Southeast Data, Assessment, and Review

An Excerpt from SEDAR Procedural Workshop 6

South Atlantic Shrimp Data Evaluation

July 22-24, 2014

SEDAR
4055 Faber Place Drive, Suite 201
North Charleston, SC 29405

Executive Summary

SEDAR Procedural Workshops provide an opportunity for focused discussion and deliberation on topics that arise in multiple assessments and are structured to develop best practices for addressing common issues across assessments. The sixth procedural workshop provided a review and evaluation of shrimp data in the South Atlantic. The impetus for the workshop began when Rick Hart presented the 2011 Gulf of Mexico pink shrimp stock assessment to the SAFMC SSC at their October 2012 meeting. The SSC recommended proceeding with an exploratory phase to assess the applicability of the assessment in the South Atlantic. The first step was to determine what shrimp data were available in this region.

SEDAR convened the procedural workshop from July 22-24, 2014 in North Charleston, SC. The main objective of the workshop was to explore available South Atlantic shrimp datasets for potential use in future shrimp stock assessments and to estimate commercial shrimp bycatch for use in finfish assessments. Participants included representatives from state and federal agencies, ASMFC, SAFMC SSC members, and SAFMC/SEDAR staff. Prior to the workshop, panelists compiled inventories of the available shrimp and environmental datasets in the South Atlantic and Gulf of Mexico.

The workshop began Tuesday morning with state agency representatives giving an overview of the shrimp monitoring and management programs in each South Atlantic state. Presentations were given by Trish Murphey and Kevin Brown (North Carolina Division of Marine Fisheries), David Whitaker (South Carolina Department of Natural Resources), Pat Geer (Georgia Department of Natural Resources), and Ryan Gandy and Steve Brown (Florida Fish and Wildlife Conservation Commission). Next, Kate Michie gave a presentation on federal shrimp management in the South Atlantic and Gulf of Mexico and Elizabeth Scott-Denton gave an overview of the Southeast Fisheries Science Center (SEFSC) Shrimp Observer Program.
Tuesday afternoon began with presentations from Xinsheng Zhang, Jeff Isely, and Katie Drew on recent methods that have been used to estimate shrimp bycatch in finfish assessments in the Atlantic and Gulf of Mexico. The panel then identified possible shrimp bycatch estimation methods and the data requirements for each method. The day concluded with presentations from Rick Hart and Katie Drew on recent assessments conducted on shrimp stocks in the Gulf of Mexico and Gulf of Maine. The panel then discussed potential stock assessment methods and identified the data requirements for each method.

Wednesday morning opened with a plenary session discussion. SEDAR staff used the shrimp and environmental inventories compiled before the workshop to draft a list of the available South Atlantic data sources for each data type identified as a requirement during the discussions Tuesday afternoon. The panel reviewed and edited the list of available data sources for each data type as necessary. For the remainder of Wednesday, the panel was divided into three working groups to: (1) discuss the strengths and weaknesses of the datasets for use in shrimp bycatch

estimation and/or shrimp stock assessment, (2) to identify data gaps and research recommendations, and to (3) identify overall recommendations on the use of the data sources. The Life History/Environmental group was tasked with discussing life history parameters important to stock assessment and their application to shrimp, evaluating the datasets available in the South Atlantic for shrimp age/length and other life history parameters, and discussing the environmental parameters that would be important when evaluating shrimp stocks. The Fishery Statistics group was tasked with evaluating the data sources identified for fishery effort, shrimp catch, kept bycatch/fish, discarded bycatch/fish, and fish age/length. The Index group evaluated the data sources available for Bycatch Catch per Unit Effort (BCPUE) estimates, for quantifying the effect of bycatch reduction devices (BRDs) / turtle excluder devices (TEDs) on BCPUE estimates, and for shrimp indices.

Thursday morning the three working groups reported back to the full panel highlighting the key points and recommendations identified during their discussions. The workshop concluded Thursday afternoon with John Carmichael leading the panel through discussions on best practice recommendations for both shrimp stock assessment and shrimp bycatch estimation methods.

The following document is a shortened version of the full document. The South Atlantic Shrimp Data Evaluation document can be found at http://www.sefsc.noaa.gov/sedar/Sedar_Workshops.jsp?WorkshopNum=0000

2. Workshop Findings

2.4 Strengths and Weaknesses for Available Datasets for Stock Assessment & Shrimp Bycatch Estimation (TOR 4 & 5)

Evaluate strengths and weaknesses of the available datasets for potential use in shrimp stock assessments. Consider both what is feasible given available data as well as additional data necessary to apply preferred approaches.

Evaluate strengths and weaknesses of the available datasets for potential use in shrimp fishery bycatch estimation methods. Consider both what is feasible given available data as well as additional data necessary to apply preferred approaches.

SEDAR staff used the shrimp and environmental inventories compiled before the workshop to draft a list of the available South Atlantic data sources for each data requirement identified for the shrimp stock assessment and bycatch estimation methods. The panel reviewed and edited the list of available data sources for each data type. The finalized lists of South Atlantic data sources for each data type are below. Language in parentheses notes whether the data type was identified as a requirement for bycatch estimation, shrimp assessment, or both.

Fishery Effort (Requirement for bycatch estimation and assessment)

- ACCSP
- State trip tickets
- South Atlantic shrimp electronic logbook (ELB) program
- South Atlantic shrimp system (SAS)
- Vessel operating units (VOU)
- NCDMF license data (number of nets – not on trip ticket data)
- SERO federal permit data
- SCDNR shrimp baiting
- NCDMF bycatch characterization studies

Additional panel comment on 'Fishery Effort':
*Port agents in the South Atlantic (federal and state) are not conducting shrimp fishery interviews.

Shrimp Catch (Requirement for bycatch estimation and assessment)

- ACCSP (includes Accumulated Landings System and General Canvas)
- State trip tickets
- SCDNR shrimp baiting
- South Atlantic shrimp system (SAS)
- Chestnut and Davis (NC historic data)

Kept Bycatch/Fish (Requirement for bycatch estimation)

- ACCSP
- State trip tickets

Discarded Bycatch/Fish (Requirement for bycatch estimation)

- SEFSC observer program
- NCDMF bycatch characterization studies (historic information found in observer program database)
- GADNR bycatch characterization studies (historic information found in observer program database)
- SEAMAP

Additional panel comments on 'Discarded Bycatch':
*Fishery independent datasets can be used as a proxy to help characterize bycatch, but important to discuss gear type/comparability caveats of fishery independent versus dependent trawls.
*Historic data sets, if available, should also be considered here as they can be useful for species that are lumped into larger species groupings to actually get counts or percentages for species.

Fish Age/Length (Requirement for bycatch estimation)

- SEFSC observer program
- NCDMF bycatch characterization studies (historic information found in observer program database)
- GADNR bycatch characterization studies (historic information found in observer program database)
- South Atlantic shrimp electronic logbook program
- Fishery independent data sources: SEAMAP, NCDMF Pamlico Sound Survey, NCDMF Estuarine Trawl, GADNR Ecological Monitoring, SCDNR Crustacean Monitoring
- Gear testing studies; but will be important to discuss gear comparisons

Fish BCPUE (Requirement for bycatch estimation)

- SEFSC observer program
- NCDMF bycatch characterization studies (historic information found in observer program database)
- GADNR bycatch characterization studies (historic information found in observer program database)

Fishery Independent CPUE (Requirement for bycatch estimation)

- SEAMAP
- Other state fishery independent surveys

BRD/TED Type (Requirement for bycatch estimation)

- SEFSC observer program
- NCDMF bycatch characterization studies (historic information found in observer program database)
- GADNR bycatch characterization studies (historic information found in observer program database)
- 2003 Florida shrimper survey
- Gulf and South Atlantic Fisheries Foundation BRD testing (historical)

Additional panel comments on 'BRD/TED Type':
*Need to develop a timeline for state regulations.
*Need to consider different types of BRD/TED positions when compiling information.
*BRD type used can vary regionally and temporally.

