FISHERY MANAGEMENT PLAN UPDATE
ATLANTIC CROAKER
AUGUST 2020

STATUS OF THE FISHERY MANAGEMENT PLAN

Fishery Management Plan History

Original FMP Adoption:	October 1987
Amendments:	Amendment 1 – November 2005 Addendum I – March 2011 Addendum II – August 2014 Addendum III – February 2020
Revisions:	None
Supplements:	None
Information Updates:	None
Schedule Changes:	None
Next Benchmark Review:	2022

The original Fishery Management Plan (FMP) for Atlantic croaker was adopted in 1987 and included states from Maryland through Florida (ASMFC 1987). Upon review of the FMP, the South Atlantic State/Federal Fisheries Management Board (here after referred to as the Board) determined that the management recommendations were vague and that an amendment was needed to better define the management measures necessary to achieve the FMP goals. The Interstate Fisheries Management Program Policy Board adopted the finding that the original FMP did not contain any management measures that states were required to implement (ASMFC 2014).

In 2002, the Board directed the Atlantic Croaker Technical Committee to conduct the first coast wide stock assessment in preparation for an amendment. The stock assessment was developed in 2003 and approved by a Southeast Data Assessment Review panel for use in management in June 2004. Amendment 1 was approved in November 2005 and fully implemented by January 1, 2006 (ASMFC 2005).

Amendment 1 expanded the original management area to include the states of Delaware and New Jersey and defined two management regions: the mid-Atlantic region which included states from New Jersey through North Carolina and the south-Atlantic region, which included states from South Carolina through the east coast of Florida (ASMFC 2005).

Amendment 1 established biological reference points to define the overfished and overfishing stock statuses for the mid-Atlantic region only. Amendment 1 did not require specific measures to restrict recreational or commercial harvest, though states with more conservative measures in place were encouraged to maintain those regulations. Amendment 1 also specified that, through adaptive management, the Board may revise Amendment 1. Regulatory and/or monitoring requirements could be included in the resulting addendum along with procedures for determining *de minimis* status and implementing alternative management programs via conservation equivalency.

Amendment 1 specified triggers for assessment of the stock in non-assessment years. However, if the technical committee felt there was sufficient evidence of changes in the stock, a stock assessment could be initiated in the absence of hitting the triggers. The triggers considered by the technical committee were:

1. Relative percent change in landings
    a. A stock assessment will be triggered if the most recent year's commercial landings are less than 70 percent of the previous two year's landings.
    b. A stock assessment will be triggered if the most recent year's recreational landings are less than 70 percent of the previous two year's average landings.
2. Biological Data Monitoring:
    a. The technical committee will compare the most recent year's mean length data from the recreational fishery to the average of the last two years' mean lengths.
    b. The technical committee will compare the most recent year's mean size (length and weight) data from the commercial fishery to the average of the last two years' mean size data.
    c. The technical committee will monitor the overall age composition (proportion at age) and calculate the mean size at age for the age groups that are present in the state samples.
3. Effort vs. [commercial] Landings
    a. Catch Per Unit Effort (CPUE) considerations for the near future: as effort data increases in quality, the trigger should change from a commercial landings basis to commercial CPUE by gear type. At this time, the technical committee will monitor effort (e.g. trips or days fished) vs. landings, on a gear type basis, to track parallel trends.
4. The technical committee will continue to derive a Marine Recreational Information Program (MRIP) CPUE, on a directed trip basis, to examine state-by-state catch rates on an annual basis.
5. State and regional surveys

Addendum I to Amendment 1 was initiated in August 2010 to modify the management area and biological reference points for Atlantic croaker, based on the updated 2010 stock assessment. The assessment evaluated the Atlantic croaker population as a single coast wide stock, whereas Amendment 1 divided the coast into two management regions. To fully utilize the stock assessment in managing the population, Addendum I consolidated the stock into one management unit and established a procedure by which the Board could approve peer-reviewed

biological reference points without a full administrative process such as an amendment or addendum (ASMFC 2011).

Addendum II to Amendment 1 was initiated in February 2014 and approved in August 2014. Addendum II establishes the use of the Traffic Light Approach (TLA) as a precautionary management framework (Caddy and Mahon 1995; Caddy 1998, 1999; Caddy 2002). The TLA is preferred because with fast-growing, early maturing species like Atlantic croaker it is more important to respond to multi-year trends rather than annual changes. The TLA more effectively illustrates long term trends than the triggers established by Addendum I. The management framework utilizing the TLA replaces the management triggers as stipulated in Addendum I (ASMFC 2014). The harvest component of the TLA is a composite of commercial and recreational harvest data and the population, or adult abundance, component is a composite of fishery independent survey indices (e.g., Northeast Fishery Science Center (NEFSC) and Southeast Area Monitoring and Assessment Program (SEAMAP)). If thresholds for both population characteristics meet or exceed thresholds for a three-year period, management measures are triggered. The TLA is reviewed annually in July.

In February 2020, the Board approved Addendum III to Amendment 1, which revised the TLA's trigger mechanism and management response for the recreational and commercial fisheries (ASMFC 2020). Under Addendum III, management action is triggered if harvest and abundance thresholds within a regional or coastwide TLA analysis are met or exceeded for any three of the four terminal years. If management action is triggered, the coastwide response includes recreational bag limits and quantifiable measures to achieve percent reductions in commercial harvest. Response requirements vary depending on which threshold is exceeded. Addendum III also defines the mechanism by which triggered management actions may be removed, after abundance characteristics are no longer triggering management action.

The North Carolina Wildlife Federation submitted a petition for rulemaking on November 2, 2016 and a modification to the petition on January 12, 2017. The petitioner put forth seven rules to designate nursery areas, restrict gear and seasonality in the shrimp trawl fishery to reduce bycatch of fish (including spot, Atlantic croaker and weakfish), and establish an eight-inch minimum size limit for spot and a 10-inch minimum size limit for Atlantic croaker. At its February 2017 business meeting, the North Carolina Marine Fisheries Commission passed a motion to approve the petitioned rules to begin the rulemaking process. Upon review by the Office of State Budget and Management it was determined that sufficient state funds are not available to implement the proposed rule changes without undue detriment to the agency's existing activities and the rules were never adopted.

To ensure compliance with interstate requirements, North Carolina also manages Atlantic croaker under the North Carolina Fishery Management Plan for Interjurisdictional Fisheries (IJ FMP). The goal of the IJ FMP is to adopt fishery management plans, consistent with N.C. law, approved by the Mid-Atlantic Fishery Management Council, South Atlantic Fishery Management Council, or the ASMFC by reference and implement corresponding fishery regulations in North Carolina to provide compliance or compatibility with approved fishery management plans and amendments, now and in the future. The goal of these plans, established under the Magnuson-Stevens Fishery Conservation and Management Act (federal council) and

the Atlantic Coastal Fisheries Cooperative Management Act (ASMFC) are similar to the goals of the N.C. Fisheries Reform Act of 1997 to "ensure long-term viability" of these fisheries (NCDMF 2015).

Management Unit

New Jersey through the east coast of Florida.

Goal and Objectives

The goal of Amendment 1 is to utilize interstate management to perpetuate the self-sustaining Atlantic croaker resource throughout its range and generate the greatest economic and social benefits from its commercial and recreational harvest and utilization over time. The four objectives of Amendment 1 are to:

- Manage the fishing mortality rate to provide adequate spawning potential to sustain long-term abundance of the population.
- Manage the stock to maintain the spawning stock biomass above the target biomass levels and restrict fishing mortality to rates below the threshold.
- Develop a management program for restoring and maintaining essential habitat.
- Develop research priorities that will further refine the management program to maximize the biological, social, and economic benefits derived from the population.

STATUS OF THE STOCK

Life History

Atlantic croaker (*Micropogonias undulatus*) inhabit marsh, submerged aquatic vegetation, mud and sand-bottom areas (Odell et al. 2017) from the Gulf of Maine to Argentina, but are most abundant from the Chesapeake Bay to northern Florida. However, the center of Atlantic croaker distribution is forecast to shift northward due to climate change (Hare et al. 2010). Atlantic croaker feed on shrimp, crabs, worms, shellfish and small fishes (Powers et al. 2005; Nye et al. 2011). Atlantic croaker has a protracted spawning season beginning in the early fall and extending through December with a peak during September and October (White and Chittenden 1977; Barbieri et al. 1994). Eggs and recently hatched larvae spawned in ocean waters drift toward land and the advanced larval stages and juveniles continue their migration inshore by actively swimming into estuarine nursery areas (Odell et al. 2017). Maximum recruitment (the number of fish entering the population) of juveniles is usually in the spring, with movement to offshore waters in the fall (Haven 1959; Norcross and Austin 1988). Higher overwinter survival of juvenile Atlantic croaker has been linked to increased winter water temperatures (Hare and Able 2007; Morley et al. 2016).

