North Carolina
Division of Marine Fisheries

2018 Fishery Management Plan Review

August 2019

INTRODUCTION

The Fishery Management Plan Review is a compilation of annual updates about state-managed, federally-managed, and Atlantic States Marine Fisheries Commission-managed species for which there are fishery management plans for North Carolina. The updates are based on data through the previous calendar year and the document is presented to the Marine Fisheries Commission at its annual August business meeting.

The Fishery Management Plan Review is an invaluable reference document and a resource for information about the latest status of fisheries occurring in North Carolina. The document is organized into two primary sections: state-managed species and Atlantic States Marine Fisheries Commission and federally-managed species. The latter section is further divided into species with and without North Carolina indices. If a species has a North Carolina index, it means there is North Carolina data that the federal Councils or Atlantic States Marine Fisheries Commission used in its respective plans.

There are currently 13 state fishery management plans, 12 of which are updated annually and included in this document. The remaining plan is the North Carolina Fishery Management Plan for Interjursdictional Fisheries. This plan adopts by reference management measures appropriate for North Carolina contained in approved federal Council or Atlantic States Marine Fisheries Commission fishery management plans.

These management measures are implemented by Marine Fisheries Commission rules to provide compliance or consistency with the approved plans and amendments. The goals of these plans, established under the Magnuson-Stevens Fishery Conservation and Management Act (federal Councils plans) and the Atlantic Coastal Fisheries Cooperative Management Act (Atlantic States Marine Fisheries Commission plans), are similar to the goals of the North Carolina Fisheries Reform Act of 1997 to "ensure long-term viability" of these fisheries. The state interjurisdictional plan reduces duplication of effort while meeting the requirements of North Carolina General Statute 113-182.1, Fishery Management Plans.

Each update in the Fishery Management Plan Review contains information about the:

- History of the plan;
- Management unit;
- Goal and objectives:
- Status of the stock;
- Status of the fishery, including current regulations and commercial and recreational landings;
- Monitoring program data, including dependent and independent monitoring;
- Management strategy;
- Management and research needs; and
- Recommendation on the timing for the next review of state plans.

UPDATES TO RECREATIONAL DATA

The Marine Recreational Information Program (MRIP) is a federal program that uses several surveys to estimate recreational catch and effort of saltwater anglers: Access Point Angler Intercept Survey (APAIS), Coastal Household Telephone Survey (CHTS), For-Hire Telephone Survey (FHS), and the Fishing Effort Survey (FES). North Carolina is an active participant in the MRIP. The APAIS survey obtains catch rate information and was improved in 2013 to sample throughout the day (24-hour coverage) and remove any potential bias by controlling the movement of field staff to alternative sampling sites. The FES replaced the CHTS in 2018 to address the concerns of under-coverage of the angling public, declining number of households using landline telephones, reduced response rates, and memory recall issues. Data from the APAIS are combined with the FHS and the FES to provide estimates of the total number of fish caught, released, and harvested; weight of the harvest; and total number of marine recreational fishing trips. Improvements within APAIS and the adoption of FES required calibrations of pre-existing data to insure consistent comparability across time and as such, all MRIP recreational data presented herein represent the latest techniques. For additional information on MRIP see https://www.fisheries.noaa.gov/topic/recreational-fishing-data.

SPECIES IMPACTED (USES MRIP)	SPECIES NOT IMPACTED
State-Managed Species	
Kingfishes	Bay Scallop
Red Drum	Blue Crab
Sheepshead	Eastern Oyster
Southern Flounder	Estuarine Striped Bass (Albemarle/Roanoke Stock and Central Southern Management Area Stocks)
Spotted Seatrout	Hard Clam
Striped Mullet	River Herring
	Shrimp
Atlantic States Marine Fisheries Commission and Federally-Managed Species	
Species with North Carolina Indices	
Atlantic Croaker	American Shad (Includes Hickory Shad)
Black Drum	Atlantic Menhaden
Black Sea Bass (North of Cape Hatteras)	Atlantic Sturgeon
Bluefish	
Spot	
Striped Bass (Atlantic Migratory)	
Summer Flounder	
Weakfish	
Species without North Carolina Indices	
Cobia	American Eel
Dolphin	Monkfish
King Mackerel	
Scup	
Sharks	
Snapper Grouper Complex (Includes Black Sea Bass South of Cape Hatteras)	
Spanish Mackerel	
Spiny Dogfish	

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FISHERY MANAGEMENT PLAN UPDATE
BAY SCALLOP
AUGUST 2019

STATUS OF THE FISHERY MANAGEMENT PLAN

Fishery Management Plan History

Original FMP Adoption:	November 2007
Amendments:	Amendment 1 – November 2010 Amendment 2 – February 2015
Revisions:	None
Supplements:	None
Information Updates:	None
Recommended Schedule Change:	None
Next MFC Scheduled Review:	July 2020

The N.C. Bay Scallop Fishery Management Plan (FMP) was adopted in November 2007. The FMP implemented prohibited take from 2006 to 2008 until an independent sampling indicator was established for re-opening in 2009. Amendment 1 of the Bay Scallop FMP was finalized in November 2010 to provide more flexibility (Adaptive Management) to open the fisheries as the bay scallop population recovers. Target indices were established from fishery independent data collected before a red tide (toxic dinoflagellate) event of late autumn 1987 and early 1988 in Core, Back, and Bogue sounds that decimated the fishery. A separate sampling indicator for re-opening was developed in 2009 for Pamlico Sound. Amendment 2, adopted in February 2015, continues to use the abundance thresholds for opening the harvest season and defining the harvest levels for all areas, except areas south of Bogue Sound. Areas south of Bogue Sound will not be managed with a specific abundance opening level, but will be opened or remain closed based on North Carolina Division of Marine Fisheries (NCDMF) evaluation of sampling results in this region. Expanded sampling is to occur in all areas including areas south of Bogue Sound and improving the reliability of the data for the recreational scallop harvest. For private culture and enhancement, the current management strategy is to modify rules for bottom culture and aquaculture operations to be consistent with rules for other shellfish species. The Shellfish Research Hatchery in Wilmington, N.C. will establish a pilot program to distribute cultured bay scallop seed on private bottom, and depending on the results potentially expand the pilot program to include enhancement for public bottom.

Management Unit

Includes the bay scallop (*Argopecten irradians)* and its fisheries in all waters of coastal North Carolina.

Goal and Objectives

The goal of the North Carolina Bay Scallop Fishery Management Plan is to implement a management strategy that restores the stock, maintains sustainable harvest, maximizes the social and economic value, and considers the needs of all user groups. To achieve this goal, it is recommended that the following objectives be met:

1. Develop an objective management program that restores and maintains sustainable harvest.
2. Promote the protection, restoration, and enhancement of habitats and water quality necessary for enhancing the fishery resource.
3. Identify, enhance, and initiate studies to increase our understanding of bay scallop biology, predator/prey relationships, and population dynamics in North Carolina.
4. Investigate methods for protecting and enhancing the spawning stock.
5. Investigate methods and implications of bay scallop aquaculture.
6. Address social and economic concerns of all user groups.
7. Promote public awareness regarding the status and management of the North Carolina bay scallop stock.

STATUS OF THE STOCK

Life History

Bay scallops are estuarine-dependent mollusks found in grass beds. Bay scallops are hermaphroditic (contain both sex cells) bivalves and mature and spawn in a year (Brousseau 2005). Their lifespan is only 12-26 months. In North Carolina, bay scallops spawn predominantly from August through January and again in March through May (Gutsell 1930). The larvae go through several swimming stages before attaching to a suitable substrate such as seagrass. Upon reaching a size of approximately 1 inch (20-30 mm), bay scallops drop to the bottom. Although other benthic structures can be used for attachment, bay scallops use seagrass beds almost exclusively, and are therefore highly dependent on this habitat for successful recruitment (Thayer and Stuart 1974). Bay scallops are filter feeders and feed on benthic diatoms (Davis and Marshall 1961). Predators of the bay scallop include cownose rays, blue crabs, starfish, whelks, and sea birds.

Stock Status

There are insufficient data to conduct a traditional stock assessment for bay scallop in North Carolina. Bay scallop in North Carolina are a species of concern because of population declines, caused by previous red tide events and the additive impacts from environmental factors and predation. Annual commercial landings of bay scallops show large fluctuations through time and are presumed to be driven by changing climate conditions (i.e., winter freezes, high freshwater

runoff), predation, and red tide. Bay scallops are vulnerable to overharvest because of the multiple factors affecting their survival.

Stock Assessment

Independent data on bay scallop have been collected by the NCDMF since 1975, and consistently collected since 1998 to evaluate recruitment into the population and recruitment into the fishery for the current fishing season. Analyses of these data have demonstrated trends between NCDMF independent data and landings data from the following year. The long term landings data (1972-2005) most likely reflected population abundance because harvest was allowed to continue until scallop densities reached levels below those that make the fishing economically viable (Peterson and Summerson 1992). However, during 2006 and after the implementation of the 2007 Bay Scallop FMP, a prohibited take on harvest went into effect to rebuild the stock and until a standardized catch per unit effort measure could be determined (NCDMF 2007). Therefore, using landings data is no longer an effective tool to indicate population size.

Data on scallop abundance from fishery independent sampling are evaluated annually and standardized scallop population level indicators were first established as progressive triggers for opening the harvest season in Amendment 1 of the Bay Scallop FMP in 2010 (NCDMF 2010). These triggers are based on NCDMF sampling that occurred between the pre-red tide months of October and December in 1984 and 1985 for Back, Bogue, and Core sounds and in post-red tide January 2009 in Pamlico Sound (Table 1). These triggers allow for flexibility to open the fisheries as the bay scallop population recovers and determines harvest limits based on 50%, 75%, and 125% of the natural log of the Catch Per Unit Effort (lnCPUE) target (Tables 2 and 3).

Fishery independent sampling shows that most tows have small or zero catch, while only a few samples exhibit large catches producing a lognormal distribution, which is usual for most fishery independent data. Each sample is averaged to get the estimated mean lnCPUE and standard deviation for the October-December time period for all areas to produce indices of abundance.

Trends in the past 10 years show bay scallop abundance is very low in all regions, which is also reflected in landings when harvest is opened (Figures 1, 2, and 3). Since the inception of the harvest opening index of abundance, the season has only opened during three years in specific regions, and at the lowest allowed harvest levels. Two of the three open harvest seasons saw very little catch (Figure 4). Expanding the sampling coverage or number of stations in all areas is recommended in Amendment 2 of the FMP to improve estimates of bay scallop abundance. As bay scallop abundances expand and retract from year to year, broader sampling coverage of these areas will help identify more precisely what is happening to the population before entering the harvest season.

STATUS OF THE FISHERY

Current Regulations

The season can only occur from the last Monday in January through April 1st and there is no minimum size limit for both the commercial and recreational user groups. Specific trip limits,

number of days to harvest, and specific gear allowances are implemented within the open season. Both the opening of the season and the harvest restrictions within the open season are based on NCDMF fishery independent sampling abundance levels determining the levels of harvest (NCDMF 2015). There was no open harvest season for bay scallops in 2018 because abundance levels were too low to meet the threshold for opening the season.

Commercial Landings

Bay scallop abundance and harvest have widely fluctuated since landings have been recorded (MacKenzie 2008). Landings are closely linked to weather and other environmental factors. Landings ranged from a peak of approximately 1.4 million pounds of meats in 1928 when North Carolina led the nation in scallop production, to a low of zero landings in 2005 even though there was an open harvest season. Landings have been virtually non-existent since 2005.

The red tide (toxic dinoflagellate) event of late autumn 1987 and early 1988 caused mortality to approximately 21% of the adult scallops in Bogue and Back sounds and reduced recruitment of juvenile scallops the following spring to only 2% of normal (the mean of the previous three red tide-free years) (Summerson and Peterson 1990). This event has had lasting impacts to the bay scallop fishery and repopulation of the Bogue, Back, and Core sound regions has not fully occurred. Landings in recent years have been extremely low due to the failure of scallop stocks to recover after the red tide event, fishing pressure, and predation.

A prohibited take on harvest occurred from 2006 to 2008 through the 2005 FMP (NCDMF 2007). Amendment 1 initiated abundance estimates to determine opening the fishery and at what levels harvest would occur based on the abundance estimates by region (NCDMF 2010). An open harvest commercial and recreational harvest season occurred in Core and Pamlico sounds in 2009, and in Pamlico Sound in 2010 (less than 500 pounds of meat were landed commercially) (Figure 4). Bogue Sound and all areas south of Bogue Sound were opened to harvest to the NC/SC state line in internal waters in 2014 (less than 1,500 pounds of meat were landed commercially) (Figure 4).

Recreational Landings

The state's recreational shellfish survey has recently added a question about bay scallop harvest, but no open season has occurred since the question's introduction. Due to this, no estimation of recreational harvest can be made.

MONITORING PROGRAM DATA

Fishery-Dependent Monitoring

There are no fishery dependent sampling programs that collect information on the commercial or recreational fisheries for bay scallops.

Fishery-Independent Monitoring

Independent sampling of bay scallops for fisheries management information has been conducted since 1975, and has varied from monthly examinations at 20 stations to seasonal monitoring at fewer locations.

Currently sampling occurs four times a year in Pamlico, Core, Back, and Bogue sounds and areas south of Bogue Sound during the second or third week of the month in January, April, July, and October. Standardized sampling occurs in Pamlico Sound using a meter-square (m^2) quadrat and a bay scallop dredge is towed in Core, Back, and Bogue sounds, and areas south of Bogue Sound. A fixed set of eight stations are towed three times for two minutes with a scallop dredge in Core, Back, and Bogue sounds and additional stations are also sampled three times for two minutes where scallops have historically been found. A set of three fixed stations, two in New River and one in Topsail Sound, are towed three times for two minutes with a scallop dredge beginning in 2009 in areas south of Bogue Sound. Sampling also occurs at five fixed stations and five non-core stations off Hatteras Island. Scallops are collected with a rake or by hand for 10 m^2 samples within the station in Pamlico Sound. The PVC m^2 quadrat is randomly placed 10 separate times within the area. Catch per unit effort (CPUE) is defined as the number of scallops (juvenile and adult combined) per one-minute tow if a dredge is used or per quadrat. Additional stations (non-fixed) are sampled in most areas dependent on scallop abundance at the given time of year. The natural log (ln) of the catch per unit effort (lnCPUE), measured as the number of scallops per minute (dredges) and number of scallops per meter squared (quadrat), is taken to avoid bias towards occasional large catches. A constant of 0.1 was added to all catches so that tows/quadrats with zero catches can be included in the estimates of the mean. All tows/quadrats taken at a station are averaged to get a single value for each station and are referred to as a sample. Each sample is averaged to get the estimated mean lnCPUE and standard deviation for the October-December time period for all areas to produce indices of abundance (Figures 1 and 2). Trends in the past 10 years show bay scallop abundance is very low in all regions which is reflected in the limited open areas to harvest in the past decade (Table 4; Figure 1).

MANAGEMENT STRATEGY

The current management strategy for the bay scallop fisheries is to allow the NCDMF Director to open a region to limited bay scallop harvest when sampling indicates bay scallop abundance is at 50% of the natural logarithm of the Catch Per Unit Effort (lnCPUE) level it was in 1984-1985 in the main harvest areas (Core, Bogue and Back sounds) (Table1). A separate sampling indicator for re-opening was developed in 2009 for Pamlico Sound (Table 1). Trip limits and fishing days will progressively increase if sampling shows bay scallop abundance is at 75% or 125% of 1984-85 lnCPUE levels (Tables 2 and 3). The open season may only occur from the last Monday in January through April 1 to ensure spawning is complete and the economic yield is at an optimum for fishermen. See Table 5 for current management strategies and the status on the implementation of each.

RESEARCH NEEDS

The list below is presented in order as it appears in Amendment 2 of the Bay Scallop FMP and the section or issue paper they come from is identified. Prioritization of each research recommendation is designated either a HIGH, MEDIUM, or LOW standing. A low ranking does not infer a lack of importance but is either already being addressed by others or provides limited information for aiding in management decisions. A high ranking indicates there is a substantial need, which may be time sensitive in nature, to provide information to help with management decisions.

Proper management of the bay scallop resource cannot occur until some of these research needs are met, the research recommendations include:

- Develop better methods to quantify the population including the means to have more precise measures of spatial and temporal variability at both within and between Sound scales – HIGH (Expanded number of stations sampled by region)
- Collect information on larval recruitment and spat settlement – LOW (Incomplete)
- Genetically identify how many separate bay scallop stocks exist in North Carolina – MEDIUM (Ongoing work through UNCW Shellfish Hatchery)
- Examine the effects of scallop culture and oyster cultch on seagrass density – MEDIUM (Incomplete)
- Perform socioeconomic surveys on commercial participants to determine specific business characteristics, the economics of working in the fishery, which issues are important to the participants, attitudes towards management of the fishery and general demographic information – LOW (Incomplete; No open seasons since FMP adopted)
- Determine a method to collect socioeconomic information on processors – LOW (Incomplete; No open seasons since FMP adopted)
- Collect information on the economic impact and value of the recreational bay scallop fishery – MEDIUM (Incomplete; No open seasons since FMP adopted)
- Determine the spatial and biological characteristics of SAV beds that maximize their ecological value to the bay scallop for enhancement or conservation purposes – LOW (Ongoing; Several SAV enhancement projects have been completed or are ongoing)
- Develop techniques to enhance SAV habitat to promote scallop survival – LOW (Ongoing; Several SAV enhancement projects have been completed or are ongoing)
- Conduct research to evaluate the role of shell hash and shell bottom in bay scallop recruitment and survival, particularly where SAV is absent – LOW (Incomplete)
- Determine the concentrations of EDCs in known bay scallop habitats and impacts on bay scallops – LOW (Incomplete)
- Assess the impacts of nutrient loading and algae on SAV and the life history of bay scallops – MEDIUM (Incomplete)
- Determine levels of TSS, turbidity, chlorophyll *a,* and other parameters necessary to achieve desired water clarity and investigate the feasibility of a water quality standard for light attenuation required for SAV growth - LOW (Incomplete)
- Complete a more comprehensive study on treading and impacts of treading on juvenile and adult bay scallops - HIGH (Incomplete)

- Survey fishermen that use a commercial license for personal consumption – LOW (Incomplete; No open seasons since FMP adopted)
- Collect more information on the value of the spring spawn to the population – MEDIUM (Incomplete)

FISHERY MANAGEMENT PLAN SCHEDULE RECOMMENDATION

Recommend maintaining the current timing of the next scheduled MFC review to begin in July 2020.

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TABLES

Table 1. Target and progressive triggers based on the lnCPUE (natural log of the number of scallops per 1-minute tow) for the October – December 1984-1985 time period for Back, Bogue, and Core sounds. Target and progressive triggers based on the lnCPUE (natural log of the number of scallops per meter squared) for Pamlico Sound based on sampling in January 2009.

	Pamlico Sound	Core Sound	Back Sound	Bogue Sound
Target lnCPUE	-0.18	1.72	2.02	2.33
Progressive trigger 50%	-0.27	0.86	1.01	1.17
Progressive trigger 75%	-0.23	1.29	1.52	1.75
Progressive trigger	-0.14	2.15	2.53	2.91

Table 2. Adaptive management measures for opening the bay scallop commercial fishery as the selected management strategy of the Marine Fisheries Commission. The harvest levels are based on progressive triggers derived from the lnCPUE1984-1985 (Oct-Dec) target indicators for Core, Bogue and Back sounds and the lnCPUEJan 2009 target indicator for Pamlico Sound.

Progressive triggers and target	Trip limit	Days open in the week	Allowed gears	Season
Less than 50% of target	No allowed harvest			
50% or greater of target but less than 75% of target	5 bushels per person per day not to exceed 10 bushels per fishing operation	Mon and Wed	By hand, hand rakes, hand tongs, dip net, and scoops	Last Monday in January to April 1st
75% or greater of target but less than 125% of target	10 bushels per person per day not to exceed 20 bushels per fishing operation	Mon, Tues, Wed, and Thur	By hand, hand rakes, hand tongs, dip net, and scoops	Last Monday in January to April 1st
	10 bushels per person per day not to exceed 20 bushels per fishing operation	Mon and Wed	Bay scallop dredges as described by rule 15A NCAC 03K .0503	Delay opening until first full week in March after hand harvest removes scallops from shallow waters to April 1st
125% or greater of target	15 bushels per person per day not to exceed 30 bushels per fishing operation	Mon, Tues, Wed, and Thur	By hand, hand rakes, hand tongs, dip net, and scoops	Last Monday in January to April 1st
	15 bushels per person per day not to exceed 30 bushels per fishing operation	Mon and Wed	Bay scallop dredges as described by rule 15A NCAC 03K .0503	Delay opening until the third full week in February after hand harvest removes scallops from shallow waters to April 1st

Table 3. Adaptive management measures for opening the bay scallop recreational fishery as the selected management strategy by the Marine Fisheries Commission. The harvest levels are based on progressive triggers derived from the lnCPUE1984-1985 (Oct-Dec) target indicators for Core, Bogue and Back sounds and the lnCPUEJan 2009 target indicator for Pamlico Sound.

Progressive triggers and target	Trip limit	Days open in week	Allowed gears	Season
Less than 50% of target	No allowed harvest			
50% or greater of target	1/2 bushel per person per day not to exceed 1 bushel per recreational fishing operation	Seven days a week	By hand, hand rakes, hand tongs, dip net, and scoops	Last Monday in January to April 1st

Table 4. Fishery Independent sampling annual lnCPUE and standard error. Pamlico Sound sampling is conducted in January with a m^2 quadrat, all other areas are sampled in October with a scallop dredge.

	Pamlico Sound		Core Sound		Back Sound		Bogue Sound		South	
Year	LnCPUE	Standard Error	lnCPUE	Standard Error	lnCPUE	Standard Error	lnCPUE	Standard Error	lnCPUE	Standard Error
2006			-2.30	0.00	-1.54	0.50	-1.02	0.34		
2007			-1.24	0.50	-2.00	0.30	-1.57	0.34		
2008			2.94	0.35	-1.41	0.40	1.21	0.57		
2009	-0.18	0.79	-1.01	0.42	-1.31	0.45	1.34	0.27	0.94	0.75
2010	0.32	0.67	-0.54	0.39	-1.10	0.54	-1.12	0.54	-2.30	0.00
2011	-1.99	0.13	-0.63	0.57	0.83	0.26	0.38	0.34	-1.77	0.37
2012	-1.66	0.26	-1.71	0.38	-0.56	0.78	1.18	0.25	-0.91	0.36
2013	-1.21	0.11	-2.30	0.00	-2.30	0.00	-0.41	0.71	-1.19	0.42
2014	-1.54	0.31	-2.00	0.30	-1.01	0.42	-2.00	0.20	-1.64	0.34
2015	-1.86	0.39	-2.14	0.16	-2.06	0.16	-1.80	0.19	-1.69	0.16
2016	-2.29	0.01	-1.93	0.25	-1.94	0.19	-1.87	0.16	-2.00	0.20
2017	-2.30	0.00	-2.18	0.12	-1.55	0.25	-1.97	0.14	-0.75	0.26
2018	-2.21	0.08	-1.61	0.75	-2.10	0.46	-2.30	0.00	-2.30	0.00
2019	-2.26	0.24								

Table 5. Summary of the management strategies and their implementation status from Amendment 2 of the Bay Scallop Fishery Management Plan.

