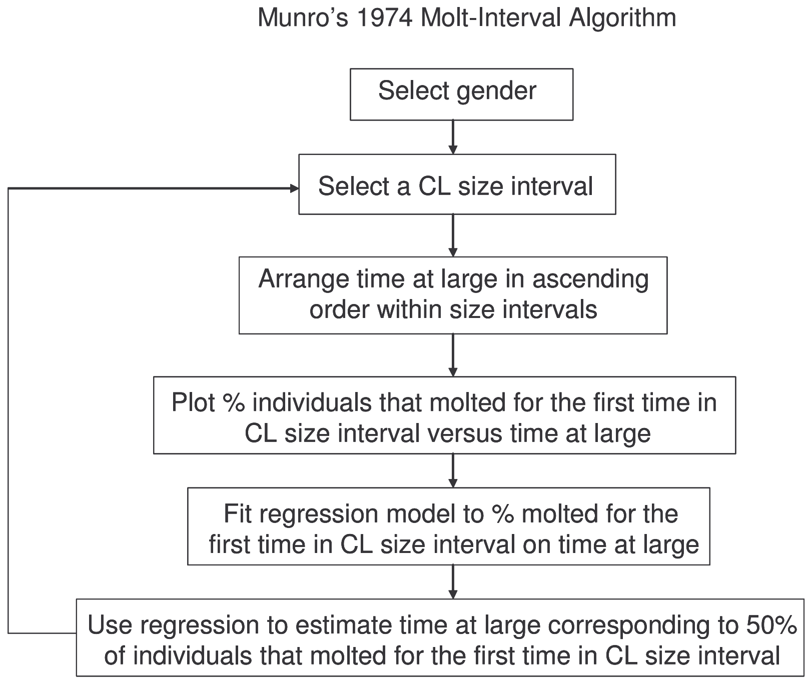

Figure 4. Algorithm adapting Munro's (1974) procedure to estimate intermolt period.

Segmented growth of male and female *P. argus* were obtained by estimating postmolt size starting at a premolt size of 5 mm CL (first post larval stage) and then applying the intermolt period until the next molt, etc. This stepwise procedure generates appropriate segmented growth trends that will take into consideration the average dynamics of growth for the species. Variability on the segmented growth can be studied by including the standard error of the functions in the stepwise procedure or conversely, using the variance of the parameters estimated for the intermolt period-premolt finction and for the premolt-postmolt relationships.

Results

The existing tag recapture database is large; however, only 16.89% and 19.91% of the female and male observations, respectively, were used in the analyses. This was due to fact that the remaining percentage of the observed recaptures fell within the measurement error bracket or showed no growth due to the extremely short time at large. In spite of these conditions there were sufficient tag-recapture data points to categorize size groups and time at large within size groups separately by gender. However, there were not sufficient individual data points to perform the analyses including seasons (winter-summer) within gender and size categories.

Analyses of size increments per molt show seasonal differences, which are gender specific. The 95% confidence intervals for the average growth per molt in mm CL for all size groups by seasons and gender are:

	Summer	Winter	Prob. t-Student Diff. Means
Females	6.48-7.20	5.26-6.36	0.0011
Males	7.08-7.66	6.00-7.10	0.0051

The significantly different growth per molt is most likely due to a confounding effect of seasonal changes in temperature and salinity. Hunt and Lyons (1986) attributed the lower winter growth per molt to a change of up to 5.2°C between the two seasons. According to Hunt and Lyons (1986) intermolt periods were longer in winter than in summer, however, this condition was not observed in the data analyzed in this study. Most likely this is due to data limitations given the high level of stratification of individual observations among sexes, size groups, and time at large within seasons required in the intermolt estimation procedure.

Intermolt period as functions of the premolt CL are shown in figure 5 (Females upper panel, males lower panel). It is observed in the figures that data on the intermolt period for the post-larval and juvenile stages of Sweat (1968) fall well within the trend of the intermolt period of the immature individuals estimated with the tagging data. Also, a significant break in the intermolt period is observed at 70 mm CL for both females and males. This may be due to the onset of full maturity when grow slows down and this process is reflected by increasing the time between molts. The parameter functions for the faster and slower growth patterns according to equation 1 are given as

	a	b	R^2
Females fast growth	0.061	0.02337	0.95
Females slow growth	0.0075	0.05062	0.80
Males fast growth	0.0655	0.01930	0.93
Males slow growth	0.0321	0.02808	0.90

Growth per molt was estimated from linear functions fitted to the premolt-postmolt data segregated by gender (Fig.6). The expected break in the growth of crustaceans at maturity described by Hiatt (1948), Kurata (1962), Mauchline (1977), Somerton (1982), Caddy (1987) is not apparent in figure 6. Hunt and Lyons (1986) found a “dramatic decrease in growth rate between the 71-75 and 76-80 mm CL size classes” for *P. argus* in Florida, which is not observed in the existing database. However, this may be an artifact due to sample size deficiencies in the extreme range and a concentration of observations in the middle range of the CL frequency distributions. Sampling experimental designs that could secure a larger number of observations in the extreme of the carapace size distribution will be necessary to elucidate this condition. The linear functions have parameters obtained through least squares from the existing database are:

	Intercept	Slope	R^2
Females	8.1918	0.9629	0.961
Males	6.3901	0.9965	0.963

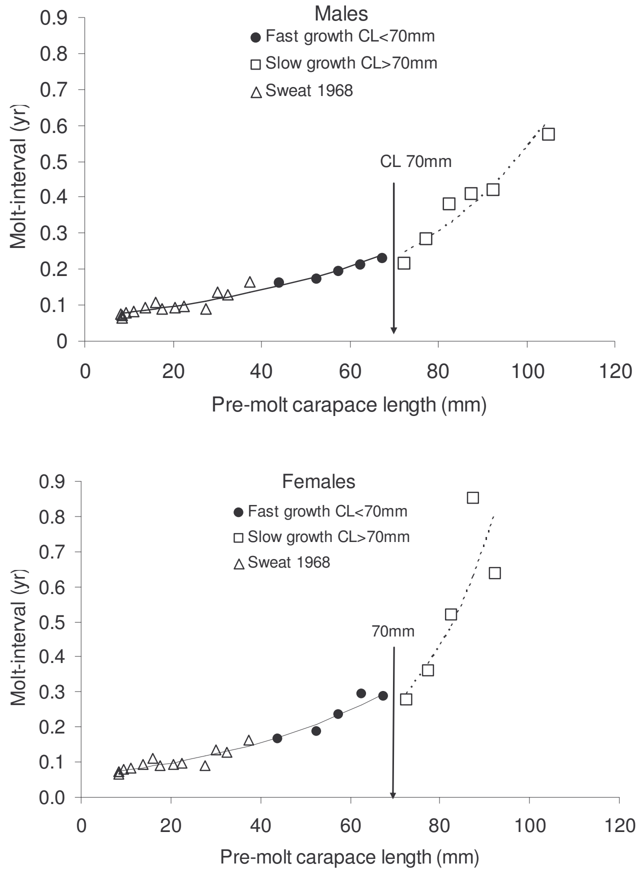

Figure 5. Molt interval in years as a function of pre-molt carapace length for males (upper panel) and females (lower panel).

Segmented growth trends by gender starting with a 5 mm CL were developed by applying the premolt-post molt functions followed by the intermolt-premolt stepwise functions. The resulting segmented growth trends are shown in figure 7. A distinct sexual dimorphism is observed in the figure where males grow to conspicuously larger sizes than females. Females reach a CL of 151 mm at the maximum simulated age of 30 years, while males reach 220 mm CL at that age. Since it was not possible to segregate the existing database by season to obtain seasonal intermolt-premolt CL, the estimated segmented growth trends are for the average annual growth of the species.

Discussion and Conclusions

The difficulty of separating the two most common components of molt increment and molt frequency in *P. argus* growth has prevented complete descriptions of this fundamental biological process. Munro (1974) and Peacock (1974) demonstrated that average intermolt periods of mature *P. argus* varied between 60 and 90 days, while Hunt and Lyons (1986) found that mature *P. argus* in Florida presented average intermolt periods between 123.9 and 149.8 days for males and females, respectively, while among immature individuals varied between 74.2 and 91.7 days in males and females, respectively. In this study molt interval of mature females varied from 100.8 to 232.0 days depending on size while in males these intervals varied between 78 and 209 days. Immature males presented inter molt periods between 58.3 and 83.4 days depending on size and females ranged between 60.5 and 104.5 days also as a function of size. The estimated differences in intermolt periods of immature and mature individuals result, in part, in the observed sexual dimorphism in that males grow to larger sizes than females. The above results are not comparable with those of Hunt and Lyons (1986) given the functional nature of the results in this study and that the average values presented by the previous authors mostly depend on sample size at intermolt periods.

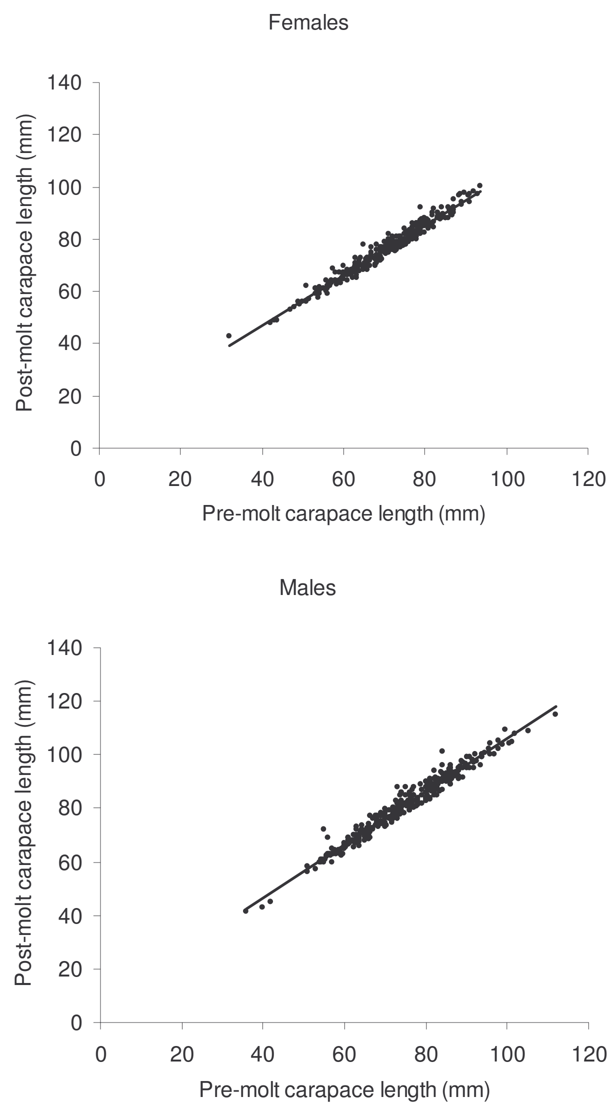

Figure 6. Pre-molt post-molt carapace length functions for females (upper panel) and males (lower panel).

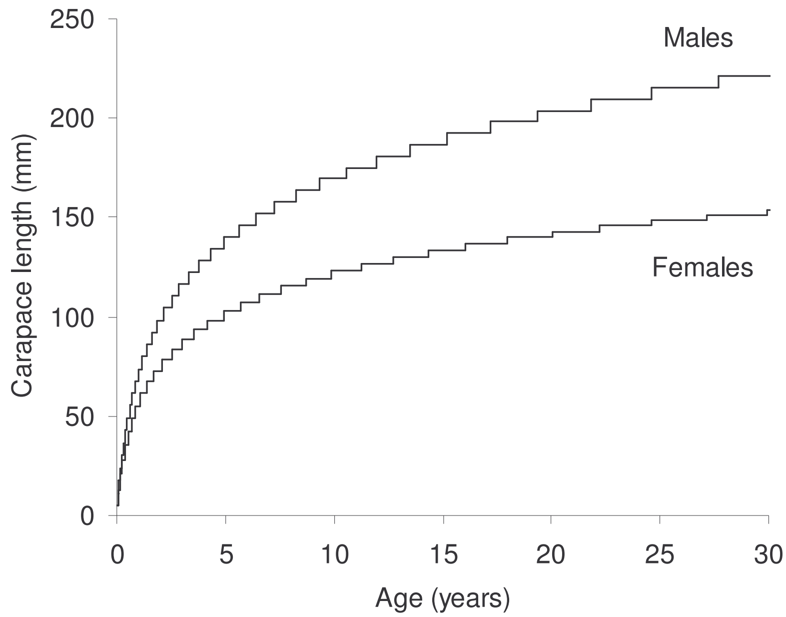

Figure 7. Segmented growth trends for female and male *P. argus*.

Growth per molt is expressed by significant linear trends both in males and females. The implication is that a constant growth rate per molt should affect the segmented growth patterns; therefore most of the growth is expressed by the non-linear changes in the intermolt period as individuals grow. This condition appears to hold in the results of Hunt and Lyons (1986; Fig.2) where molt increments are approximately constant in the <50 to 90mm CL range. Lower values for the 91-95 and 96-100 mm CL classes expressed by the above authors may be due to very low sample sizes (7 and 2 respectively). The average growth per molt provided by Hunt and Lyons (1986) varies between 6.57-6.66 mm CL for immature and mature males and 5.46-6.56 mm CL for immature and mature females.

Growth at old ages (age 30 years) obtained by integrating the piecewise processes of intermolt growth and frequency is 151 mm CL in females and 220 mm CL in males. The 95% confidence intervals of the asymptotic lengths of the published von Bertalanffy growth function estimated indirectly from length frequency distributions (FAO, 2001) are 180.6-210.2 mm CL for males and 157.4-180.0 mm CL for females *P.argus*. However, these seemingly approximate maximum CL estimates do not portray the highly significant differences regarding the trends in growth corresponding to the 95% confidence intervals and those of the segmented growth (Fig 8). Given that the indirect methods to estimate growth by separating unimodal frequency distributions corresponding to ages from length frequencies is highly inaccurate, it is concluded that the various von Bertalanffy growth parameters published in the literature (FAO, 2001) might not express the growth of *P. argus* adequately when compared with the results of growth estimation from the vast tag-recapture database used in this study. This condition has profound implications on stock assessments as well as in management bench marks for the species.