BRD/TED Impact (Requirement for bycatch estimation)

- SEFSC TED testing
- SEFSC BRD testing
- SEFSC NC skimmer trawl TED testing
- GADNR bycatch characterization studies
- UGA Marine Extension studies (contact: Lisa Ligouri)
- NCDMF BRD certification
- NCDMF Sea Grant fisheries resource grants (gear component)

Additional panel comment on 'BRD/TED Impact':
*Some gear testing studies identify fish to group level, not necessarily to species.

Shrimp Indices (Requirement for assessment)

- Fishery Independent
    - SEAMAP
    - GADNR ecological trawl survey
    - SCDNR crustacean monitoring survey
    - FL FWCC Fishery Independent Monitoring (FIM) survey
    - NCDMF estuarine trawl survey
    - NCDMF Pamlico Sound survey
    - NCDMF juvenile shrimp sampling
- Fishery Dependent

- SEFSC Observer Program
- State trip tickets
- SCDNR shrimp baiting
- University of South Carolina Baruch Survey

Additional panel comment on 'Shrimp Indices':
*Should investigate academic institutions with surveys that could have potentially useful information.

Life History (Requirement for assessment)

- Sex
  - GADNR ecological monitoring trawl survey
  - GADNR juvenile trawl survey
  - GADNR bycatch characterization
  - SCDNR crustacean monitoring
  - SEAMAP

Additional panel comment on 'Life History'
*Need to discuss life history parameters important to assessment and their application to shrimp.

Environmental (Requirement for assessment)

- Large number of datasets were submitted in both the shrimp and environmental inventories (see inventories for complete list)
- Need to determine what environmental factors are important to shrimp stocks

Shrimp Age/Length (Requirement for assessment)

- GADNR ecological monitoring trawl survey
- GADNR bycatch characterization
- SCDNR crustacean monitoring
- SEAMAP
- FL FWCC Fishery Independent Monitoring (FIM) survey
- NCDMF estuarine trawl survey
- NCDMF Pamlico Sound survey
- NCDMF juvenile shrimp sampling
- SEFSC Observer Program
- NCDMF bycatch characterization
- State trip tickets (counts only)
- South Atlantic shrimp system (counts only)
- SEFSC BRD testing

- SEFSC TED testing (counts only)
- SEFSC NC skimmer trawl TED testing (counts only)

After developing the lists of available South Atlantic data sources for each data type, the panel was divided into three working groups to discuss the strengths and weaknesses of the datasets for use in shrimp bycatch estimation and/or shrimp stock assessment, to identify data gaps and research recommendations, and to identify overall recommendations on the use of the data sources. The Life History/Environmental group was tasked with discussing life history parameters important to stock assessment and their application to shrimp, evaluating the datasets available in the South Atlantic for shrimp age/length and other life history parameters, and discussing the environmental parameters that would be important when evaluating shrimp stocks. The Fishery Statistics group was tasked with evaluating the data sources identified for fishery effort, shrimp catch, kept bycatch/fish, discarded bycatch/fish, and fish age/length. The Index group evaluated the data sources available for Bycatch Catch per Unit Effort (BCPUE), shrimp indices, and BRD/TED impact on BCPUE estimates. Summary reports from each working group are below.

2.4.1 Life History / Environmental Working Group

2.4.1.1 Group Membership

Carolyn Belcher (leader/moderator), Amy Fowler, Ryan Gandy, Rick Hart, Eric Johnson, Trish Murphy, Mark Stratton, David Whitaker, SEDAR/SAFMC staff – Chip Collier

2.4.1.2 Group Objective

The Life History / Environmental working group was charged with discussing life history parameters important to stock assessment and their application to shrimp; evaluating the datasets available in the South Atlantic for shrimp age/length and other life history parameters; determining what environmental parameters are important to consider when evaluating shrimp stocks and discussing the available environmental datasets.

2.4.1.3 Life History Parameter and Modeling Discussions

Natural mortality

- Contributing factors
    - Predation (very important), but data aren't available: some evidence of competitive exclusion of pink shrimp by white shrimp in NC (in warmer winters, more white shrimp are produced and less pink shrimp); some predation data from diet studies
    - Disease, some data available

  - Environmental extremes, namely cold stunning of mature adults
  - Density dependence of early life stages
- How to measure
  - Existing tagging studies
  - Changes in length-frequency distributions over time
  - Use mortalities calculated in the Gulf of Mexico; however, borrowing natural mortality from the Gulf of Mexico for other species has not been accepted in some other assessments
  - Need to consider regional differences, even within states, due to differential habitat preferences between the species (e.g. pink shrimp and sea grass)
- Natural mortality is likely much more impactful to the population than fishing mortality. Natural mortality rates do exist in the literature for adults and juveniles, but based on older studies

Ageing

- No one is ageing shrimp, but could you do it for year and hindcast based on length?
- Ageing is hard and the age structure is relatively simple. Monthly sizes could be used, but there are not multimodal cohort structures for these species.
- Notable growth curve differences and nutritional requirements among Penaeid species, which could impact length frequency interpretations as a proxy for age. For example, brown shrimp stop growing in ocean, white shrimp continue (because they are omnivorous). Relatively good growth curves calculated for Gulf of Mexico pink shrimp – could use as proxy?
- There is information in the lengths, but are they a good proxy for age? Probably not due to variation in growth curve due to density-dependence, non-continuous growth, and environmental conditions. For this reason, should include environmental parameters in any von Bertalanffy or stock recruitment before feeding this information into a stock assessment.

Stock recruitment

- Poor relationship for white shrimp.
- Stock recruitment curve of Chesapeake Bay blue crab can move up and down with environmental conditions. There was some indication that shrimp might have a similar response due to the changes in rainfall pattern in the 2000s.
- Even low SSB can sustain the population. Protection of critical habitats can act as a buffer.
- Location of spawning stocks for pink and brown shrimp unknown. For pink shrimp, likely that spawning stocks are located offshore in NC which then supplies GA and SC with juveniles and adults. Work has been done in the FL Keys on pink spawning stock.

Habitat

- Definite regional differences in nursery areas: shrimp type, salinity, predator types/abundance, and habitat.
- Consider critical habitat protection. This would also impact many other managed species and activities in the area.

Modeling

- Can shrimp ever be overfished? If not, what's the point in building a model that provides this?
- Are models that have output of MSY necessary for management?
- There have been some yield-per-recruit models fit for shrimp. Yield-per-recruit model to provide recommendations on optimal harvest size?
- Models that rely on a stock-recruitment relationship may not be appropriate, unless variability in the relationship can be accounted for by environmental factors.
- Age-structured models are likely not appropriate given these are annual species. Length-based models perhaps better, but the environment and density-dependence can cause incredible variability in individual growth rates. A benefit of South Atlantic Penaeid stocks is that they don't have a protracted spawning season (spring-spawning only).
- Possible to incorporate economics into a model about best/optimal size at harvest?
- Recommended to not segregate by sex, as the fishery does not target one sex over another, but growth rates may be different between the sexes (especially white shrimp).