Management Strategy	Implementation Status
ENVIRONMENTAL CONCERNS	
Status quo (manage fishing gear based on scallop densities)	No action required
Continue to support CHPP recommendations that enhance protection of existing bay scallop habitat	No action required; Already support the CHPP
Support programs that enhance bay scallop habitat by planting sea grass or other suitable settlement substrate	No action required; Already support the CHPP
Identify and designate SHAs that will enhance protection of the bay scallop	Ongoing through CHPP implementation plan
Remap and monitor SAV coverage in North Carolina to assess distribution and change over time.	Ongoing through CHPP implementation plan
Restore coastal wetlands to compensate for previous losses and enhance water quality conditions for the bay scallop	Ongoing through CHPP implementation plan
Work with CRC to revise shoreline stabilization rules to adequately protect riparian wetlands and shallow water habitat and significantly reduce the rate of shoreline hardening	Ongoing through CHPP implementation plan
Develop and implement a comprehensive coastal marina and dock management plan and policy to minimize impacts to SAV and other fish habitats	Ongoing through CHPP implementation plan
Evaluate dock criteria siting and construction to determine if existing requirements are adequate for SAV survival and growth, and modify if necessary	Ongoing through CHPP implementation plan
Assess the distribution, concentration, and threat of heavy metals and other toxic contaminants in freshwater and estuarine	Ongoing through CHPP implementation plan

Management Strategy	Implementation Status
sediments and identify the areas of greatest concern to focus water quality improvement efforts	
Shallow areas where trawling is currently allowed should be re-examined to determine if additional restrictions are necessary	Ongoing through CHPP implementation plan
Accelerate and complete mapping of all shell bottom in coastal North Carolina	Ongoing through CHPP implementation plan
Improve methods to reduce sediment and nutrient pollution from construction sites, agriculture, and forestry	Ongoing through CHPP implementation plan
Reduce impervious surfaces and increase on-site infiltration of storm water through voluntary or regulatory measures	Ongoing through CHPP implementation plan
Provide more incentives for low-impact development	Ongoing through CHPP implementation plan
Aggressively reduce point source pollution from wastewater through improved inspections of wastewater treatment facilities, improved maintenance of collection infrastructure, and establishment of additional incentives to local governments for wastewater treatment plant upgrading	Ongoing through CHPP implementation plan
Aggressively reduce point and non-point nutrient and sediment loading in estuarine waters, to levels that will sustain SAV habitat, using regulatory and non-regulatory actions	Ongoing through CHPP implementation plan
ENVIRONMENTAL CONCERNS	
Provide proper disposal of unwanted drugs, reduce insecticide and heavy metal run-off, and develop technologies to treat wastewater for antibiotics and hormones	Ongoing through CHPP implementation plan
Discourage use of detergents in coastal waters, especially detergents with antimicrobial components	Ongoing through CHPP implementation plan
INSUFFICIENT DATA	
Support improving the reliability of the data for the recreational scallop harvest	Incomplete
MANAGEMENT	
Eliminate the August 1 through September 15 season open period in rule	Rule change required to 15A NCAC 03K .0501; Rule change completed on May 1, 2015
Expand sampling in all regions and manage harvest conditionally in areas south of Bogue Sound until adequate sampling can determine a harvest trigger for management.	Existing authority
Continue current progressive triggers with adaptive harvest levels in all areas, except areas south of Bogue Sound, and modify harvest management measures as shown in Table 12.7 and Table 12.8 in the issue paper. And continue to improve the statistical rigor of the abundance index.	Existing proclamation authority
Keep dredges at the 75% trigger harvest level in Table 12.7	Existing proclamation authority
Modify the daily commercial harvest possession limit in Rule 15A NCAC 03K .0501 to a quantity of no more than 15 standard U.S. bushels per person per day not to exceed 30 standard U.S. bushels in any combined commercial fishing operation per day to be consistent with the adaptive management measures trip limits.	Requires rule change to rule 15A NCAC 03K .0501; Rule change completed on May 1, 2015
Exempt bay scallop harvest from leases from the regular season and harvest limits	Requires rule change to rules 15A NCAC 03K .0111, 03K .0206, 03K .0303, 03K .0501, 03K .0502, 03K .0507, 03K .0508, 03O .0501; Rule changes completed on May 1, 2015
Support an exemption from G.S. 113-168.4 (b) (3) when the sale is to lease or Aquaculture Operations permit holders for further rearing	Requires statutory change to G.S. 113-168.4; NCDMF will take this suggested change to legislators at the next short session.
STOCK ENHANCEMENT	

Management Strategy	Implementation Status
Establish a pilot program with the Shellfish Research Hatchery to distribute cultured seed on private bottoms	Will need to start communicating with Shellfish Hatchery staff and interested private culturists interested in establishing this pilot work
Contingent on results to distribute seed on private bottom, expand the pilot program to include public bottom	Dependent on results from previous management strategy.

FIGURES

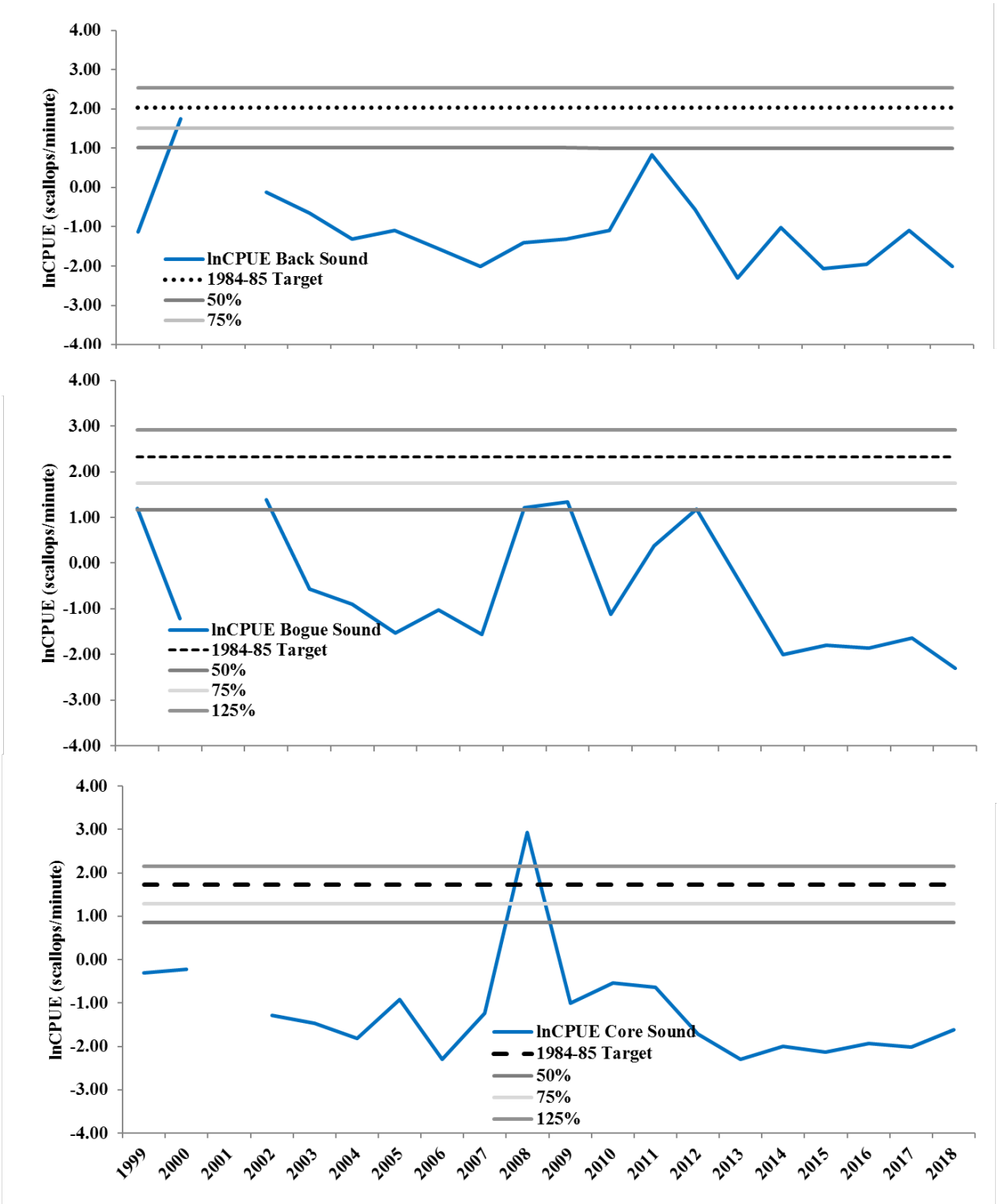

Figure 1. The mean number of scallops (lnCPUE)(scallops/minute) for Back, Bogue, and Core sounds during the October-December sampling time period and average lnCPUE (target) for the 1984-1985 period showing progressive triggers at 50%, 75%, and 125% of the target. Year indicates the sampling year which is used to determine the harvest season for the next calendar year.

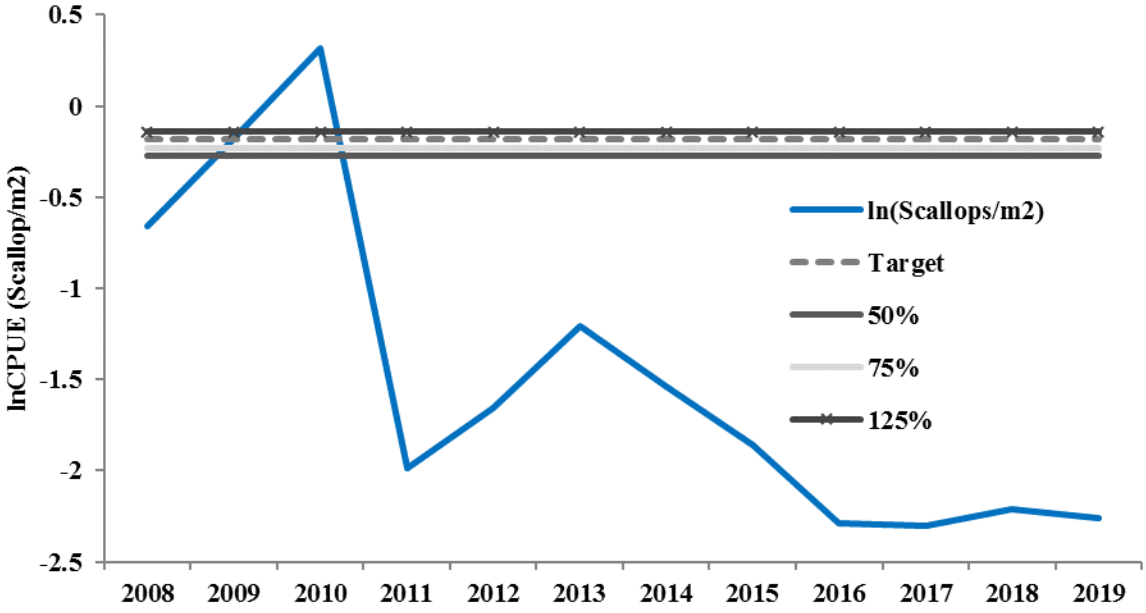

Figure 2. The mean number of bay scallops, lnCPUE (ln(scallops/m^2)), for Pamlico Sound during the January sampling time period and target for the January 2009 period showing progressive triggers at 50%, 75%, and 125% of the target. Year indicates the sampling year which is used to determine the harvest season for the same calendar year.

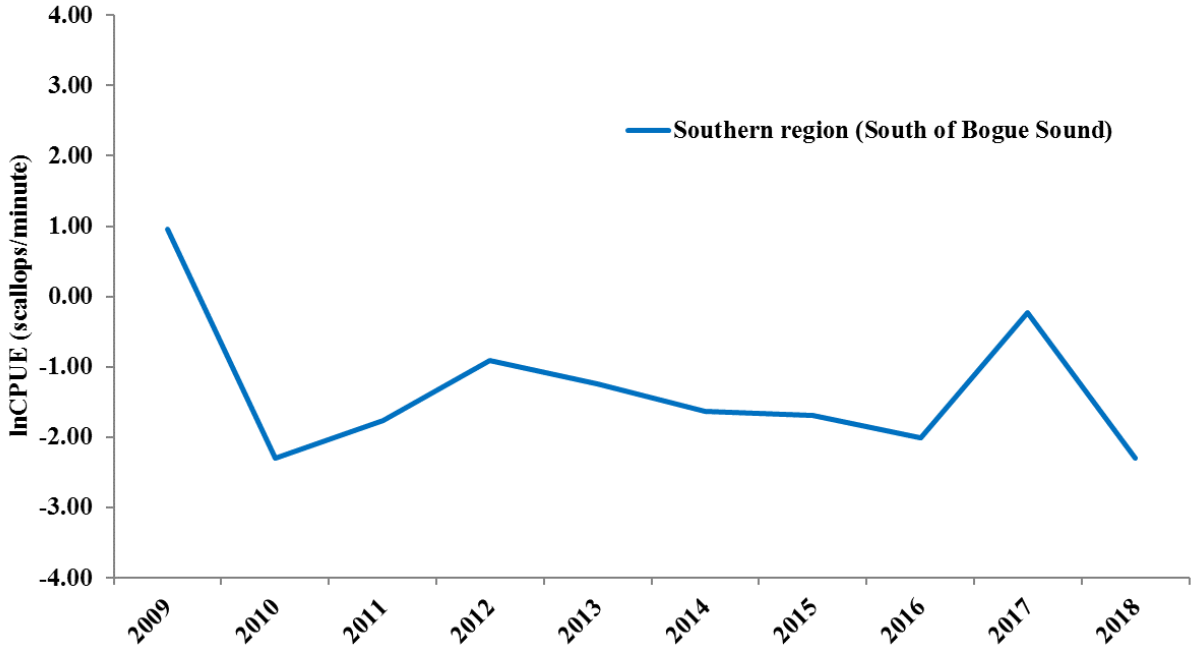

Figure 3. The mean number of scallops (lnCPUE)(scallops/minute) for areas south of Bogue Sound in October, 2009-2018. Target opening estimates and progressive triggers are not defined for this region until sampling is expanded and a longer time series is established.

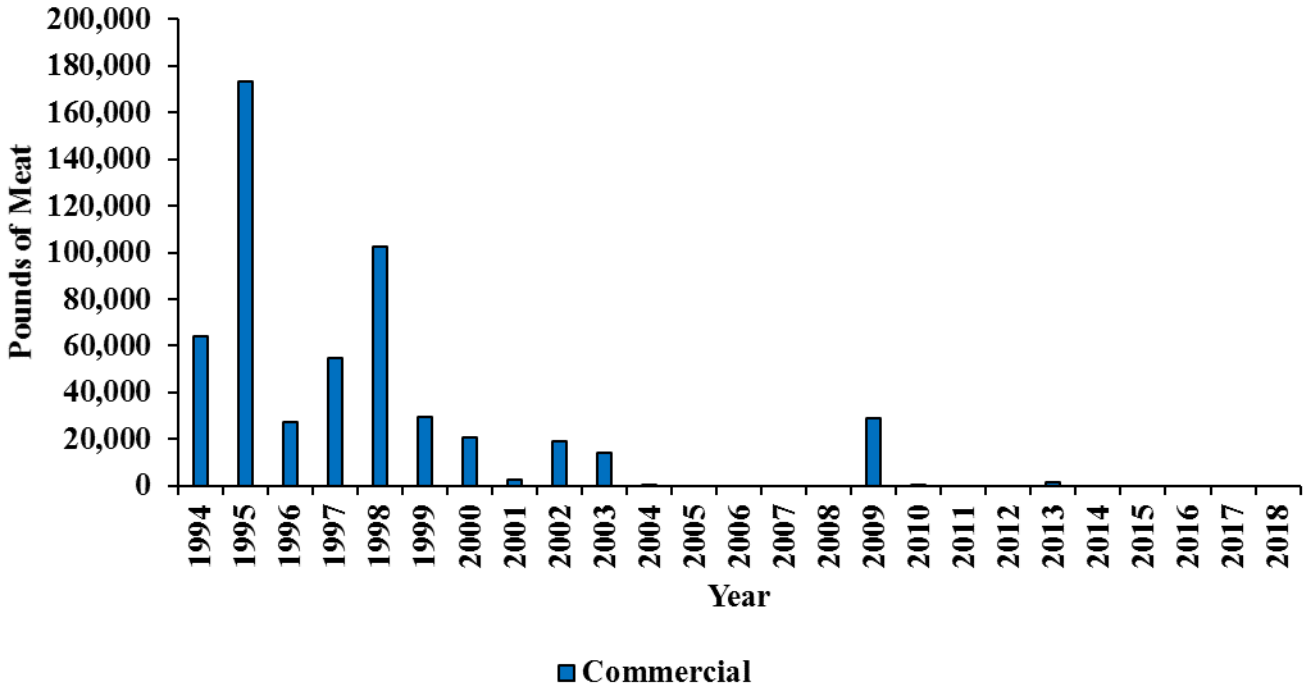

Figure 4. Bay scallop landings (pounds of meat) in North Carolina, 1994-2018. Landings occurred in 2010 and 2013 but are not evident in the figure due to the scale required to show the range of landings for the time series.

FISHERY MANAGEMENT PLAN UPDATE
BLUE CRAB
AUGUST 2019

STATUS OF THE FISHERY MANAGEMENT PLAN

Fishery Management Plan History

Original FMP Adoption:	December 1998
Amendments:	Amendment 1 – December 2004 Amendment 2 – November 2013
Revisions:	May 2016
Supplements:	None
Information Updates:	None
Recommended Schedule Change:	None
Next MFC Scheduled Review:	July 2025

The original North Carolina Blue Crab Fishery Management Plan (FMP) was adopted in December 1998 (NCDMF 1998). The plan adopted several management changes including: 1) requiring sinking lines to be used on all crab pot buoys, 2) prohibited commercial gears (except attended gill nets) in crab spawning sanctuaries from March 1 through August 31, 3) prohibited baiting peeler pots except with live legal-size male blue crabs, 4) repealed the exemption for culling peelers before reaching shore in the hard crab fishery, 5) prohibiting the possession of white line peelers from June 1 through September 30, 6) changed the unattended pot rule from 10 days to seven days, 7) prohibiting setting pots in any navigation channel marked by State or Federal agencies, 8) modified crab pot area regulations to use depth instead of distance from shore, 9) implemented marking requirements for recreational pots, 10) defined collapsible traps as non-commercial gear, and 11) established a permit for shedding operations.

Amendment 1 was adopted in December 2004 (NCDMF 2004). The amendment implemented several management changes including: 1) establishing a 6.75-inch maximum size limit for mature females from September 1 through April 30 if the spawner index fell below the threshold for two consecutive years, 2) establishing a 5.25-inch maximum size limit for female peeler crabs from September 1 through April 30 if the spawner index fell below the threshold for two consecutive years, 3) prohibiting the sale of white-line peelers but allow possession by licensed peeler operations and requiring white-line peelers to be kept separate from pink and red-line peelers, 4) extending the pot cleanup period by nine days, 5) change the unattended pot rule from seven days to five days, 6) requiring a four-inch stretch mesh tail bag for crab trawls in western Pamlico Sound (including the Pamlico, Pungo, Bay, and Neuse rivers), 7) separate hard and

peeler crab trawl landings on trip ticket, 8) modifying channel net rule to incorporate limited blue crab bycatch provisions identical to those for shrimp trawls, 9) modifying user conflict rule to resolve user conflicts on a regional basis, 10) rule change to allow crab pots in all designated long haul areas in the Hyde, Beaufort, and Pamlico counties, 11) modifying the dates for designated crab pot areas from May 1 through October 31 to June 1 through November 30, 12) change designated pot area boundary description to a standardized six foot depth contour in many areas, and 13) prohibit the use of trawls in designated pot areas.

Amendment 2 was adopted in November 2013 (NCDMF 2013). The amendment implemented several management changes including: 1) repealing the spawner index trigger (and associated maximum size limits for mature female and peeler blue crabs) and replacing it with adaptive management framework based on the results of the annual Traffic Light Stock Assessment update, 2) open long haul areas in the Pungo River to pots, 3) add Lower Broad Creek to non-pot areas in rule, 4) modify crab dredging rule to conform to current harvest management, 5) incorporate Pamlico Sound four-inch crab trawl line into rule, 6) redefine criteria for exempting escape rings in crab pots from the 1.5-inch pot mesh size to unbaited pots and pots baited with a male crab, 7) repeal proclamation authority that allowed for the exemption of escape ring requirement to allow harvest of peeler crabs, 8) adopt no trawl line in Pamlico Sound and Newport River boundary in rule as new boundary for areas where closure of escape rings to take small mature female crabs is allowed, 9) modify trawl nets rule to identify Pamlico, Back, and Core sounds as areas that can open to peeler trawling by proclamation, 10) modify rule to clearly state the intent of the exceptions, culling tolerance, and separation requirements for various crab categories, and 11) establish proclamation authority to require terrapin excluders in crab pots and establish a framework for developing criteria and terrapin excluder specifications.

The NCMFC preferred adaptive management strategy for blue crabs (Table 1) relies on the Traffic Light Stock Assessment as the tool to provide information on the relative condition of the stock. The base years (1987 to 2009) for assigning the signals in the Traffic Light Stock Assessment will remain constant until the next amendment of the FMP. The Traffic Light Stock Assessment will be updated annually by July of each year.

Based on the results of the annual Traffic Light update, with 2015 data, management action was required by the North Carolina Marine Fisheries Commission (NCMFC). At their May 19, 2016 business meeting, the NCMFC was presented with several management options identified in the adaptive management framework in Amendment 2 to the N.C. Blue Crab FMP (NCDMF 2016). To improve the condition of the blue crab stock the NCMFC adopted the following management measures: 1) require one additional escape ring in crab pots and one of the three escape rings must be located within one full mesh of the corner of the pot and within one full mesh of the bottom of the apron/stairs (divider) of the upper chamber of the pot; 2) eliminate the harvest of v-apron immature female hard crabs (excluding peeler crabs); and include v-apron immature female hard crabs in the culling tolerance; 3) prohibit the harvest of dark sponge crabs (brown and black) from April 1-April 30 each year; and include dark sponge crabs in the culling tolerance; 4) lower the culling tolerance from 10 percent to five percent for all crabs, except mature females; and 5) prohibit the harvest of crabs with dredges except incidental to lawful oyster dredging as outlined in NCMFC Rule 15A NCAC 03L .0203(a)(2).

All adaptive management measures became effective June 6, 2016 except for the additional escape ring requirement which was postponed until January 15, 2017 (NCDMF 2016). This delay coincided with the annual pot closure period to allow fishermen time to modify pots. The above actions taken by the NCMFC are documented in the May 2016 Revision to Amendment 2 to the N.C. Blue Crab FMP (NCDMF 2016).

The Benchmark Review of the Blue Crab FMP was originally scheduled to begin in July 2018 but at their August 2016 business meeting the NCMFC voted to move the review up on the FMP schedule to begin immediately. Consequently, the review of the Blue Crab FMP for development of Amendment 3 began in August 2016. The stock assessment has been completed and accepted for management use and the division's plan development team is working on development of Amendment 3 in conjunction with the advisory committee and is expected to be adopted in early 2020.

Management Unit

The management unit includes the blue crab (*Callinectes sapidus*) and its fisheries in all coastal fishing waters of North Carolina.

Goal and Objectives

The goal of Amendment 2 to the North Carolina Blue Crab FMP is to manage the blue crab fishery in a manner that promotes its ecological and economic value, and the long-term viability of the resource through sustainable harvest. The following objectives will be utilized to achieve this goal.

1. Utilize a management strategy that provides resource protection and sustainable harvest, promotes blue crab ecological and economic value, provides opportunity for resource utilization, and considers the needs of all users.
2. Promote harvesting practices that minimize waste of the resource and environmental damage.
3. Promote the protection, restoration, and enhancement of habitats and environmental quality necessary for the perpetuation of the blue crab resource.
4. Maintain a clear distinction between conservation goals and allocation issues.
5. Minimize conflicts among and within user groups, including non-crabbing user groups.
6. Identify and promote research to improve the understanding and management of the blue crab resource.
7. Promote education and public information to help users understand the causes and nature of problems for blue crabs in North Carolina, its habitats and fisheries, and the rationale for efforts to address resource management.