Atlantic croaker grow quickly, and can reach sizes of over 20 inches (Ross 1988). Most Atlantic croaker are mature by the end of their first year (White and Chittenden 1977; Barbieri et al. 1994; ASMFC 2010), with length at 50 percent maturity generally falling from seven to nine inches total length (Barbieri et al. 1994; ASMFC 2010). While it is uncommon to see Atlantic croaker over age 10 (NCDMF 1999; Bobko et al. 2003), the oldest observed specimen, caught in the Chesapeake Bay Multispecies Monitoring and Assessment Program (ChesMMAP), was 17 years.

Stock Status

A benchmark stock assessment was completed in 2017 but did not pass peer review and was not recommended for use in management (ASMFC 2017). As a result, the stock status with relation to overfished and overfishing is unknown. The peer review panel did not identify any major problems in the fishery that would require immediate management action and recommended continued use of the TLA to monitor the stock (ASMFC 2017, 2019).

For reference, the most recent stock assessment accepted for use in management was completed in 2010 (ASMFC 2010). Results of the 2010 stock assessment indicated the population was not experiencing overfishing and was likely not overfished. The assessment indicated biomass had been increasing and the age-structure of the population had been expanding since the late 1980s. Biological reference points in the 2010 stock assessment are ratio based. Overfishing is occurring if F/F_{MSY} is greater than 1 and the stock is considered overfished if $SSB/(SSB_{MSY}(1-M))$ is less than 1.

To evaluate the status of the stock between stock assessments, the TLA established under Addendum II and revised under Addendum III, is reviewed annually in years when an assessment is not already being conducted. The name comes from assigning a color (red, yellow, green) to categorize relative levels of indicators on the condition of the population (abundance metric) or fishery (harvest metric). For example, as harvest or abundance decrease, the amount of red in that year becomes more predominant.

Under the TLA configuration established under Addendum II, management was not triggered in 2018 since both the harvest and adult abundance characteristics were not above the 30 percent threshold for the 2016-2018 time period (ASMFC 2019; Figures 1-3). However, the harvest index has generally indicated a declining trend while the adult abundance index has indicated an increasing or stable trend. The NEFSC survey was not conducted in 2017 due to mechanical problems with the RV Bigelow. The three-year average of 2014-2016 values was imputed to estimate the 2017 value for this index. While not used for management decisions, the composite juvenile abundance index consisting of North Carolina Program 195 and Virginia Institute of Marine Science (VIMS) trawl survey data is reviewed annually. The index has been variable since 1989 with some indication of increases in abundance since 2010.

Stock Assessment

A benchmark stock assessment, completed in 2017, did not pass peer review and will not be used for management. The assessment was not recommended for management because of concern over uncertainty in biomass estimates due to conflicting signals among abundance indices and

catch time series as well as sensitivity of model results to assumptions and model inputs (ASMFC 2017, 2019). The review panel noted that discard estimates from the shrimp trawl fishery was an improvement from the last assessment and recommended shrimp trawl discard estimates be incorporated into annual monitoring using the TLA.

STATUS OF THE FISHERY

Current Regulations

There are no commercial or recreational regulations for Atlantic croaker in North Carolina.

Commercial Landings

Four gear types (gill nets, fly nets, flounder trawl, and haul seines) are used in directed commercial trips and harvest of Atlantic croaker, and account for approximately 99% of the total commercial landings. Since 1994, the North Carolina Trip Ticket Program (NCTTP) has collected data on the commercial harvest of Atlantic croaker. From 1989 through 2019 commercial harvest in North Carolina ranged from 1,007,963 to 14,429,197 pounds, with the lowest landings occurring in 2017 (Table 1; Figure 4). Commercial harvest averaged 6,534,767 pounds from 1989 through 2019 and has generally been declining since 2003 with significant landings declines beginning in 2007. Commercial landings are currently supported primarily by consistent landings in the ocean gill net fishery due to effort declines in the fly net and haul seine fisheries (Figure 5). In 2019, there were no landings of Atlantic croaker from fly nets. Atlantic croaker are a component of the scrap or bait fishery in North Carolina but this component generally makes up a small percentage of landings.

Recreational Landings

Atlantic croaker are targeted recreationally by shore based anglers and those fishing from private vessels during the summer and fall. Recreational estimates across all years have been updated and are now based on the Marine Recreational Information Program (MRIP) Fishing Effort Survey-based calibrated estimates. For more information on MRIP see https://www.fisheries.noaa.gov/topic/recreational-fishing-data. From 1989 through 2019 recreational harvest of Atlantic croaker in North Carolina ranged from 164,644 to 1,749,275 pounds and has generally been declining since 2014 with the lowest harvest occurring in 2018 (Table 1; Figure 4). In 2019, recreational anglers harvested 224,337 pounds of Atlantic croaker (651,268 individuals). From 1989 through 2019, the number of releases averaged 4,093,964 individuals, with 3,634,211 releases in 2019.

The number of Atlantic croaker measured during MRIP sampling has generally been declining (Table 2). Mean total length (TL) in 2019 was 9.0 inches and has fluctuated little since 1989. Similarly, minimum and maximum TL have fluctuated little since 1989. In 2019, modal length in the recreational harvest was 9.0 inches TL with few fish over 10.0 inches harvested (Figure 6). The recreational fishery did harvest Atlantic croaker between 5.0 and 7.0 inches TL which are size classes that are not caught or make up a small percentage of landings in the commercial fishery. Most of the recreational catch consists of fish from 6.0 to 10.0 inches TL with little

change in length composition since 1989 (Figure 7). However, in the 90's and early 2000's there were a wider range of lengths harvested in the recreational fishery.

Harvest data from the Recreational Commercial Gear License (RCGL) were collected from 2002 to 2008. The program was discontinued in 2009 due to lack of funding. From 2002-2008, an average of 14,534 pounds were harvested per year (Table 3).

MONITORING PROGRAM DATA

Fishery Dependent Monitoring

The number of Atlantic croaker lengths obtained from commercial fish house sampling from 1994 through 2018 ranged from 3,771 in 2018 to 32,293 in 1996 (Table 4). Mean TL varied little ranging from 9.4 inches to 12.1 inches and has generally declined since 2005. Minimum TL ranged from 3.0 inches to 7.4 inches. Maximum TL ranged from 15.2 inches to 20.0 inches. Bait samples are included in calculations of mean, minimum and maximum length.

In 2019, modal length in the commercial fishery was 9.5 inches TL and only a few fish harvested were over 10.5 inches TL (Figure 6). In general, the commercial fishery harvested a narrower range of sizes compared to the recreational fishery but also harvested larger fish. The length composition and modal length of fish caught in the commercial fishery (excluding bait samples) generally increased from 1994 through the early 2000's and has contracted and declined recently (Figure 8).

Fishery Independent Monitoring

The number of Atlantic croaker aged in North Carolina from 1996 through 2019 has ranged from 237 in 2011 to 1,070 in 2014 (Table 5). Modal age was one or two in most years. However, modal age was zero in 2008, 2016, and 2017 and five in 2007. Minimum age was zero in every year while maximum age ranged from six to 15 years. Maximum age was between 11 and 15 years from 2001-2010 and between six and ten from 2011-2019. There is significant overlap in length at age, though mean length tends to plateau at age seven (Figure 9).

The Pamlico Sound Survey (P195) samples 54 stations (grids) annually in June and September. Stations are randomly selected from strata based upon depth and geographic location. Tow duration is 20 minutes, using double rigged demersal mongoose trawls (9.1 m headrope, 1.0 X 0.6 m doors, 2.2-cm bar mesh body, 1.9-cm bar mesh cod end and a 100-mesh tailbag extension). Data from this survey is used to produce juvenile abundance indices (JAI) that are incorporated into ASMFC stock assessments and reported annually to ASMFC as part of compliance reports and for incorporation into the juvenile composite TLA. The Atlantic croaker juvenile abundance index from the Pamlico Sound Survey (June only, fish <140 mm, 5.5 inches) from 1987 through 2019 has been variable, and since 2009 there has been significant annual fluctuations (Figure 10). The JAI has ranged from 67 individuals per tow in 1996 to 1,175 individuals per tow in 2010. The JAI increased to 1,111 individuals per tow in 2019, which is a 711% percent increase from the 2018 JAI. The 2018 JAI was the 15th lowest value in the time series and the 2019 JAI

is the fourth highest value in the time series. The mean JAI over the 33-year time series is 365 individuals per tow.

Most Atlantic croaker captured in the Pamlico Sound Survey are juveniles (age-0), but because of the protracted spawning and recruitment period, the length composition of Atlantic croaker captured in the survey can be variable. There is more variability in length compositions of Atlantic croaker caught in the June portion of the survey compared to the September portion of the survey (Figure 11). Modal length in June is generally 3.0 to 5.0 inches while modal length in September is around 5.0 inches with little fluctuation between years.