Management

- Need to define the stock. This will impact management (state vs. basin-wide). Genetic studies suggest a regional white shrimp population.
- Perhaps the lowest hanging fruit for shrimp fishery management is to optimally manage fleet size. Economics places a cap on the upper end of fleet size, but a few good years could result in fleet size inflation that may be problematic if the environment negatively impacted the species in the following years.
- The current assessment and then management cycle is relatively long and could exceed the life span of the stock. Are there other techniques that are available to managers for sustaining the population within a shortened timeframe? Need to decide if assessment is useful given the short life cycle of the species and the relatively long time it takes to enact management action.

Environmental influences

- Temperature/salinity consistently noted as important
- Regime shifts possibly important (e.g. rainfall, temperatures). Climate change/oscillations informed the Gulf blue crab assessment. If included on the front end, environmental

effects would inform the biological patterns but might be difficult to interpret in management decisions. Taking this 'intrinsic' approach is not classical.

- Overfishing/overfished may not be based on changes in effort but more on environmental changes.
- How would any capable assessment model account for environmental impacts? Will natural mortality be varied? Other methods?

2.4.1.4 Dataset Review

Datasets

- Fishery-dependent datasets are perhaps not useful for informing population dynamics (NCDMF Juvenile Shrimp Sampling not useful either)
- Both fishery-independent environmental datasets and external environmental datasets will be important to include, certain characteristics should be considered.

Datasets useful for shrimp age/length

- Any available fishery-dependent datasets are likely biased for population life history data—do not use
- Useful fishery-independent datasets by species:

Whites

- SCDNR Crustacean Monitoring – juvenile to adult; for growth rates may be most informative for juveniles
- GADNR EMS – juvenile to adult
- FL FIMS
- SEAMAP – abundance (adult size), sex, size, disease, maturity
- NCDMF Estuarine Trawl Survey (perhaps only older data that had more months)
- NCDMF Pamlico Sound Survey

Browns

- SCDNR Crustacean Monitoring – juvenile to adult; for growth rates may be most informative for juveniles
- GADNR EMS – does not sample spawning areas
- FL FIMS?
- SEAMAP?
- NCDMF Estuarine Trawl Survey
- NCDMF Pamlico Sound Survey

Pinks

- GADNR EMS – limited use. Not frequently encountered
- FL FIMS
- NCDMF Pamlico Sound Survey

- NCDMF Estuarine Trawl Survey (perhaps only older data that had more months and sampled at night)

Available Environmental Data (from biological datasets)

- Any fishery-independent survey that measures standard water quality parameters is potentially useful (definitely temperature and salinity, others such as dissolved oxygen also helpful)
- GADNR Juvenile Trawl Survey not useful for habitat mismatch reasons (salinity in particular)
- NCDMF Juvenile Shrimp Sampling not useful due to spotty sampling

Available Environmental Data (from external datasets)

- The datasets in the inventory were not individually evaluated because the group was not familiar with most of them.
- USGS water quality data collected from estuaries should be added (definitely temperature and salinity, perhaps rainfall and river flow).
- There was talk of climate indices being important to inform local water quality conditions (some of these are already included in the inventory).
- Available habitat; e.g., Submerged Aquatic Vegetation coverage in NC should be added to inform pink shrimp habitat availability.
- There was concern that some data available are from "virtual buoys". These buoys should not be used because information is inferred from surrounding buoys to estimate water quality data at that station.
- The following characteristics should be considered for any dataset:
    - Data collection tool (actual readings or virtual buoy type)
    - Consistency (i.e., number of data gaps)
    - Length of time series
    - Coverage area
    - Temporal/spatial overlap with biological sampling (life stage-specific)
    - Impact to time series from water management

Life History

- Important life history components to consider for modeling purposes
    - Stock recruitment
    - Natural mortality
    - Age or length
    - Growth (also maturity, but perhaps less important for shrimp)
- GADNR EMTS has useful data throughout the year.
- Other GADNR surveys (juvenile trawl survey, bycatch characterization) not useful because of mismatch with habitat and population.

- SCDNR Crustacean Monitoring data useful for spring white shrimp data.
- Sex may not be needed, but could inform growth rates.
- Need to standardize for gear types.

2.4.1.5 Recommendations / Take-home points

- Shrimp are not fish.
- The environment and economics matter.
- Protect habitat. No-fishing zones and times are likely important for ensuring stock health.
- No good way to age. This major issue has implications for model type choice.
- Stock-recruitment relationships, growth, and natural mortality are all influenced by environmental factors.
- Sex identification is not crucial for assessment.
- Fishery-dependent data are not useful for characterizing population life history characteristics.
- Species coverage and time series for fishery-independent surveys vary.
- Management for fishery capacity and optimal yield could be useful approaches.
- In general, there is very limited directed shrimp research.

2.4.2 Fisheries Statistics Working Group

2.4.2.1 Group membership

Marcel Reichert (leader/moderator), Alan Bianchi, Steve Brown, Julie Defilippi, Dave Gloeckner, Frank Helies, Eric Hiltz, Kate Michie, Jeff Isley, Blake Price, SEDAR/SAFMC staff: Julie Neer

2.4.2.2 Group Objective and Overview

The Fishery Statistics Group was tasked with discussing and identifying current statistical data sources and data gaps for the South Atlantic Penaeid and rock shrimp fisheries. The group reviewed the adequacy of most known sources of data for effort, bycatch, and length/age of bycatch including:

- ACCSP
- State trip tickets
- Vessel operating units (VOU)
- E-logbooks
- South Atlantic shrimp system
- State databases

- the federal permit database
- the Southeast Fisheries Science Center (SEFSC)observer program
- SEAMAP

2.4.2.3 Types of Effort Data Needed

The Fishery Statistics Group began their session with a discussion of what types of information are required or most desired as effort data. The group determined the following elements are most necessary to compile an adequate suite of shrimp fishery effort data:

- Long time series of data, including historical data.
- Catch data: Entire catch and species specific data are ideal. Other factors such as age or other information are desired.
- Unit time: It is ideal to have active hours fishing, tow times, and numbers of tows in the data set. Must achieve a consistent definition of "trip" across programs for analytical purposes.
- Location: Statistical grid area is sufficient. Depth, or distance from shore is also needed.
- Gear: It is ideal to have a detailed gear description including head rope length, number of nets, mesh size, and BRD/TED type.
- Consistent documentation: Documentation should be consistent across programs, and should include historical changes in the fishery.

Each data set was discussed in terms of the adequacy of each of these information elements.

2.4.2.4 Fishery Effort/Catch Data Set Discussion

The group proceeded to discuss each of the data sets identified during the prior plenary session to determine whether or not they provide information that could be used in a future stock assessment or to fulfill other analytical needs.

ACCSP

- Catch data are available, but information varies by state, by species, and over time. It is not known whether or not these data are sufficient for characterizing effort.
- Unit of fishing time collected by ACCSP could possibly be sufficient depending on the state. Active time trawling is available through the observer program.
- Gear characterization is insufficient. Only captures number of nets. (SC is collecting gear data that is not being sent to ACCSP.)
- Location data are sufficient. Includes statistical grids, and depth (distance from shore as a proxy)
- Time series information is better for catch than for effort. Sufficiency of time series data is unknown.
- ACCSP DATA GAP RECOMMENDATIONS:

- States provide increased information to ACCSP
- Coordination/comparison/verify between state data and ACCSP to strengthen historical data.