STATUS OF THE STOCK

Life History

The blue crab is common to all North Carolina coastal waters, but most reside in the Albemarle and Pamlico sounds and their tributaries. Blue crabs mature at approximately 12 to 18 months of

age and have an average lifespan of three years with some living as long as eight years (Fischler 1965; Johnson 2004; Rugolo et al. 1997). Mating occurs in brackish areas of the estuary and lower portions of the rivers from late spring to early fall, and spawning occurs in high-salinity waters near the ocean inlets from early summer to fall (Forward et al. 2003; Whitaker 2006). The first larval stage is carried offshore by ocean currents where they undergo several stages of development (Van Engel 1958; Epifanio 1995). Settlement of larval blue crabs occurs in the estuaries after winds and tides transport them through the inlets from the ocean. Once within the estuary, larval blue crabs settle in beds of submerged aquatic vegetation and other complex habitats, like salt marsh and oyster shell, where they become juvenile blue crabs. Juvenile blue crabs gradually migrate to lower salinity waters in the upper estuaries and rivers to grow (molt) and mature (Etherington and Eggleston 2000). Molting is a process of growth in blue crabs that requires shedding the hard exoskeleton. Following each molt, the shell is soft for several hours until it hardens, during this time the crab is more vulnerable to predators. Juvenile and adult blue crabs typically eat what is available to them such as dead and live fish, crabs, shrimp, and shellfish (Laughlin 1982; Williams 1984; Hines et al. 1990; Cordero and Seitz 2014) and serve as food for predator species such as striped bass and red drum (NCSU unpublished data).

Male and female blue crabs are easily identified by the shape of the apron on their abdomen. A mature male crab is called a "jimmy" and is easily recognized by the blue shading on his shell and claws and T-shaped apron on its underside. Female crabs are either called "sooks" as adults or "she-crabs" when immature. The immature female apron is triangular-shaped and held tightly against the abdomen. The mature female's apron becomes rounded and can be easily pulled away from the body after the final molt. The "sponge crab" is a female that has an egg mass on her abdomen.

Stock Status

Results of the 2018 blue crab stock assessment indicate the stock is overfished and overfishing is occurring (NCDMF 2018). The threshold spawner abundance was estimated to be 64 million mature females on average, and the target spawner abundance was estimated to be 73 million mature females on average (Figure 1). The average spawner abundance for 2016 was estimated to be 50 million mature females (< the threshold) with a 95% CI of 37-68 million, which determines the population in 2016 is overfished with a probability of 0.98. The fishing mortality threshold and target were estimated to be 1.46 and 1.22 on average, respectively. The average fishing mortality for 2016 was 1.48 (> *F* threshold) with a 95% CI of 0.86-2.42, which indicates overfishing is occurring in 2016 with a probability of 0.52.

Stock Assessment

The 2018 blue crab stock assessment used a sex-specific two-stage model applied to available data to assess the status of North Carolina's blue crab stock for 1995–2016 (NCDMF 2018). Data were available from commercial fishery monitoring programs and several fishery-independent surveys. Only hard crab landings were incorporated in the model and neither recreational or soft/peeler landings were included primarily due to their minimal contribution to the overall harvest. The two-stage model was developed based on the catch-survey analysis designed for species lacking information on the age structure of the population. The model

synthesized information from multiple sources, tracked population dynamics of male and female recruits and fully recruited animals, estimated critical demographic and fishery parameters such as natural and fishing mortality, and thus, provided a comprehensive assessment of blue crab status in North Carolina. The hierarchical Bayesian approach was used to estimate model parameters, which can incorporate uncertainty associated with the data and model assumptions.

The model estimated an overall declining trend in catch, relative abundance indices, population size of both male and female recruits and fully recruited crabs, with a rebound starting in 2007. Females had higher natural mortality estimates than males. The estimated fishing mortality remained high before 2007, and decreased by approximately 50% afterwards.

The status of the blue crab stock was evaluated using biological reference points based on maximum sustainable yield (MSY). The MSY-based biological reference points (BRPs) have been widely used in fishery stock assessments including blue crabs, e.g., Chesapeake Bay 2001 (Miller et al. 2011), Florida 2007 (Murphy et al. 2007) and Gulf of Mexico 2013 assessments (VanderKooy 2013).

The fishing mortality that maximizes the total yield (F_{MSY}) was set to be the threshold for overfishing, and $0.75F_{MSY}$ was set to be the target fishing mortality. The spawner abundance at F_{MSY} (SP_{MSY}) and 0.75 F_{MSY} was set to be the threshold and target for overfished population, respectively. In the current stock assessment, the populaion is determined to be overfished if the average spawner abundance in 2016 falls below SP_{MSY}, and is determined to be undergoing overfishing if the average F in 2016 remains above F_{MSY}.

STATUS OF THE FISHERY

Current Regulations

General Statutes

All management authority for North Carolina's blue crab fishery is vested in the State of North Carolina. Statutes that have been applied to the blue crab fishery include:

- Definitions relating to resources. G.S. 113-129.
- Definitions relating to activities of public. G.S. 113-130.
- Jurisdiction of fisheries agencies. G.S. 113-132.
- It is unlawful for any person without the authority of the owner of the equipment to take fish from said equipment. G.S. 113-268(a).
- It is unlawful for any vessel in the navigable waters of the State to willfully, wantonly, and unnecessarily do injury to any seine, net, or pot. G.S. 113-268(b).
- It is unlawful for any person to willfully destroy or injure any buoys, markers, stakes, nets, pots, or other devices or property lawfully set out in the open waters of the state in connection with any fishing or fishery. G.S. 113-268(c).

Marine Fisheries Commission Rules

The NCMFC has established several rules that directly govern the harvest of blue crabs. Below are rules and excerpts from rules that directly affect the blue crab fishery. The rules below do not

cover all gear, area, or other rules which may impact the blue crab fishery. As regulations may change, please contact the North Carolina Division of Marine Fisheries (NCDMF) for the most current regulations.

Definitions

Blue Crab Shedding: The process whereby a blue crab emerges soft from its former hard exoskeleton. A shedding operation is any operation that holds peeler crabs in a controlled environment. A controlled environment provides and maintains throughout the shedding process one or more of the following: (i) food, (ii) predator protection, (iii) salinity, (iv) temperature controls, or (v) water circulation, utilizing technology not found in the natural environment. A shedding operation does not include transporting pink or red-line peeler crabs to a permitted shedding operation. 15A NCAC 03I .0101(2)(c).

Peeler Crab: A blue crab that has a soft shell developing under a hard shell and having a white, pink, or red-line or rim on the outer edge of the back fin or flipper. 15A NCAC 03I .0101(2)(f).

Commercial Fishing Equipment or Gear: All fishing equipment used in coastal fishing waters except: (i) Cast nets; (ii) Collapsible crab traps, a trap used for taking crabs with the largest open dimension no larger than 18 inches and that by design is collapsed at all times when in the water, except when it is being retrieved from or lowered to the bottom; (iii) Dip nets or scoops having a handle not more than eight feet in length and a hoop or frame to which the net is attached not exceeding 60 inches along the perimeter; (iv) Gigs or other pointed implements which are propelled by hand, whether or not the implement remains in the hand; (v) Hand operated rakes no more than 12 inches wide and weighing no more than six pounds and hand operated tongs; (vi) Hook and line and bait and line equipment other than multiple hook or multiple bait trotline; (vii) Landing nets used to assist in taking fish when the initial and primary method of taking is by the use of hook and line; (viii) Minnow traps when no more than two are in use; (ix) Seines less than 30 feet in length; (x) Spears, Hawaiian slings or similar devices, which propel pointed implements by mechanical means, including elastic tubing or bands, pressurized gas or similar means. 15A NCAC 03I .0101(3)(c).

Mesh Length: The diagonal distance from the inside of one knot to the outside of the other knot, when the net is stretched hand-tight. 15A NCAC 03I .0101(3)(k).

Crab Harvest Restrictions

Hard crab minimum size limit of five inches measured from tip of spike to tip of spike for male and immature female hard blue crabs. Soft crabs shall be separated where taken and placed in a separate container. Peeler crabs shall be separated where taken and placed in a separate container. White-line peeler crabs shall be separated from pink and red-line peeler crabs where taken and placed in a separate container. Male crabs to be used as peeler bait are exempt from the five-inch size limit from March 1 through October 31 and shall be placed in a separate container. A culling tolerance of not more than five percent by number shall be allowed for white-line peelers in the pink and red-line peeler container [suspended by Proclamation M-11-2016]. It is unlawful to: sell white-line peelers, possess white-line peelers unless they are to be used by the harvester in the harvester's permitted blue crab shedding operation, possess male white line peelers from June 1 through September 1. It is unlawful to possess more than 50 crabs

per person per day not to exceed 100 blue crabs per vessel per day for recreational purposes. To comply with management measures in the N.C. Blue Crab Fishery Management Plan, the Director, may by proclamation, close the harvest of blue crabs and may impose any or all of the following restrictions on the commercial and recreational blue crab harvest: specify, areas, season; time periods, means and methods, culling tolerance, and limit harvest based on size, quantity, sex, reproductive stage, or peeler stage. 15A NCAC 03L .0201.

Spawning Sanctuaries
It is unlawful to set or use trawls, pots, and mechanical methods for oysters or clams or take crabs with the use of commercial fishing equipment from crab spawning sanctuaries [15A NCAC 03R .0110] from March 1 through August 31. During the remainder of the year the Director may, by proclamation, close these areas and may impose any or all of the following restrictions: areas, time periods, means and methods, and limit harvest based on size, quantity, sex, reproductive stage, or peeler stage. 15A NCAC 03L .0205.

Peeler and Soft Crabs
It is unlawful to possess more than 50 blue crabs in a shedding operation without first obtaining a Blue Crab Shedding Permit from the NCDMF. 15A NCAC 03O .0503(c).

Recreational Harvest
- Blue crabs may be taken without a commercial license if the following gears are used; cast nets, collapsible crab traps with the largest open dimension no larger than 18 inches, a dip net having a handle not more than eight feet in length and a hoop or frame to which the net is attached not exceeding 60 inches along the perimeter; single bait-and-line equipment, or seines less than 30 feet. 15A NCAC 03I .0101(3)(c)(i), (ii), (iii), (vi), and (ix).
- Recreational crab pot buoys must be any shade of hot pink in color, and be no less than five inches in diameter and length and be engraved with the owner's last name and initials. If a vessel is used the buoy must also be engraved with the gear owner's current motorboat registration number or owner's U.S. vessel documentation name. 15A NCAC 03J .0302(a)(1) and (2).
- It is unlawful for a person to use more than one crab pot attached to the shore along privately owned land or to a privately-owned pier without possessing a valid Recreational Commercial Gear License. 15A NCAC 03J .0302(b).
- Up to five crab pots may be used by holders of the Recreational Commercial Gear License. 15A NCAC 03O .0302(a)(3).
- Peeler pots are not permitted to be used by holders of the Recreational Commercial Gear License. 15A NCAC 03O .0302(a)(3).
- One multiple hook or multiple bait trotline up to 100 feet in length may be used to harvest blue crabs. 15A NCAC 03O .0302(a)(4).
- Trotlines must be marked at both ends with any shade of hot pink in color, and be no less than five inches in diameter and length and be engraved with the owner's last name and initials. If a vessel is used the buoy must also be engraved with the gear owner's current motorboat registration number or owner's U.S. vessel documentation name. 15A NCAC 03J .0302.

Trawls

- It is unlawful to use trawl nets in designated pot areas opened to the use of pots and within an area bound by the shoreline to the depth of six feet. 15A NCAC 03J .0104(b)(6).
- It is unlawful to use shrimp trawls for the taking of blue crabs in internal waters, except that it shall be permissible to take or possess blue crabs incidental to commercial shrimp trawling provided that the weight of the crabs shall not exceed; 50 percent of the total weight of the combined crab and shrimp catch; or 300 pounds, whichever is greater. For individuals using shrimp trawls authorized by a Recreational Commercial Gear License, 50 blue crabs, not to exceed 100 blue crabs if two or more Recreational Commercial Gear License holders are on board. The Fisheries Director may, by proclamation, close any area to trawling for specific time periods in order to secure compliance with this rule. 15A NCAC 03J .0104(f)(1), (f)(2)(A) and (B), and (g).
- From December 1 through March 31 it is unlawful to possess finfish caught incidental to shrimp and crab trawling in the Atlantic Ocean unless the weight of the combined catch of shrimp and crabs exceeds the weight of finfish; except that trawlers working south of Bogue Inlet may keep up to 300 pounds of kingfish, regardless of their shrimp or crab catch weight. 15A NCAC 03J .0202(5).
- It is unlawful to take or possess crabs aboard a vessel in internal waters except in areas and during such times as the Fisheries Director may specify by proclamation. 15A NCAC 03L .0202(a).
- It is unlawful to take crabs with crab trawls with a mesh less than three inches, except in areas of western Pamlico Sound the minimum mesh length is four inches; the Director may, by proclamation, specify other areas for trawl mesh length and increase the minimum mesh length to no more than four inches. 15A NCAC 3L .0202(b)(1) and (2).
- It is unlawful to use trawls with a mesh length less than two inches or with a combined total headrope length exceeding 25 feet for taking soft or peeler crabs. 15A NCAC 03L .0202(c).
- It is unlawful to use trawl nets for any purpose in any of the special secondary nursery areas, except that the Fisheries Director, may, by proclamation, open any or all of the special secondary nursery areas, or any portion thereof to crab trawling from August 16 through May 14. 15A NCAC 03N .0105(b), 03R .0105, 03L .0100 and .0200.
- It is unlawful to use trawl nets in areas listed in 15A NCAC 03R .0106, except that certain areas may be opened to peeler trawling for single-rigged peeler trawls or double-rigged boats whose combined total headrope length does not exceed 25 feet. 15A NCAC 03J .0104(b)(4) and 03R .0106(1).

Crab Pots

- It is unlawful to leave pots in any coastal fishing waters for more than five consecutive days, when such pots are not being employed in fishing operations, except upon a timely and sufficient showing of hardship. 15A NCAC 03I .0105(b)(1), (b)(2)(A) and (B), (b)(3), and (c).
- All pots shall be removed from internal waters from January 15 through February 7. Areas may be reopened, by proclamation, to the use of pots after January 19 if it is determined that such areas are free of pots. 15A NCAC 03J .0301(a)(1).
- From June 1 through November 30 the use of crab pots is restricted in certain areas north and east of the Highway 58 Bridge at Emerald Isle. These areas are described in 15A NCAC 03R .0107(a). To allow for the variable spatial distribution of crustacea and finfish, the

Fisheries Director may, by proclamation, specify time periods for or designate the areas described in 15A NCAC 03R .0107(b); or any part thereof, for the use of pots. From May 1 through November 30 in the Atlantic Ocean and west and south of the Highway 58 Bridge at Emerald Isle in areas and during time periods designated by the Fisheries Director by proclamation.15A NCAC 03J .0301(a)(2)(A) and (B), (a)(3), and 03R .0107(a) and (b).

- It is unlawful to use pots in any navigation channel maintained and marked by State or Federal agencies. 15A NCAC 03J .0301(b)(1).
- It is unlawful to use pots in any turning basin maintained and marked by the North Carolina Ferry Division. 15A NCAC 03J .0301(b)(2).
- It is unlawful to use pots in a commercial fishing operation unless each pot is marked by attaching a floating buoy which shall be of solid foam or other solid buoyant material no less than five inches in diameter and no less than five inches in length. Buoys may be any color except yellow or hot pink or any combination of colors that include yellow or hot pink. The pot owner's N.C. motorboat registration number, or U.S. vessel documentation name, or last name and initials shall be engraved in the buoy, or on a metal or plastic tag attached to the buoy. 15A NCAC 03J .0301(c)(1), (2), and (3).
- It is unlawful to use crab pots in coastal fishing waters unless each pot contains no less than two unobstructed escape rings that are at least 2 and 5/16 inches inside diameter and located in the opposite outside panels of the upper chamber of the pot except: unbaited pots, pots baited with a male crab, and pots set in areas described in 15A NCAC 03R .0118. 15A NCAC 03J .0301(g) [suspended by Proclamation M-11-2016, effective January 15, 2017].
- The Fisheries Director may, by proclamation, exempt the escape ring requirement describe in paragraph (g) in order to allow the harvest of mature female crabs and may impose any or all of the following restrictions: specify time, areas, means and methods, seasons, and quantity. 15A NCAC 03J .0301(h).
- It is unlawful to use more than 150 pots per vessel in the Newport River. 15A NCAC 03J .0301(i).
- It is unlawful to remove crab pots from the water or remove crabs from pots between one hour after sunset and one hour before sunrise. 15A NCAC 03J .0301(j).
- It is unlawful to use pots to take crabs unless the line connecting the pot to the buoy is non-floating. 15A NCAC 03J .0301(k).

Crab Dredging

- It is unlawful to use any dredge weighing more than 100 pounds except in the Atlantic Ocean. 15A NCAC 03J .0303(a).
- It is unlawful to use more than one dredge per vessel to take crabs or to use any dredges between sunset and sunrise. 15A NCAC 03J .0303(b).
- It is unlawful to take crabs with dredges except from January 1 through March 1 in portions of Pamlico Sound. 15A NCAC 03L .0203(a)(1) [suspended by Proclamation M-11-2016, effective June 6, 2016] and 15A NCAC 03R .0109.
- Crabs may be taken incidental to lawful oyster dredging provided the weight of the crabs shall not exceed 50 percent of the total weight of the combined oyster and crab catch; or 500 pounds, whichever is less. 15A NCAC 03L .0203(a)(2)(A) and (B) [suspended by Proclamation M-11-2016, effective June 6, 2016].

- It is unlawful to take crabs with dredges between sunset and sunrise and between sunset on any Saturday and sunrise on the following Monday, except in the Atlantic Ocean. 15A NCAC 03L .0203(b).

Miscellaneous

- It is unlawful to possess, sell, or purchase fish under four inches in length except for use as bait in the crab pot fishery in North Carolina with the following provision: such crab pot bait shall not be transported west of U.S. Interstate 95 and when transported, shall be accompanied by documentation showing the name and address of the shipper, the name and address of the consignee, and the total weight of the shipment. 15A NCAC 03M .0103(1).

Wildlife Resources Commission Rules

Manner of Taking Nongame Fish Purchase and Sale

- Blue crabs shall have a minimum carapace width of five inches (point to point) and it is unlawful to possess more than 50 crabs per person per day or to exceed 100 crabs per vessel per day. 15A NCAC 10C .0401(a)(1).
- Blue crab taken by hook and line, grabbling or by licensed special devices may not be sold. 15A NCAC 10C .0401(c).

Taking Nongame Fish, Crustaceans, and Mollusks for Bait or Personal Consumption

- A single, multiple bait line for taking crabs not to exceed 100 feet in length that is under the immediate control and attendance of the user and is limited to one line per person and no more than one line per vessel. The line is required to be marked on each end with a solid float no less than five inches in diameter and bearing legible and indelible identification of the user's name and address. 15A NCAC 10C .0402(a)(6).
- A collapsible crab trap with the largest opening not greater than 18 inches and which, by design, collapses at all times when in the water, except when being retrieved or lowered to the bottom. 15A NCAC 10C .0402(a)(7).
- Nongame fishes, crustaceans (crayfish and blue crabs), and mollusks taken for bait or personal consumption may not be sold. 15A NCAC 10C .0402(b).
- No more than 50 crabs per person, per day or 100 per vessel, per day with a minimum carapace width of five inches (point to point) from inland fishing waters or in designated waterfowl impoundments located on game lands. 15A NCAC 10C .0402(d)(3).

Special Device Fishing

- It is unlawful to use crab pots in inland fishing waters, except by persons owning property adjacent to the inland fishing waters of coastal rivers and their tributaries who are permitted to set two crab pots to be attached to their property and not subject to special device license requirements. 15A NCAC 10C .0404(e).

Commercial Landings

Commercial blue crab landings (hard, soft, and peeler crabs) averaged 40.5 million pounds from 1987 – 2009 (base years used in the traffic light; Table 2). Generally, commercial blue crab landings have been lower recently and ranged from a high of 67.1 million pounds in 1996 to a

low of 17.0 million pounds in 2018 The majority of blue crab landings are hard blue crabs. Landings for 2018 were 17.0 million pounds, under the base years' average (Figure 2). Landings for 2018 were 12 percent lower than 2017 and have been below the base years' average since 2004. The majority of blue crab landings come from crab pots (97.1 percent in 2018) followed by peeler pots (2.7% in 2018), crab trawls (0.1% in 2018) and other gears (0.1% in 2018; Figure 3). Most crabs landed in 2018 were hard crabs (96.5 percent), followed by peeler (2.1 percent) and soft (1.4 percent) crabs (Figure 4).

Recreational Landings

A survey of Recreational Commercial Gear License (RCGL) holders conducted from 2002 – 2008 by the NCDMF indicated blue crabs were the most abundant species landed (by weight) by RCGL participants. During this time, on average, blue crabs accounted for 20 percent (116,797 pounds) of the total poundage (587,172 pounds) landed by RCGL holders. This survey was discontinued in 2009 so more recent estimates of RCGL harvest are unavailable. The harvest of RCGL exempted shore and pier based pots, as well as other non-commercial gear, is unknown.

The Marine Recreational Information Program is primarily designed to sample anglers who use rod and reel as the mode of capture. Since blue crab are also harvested recreationally throughout coastal North Carolina, primarily by pots, this program does not provide precise estimates of recreational harvest. To address this, the division began a mail survey of Coastal Recreational Fishing License (CRFL) holders in the fall of 2010 to attempt to generate recreational harvest estimates for blue crab. One weakness of the survey is a CRFL is not required to harvest blue crab so the harvest from the recreational sector is likely underestimated. Full year results from this survey are available for 2011-2018 (Figure 5; Table 2). Generally, estimates of recreational blue crab harvest were low, ranging from 47,766 blue crabs (approximately 15,922 pounds, using an average of three crabs per pound) in 2018 to 120,979 blue crabs (approximately 40,326 pounds) in 2012. For 2011 – 2018, the average annual recreational harvest of blue crab was 88,382 blue crabs (approximately 29,461 pounds).

MONITORING PROGRAM DATA

Fishery-Dependent Monitoring

The number of blue crab lengths obtained from the fishery dependent sources from 1995 through 2018 ranged from 7,698 in 2018 to 33,007 in 1995 (Table 3). Mean carapace width (CW) varied little ranging from 5.5 inches to 6.0 inches. Minimum CW ranged from 1.2 inches to 3.8 inches. Maximum CW ranged from 7.8 inches to 9.1 inches. In general, the commercial fishery harvests a narrow size range of blue crab, with most crabs running from 5 to 6.25 inches CW. The length composition and modal length of blue crab caught in the commercial fishery has varied little over time (Figure 6).

The Traffic Light, used to monitor the health of the blue crab stock, uses commercial crab sampling data (combined with fishery-independent data) to determine the annual length of 50 percent maturity for female blue crabs. This index is used in the Production characteristic of the Traffic Light. The annual length of 50 percent maturity is compared to the mean length of 50

percent maturity for the base years of 1987 – 2009 (112.1 mm CW [4.4 inches]). In 2018, the length of 50 percent maturity was 118.7 mm CW (4.7 inches) and was above the mean for the base years (112.1 mm CW [4.4 inches]). The length of 50 percent maturity has been above the base years mean since 2005 (Figure 7).

Fishery-Independent Monitoring

The Traffic Light, used to monitor the condition of the blue crab stock, uses several fishery-independent indices for the Adult Abundance, Recruit Abundance, and Production characteristics. The status of each indicator is compared to the mean of that indicator over a set of base years. The base years used for the blue crab traffic light were 1987 – 2009.

Adult Abundance

The adult abundance characteristic uses data from the Juvenile Anadromous Trawl Survey (Program 100), the Estuarine Trawl Survey (Program 120), and the Pamlico Sound Survey (Program 195) to monitor adult blue crab abundance. Indices from Program 120 and Program 195 consist of blue crabs greater than or equal to 100 mm CW (3.9 inches); an index of total abundance (no size restrictions) is derived from Program 100. Two indices are derived from Program 120, a Pamlico index using data from tributaries in and around Pamlico Sound and Core Sound and a Southern index using data collected from Back Sound and south (Figure 8).