MANAGEMENT STRATEGY

Per Addendum II to Amendment 1, the TLA is used as a precautionary management framework for Atlantic croaker. The TLA provides guidance in lieu of a current stock assessment. Under this management program, if the amount of red in the Traffic Light for both population characteristics (adult abundance and harvest) meet or exceed the threshold for the specified three-year period, then management action is required. Management triggers were not tripped in 2018 since both population characteristics (harvest and abundance) were not above the 30 percent threshold for the 2016-2018 time period. In February 2020, the Board approved Addendum III which revises the TLA and requires coastwide management action if harvest and abundance thresholds are exceeded in three of the four most recent years (ASMFC 2020). See Table 6 for a summary of management strategies.

RESEARCH NEEDS

There are no research or monitoring programs required of the states except for the submission of an annual compliance report. However, several coastwide and state specific research recommendations have been identified and ranked through the ASMFC FMP and stock assessment process and include (ASMFC 2017, 2019):

- 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 – HIGH (Ongoing through NCDMF ongoing through NCDMF fishery dependent sampling)
- Describe the coastwide distribution, behavior, and movement of croaker by age, length and season, with emphasis on collecting larger, older fish – HIGH (Ongoing through NCDMF fishery dependent and independent sampling)
- Continue state and multi-state fisheries independent surveys throughout the species range and subsample for individual lengths and ages. Examine potential factors affecting catchability in long term fishery independent surveys – HIGH (Ongoing through NCDMF fishery independent sampling)
- Quantify effects of BRDs and TEDs implementation in the shrimp trawl fishery by examining their relative catch reduction rates on Atlantic croaker – HIGH (Ongoing through NCDMF fishery dependent sampling)
- Continue to develop estimates of length at maturity and year round reproductive dynamics throughout the species range. Assess whether temporal or density dependent shrifts in reproductive dynamics have occurred – HIGH (Ongoing in North Carolina)

- 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, MD) and coastal data sets (MARMAP, EcoMon) - HIGH (Needed)
- Conduct studies of discard mortality for recreational and commercial fisheries by each gear type in regions where removals are highest – MEDIUM (Needed)
- In the recreational fishery, develop sampling protocol for collecting lengths of discarded finfish and collect otolith age samples from retained fish – MEDIUM (Needed)
- Encourage fishery dependent biological sampling, with proportional landings representative of the distribution of the fisheries. Develop and communicate clear protocols on truly representative sampling – MEDIUM (Ongoing through NCDMF fishery dependent sampling)
- Investigate environmental covariates in stock assessment models including climate cycles (e.g., Atlantic Multi-decadal Oscillation, AMO, and El Niño Southern Oscillation, El Niño) and recruitment and/or year class strength, spawning stock biomass, stock distribution, maturity schedules and habitat degradation – MEDIUM (Needed)
- Utilize NMFS Ecosystem Indicators bi-annual reports to consider folding indicators into the assessment; identify mechanisms for how environmental indicators affect the stock – MEDIUM (Needed)
- Encourage efforts to recover historical landings data, determine whether they are available at a finer scale for the earliest years than are currently reported – MEDIUM (Needed)
- Collect data to develop gear specific fishing effort estimates and investigate methods to develop historical estimates of effort – MEDIUM (Ongoing through NCDMF fishery dependent sampling)
- Develop gear selectivity studies for commercial fisheries with emphasis on age 1+ fish – MEDIUM (Needed)
- 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 – MEDIUM (Needed)
- Develop and implement sampling programs for state specific commercial scrap and bait fisheries to monitor the relative importance of Atlantic croaker. Incorporate biological data collection into programs – MEDIUM (Ongoing through NCDMF fishery dependent sampling)
- Investigate the relationship between estuarine nursery areas and their proportional contribution to adult biomass, i.e., are select nursery areas along the Atlantic coast ultimately contributing more to SSB than other, reflecting better quality juvenile habitat? – MEDIUM (Needed)

LITERATURE CITED

ASMFC (Atlantic States Marine Fisheries Commission). 1987. Fishery Management Plan for Atlantic croaker. Washington (DC): ASMFC. Fishery Management Report No. 10. 90 pp.

ASMFC. 2005. Amendment I to the Interstate Fishery Management Plan for Atlantic croaker. Washington (DC): ASMFC. Fishery Management Report No. 44. 92 pp.

ASMFC. 2010. Atlantic croaker 2010 Benchmark Stock Assessment. Washington (DC). 366 pp.

ASMFC. 2011. Addendum I to Amendment I to the Atlantic croaker Fishery Management Plan. Washington (DC). 7 pp.

ASMFC. 2014. Addendum II to Amendment I to the Atlantic croaker Fishery Management Plan. Arlington, VA. 7 pp.

ASMFC. 2017. 2017 Atlantic croaker stock assessment peer review. Arlington, VA. 14 pp.

ASMFC. 2019. 2019 Review of the Atlantic States Marine Fisheries Commission Fishery Management Plan for Atlantic croaker (*Micropogonias undulatus*). Arlington, VA. 19 pp.

ASMFC. 2020. Addendum III to Amendment 1 to the Interstate Fishery Management Plan for Atlantic croaker. Arlington, VA. 14 pp.

Barbieri L.R., M.E. Chittenden Jr., and S.K. Lowerre-Barbieri. 1994. Maturity, spawning, and ovarian cycle of Atlantic croaker, *Micropogonias undulatus*, in the Chesapeake Bay and adjacent coastal waters. Fishery Bulletin 92:671-685.

Bobko, S.J., C.M. Jones, and E.M. Robillard. 2003. Results of 2001 Virginia-Chesapeake Bay finfish ageing. VMRC/ODU Age and Growth Lab, Old Dominion University, Norfolk, VA. 67 pp.

Caddy, J.F. and R. Mahon. 1995. Reference points for fisheries management. FAO Fisheries Technical Paper No. 347, 50 p.

Caddy, J.F. 1998. A short review of precautionary reference points and some proposals for their us in data-poor situations. FAO Fisheries Technical Paper No. 379, 30 p.

Caddy, J.F. 1999. Deciding on precautionary management measures for a stock based on a suite of Limit Reference Points (LRPs) as a basis for a multi-LRP harvest law. NAFO Scientific Council Studies, 32:55-68.

Caddy, J.F. 2002. Limit reference points, traffic lights, and holistic approaches to fisheries management with minimal stock assessment input. Fisheries Research 56:133-137.

Hare, J.A., and K.W. Able. 2007. Mechanistic links between climate and fisheries along the east coast of the United States: explaining population outbursts of Atlantic croaker (*Micropogonias undulatus*). Fisheries Oceanography 16(1):31-45.

Hare, J.A., M.A. Alexander, M.J. Fogarty, E.H. Williams, and J.D. Scott. 2010. Forecasting the dynamics of a coastal fishery species using a coupled climate-population model. Ecological Application 20(2):452-464.

Haven, D.S. 1959. Migration of croaker, *Micropogonias undulatus*. Copeia 1:25-30.

Morley, J.W., R.D. Batt, and M.L. Pinsky. 2016. Marine assemblages respond rapidly to winter climate variability. Global Change Biology 23:2,590-2,601.

Norcross, B.L., and H.M. Austin. 1988. Middle Atlantic Bight meridional wind component effect on bottom water temperature and spawning distribution of Atlantic croaker. Continental Shelf Research 8(1):69-88.

NCDMF (North Carolina Division of Marine Fisheries). 1999. Shrimp and crab trawling in North Carolina's estuarine waters. Report to the North Carolina Marine Fisheries Commission, North Carolina Division of Marine Fisheries. 118 pp.

NCDMF. 2015. Fishery Management Plan for Interjurisdictional Fisheries: Information Update. North Carolina Department of Environmental Quality. North Carolina Division of Marine Fisheries. Morehead City, North Carolina. 85 pp.

Nye, J.A., D.A. Loewensteiner, and T.J. Miller. 2011. Annual, seasonal, and regional variability in diet of Atlantic croaker (*Micropogonias undulatus*) in Chesapeake Bay. Estuaries and Coasts 34(4):691-700.

Odell, J., D.H. Adams, B. Boutin, W. Collier II, A. Deary, L.N. Havel, J.A. Johnson Jr., S.R. Midway, J. Murray, K. Smith, K.M. Wilke, and M.W. Yuen. 2017. Atlantic sciaenid habitats: A review of utilization, threats, and recommendations for conservation, management, and research. Atlantic States Marine Fisheries Commission Habitat Management Series No. 14, Arlington, Va.

Powers, S.P., C.H. Peterson, R.R. Christian, E. Sullivan, M.J. Powers, M.J. Bishop, and C.P. Buzzelli. 2005. Effects of eutrophication on bottom habitat and prey resources of demersal fishes. Marine Ecology Progress Series 302:233-243.

Ross, S.W. 1988. Age, growth and mortality of the Atlantic croaker. Transactions of the American Fisheries Society 117(5):461-473.