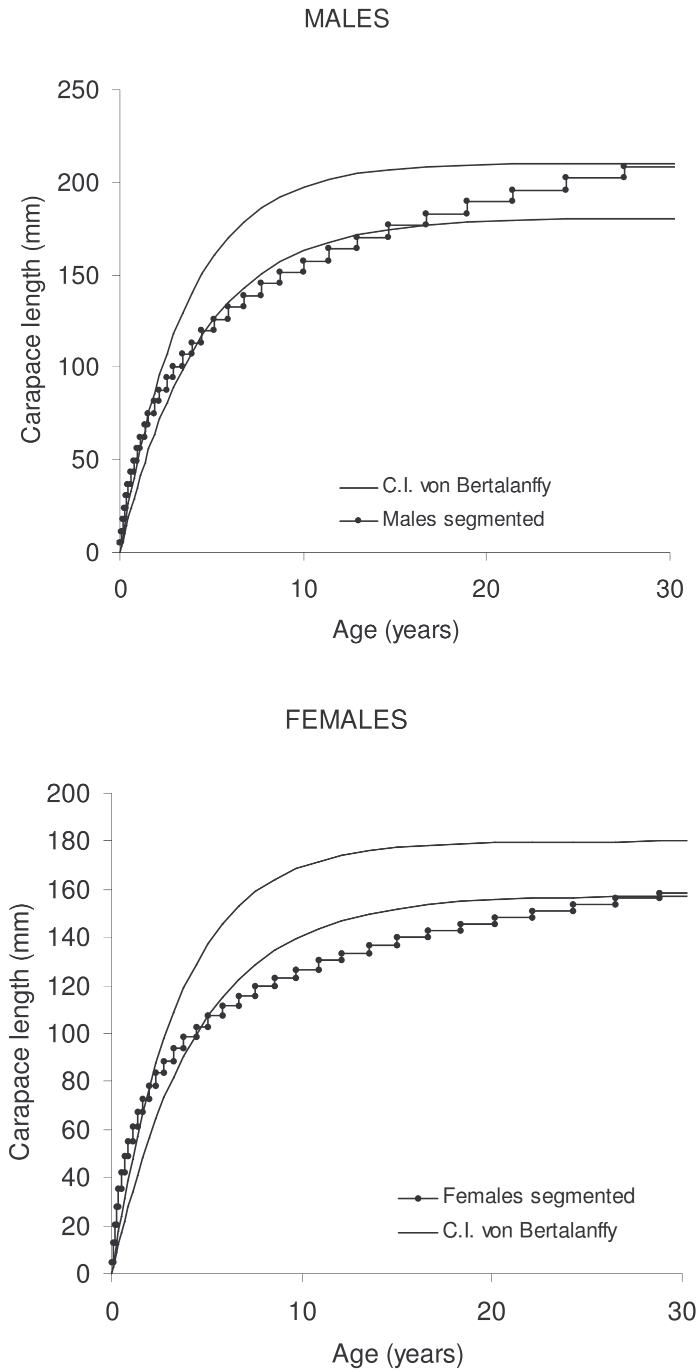

Figure 8. Segmented growth trends for female and male *P. argus* compared with the 95% confidence interval generated by all the von Bertalanffy growth parameters presented in FAO (2001).

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APPENDIX II

Assessment of seasonal exploitation of the spiny lobster, *Panulirus argus,* in Florida

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31 August 2007

Introduction

The Florida spiny lobster fishery is the most economically important in the State of Florida. The fishery is characterized by intense exploitation of the resource by several groups of commercial and sport fishing interests. Landings by these groups (Fig. 1) vary through time and within seasons. But in general, high competition for the resource use resulted in management needs to protect the local stock. Lately, controls may be increasingly necessary given that landings decreased to a persistent and significantly lower level since the 2001 fishing season (Fig. 2). Landings represent 53.8% of the average landings achieved during the preceding fishing seasons (1994-1999), with the lowest landing in recent times (43%) recorded in the 2005 fishing season. Industry and fishers have expressed concern on the alarming decrease in fishery production observed during the last four fishing seasons.

Assessments of the status of exploitation of the stock have been presented by Muller et al. (1999), Harper and Muller (2001) and SEDAR 08 (2005). The assessments are conclusive regarding the high fishing intensity historically being exerted on the stock. The SEDAR 08 (2005) report mentions fundamental issues that still remain uncertain concerning several key aspects of the assessments. For example, growth determination needs urgent revision given that growth of the larger, hence older, individuals is not properly described by the existing models. This has a direct effect on the catch-at-age matrices used in stock assessments. There is a lack of spawner-recruit functions that may explain some of the observed trends in abundance due to difficulties in interpreting the Pan-Caribbean nature of the lobster larval sources. There is a declared uncertainty on the stock assessment models used, and more importantly, an uncertainty on the origin of the low landings observed in the later seasons when the stock abundance estimates appear stable and fishing mortality also stable in spite of their high values.

A common characteristic of this fishery is the large fishing capacity and the concomitant large seasonal utilization of the local biomass. High rates of stock utilization are until now justified on the principle that a significant amount of recruitment might have an upstream origin. Although the upstream larval premise has long been postulated (Lyons, 1982; Ehrhardt, 2005) and genetic studies show a high level of stock mixing (Silberman et al., 1994a and b; Sarver at al., 2000), there is an absence of conclusive results regarding this issue. Recent stock assessment studies by Ehrhardt (2005, 2006, 2007a) in Central America and Brazil show significant upstream mature stock abundance reductions mostly due to stock over exploitation and heavy exploitation of undersized; therefore immature, spiny lobsters in most fisheries in the regions considered. If these depletion events are common, then it will be expected that future upstream larval recruitment to the Florida fishery may be compromised.

In this study, a revised stock assessment is provided using the same database as in the SEDAR 08 with the exception of newly developed segmented growth functions by gender obtained from tagging (Ehrhardt 2007b in this final report). Depletion and age-structured models are used jointly to generate results that are used to compare trends in mature stock abundance, recruitment, and fishing mortality rates.

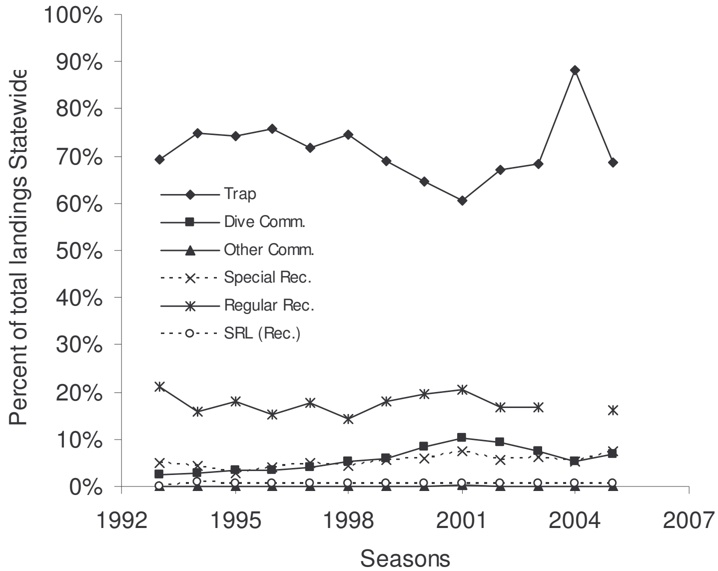


Figure 1. Percent distribution of total Florida spiny lobster landings by year and fishing group.

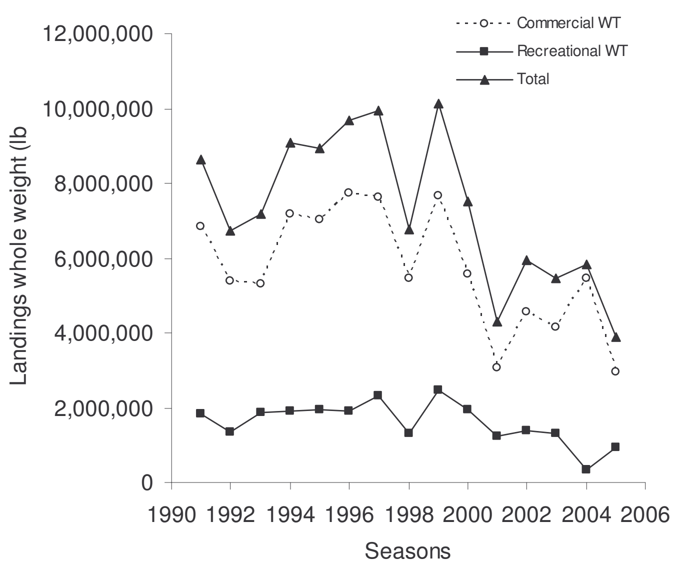


Figure 2. Landings of Florida spiny lobster by commercial (all types) and recreational (all types) and total landings by all fishing groups.

Materials and Methods

The data used in the assessments were provided by the Florida Fish and Wildlife Conservation Commission (kindly provided by Dr. Robert Muller, Mr. John Hunt, and Mr. Rick Weaver). The characteristics of these databases are described in SEDAR 08 (2005). The data available for this study consist of: 1) total landings by fishing groups (commercial traps and divers, bully, others, unknown, and bait; sport regular and special seasons, and SRL) for the 1991-2005 fishing seasons, 2) carapace length frequencies for spiny lobsters caught in traps (commercial), divers (commercial and sport), others, and as attractants used in the trap fishery for the period covering from the 1985 to the 2003 fishing seasons, 3) monthly trap landings and corresponding fishing effort (soaking time and number of traps fished per trip), and all gear landings for the 1991-2005 fishing seasons and by sub-regions (Miami, Upper Keys, Middle Keys, Lower Keys and Key West). Catch per unit of effort for the trap fishery corrected by soaking time was assumed as standard in this study. The reason for this assumption was the large fraction of total landings represented by the trap fishery and the wide range of sizes captured with this gear. Total (all gear) monthly effective fishing effort was estimated as the ratio of all gear landings to the soak time corrected trap catch per trip.

A depletion model based on seasonal catch per unit of effort used by Ehrhardt and Deleveaux (2004) was used to estimate seasonal catchability (q), average seasonal abundance, and recruitment accumulated through the closed season. The depletion model is a modified version of those widely used in the scientific literature (Leslie and Davis, 1939; DeLury, 1947; Chien and Condrey, 1985; Sanders, 1988; Rosemberg, et al., 1990, Restrepo, 2001). The depletion model uses Pope's (1972) approximation to Baranov's catch equation under the assumption that total catch in a given month will be taken instantaneously at the middle of the month. Such an approximation will generate unbiased estimates of population abundance at the beginning (N_t) and end (N_{t+1}) of each month given that the monthly natural mortality (M) rate is not greater than 0.3 for each time period considered, and that the fishing mortality rate experienced by the stock does not surpass 1.2 in each time period. In the assessments, M= 0.0129167 m^{-1} (0.35 yr^{-1}) was adopted. The basic sequential population abundance equation is expressed as

$$N_{t+1} = (N_t e^{-M/2} - C_t)e^{-M/2} \qquad (1)$$

During the closed season, the stock abundance is only affected by natural mortality (i.e., C=0 in equation 1) and the average monthly abundance is expressed as

$$\overline{N_t} = N_t e^{-M/2} - \frac{C_t}{2} \qquad (2)$$

where C_t is the catch realized during month t.

Also, the relative stock abundance expressed as the catch in numbers per unit of effort in month *t* is assumed to be directly proportional to the average abundance in the given month. Hence,

$$CPUE_t = q * \overline{N_t} \qquad (3)$$

where q is assumed constant for a given season but variable among seasons.

Application of equation (1) to express seasonal depletion in the spiny lobster fishery requires that N_t varies with fishing (F_t) and natural (M) mortality under the time schedule assumed by the model. However, at the beginning of the fishing season

(August), the stock abundance is composed of the last season's remnant of stock abundance that escaped fishing mortality, and the new recruits that accumulated during the closed season. In this manner, the seasonal depletion population model adopted in this study to estimate the seasonal population abundance (N_t) is:

$$N_{t+1} = (N_t e^{-M/2} - \frac{C_t}{2})e^{-M/2} + R_{t+1} \qquad (4)$$

The model expressed by equation (4) was used to estimate seasonal population abundance, average population abundance and expected $CPUE_{exp}$ (equation 3). $CPUE_{exp}$ and the observed soak time corrected monthly $CPUE_{obs}$ for the period 1991 through the 2005 fishing seasons were used in the negative log-likelihood objective function (equation 5) to estimate seasonal catchability and recruitment. An important consideration in the estimation of the seasonal catchability coefficient is that it was assumed to be constant within a season, but allowed variation inter-seasonally following a simple random walk model expressed as:

$$q_i = q_{i-1} e^{\varepsilon_i}$$

where i is season and ε_i's are annual, and normally distributed with mean zero and variance σ_ε^2. The model was fitted by minimizing the negative log-likelihood objective function:

$$\frac{n}{2}\sum_t (\ln(U_t) - \ln(\hat{U}_t))^2 + \frac{\sum_t \varepsilon_i^2}{\sigma_\varepsilon^2}, \qquad (5)$$

where U_t's represent $CPUE_{obs}$ and $CPUE_{exp}$ in month *t,* and σ_ε^2 was fixed to achieve a coefficient of variation of 10% (in log space). In theory, allowing for a random walk in *q* should accommodate situations such as the one studied here in which gear efficiency changed smoothly over the 1993-1995 fishing seasons as a consequence of the trap reduction program implemented in those seasons.