State Trip Tickets

- Catch data: Good for all states
  - NC: good, minimal exceptions
  - SC: good, shrimp species are grouped (creel clerk information is used as a proxy for shrimp species).
  - GA: good species ID (species identification is augmented with fishery independent information. Dealers separate by count size, but not species.
  - FL: Good
- Unit of time: Sufficient
  - NC: Collects days at sea back to 1999, not reliable.
  - SC: Active time fishing, trip start time and unload date, number of tows.
  - GA: Tow time by hours, trip start time and unload date, number of tows.
  - FL: Time fished, days at sea, number of tows.
- Gear Information: Insufficient
  - NC: General gear type (wingnet, otter trawl, cast net, etc.), records up to three gears per trip, number of nets and mesh size not collected. BRD/TED assumed based on management, mostly "fish eye".
  - SC: Number of nets, head rope length, BRD/TED assumed based on management.
  - GA: General gear type, number of nets.
  - FL: General gear type (older information ca be merged with license data for more specific information). More recently recording specific gear type, number of nets.
- Location: Sufficient. All states have at least a code for area fished.
- STATE TRIP TICKET DATA GAP RECOMMENDATIONS:
  - Verify what it reported on trip tickets through
    - Increased coverage by the observer program, or
    - A periodic survey of the fishery

Vessel Operating Units (VOUs)

- A data source to supplement other data sources.
- May verify existing information.
- May be used for tuning proxies.
- Not useful for effort or catch characterization because it is more of an index.

South Atlantic Logbook

- GA: Pilot program with 20 vessels 2012-2013, provided tow time, location, gear info etc.
- E-logbooks may make VMS redundant

South Atlantic Shrimp System

- Catch data: Sufficient within time series. Species and size specific for shrimp only. Not useful for bycatch characterization.
- Unit of time: Insufficient (historic data only). Days at sea were recorded for GA from 1978-2001, in NC since 1991, in FL from 1981-1986, in SC from 1978-2001, and falls off when trip tickets were implemented.
- Location: Sufficient for all states within the available time series.
- Gear: General descriptions, historical data only.

NCDMF License Data

- Catch data: Not collected from license sales
- Unit of time: Based on a fiscal year
- Location: Insufficient, not collected
- Gear: Insufficient. Number of nets, head rope length. (Information on number of nets is not included on the trip ticket).

Other State License Data Sets

- Similar issues as NC.

NMFS Southeast Regional Office Federal Permit Database

- Catch/Effort: Insufficient. No log books.
- Vessel characteristics are available.
- Permit data are reliable from 2008 to present. Before that time permit data resided in R-Base and requires additional work to get accurate annual permit counts.
- Captures only federal permits, many vessels in the South Atlantic do not have a federal shrimp permit.
- Supplementary data set.

SCDNR Shrimp Baiting

- Annual mail survey (may be issues with voluntary survey and recall)
- Catch: Estimates general catch by trip: Sufficient for effort, not sufficient for catch.
- Effort: Sufficient. Trip data collected.
- Gear: Sufficient. Cast net only, mesh size determined by regulations.
- Location: Sufficient.
- Useful for historical catch trends.

Chestnut and Davis (NC Historic)

- Shrimp landings and landings for other species prior to 1950, back to 1880's.

- No gear or other information.
- Useful for historical trends.

2.4.2.5 Bycatch Data Discussion

The Fishery Statistics Group next discussed various data sets that include bycatch information. Each dataset was discussed in terms of its adequacy for shrimp kept and discarded bycatch information. In general, shrimp catch and kept bycatch data sets have issues similar to those for fishery effort listed above. Discarded bycatch data used for rarely encountered species may not be useful as it results in spikey data points; and therefore, should be avoided. The following outlines the attributes and inadequacies for each of the data sets used for bycatch information.

SEFSC Observer Program

- Observer coverage: Insufficient, the shrimp fishery is not adequately sampled. The program only targets vessels with federal shrimp permits; however, many vessels harvest shrimp with only a state license and do not get sampled by the observer program.
- Sampling is less than 1% of federal permitted vessels, and much less than 1% for all fleets.
- Data: The only federal source of shrimp bycatch information. Includes species, length, and no age data.
- Length/Age Data: lengths during special projects only, no gonads or otoliths from the shrimp fishery.
- Important for characterizing the fleet.
- Includes several gear comparison studies.
- OBSERVER PROGRAM RECOMMENDATIONS:
    - Increase coverage to 2-5% or 20-30% PSE (number of trips/sea days) for all fleets.
    - Requires data collection consistency among non-mandatory programs.

NCDMF Bycatch Characterization

- Data: Sufficient. Species, length, gear, trawl duration, location. No age information collected.
- Length/Age Data: length data for all samples. Age data for certain species through the estuarine trawl and Pamlico Sound surveys.
- The program is grant funded for the short term only, and only observes otter trawls. From 2007-2008 nearshore coverage was 5%, in 2009 Pamlico Sound coverage was 1%, and from 2012-2015 statewide year round coverage is less than 1%.

GADNR Bycatch Characterization

- Data: Sufficient. Length, gear, effort to species.

- Length/Age Data: Length; no age collected
- Program covered large shrimp trawl vessels from 1995-1998. During this time, it was a voluntary program targeting four observer trips per month. From 1998-2005, covered two trip per month.

SEAMAP-SA Coastal Trawl Survey

- Data: Only source of FL bycatch data, reliable effort, full catch characterization, lengths, total weights, age/reproductive data, and detailed gear descriptions.
- Length/Age Data: Subsample lengths, age and reproductive data for certain species.
- Samples during three sampling seasons with 20 minute tows, in areas between Cape Hatteras to Cape Canaveral in depths of 8-12 m.
- Data are available online with a 6-12 month delay.
- SEAMAP TRAWL SURVEY RECOMMENDATIONS:
    - Compare SEAMAP-SA data and observer data where there is temporal and spatial overlap.
    - Address calibration issues by: 1) doing paired trawls with commercial and SEAMAP gear; 2) consider tow durations, time of day, BRD/TED covariant; and 3) account for variety of commercial gear and fishing behavior.

LENGTH/AGE BYCATCH DATA RECOMMENDATIONS:

- Need additional age data, could use age/length relationships from other sources.

FISHERY STATISTICS GROUP OVERALL RECOMMENDATIONS:

In addition to making recommendations for how fishery effort, bycatch, and length/age bycatch data could be improved, the group also discussed several general data gathering and improvement recommendations. Those recommendations include:

- Investigate other sources of data such as state and academic sources i.e., Baruch long term creek data for (juvenile) index of abundance.
- Establish a gear type overview and assemble historical timelines.
- Increase observer coverage with special attention to temporal and spatial factors such as seasons, day vs. night, and coverage of various fleets without compromising statistical design.
- Develop video techniques to characterize catch.
- Add depth sensors to trawls to increase data collection.
- Participate in and support state cooperative projects.
- Account for the effects of fishing behavior on catch and bycatch.