Adult abundance for Program 100 was above the mean for the base years (0.27 crabs/minute) from 2006 – 2012, both 2013 (0.266 crabs/minute) and 2014 (0.23 crabs/minute) adult abundance estimates were below the base year mean but in 2015 (1.04 crabs/minute), 2016 (0.78 crabs/minute), 2017 (1.39 crabs/minute), and 2018 (1.82 crabs/minute) adult abundance estimates were above the base year mean. Adult abundance for Program 120 in the Pamlico region has been below the base year mean (0.62 crabs/tow) since 2013 (2018=0.28 crabs/tow). In the Southern region, adult abundance for Program 120 was below the base year mean (0.15 crabs/tow) from 2011-2014, 2016, 2017, and 2018 (0.13 crabs/tow). Adult abundance for Program 195 has been below the base year mean (4.52 crabs/tow) since 2000. In 2018 adult abundance was 3.20 crabs/tow, the highest it has been since 2003. Figure 9 shows the individual traffic lights for each index as well as the composite adult abundance traffic light.

Recruit Abundance

The recruit abundance characteristic uses data from the Estuarine Trawl Survey (Program 120) and the Pamlico Sound Survey (Program 195) to monitor blue crab recruit abundance. Each index consists of blue crabs less than 100 mm CW (3.9 inches) and greater than or equal to 30 mm CW (1.2 inches). Two indices are derived from Program 120, a Pamlico index using data from tributaries in and around Pamlico Sound and Core Sound and a Southern index using data collected from Back Sound and south. Two indices are also derived from Program 195, a summer (June) and a fall (September) index (Figure 10).

Recruit abundance for Program 120 in the Pamlico region has been below the base year mean (1.93 crabs/tow) since 2013 (2018=0.93 crabs/tow). In the Southern region, recruit abundance has been below the base year mean (0.44 crabs/tow) since 2005. In 2018, recruit abundance was 0.31 crabs/tow in the Southern region. Recruit abundance for Program 195 in the summer has

been below the base year mean (29.66 crabs/tow) since 2011 and was 8.95 crabs/tow in 2018. In the fall, recruit abundance was below the base year mean (3.49 crabs/tow) from 1998-2017. In 2018, recruit abundance was 6.93 crabs/tow in the fall, almost double the base year mean. Figure 11 shows the individual traffic lights for each index as well as the composite recruit abundance traffic light.

Production

The production characteristic uses data from the Juvenile Anadromous Trawl Survey (Program 100), the Estuarine Trawl Survey (Program 120), and the Pamlico Sound Survey (Program 195) to monitor the blue crab stock's production potential. The production indicators include measures of median carapace width, pre-recruit abundance (blue crabs less than 30 mm CW [1.2 inches]), length at 50 percent maturity (see fishery-dependent monitoring section), spawning stock (mature female mm/minute), and frequency of occurrence of mature females (percent of samples with mature female blue crabs; Figure 14).

Three indices are derived from Program 100 including median carapace width, spawning stock, and frequency of occurrence of mature females (Figure 11). Median carapace width was below the base year mean (114.2 mm [4.5 inches]) from 2009-2017 (2018=102 mm [4.0 inches]). The spawning stock index was below the base year mean (19.54 mm/minute [0.8 inches]) from 2012-2014 and 2016. In 2017 (32.44 mm/minute [1.3 inches]) and 2018 (24.44 mm/minute [1.0 inches]), the spawning stock index was above the base year mean. The frequency of occurrence of mature females was above the base year mean (23.4 percent) from 2005 – 2013 and 2015 – 2018 (2018=51.3 percent).

Three indices are derived from Program 120 including Pamlico and Southern region median carapace width and a statewide pre-recruit abundance index (Figure 12). Median carapace width was below the base year mean (34.3 mm [1.4 inches]) in 2018 (31.0 mm [1.2 inches]) in the Pamlico region. In the Southern region, median carapace width was below the base year mean (32.7 mm [1.3 inches]) in 2018 (29.0 mm [1.1 inches]). The statewide pre-recruit index has been below the base year mean (1.10 crabs/tow) since 2010; in 2018 the pre-recruit index was 0.73 crabs/tow.

Four indices are derived from Program195 including summer and fall median carapace width, fall spawning stock, and fall frequency of occurrence of mature female indices (Figure 13). The summer median carapace width index was below the base year mean (72.2 mm [2.8 inches]) in 2018 (62 mm [2.4 inches]). The fall median carapace width index was below the base year mean (109.1 mm [4.3 inches]) in 2018 (57 mm [2.2 inches]). The fall spawning stock index has been below the base year mean (741.7 mm/tow [29.2 inches]) since 2004; in 2018 the fall spawning index was 585.7 mm/tow (23.1 inches). The frequency of occurrence of mature females was below the base year mean (55.9 percent) from 2004-2017; in 2018 the frequency of occurrence of mature females was above the base year mean at 63.0 percent. Figure 15 shows the individual traffic lights for each index as well as the composite production traffic light.

MANAGEMENT STRATEGY

Traffic Light

The NCMFC preferred management strategy under Amendment 2 relies on the Traffic Light analysis to provide information on the relative condition of the stock. The base years (1987 to 2009) for assigning the signals in the Traffic Light analysis will remain constant until the next amendment of the FMP. The adaptive management framework in Amendment 2 will remain in effect until the adoption of Amendment 3. The Traffic Light analysis is updated annually by July of each year to gauge the status of the stock. To trigger management actions, either the adult abundance or production characteristic of the assessment must be at or above the 50 percent red threshold for three consecutive years to trigger the moderate management actions and must be at or above the 75 percent red threshold for two of three consecutive years to trigger the elevated management actions established in the plan (Table 1). The recruit abundance indicator, while not used to trigger initial management action, may be used to supplement any management actions taken if the adult abundance or production triggers are activated.

Based on the results of the Traffic Light update in 2016, management action was required by the NCMFC. At their May 19, 2016 business meeting the NCMFC was presented with several management options identified in the adaptive management framework in Amendment 2 to the N.C. Blue Crab FMP. To improve the condition of the blue crab stock, the NCMFC took the following actions:

1. Required one additional escape ring in crab pots and one of the three escape rings must be located within one full mesh of the corner of the pot and within one full mesh of the bottom of the apron/stairs (divider) of the upper chamber of the pot.
2. Eliminated the harvest of v-apron immature female hard crabs (excluding peeler crabs); and include v-apron immature female hard crabs in the culling tolerance.
3. Prohibited the harvest of dark sponge crabs (brown and black) from April 1-April 30 each year; and include dark sponge crabs in the culling tolerance.
4. Lowered the culling tolerance from 10 percent to five percent for all crabs, except mature females.
5. Prohibited the harvest of crabs with dredges except incidental to lawful oyster dredging as outlined in NCMFC Rule 15A NCAC 03L .0203(a)(2).

All adaptive management measures were effective June 6, 2016 except for the additional escape ring requirement which was not effective until January 15, 2017 (NCDMF 2016). This delay was to allow fishermen time to modify their pots.

For the management measures implemented in May 2016 under the adaptive management framework to be relaxed, the adult abundance characteristic of the traffic light must fall below the 50 percent red threshold for three consecutive years. For 2018, the adult abundance characteristic is at 47 percent red, this was the first year below the moderate management threshold since 2012. The production characteristic is at 48 percent red and has been above the moderate management threshold for one (2016) of the last three years (2016-2018). The recruit abundance characteristic has exceeded the moderate threshold for eight consecutive years (2011-

2018) and had exceeded the elevated threshold for five consecutive years (2013-2017). For 2018, recruit abundance characteristic is at 67 percent red (Figure 15).

The current update indicates 2018 will count as the first of three consecutive years required below the 50 percent red threshold for the adult abundance characteristic to allow management measures to be relaxed.

Principal Issues
Several management issues were explored in Amendment 2; Table 4 outlines the specific issues explored and the implementation status of each management strategy.

RESEARCH NEEDS

Several research needs were identified in N.C. Blue Crab Fishery Management Plan Amendment 2; the bulleted list below outlines the specific needs and highlights the progress made towards each management and research need.

- Continue to support research to determine the status of protected species (e.g., migration patterns, habitat utilization) along the North Carolina coast to better anticipate and prevent interactions (needed)
- Support research on blue crab fishery interactions with protected species (e.g., identifying any seasonal or spatial peaks in potential for interactions) (needed)
- Support gear modification research and testing that could reduce protected species interactions (needed)
- Continue socioeconomic surveys of blue crab harvesters and include wholesale and retail benefits, the entire support industry for this fishery including suppliers, picking houses, and restaurants (needed)
- Update Recreational Commercial Gear License (RCGL) survey (needed)
- Continue survey and compile data of recreational crabbers not possessing a RCGL license (ongoing through NCDMF mail survey of CRFL holders)
- Determine the economic effects of imported crabmeat, including the mixture of imported meat with local crabmeat, on processing and demand (needed)
- Determine the costs associated with crab processing. Identify the factors and their relative importance in predicting processor closures (needed)
- Research the changing demographics of the commercial blue crab fishery (needed)
- Continue research on the impacts of endocrine disrupting chemicals (EDCs) on the various life stages of the blue crabs and way to reduce introduction of EDCs into estuarine waters. (needed)
- Assess the impact of winter inlet deepening dredge activities on the overwintering female blue crabs and their habitat (needed)
- Determine the spatial and biological characteristics of SAV beds that maximize their ecological value to the blue crab for restoration or conservation purposes (needed)
- Identify, research, and map shallow detrital areas important to blue crabs (needed)
- Additional research is needed on the extent, causes, and impacts of hypoxia and anoxia on blue crab behavior and population abundance in North Carolina’s estuarine waters (needed)

- Conduct research on the water quality impacts of crab pot zincs, bait discard, and alternative crab baits in the pot fishery (needed)
- Develop methods to expand sampling effort to more accurately assess the status of the blue crab stock and its fisheries (needed)
- Continue research on blue crab discards in the shrimp trawl fishery (ongoing through NCDMF observer studies)
- Expand research state wide on the use of terrapin excluder devices in crab pots (needed)
- Implement outreach programs to inform state agencies, the public, and the commercial and recreational fishing industries about issues relating to protected species and fishery management (needed)
- Continue gear development research to minimize species interactions (needed)
- Continue existing programs that have been used to monitor North Carolina's blue crab stock to maintain baseline data (ongoing through NCDMF fishery-independent sampling)
- Identify key environmental factors that significantly impact North Carolina's blue crab stock and investigate assessment methods that can account for these environmental factors (needed)
- Conduct a study of the selectivity of the gear used in the Juvenile Anadromous Trawl Survey (Program 100) to evaluate the size at which blue crabs are fully-selected to the survey gear; the results of such a study could help determine whether the survey data could be used to develop a reliable index of blue crab recruitment for the Albemarle region; no such index is currently available (needed)
- Expand spatial coverage of the Estuarine Trawl Survey (Program 120) to include shallow-water habitat in Albemarle Sound; sampling in shallow-water habitat is intended to target juvenile blue crabs so that a recruitment index for the Albemarle Sound could be developed (needed)
- Expand temporal coverage of the Estuarine Trawl Survey (Program 120) beyond May and June sampling; additional sampling later in the blue crab's growing season would provide more information on within-year changes in growth, mortality, and abundance; at a minimum, recommend addition of September sampling in order to capture the fall settlement peak (needed)
- Expand spatial coverage of Pamlico Sound Survey (Program 195) to include deep water habitat in Albemarle Sound and the Southern Region; expanding the sampling region of adult blue crab habitat would allow for a more spatially-comprehensive adult index; additionally, there would be increased confidence in comparison of adult abundance trends among regions since all would derive from the same sampling methodology (needed)
- Implement a statewide survey with the primary goal of monitoring the abundance of blue crabs in the entire state; such a survey would need to be stratified by water depth to ensure capture of all stages of the blue crab life cycle and standardized among North Carolina waters (needed)
- Implement monitoring of megalopal settlement near the ocean inlets could potentially add a predictive function to the blue crab stock assessments in the future; Forward et al. (2004) detected a positive, linear relationship between megalopal abundance and commercial landings of hard blue crabs for both the local estuarine area and the entire state of North Carolina when a two-year time lag was implemented (Forward et al. 2004); such monitoring is critical to track larval ingress peaks and the effect of natural forces, such as tropical storms and prevailing winds, on ingress (needed)

- Continue surveys of recreational harvest and effort to improve characterization of the recreational fishery for blue crabs (ongoing through NCDMF mail survey of CRFL holders)
- Identify programs outside the NCDMF that collect data of potential use to the stock assessment of North Carolina's blue crabs (needed)
- Perform in-depth analysis of available data; consider standardization techniques to account for gear and other effects in development of indices; explore utility of spatial analysis in assessing the blue crab stock

FISHERY MANAGEMENT PLAN SCHEDULE RECOMMENDATION

The division will continue developing Amendment 3 in conjunction with the advisory committee. Amendment 3 is scheduled for adoption in spring 2020.

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TABLES

Table 1. Management measures in N.C. Blue Crab Fishery Management Plan Amendment 2 that may be implemented by proclamation as described in the blue crab adaptive management framework when a stock characteristic exceeds a designated management threshold.

Characteristic	Moderate management level	Elevated management level
Adult abundance	A1. Increase in minimum size limit for male and immature female crabs	A4. Closure of the fishery (season and/or gear)
	A2. Reduction in tolerance of sub-legal size blue crabs (to a minimum of 5%) and/or implement gear modifications to reduce sublegal catch	A5. Reduction in tolerance of sub-legal size blue crabs (to a minimum of 1%) and/or implement gear modifications to reduce sublegal catch
	A3. Eliminate harvest of v-apron immature hard crab females	A6. Time restrictions
Recruit abundance	R1. Establish a seasonal size limit on peeler crabs	R4. Prohibit harvest of sponge crabs (all) and/or require sponge crab excluders in pots in specific areas
	R2. Restrict trip level harvest of sponge crabs (tolerance, quantity, sponge color)	R5. Expand existing and/or designate new crab spawning sanctuaries
	R3. Close the crab spawning sanctuaries from September 1 to February 28 and may impose further restrictions	R6. Closure of the fishery (season and/or gear)
		R7. Gear modifications in the crab trawl fishery
Production	P1. Restrict trip level harvest of sponge crabs (tolerance, quantity, sponge color)	P4. Prohibit harvest of sponge crabs (all) and/or require sponge crab excluders in pots for specific areas
	P2. Minimum and/or maximum size limit for mature female crabs	P5. Reduce peeler harvest (no white line peelers and/or peeler size limit)
	P3. Close the crab spawning sanctuaries from September 1 to February 28 and may impose further restrictions	P6. Expand existing and/or designate new crab spawning sanctuaries
		P7. Closure of the fishery (season and/or gear)

Table 2. Blue crab recreational harvest (number and weight) and releases (number) and commercial harvest, 1987 – 2018. Recreational harvest weight is calculated using a standard conversion of 3 crabs per pound.

	Recreational*			Commercial	Total
	Numbers		Weight (lb)	Weight (lb)	Weight (lb)
Year	Landed	Released	Landed	Landed	Landed
1987	-	-	-	32,423,604	32,423,604
1988	-	-	-	35,604,423	35,604,423
1989	-	-	-	34,724,673	34,724,673
1990	-	-	-	38,070,328	38,070,328
1991	-	-	-	41,829,676	41,829,676
1992	-	-	-	41,068,374	41,068,374
1993	-	-	-	43,672,732	43,672,732
1994	-	-	-	53,513,124	53,513,124
1995	-	-	-	46,443,541	46,443,541
1996	-	-	-	67,080,200	67,080,200
1997	-	-	-	56,090,109	56,090,109
1998	-	-	-	62,076,171	62,076,171
1999	-	-	-	57,546,676	57,546,676
2000	-	-	-	40,638,384	40,638,384
2001	-	-	-	32,180,390	32,180,390
2002	-	-	-	37,736,319	37,736,319
2003	-	-	-	42,769,797	42,769,797
2004	-	-	-	34,130,608	34,130,608
2005	-	-	-	25,430,119	25,430,119
2006	-	-	-	25,343,158	25,343,158
2007	-	-	-	21,424,960	21,424,960
2008	-	-	-	32,916,691	32,916,691
2009	-	-	-	29,707,232	29,707,232
2010	-	-	-	30,683,011	30,683,011
2011	114,426	81,763	38,142	30,035,392	30,073,534
2012	120,979	79,072	40,326	26,785,669	26,825,995
2013	94,174	61,452	31,391	22,202,623	22,234,014
2014	100,597	67,413	33,532	26,231,112	26,264,644
2015	71,587	60,135	23,862	32,127,043	32,150,905
2016	84,879	82,781	28,293	25,462,740	25,491,033
2017	72,645	67,667	24,215	19,273,156	19,297,371
2018	47,766	57,024	15,922	17,012,354	17,028,276
Average	88,382	69,663	29,461	36,319,825	36,327,190
Traffic Light Base Years' Average (1987-2009)				40,540,056	

*Recreational data collection began in October 2010 and the first full year estimates were available in 2011.

Table 3. Blue crab length (carapace width [CW], inches) data from commercial fish house samples, 1995-2018.

Year	Mean CW	Minimum CW	Maximum CW	Total Number Measured
1995	5.6	2.0	8.3	33,007
1996	5.7	2.7	8.3	23,333
1997	5.6	2.7	8.1	22,001
1998	5.7	3.4	7.9	15,246
1999	5.5	1.2	7.8	13,456
2000	5.7	3.4	8.0	15,560
2001	5.7	2.9	9.1	18,316
2002	5.5	3.5	8.3	11,417
2003	5.7	3.3	7.8	11,802
2004	5.7	3.2	8.6	17,386
2005	5.6	3.2	8.3	10,474
2006	5.7	3.3	8.1	10,867
2007	5.7	3.4	8.0	14,898
2008	5.9	3.0	8.7	20,420
2009	6.0	3.7	8.7	17,910
2010	5.7	2.7	8.4	16,123
2011	5.8	2.9	8.3	16,461
2012	5.8	3.8	8.6	12,918
2013	5.8	1.9	8.5	17,616
2014	5.9	2.3	8.5	11,304
2015	5.8	2.2	9.0	14,681
2016	5.7	3.5	9.0	13,531
2017	5.8	3.6	8.1	9,978
2018	5.8	3.7	8.1	7,698

Table 4. Summary of management strategies and outcomes from N.C. Blue Crab Fishery Management Plan Amendment 2.

Management Strategy	Implementation Status
STOCK PROTECTION	
Repeal the current female stock conservation management trigger.	Rule change to 15A NCAC 03L .0201; Rule change implemented on April 1, 2014.
Continue existing sampling programs to maintain baseline information for the Traffic Light Stock Assessment method.	No action required.
Adopt the adaptive management framework based on the Traffic Light Stock Assessment and the proposed moderate and elevated management levels for recruit abundance, adult abundance, and production characteristics. Initial management action will only be implemented when either the adult abundance or production characteristic reach the management trigger of 50% red or greater for three consecutive years. The recruit abundance characteristic will be used as a supplement to further direct conservation management actions, if deemed necessary.	Rule change to 15A NCAC 03L .0201, 03L .0203, 03L .0204, 03L .0205, 03L .0206, 03L .0209 and 03J .0301; Rule change implemented on April 1, 2014.
USER CONFLICTS	
Status quo, continue with no crab pot limit in southern Bogue Sound.	No action required.
Open the non-pot (long haul net) areas all the time by rule in the Pungo River and keep status quo in the Long Point area on the Pamlico River.	Rule change to 15A NCAC 03R .0107; Rule change implemented on April 1, 2014.
CLARIFICATION OF RULES	
Modify the rule to include the lower Broad Creek area that is closed to crab pots from June 1 through November 30.	Rule change to 15A NCAC 03R .0107; Rule change implemented on April 1, 2014.
Amend the rule to match harvest management for crab dredging.	Rule change to 15A NCAC 03L .0203; Rule change implemented on April 1, 2014.
Modify Rule 15A NCAC 03L .0202 to incorporate the long-standing provisions of Proclamation SH-5-2007 (Pamlico Sound four-inch mesh crab trawl line), and retain the Director's proclamation authority to restrict crab trawl mesh size.	Rule change to 15A NCAC 03L .0202; Rule change implemented on April 1, 2014.
Amend the current rule to redefine criteria for exempting escape rings in crab pots from the 1.5-inch pot mesh size to unbaited pots and pots baited with a male crab.	Rule change to 15A NCAC 03J .0301 and 03L .0301; Rule change implemented on April 1, 2014.

Management Strategy	Implementation Status
Repeal the proclamation authority that allows for exempting the escape ring requirement in order to allow the harvest of peeler crabs.	Rule change to 15A NCAC 03J .0301; Rule change implemented on April 1, 2014.
Adopt the no trawl line along the Outer Banks in Pamlico Sound as the new boundary in Pamlico Sound, and the Newport River boundaries as delineated in the proposed rule as new boundaries for the area where closure of escape rings to take small mature females is allowed.	Rule change to 15A NCAC 03J .0301 and add new rule 03R .0118; Rule change implemented on April 1, 2014.
Modify Rule 15A NCAC 03J .0104(b)(4) TRAWL NETS to correctly reference the Pamlico, Back and Core sounds as the areas in which the Director can open peeler trawling by proclamation.	Rule change to 15A NCAC 03J .0104; Rule change implemented on April 1, 2014.
Modify rule to clearly state the intent of the exceptions, culling tolerance, and separation requirements for the various categories of crabs.	Rule change to 15A NCAC 03L .0201; Rule change implemented on April 1, 2014.
HARVEST PRACTICES	
Continue with non-floating line on crab pots.	No action required.
Establish proclamation authority for requiring terrapin excluder devices in crab pots.	Rule change to 15A NCAC 03L .0204; Rule change implemented on April 1, 2014.
Establish a framework for developing proclamation use criteria and terrapin excluder specifications which may extend until after adoption of the amendment.	Will be addressed in next fishery management plan amendment.
Do not allow multiple pots to a single buoy.	No action required.
Encourage crab potters in areas of high pot loss to incorporate methods to reduce pot loss. Develop and provide information on potential methods to reduce pot loss.	Need to develop and provide information on potential methods to reduce pot loss.
Encourage crab potters in areas of high pot loss to incorporate escape panel designs in pots to reduce potential ghost fishing impacts. Develop and provide information on potential methods and materials to reduce ghost fishing impacts.	Need to develop and provide information on potential methods and materials to reduce ghost fishing impacts.
ENVIRONMENTAL FACTORS	
Identify and designate Strategic Habitat Areas that will enhance protection of the blue crab.	Existing authority through the Coastal Habitat Protection Plan (CHPP).
Identify, research, and designate additional areas as Primary Nursery Areas that may be important to blue crabs as well as other fisheries.	Existing authority through the CHPP.

Management Strategy	Implementation Status
Continue to map blue crab spawning areas and evaluate any that need to adjust or expand the boundaries or restrictions of the crab spawning sanctuaries based on recent research.	Existing authority through the CHPP.
Remap and monitor submerged aquatic vegetation in North Carolina to assess distribution and change over time.	Existing authority through the CHPP.
Restore coastal wetlands to compensate for previous losses and enhance habitat and water quality conditions for the blue crab.	Existing authority through the CHPP.
Work with Coastal Resource Commission to revise shoreline stabilization rules to adequately protect riparian wetlands and shallow water habitat and significantly reduce the rate of shoreline hardening.	Existing authority through the CHPP.
Develop and implement a comprehensive coastal marina and dock management plan and policy to minimize impacts to submerged aquatic vegetation, wetland edge, and other habitat important to blue crab.	Existing authority through the CHPP.
Assess the distribution, concentration, and threat of heavy metals and other toxic contaminants in freshwater and estuarine sediments and identify the areas of greatest concern to focus water quality improvement efforts.	Existing authority through the CHPP.
Support oyster shell recycling and oyster sanctuary programs to provide areas of enhanced or restored shell bottom habitat.	Existing authority through the CHPP.
Consider if prohibition of crab dredging is advisable.	Existing authority through the CHPP.
Protect “recruitment bottlenecks”, like inlets for the blue crab, from trawling or other impacts including natural channel modification using hardened structures like groins and jetties.	Existing authority through the CHPP.
Shallow areas where trawling is currently allowed should be re-examined to determine if additional restrictions are necessary.	Existing authority through the CHPP.
Improve methods to reduce sediment and nutrient pollution from construction sites, agriculture, and forestry.	Existing authority through the CHPP.
Increase on-site infiltration of storm water through voluntary or regulatory measures.	Existing authority through the CHPP.
Provide more incentives for low-impact development.	Existing authority through the CHPP.