White, M.L., and M.E. Chittenden Jr. 1977. Age determination, reproduction, and population dynamics of the Atlantic croaker, *Micropogonias undulatus*, Fishery Bulletin 75(1):109-123.

TABLES

Table 1. Atlantic croaker recreational harvest and number released (Marine Recreational Information Program) and commercial harvest (North Carolina Trip Ticket Program), 1989-2019. All weights are in pounds.

	Recreational				
	Numbers		Weight (lb)	Commercial	Total
Year	Landed	Released	Landed	Weight (lb)	Weight (lb)
1989	5,448,002	2,289,602	1,749,275	6,824,088	8,573,363
1990	2,298,692	3,298,860	722,352	5,769,512	6,491,864
1991	1,335,923	2,031,277	488,193	3,436,960	3,925,153
1992	1,836,941	2,565,212	556,026	2,796,612	3,352,638
1993	1,590,195	2,594,149	590,338	3,267,652	3,857,990
1994	1,921,848	4,302,429	557,403	4,615,754	5,173,157
1995	1,632,366	2,024,031	602,628	6,021,284	6,623,912
1996	1,224,357	2,051,175	564,016	9,961,834	10,525,850
1997	1,142,169	2,367,265	550,949	10,711,667	11,262,616
1998	865,487	2,038,932	376,255	10,865,897	11,242,152
1999	1,042,224	2,848,626	525,970	10,185,507	10,711,477
2000	860,246	3,475,554	394,037	10,122,627	10,516,664
2001	1,285,029	2,387,491	647,119	12,017,424	12,664,543
2002	1,265,031	2,218,039	651,611	10,189,153	10,840,764
2003	1,127,298	2,765,303	708,487	14,429,197	15,137,684
2004	1,218,206	3,407,280	683,113	11,993,003	12,676,116
2005	672,437	3,038,472	323,380	11,903,292	12,226,672
2006	1,376,403	6,381,434	498,741	10,396,554	10,895,295
2,007	1,058,663	3,933,603	336,486	7,271,162	7,607,648
2008	678,638	3,274,873	275,052	5,791,766	6,066,818
2009	958,128	5,623,278	359,703	6,135,437	6,495,140
2010	1,280,446	4,571,287	638,817	7,312,159	7,950,976
2011	873,659	7,005,152	360,390	5,054,186	5,414,576
2012	848,495	3,878,710	307,338	3,106,616	3,413,954
2013	1,300,804	6,729,556	453,881	1,927,938	2,381,819
2014	1,935,961	10,347,332	758,751	2,629,908	3,388,659
2015	1,437,019	9,632,560	557,735	1,819,070	2,376,805
2016	1,109,570	7,254,382	443,728	2,092,135	2,535,863
2017	666,930	4,631,445	237,160	1,007,963	1,245,123
2018	472,917	4,311,368	164,644	1,643,607	1,808,251
2019	651,268	3,634,211	224,337	1,277,829	1,502,166
Mean	1,335,979	4,093,964	526,062	6,534,767	7,060,829

Table 2. Total number measured, mean, minimum, and maximum length (inches) of Atlantic croaker measured by MRIP sampling in North Carolina, 1989-2019.

Year	Number Measured	Mean Length	Minimum Length	Maximum Length
1989	1,138	8.3	5.1	13.2
1990	1,066	8.3	4.3	15.5
1991	627	8.5	5.1	39.3
1992	535	8.5	4.6	13.2
1993	861	8.7	5.0	21.2
1994	2,065	8.6	4.8	15.6
1995	1,268	9.2	4.3	15.6
1996	1,169	10.0	5.3	16.7
1997	937	9.6	5.0	16.5
1998	599	9.3	6.0	16.7
1999	681	9.7	6.3	17.2
2000	360	9.6	6.7	17.6
2001	529	10.0	6.5	15.8
2002	255	9.7	6.0	15.0
2003	289	10.4	7.3	18.4
2004	263	10.1	7.0	17.4
2005	140	9.6	6.7	17.2
2006	198	8.8	4.8	14.9
2007	113	8.4	4.1	13.9
2008	188	9.4	4.3	15.4
2009	210	8.9	5.7	15.8
2010	330	9.8	6.2	16.8
2011	255	9.6	4.9	14.3
2012	230	9.2	4.9	14.1
2013	267	9.1	5.9	15.4
2014	215	9.1	4.1	14.1
2015	142	9.2	5.8	13.9
2016	219	9.3	6.3	13.2
2017	169	9.0	6.7	12.5
2018	119	8.9	6.5	19.1
2019	147	9.0	5.9	19.1

Table 3. North Carolina RCGL harvest of Atlantic croaker 2002-2008. Estimates of trips and landings are from a RCGL survey conducted from 2002-2008; funding was discontinued in 2009.

Year	Number Harvested	Pounds Harvested	Number Released	Total Catch
2002	50,132	36,392	33,253	83,386
2003	19,584	12,136	21,764	41,348
2004	22,858	13,956	24,134	46,992
2005	15,692	9,544	14,453	30,146
2006	11,975	7,328	37,970	49,946
2007	14,800	8,899	9,486	24,285
2008	18,080	13,480	10,480	28,560

Table 4. Mean length, minimum length, maximum length (inches), and total number of Atlantic croaker measured from North Carolina commercial fish house samples, 1994-2019. Bait samples are included in calculations of mean, minimum and maximum length.

Year	Mean Length	Minimum Length	Maximum Length	Number Measured
1994	9.4	3.0	15.2	20,151
1995	9.6	4.6	18.0	18,628
1996	10.8	2.5	18.3	32,293
1997	11.2	4.3	17.9	26,231
1998	11.6	3.7	19.7	22,583
1999	11.7	3.9	19.1	20,976
2000	11.6	3.9	19.8	29,023
2001	11.8	4.5	19.7	30,506
2002	11.9	5.1	19.7	21,985
2003	12.1	4.9	18.6	25,881
2004	12.0	3.9	20.0	23,330
2005	12.0	4.9	19.7	21,719
2006	11.4	4.7	19.2	20,533
2007	11.4	4.6	19.4	15,011
2008	11.1	4.6	19.5	15,032
2009	11.2	4.8	19.1	20,448
2010	11.2	5.0	17.8	21,511
2011	11.5	3.8	16.6	15,949
2012	11.2	5.7	17.9	10,923
2013	11.1	5.6	17.2	9,059
2014	10.4	4.4	16.7	11,523
2015	10.8	5.4	15.5	9,593
2016	10.7	7.4	15.2	6,959
2017	10.1	6.6	15.2	6,022
2018	10.4	6.2	15.2	3,771
2019	10.0	7.2	17.2	4,427

Table 5. Total number aged, modal, minimum, and maximum age of Atlantic croaker in North Carolina from fishery dependent and fishery independent sampling, 1996-2019. Includes otolith ages only. Age data from 2019 are preliminary.

Year	Modal Age	Minimum Age	Maximum Age	Total Number Aged
1996	2	0	6	836
1997	1	0	9	428
1998	1	0	9	1,030
1999	1	0	9	671
2000	1	0	9	815
2001	2	0	12	793
2002	1	0	11	605
2003	1	0	12	516
2004	2	0	13	681
2005	3	0	14	597
2006	1	0	13	658
2007	5	0	15	321
2008	0	0	15	739
2009	1	0	14	709
2010	4	0	13	703
2011	1	0	8	237
2012	2	0	7	349
2013	1	0	8	577
2014	2	0	8	1,070
2015	1	0	9	993
2016	0	0	6	474
2017	0	0	7	451
2018	1	0	8	544
2019	2	0	10	451

Table 6. Summary of management strategies and needs.

Management Strategy	**Implementation Status**
Revise Traffic Light to better reflect trends in the Atlantic croaker population	Addendum III to Amendment 1, approved February 2020.
Establish Traffic Light method for monitoring the stock in non-assessment years	Addendum II to Amendment 1, approved August 2014. Replaced triggers established by Amendment 1
Change management unit to single coast wide stock (New Jersey to east coast of Florida) and set new biological reference points	Addendum 1 to Amendment 1, approved March 2011
Establish triggers to be used in monitoring stock in non-assessment years ASMFC annual state compliance reports submitted in July each year	Amendment 1 to the Interstate Fisheries Management Plan for Atlantic croaker, approved November 2005
Promote the development and use of trawl efficiency devices (TEDs) through demonstration in the southern shrimp fishery, and fish separators in the finfish trawl fishery Promote increases in yield per recruit through delaying entry to croaker fisheries to age one and older Improve data collection to produce a stock assessment and improve management	Fishery Management Plan for Atlantic croaker, 1987 Ongoing
Encourage the use of circle hooks to minimize recreational discard mortality	Needed
Consider approval of *de minimis* requests from Delaware, South Carolina, Georgia, and Florida	Ongoing
Consider basic research and monitoring information needed for informed management in light of budgetary constraints	Ongoing

