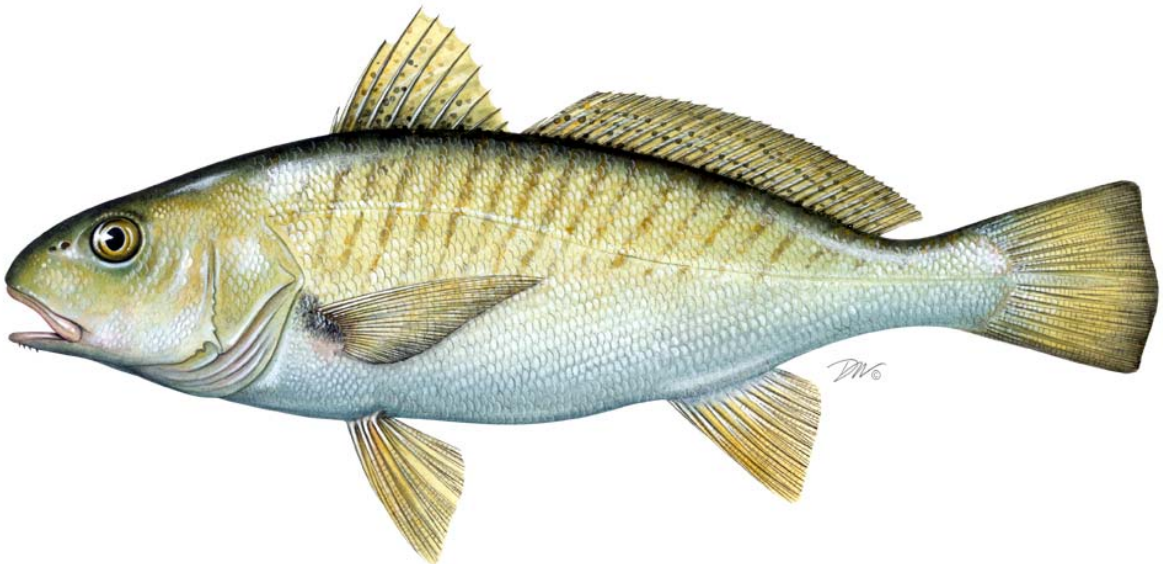
# Atlantic States Marine Fisheries Commission

*2017 Atlantic Croaker Stock Assessment Peer Review*



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**Vision: Sustainably Managing Atlantic Coastal Fisheries**

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*2017 Atlantic Croaker Stock Assessment Peer Review*

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Prepared by the
ASMFC Atlantic Croaker and Spot Stock Assessment Review Panel

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# Executive Summary

The Atlantic croaker, *Micropogonias undulatus*, is a demersal sciaenid common in estuarine and nearshore waters from the Gulf of Maine to Argentina. Along the U.S. Atlantic coast, the species is abundant between Indian River Lagoon, Florida, and Chesapeake Bay and supports important commercial and recreational fisheries in both the South Atlantic Bight (NC to FL) and Mid-Atlantic Bight (NY to VA). Atlantic croaker are migratory along the Atlantic coast and genetic studies indicate a single stock for Atlantic coast. The management area for Atlantic croaker is the Atlantic coast from New Jersey to Florida, from inshore estuarine waters seaward to the boundary of the Exclusive Economic Zone.

The majority of annual removals for Atlantic croaker were discards from the shrimp trawl fishery, followed by commercial landings and recreational harvest. From 1989-2014, total annual removals of Atlantic croaker from all fishery sources (landings and discards) ranged from 101,132 to 519,449 metric tons. Removals, while annually variable, have been relatively stable since the series peak in 1991, ranging from approximately 125,000 to 225,000 metric tons. The relative stability of total removals in the mid-1990s coincides with the requirement of bycatch reduction devices (BRDs) across shrimp trawl fisheries. The long term mean annual removals was 193,621 metric tons. Annual discards from the shrimp trawl fishery ranged from 82,040 to 513,801 metric tons with a long term mean of 179,873 metric tons. Shrimp trawl bycatch accounted for 81-99% of annual Atlantic croaker removals and averaged 91.6% of all removals. Indices of relative abundance suggest biomass of adult Atlantic croaker generally increased from the mid-1990s to the late 2000s, but decreased somewhat in the most recent years. Surveys of juveniles suggest substantial annual variability without clear trends.