2.4.3 Indices Working Group

2.4.3.1 Group membership

Katie Drew (leader/moderator), Pat Geer, Jeanne Boylan, Kevin Brown, Larry DeLancey, Jeff Gearheart, Liz Scott-Denton, Xinsheng Zhang, Jeff Brunson, SEDAR/SAFMC staff: Mike Errigo

2.4.3.2 Group Objectives

The Indices Workgroup covered two main topics:

1. The development of a bycatch catch-per-unit-effort (BCPUE) for non-shrimp species, either to be combined with effort estimates to develop a time-series of bycatch, or to be used as a fishery-dependent index of abundance for non-shrimp species.
2. The evaluation of existing fishery-independent and -dependent indices of abundance for use in shrimp stock assessments.

2.4.3.3 Development of a BCPUE

Bycatch catch-per-unit-effort of non-shrimp species is a function of many different factors, including gear type and configuration, area fished, season, and abundance of the non-shrimp species. The WG recommends using a stratified mean approach or a GLM-standardization approach to take into account these factors.

The WG identified three major strata or factors that should be used when developing a BCPUE in the south Atlantic:

- Year
- Season
- Area (Sounds/Estuaries, nearshore, offshore)

In addition, four secondary strata/factors were identified that could improve the estimates of BCPUE and should be used if sample size allows:

- Gear
- North/South or state
- Target (bait vs. food, Penaeid vs. rock shrimp)
- Depth

However, the WG recognized that achieving an adequate sample size within even the primary strata may be difficult, especially for early years. Analysts may need to pool over some or all of the recommended strata, depending on the length of the time-series needed and the species in question (e.g, estimates of BCPUE of rare-event species like sharks will most likely require

pooling over more strata that estimates of BCPUE for more common bycatch species like Atlantic croaker). The final strata or factors used to develop BCPUE should be determined by the analysts based on species-specific considerations.

The WG evaluated the utility of three observer program datasets to develop estimates of BCPUE in the south Atlantic.

1. SEFSC Observer Program: early 1990s – present
2. NCDMF Bycatch Characterization: 2007-2008, 2009, 2012 – present (funded to 2015)
3. GADNR Bycatch Characterization: 1995 – 2005

SEFSC Observer Program

The SEFSC Observer Program represents the longest time-series and the largest area covered out of the three datasets. In the early 1990s, the focus was split between bycatch characterization and TED/BRD evaluations. In 2003, the focus shifted to bycatch characterization. Gear evaluation studies are clearly indicated within the database, and analysts should be conscious of those distinctions when developing BCPUE estimates.

Participation in the program was voluntary for vessels at the beginning, but became mandatory for federally permitted vessels in 2008. In 2009, the sampling protocol was adjusted slightly to identify certain priority species like sharks down to species level. The observed trips from the mandatory period are more representative of the fishery than those from the voluntary fishery.

Coverage has been ~1% of trips in the south Atlantic after the program became mandatory. Sampling levels varied in earlier years, but were generally lower.

There may need to be further discussion of state versus federally permitted vessels and whether there would be significant differences in bycatch rates that would not be accounted for with other factors (area fished, etc.).

Pros:

- Long time-series
- Coverage throughout the south Atlantic
- Commercial gear configurations and behavior observed

Cons:

- Sample size by recommended strata is low, especially for early years and for certain species
- Identification to species level not done for all species (requiring extrapolation for some species groups)

Recommendation: Despite sample size issues, the SEFSC Observer Program represents the best available data for most years and areas to develop BCPUE for non-shrimp species and should be used.

The NEFSC Pelagic Observer Program has explored the possibility of funding observer coverage on shrimping vessels in North Carolina. The WG recommends that analysts check with the NEFSC in the future to track progress of this possibility.

NCDMF Bycatch Characterization Program

NCDMF used observers to characterize bycatch rates in three areas of NC. From mid-2007 to mid-2008, coverage was focused in nearshore waters (~5% of trips). In 2009, coverage was focused in Pamlico Sound (~1% of trips). From 2012 – present, coverage was statewide (~1% of trips). The program is funded through 2015 in theory, but continuation of the program is contingent on funding levels.

The sampling protocol is very similar to the SEFSC observer program, although NCDMF samples from all nets deployed (instead of just one) and identified all shrimp and bycatch down to species level.

Pros:

- Sample size within recommended strata (year-season-area) is good for years and areas covered
- More detailed species information is collected

Cons:

- Length of time-series is limited
- Area covered is limited

Recommendation: The NCDMF Bycatch Characterization Program should be used to supplement the SEFSC Observer Program to develop BCPUE estimates.

GADNR Bycatch Characterization Program

GADNR operated a voluntary observer program on shrimping vessels from 1995-2005. Coverage was low (~0.5%) and the program was eventually discontinued because the cost was deemed not worth the coverage obtained.

Sampling protocols were similar to the SEFSC Observer Program. GADNR only sampled from one net, but identified shrimp and bycatch to the species level. Sampling occurred in nearshore water, as sounds are closed to shrimping in GA. The dataset does include coverage of trips prior to BRD regulations.

There is some discrepancy (mainly number of observed trips) between the data that GA holds and the data from this program that are held in the SEFSC database. Until this discrepancy is resolved, data should be obtained from GA directly.

Pros:

- More detailed species information is collected
- Adequate sample size by strata for some years and areas
- Pre-BRD data are available

Cons:

- Voluntary, low coverage rates
- Limited time and area coverage

Recommendation: The GADNR Bycatch Characterization Program should be used to supplement the SEFSC Observer Program to develop BCPUE estimates.

The WG also discussed the use of fishery-independent surveys to develop BCPUE estimates. Fishery-independent surveys are not proxies in and of themselves for commercial BCPUE effort estimates but may be useful when combined with observer data. Even surveys that use shrimping vessels and nets as survey platforms (e.g., SEAMAP) show much higher rates of BCPUE than observer programs do. This is most likely due to differences in gear configuration (TEDs and BRDs are not used in FI surveys), timing of sampling (most FI surveys take place during the day while shrimping is often done at night), and areas fished (FI sampling sites are randomly distributed throughout available habitat, while shrimpers target areas with high shrimp abundance). However, fishery-independent indices may be correlated with commercial BCPUE, since both could reflect the abundance of non-shrimp species. Thus, the WG recommends that analysts should explore the use of FI indices to scale/extrapolate/tune BCPUE estimates where observer sample size is not adequate to produce year-specific BCPUE estimates. When exploring this approach, analysts should consider:

- the strength of relationship in overlap years
- the timing of BRD implementation
- the spatial and temporal coverage of the survey relative to fleet
- the size/age structure of survey-caught individuals vs. bycatch individuals
- the quality of index for species of interest (e.g., if the survey is not an adequate index of abundance for your bycatch species, do not use it to tune BCPUE)
- whether to use smoothed or observed index values, and the relationship between CPUEs based on shrimp fleet Observer Program and survey (e.g. SEAMAP) to scale/extrapolate BCPUE when Observer program data were very limited

The WG also discussed quantifying the effects of TED and BRD regulations when developing BCPUE estimates. TEDs became mandatory in the late 1980s (large-opening TEDs became required in 2003). BRDs were required in the mid- to late-1990s. The date of implementation and the type of BRD required varied between states and between state and federal waters.

The most recent observer data, with the best sample size by strata, only cover years when BRDs and TEDs are required. As a result, these estimates of BCPUE will be biased relative to earlier years, when one or both sets of devices were not used commercially. To extend estimates of BCPUE back in time, the estimates will need to be calibrated to account for the effects of TEDs and BRDs.

The SEFSC Observer Program database does contain data from gear testing work that could be used to develop calibration coefficients. In addition, the WG identified possible gear testing datasets that are not included in the SEFSC database that could also be used to develop calibration coefficients. This includes GA Sea Grant projects and older SEFSC datasets that were used to develop the original estimates of sea turtle bycatch. The WG recommends that these data be obtained and evaluated.