FIGURES

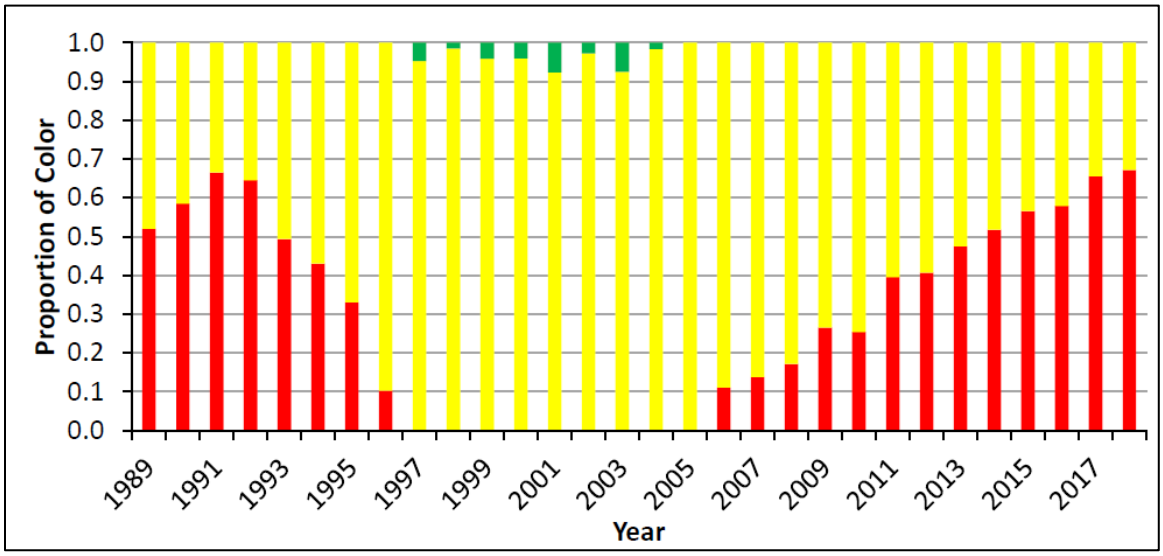

Figure 1. Annual color proportions for the harvest composite Traffic Light Analysis of Atlantic croaker recreational and commercial landings, 1989-2018 (ASMFC 2019). The reference period is 1996-2008.

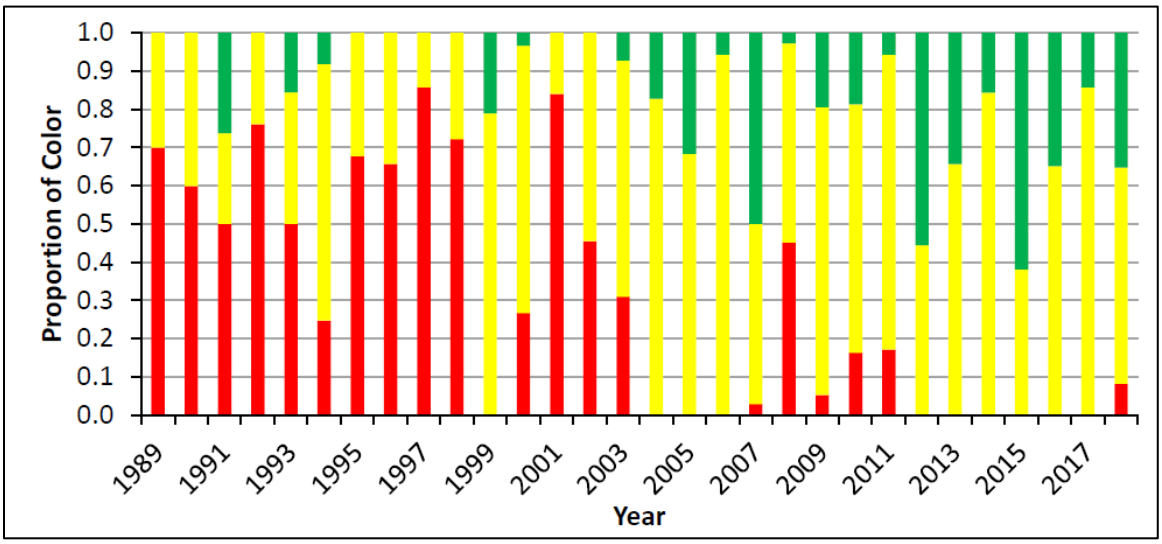

Figure 2. Annual color proportions for the adult Atlantic croaker Traffic Light Analysis composite characteristic index (NEFSC and SEAMAP surveys), 1989-2018 (ASMFC 2019). The NEFSC survey was not conducted in 2017 due to mechanical problems with the RV Bigelow. The three-year average of 2014-2016 values was imputed to estimate the 2017 value for this index. The reference period is 1996-2008.

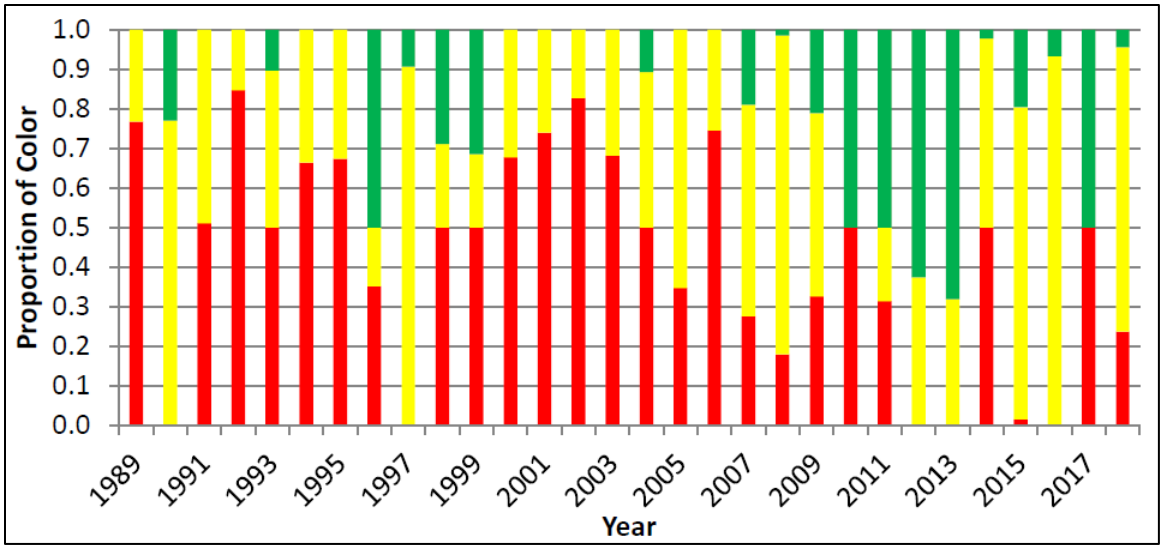

Figure 3. Annual color proportions for the juvenile Atlantic croaker Traffic Light Analysis composite characteristic index (Pamlico Sound Survey and Virginia Institute of Marine Science Survey), 1989-2018 (ASMFC 2019). Reference period is 1996-2008. Juvenile index does not trip management action.