The depletion model used soak CPUE in numbers caught per trap, per trip. Consequently, the monthly CPUE provided in the database was transformed from weight to numbers by simply dividing each CPUE by a 1992-2003 average weight of individuals in the landings, which were also provided in the database. One important consideration in the preparation of the data necessary to fit the model in equation 5 was the realization that soak time vary considerably throughout the fishing season with an increasing trend as the fishing season progresses (Fig. 3). Also, soaking times vary considerably according to seasonal stock abundance (Fig. 3) due to the fact that with higher abundance, there is a need to empty traps more often, and vice versa. Hence, the catch per trap per trip needs to be referenced to the changing seasonal soaking time. For this purpose an average monthly soaking time was estimated from those records in the trip ticket database that presented number of traps and soaking time. The resulting CPUE is then referred to as the catch in numbers per trap-day per trip.

Catch-at-age Model

Data on total (all gear combined) annual length composition by gender in the seasonal landings were converted to seasonal age compositions in the landings by slicing length frequencies using new segmented growth functions specified by sex (Ehrhardt

2007b). These data were used in a tuned least squares backward age-structured sequential population analysis (SPA) algorithm.

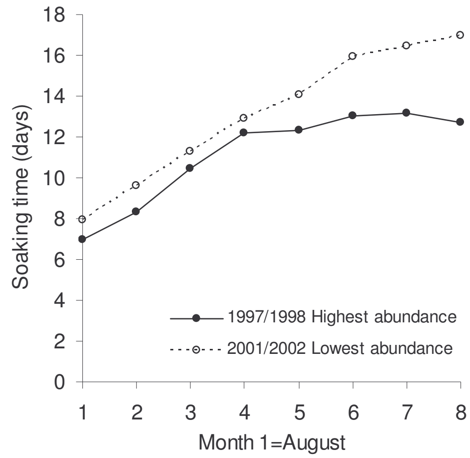


Figure 3. Soaking time as a function of months within fishing seasons and as function of relative seasonal stock abundance.

Conceptually, fishing mortality rates at age and abundance at age in each season are estimated by a least squares procedure that minimizes an objective function expressing the sum of squares of the residuals of observed CPUE and expected $CPUE = q_i \overline{N_{i,a}}$. Therefore, the objective function is defined as:

$$\min \sum_{i=1985}^{2003} \sum_{a_r}^{\max a} (CPUE_{i,a} - q_i \overline{N_{i,a}})^2$$

where i identifies the season, *a* the age, *r* is an index for variable recruitment age, $CPUE_{i,a}$ is the observed catch in numbers per trap-day per trip for ages a_r to maximum age in season i, q_i is the catchability coefficient in season i, and $\overline{N_{i.a}}$ is the average abundance of age *a* estimated by the minimization algorithm in season i. Average population abundance is estimated in the usual manner, $\overline{N_{i.a}} = \frac{(1-e^{-Z_{i.a}})N_{i.a}}{Z_{i,a}}$. The catchability coefficient (q) was estimated internally by setting the first derivative of the objective function with respect to q equal to zero and solving for q such that

$$q = \frac{\sum_{i=1991}^{2003} \sum_{a_r}^{\max a} CPUE_{i,a} * \overline{N_{i,a}}}{\sum_{i=1991}^{2003} \sum_{a_r}^{\max a} \left(\overline{N_{i,a}}\right)^2} \qquad (6)$$

This algorithm allows partitioning both time (sums over an i-range) and ages (sum over an a-range) in a way that it is possible to search for the fit that best portrays cohort abundance signals in the catch-at-age matrix and the CPUE index used in the tuning. Graphic representations of the algorithm and SPA diagram are shown in Figs. 4 and 5.

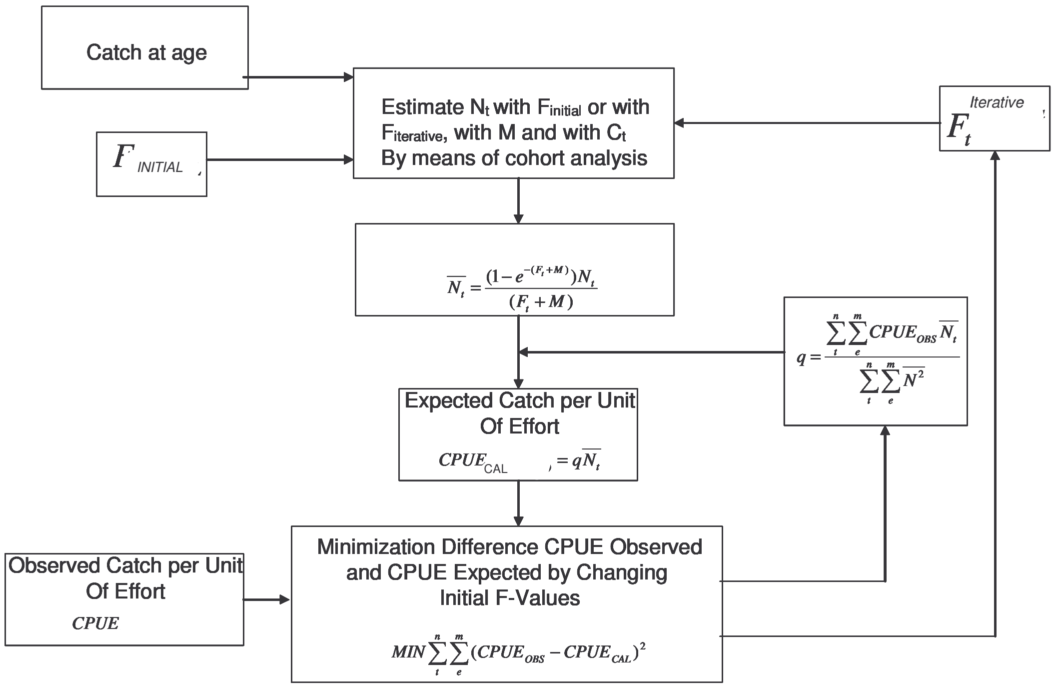


Figure 4. Least squares algorithm developed for the assessments of abundance and fishing mortality rate at age and season using a catch at age matrix and calibration or tuning indices.

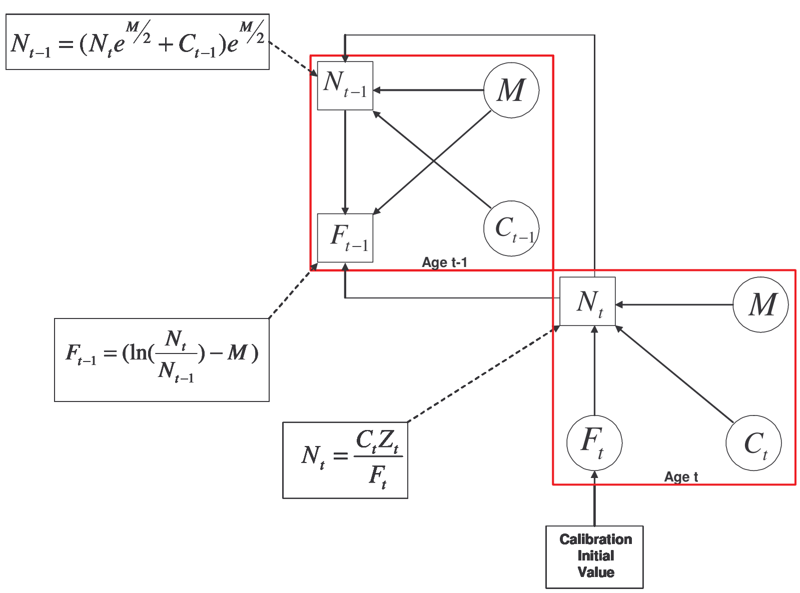


Figure 5. Diagram of the sequential population analysis (SPA) used in the stock assessment algorithm.

The algorithm in Fig. 4 was developed specifically for the conditions of the Florida spiny lobster fishery. The backward cohort abundance estimation (Fig. 5) starts with a single initial guessed estimate of F that is the apical fishing mortality for the fully recruited ages. For the remaining ages, fishing mortality is estimated from an exploitation pattern initially adopted. This exploitation pattern changes in every run until convergence is achieved. Once the F's at age for the last season are estimated, abundance at age in the last season is estimated from a catch equation and the cohort equation similar to equation 1, and the algorithm in Fig. 5 is applied backwards to obtain all the other parameters as shown in the figure. The next step estimates q and the average population numbers at age for each season and use these estimates in the evaluation of the objective function. The process continues iteratively by changing the apical F until the sum of square deviations between the observed and expected CPUE's is minimized. The algorithm was fit separately by sex and for the 1985-2003 fishing seasons. Eight ages were available for the females and 11 ages for the males.

Results

Depletion model

The observed and expected monthly CPUE's corresponding to the entire fishery (i.e. no sub-regional stratifications) and for the 1991-2005 fishing seasons are given in Fig. 6. A consistent fit is shown for all fishing seasons. The ANOVA for the depletion model fit is given in the table below:

Data	Parameters	d.f.	SSQ	Variance
120	31	89	4.2769	0.04806

The trend in seasonal catchability estimates is shown together with the historic trend in trap reductions in Fig. 7. A negative correlation between the two trends is observed for the period when the trap reduction program was in full implementation (1993-1995). The number of traps was reduced from 939,000 in 1992 to 606,190 in 1995; therefore, the increased catchability was an expected result under the assumption that a reduction in the number of traps should not result in a decrease in landings. Under the same assumption, a stabilized catchability should be expected during the period when the number of traps is maintained roughly constant. From the 1995-1998 fishing seasons the number of traps was only slightly reduced to 544,056 while on average 513,000 traps were operated in the remaining seasons. Accordingly, the estimated catchability coefficients appear stabilized between the 1996-2005 fishing seasons at 0.15933 E-04 trap-day-trip except in the 2000 and 2001 fishing seasons when q is significantly higher relative to the stabilized trend. These large q estimates cannot be explained with the existing data. Seasonal catchability estimates plotted on the seasonal number of traps (Fig. 8) show the significant increase in the fraction of the stock that is presently taken per trap-day-trip as the number of traps was reduced in the fishery.

The percent change in catchability that occurred in each zone of the Florida Keys and Miami at the peak of the trap reduction program (1993-1995) (Fig. 9) indicates that

Miami and the Upper Keys had larger gains in q than the Middle Keys, Lower Keys, plus Key West. Generally, during the period from the 1991 to the 2005 fishing seasons, fishing effort expressed in traps-day-trips became at least 31% more efficient in their catching capability throughout the region. The drop in q in the 1998 season may be a consequence of Hurricane George that passed through the region in September of 1998, dispersing the traps.

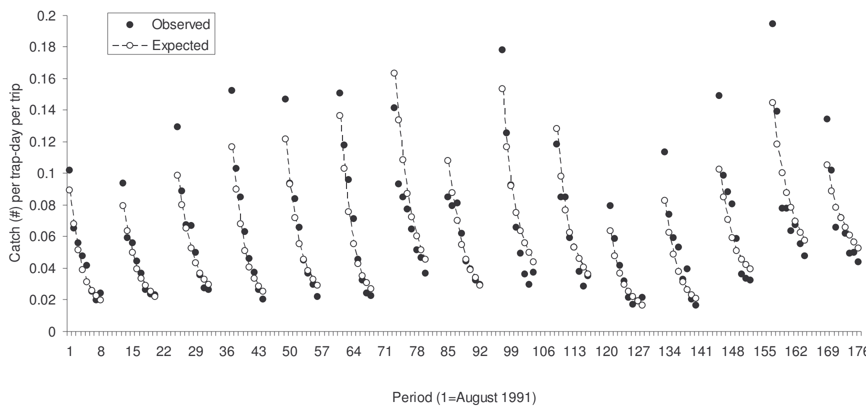


Figure 6. Observed and fitted CPUE's corresponding to the seasonal depletion model applied to the 1991/1992 to 2005/2006 fishing seasons.

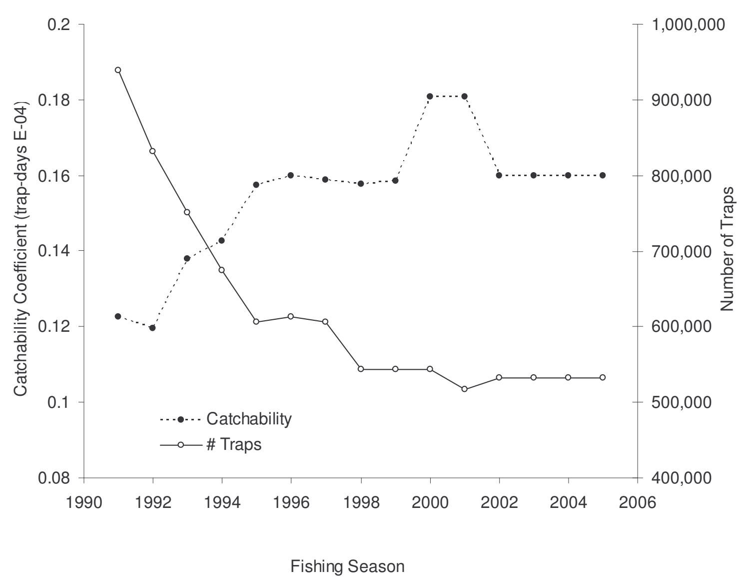


Figure 7. Seasonal catchability estimates and number of traps operated.

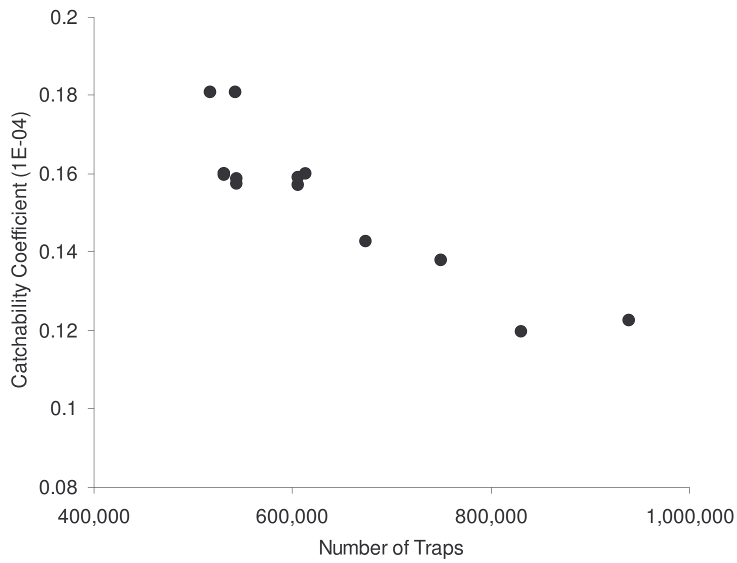


Figure 8. Trend in seasonal catchability coefficients on number of traps operated.