The current stock status of Atlantic croaker could not be determined because the assessment results were sensitive to certain modeling assumptions, particularly those regarding fishery and survey gear selectivity (i.e., commercial fleet, NMFS/Northeast Fisheries Science Center fall groundfish trawl survey). In the base model configuration, selectivity in all fisheries and surveys was estimated to be strongly dome-shaped. This configuration allowed the model to estimate a substantial increase in 'cryptic biomass' of spawners and a corresponding decrease in fishing mortality, which allowed biomass estimates that indicated a healthy stock status (i.e. not overfished; no overfishing). However, the magnitude of this increase in abundance was not corroborated by the available length and age composition data, which indicated a static if not declining population. During the Review Workshop, the Panel requested and evaluated plausible alternative model configurations, including asymptotic selectivity, that indicated current stock status was both overfished and undergoing overfishing.

Although the current stock status could not be inferred with confidence, the Panel noted the base model and all sensitivity runs evaluated suggested the spawning biomass was increasing. Therefore, the Panel agreed that recent removals are likely sustainable (i.e., unlikely to result in further depletion of Atlantic croaker), and no immediate management actions are required.

Until a new assessment is conducted and uncertainties addressed, monitoring of abundance indices, fishery removals, and age/length composition should continue. If new information suggests the stock could be declining, a new assessment should be expedited.

The Panel noted the uncertainty of the stock assessment outcome was due to inherent data uncertainties, and to conflicting information regarding population trends contained in the various data components. The Panel agreed the assessment included the best available information, all significant removals were incorporated, the data analyses conducted were based on current best practices, the structure and application of the assessment model was reasonable, and that important uncertainties were identified and explored. The Panel commended the analytical team for their expertise, professionalism, and comprehensive understanding and communication of the model inputs and results.

## Terms of Reference

1. **Evaluate the thoroughness of data collection and the presentation and treatment of fishery-dependent and fishery-independent data in the assessment, including the following but not limited to:**
    a. **Presentation of data source variance (e.g., standard errors).**
    b. **Justification for inclusion or elimination of available data sources,**
    c. **Consideration of data strengths and weaknesses (e.g., temporal and spatial scale, gear selectivities, aging accuracy, sample size),**
    d. **Calculation and/or standardization of abundance indices.**

The Review Panelists commended the analytical team for their concise and comprehensive presentation of the data inputs used in the stock assessment. The panelists agreed the written report and summary presentations were unusually complete which greatly facilitated evaluation.

All major sources of removals of Atlantic croaker were described including: commercial and recreational landings and discards, the scrap (bait) fishery (NC and VA), and bycatch from the southern shrimp trawl fishery and the mid-Atlantic gill net and trawl fin fisheries. Five relative indices of abundance from fishery-independent surveys were used in base and sensitivity models including: the NMFS/Northeast Fisheries Science Center fall groundfish trawl survey (NMFS), the Southeast Area Monitoring and Assessment Program (SEAMAP) coastal trawl survey, the Virginia Institute of Marine Science juvenile trawl survey in Chesapeake Bay (VIMS), the North Carolina Pamlico Sound Survey (NC195), and the Chesapeake Bay Monitoring and Assessment Program (ChesMMAP) trawl survey. While biological information (e.g. length composition, age composition) from all of the survey programs were used in the base model, the relative index developed from the ChesMMAP survey was excluded (for reasons described below). The base model was also fit to effort estimates for the southern shrimp trawl fishery. The assessment period was 1989-2014. This timeframe was used because fishery dependent and independent data sets were more widely available. The Panelists noted that important removals began much earlier than 1989. Therefore, it may be useful to attempt to recover or estimate historical removals to improve initial estimates of depletion in the stock assessment.

The justification for inclusion or elimination of available data sources was evaluated, particularly criteria for inclusion of abundance indices. A total of 35 fishery-independent surveys that encountered Atlantic croaker were considered during the assessment. Of all the surveys, only five met most of the criteria for inclusion. The criteria included the length and continuity of the time series, the spatial scale (e.g. population-wide/regional/local) and the constancy of survey methodologies. The Panelists agreed the index selection criteria were adequate and correctly applied. Some potential data sources were not considered during the assessment, including fishery-dependent catch rate indices and annual effort estimates from the commercial and recreational fleets. It was not mandatory to include these inputs in the assessment, and some reviewers would not recommend including fishery-dependent indices in assessment models when high-quality fishery-independent indices are available. However, the availability of fishery catch-per-unit-effort (CPUE) indices may have facilitated interpretation of the commercial and recreational catch series in the context of increasing stock biomass predicted by the assessment model. I.e., catch in many of the fisheries has been decreasing while the indices of abundance have been increasing. Typically, catches increase with increasing population abundance.