Management Strategy	Implementation Status
Aggressively reduce point source pollution from wastewater through improved inspections of wastewater treatment facilities, improved maintenance of collection infrastructure, and establishment of additional incentives to local governments for wastewater treatment plant upgrading.	Existing authority through the CHPP.
Provide proper disposal of unwanted drugs, prevent the use of harmful JHA insecticides near-surface waters or in livestock feed, and develop technologies to treat wastewater for antibiotics and hormones.	Existing authority through the CHPP.

FIGURES

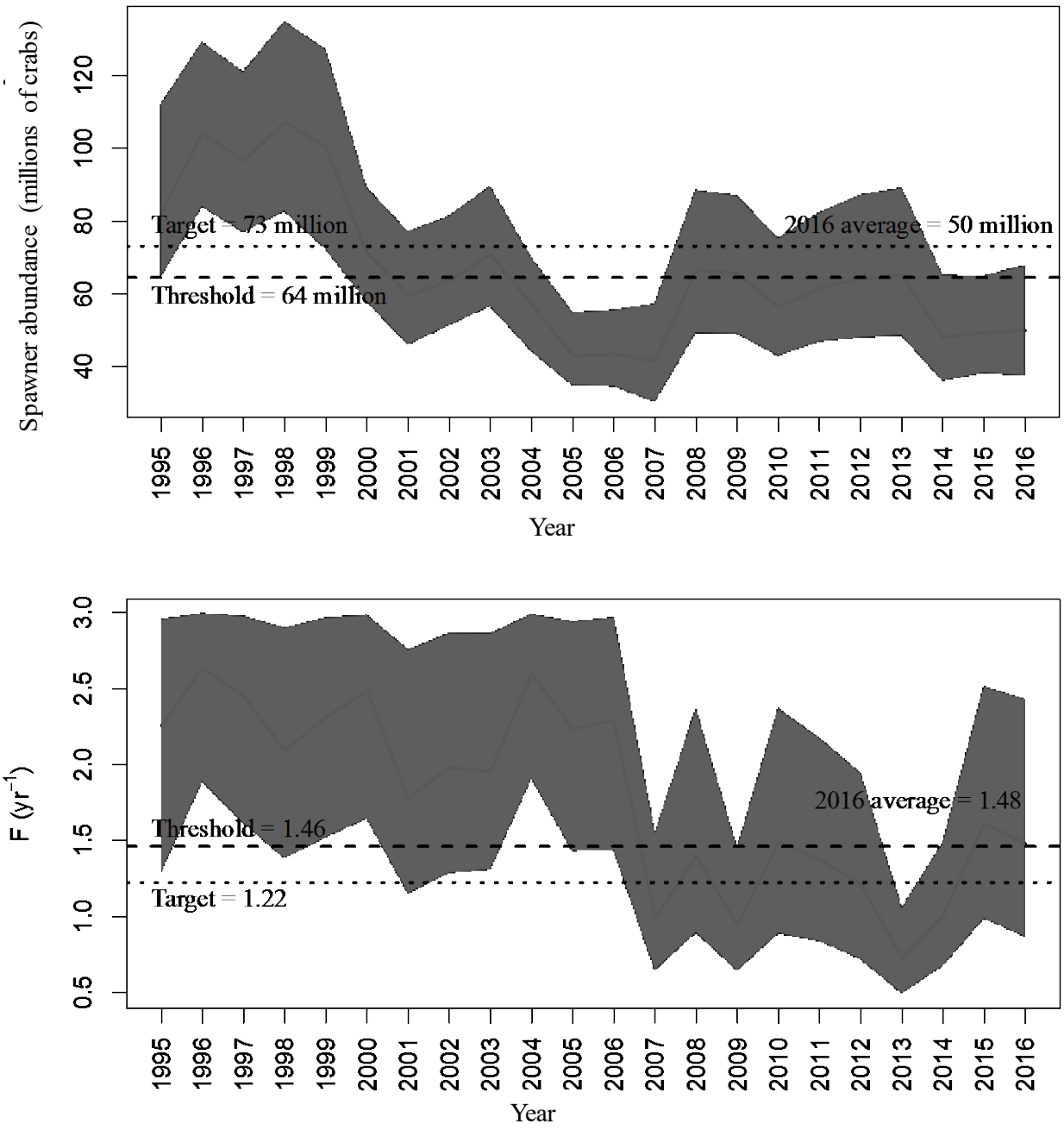

Figure 1. Estimated spawner abundance (mature female blue crabs) and fishing mortality (F) from the 2018 blue crab stock assessment (NCDMF 2018). The solid lines represent the posterior mean and the shaded area represents the 95% credible interval. The threshold and target values are the posterior means (dashed lines).

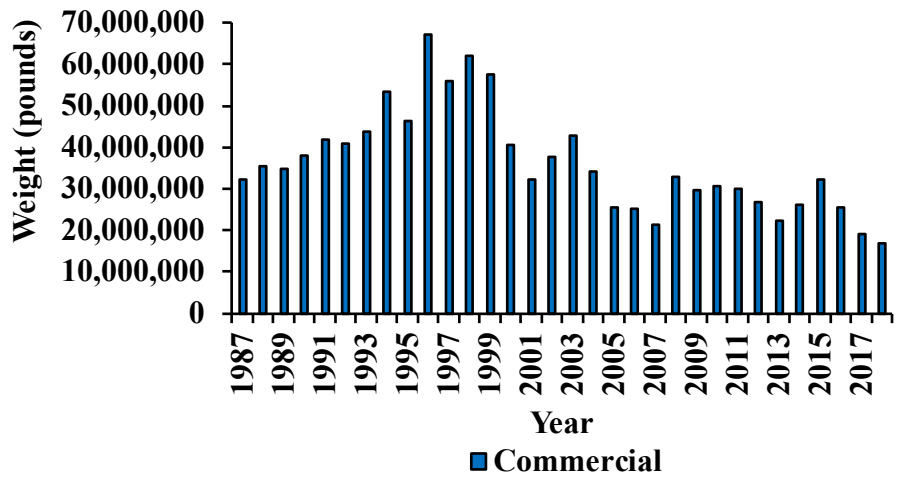

Figure 2. Annual blue crab commercial landings, 1987-2018. Landings include hard, soft, and peeler crabs.

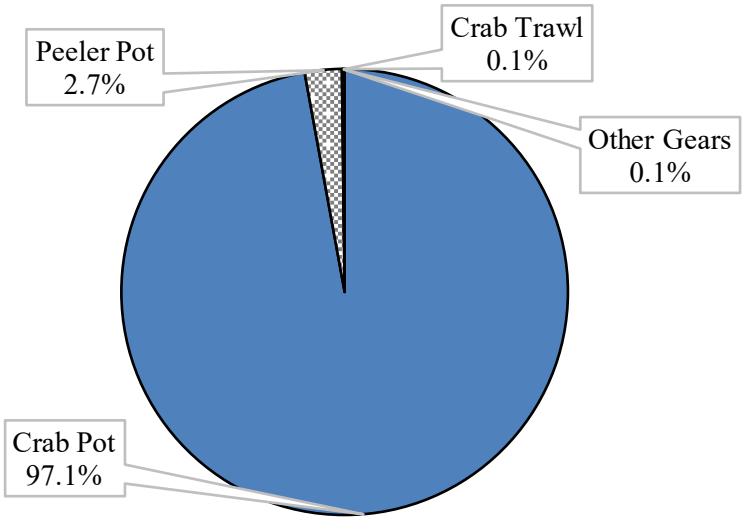

Figure 3. Commercial harvest (pounds) of blue crab by gear, 2018.

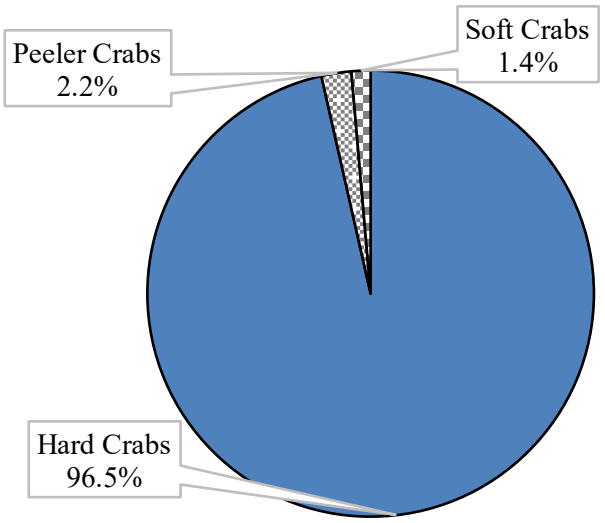

Figure 4. Commercial harvest (pounds) of blue crab by crab type, 2018.

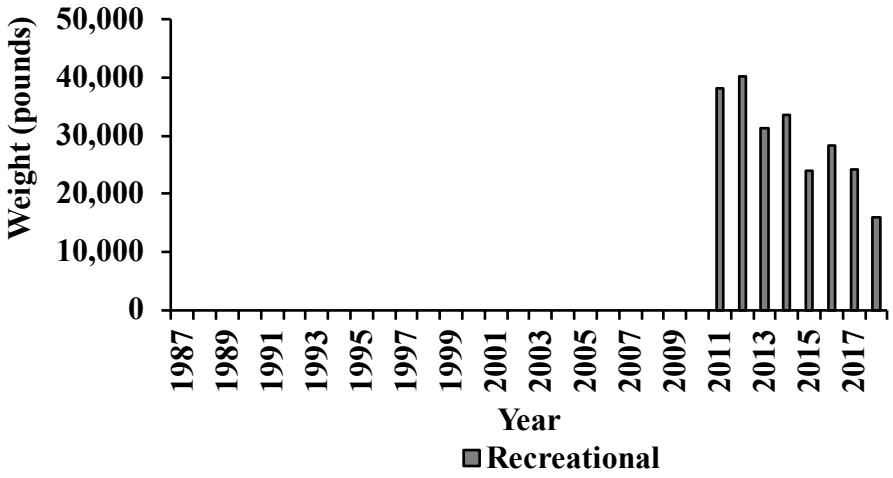

Figure 5. Annual blue crab recreational harvest, 1987-2018. Recreational mail survey began in October 2010 with the first full year of data available for 2011.

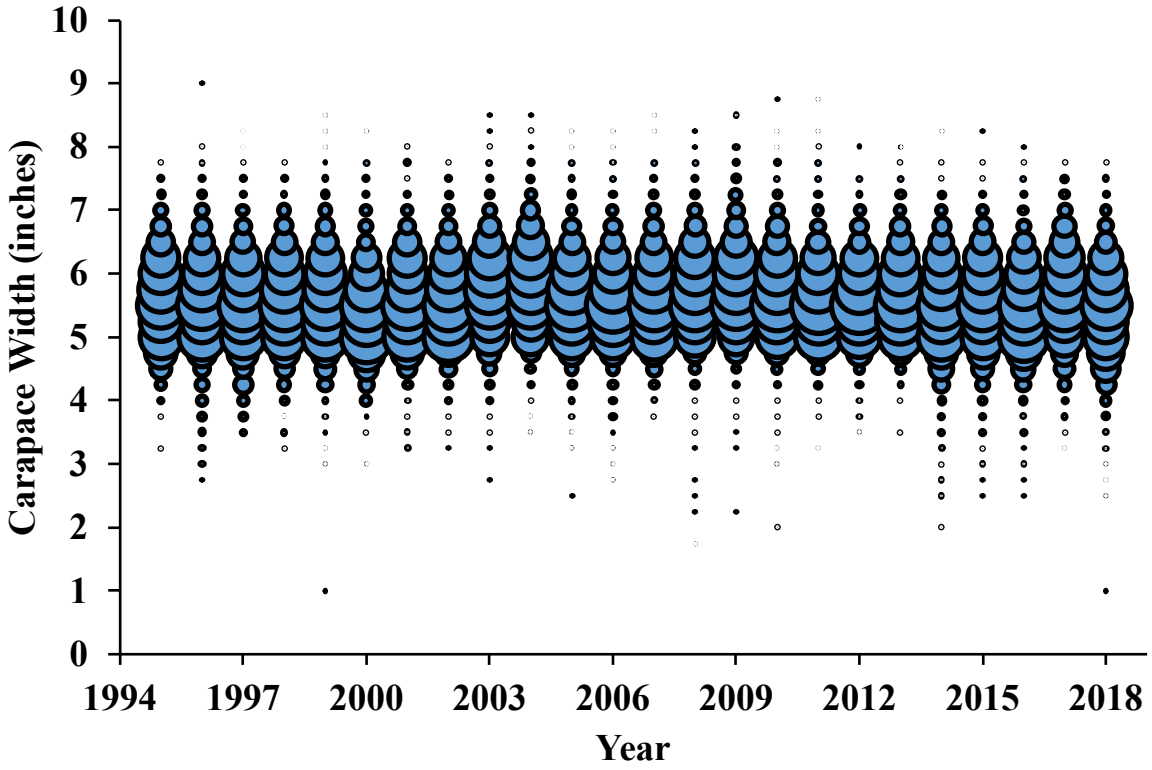

Figure 6. Commercial length frequency (carapace width, inches) of hard blue crab harvested, 1995-2018. Bubble represents the proportion of crabs at length.

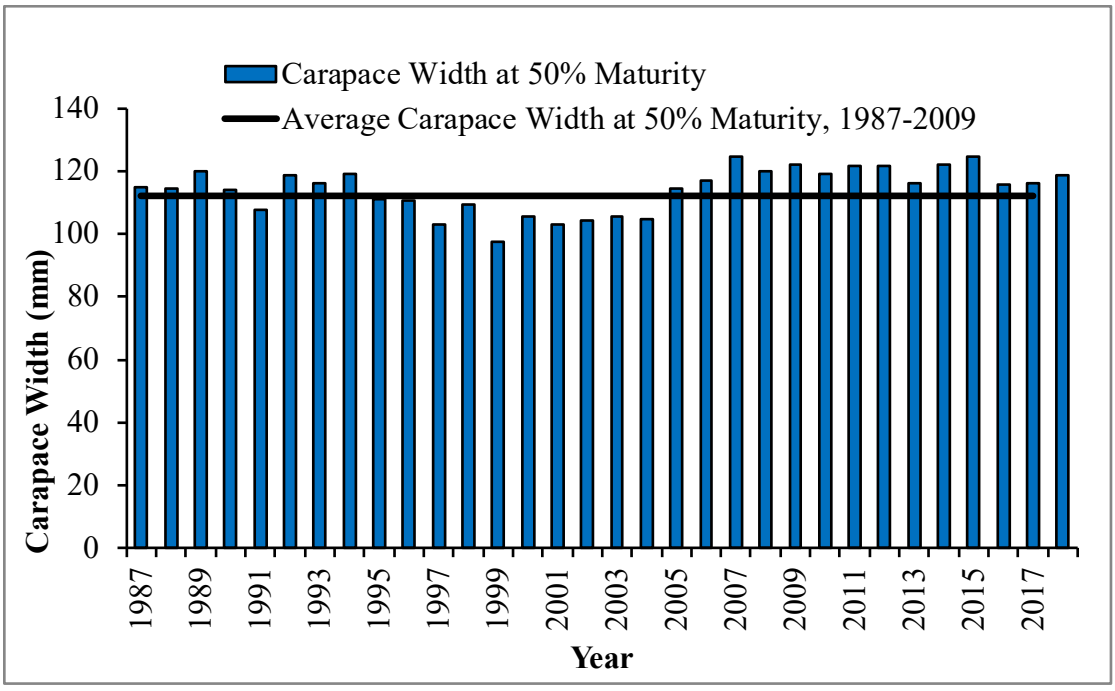

Figure 7. Length at 50% maturity for female blue crabs used in the production characteristic of the Blue Crab Traffic Light, 1987-2018. Fishery-dependent and independent data were included in the analysis.

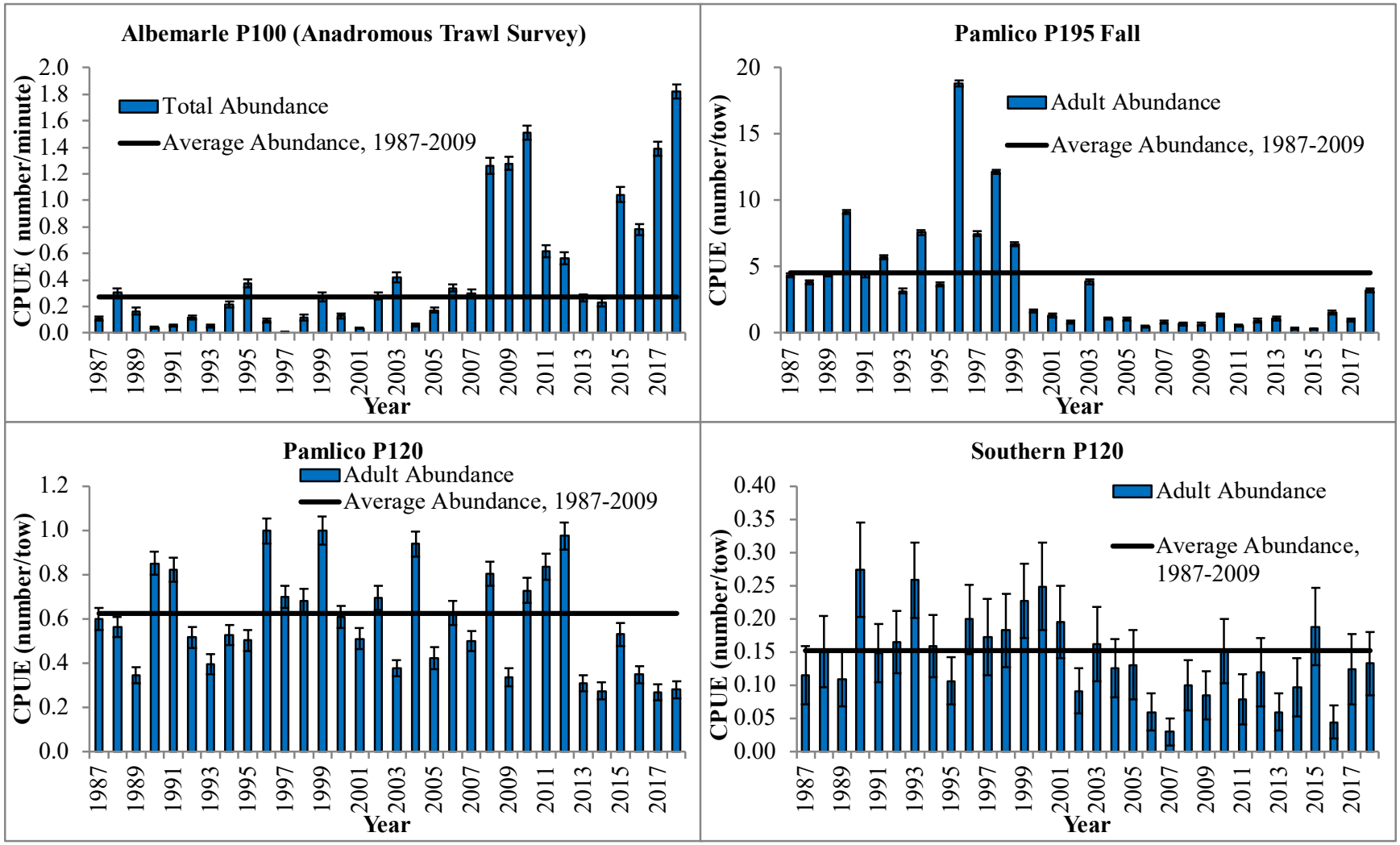

Figure 8. Indices from NCDMF sampling programs 100, 120, and 195 used for the adult abundance characteristic of the Blue Crab Traffic Light, 1987-2018. Error bars represent one standard error of the mean.

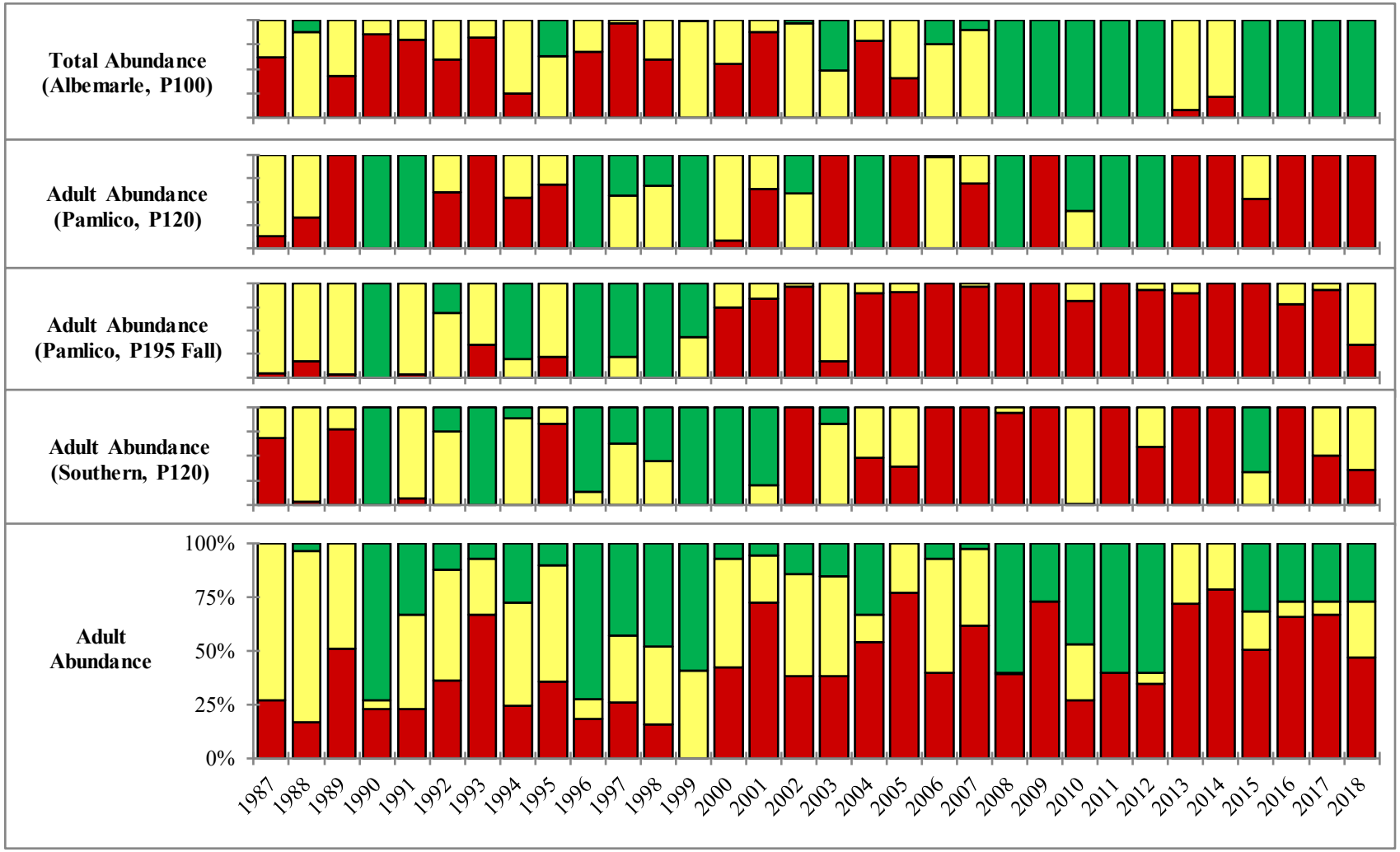

Figure 9. Blue Crab Traffic Light individual adult abundance indicators and the integrated summary (bottom figure), 1987-2018.