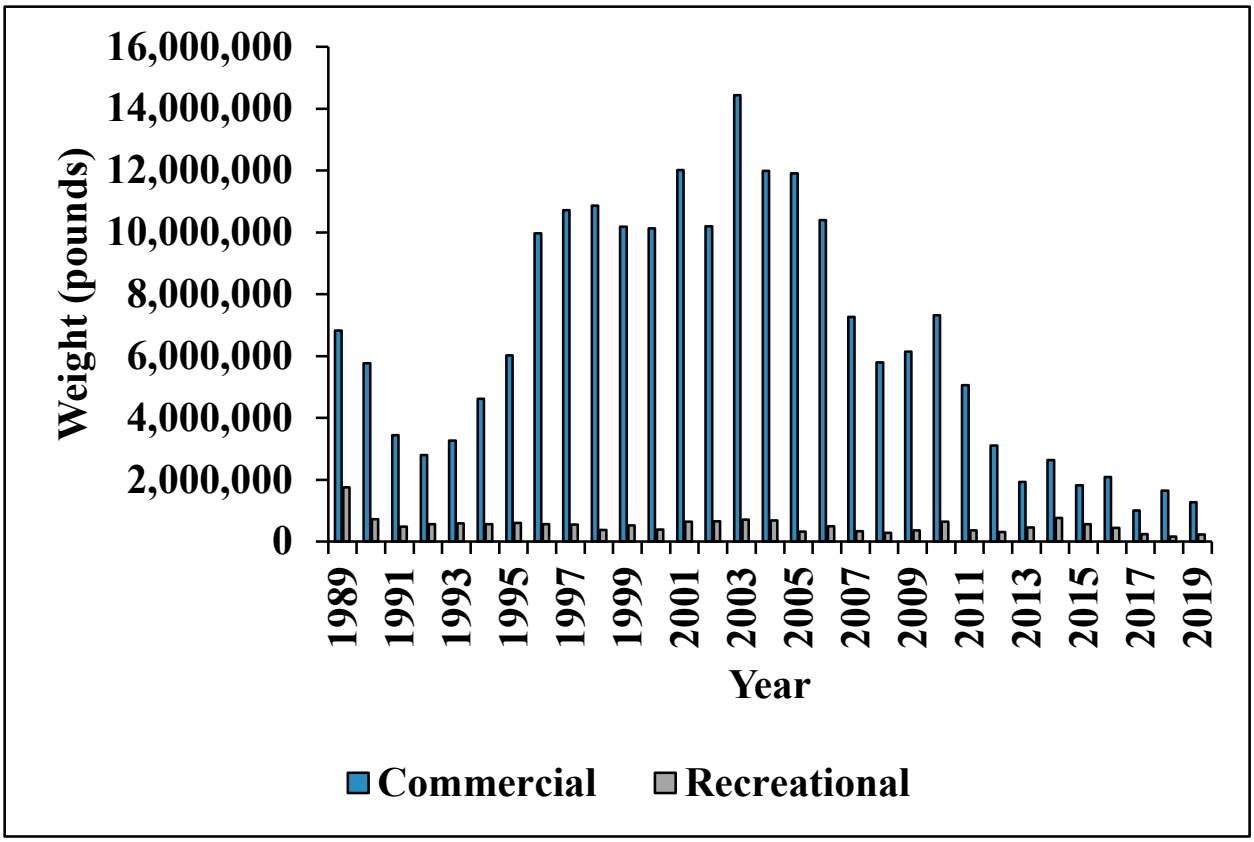

Figure 4. Annual commercial landings (1989-2019) and recreational (1989-2019) harvest in pounds for Atlantic croaker in North Carolina.

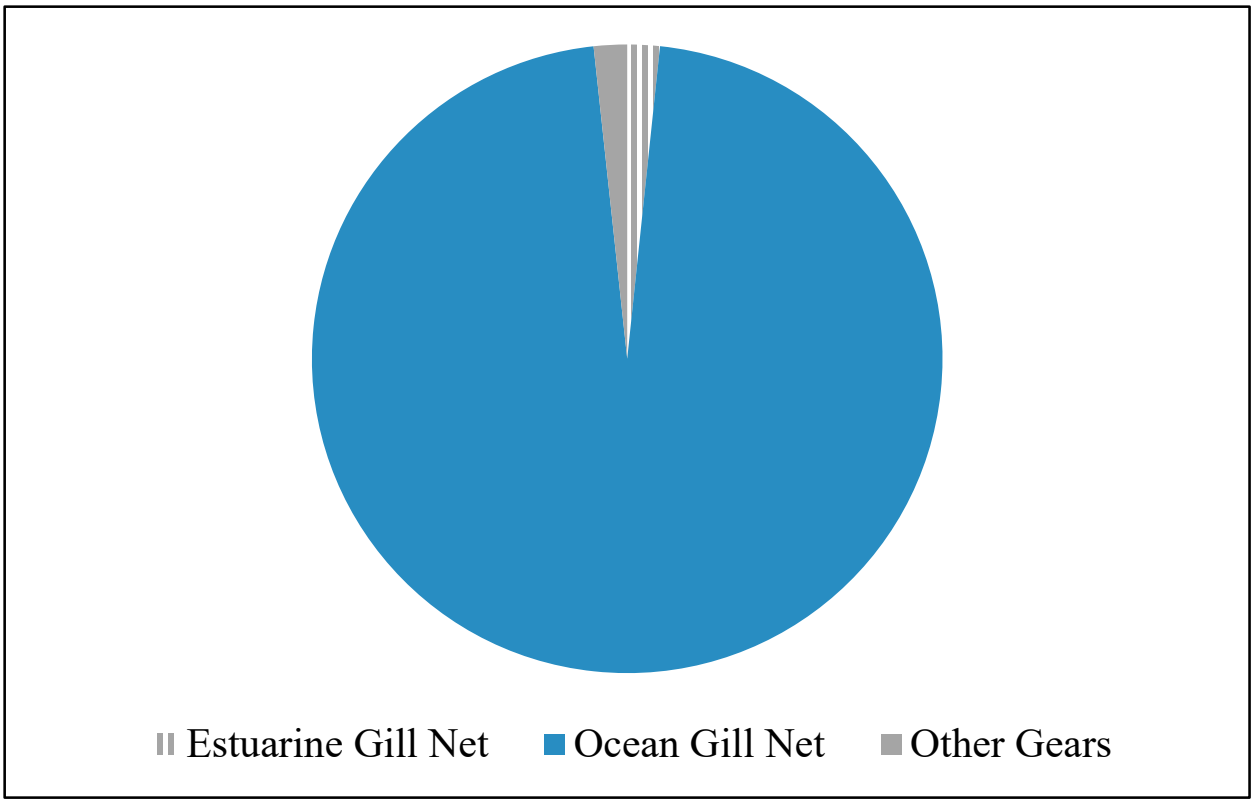

Figure 5. Commercial harvest of Atlantic croaker by gear, 2019. Other gears include flounder trawls, haul seines and pound nets. There were no flynet landings in 2019.

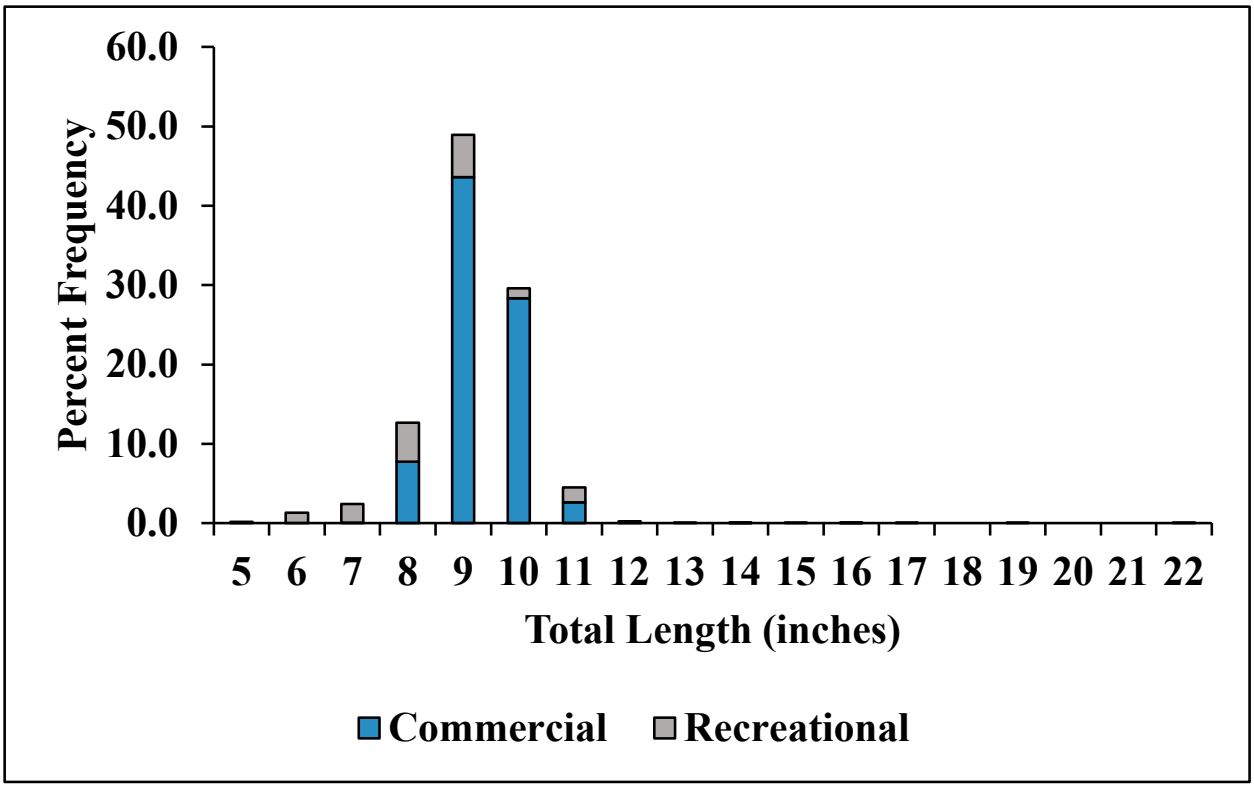

Figure 6. Commercial and recreational length frequency distribution from Atlantic croaker harvested in 2019.