All but one of the indices of relative abundance were developed using a statistical standardization (e.g., delta-logormal, negative-binomial). The exception was the NMFS/Northeast Fisheries Science Center fall groundfish trawl survey which was a non-standardized, nominal index developed from stratified design-based estimates. The Panelists noted that many expert reviewers endorse this approach, but also suggested that a standardized index be developed for future assessments, and that the sensitivity of the model results to these alternative approaches be considered.

Data strengths and weaknesses – such as temporal and spatial scale, gear selectivities, ageing accuracy, sample size – were described in the stock assessment report, and input directly in the stock assessment when possible (sample sizes, annual estimates of variance by data source, ageing imprecision and otolith reader error). Known and assumed changes in gear selectivity due to size limits or different proportions of gear types in the commercial fishery were modeled using time-varying parameters. Annual estimates of variance for each data source were available and used in the base model to scale the uncertainty of annual estimates within each data source, and to inform initial weightings of the various data components. Final relative weightings of the model components were computed using an automated reweighting procedure (Francis 2011). Although these are standard and supported practices for stock assessment, the Panelists expressed concerns that the determination of stock status was quite sensitive to the weightings of the various data components (e.g., survey indices, length and age composition) and recommended future assessments consider criteria to better evaluate the reliability of each model component. See TOR 3-c below for more detail.

Atlantic croaker are a major component of Atlantic coast scrap (bait) landings. Quantifying the amount of croaker landed as scrap fish along the Atlantic coast is problematic due to the limited availability of sampling data. The Panel agreed the methods used in the assessment appear reasonable, but noted the resulting estimates from the scrap fishery are quite uncertain due to the number of required assumptions. However, as the magnitude of scrap landings is very small relative to total croaker removals, the Panel agreed the assessment is not likely to be sensitive to these assumptions.

## 2. Evaluate methods used to develop discard and bycatch estimates.

Estimates of Atlantic croaker discard rates in South Atlantic shrimp trawl fisheries were developed using discard rate data from the Shrimp Trawl Observer Program to estimate the magnitude of discard rates and the SEAMAP Trawl Survey to estimate the trend of discards prior to (1989-2000) and during the observer program (2001-2014). Discard rate estimates were then applied to effort data from state trip ticket programs and the South Atlantic Shrimp System (SASS) to estimate total discards in these fisheries from 1989-2014 following the methods used by Walter and Isley (2014). Discard rates were applied to effort estimates summarized by "strata" (combinations of factors included in the model). Because there were no observer data before Bycatch Reduction Devices (BRDs) were required in the penaeid shrimp fishery, discard estimates prior to 1997 were adjusted for the reduction in catch due to the required use of certified BRDs on observed tows. Adjustments were based on a weighted average of Atlantic croaker catch reductions in the Gulf of Mexico shrimp trawl fishery estimated depending on the distance of fisheye BRDs from tie-off rings (Helies et al. 2009).

Discards from the Mid-Atlantic gill net and trawl fisheries were estimated using observer data from the Northeast Fisheries Science Center's Northeast Fisheries Observer Program (NEFOP) and At-Sea Monitoring Program (ASM). Annual ratios of observed discarded Atlantic croaker to observed landings of all species by gillnets and bottom trawls were calculated, then applied to reported gillnet and bottom trawl landings of all species to estimate total discards of croaker.

The Panelists recognized that discard/bycatch estimates are unusually uncertain due to data insufficiencies, but agreed the method used to develop estimates of croaker bycatch from the southern shrimp trawl fishery was current, supported, and similar (or identical) to methods used in SEDAR assessments of South Atlantic king mackerel, and Gulf of Mexico red snapper, king mackerel, gray triggerfish and domestic sharks. The Panel also agreed the method used to estimate Atlantic croaker discards from the commercial and recreational fisheries were acceptable given the available data, and the relatively small contribution of these discards to the total removals.