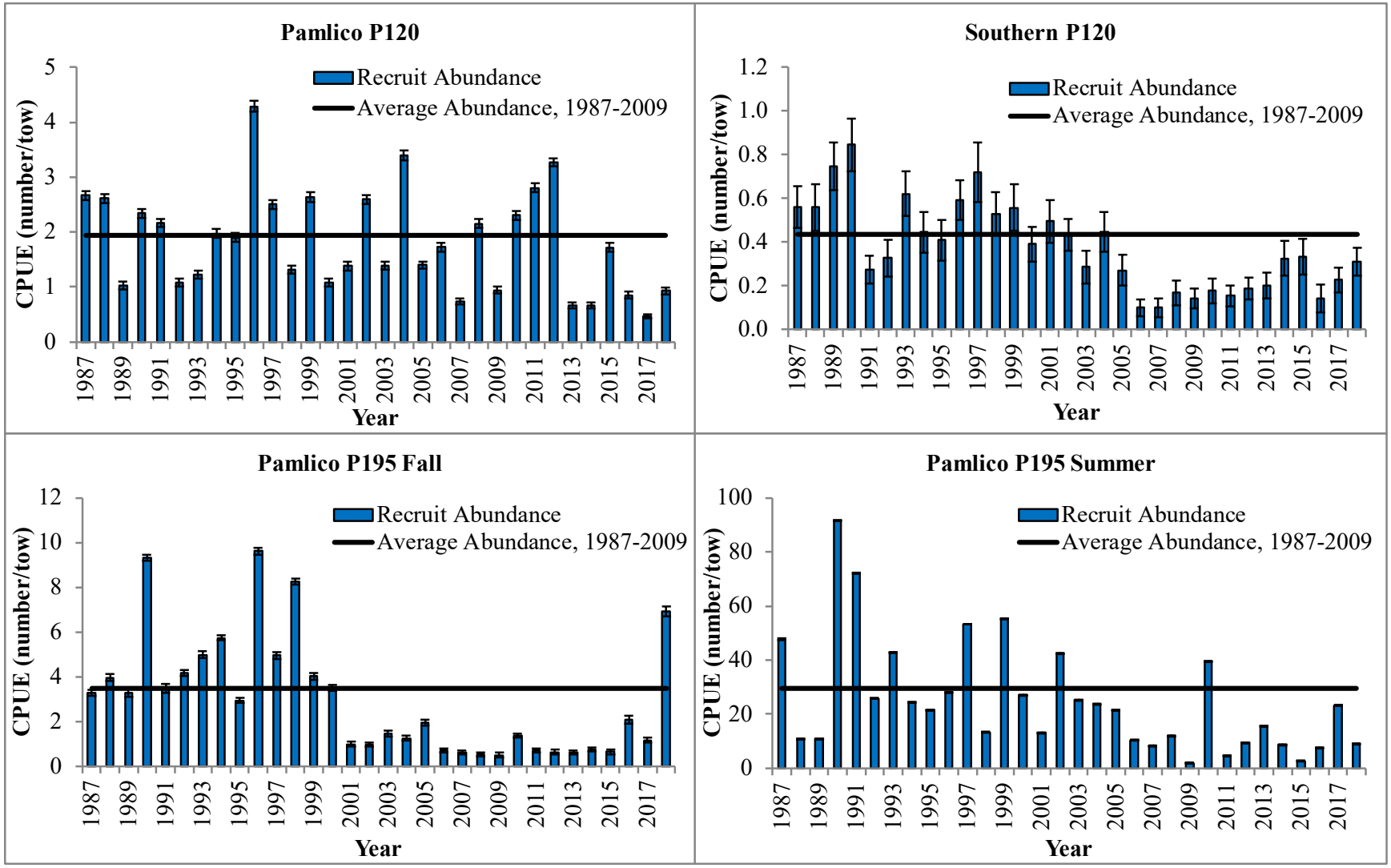

Figure 10. Indices from NCDMF sampling programs 120 and 195 used for the recruit abundance characteristic of the Blue Crab Traffic Light, 1987-2018. Error bars represent one standard error of the mean.

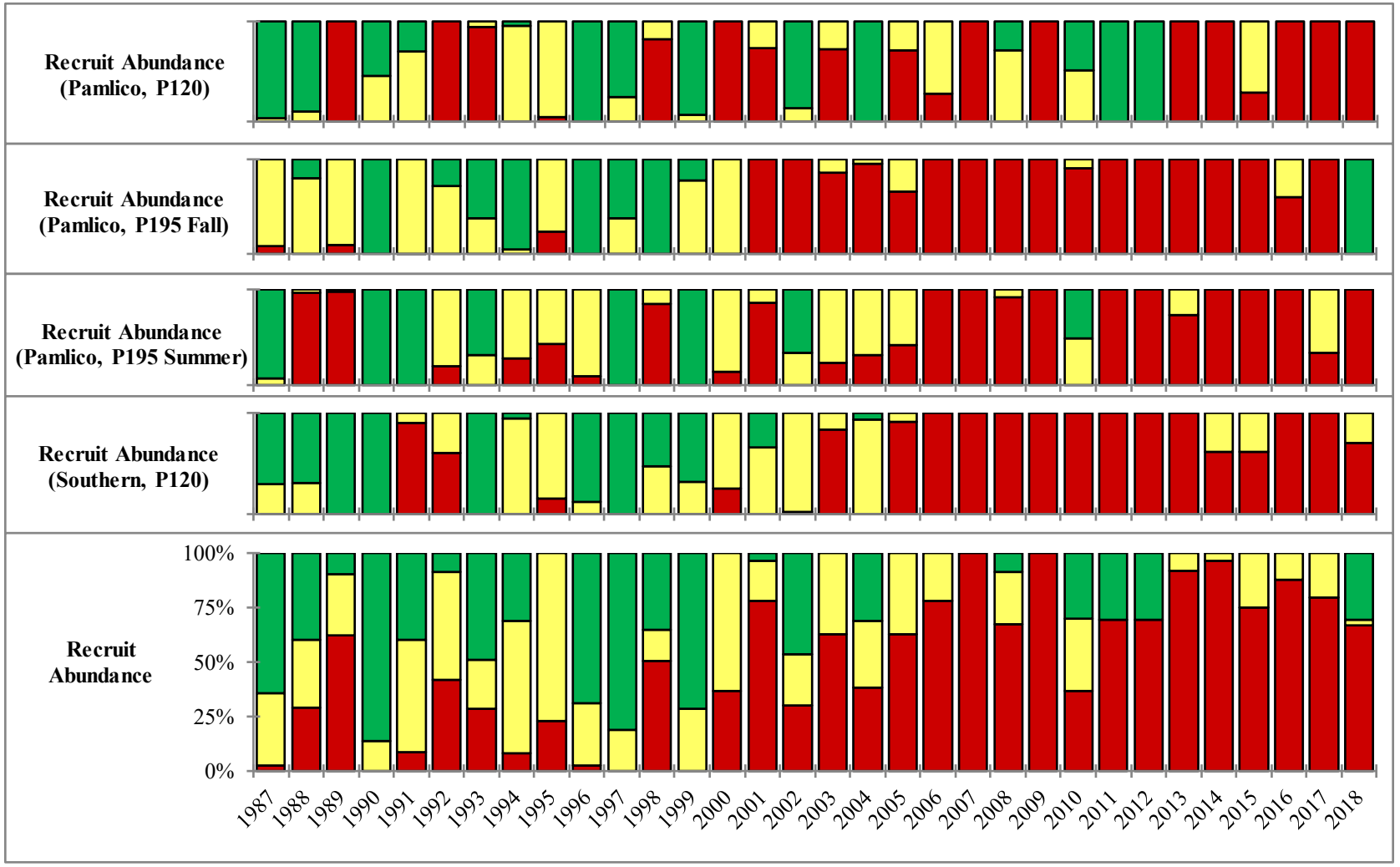

Figure 11. Blue Crab Traffic Light individual recruit abundance indicators and the integrated summary (bottom figure), 1987-2018.

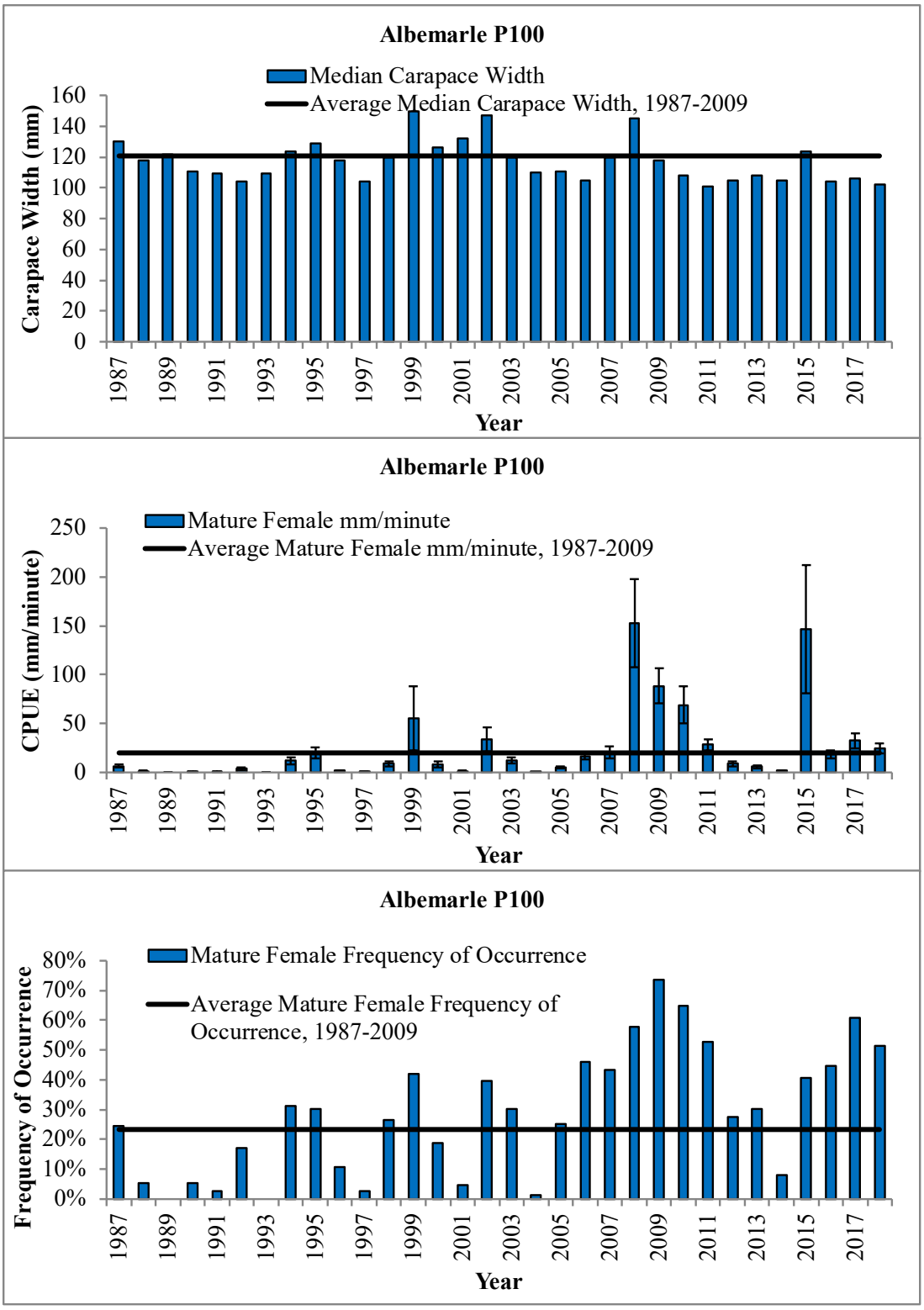

Figure 12. Indices from NCDMF sampling program 100 used for the production characteristic of the Blue Crab Traffic Light, 1987-2018. Error bars represent one standard error of the mean.

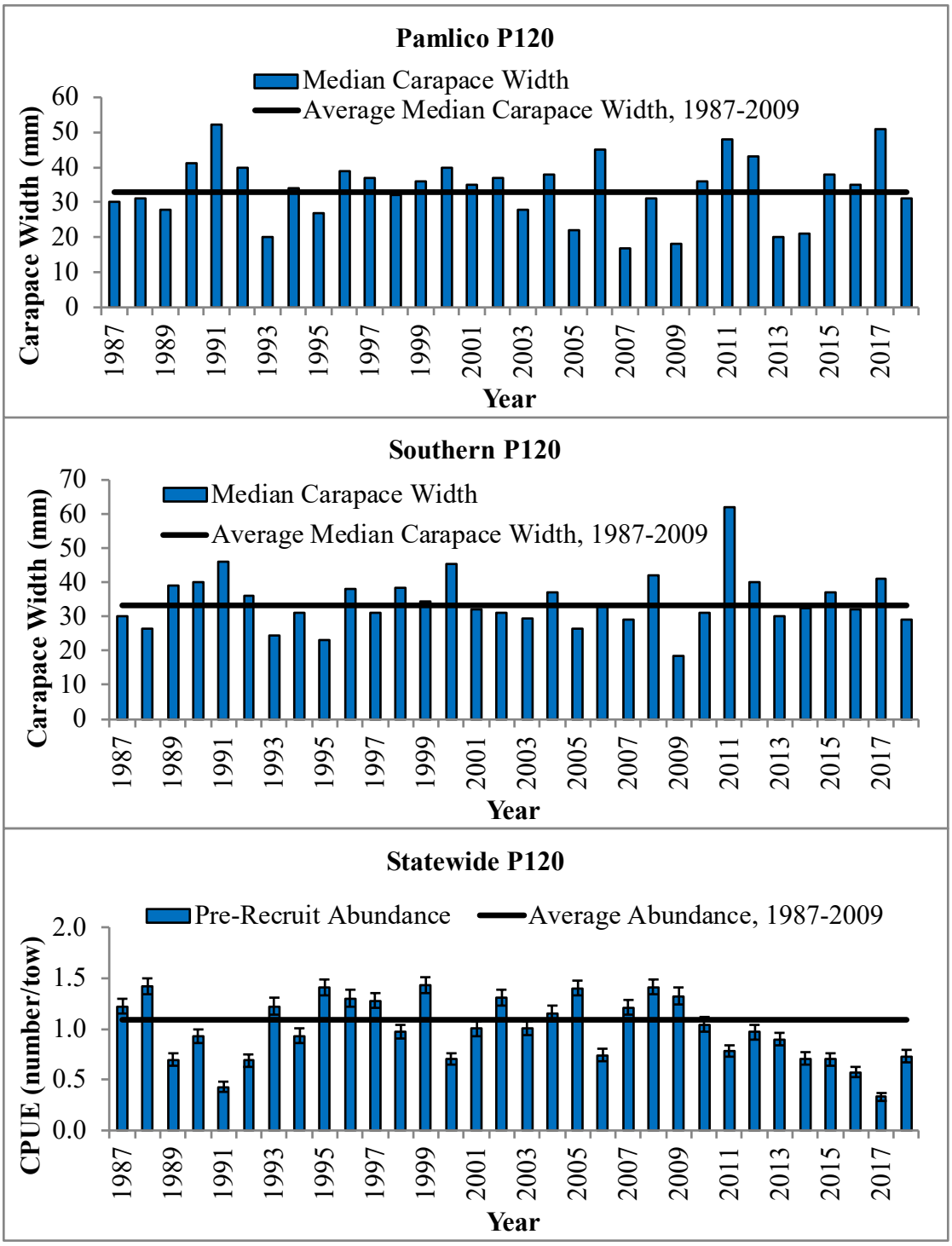

Figure 13. Indices from NCDMF sampling program 120 used for the production characteristic of the Blue Crab Traffic Light, 1987-2018. Error bars represent one standard error of the mean.

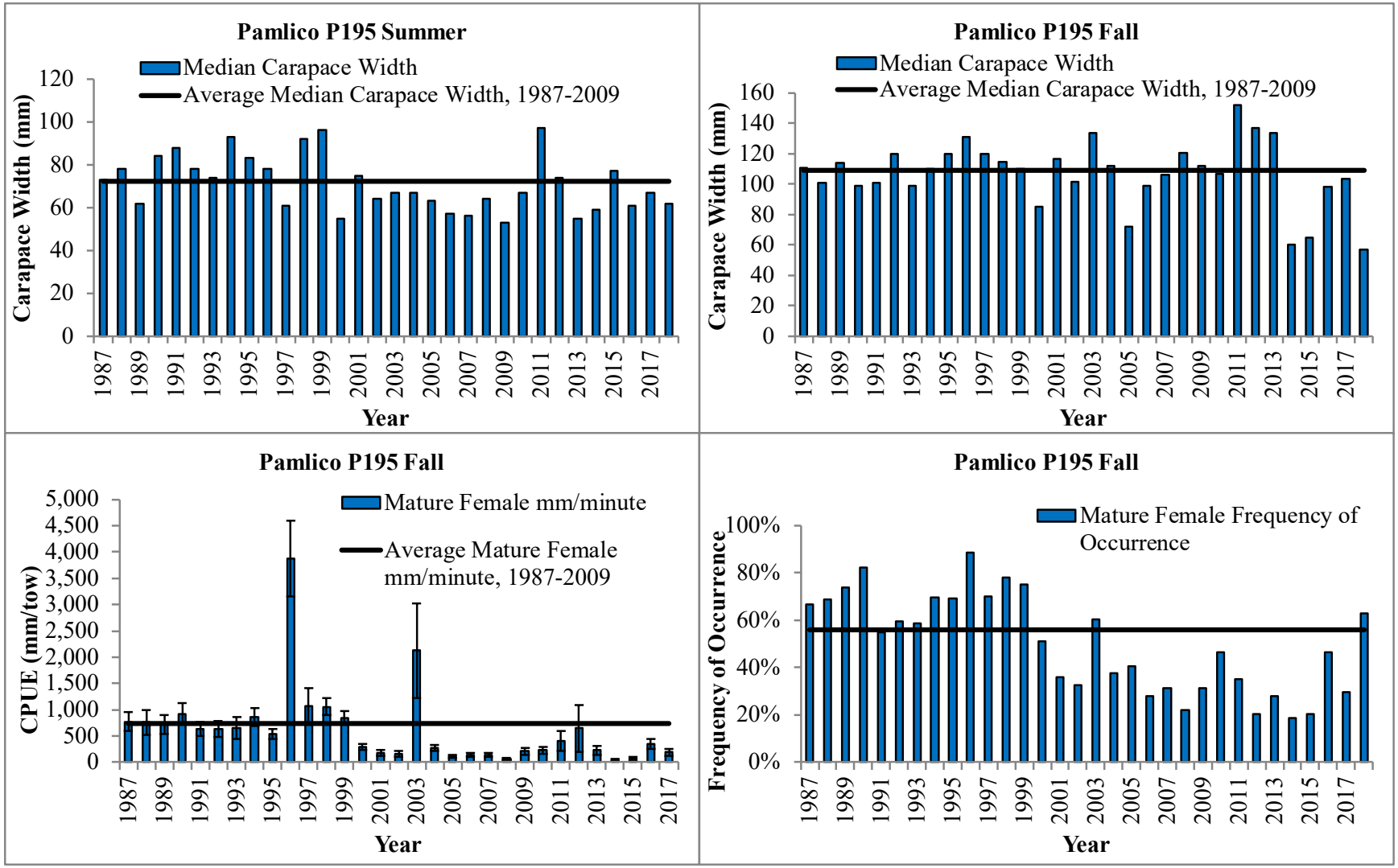

Figure 14. Indices from NCDMF sampling program 195 used for the production characteristic of the Blue Crab Traffic Light, 1987-2018. Error bars represent one standard error of the mean.

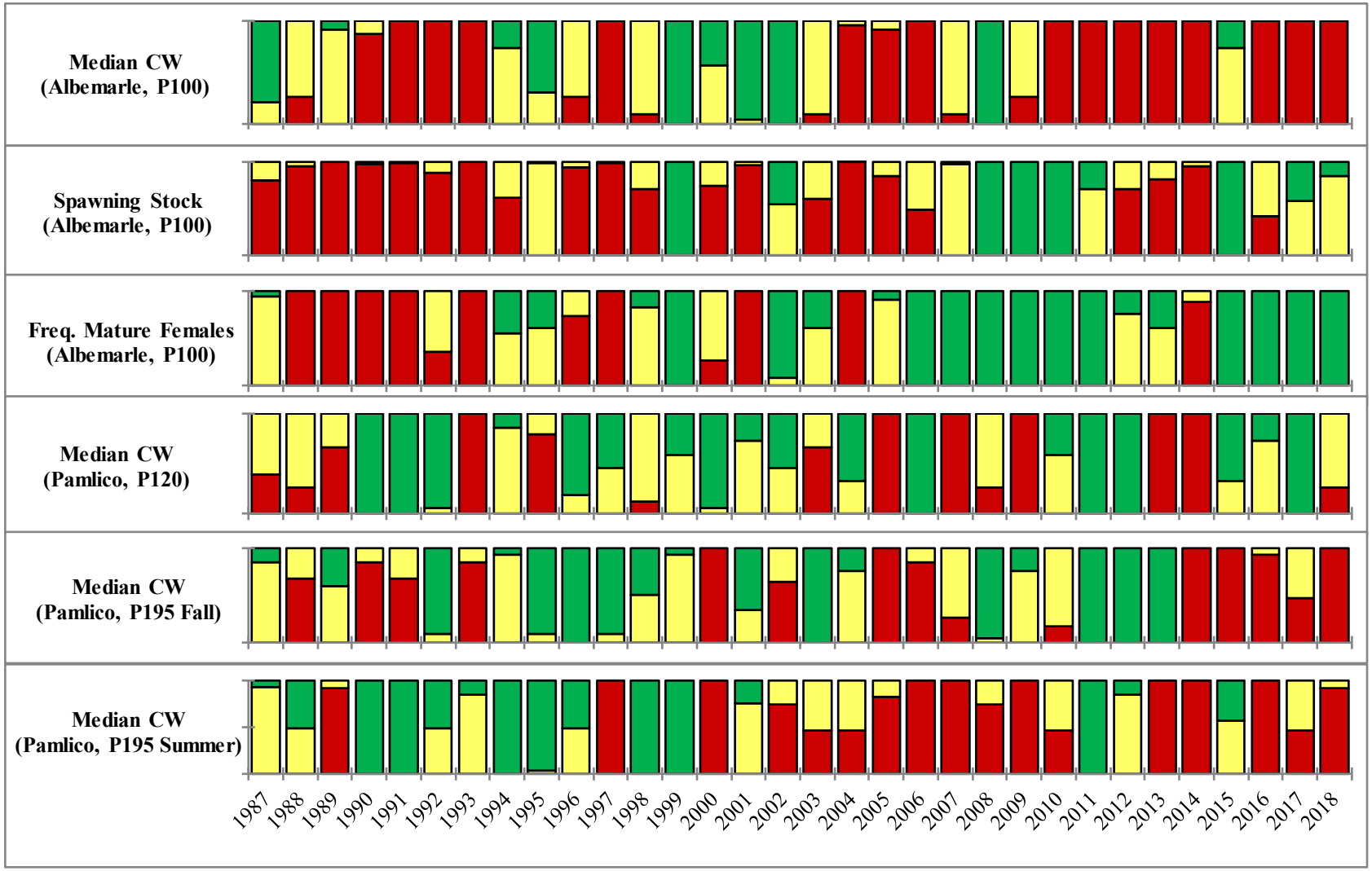

Figure 15. Blue Crab Traffic Light individual production indicators and integrated summary (bottom figure, next page), 1987-2018.

Figure 15 (cont.). Blue Crab Traffic Light individual production indicators and integrated summary (bottom figure), 1987-2018.