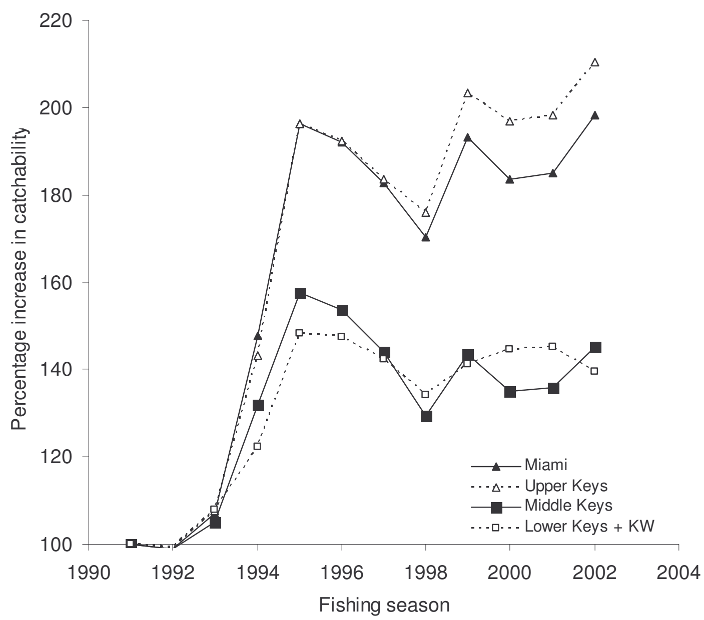


Figure 9. Per cent increase in catchability due to rap reductions by zones.

Results from the depletion model fit show highly variable seasonal recruitment abundance (Fig. 10) with periods of apparently higher recruitment in the mid-1980's. A decreasing recruitment trend since the 1997 fishing season reached a minimum level during 2001 that extended through the 2003 fishing season, recuperating in 2004 but decreasing again in the 2005 fishing season. The generally lower recruitment estimates observed in the early 2000's may the reason for the lower landings observed in the fishery during subsequent seasons (Fig. 10 and Fig.2).

Catchability was estimated from the depletion model with the purpose of using the q-series in the SPA tuning procedure and estimation of the recruitment index for the purpose of analyzing the most credible recruitment dynamics emerging for the SPA algorithm. Therefore, no further use of the results is provided relative to the status of exploitation of the resource.

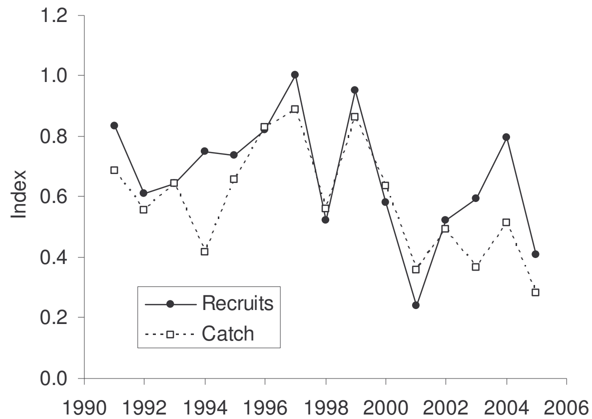


Figure 10. Indexed recruitment estimated by the deletion model and indexed total seasonal landings.

Sequential Population Analysis (SPA)

Age-structured sock assessments using the catch-at-age least squares algorithm used three different approaches in the tuning procedure: 1) variable q, 2) constant q, and 3) q estimated from the depletion model fit. Therefore, the first two tuning procedures are internal to the algorithm (equation 6) while the third is external or input to the algorithm. In the case of variable q, tuning proceeded within the algorithm (Fig. 4) with q estimated according to equation 6 for each season. The average abundance in equation 6 was adjusted to the age range that best linked the least squares procedure with the relative abundance signals expressed by CPUE estimated from the catch-at-age matrix. In the case of constant q, the tuning used average values of q estimated within the algorithm and according to equation 6, but grouped by seasons when q was known to have changed due to the trap reduction program. The time groups were drawn from the results of the depletion model (Fig. 7). Therefore, an average q-estimate was obtained for fishing seasons prior to the trap reduction program implementation (1991-1992). another average for the 1993 and 1994 that are transitional fishing seasons regarding q, and finally an average q for the stabilized period starting with the 1995 fishing to the end of the period of analysis. The third case used q values estimated from the depletion model (Fig. 7).

Therefore, the tuning was both relative to the observed CPUE and externally estimated q. The assessments were done separately by sex; hence, total seasonal abundance in numbers is the sum of the abundance at age and gender. Meanwhile seasonal fishing mortality rates by gender were estimated as the weighted average with abundance-at-age as the weighting factor.

The expected and observed CPUE trends obtained from the q-constant and q-variable tunings of the model are shown in figure 11 for females and figure 12 for males.

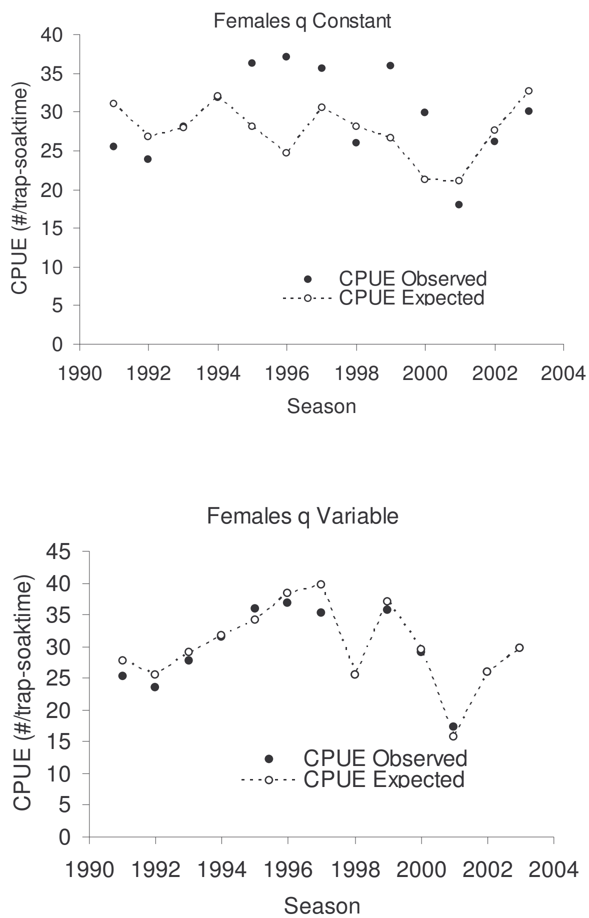


Figure 11. Females observed and expected CPUE resulting from the least squares process with q-constant (Upper Panel) and q-variable (Lower Panel).

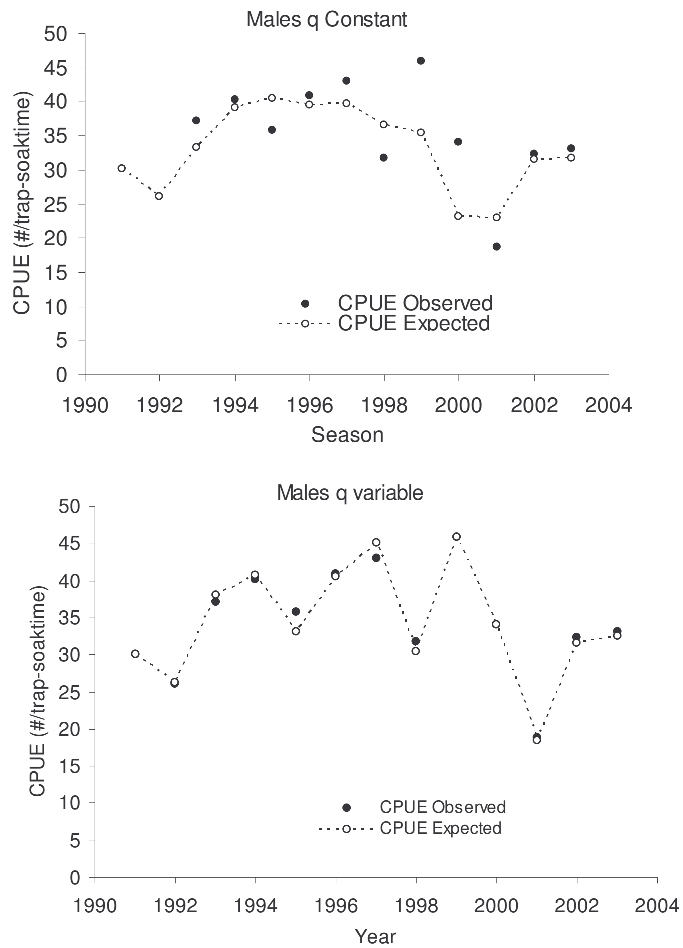
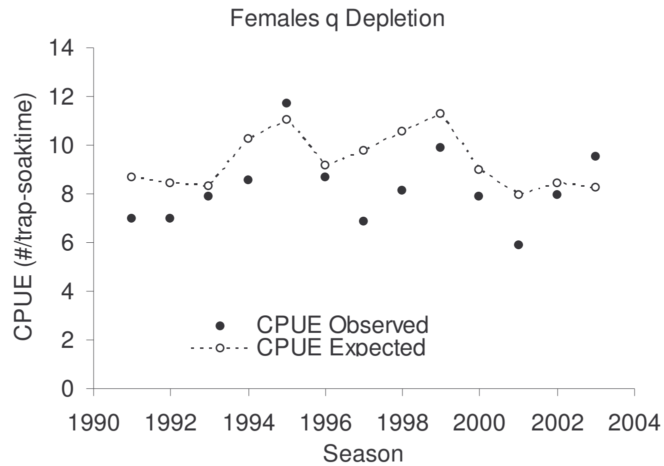
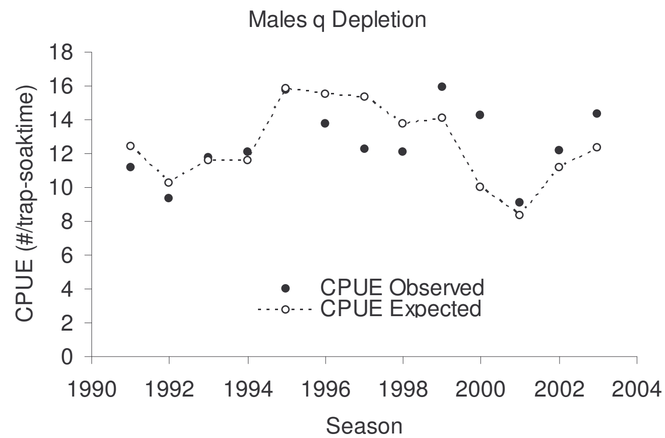


Figure 12. Males observed and expected CPUE resulting from the least squares process with q-constant (Upper Panel) and q-variable (Lower Panel).

Calibrations with the external q-estimates obtained from the depletion model are shown in Figure 13 for females (Upper Panel), males (Middle Panel) and sexes combined (Lower Penel). Combined genders were used to analyze the effect of using q-depletion estimates that were obtained with CPUE data compounded for males and females; therefore, the average expected CPUE estimated from calibrations using the external q-depletion for males and females are compared to the average CPUE observed for sexes combined in the Lower Panel in Figure 13.





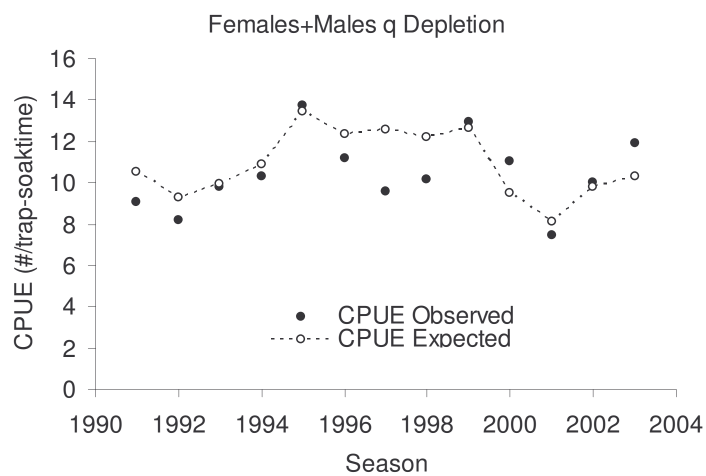


Figure 13. Observed and expected CPUE resulting from the least squares process with q-external for females (Upper Panel), males (Middle Panel), and sexes combined (lower Panel).

The model implementing tuning was carried out with q estimated within the algorithm. This model estimated 59 and 67 parameters for q-constant and q-variable, respectively, and 46 and 54 parameters corresponding when q was input from the depletion model fit. The ANOVA corresponding to each fit are:

Tuning	Sex	Data	Parameters	d.f.	SSQ	Variance
q Constant	Females	152	59	93	0.254	0.00274
q Variable	Females	152	67	85	0.031	0.00037
q Depletion	Females	152	46	106	0.473	0.00477
q Constant	Males	228	59	169	0.308	0.00182
q Variable	Males	228	67	161	0.108	0.00067
q Depletion	Males	228	54	174	0.278	0.00160

Generally the tuning process is adequate. However, the higher SSQ found in the case of females tuned with q depletion (Fig. 13 Upper Panel) relative to the males (Fig.13, Middle Panel) should be indicative of the differences that might exist between the CPUE signals found in catch-at-age matrices by gender as used in the SPA. This conclusion is drawn from the fact that the average expected and observed CPUE values for sexes combined (Fig. 13, Lower Panel) shows a much improved fit. As expected, the best tuned cases correspond to the q-variable tuning- given that each fishing season has an independent estimate of q contributing directly to the expected CPUE for the season. The cases for q-constant over periods when it was known that q was either stable or in a transitional mode (due to the trap reduction program) show an intermediate value for the SSQ among females and the highest value for the case among males.