## 3. Evaluate the methods and models used to estimate population parameters (e.g., F, biomass, abundance) and biological reference points, including but not limited to:

The Atlantic croaker assessment used a state-of-the-art forward-projecting length-based, age-structured model (Stock Synthesis (SS) text version 3.24y). SS has been simulation tested, and is widely used in the United States and internationally. With a few exceptions noted below, the Panelists agreed the base model configuration and parameterization were appropriate to capture the primary biological dynamics and differences in fleet characteristics (e.g., selectivity, catchability).

The base model configuration suggested an extremely depleted stock in 1989 (<3% of unfished biomass) which experienced a rapid increase in spawning biomass through the time series, mostly due to reduced effort/fishing mortality in the shrimp fishery, and recovered to a healthy stock status by 2014 (not overfished, not undergoing overfishing). To evaluate the plausibility of this outcome, the Panelists requested and explored alternative model configurations (see TOR 4-a below). Noting the assessment results were quite sensitive to certain assumptions, the Panel made several recommendations for future assessments:

a. **Evaluate the choice and justification of the preferred model(s). Was the most appropriate model (or model averaging approach) chosen given available data and life history of the species?**

The Panel noted the initial stock depletion is often difficult to estimate, particularly when significant but largely uncertain removals occur before the initial year of the model (1989). The model may be more stable with a recent starting year when more data sources are available. However, to improve the characterization of initial depletion, the Panelists recommended an attempt be made to recover/estimate the magnitude of total removals that occurred before 1989, as far back to the unfished condition as feasible.

b. **If multiple models were considered, evaluate the analysts' explanation of any differences in results.**

The Stock Synthesis was the single primary model put forth as part of the Atlantic croaker assessment. No secondary models were included in the assessment report. A non-equilibrium Schaefer form of the surplus production model (ASPIC) for was run during development of the croaker assessment but not put forth as a supporting model. The Panel requested and were provided with the ASPIC croaker model results at the Review Workshop. The model used two fishery-independent surveys, the fall portions of the NMFS and SEAMAP trawl surveys, as well as the complete time series of harvest data. Coast-wide total harvest was calculated in weight (mt) from 1989-2014 from commercial and recreational landings, recreational discards, commercial discards from mid-Atlantic gillnet and trawl fisheries, landings from the scrap/bait fishery, and bycatch from the shrimp trawl fishery.

Both the ASPIC and SS models estimated similar trends; average biomass increased over the time series while total fishing mortality declined. The base ASPIC model indicated that current fishing mortality on Atlantic croaker appears to be sustainable, and it is not likely that overfishing is occurring or that the stock is overfished in recent years. However, the Panel observed these determinations were sensitive to the assumed initial biomass, which could not be reliably estimated.

c. **Evaluate model parameterization and specification (e.g., choice of CVs, effective sample sizes, likelihood weighting schemes, calculation/specification of M, stock-recruitment relationship, choice of time-varying parameters, plus group treatment).**

The Panelists noted that some selectivity and retention parameters were poorly estimated (i.e., very large standard variations, and values that do not move away from initial guesses). To improve the estimation of parameters the panel recommended:

- Assume an asymptotic selectivity function (e.g., logistic) for at least one fleet/survey to improve the estimation of selectivity and retention parameters for all fleets.
- When poorly estimated (as determine by large asymptotic standard errors or failure to move from starting values), consider fixing retention parameters at reasonable values (e.g., knife-edged retention at size limit)
- Consider a "super-year" approach to estimate the annual discards of fleets that are characterized by large uncertainty and variability. Fit to the average discards over specified years, but allow annual estimates to be informed by an effort series.
- Consider aggregating fisheries with small removals and similar selectivity patterns to reduce the number of parameters that require estimation without sufficient data to support those estimations.
- The Panelists noted SS model results are often quite sensitive to assumptions regarding the growth function and variability in length-at-age, and recommended further exploration the relationship between the coefficient of variation and age/length and reader error/bias.
- The Panel also made several general recommendations:
    - Poorly estimated parameters – unusually large standard deviations, or final values unchanged from initial guess – should be identified and addressed to the extent possible. In addition to the recommendations above, the Panel also recommended estimating the 'problem parameters' separately in the final phase of estimation.
    - Bounded growth, selectivity, and retention parameters should be addressed since they degrade model performance, and can influence model results.
    - Model reweighting should not be attempted until the model fits have been optimized (see recommendations above). The reweighting coefficients (model component weightings) should be examined to determine their acceptability, and set to sensible values if expert opinion suggests the coefficients derived from the statistical reweighting are implausible. For example, when variability of all model components is greatly inflated, or better known components are downweighted in favor of other less certain components.