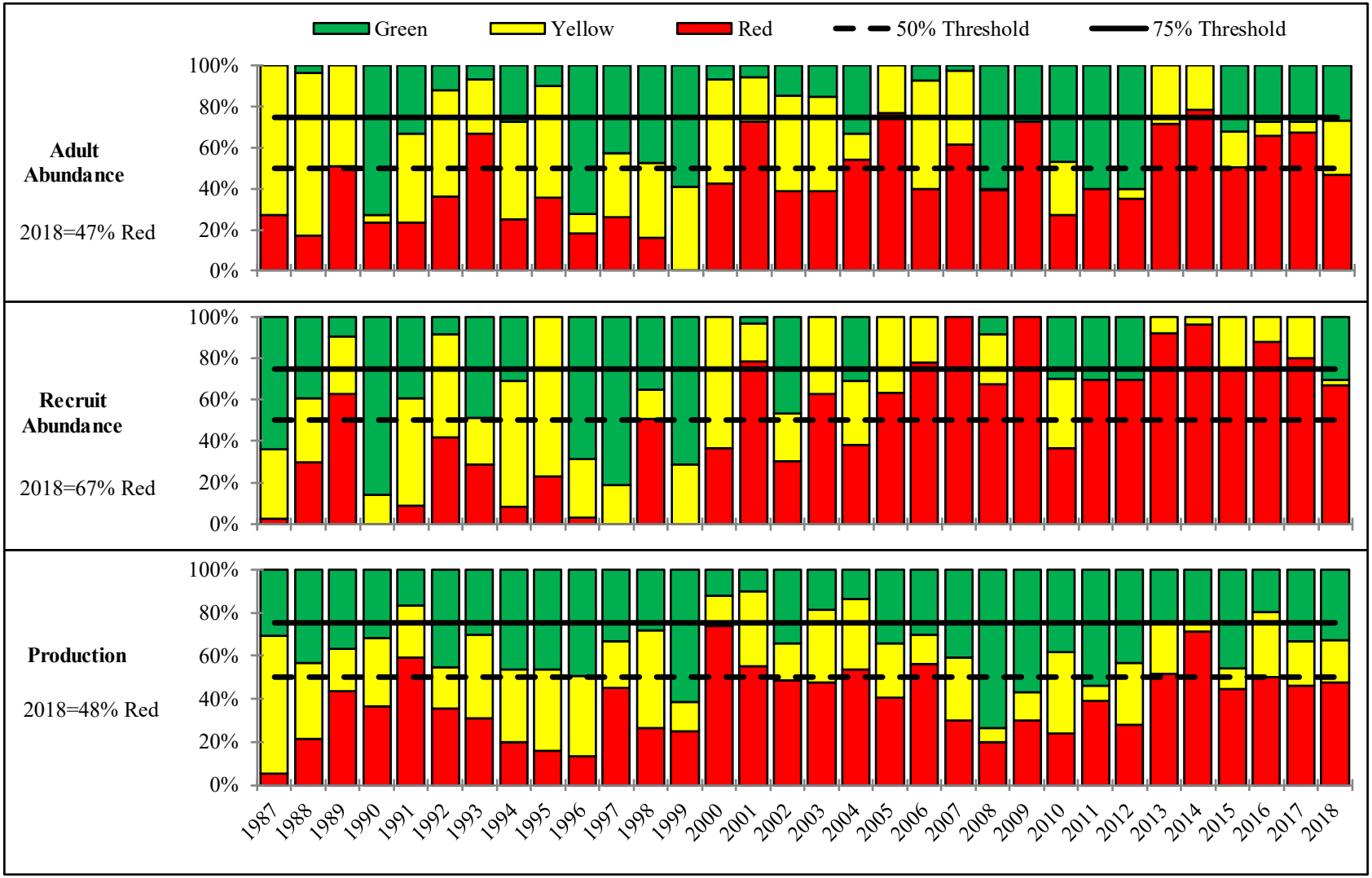

Figure 16. Blue Crab Traffic Light indicators for the adult abundance, recruit abundance, and production characteristics, 1987-2018. The dashed line represents the second quartile (50%) moderate management trigger and the solid line represents the third quartile (75%) elevated management trigger relative to the proportion of red.

FISHERY MANAGEMENT PLAN UPDATE
EASTERN OYSTER
AUGUST 2019

STATUS OF THE FISHERY MANAGEMENT PLAN

Fishery Management Plan History

Original FMP Adoption:	August 2001
Amendments:	Amendment 1 – January 2003 Amendment 2 – June 2008 Amendment 3 – April 2014 Amendment 4 – February 2017
Revisions:	None
Supplements:	Supplement A to Amendment 2 – November 2010
Information Updates:	None
Recommended Schedule Change:	None
Next MFC Scheduled Review:	July 2022

The original N.C. Oyster Fishery Management Plan (FMP) was adopted by the North Carolina Marine Fisheries Commission (NCMFC) in 2001. This FMP set up a process for designation of additional areas limited to hand harvest methods around Pamlico Sound and recommended several statutory changes to the shellfish lease program including higher fees, training requirements, and modified lease production requirements (NCDMF 2001). The N.C. Oyster FMP Amendment 1 simply changed one of the criteria for designation of hand harvest areas from waters generally less than 10 feet deep to waters less than six feet deep (NCDMF 2003). Highlights of the management measures developed in the N.C. Oyster FMP Amendment 2 included adopting a 15-bushel harvest limit in Pamlico Sound and a 10-bushel harvest limit for all gears (hand and mechanical) in designated areas around the sound, reducing the available harvest season, changing the way lease production averages were calculated, limited lease applications to five acres and had a recommendation to expand oyster sanctuary construction efforts (NCDMF 2008). Supplement A raised the potential harvest limit in Pamlico Sound to 20 bushels and created a monitoring system for determining when to close mechanical harvest in that area (NCDMF 2010). The N.C. Oyster FMP Amendment 3 created two seed oyster management areas in Onslow County. Amendment 4 was adopted in February 2017 with selected management measures including: the continuation of the monitoring system for when to close mechanical harvest off public bottom in an area, a reduction of the culling tolerance from ten to 5% in the commercial fisheries off public bottom, a reduction of the daily harvest limit for holders of the Shellfish License off public bottom to two bushels per person per day maximums

four bushels per vessel, the continuation of the six-week open season to mechanical harvest off public bottom in the bays with changes in the timing of the six-week opening, modifications to shellfish lease provisions, and adding convictions of theft on shellfish leases and franchises to the types of violations that could result in license suspension or revocation.

Management Unit

The management unit includes the eastern oyster (*Crassostrea virginica*) and its fisheries in all waters of coastal North Carolina.

Goal and Objectives

The goal of the N.C. Oyster FMP is to manage the state's oyster population so that it achieves sustainable harvest and maximizes its role in providing ecological benefits to North Carolina's estuaries. To achieve this goal, it is recommended that the following objectives be met:

1. Identify, restore, and protect oyster populations as important estuarine habitat.
2. Manage and restore oyster populations to levels capable of maintaining sustained production through judicious use of natural oyster resources, enhancement of oyster habitats, and development and improvement of oyster production on shellfish leases and franchises.
3. Minimize the impacts of oyster parasites and other biological stressors through better understanding of oyster disease, better utilization of affected stocks, and use of disease resistant and biological stress resistant oysters.
4. Consider the socioeconomic concerns of all oyster resource user groups, including market factors.
5. Recommend improvements to coastal water quality to reduce bacteriological-based harvest closures and to limit other pollutants to provide a suitable environment for healthy oyster populations.
6. Identify and encourage research to improve understanding of oyster population ecology and dynamics, habitat restoration needs, and oyster aquaculture practices.
7. Identify, develop, and promote efficient oyster harvesting practices that minimize damage to the habitat.
8. Initiate, enhance, and continue studies to collect and analyze economic, social, and fisheries data needed to effectively monitor and manage the oyster resource.
9. Promote public awareness regarding the ecological value of oysters and encourage public involvement in management and enhancement activities.

STATUS OF THE STOCK

Life History

The eastern oyster (*Crassostrea virginica*) is a non-moving, filter feeding shellfish occurring naturally along the western Atlantic Ocean from the Gulf of St. Lawrence off Quebec, Canada to the Gulf of Mexico and the Caribbean Islands. The eastern oyster has been called the ultimate estuarine animal. It can tolerate a wide range of salinity, temperature, turbidity and dissolved oxygen levels, making it well adapted to the ever-changing conditions of the estuary. The

distribution and survival of eastern oysters within habitat types is influenced by abiotic factors such as salinity, tide, oxygen levels and flow, as well as biotic factors such as disease, shell erosion caused by other species and predation. North Carolina's oyster stocks are composed of both intertidal (oysters growing between the mean high and low tide levels) and subtidal (oysters growing below the mean low water level) populations.

Oysters are typically dioecious but can change their sex (hermaphroditic) once each year. Researchers have found that natural oyster populations maintain relatively balanced sex ratios, but exposure to stress, such as food limitation and pollution, results in a higher ratio of males. Gonads may develop in oysters two to three months old. Fully developed oysters entering their first summer season may spawn, but large portions of these young oysters are not sexually mature. Age or size selective mortality from disease and harvest pressure can alter oyster population demographics and result in a shift from male to female. The rate of oyster growth is highest during the first six months after the spat (juvenile oyster) sets and gradually declines throughout the life of the oyster. Seasonally, adult oysters grow most rapidly during spring and fall in North Carolina, reaching market size (3 inches) in about three years. Growth rates in other East Coast and Gulf Coast regions produce market size oysters in time periods ranging from 18 to 24 months in the Gulf of Mexico to four to five years in Long Island Sound.

Stock Status

There are insufficient data to conduct a traditional stock assessment for the eastern oyster in North Carolina, therefore population size and the rate that oysters are removed from the population could not be determined. North Carolina commercial oyster landings have been in decline for most of the past century. This decline was likely initiated by overharvest and compounded by habitat disturbance, pollution, and biological and environmental stressors. Oysters are believed to be more vulnerable to overharvest because these other factors negatively impact their survival.

Stock Assessment

An oyster stock assessment was attempted in 1999, but the necessary data were lacking to determine levels of sustainable harvest (NCDMF 2001). Since there were no significant changes in the types and quantity of data collected, an oyster stock assessment could not be achieved in 2006 and again in 2014 (NCDMF 2008; NCDMF 2017). Collection of appropriate data is needed in order to conduct a stock assessment and determine levels of sustainable harvest (NCDMF 2008).

Data are not available to perform a traditional assessment so it was not possible to estimate population size, demographic rates, or removals from the population in the latest FMP adopted in 2017. The only data representative of the stock were the commercial landings and associated effort. For this reason, the most recent analysis focused on trends in catch rates in the commercial oyster fishery. These catch rates could not be considered an unbiased representation of trends in population size; fisheries-dependent data are often not proportional to population size due to a number of caveats and should be interpreted with caution if the interest is relative to changes in the population. In order for a fisheries-dependent index to be proportional to

abundance, fishing effort must be random with respect to the distribution of the population and catchability must be constant over space and time (NCDMF 2017). Other factors affecting the proportionality of fishery-dependent indices to stock size include changes in fishing power, gear selectivity, gear saturation and handling time, fishery regulations, gear configuration, fishermen skill, market prices, discarding, vulnerability and availability to the gear, distribution of fishing activity, seasonal and spatial patterns of stock distribution, changes in stock abundance, and environmental variables. Many agencies, such as the NCDMF, do not require fishermen to report records of positive effort with zero catch; lack of these "zero catch" records in the calculation of indices can introduce further bias.

The North Carolina commercial oyster fishery is subject to trip limits, which could bias catch rates (Mike Wilberg, University of Maryland Center for Environmental Science, personal communication; John Walter, National Oceanic and Atmospheric Administration Fisheries, personal communication). The trip limits affect the amount of catch that is observed per unit effort, preventing the true value of this variable from being observed. A censored regression approach was attempted to calculate an index of relative abundance (numbers harvested per transaction) using data collected from a fishery with trip limits.

Data were obtained from the North Carolina Trip Ticket Program for 1994 through 2013. The censored response variable (catch per unit effort) was fit within a Generalized Additive Models for Location Scale and Shape framework using the 'gamlss.cens' (Stasinopoulos et al. 2014) and 'survival' (Therneau 2014) packages in R (R Core Team 2014). Catch rates were estimated for both hand harvest and mechanical harvest in each of the major water bodies from which eastern oysters are harvested where sufficient data were available. Data were summarized by fishing year (October through March for hand harvest and November through March for mechanical harvest). Only landings from public bottom were examined.

Catch rates were expressed as bushels harvested per transaction. The censored regression approach failed for both hand and mechanical harvest data despite trying three different distributional assumptions (lognormal, gamma, t). This failure was believed to be due to the large number of trips (transactions) that meet or exceed the trip limit in both fisheries. Similar work found that when about 50% or more of the trips equaled or exceeded the trip limits, there was not enough information from the uncensored trips to produce a reliable model. Here, 51.4% of trips by hand gears equaled (39.3%) or exceeded (12.1%) the trip limits over all water bodies and fishing years combined; the number of trips equaling or exceeding the trip limits for mechanical gears was 43.5% (42.9% equaled and < 1% exceeded).

Available data were considered insufficient for estimating reliable fishing mortality rates.

A pilot project is underway over the next three years by The Nature Conservancy and North Carolina State University, with guidance from NCDMF, to develop a subtidal oyster population survey with the potential to become a long-term biological sampling program in NCDMF. Concurrent with these efforts and outside the scope of this pilot project, The Nature Conservancy is collaborating with the NCDMF and commercial oystermen to refine the collection of harvest data to gather more accurate information on harvest levels and effort, as well as discard mortality from dredges. The NCDMF is developing a biological sampling program for intertidal oysters

using existing bottom mapping sampling program data to delineate oyster reefs and evaluate changes over time for intertidal oysters in the southern region of the state.

STATUS OF THE FISHERY

Current Regulations

Oysters cannot be taken from any public or private bottom in areas designated as prohibited (polluted) by proclamation except for special instances for: Shellfish Management Areas (NCMFC Rule 15A NCAC 03K .0103), with a permit for planting shellfish from prohibited areas (NCMFC Rule 15A NCAC 03K .0104), and for the depuration of shellfish (NCMFC Rule 15A NCAC 03K .0107). Beginning in April 2014, time and temperature control measures were initiated for oysters to prevent post-harvest growth of naturally-occurring *Vibrio* sp. bacteria that can cause serious illness in humans between April 1 and September 30 of each year. Oysters cannot be taken between the hours of sunset and sunrise of any day. Beginning in the 2017-2018 season the culling tolerance was reduced from 10% to 5% off public bottom based on management measures adopted in Amendment 4 of the N.C. Oyster Fishery Management Plan.

Public Bottom

The minimum size limit for oysters from public bottom is three-inch shell length. Both the hand and mechanical oyster harvest season from public bottom are opened annually by proclamation. It is unlawful to sell oysters taken on Saturday and Sunday from public bottom. The hand-harvest season for commercial and recreational harvest begins on October 15 each year with commercial harvest limited to Monday through Friday each week and recreational harvest allowed seven days a week. Hand-harvest methods to take oysters are allowed in all areas found suitable for shellfish harvest by the Shellfish Sanitation and Recreational Water Quality Section of the NCDMF during the open season. Beginning in 2013 through statutory changes, the Shellfish License was restricted to hand harvest only, and harvest by mechanical methods was prohibited. Recreational harvest is only allowed by hand methods. The hand harvest season typically continues until closed by rule on March 31 although some locations close earlier due to perceived excessive harvest. Brunswick County is the only area frequently closed early due to this concern and it closed prior to March 31 sixteen times between the1996-1997 and 2018-2019 seasons.

The daily hand harvest limit for oysters in Pamlico Sound outside the bays is 15 bushels per day per commercial fishing operation and 10 bushels per day per commercial fishing operation in the bays and in the Mechanical Methods Prohibited area along the Outer Banks of Pamlico Sound. Areas from Core Sound south have a daily hand harvest limit of five bushels per person not to exceed 10 bushels in any combined fishing operation regardless of the number of persons, license holders, or boats involved. Recreational daily harvest limits in 2018-2019 were one bushel per person per day not to exceed two bushels per vessel per day.

Beginning in October of the 2017-2018 season, hand harvest for Shellfish License holders was limited to two bushels per person per day not to exceed four bushels per vessel per day if two or more Shellfish License holders are on board the vessel (NCDMF 2017). Hand harvesters with

the Standard Commercial Fishing License could continue landing the higher daily harvest limits in all areas.

The mechanical harvest season for oysters in 2018-2019 was opened November 12, 2018, and was restricted to deeper portions of the sounds, rivers and bays north of Pamlico Sound. These mechanical harvest areas are designated by rule (NCMFC Rule 15A NCAC 03R .0108). Mechanical methods for oysters were only allowed to operate from sunrise to 2:00 p.m. during the 2018-2019 season (November 12 – March 31). Beginning in the 2017-2018 harvest season, the six-week open period for the bays was split into two potential open periods. The first opening in the bays could begin on the Monday of the week prior to Thanksgiving and run through the Friday after Thanksgiving. The second opening of the bays could begin two weeks before Christmas and remain open for the remining four weeks.

Areas outside the bays open to mechanical harvest were limited to a daily harvest limit of 15-bushels of oysters per operation and limited to 10-bushels of oysters per operation within the bays.

The mechanical harvest season can close sooner for areas in Pamlico Sound if sampling by NCDMF indicates that oysters of legal size have been reduced to below 26% of the live oysters sampled for two consecutive sampling trips, as directed by Amendment 4 of the Oyster FMP. Mechanical harvest was closed on December 13, 2018 in the Neuse River, Pamlico River, and Northern Dare and Hyde County areas (Table 1; Figure 1). All mechanical harvest areas remained closed until the season ended on March 31, 2018, which also prevented the re-opening of the bays for the second period.

There are also further restrictions for mechanical oyster harvesters to make sure that cultch material and culled oysters are either put back into the water where they were taken or remain on the existing rocks. North Carolina has a rule in place (NCMFC Rule 15A NCAC 03K .0202) requiring culling on site. The following restrictions were put in place beginning with the 2012-2013 oyster season to discourage harvesters from not culling and removing extra cultch material.

> It is unlawful to possess more than five bushels of unculled catch onboard a vessel. Only material on the culling tray is exempt from culling restrictions.
>
> It is unlawful to possess unculled catch or culled cultch material while underway and not engaged in mechanical harvesting.

Some harvesters did not have vessels or dredges rigged for circular dredging patterns which work best with towing points over the side of the vessel or for short tows to allow for culling between pickups. The following restrictions were put in place to encourage circular dredging patterns and shorter tows to keep the cultch and culled oysters on the existing rocks.

> It is unlawful for the catch container (bag, cage) attached to a dredge to extend more than two feet in any direction from the tooth bar.

It is unlawful to tow a dredge unless the point where the tow line or cable exits the vessel and goes directly into the water is on the port or starboard side of the vessel forward of the transom.

Private Bottom

There is a specific application process and public comment period required for an individual to obtain a franchise or lease for the culture of oyster on private bottom. Owners of shellfish leases and franchises must provide annual production reports to the division. Failure to furnish production reports can constitute grounds for termination, and cancellation proceedings will begin for failure to meet production requirements and interfering with public trust rights. Public bottom must meet certain criteria to be deemed suitable for leasing for shellfish cultivation and there are specific planting, production, and marketing standards for compliance to maintain a shellfish lease or franchise. There are also management practices that must be adhered to while the lease is in operation, such as: marking poles and signs, spacing or markers, and removal of markers when the lease is discontinued.

The minimum size limit for oysters from private bottom is a three-inch shell length with a 5% culling tolerance, that only is required during the open public harvest season. During the rest of the year there is no minimum size or culling requirement for oysters taken from private bottom. There is no daily maximum harvest limit applied to the taking of oysters from private bottom. Permits are required to use mechanical methods for oysters on a lease or franchise.

Possession and sale of oysters by a hatchery or aquaculture operation and purchase and possession of oysters from a hatchery or aquaculture operation are exempt from the daily harvest limit and minimum size restrictions. The possession, sale, purchase and transport of such oysters must be in compliance with the Aquaculture Operation Permit. Leases that use the water column must also meet certain standards as outlined in G.S. 113-202.1 in order to be deemed suitable for leasing and aquaculture purposes.

Commercial Landings

Landings in the North Carolina oyster fishery are impacted by the both biotic and abiotic factors that influence oyster survival and growth.

Data on landings from public bottom by gear indicate that, prior to 1960, most of the oysters were taken by dredge when compared to all hand methods. Chestnut (1955) reported that 90% of the oysters landed in North Carolina came from Pamlico Sound. The Pamlico Sound area is largely dependent on dredging. The resurgence of the dredge landings in 1987 was due, in part, to increased oyster populations and in part to increased effort, as displaced mechanical clam harvesters turned to oyster dredging due to closure of southern clam areas by a red tide. The red tide was a neurotoxic dinoflagellate bloom (*Karenia brevis*) that caused closure of over 361,000 acres of public bottom to shellfish harvest from November 1987 to May 1988. Hand harvest landings of oysters failed to reach their potential that same year since the majority of the hand-harvest-only areas were also closed because of the red tide. Hand harvest landings are the most consistent contributor to the state's oyster fishery. Hand harvest landings have exceeded dredge

landings for significant periods between 1961 and 1970 and between 1989 and 2008 (NCDMF 2017).

The oyster parasite *Perkinsus marinus*, also known as Dermo disease, has been responsible for major oyster mortalities in North Carolina during the late 1980s to mid-1990s. Once infected with this protist, oysters suffer reduced growth, poor condition, diminished reproductive capacity and ultimately mortality (Ford and Figueras 1988; Ford and Tripp 1996; Haskin et al. 1966; Ray and Chandler 1955). Chestnut (1955) may have been the first to report its occurrence in North Carolina. However, no extensive assessments were attempted until large-scale oyster mortalities prompted investigations during the fall of 1988, and Dermo infection was determined to be the cause by the Virginia Institute of Marine Science (VIMS) and the Cooperative Oxford Laboratory (NCDMF 2008).

NCDMF observed in the southern estuaries, while the Dermo infections were on the rise, that during late summer, moderate and high Dermo infection levels did not reduce oyster populations. Hand harvest landings in the south from 1991 through 2002 did not decline in the same manner as landings from Pamlico Sound during the same time. It is suspected that the small, high salinity estuaries may inhibit mortality by flushing out parasites at a higher rate or by exceeding the salinity tolerance of the Dermo parasite, allowing for a higher survival rate compared to Pamlico Sound. The link between low dissolved oxygen, increased availability of iron and increased parasite activity may also be a factor in the different mortality rates as the smaller, high salinity estuaries are less prone to low dissolved oxygen events than the Pamlico Sound (Leffler et al. 1998). Dermo infection intensity levels since 2005 have remained low; however, prevalence appears to be increasing (NCDMF unpublished data; Colosimo 2007). Dermo infection intensity has remained low and mechanical harvest landings in Pamlico Sound continued to recover from the extremely high Dermo mortality levels and hurricane impacts of the mid-1990s until additional environmental impacts (i.e., low dissolved oxygen & hurricanes) began affecting the fishery in 2011 (Figure 2).

Bioeroders (organisms that tunnel into oyster shell), in particular boring sponge (*Cliona* sp.), are also of concern for their impacts to oyster reefs in North Carolina. These sponges can chemically etch out canal systems within oyster reefs, as well as encrust and smother them. Boring sponges can cause mortality by weakening the shell, preventing the oyster from protecting itself from predators. Once the oyster reef has been compromised, there is a loss of material for spat attachment and eventually a reduction in the vertical height of the reef. Boring sponges are linked to salinity gradients with some species found in high salinity waters while other species are found in the low to mid-range salinities but typically are not found in waters with less than 10 parts per thousand. Intertidal oysters have some refuge from boring sponge. Dunn et al. (2014) examined the distribution and abundance of oyster reef bioerosion by *Cliona* sp. in North Carolina. The study examined levels of boring sponge infestations across salinity gradients in multiple oyster habitats from New River through the southern portions of Pamlico Sound. The study found boring sponge infestations in all oyster communities sampled, with the exception of those found in the upper reaches of some tidal creeks in the Newport and North rivers in Carteret County. Low salinity areas had mean salinity levels of 15 parts per thousand while the higher salinity areas had a mean salinity of 20 parts per thousand or greater. High salinity areas were

infested by the high salinity tolerant boring sponge *Cliona celata*. The study found that as salinities increased, infestations increased.