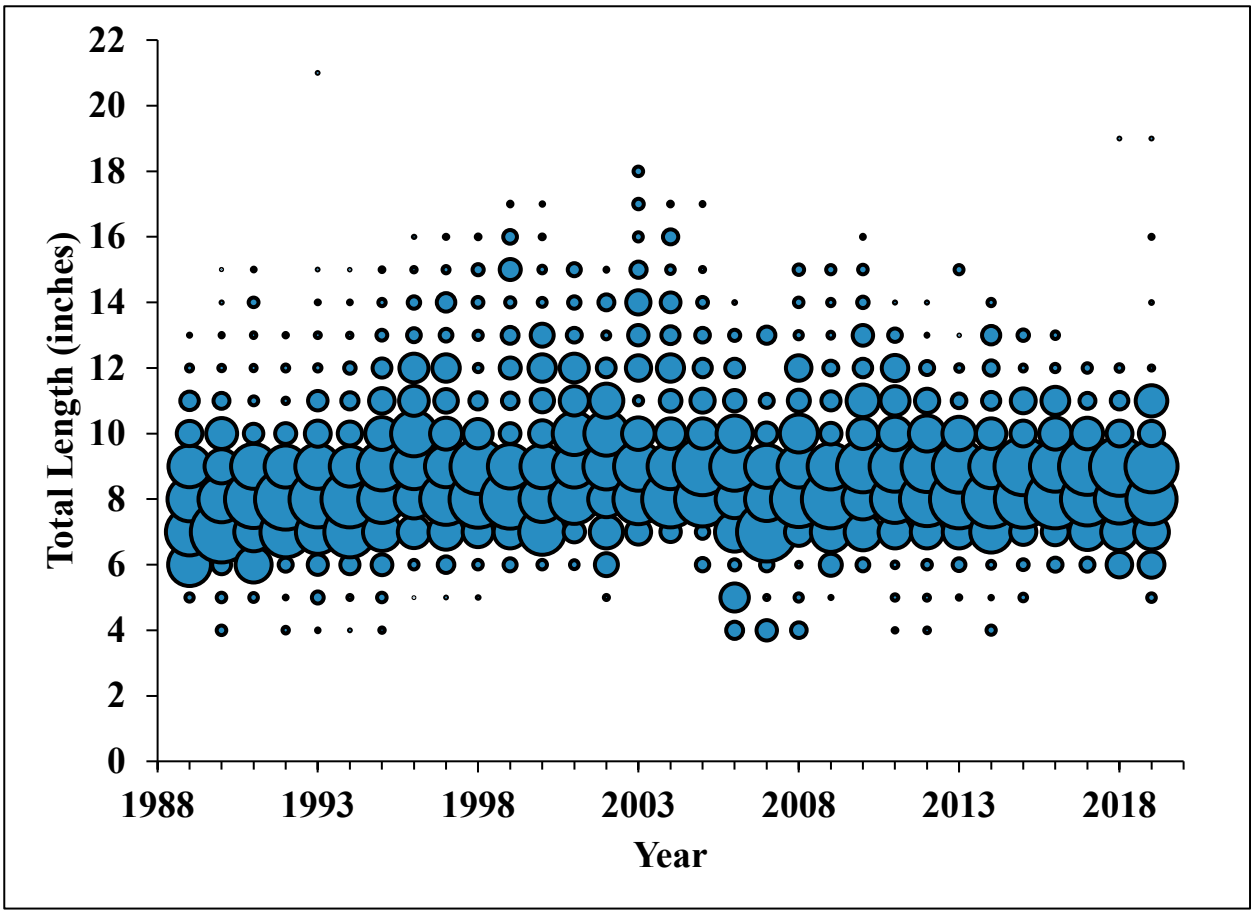

Figure 7. Recreational length frequency (total length, inches) of Atlantic croaker harvested from 1989-2019. Bubble represents the proportion of fish at length.

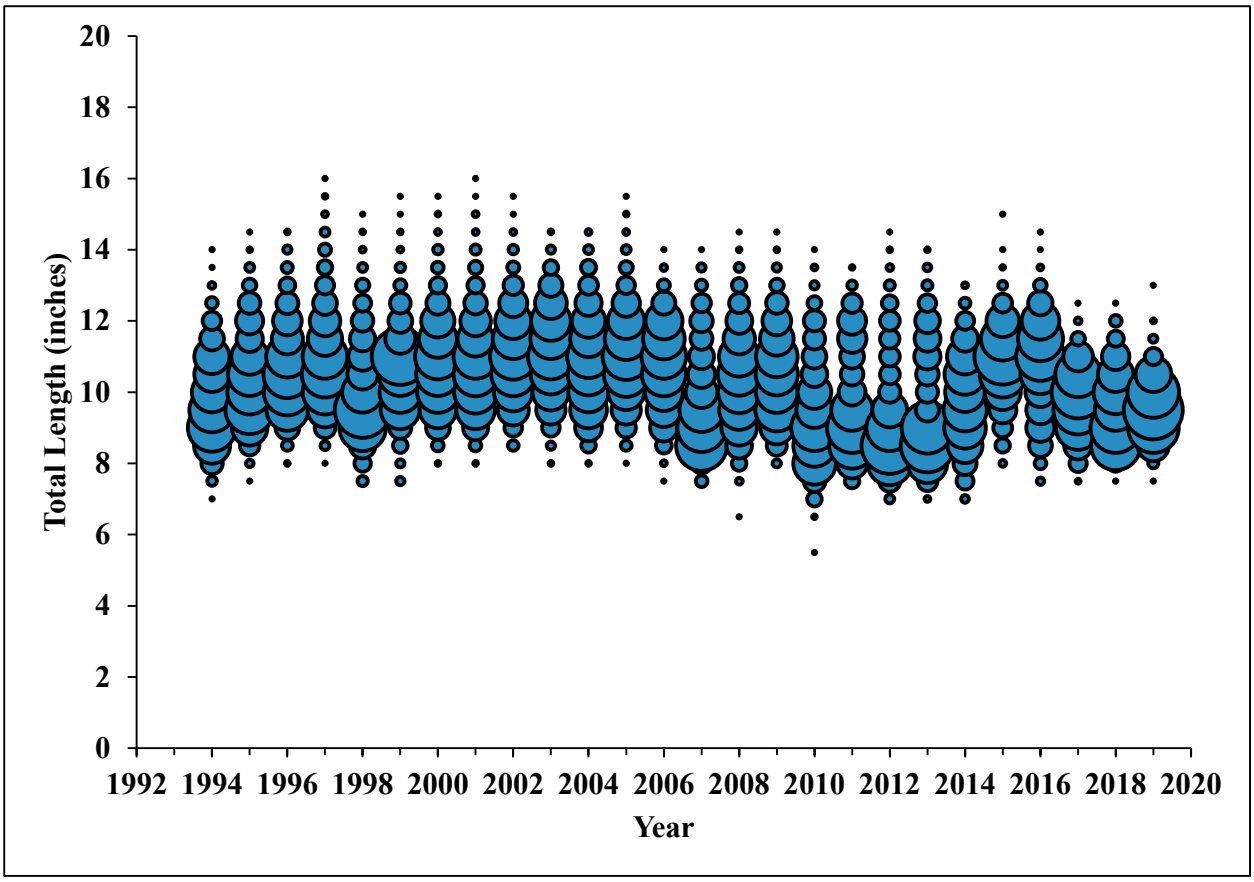

Figure 8. Commercial length frequency (total length, inches) of Atlantic croaker harvested from 1994-2019. Bubble represents the proportion of fish at length. Bait samples not included.