The truncated nature of the cohorts that are available in the upper right-hand corner of the catch-at-age matrix limits the amount of information that is useable in the SPA fit of those cohorts. Consequently, the SPA estimates abundance and fishing mortality of the younger ages in the most recent seasons with higher uncertainty. This depends to a great extent on the quality of the data series available for tuning. In this regard, depletion models are equally robust throughout the fishing seasons and q estimated from these models should provide important information to the SPA tuning process.

The results of the different SPA model tuning configurations were further analyzed relative to the recruitment index for ages and sexes combined obtained from the depletion model (Fig. 10). The comparisons were for sex combined recruitment at age 1 estimated by the SPA algorithm. A one-year time delay was used in the comparisons given the compounded age and time nature of the depletion model estimates (Fig. 13).

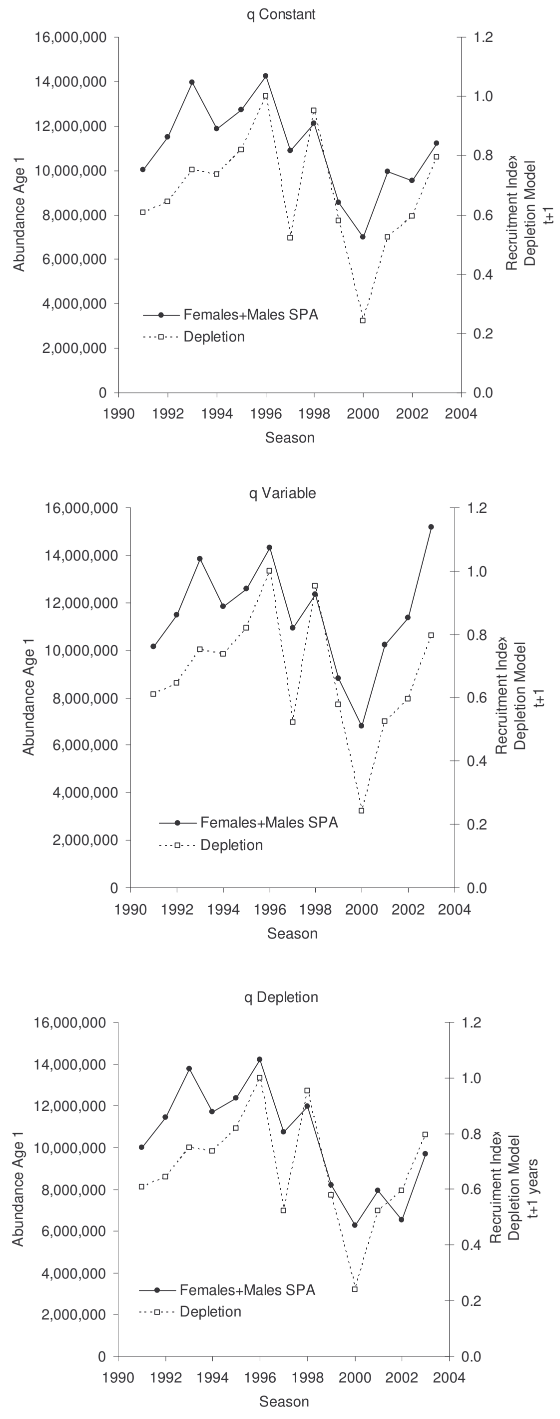


Figure 14. Recruitment age 1 (SPA males+females) for 3 tuning conditions and recruitment index estimated from the seasonal depletion model.

The trends in Fig.14 show that the SPA algorithm and the depletion model generate recruitment abundance estimates with approximately similar signals. As usual, large recruitment fluctuations are observed during the period of analysis. However, higher recruitment levels are estimated for the period 1992 to 1998. Decreased recruitment persists for 3 to 5 years thereafter. The estimates for this later period appear to depend on the tuning approach used, generating a more optimistic trend for the q-variable tuning case than those estimated with q-constant and q-depletion. It is worth noting that the significant recruitment recovery trend observed in 2003 with q-variable (Fig. 14) is still congruent with the sustained lower level in total landings observed 2 to 3 years later from 2003 to 2005 (Fig. 15) when these recruits reach apical exploitation ages. The use of the q-variable recruitment estimates to forecast landings in the following season resulted in high correlation of 0.85 (Fig. 16), a finding that agrees with Powers and Banerott's (1983) conclusion that landings in the Florida fishery mostly reflect changes in recruitment.

Review of the exploitation patterns estimated by each tuning process (Table 1) shows that age 2 in males is of relative importance but age 3 is more predominant; while among females, ages 2 to 4 contribute significantly to the landings. Consequently, recruitment abundance signals at age 1 in both males and females may be carried forward to the landings for 2 to 4 years. This supports the fact that the observed reduced landings in the Florida fishery during 2001-2005 time frame should be the consequence of the lower gender-combined 1999-2003 recruitment abundance estimated by SPA.

Table 1. Exploitation patterns for males and females *P. argus* according to tuning process.

Males	Tuning			Females	Tuning		
Age	q constant	q variable	q depletion	Age	q constant	q variable	q depletion
1	0.01	0.02	0.01	1	0.05	0.05	0.05
2	0.54	0.62	0.56	2	0.92	0.90	0.89
3	1.00	1.00	1.00	3	1.00	1.00	1.00
4	0.21	0.17	0.20	4	0.88	0.91	0.95
5	0.32	0.26	0.29	5	0.37	0.38	0.41
6	0.11	0.09	0.10	6	0.32	0.31	0.31
7	0.12	0.11	0.11	7	0.38	0.33	0.33
8	0.11	0.11	0.11	8	0.35	0.32	0.32
9	0.25	0.27	0.25				
10	0.16	0.16	0.15				
11	0.18	0.20	0.18				

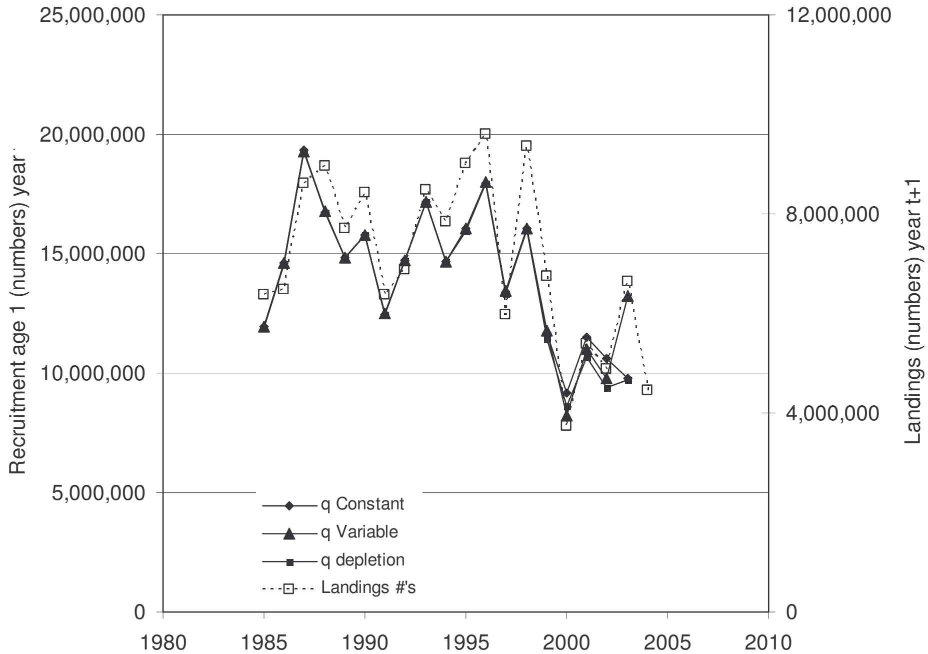


Figure 15. One-year delayed recruitment at age 1 trends using three different tuning procedures and landings. Units are number of individuals.

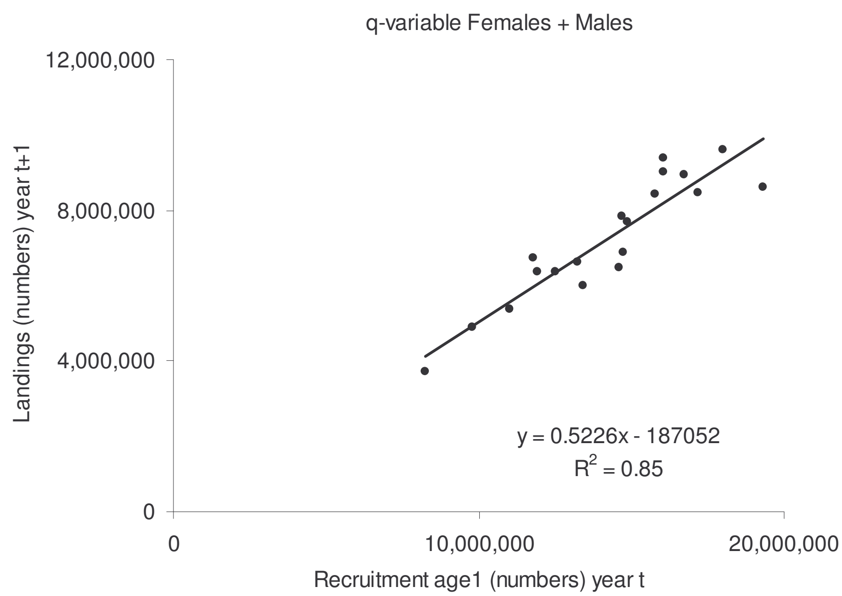


Figure 16. Landings in numbers in year t on recruitment at age 1 estimated by the q-variable tuning procedure.

On average, 50% of the female Caribbean spiny lobster, *P. argus*, are mature when carapace length reaches 90.3 mm (FAO 2001). In Florida, 50% of the females are mature between 86 and 95 mm CL (average 90.4 mm CL)(Davis, 1975; Pike, 1993). According to the segmented size-age trends obtained by Ehrhardt (2007b), females of age 3 should be 83.7-93.7 mm CL. Therefore, in the analysis presented here mature stock was defined as that comprised by individuals of age 3 and above. The SPA-estimated mature male+female abundance by the three tuning procedures is presented in Fig. 17. The trends are very similar and only the q-constant estimates deviates somewhat above the other two estimates in the 2002 and 2003 fishing seasons. Generally, the trends show a mature stock that may be in more serious condition than the estimates presented in the SEDAR 08 assessments. Analyses pertaining to puerulus seasonal abundance (Ehrhardt and Fitchett, 2007) also show a significantly decreasing trend in post larval abundance that is conspicuously similar to that of the mature stock estimated by either the q-depletion or q-variable tuning procedures.

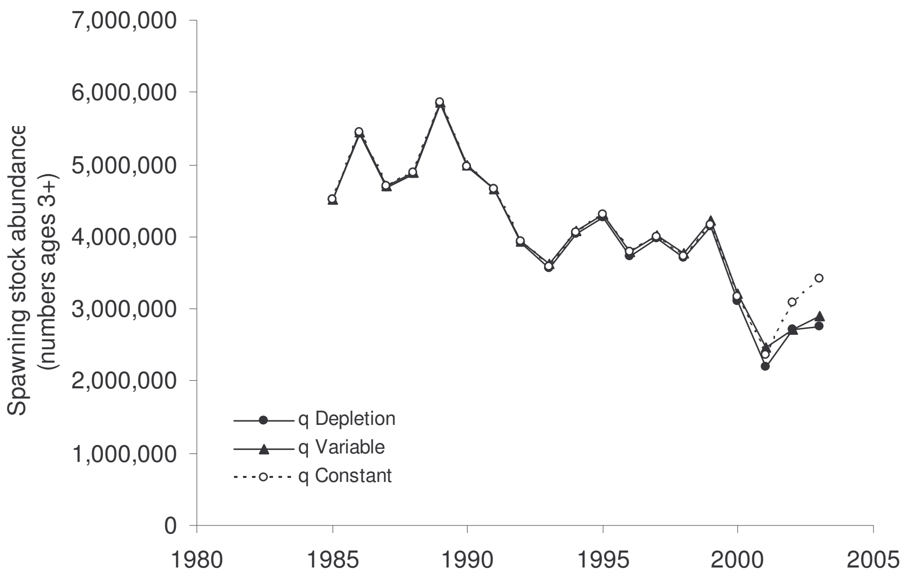


Figure 17. Mature or spawning stock abundance (numbers) estimated by the three tuning procedures.

Weighted average fishing mortality rates for females and males combined and for each of the three tuning procedures are presented in Fig. 18. These mortalities are high throughout the study period and substantially exceeding the level of natural mortality rate except in three occasions, 1987, 1998, and 2001.