There is very little information on levels of compliance with TED and BRD regulations, so analyses will have to assume perfect compliance with regulations to estimate and/or calibrate BCPUE. The WG recommends creating a matrix of regulations by state and year to identify regulatory periods and gear testing or observer datasets that could allow estimation or calibration for those periods.

2.4.3.2 Evaluation of Shrimp Indices for Use in Shrimp Assessments

The WG identified a number of factors that should be considered when evaluating the utility of a dataset as an index of abundance:

- Percentage of positive tows
- Length of the time series
- Spatial and seasonal coverage
- Size structure – juveniles and adults
- Survey design
- Major modifications to gear/vessel/survey design
- Identified to species
- Associated environmental data

Overall, the WG recommends that fishery-dependent CPUEs should not be used as indices of abundance in shrimp assessments. There are several good fishery-independent indices for

shrimp, and developing a standardized unit of effort for fishery-dependent data is difficult, due to changes in gear configuration and efficiency over time in the fishery. The recommendations are highlighted to qualitatively rank the utility of the data source for developing an index (green = good, should explore for use; yellow = okay to use, should be used to compliment other indices; red = not recommend for use if other indices available).

Fishery Independent Surveys

SEAMAP-SA Coastal Survey

- Contacts: Marcel Reichert and Jeanne Boylan
- Design: Random Stratified Survey
- Gear:
    - Paired 22.9 m (75 ft) mongoose-type Falcon trawls
    - 47.6 mm (1.875 in) stretch mesh in body, 41.3 mm (1.625 in) in cod end
    - 305 x 102 cm (120 x 40 in) wooden doors with tickler chain
- Tow Duration: 20 minutes, Speed ~ 2.5 kt
- Longevity: 1990 to present
- Temporal: 3 cruises. Spring: Apr-May, Summer: Jul-Aug, Fall: Sep-Nov
- Spatial: Offshore, Hatteras to Canaveral
- Depth Ranges: 4-10 m
- Annual Effort: 3 seasons x 112/season = 336
- Shrimp Information
    - Mostly adults
    - Some juveniles
    - Size
    - Sex
    - Gonad information
    - Identified to species
    - High percent of positive tows
- Clean dataset (all questionable data excluded)
- Consistent vessel and protocols over time
- Environmental data
- Cons:
    - Funded year to year
    - Not in sounds and estuaries
- Recommend use as adult CPUE for all 3 species

GADNR Ecological Monitoring Trawl Survey

- Contacts: Pat Geer and Jim Page
- Design: Fixed Station, Stratified Design (by sector: creek, sound, ocean)

- Gear:
  - 12.2 m headrope (40 ft) flat trawl
  - 48 mm (1.875 in) stretched mesh throughout
  - Tickler chain
  - 152 x 71 cm (60 x 28 in) wooden trawl doors
- Tow Duration: 15 min
- Longevity: 1976 to present
- Temporal: Monthly, January - December
- Spatial: Six Sound Systems: Wassaw, Ossabaw, Sapelo, St Simons, St Andrew, and Cumberland. Minimum a two stations per sector per sound.
- Depth Ranges: 3 – 10 m
- Annual Effort 42 per month, 504 annually
- Shrimp Information
  - Both adults and juveniles
  - Size
  - Sex
  - Gonad information
  - Identified to species
  - Disease
  - High percent positive tows for whites and browns (pinks are uncommon)
- Consistent vessel, gear, protocols, and effort over time
- Environmental data
- Cons:
  - Fixed stations
  - Spatially limited
  - Data may need a thorough QA/QC
- Recommend as inshore CPUE to supplement SEAMAP

SCDNR Crustacean Monitoring Survey

- Contacts: Larry DeLancey
- Design: Fixed Stations
- Gear:
  - 6.1 m (20 ft) headrope flat otter trawl
  - 25.4 mm (1 in) stretch mesh throughout
  - tickler chain
  - Prior to 2002: twin trawls
- Tow Duration: 15 minutes, 30 minutes in 1980s
- Longevity: 1979 – present

- Temporal:
    - Monthly in Charleston Harbor
    - Quarterly south of Chas. (Mar, Apr, Aug, Dec): Edisto R., St. Helena, Port Royal, and Calibogue Sounds.
- Spatial: Sounds and Estuaries: Charleston Harbor, Edisto River, St. Helena, Port Royal Sounds
- Depth Ranges: 3.7 – 15.2 m (12 – 50 ft)
- Effort: ranged from 111 to 159 collections annually in the last five years
- Shrimp Information
    - Both adults and juveniles
    - Size
    - Sex
    - Gonad information
    - Identified to species
    - Disease
    - Very high percent positive tows for all 3 species (not much pink recently, lots historically)
- Environmental data
- Cons:
    - Fixed stations
    - Spatially limited
    - Vessel and gear changes (twin vs single trawl) 2002. Changed vessels with side-by-side comparisons
- Recommend as inshore CPUE to supplement SEAMAP

FWRI Fishery Independent Monitoring Survey (FIMS)

- Contact: Ryan Gandy
- Design: Random Stratified Design
- Gear(s):
    - 21.3 m (70 ft) center bag seine, 3.2 mm (0.125 in) mesh
    - 6.1 m (20 ft) otter trawl, 38.1 mm (1.5 in) body, 3.2 mm (0.125 in) liner
- Depth: Seine $\leq$ 1.8 m, Trawl 1.0 – 7.6 m
- Tow Duration: 1 min
- Longevity: 1990 - present
- Temporal: Seasonal prior to 1996, monthly afterwards
- Spatial: Sounds and Estuaries: Northeast Florida (2001), Northern Indian River Lagoon (1990)
- Depth Ranges: 1.8 – 7.6 m

- Effort: 2012 numbers
  - 21.3m Seine: 1064 collections
  - 6.1 m trawl: 684 collections
- Shrimp Information
  - Both adults and juveniles
  - Size
  - Sex
  - Gonad information
  - Identified to species
  - High percent of positive tows for each white, brown, and pink shrimp
- Consistent in vessel, methodology, and gear
- Environmental data
- Cons:
  - Spatially limited
- Recommend as inshore CPUE to supplement SEAMAP

NCDMF Pamlico Sound Survey (Program # 195)

- Contact: Katy West and Jason Rock
- Design: Random stratified design (7 strata based on depth and region)
- Gear:
  - double rigged 9.1 m (30 ft) demersal mongoose trawls
  - 44 mm (1.75 in) stretched mesh body, 38 mm (1.5 in) cod end, and 100 mesh tailbag,
  - 100 x 60 cm doors
- Tow Duration: 20 min, 2.5 kt
- Longevity: 1987 - present
- Temporal: Spring (June) and Fall (September)
- Spatial: Sounds and Estuaries: Pamlico Sound
- Depth: $\geq$ 2 m (6 ft)
- Effort: 54 stations per season, 108 stations annually
  - Shrimp Information
  - Both adults and juveniles
  - Size
  - Identified to species
- High percent of positive tows for whites and browns (mostly browns)
- Consistent in vessel, methodology, and gear
- Environmental data
- Cons:

  - Spatially (Pamlico Sound) and temporally (June and September) limited
- Recommend as inshore CPUE to supplement SEAMAP

NCDMF Juvenile Trawl Survey (Program # 120)