4. **Evaluate the diagnostic analyses performed, including but not limited to:**

   a. **Sensitivity analyses to determine model stability and potential consequences of major model assumptions**

A range of sensitivity analyses were conducted to explore how results from the base Stock Synthesis model responded to alternative assumptions. Overall, the range of sensitivity diagnostics conducted by the assessment team was reasonable. The Review Panel recommended additional sensitivity analyses around the shapes of the selectivity function for some fleets and additional sensitivity runs for the Coefficients of Variation (CVs) and effective sample sizes of the data. The Stock Synthesis model was quite sensitive to the assumed shape of the selectivity pattern for the commercial fleet. The model with dome-shaped selectivity estimated that biomass was substantially above the overfished reference point, while a model with logistic (asymptotic) selectivity estimated biomass to be substantially below the overfished reference point.

The model was also quite sensitive to the amount of observation error (CVs and effective sample sizes) for the indices, size compositions, and size-age compositions. The sensitivities are likely caused by substantial differences in the indices with regard to how much the stock has increased since the beginning of the time series. The NMFS trawl survey indicates about a 15X increase in biomass (1990-1993 average 1.75 kg/tow; 2011-2014 average 25.7 kg/tow), whereas the SEAMAP trawl survey indicates about a 2.5X increase in biomass (1990-1993 average 1.3 kg/tow; 2011-2014 average 3.2 kg/tow). The model has a very difficult time reconciling the two trends. The CVs for both surveys should be increased as the model interprets the CVs as representing the total error between observed CPUE and stock size rather than just the precision of the CPUE estimate. However, increasing CVs for the indices does not completely solve the problem.

The base model results were low to moderately sensitive to assumptions about the value of shrimp trawl bycatch in 1991, the discard mortality for shrimp trawl bycatch, recreational discard mortality, inclusion of indices, and steepness. Although there is a substantial amount of uncertainty around recreational discard mortality, it did not have a substantial effect on the estimates. The discard mortality for shrimp trawl bycatch had a larger effect than the recreational discard mortality because shrimp trawl bycatch is a much larger fraction of removals than recreational discards.

   b. **Retrospective analysis**

Retrospective analyses were conducted by the assessment team for the base Stock Synthesis model. The model had a moderate retrospective pattern for biomass in which the biomass estimates were lower, on average, in the terminal year after new data were added. In contrast, there was relatively little retrospective pattern for fishing mortality.

5. **Evaluate the methods used to characterize uncertainty in estimated parameters. Ensure that the implications of uncertainty in technical conclusions are clearly stated.**

The assessment primarily used asymptotic standard errors to estimate the uncertainty in model estimates. Profiling over the likelihood may have been helpful for better understanding the uncertainty associated with certain key parameters such as the steepness of the stock-recruitment relationship.

6. **Recommend best estimates of stock biomass, abundance, and exploitation from the assessment for use in management, if possible, or specify alternative estimation methods.**

The Review Panel does not recommend using specific estimates of stock biomass, abundance, and exploitation for management because of the sensitivity of the model to several key assumptions. Changing the shape of the selectivity curve for the commercial fishery led to very large changes in estimated biomass and stock status. The Panel and Stock Assessment Subcommittee were not able to develop a new base model during the Review Workshop that they believed would provide reliable estimates of biomass, abundance, or fishing mortality.

Despite the inability to arrive at a new base model, several patterns seem clear from the data:

1) The indices of abundance for croaker appear to be increasing across most of the stock's range.
2) Catch appears to be stable or declining over time.
3) The combination of these two patterns indicates that it is likely that fishing mortality rates have also declined over time such that the relative status of the stock in the most recent years is likely better than it was in the late 1980s – early 1990s.
4) Shrimp fishery effort and croaker bycatch magnitude appear to be declining. The Stock Assessment Subcommittee should consider adding shrimp bycatch estimates to annual Traffic Light analyses. The new estimates of shrimp bycatch are a notable improvement from previous croaker assessments and should be reviewed annually given their substantial contribution to overall croaker removals and mortality.

7. **Evaluate the choice of reference points and the methods used to estimate them. Recommend stock status determination from the assessment, or, if appropriate, specify alternative methods/measures.**

Because of the uncertainty in the scale of biomass and fishing mortality, the Review Panel does not recommend specific values for reference points. Additionally, given that models with alternative plausible selectivity assumptions resulted in very different estimates of stock status, stock status cannot be determined reliably at this time.