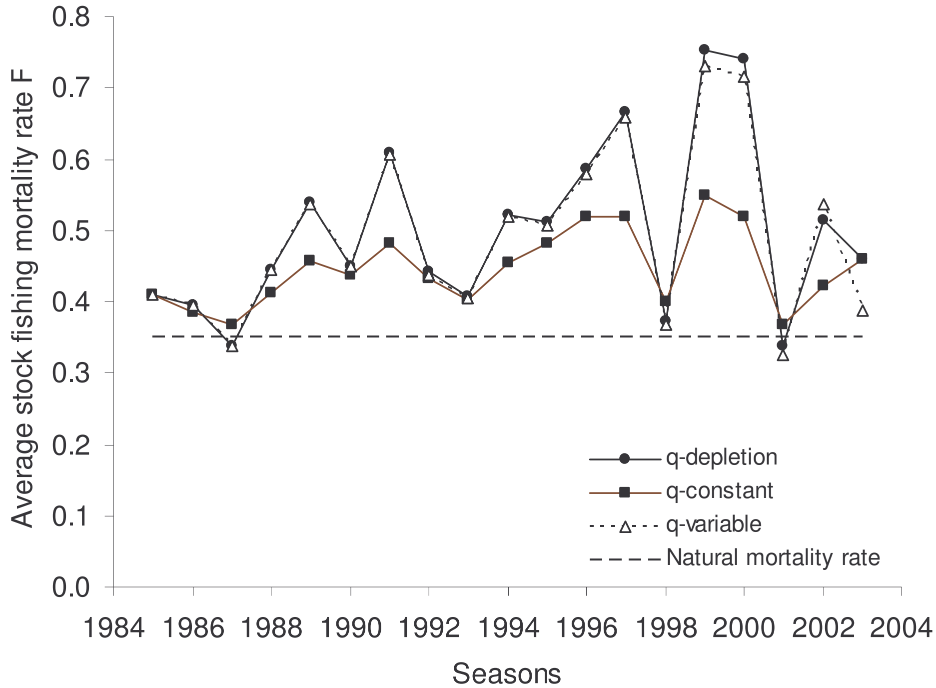


Figure 17. Average fishing mortality rates for sexes combined and for three tuning procedures.

The trends of F-estimates obtained with q-variable and q-depletion are almost identical, which follows the similarity of the abundance estimates obtained by these two procedures. The low F-estimates for the 1998 fishing season may be due to the lost of gear during Hurricane George that passed through the main fishing grounds at the start of the fishing season. Generally, fishing mortality followed an increasing trend until the 2000 fishing season (excepting for 1998), and then dropped sharply to levels much closer to that of the natural mortality rate. This last trend could be a response of the stock to lower landings under lower fishing effort regimes relative to the decrease in abundance. The previous F-trends differ significantly with the more optimistic decreasing trends in fishing mortality found in SEDAR 08 for the same period.

The average apical fishing mortality rate for the period 1995-2003 when the number of traps stabilized in the fishery was 1.46 per season or 4.19 times de level of the natural mortality. If the natural mortality rate is a limit that may frame F closer to maximum sustainable yield (Gulland 1971), then the Florida spiny lobster fishery should be classified as heavily over exploited. The apical fishing mortality affects most significantly ages 2 and 3, which appear to be the two annual classes that sustain most of the exploitation but also these are ages when the full fecundity is still limited. These extraordinary levels of fishing mortality are the consequence of the exploitation concept that fishing efficiency is high by using sub legal size lobsters as attractants and that full utilization (no quota) of the seasonal resource should not impact the resource under the Pan Caribbean principle of the recruitment.

Conclusions

Stock assessment results show that the spiny lobster fishery in Florida is subjected to very high levels of exploitation that may be compromising the future sustainability of the fishery. This conclusion is based on the signs of steady decreasing trends in the abundance of the mature stock, which decreased in about 50% between 1989 and 2003, and the abrupt reduction of recruitment after the 1998 fishing season. Recruitment reduction is critical because recruitment level in one season explains a large fraction (85%) of the landings in the immediately following fishing season. Since the lowest recruitment was in 2000, the result was a much lower landing in the commercial fishery during the 2001 fishing season. Generally, much lower recruitment observed during the 2001-2003 period is reflected in the lower landings in the 2002-2004 in the commercial fishery. Similarly, the steady decline in the landings in the recreational fishery since 1999 may be the consequence of the lower recruitment during the period. It is of concern that the lower landings observed in the 2005 fishing season may be a response of yet another low recruitment year in 2004. At the time when these analyses were carried out no information was available to assess recruitment abundance in the 2004-2006 fishing seasons.

The fishing mortality rates affecting the stock increased significantly since 1985 through 2000, showing a lower value only in 1998, which may be attributed to the destruction of gear by Hurricane George in that year. These mortality rates are considered too high relative to the natural mortality rate adopted for the species. Lower fishing mortality rates in the later years are thought to be a response of lower landings relative to the decreasing levels of abundance. The apical mortality rates affecting ages 2 and 3 in males and females, is about 4.19 times the level of natural mortality adopted in this study. This condition is of the highest concern given the impact that this mortality has on the future spawning stock potential. The overall exploitation of the spiny lobster is further complicated by the use of the juveniles (ages 1 and 2) as attractants in the traps. In the absence of increased up-stream recruitment, control of the mortality of these juvenile lobsters may prove essential for the sustenance of the fishery.

At present, the fishery is a limited entry fishery; however, the prognosis of a severely declining stock abundance may prompt the implementation of annual quotas that could enhance the control on the overall fecundity of the stock. This is particularly important given the findings by Ehrhardt and Fitchett (2007, in this report) who fond out a closely correlated function between the mature spiny lobster stock and the puerulus abundance in South Florida. The adoption of a quota in the spiny lobster fisheries of Florida will undoubtedly bring further economic stress to the fisheries communities (sport and commercial), but this condition is a consequence of the extremely large demand for a reduced product.

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APPENDIX III

Recruitment dynamics of the spiny lobster, *Panulirus argus*, in Florida

By

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31 August 2007

Introduction

Florida spiny lobster commercial landings are significantly correlated (R=0.92) to recruitment abundance in the preceding fishing season (Ehrhardt 2007b; in this report) and fluctuations of annual landings have long been identified with recruitment variability (Powers and Banerott, 1984). The Florida fishery experienced a large decrease in landings in the early 2000's that persists until today. Such change occurred in spite of the various and stiff conservation measures that the State of Florida had previously implemented to secure long range sustainability of the fishery (e.g. 50% trap reduction; minimum size and closed season regulations; gear restrictions, etc.). Significant variability of recruitment abundance is common among spiny lobsters and a few studies demonstrate the link between larval and post larval abundance with environmental variables (Pearce and Phillips 1988; Pringle 1986; Phillips and McWilliam 1989; Polovina and Mitchum 1992). These variables affect survival and advection of the early life stages in many (yet unknown) ways. A limited number of correlative studies have succeeded in forecasting landings using one or more environmental variables and larval abundance indices (Phillips et al. 1994; Cruz et al. 1993, 1995).

The long *P. argus* larval span (Lyons 1980) evolves while passively migrating through one or more localized ecosystems in the wider Caribbean Sea, which is characterized by strong and persistent ocean currents. Therefore, varying spiny lobster extraterritorial recruitment rates to downstream regions (colonization) may impact spiny lobster fishery production in varying but uncertain manners. Therefore, it appears that simple local single-species conceptual management frameworks should not be sufficient to properly manage this resource and the Pan Caribbean concept of larval replenishment has influenced the spiny lobster exploitation and management schemes adopted in Florida. Not surprisingly, the existing theoretical and empirical fishery management models do not provide a comprehensive framework to evaluate the long-term impacts of these complex regionally-interlinked population dynamic effects on the Florida landings. The analyses presented here provide an assessment of the post larval (pueruli) abundance and elucidates some of the links that may exist between local parent stock, post larval abundance, and future stock recruitment while considering changes in oceanographic conditions.

The species, ecosystem, and fishery

The *P. argus* fishery is an economically important component of the commercial and sport fishing industries in southwest Florida. Management issues such as overfishing, excessive gear deployed (overcapitalization), and significant interactions and competition for finite resources among users characterize the spiny lobster fishery in the ecologically sensitive Florida Keys. Efforts to address management issues in this fishery have historically been approached on a single-species basis, with management strategies traditionally used in open-access fisheries. The need to consider restricted access management measures is reflected in the Florida spiny lobster trap reduction program established in 1992. This program was implemented based on the principle that catch per trap (CPUE) should increase if fewer traps were used because landings until then varied with no trend. An unintended effect of the program was the re-direction of non-regulated spiny lobster fishing effort to other fisheries and a sensible emigration of participants in the spiny lobster fishery that resulted in an accumulation of *P. argus* fishing rights among fewer fishers (Shivlani et al. 2004). In spite of the increased trap fishing efficiency resulting from the trap reduction program (Ehrhardt and Deleveaux, 2004), the economic outcome deteriorated significantly as landings in the Florida spiny lobster trap fishery decreased by over 57% in the 2001 through 2005 fishing seasons. The causes of such large decrease appears to be the result of significant abundance declines in the mature stock in Florida (Ehrhardt 2007b, in this report) and elsewhere in the Caribbean Sea (Food and Agriculture Organization of the United Nations -FAO- Third Workshop on the Management of Caribbean Spiny Lobster in the Western Central Atlantic Region. Mérida, Yucatán, México September 2006).

The Caribbean spiny lobster possesses larvae that may remain in the ocean currents for extended periods of time (i.e. 6 to 12 months) (Lewis, 1951; Lyons, 1980) before settling in a suitable juvenile habitat. The likelihood that spiny lobster stocks may originate from a single gene pool in the Caribbean Sea was postulated by Menzies and Kerrigan (1980) and Lyons (1981) while Caribbean-wide genetic studies provide more conclusive evidences that may sustain the above statement (Silberman, et al. 1994.a,b). Furthermore, there are significant common signals on the trends and variances associated with spiny lobster landings among such distant places as Brazil, Nicaragua-Honduras, Cuba and Florida (Ehrhardt, 2005). This fact shows the relative importance of potential regional linkages in spiny lobster population dynamics on local productivity. Thus, regional genetic mixing and similitude in stock productions appear unquestionable regarding the local Florida fishery dynamics.

The general oceanography in the Florida Keys region is dominated by the extent and intensity of the Gulf Stream (Fig. 1) and the mechanisms of larval retention in this area may be explained by the various temporal and spatial formation of spin-off eddies (Yeung and McGowan 1991; Limouzy-Paris et al. 1997; Yeung, et al. 2001). The Caribbean Current plays a major role in the seasonal displacement of the Loop Current in the Gulf of Mexico and the subsequent dynamics of the Gulf Stream off the Florida Keys. These regional ocean circulation systems play a major role in distributing the *P. argus* larval stages. Simulations by Dr. Donald Olson (Ehrhardt and Olson, 2004) show the high likelihood that these oceanographic regimes are responsible for the potential upstream contributions of spiny lobster larva in Florida (Fig. 2).

The Caribbean spiny lobster utilizes the various environments in ways that appear to influence its reproductive dynamics. For example, spawning throughout the Caribbean region occurs year around with peaks between March and July and also in September to October while in Florida a single peak is observed between the months of April and August (Arce and Leon 2001). On the other hand, puerulus settlement reported by Cruz et. al. 2001 shows increased settlement intensity during May and another peak in October that can last until December in some years. In Florida, however, the largest peak of post larval recruitment is reported during February and March with a minimum in August. In figure 3 we show the average seasonal pattern of mean sea level in Florida Bay, which may be a fundamental physical driving variable responsible for the chronological events that regulate spawning and recruitment of *P. argus* in Florida. In the figure there is period of significant increase in mean sea level during September-November and a regime of lower mean sea level during December-August. The spawning activity appears to center

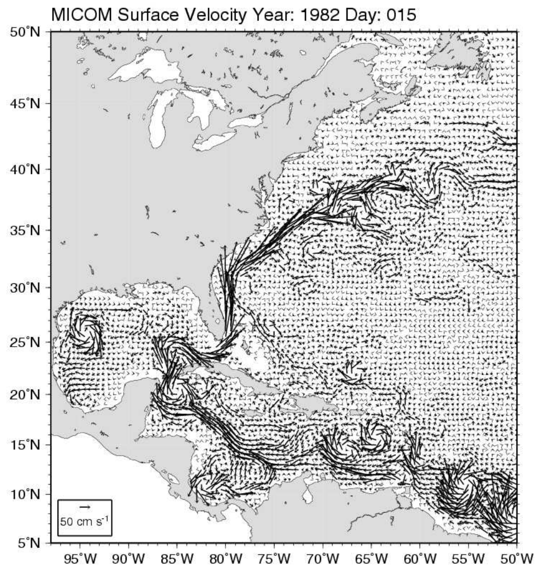

Figure 1. Daily velocity fields from the MICOM expressing water masses circulation in the Western Central Atlantic Ocean (Olson personal communication).

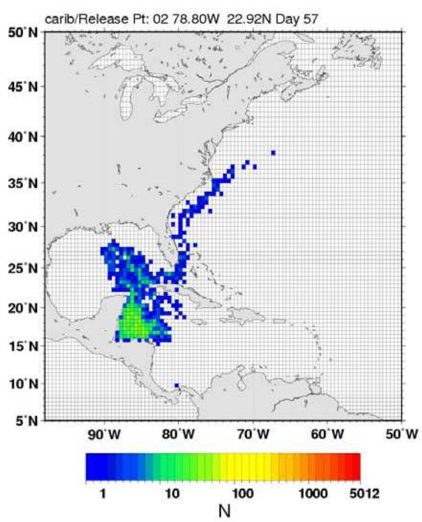

Figure 2. Simulation of 5-year total particle density simulation runs from the Nicaragua shelf.

between April-August with a peak in May-June. Figure 3 provides a frame that defines the seasonality of the reproductive cycle based on the consideration that larval retention should be optimized by avoiding the potential for larger advection during the months of higher mean sea level. All these environmental and ecosystem aspects have not been incorporated in the analyses of the present day spiny lobster landings crisis in Florida.

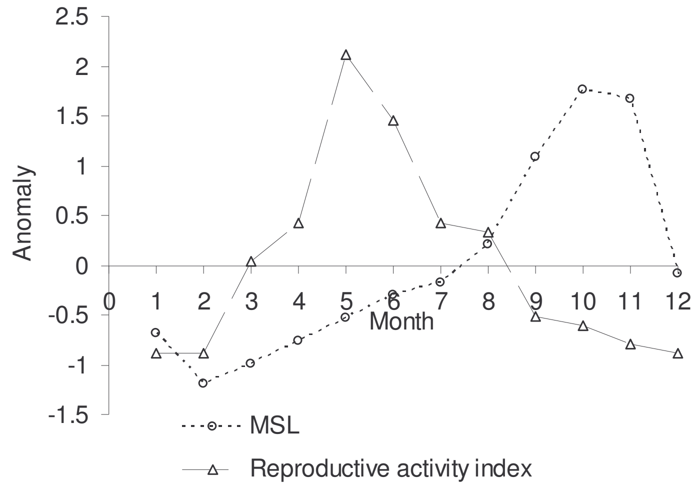

Figure 3. Seasonal average mean sea level (MSL) in the Florida Keys and the average *P. argus* seasonal reproductive (spawning) activity.