- Contact: Katy West
- Design: Fixed stations – 105 core stations
- Gear: 3.2 m (10.5 ft) two seam otter trawl, 3.175 mm (0.125 in) bag
- Tow Duration: 1 minute
- Longevity: 1978-present
- Temporal: May and June after 1989, (monthly 1978-1988)
- Spatial: Estuaries, statewide, typically in nursery areas
- Depth Ranges: unknown (?)
- Effort: 105 stations per year
- Shrimp Information
  - Both adults and juveniles
  - Size
  - Identified to the species
  - High percent of positive tows for white, brown, and pink shrimp (mostly browns)
- Consistent in vessel and gear
- Environmental data
- Cons:
  - Spatially limited
  - Temporally limited since 1989
- Recommend as inshore CPUE to supplement SEAMAP; probably best for brown shrimp; older monthly data good for the other species or for scaling/tuning historical data/recruitment

NCDMF Juvenile Shrimp Sampling (Program # 510)

- Contact: Trish Murphey
- Design: need information here
- Gear: Varies based on species and areas, 10.5 to 25 ft trawls
- Depth Range: unknown (?)
- Tow Duration: 1 to 10 minutes based on abundance and gear
- Longevity: 1978-2011
- Temporal: June to November dependent on shrimp recruitment
- Spatial: Estuaries not designated as primary or secondary nursery areas – statewide
- Effort: variable

- Shrimp Information
  - Lengths
  - Brown, white, and pink shrimp
  - Mostly juveniles
- Environmental data
- Cons:
  - Spatially limited
  - Discontinued
  - Methodologies are designed for management purpose to determine when to open areas to trawling.
- Recommend use for scaling/tuning historical data/recruitment

Fishery-Dependent Surveys

SEFSC Observer Program

Contact: Elizabeth Scott-Denton (NMFS, SEFSC – Galveston)

- Longevity: 1992 – present, Mandatory since 2008
- Coverage: ~1% coverage since 08, Less than 0.5% coverage prior
- Methods
  - Total weight for 2 outboard nets
  - Kg/net
  - Can get distance from speed and duration of tow
  - Lengths, weight, and count of net subsamples during bycatch characterization studies
  - Have all gear and vessel info
  - Adults only
  - All species
  - May be able to model time blocks with different selectivity?
- Pros:
  - Set level info
  - Gear and vessel info
  - Best of fishery-dependent datasets
- Cons:
  - Low coverage; may not be in center of abundance for brown shrimp
  - Change in design
  - Short time series
- Can use for CPUE if fishery-independent data is unavailable or to fill gaps

State Trip Tickets

- Contacts: NC: Alan Bianchi; SC: Amy Dukes; GA: Julie Califf; FL: Steve Brown
- Longevity:
  - Varies state to state. Contains harvest and value data back to at least 1950's
  - Trip level data – early 1990's; varies by state
  - Lbs per trawl-hour since early 2000s; varies by state
- Methods:
  - Need to estimate number of nets and tow time
- Pros:
  - Long time series with thousands of records
- Cons:
  - Data is not fine scale enough for use as a decent CPUE
  - Non-reporting issues
  - Reliability issues
- Recommend not using this for Penaeid CPUE
- Recommend exploring use for rock shrimp CPUE with VMS data

SCDNR Shrimp Baiting Survey (Recreational)

- Contacts: David Whitaker
- Longevity: 1988 – present
- Methods:
  - Self-reported
  - Mail out after season ends
  - Due 60 days later (recall bias)
  - Random sample of permittees selected for survey
  - Creel survey for ground truthing – matches well with self-reported data
  - White Shrimp only
  - Estuaries only
  - During fall cast net season
  - Information includes catch per trip, effort, , and location
- Pros:
  - 25% return rate
  - Catch rates stable over time
- Cons:
  - SC only (baiting has started in FL recently)
  - Reporting bias
- Up to 1/3 of commercial catch at highest
- Recommend using fishery-independent surveys for CPUE over this one

Baruch Survey

- Contact: http://www.baruch.sc.edu/biological-databases
- Pros:
  - Long time series, 1980's to present
  - Lots of data, lots of species – much of which is available online
- Cons:
  - North Inlet, SC only
  - Some net and design changes
- Recommend exploring for use in life history studies
- Recommend for possible use as supplement to SEAMAP since the SCDNR Crustacean Monitoring Survey does not sample North Inlet, if effort can be standardized

FL Shrimper Survey

- Contact: Steve Brown, FL FWCC
- 2003 only
- Surveyed shrimpers for their gear
- Can be used for estimating compliance of shrimpers to the BRD/TED regulations

2.5 Data Gaps and Research Recommendations (TOR 6)

Identify data gaps and provide recommendations for future shrimp research, monitoring and data collection efforts.

Each working group (Life History/Environmental, Fishery Statistics, and Indices) was tasked with identifying data gaps and research recommendations during their discussions. Specific recommendations from each working group are listed below.

2.5.1 Life History / Environmental Working Group

- Better port sampling of species and sizes.
- More accurate information is needed on where shrimp are actually being fished, not just where they are landed.
- Data/models to understand trophic dynamics related to shrimp as an important lower trophic level species.
- Collect new data to define the stock and center of abundance for each species. Genetic evidence indicates stock homogeneity for all three species, but response to environmental factors may differ within the region (e.g., a cold winter in SC may not impact individuals in FL).
- Conduct an interstate tagging study to look at stock connectivity and migration patterns.

- Need sampling to identify habitat usage by life stage (all stages) for pinks (see SEDAR-PW6-RD62) and browns, especially for mature adults.
- Determine how to incorporate environmental factors into any assessment model that would be developed. Should they be incorporated intrinsically into the population dynamics (e.g. into a stock-recruitment function), or extrinsically once the model outputs has been generated? It is possible to use environmental factors to predict the next harvest because these are annual species.
- Assuming time-varying natural mortality should be included, how should this be done for any selected assessment model?
- Quantify/estimate benefit of nursery areas.

2.5.2 Fishery Statistics Working Group

ACCSP Data Gap Recommendations

- States provide increased information to ACCSP.
- Coordination/comparison/verify between state data and ACCSP to strengthen historical data.

State Trip Ticket Data Gap Recommendations

- Increased coverage by the observer program or a periodic survey of the fishery if states can't conduct an observer program to verify data collected on trip tickets.

SEFSC Observer Program

- Increase coverage of SEFSC Observer Program coverage to 2-5% or 20-30% PSE (number of trips/sea days) for all fleets.
- Require data collection consistency among non-mandatory programs.

SEAMAP-SA Coastal Trawl Survey

- Compare SEAMAP-SA data and observer data where this is temporal and spatial overall.
- Address calibration issues by: 1) Doing paired trawls with commercial and SEAMAP gear; 2) Consider tow durations, time of day, BRD/TED covariant; 3) Account for variety of commercial gear and fishing behavior.

Length/Age Bycatch Data

- Need additional age data, could use age/length relationships from other sources.

Overall Recommendations

- Investigate other sources of data such as state and academic sources i.e., Baruch long term creek data for (juvenile) index of abundance.
- Establish a gear-type overview and assemble historical timelines.

- Increase observer coverage with special attention to temporal and spatial factors such as seasons, day vs. night, and coverage of various fleets without compromising statistical design.
- Develop video techniques to characterize catch.
- Add depth sensors to trawls to increase data collection.
- Participate in and support state cooperative projects.
- Account for the effects of fishing behavior on catch and bycatch.