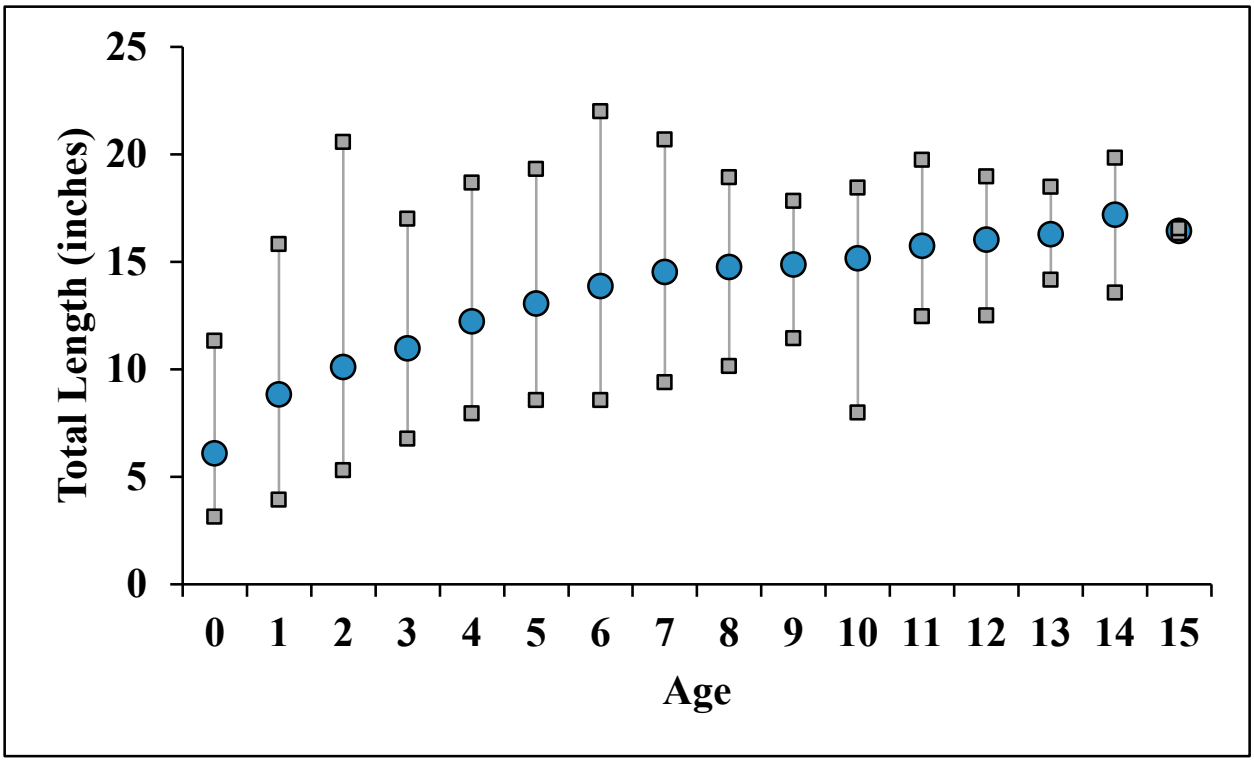

Figure 9. Atlantic croaker length at age based on all age samples collected from 1996 to 2019. Blue circles represent the mean size at a given age while the grey squares represent the minimum and maximum observed size for each age. Age data from 2019 are preliminary.

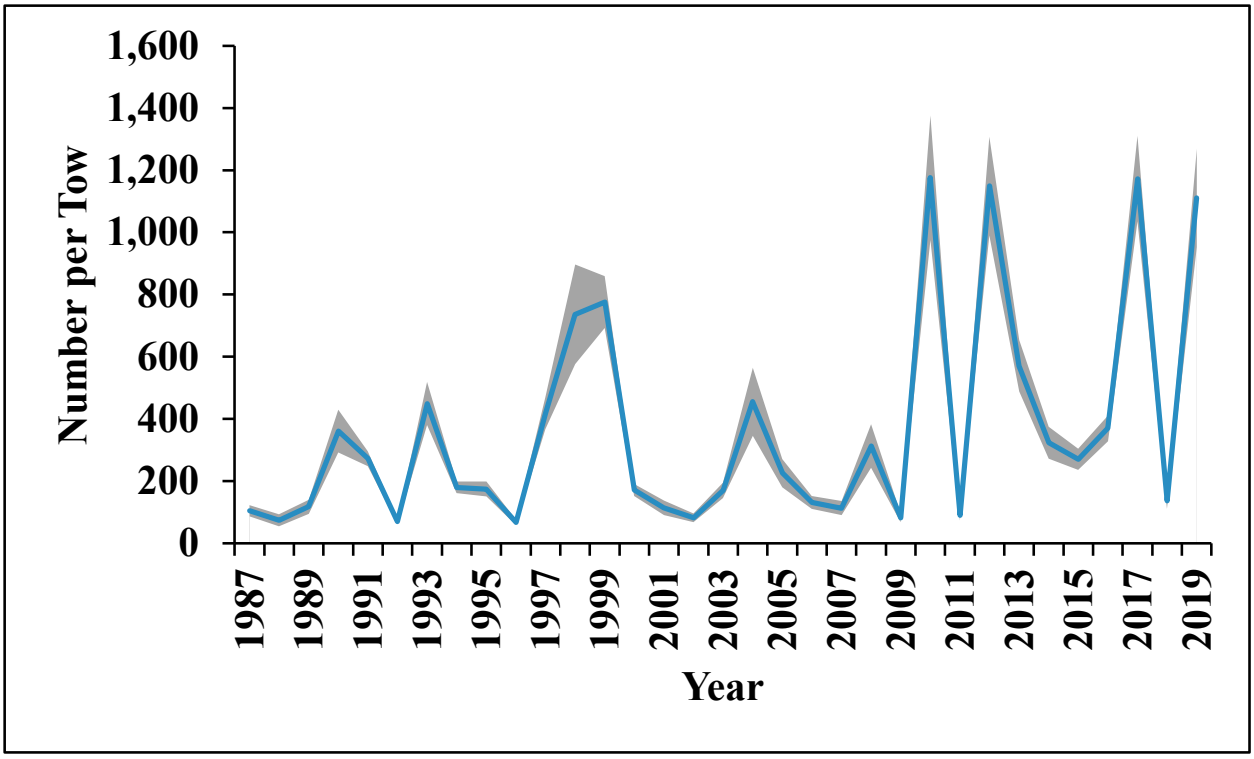

Figure 10. Atlantic croaker juvenile (<140 mm, 5.5 inches TL) abundance index (number per tow) for June from the Pamlico Sound Survey, 1987-2019. Shaded area represents standard error.

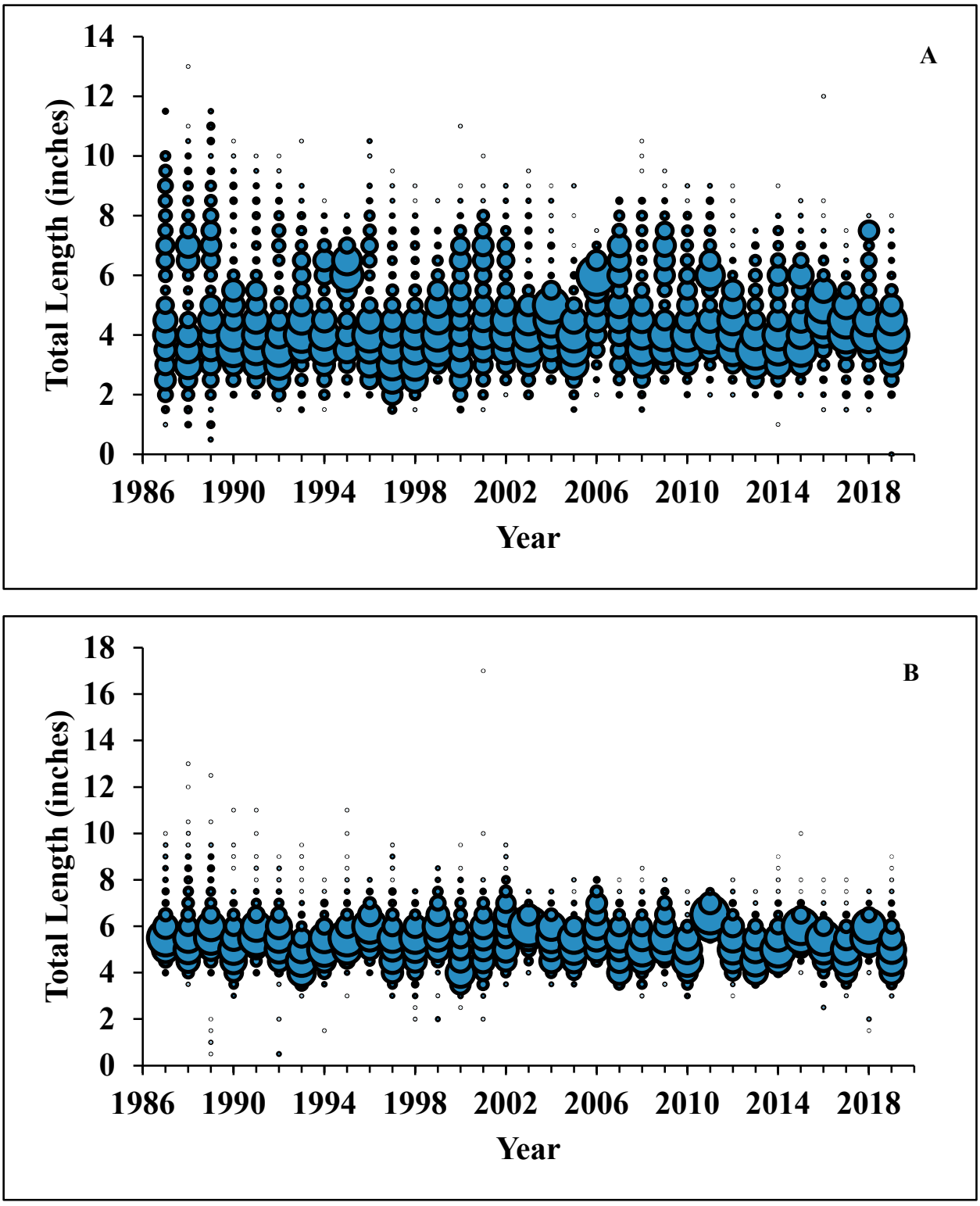

Figure 11. Length frequency of Atlantic croaker captured in Pamlico Sound Survey sampling during June (A) and September (B), 1987-2019.