Data and analysis

Puerulus data

To achieve an annual index of abundance for puerulus in the Florida Keys, catch and sampling effort data of puerulus collectors were obtained from the Florida Fish and Wildlife Conservation Commission (We are grateful for these data provided by Thomas Matthews). Puerulus collectors were stationed in the Lower Florida Keys in several locations, including Long Key and Big Pine Key. These collectors are comprised of a suspended frame (with the dimensions 48' x 48') with filamentous fibers in two layers to collect puerulus moving through the area. The collectors are suspended below the surface in the water column by a series of floats. Data collectors from Big Pine Key were exclusively used in these analyses because the collectors were suspended in between sections of the Seven Mile Bridge, one of the largest entrances into Florida Bay from the Atlantic Ocean. In addition, data from Big Pine Key was the most comprehensive from 1988 to 2007.

In this study, CPUE indices for pueruli are analyzed with "sampling effort" being defined as a puerulus collector soaked for an entire day. Each puerulus collector is analyzed as a separate observation for CPUE standardization analyses. Collectors were employed with varying soak times, with an average of 29 days soaking time from 1993 until 2006. However, data prior to 1993 varied greatly in soaking periods (Fig. 3) due to changes in soaking time sampling strategies. Therefore, the observations for the period 1988-1993 were converged into time periods averaging 29 days to be comparable with average soak time from 1993 to 2006.

Several environmental variables were examined and tested against CPUE of puerulus entering Florida Bay via Seven Mile Bridge. One of the most important environmental indices showing a strong relationship (seasonally) with puerulus CPUE is mean sea level. Mean sea level (MSL) is the direct result of atmospheric pressure change and resulting winds and is often used as a proxy for wind-driven upwelling in coastal regions. Given the shallow bathymetry of Florida Bay, low mean sea level could be indicative of an extremely confined nektonic habitat. Mean sea level data was collected on an hourly basis from 1988 to 2007 by the National Buoy Data Center (www.nbdc.noaa.gov). This data was used in the analysis of puerulus CPUE data standardization procedures as explanatory variables that contribute to variance in catch rates.

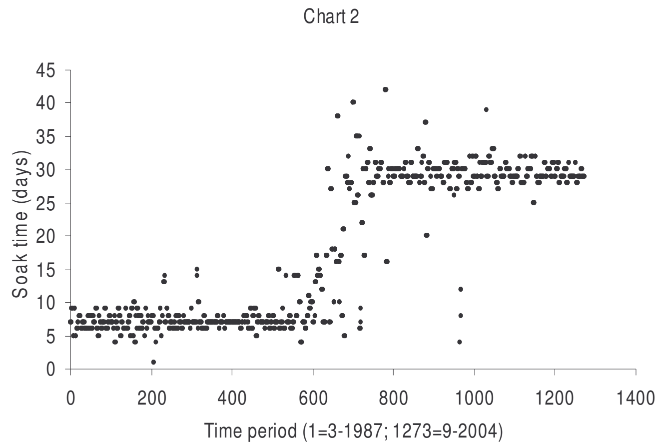

Figure 3. Historic sampling soak time effort used to check puerulus collectors and retrieve number of post larva collected.

Generalized Linear Models (GLMs) are commonly used methods of standardizing CPUE for exploited fish stocks to develop a relative index of abundance (Maunder and Punt, 2004). GLMs are based upon the principle that a response variable (CPUE, $\overline{\mu}$) is dependent on a set of explanatory variables (x_k), which are of interest to explain process oriented reasoning. The model is generally expressed as:

$$\overline{\mu}(\log_{\lambda} CPUE) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + ... + \beta_k x_k + \varepsilon$$

with β_0 representing the overall mean (intercept) for a given the time period, i, in which $\overline{\mu}$ is defined. Each β_i represents the intercept at which an explanatory variable, x_i, linearly contributes to the model. GLMs depend on the distribution of catch rates (CPUE) and how some linear combination of a set of explanatory variables (x_i) aide in predicting the expected value of CPUE by reducing extraneous sources of variance. In this study, we use log-transformed catch rates which follow a normal distribution.

The removal of variance due to explanatory variables and their interactions with one another allow the response variable to be considered as more statistically robust index than of the observed puerulus CPUE. However, explanatory variables and their linkages to the response variable must be clearly understood by an investigator. In this study, we use year and season as class explanatory variables and we use mean sea level

(MSL) as a continuous explanatory variable. Seasons take the role of temperature regime changes while a priori examinations of puerulus catch rates and mean sea level rendered a negative relationship between these two variables throughout the time series. Mean sea level patterns also exhibited inter-annual variation. In this study, we use the GLM procedure to determine an annual index of abundance for puerulus in the Florida Keys with the following model:

$$\overline{\mu}(\log CPUE)_{YEAR} = \beta_0 + \beta_i \chi_{YEAR} + \beta_j \chi_{SEASON} + \beta_{i,j} \chi_{MSL} + \varepsilon$$

with i = year, j = season, and β_i, β_j, and βij parameters to be estimated by ANOVA. The model and corresponding factors are then tested by analysis of variance (ANOVA) for significance.

Fishery data

Spiny lobster abundance at age was estimated for the spawning stock comprised of males and females ages 3+ and for the recruitment of males and females at age 1. This was accomplished through a tuned age-structured stock assessment algorithm (Ehrhardt 2007b; in this report). The assessments were carried out using catch-at-age matrices constructed from total (all gear) catch-at-size matrices made available to the project by the Florida Fish and Wildlife Conservation Commission (We are grateful for these data provided by Robert Muller, John Hunt, and Rick Weaver), and transformed to age compositions through slicing size data from size frequency data into age using a new segmented growth equation developed by Ehrhardt (2007a; in this report). The conceptual algorithm minimizes a specific objective function given initial mortality rates at age for the last year in the data sets and for the oldest age classes in every year.

Results and discussion

Through ANOVA, we found that each single explanatory factor in the selected GLM model significantly reduce the sum of squares or extraneous variance (Table 1). $\beta_i \chi_{YEAR}$, the annual effect on CPUE, naturally contributes a significant source of variance for puerulus abundance. However, the partitioning of seasonal $\beta_j \chi_{SEASON}$ and MSL $\beta_{i,j} \chi_{MSL}$ effects contribute to the most significant reduction of Sum of Squares in the ANOVA procedures. The annual index calculated from GLM procedures share a similar trend with nominal annual CPUE of puerulus (Figure 4). Much of the variation in nominal catch rates can be attributed to mean sea level (MSL) followed by the seasonal effect that should mostly represent temperature effects. The resulting annual index for each year can be representative for abundance of spiny lobster pueruli entering the Lower Florida Keys each year.

Table 1. ANOVA Table of GLM for Puerulus Annual Indices, 1988-2006.

	df	Sum Squares	Mean Squares	F value	Pr > F
YEAR	18	79.380	4.410	8.53	<.0001
SEASON	3	76.081	25.360	49.06	<.0001
MSL	1	32.656	32.656	63.17	<.0001

From the inception of puerulus collection in 1988 to 2006, the annual index of pueruli influx into the Lower Florida Keys decreased by 36%. The years with the highest puerulus indices were 1990 and 2004 and lowest in 1997 and 2004. The period 2000-2006 shows a relatively stabilized puerulus abundance relative to the previous seasons, but such stabilization also appears to occur at a much lower level of abundance.

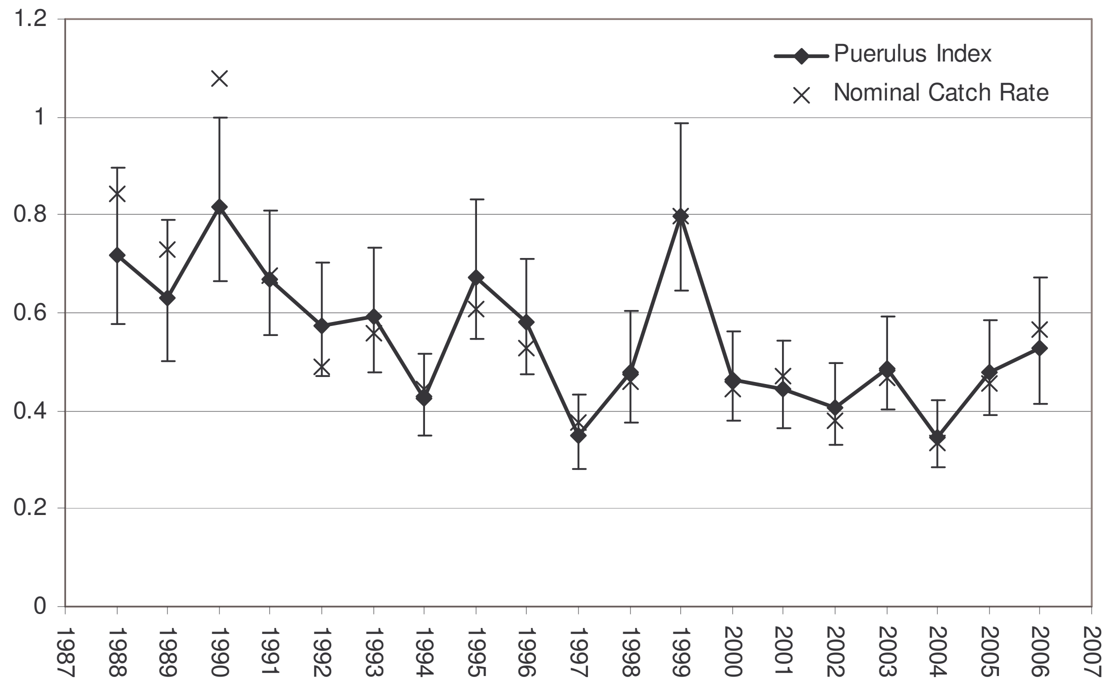

Figure 4. Annual indices of puerulus entrance into the Lower Florida Keys versus nominal CPUE of puerulus in collectors, 1988 to 2006. Error bars represent 95% confidence intervals.

The reproductive activity index anomaly shown in figure 3 is compared in figure 5 with the anomaly of the average 1988-2006 puerulus monthly CPUE estimated from the GLM. The peak of the reproductive activity happens on average one ahead in the time scale with the implication that the trend in post larval recruitment should occur 11 months after the reproductive activity trend for these two trends to match biologically. Furthermore, it was found that the 11-month delayed unimodal trends in reproductive activity and post larval CPUE are highly correlated (R=0.84)(Fig. 6) providing a credible time link to the growth and recruitment schedule of *P. argus* in Florida. Data from Cuba (Arce and Leon, 2001) show that the transition from the two peaks in spawning activity to the corresponding peaks in post larval settlement takes between 7 and 9 months. These time scales are approximately similar to the case in Florida given the difference between bimodal and unimodal behavior of the reproductive cycles observed in these two distinct regions.

Analysis of the source of puerulus was attempted by correlating the female spawning stock (ages 3+) abundance (Ehrhardt 2007b; in this report) and the resulting puerulus index shown in figure 4. As a result two remarkable data series showing similar trends and variances are observed in figure 7. In fact, the correlation between these two variables is 0.76 (Fig. 8).

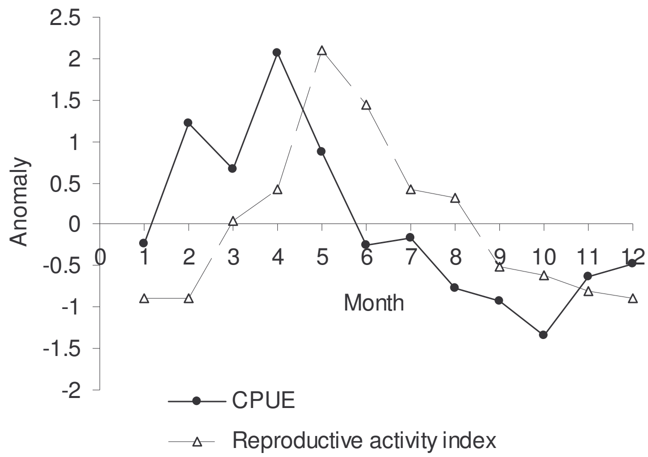

Figure 5. Reproductive activity anomaly of *P. argus* in Florida and 1988-2006 average monthly anomaly of the puerulus abundance estimates from GLM.

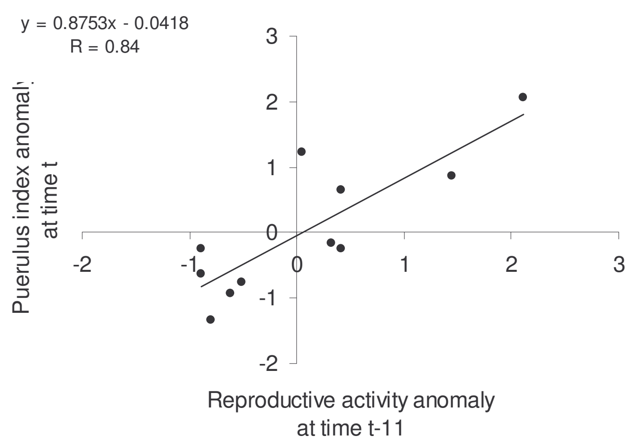

Figure 6. Anomalies of the reproductive activity versus post larval abundance of *P. argus* in Florida.