2.5.3 Indices Working Group

- Obtain older datasets that looked at TED and BRD impacts to calibrate observer data back in time.
- Develop matrix of regulations by state and year to identify need for calibration and link to appropriate study.
- Investigate possible NEFSC observer coverage on shrimp trawls.
- Look at surveys north of NC (e.g., VIMS) for changes in shrimp abundance and distribution.
- Increase observer coverage in the S. Atlantic to increase sample size by strata.
- Data gaps
    - Bait shrimp fishery
    - Rock shrimp
    - Gears other than otter trawls

2.6 Best Practice Recommendations (TOR 7)

Provide best practice recommendations for estimating finfish bycatch by the South Atlantic shrimp fishery, and for estimating population and management parameters of South Atlantic shrimp resources.

2.6.1 Best Practices for Shrimp Stock Assessment

Stock assessments are done to evaluate stock status (overfishing/overfished), to describe past dynamics (abundance, biomass, exploitation) and to predict future dynamics to determine the yield available to be managed. Many of the traditional 'finfish' stock assessment methods whether they are data rich (catch at age/length) or data poor (trends, ORCS, etc.) rely on the same basic underlying principles: the stock/recruitment relationship is key to production; fishing is a primary population influence; stability and precaution are gained from preservation of the spawners; and the dynamics 'of interest' are on yearly scales. John Carmichael led the panel discussion on whether these principles are applicable to shrimp stocks. A summary of the panel discussion by topic is below.

Maximum Sustainable Yield (MSY) and Application to Shrimp

- MSY in the traditional sense - connecting YPR to the stock recruitment relationship to get model based estimates of MSY may not be appropriate for shrimp.
- Applicability of MSY to shrimp stocks depends on definition of MSY; if MSY is defined as a proxy of Bmsy using a historical reference point (through indices or model based approaches) where managers were satisfied with the productivity of the stock and the behavior, economics, and dynamics of the fishery and try to maintain this level – then concept is potentially realistic and appropriate for shrimp.

Can shrimp experience overfishing?

- Growth and recruitment overfishing are both possible in shrimp fisheries; the Gulf of Mexico brown shrimp fishery has experienced growth overfishing; the Mexican pink and white shrimp fisheries have experienced recruitment overfishing.
- Recruitment overfishing is less probable in the South Atlantic due to management and the way the fishery is executed; for example, most states have some measure of seasonal white shrimp spawning stock protections (fishery closure to protect overwintering shrimp); precaution is justified by experience.
- Recently many South Atlantic states have seen several years with poor fall stocks; likely due to disease or other environmental factors, not overfishing; panelists noted seems to be a new paradigm – is there a lower spawner recruit curve perhaps due to disease and other environmental factors?
- Available stock recruitment relationships are flat over a large range of stock sizes; doesn't seem that stock size (at least over ranges observed) has a large impact on recruitment.
- Natural mortality may be a bigger concern than fishing mortality.
- Much of management is directed toward growth overfishing.

How to measure growth overfishing

- Yield per recruit (YPR) models
    - Can be modified to include economics.
    - Availability versus size versus price.
    - Many states do some management based on shrimp size.
    - Little (or no) formal modeling of yield per recruit used in shrimp management.
    - YPR are long term equilibrium models; can be modified to incorporate stochastic effects; may be useful to think about long term trends in growth rates and natural mortality; rates vary a lot by year which can affect YPR model, but may be trending over time with climate change, etc. and would potentially affect reference points.
- Management typically practiced without formal models and through experience

- Rely considerably on judgment and experience
- Rely upon monitoring of size and abundance
- Considerable collaboration/feedback between managers and fishermen for season openings and closings

Considerations for assessment

- Monitoring of broodstock
  - Would it be helpful to establish minimum standards and have a management response when below this level?
  - Have good information for white broodstock, but do not have data for spawning pink and brown shrimp.
  - Need more information before can sufficiently answer this question.
- Is there a need to develop more robust YPR approaches, especially when more experienced managers leave?
  - Not clear; need research to better understand spawning stock/stock identification, ecosystem factors, and reference values for metrics used by states.

Shrimp Productivity Factors

- Productivity tied to environmental factors.
  - Temperature – for example, winter temperatures affect next spawning stock for white shrimp. SC cold temperatures have resulted in sustained closure of white shrimp.
  - Salinity/rainfall
  - Habitat – for example, grass beds important for pink shrimp
- Disease
  - Blackgill causes shrimp to molt more frequently and may make more prone to predation
- Fishing mortality
- Productivity factors may vary by species.
- What do managers want to do with this information – explain past trends or forecast?
- Important to note what time scale is needed to address issues; this will dictate the forecast projection window and will greatly influence how to model the populations in an assessment; shrimp likely need to be looked at annually or monthly.

Can shrimp be overfished?

- Possibly, particularly if management allows for unlimited fishing effort on spawners early in the year (white shrimp).
- Conceptually different than finfish assessment where preserving multiple age classes; no carryover biomass from year to year - more similar to salmon.

Recommendations for shrimp assessment

- Investigate combining state fishery-independent surveys; develop region-wide, comprehensive approach; then pursue rigorous evaluation.
    - Recommended as next appropriate step.
    - Convene workshop with individuals who conduct state fishery-independent indices and individuals with experience combining indices.
- Could develop stoplight or ARIMA trends approach; bring surveys together in a consistent framework that can be updated every year; would have quantitative, more rigorous approach to manage shrimp stocks; seems to be what is needed for management in short term.
- Management and assessment must occur within season.
    - States are able to apply a variety of methods quickly.
    - Current federal temperature based trigger can operate quickly.
- Improve or develop other management triggers (environmental or population level) similar to current temperature trigger; need to identify parameters and appropriate levels.
- Compare fishery-independent and fishery-dependent data; how did fishery/population respond?
- Further research and field testing of more complex models (length/stage based) worthwhile for long term.

2.6.2 Shrimp Bycatch Estimation Method Best Practices

Shrimp bycatch estimation is important for finfish stock assessments because it is a potential source of mortality (could be significant for some finfish species) and it can be a potential indicator of finfish abundance particularly for many federally managed species in the South Atlantic that lack traditional young of the year indices. During the workshop two methods were identified to estimate shrimp bycatch: the ratio method and the BCPUE method.

The panel determined the ratio method was NOT the preferred method for bycatch estimation and noted it should be phased out as the fishery effort time series becomes more reliable. However it was noted that a slightly modified version of this is used in the Gulf of Mexico to get effort estimates. The following issues were identified as potential problems with the ratio method.

- Difficult to separate fishing trends from fish population trends.
- Shrimp and fish populations are often on different trends. Unless there is a correlation between shrimp and the species of interest, should not use the ratio method.
- Should only use the ratio method when you have fishery-independent indices for shrimp and the fish species of interest so the ratio can be scaled.

The panel identified the BCPUE method as the preferred method for bycatch estimation. It provides a better measure but needs a reliable effort time series. Based on the discussions at this workshop, there seems to be the potential to fill gaps in the effort time series to produce more reliable estimates. When applying this method if observer sample size is not adequate to calculate BCPUE and fishery-independent data must be used to scale/extrapolate BCPUE estimates, it is important to understand how representative the fishery independent data are of the fishing activities and patterns of the commercial fishery. Panelists also noted it was important to incorporate regulatory information into bycatch estimates and that it would be helpful to develop regulatory histories for each South Atlantic state.

Future Work