Going forward, the Review Panel recommends using Spawning Potential Ratio (SPR) reference points for management because the stock-recruitment parameters for calculating maximum sustainable yield (MSY) reference points did not appear to be well estimated.

8. **Review the research, data collection, and assessment methodology recommendations provided by the TC and make any additional recommendations warranted. Clearly prioritize the activities needed to inform and maintain the current assessment, and provide recommendations to improve the reliability of future assessments.**

The Panel thoroughly reviewed the research recommendations identified by the Technical Committee, in addition to noting addition research and data collection needs. Following discussions with the SASC at the Review Workshop, the Panel worked closely with the SASC chair to refine and prioritize a final set of research recommendations, adapted from the stock assessment report and provided here as High or Medium Priorities, within Short-term vs. Long-term research categories.

<u>Short term:</u>

HIGH PRIORITY

- Increase observer coverage for commercial discards, particularly the shrimp trawl fishery. Develop a standardized, representative sampling protocol for observers to use to increase the collection of individual lengths and ages of discarded finfish.

- Describe the coast-wide distribution, behavior, and movement of croaker by age, length, and season, with emphasis on collecting larger, older fish.

MEDIUM PRIORITY

- Conduct studies of discard mortality for recreational and commercial fisheries by each gear type in regions where removals are highest.

- In the recreational fishery, develop sampling protocol for collecting lengths of discarded finfish and collect otolith age samples from retained fish.

- Encourage fishery-dependent biological sampling, with proportional landings representative of the distribution of the fisheries. Develop and communicate clear protocols on truly representative sampling.

Long term:

HIGH PRIORITY

- Continue state and multi-state fisheries-independent surveys throughout the species range and subsample for individual lengths and ages. Ensure NEFSC trawl survey continues to take lengths and ages. Examine potential factors affecting catchability in long-term fishery independent surveys.

- Quantify effects of BRDs and TEDs implementation in the shrimp trawl fishery by examining their relative catch reduction rates on Atlantic croaker.

- Continue to develop estimates of length-at-maturity and year-round reproductive dynamics throughout the species range. Assess whether temporal and/or density-dependent shifts in reproductive dynamics have occurred.
- Re-examine historical ichthyoplankton studies for an indication of the magnitude of estuarine and coastal spawning, as well as for potential inclusion as indices of spawning stock biomass in future assessments. Pursue specific estuarine data sets from the states (NJ, VA, NC, SC, DE, ME) and coastal data sets (MARMAP, EcoMon).

MEDIUM PRIORITY

- Investigate environmental covariates in stock assessment models, including climate cycles (e.g., Atlantic Multi-decadal Oscillation, AMO, and El Nino Southern Oscillation, El Nino) and recruitment and/or year class strength, spawning stock biomass, stock distribution, maturity schedules, and habitat degradation.

- Utilize NMFS Ecosystem Indicators bi-annual reports to consider folding indicators into the assessment; identify mechanisms for how environmental indicators affect the stock

- Encourage efforts to recover historical landings data, determine whether they are available at a finer scale for the earliest years than are currently reported.

- Collect data to develop gear-specific fishing effort estimates and investigate methods to develop historical estimates of effort.

- Develop gear selectivity studies for commercial fisheries with emphasis on age 1+ fish.

- Conduct studies to measure female reproductive output at size and age (fecundity, egg and larval quality) and impact on assessment models and biomass reference points

- Develop and implement sampling programs for state-specific commercial scrap and bait fisheries in order to monitor the relative importance of Atlantic croaker. Incorporate biological data collection into program.

- Investigate the relationship between estuarine nursery areas and their proportional contribution to adult biomass. I.e., are select nursery areas along Atlantic coast ultimately contributing more to SSB than others, reflecting better quality juvenile habitat?

**9. Recommend timing of the next benchmark assessment and updates, if necessary, relative to the life history and current management of the species.**

A benchmark stock assessment is recommended in five years. No assessment updates are called for given challenges with the current model, and the existing annual use of Traffic Light analyses. Despite uncertainty in the assessment model results and an inability to confidently determine stock status, trends in landings and indices do not indicate immediate cause for concern, and therefore do not call for a subsequent new stock assessment in the short-term.

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