The female spawning abundance used in the above figures is the one resulting from internally tuning the stock assessment algorithm with q-variable for each fishing season. This data set is the result of the best tuning and also of significant similitude with other recruitment indices used in an ad hoc procedure to corroborate the estimated abundances. The spawning abundance refers to the start of the season (i.e. August 1) while the puerulus index refers to the resulting abundance during the fishing season. That is, the puerulus index is estimated according to nominal data selected for each fishing season. Therefore, these two trends are in fact 12 months out of phase when it was previously determined that post larval settlement appears to occur 11 months after the reproductive activity. However, these differences are regarded as nil compared with the significance of the trends and their correlations observed in figures 7 and 8.

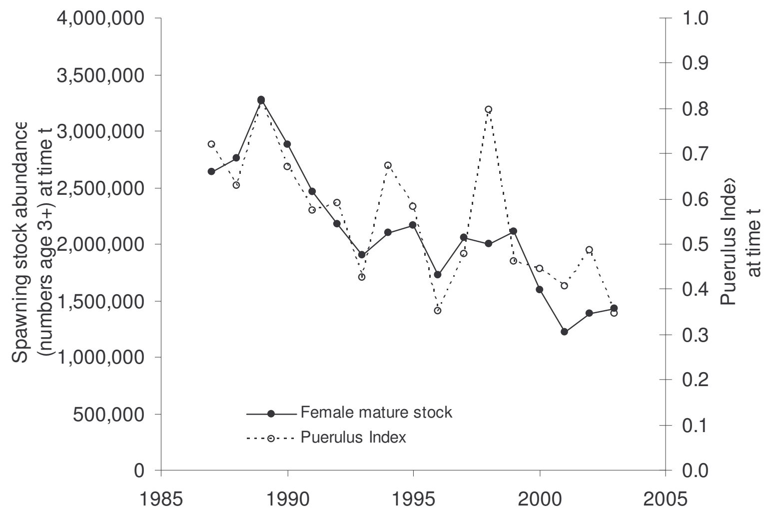

Figure 7. Trends of estimated female spawning abundance and puerulus index.

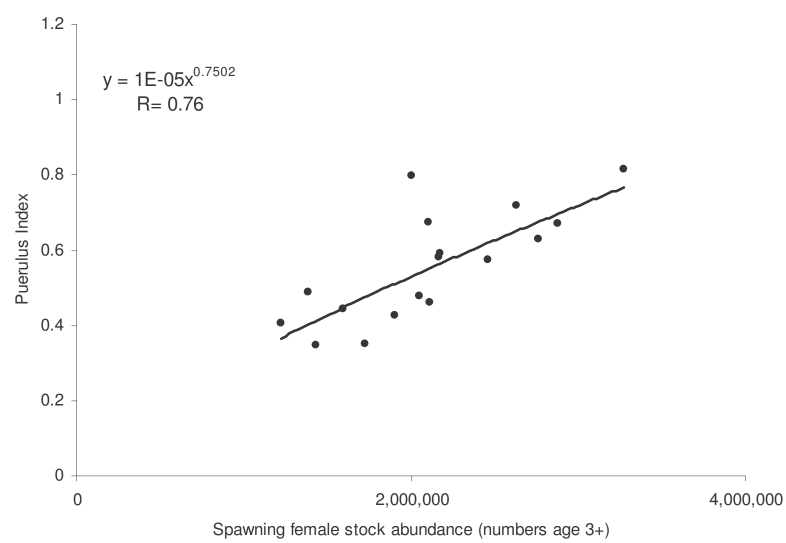

Figure 8. Regression of the puerulus index estimates on female spawning stock estimates corresponding to the same post larval generation.

One aspect that is of immediate concern is the significant decrease in spawning abundance found in Ehrhardt (2007b; in this report) that appears to justify the significant decrease in the post larval supply. This is the first ever indication that the local Florida spawning stock is important to the replenishment of the post larval supply and that the Pan Caribbean may be of only relative importance to overall recruitment. Such upstream recruitment contributions may be represented in the above data by significant random departures from the puerulus abundance trend in some years, for example in 1994, 1996, 1998, 2001, and 2002.

Consideration of the effect of exploited age (and size) structure on overall stock fecundity was accomplished by integrating a fecundity at size function (Cox and Bertelsen 1997) in conjunction with the segmented growth function developed by Ehrhardt (2007a; in this report) to estimate stock fecundity in number of eggs spawned. The results are shown in figure 9 where a high correlation of 0.73 was found indicating that local eggs production is correlated to post larval recruitment.

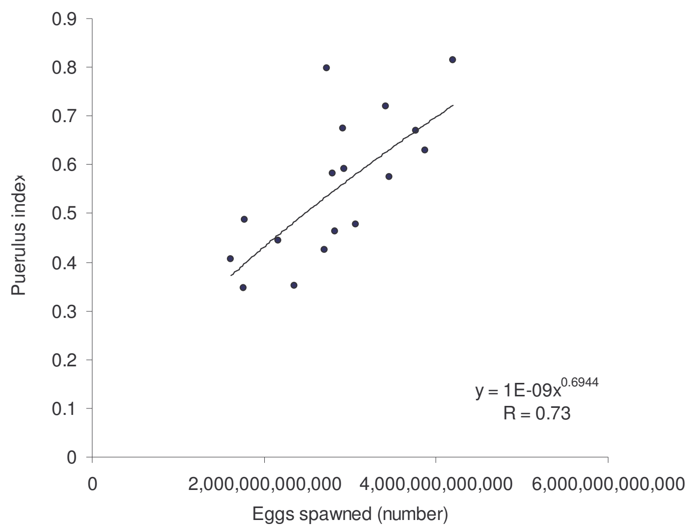

Figure 9. Stock fecundity (number of eggs) and post larval (puerulus) index.

Recruitment of age 1 spiny lobster does not show a strong correlation with the post larval (puerulus) abundance index (Fig 10). However, a more detailed analysis of these data shows that the recruitment in the last four years in the database are lower for similar levels of post larval abundance relative to previous years.

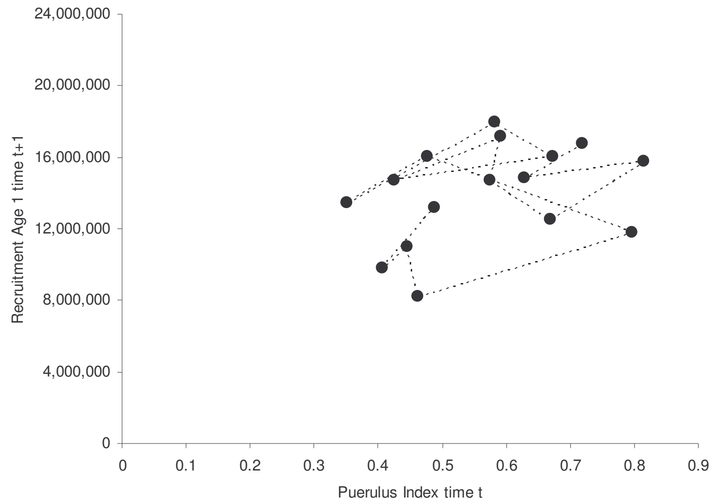

Figure 10. Recruitment at age in season t relative to puerulus abundance index in season t.

The points in figure 10 corresponding with the period 1988-1999 appear to follow a density dependent trend as if a larval-to-recruit function might exist. Then a change in the mortality risks appear to have affected the point in the period 2000-2003 that for the same range of post larval abundance show a lower recruitment. Similarly, in figure 11 a recruitment-to-spawner relationship may be depicted with the consideration that recruitment during 1999-2002 shows less abundance than the existing trend in previous years. This condition prompted a search for possible effects that may have driven the recruitment success down.

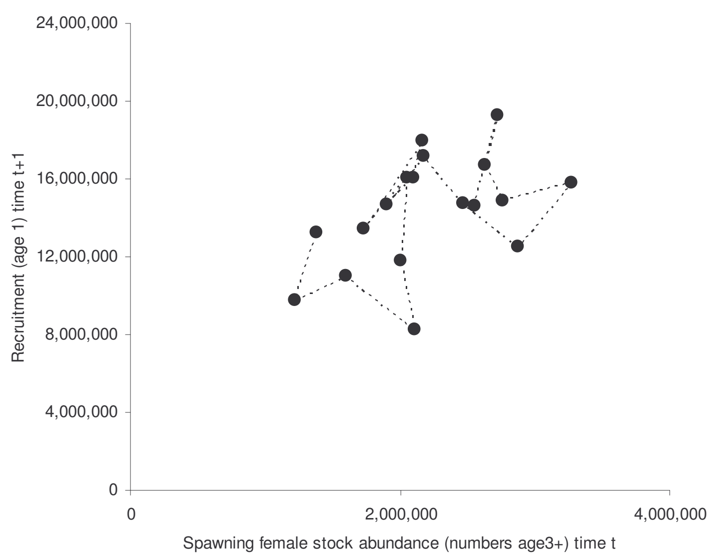

Figure 11. Recruitment at age 1 in time t+1 and spawning stock abundance in time t (all units are number of individuals)

A direct ratio of recruitment at age 1 to the puerulus abundance index was estimated and plotted against spawner female stock abundance 1-year delayed (Fig. 12). In this figure we separated the data into two periods, 1988-1998 and 1999-2002, corresponding to the periods that appear to have an extraneous source of variance not identified in figures 10 and 11. The results shown in figure 12 are indicative of the likelihood of two density dependent regimes that significantly affects recruitment success from post larva to recruitment at age 1. Such situation could only be explained if in fact a regime shift occurred in the ecosystem affecting the post larval recruitment.

The single most important event that could be identified at this time is the significant increase in mean sea level observed in the Caribbean Sea and also in the Gulf of Mexico during the period 1998-2001 (Fig. 13). When the puerulus abundance index is plotted against the Caribbean Mean Sea Level (Fig. 14), there appears to be a positive correlation among these variables, although we observe the likelihood of an increasing trend regarding the Caribbean MSL. The consequences of these physical variants on the survivorship of the puerulus to recruitment at age 1 need to be further investigated- given that these factors appear to fundamentally regulate the important process of recruitment success in the spiny lobster in Florida.

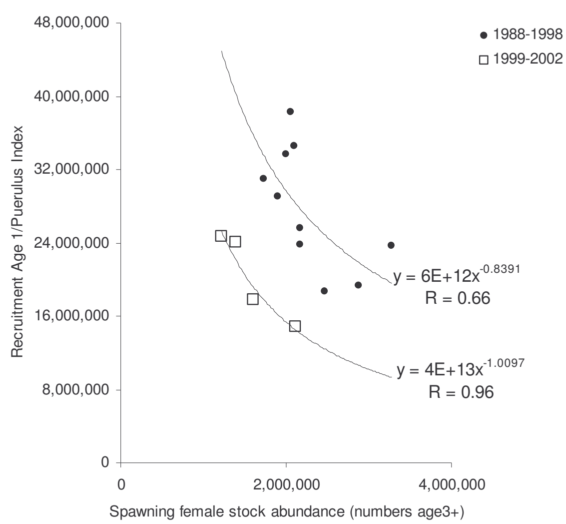

Figure 12. Recruitment success measured as the ratio of recruitment at age 1 and post larval abundance index on spawning stock delayed 1 year.

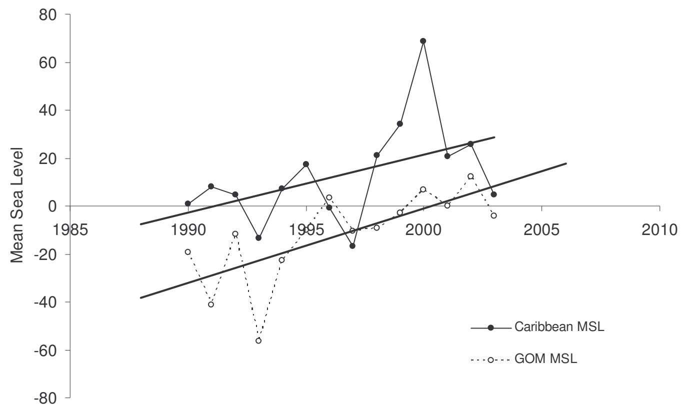

Figure 13. Trends in Mean Sea Level in the Caribbean Sea and in the Gulf of Mexico.

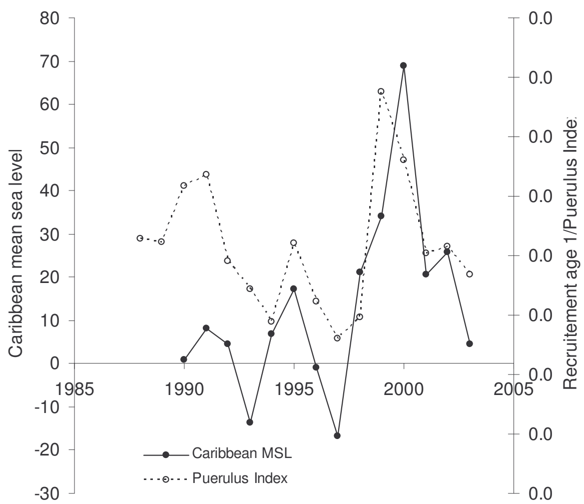

Figure 14. Recruitment/Puerulus ratio and Caribbean Mean Sea Level.

Conclusions

This study contributes several significant results to the understanding of the recruitment dynamics of *P. argus* in the Florida region. First and foremost, it shows that the Pan Caribbean hypothesis that has dominated the spiny lobster management paradigm may be erroneous and that a significant recruitment driving variable is the local spawning stock. In second term, the decreasing spawning stock abundance estimated by Ehrhardt (2007b; in this report) mirrors the decreasing trend in puerulus abundance. This may mean that the results, in spite of using extremely different databases and methods, converge into a major conclusion and that is that the *P. argus* stock is in much more serious condition that previously estimated in the SEDAR 8 process.

The results also explain the reasons for the lower landings observed in the fishery after the 2000 fishing season. This is due to a significant depletion of the parent stock that has resulted in reduced recruitment as well as a reduced recruitment success that may be framed in physical, yet unknown, processes associated with higher mean sea level in the Caribbean region. The coincidence in the variance of recruitment success and Caribbean MSL should prompt new research that may lead to the discovery of the Florida recruitment variability that ultimately forecasts landings.

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