Commercial oyster landings from private bottom have generally been increasing annually while landings off public bottom have been much more variable (Figure 2). Over the last five years an increasing trend in landings from production on private bottom coupled with decreasing landings from public bottom has led to landed bushels from private culture exceeding public landings in both 2017 and 2018 (Figure 2). Hand harvest landings exceeded the mechanical landings from public bottom in 2007 to 2008, 2012 to 2013, and 2015 to 2018 (Figure 3). The most significant increase in oyster landings from public bottom in the past ten years occurred in the mechanical harvest fishery in Pamlico Sound during the 2009-2010 and 2010-2011 seasons (Figures 2 and 3). There was a high abundance of oysters in some areas in Pamlico Sound that had not been seen in over 20 years, high market demand, and an increase in new participants in the fishery likely influenced these higher landings. In 2013, General Statute 113-169.2 limited the use of the Shellfish License to hand harvest methods only, this license is available to all residents of North Carolina for a lower fee than the Standard Commercial Fishing License. Hand harvest landings are relatively stable across years when compared to the fluctuations in landings from the mechanical fishery and are an important component of the public bottom oyster fishery. In 2018, hand harvest commercial landings off public bottom were 15 times higher than mechanical harvest landings off public bottom (Figure 3).

Mechanical Harvest Fishery Off Public Bottom

During the early 2009-2010 mechanical harvest oyster season, the Narrows area between Great Island and the mainland in Hyde County in Pamlico Sound experienced intensive oyster harvest (Figures 1, 2 and 3). Some of the operations were harvesting the 15-bushel limit, offloading then returning to the area with a new crew and harvesting an additional limit the same day. The 2010-2011 season began with a 2:00 p.m. time limit on dredging to attempt to stop the two-trips-per-day loophole. This added time limit likely had little impact on overall mechanical harvest landings, as experienced dredgers could take their limit in a few hours and there appeared to be many new entrants into the fishery. The traditionally harvested oyster rocks in the deeper waters of western Pamlico Sound contributed greatly to the increased landings in the 2009-2010 and 2010-2011 seasons but the Middle Ground area in 2010-2011 provided another unexpected source of significant oyster production much like the Great Island Narrows did in 2009 (Figures 2 and 3). Interest in taking advantage of expected high market demand caused by closure of oyster harvest areas in the Gulf of Mexico due to the Deepwater Horizon oil spill lengthened the season slightly with a November 1 mechanical harvest season opening in the fall of 2010.

Hurricane Irene hit the North Carolina coast on August 27, 2011 and had major impacts on the mechanical harvest area for oysters. Many deep-water oyster areas in Pamlico Sound were damaged or covered. Oyster resources in the Neuse and Pamlico rivers did not appear to suffer much damage, but did not show any growth during the following months. These factors had a pronounced effect on the mechanical harvest oyster season in 2011-2012 and the mechanical harvest area in western Pamlico Sound was closed in January. Mechanical harvest landings declined to near 2008-2009 levels during the 2011-2012 season (Figure 3). Regular sampling of oyster sizes to fulfill the requirements of Amendment 4 to the N.C. Oyster FMP has made it clear that oyster growth during the harvest season is essential to sustain acceptable harvest levels.

In the summer prior to the 2012-2013 mechanical harvest season, a severe low dissolved oxygen event occurred in the Neuse River that caused virtually a 100% mortality of the oyster resources at 18 feet or greater depths. The Pamlico River area also had not recovered from the effects of Hurricane Irene at this time. There still was little evidence of any recovery of the Neuse River oyster resources prior to the 2013-2014 season but the Pamlico River area appeared to be recovering and growth indicators were good during the season. The Northern Dare area in Pamlico Sound also supported some significant mechanical harvest activity throughout the 2013-2014 season.

During the 2014-2015 mechanical harvest season effort was still consistently low in the Neuse River, with effort peaking in all areas in mid-December. Closures of the Northern Hyde and Dare areas resulted in declines in harvest in January and foul weather increased these declines in February. Staff continued to sample and Northern Dare was re-opened in early March and closed by rule on March 31, 2015. The fleet encountered what was described as a "crust" covering much of the oyster rocks fished on re-opening day and took several days to break up this "crust". Effort was high for the re-opening with approximately 50 boats fishing on the first day and dropping off to around 20 boats after a few days.

Water temperatures were quite warm throughout the 2015-2016 season and not a lot of new growth was observed until January on the oysters. Some areas in Northern Hyde were covered in tunicates the previous year and little spat was seen in these locations during this season. The Neuse River area was limited in locations to harvest oysters and closed early during this season. Effort was highest in the Pamlico River at the beginning of the season and then after Christmas effort shifted to areas off Northern Hyde.

Like the previous season, water temperatures were quite warm and little growth was observed in the oysters until January in the 2016-2017 season. In the Neuse River live oysters were present in only a few locations. A confirmed low dissolved oxygen event occurred earlier that summer over a prolonged period near the mouth of the Neuse River which may have had an impact on oysters in this area. Within a few weeks of the season opening, only a few oyster harvesters were working in the Neuse River area, and most live oysters were found in shallow water (less than 20 feet deep). By late December the few oyster harvesters seen on the water were having to move around a lot to find oysters. Mechanical harvest was closed for the remainder of the season in mid-January for the Neuse River and Northern Dare areas. The Pamlico River and Northern Hyde areas remained open for the entire 2016-2017 season, but only a few fishermen remained harvesting oysters in early February and by mid-February no effort was seen in the open areas while sampling.

Pre-season sampling in October-November 2017 showed a lot of spat and small oysters in all areas, and two areas (Neuse River and Northern Dare) came in below the threshold (<26%) of legal-sized oysters in the samples. The 2017-2018 mechanical harvest season began Monday, November 13, 2017, and the six-week open period in the bays was split into two. The culling tolerance was also reduced from 10 to 5% following the latest management strategies. Oysters were small according to the dealers at the beginning of the season and showed little growth. The Neuse River only had a few areas with live oysters available and closed on December 7, 2017

after reaching the legal-sized threshold for closure. Small oysters that would not grow into legal-size this season were also pre-dominant in the Pamlico River and Northern Dare areas sampled early in the season. Both Pamlico River and Northern Dare areas were closed to mechanical oyster harvest on December 25, 2017. Only Northern Hyde County remained open into 2018 but closed to mechanical harvest by late January. All mechanical harvest areas for oysters remained closed for the rest of the season. In addition, starting the first week of January 2018 and for the next two weeks, coastal North Carolina experienced record low temperatures, with at least one consecutive 72-hour period where air temperatures were below freezing. Most inshore areas and some of the deeper water areas had ice. Some areas maintained ice for two weeks. In mid-January reports were coming in that some of the subtidal oysters in Pamlico Sound had been impacted by the freezing. Particularly in shallow water areas where oysters are exposed to the air for a period of time caused by wind-driven tides.

In September 2018, Hurricane Florence made landfall in North Carolina and caused significant impacts on the oyster resource. Extended periods of hypoxic or anoxic conditions occurred in in many of the deep-water areas of Pamlico sound during the following weeks. Dive surveys of reefs on the Middle Grounds were conducted by NC state researches, and they observed large-scale oyster mortality due to Hurricane Florence. Observations by their team did not suggest that oyster reefs in the shallow bays were as impacted. During initial sampling, the Neuse River, Pamlico River, and Northern Dare areas all showed low numbers of living oysters and were all below the 26% legal size threshold. The initial sampling at Northern Hyde areas showed a legal percentage of 27%, just above the threshold. Mechanical fishing effort was relatively low due to poor catch, and the mechanical season was closed in all management areas on December 13, 2018. This closure prevented the second opening period of the bays to mechanical harvest. Impacts from Hurricane Florence are reflected in both reduced mechanical and overall oyster landings for the 2018-2019 season (Figures 2 and 3).

Hand Harvest Fishery Off Public Bottom

Hand harvest gear accounts for the majority of the landings and has been the dominant harvest gear for oysters in North Carolina since the 1960s. Hand harvest oyster landings are also less variable than landings from mechanical gears (Figure 3). These higher, more consistent landings come from Core Sound south to the state line. The hand harvest areas in the northern region of the state are exclusively subtidal reefs with depths of two to six feet in which hand tongs are used. Hand harvest gear has not been extensively used in the northern area since oyster dredging was allowed in 1887. In Amendment 2 to the N.C. Oyster FMP in 2008, the MFC adopted the strategy to promote a more habitat friendly fishery by increasing the hand harvest limits to match dredging limits in the Pamlico Sound bay areas. Amendment 2 put in place a 15 bushel per day hand/mechanical harvest limit per commercial fishing operation in Pamlico Sound mechanical harvest areas outside the bays, a 10 bushel per day hand/mechanical harvest limit per commercial fishing operation in the bays and in the Mechanical Methods Prohibited area along the Outer Banks of Pamlico Sound. This management option raised the limits of hand harvest to encourage less destructive harvest methods in those particular bays and open waters.

Hand harvest limits are five bushels per person, not exceeding 10 bushels per commercial fishing operation from Core Sound south to the North Carolina-South Carolina border for holders of the

Standard Commercial Fishing License. As of October 2018, harvesters holding a Shellfish License statewide are limited to two bushels of oysters per person per day no more than four bushels per vessel, following the selected management strategy adopted by the NCMFC in Amendment 4 of the N.C. Oyster FMP. Areas in the southern region from Core Sound south are closed to mechanical harvest of oysters.

Other factors affecting the hand harvest fishery are the loss of harvest area due to pollution closures. Many shellfish waters in North Carolina are permanently or conditionally closed due to bacterial contamination associated with urban development (Table 2). The greatest proportion of closed shellfish waters occur in the southern district (Onslow, Pender, New Hanover, and Brunswick counties) where over half of the waters are closed and can be attributed to small, narrow waterbodies and more developed watersheds. The area north of Core Sound with the higher hand harvest limits does not have the same problem with large percentages of the available harvest area closed by pollution so oyster harvest is not impacted.

Hand-harvest oyster landings have generally increased in recent years (Figure 3). Oyster hand harvest south of the Highway 58 Bridge generates a significant amount of the overall oyster landings even though the area only encompasses 5% of the total area open to shellfishing in the state.

The 2017-2018 the intertidal oysters in the southern region of the state were impacted by record low temperatures that lasted over two weeks in early January. Reports were received that the cold temperatures and low tides during this period caused the oysters to die. In September 2018, Hurricane Florence caused oyster mortality in many of the hand harvest areas south of the Highway 58 Bridge. Market demand for local North Carolina oyster early in the 2018-2019 season in the southern region of the state was low due to public perception of water quality issues which may have been caused by the storm.

The oyster season typically closes 15 days early in Brunswick County due to public comment and management's concerns of excess harvest pressure on an ever-decreasing area open to shellfishing. Brunswick County continues to be closed more often during the season because of temporary shellfish closures after rainfall events, compressing harvest into small areas and decreasing the number of legal-sized oysters available to harvesters much quicker than in most other areas.

Permanent and Temporary Shellfish Closures

Microbial contamination from fecal matter is important to NCDMF because it affects the opening and closing of waters to shellfish harvest. Fecal coliform bacteria occur in the digestive tract of, and are excreted in the solid waste from, warm-blooded animals including humans, wildlife and domesticated livestock (Mallin 2009). Because consumption of shellfish containing high levels of fecal coliform bacteria and associated pathogens can cause serious illness in humans, shellfish growing waters must be closed to shellfish harvest when fecal coliform counts increase above the geometric mean standard of 14 MPN/100mL [NCMFC Rules 15A NCAC 18A Section .0900 Classification of Shellfish Waters], where MPN denotes "most probable number." The NCDMF closes waters where a high potential for bacterial contamination exists,

such as around marinas and point source discharges. Shellfish harvest closures have continued to occur over time, which has led to a reduction in available shellfish harvest areas. Long term shellfish closures due to bacterial contamination remove available harvest area for shellfish and concentrate those activities on remaining resources compounding harvest related impacts on the oyster habitat in those areas.

Between 2007 and 2014, there were 1,427 acres of water permanently closed to shellfish harvesting in North Carolina, while between 2015 and early 2019, 6,876 additional acres were closed (Table 2). On February 4, 2015, approximately 314,710 acres were closed administratively in lower resource areas because of the inability to sample due to budget constraints. The areas closed to shellfish harvest because of the inability to meet federal sampling requirements caused by funding cuts were approximately 11,834 acres in the Neuse River, approximately 3,042 acres in the Pungo River, and approximately 299,107 acres in Albemarle Sound.

In addition to the areas that are permanently closed to shellfishing, other areas are temporarily closed during periods of high rainfall due to runoff. The rainfall closure threshold varies by growing area as detailed in each management plan and can vary from 1 inch to 2.5 inches of rain in a 24-hour period. Closures last from several days to more than a month and reopen when bacteriological water sample results show the area has returned to normal conditions. Large storms, such as hurricanes, result in harvest closures covering much larger areas, sometimes including all of North Carolina's estuarine waters. The conditionally approved areas are concentrated in the Core-Bogue, New-White Oak, and Southern Estuaries management units. Within these watersheds, permanent closures are most common in the upper reaches of tidal creeks and rivers, with conditionally approved areas occurring downstream of those areas or in the upper portions of less degraded creeks. As temporary closures have increased in frequency and duration, they have become an issue of great concern to the public, particularly in the southern area of the coast. For 2019, an additional classification of “restricted” was adopted for “areas that do not meet approved area criteria but is not grossly polluted” and can be used for limited shell fishing activities such as relay.

2018 was a record year for rainfall amounts throughout the North Carolina coast, with the landfall of Hurricane Florence contributing greatly to the total amounts. Temporary closures during the beginning of the oyster season were directly attributed to that event, with some area closures in the southern portion of the state lasting for over 30 days past the storm.

Private Culture

Authority to lease bottomland for private shellfish cultivation can be traced back to a state statute adopted in 1909. The NCDMF administers the shellfish lease program whereby state residents may apply to lease estuarine bottom and water columns for the commercial production of shellfish. The NCDMF does not differentiate between clam, oyster, bay scallop, and mussel leases; therefore, allowing shellfish growers to grow out multiple species simultaneously or as their efforts and individual management strategy allows. For the period of 2003-2013, roughly 40% of all private culture operations harvested only oysters (NCDMF 2017).

Since 1994 there has been an overall increase in oyster harvest from private culture operations. Oyster harvest from private culture operations in the period from 1994 to 2013 only account for 12% of all oyster landings (NCDMF 2017). However, due to increase interest in private culture of oysters and lower landings off public bottom, private culture harvest accounted for 65% of the total oyster landings in 2018 (Figure 2).

As of 2019, the lease program had 354 leases, and 36 bottom lease and 46 water columns amendment applications during the year. Currently shellfish leases take up about 2,020 acres of bottom (M. Graven; Lease Program Coordinator, NCDMF; June 2019).

Recreational Landings

Recreational landings for oysters in North Carolina are unavailable because there are no license requirements to take shellfish for personal consumption and therefore no way to fully determine the user group to collect their harvest information. Since 2011, the division has collected effort and catch data from the recreational oyster harvesters by surveying those individuals that indicate participation when purchasing a recreational fishing license. This survey does not include recreational oyster harvesters that do not purchase a recreational fishing license. Effort continues to produce state wide estimates of recreational oyster harvest.

MONITORING PROGRAM DATA

Fishery-Dependent Monitoring

Currently, the only data available for the stock in all areas are the commercial landings and associated effort from the Trip Ticket Program. No fishery dependent monitoring programs occur for oysters.

Fishery-Independent Monitoring

There are two independent programs for oysters. One is an indicator for habitat disturbance and damage of the commercial dredge fishery on public bottom to determine closure of the season for habitat protection of oyster rocks (Program 627). The second program. is a long-term spatfall sampling program conducted by the Habitat and Enhancement section to estimate recruitment of spat (Program 610).

Public Bottom Mechanical Harvest Area Oyster Sampling

Supplement A to Amendment 2 established the trigger for closing areas to mechanical harvest to protect the resource and habitat, which was approved to continue under Amendment 4 of the Oyster FMP. The management trigger was established and defined as when the sampling indicates the number of legal-sized (three-inch) oysters in the area has declined to 26% of the live oysters sampled. The management areas are divided geographically into four areas; the Neuse River Area, Pamlico River Area, Northern Hyde Area, and Northern Dare Area (Figure 1). Sampling targets areas and oyster rocks being worked by commercial oystermen, directly before the opening of and throughout the mechanical harvest oyster season. The sampling sites

are selected based on the presence/absence of commercial oystermen working in the area. Only areas where commercial oystermen are working are sampled to determine localized depletion and address habitat protection. From each sample, the first 100 live oysters, including spat and any boxes, are collected for workup. Each oyster, up to a maximum of 100, is measured to the nearest mm and inspected for any damage. Shell damage is denoted as none, minor, or substantial for further evaluation.

Sampling began on September 23, 2009 with pre-season oyster sampling, in four management areas, using mechanical harvesting methods. Sampling has consistently continued with a target of 10 sites per management area, throughout the four management areas. All sampling is conducted using NCDMF vessels and standard oyster dredges with comparable construction to those used by commercial oystermen. Samples are collected at least bi-monthly in each management area (weather permitting) before, during, and after the open mechanical oyster harvest season. More intensive sampling is conducted if samples are near the trigger percentage. Sampling continues after an area is closed to assess the possibility of reopening. Sampling is discontinued when it is apparent that reopening is not likely to occur. Mean oyster shell height (commonly referred to as length) is calculated for each 100-oyster sample. The number of legal-sized (≥76 mm; ≥ 3 inches) and undersized (<76 mm; < 3 inches) oysters is determined for each sample. The total legal-sized oysters for all the samples taken in a management area on a sampling trip is divided by the total of all oysters sampled on that trip to calculate the percentage used to assess compliance with the harvest closure trigger. Oyster sizes are also sorted into five-mm size bins and the size distribution for the area is presented as a bar graph. Sampling results are reported to interested dealers/fishermen and staff after each sampling event.

This sampling is not intended for use as a species abundance index, but instead to reflect the conditions of the habitat during the open oyster mechanical harvest season to determine closure of an area as a protection measure. The 2018-2019 mechanical harvest season trigger sampling revealed low abundance and percent legal in all mechanical harvest management areas (Table 1; Figure 1) and following the steps in the selected management strategy the season was closed by proclamation on December 13, 2018.

Spatfall Evaluation

NCDMF conducts spatfall sampling annually (Program 610), on cultch planting sites from the previous three years during January, but samples may be collected through April if required. Subtidal sites are sampled by towing a standard oyster dredge over the planting site until, at a minimum, 30 pieces of cultch are collected. Patent tongs and hand tongs may also be used to obtain cultch samples. Intertidal sites are sampled by hand at low tide in all applicable intertidal areas of the Southern District and patent or hand tongs are used in the more northerly subtidal areas of Stump Sound and New River. Three tong grabs per location are usually taken to obtain the minimum amounts of cultch required. Gear type and any other valuable gear parameters are recorded. Prior to 2005, data was not collected south of New River.

Thirty pieces of cultch are randomly selected from each sample and the type of cultch (oyster, calico scallop, surf clam, sea scallop, or marl) is noted. The total number of spat on each piece of cultch is counted, with each spat being measured to nearest millimeter shell length. The average

number of spat per piece of cultch is calculated by summing the number of spat per cultch piece, divided by the total number of cultch pieces sampled. An annual spatfall index is calculated as the average number of spat per site and then averaged across all sites within that year. The 10-year average is calculated by averaging the annual index over the last 10 years.

The spatfall index has been somewhat variable from year to year in the early years of the time series, but overall showing a declining trend for the past 10 years (Figure 5). The 2018 and 2019 indices were the lowest and below the 10-year average (Annual average number of spat across all sampling sites) (Figure 5).

MANAGEMENT STRATEGY

There are no management triggers or methods to track stock abundance, fishing mortality, or recruitment between benchmark reviews in the current FMP.

Amendment 4 was adopted in February 2017 and implementing rule changes became effective May 1, 2017. The selected management strategies of the NCMFC in Amendment 4 for oysters taken from public bottom include:

- the continuation of the monitoring system to determine when to close mechanical oyster harvest in an area;
- aligning the maximum daily harvest limit for oysters with current management;
- continuing the six-week open mechanical harvest in the bays, but close the bays to mechanical harvest for two weeks after Thanksgiving and then re-open two weeks before Christmas for the remainder of the six-week open mechanical harvest in the bays;
- a reduction of the culling tolerance from 10% to 5% for the possession of sublegal oysters; and
- a reduction of the daily harvest limit for Shellfish License holders to two bushels per person not to exceed four bushels per vessel.

For private culture of oysters, the selected management strategies in Amendment 4 include:

- adding convictions for theft of shellfish from leases or franchises to the list of convictions that may result in revocation of fishing licenses to implement stronger deterrents to shellfish theft and intentional aquaculture gear damage;
- clarifying how production and marketing rates are calculated for shellfish leases and franchises to meet minimum production requirements;
- expanding the maximum proposed lease size to 10 acres in all areas; and
- specifying criteria that allow a single extension period for shellfish leases of no more than two years per contract period to meet production and marketing requirements in the case of unforeseen circumstances and reorganize the rules for improved clarity.

Amendment 4 also included the expansion of oyster enhancement activities.

The selected management recommendations and implementation status can be found in Amendment 4 of the FMP adopted by the NCMFC in February 2017 (Table 3).

RESEARCH NEEDS

The specific research recommendations from Amendment 4, with its priority ranking are provided below. The prioritization of each research recommendation is designated either a HIGH, MEDIUM, or LOW standing. A low ranking does not infer a lack of importance but is either already being addressed by others or provides limited information for aiding in management decisions. A high ranking indicates there is a substantial need, which may be time sensitive in nature, to provide information to help with management decisions.

Amendment 4

Many environmental considerations are applied throughout the Coastal Habitat Protection Plan (CHPP) and are not part of this list but are still considered very important to oyster. Specifically, the proposed implementation actions on sedimentation within the CHPP are considered a high priority.

Proper management of the oyster resource cannot occur until some of these research needs are met, the research recommendations include:

- Support all proposed implementation actions under the priority habitat issue on sedimentation in the CHPP – HIGH (Ongoing through the CHPP)
- Improve the reliability for estimating recreational shellfish harvest – HIGH (Ongoing)
- Survey commercial shellfish license holders without a record of landings to estimate oyster harvest from this group – HIGH (Needed)
- Develop regional juvenile and adult abundance indices (fisheries-independent) – HIGH (Pilot study in progress with the Nature Conservancy and NC State University)
- Complete socioeconomic surveys of recreational oyster harvesters – MEDIUM (Needed)
- Continue to complete socioeconomic surveys of commercial oyster fishermen – LOW (Needed)
- Determine alternative substrates for reef development and monitoring of intertidal and subtidal reefs (cost-benefit analysis for reefs and cultch planting) – HIGH (Ongoing)
- Identify number and size of sanctuaries needed – LOW (Ongoing)
- Identification of larval settlement cues which influence recruitment to restored reefs (i.e. sound, light, current, etc.) – LOW (Ongoing)
- Support collaborative research to more efficiently track bacterial sources for land-based protection and restoration efforts - MEDIUM (Ongoing)
- Quantify the impact of current fishing practices on oyster habitat suitability in North Carolina – HIGH (Needed)
- Quantify the relationship between water quality parameters and the cumulative effect of shoreline development units (e.g., docks, bulkhead sections) - MEDIUM (Needed)
- Develop peer reviewed, standardized monitoring metrics and methodologies for oyster restoration and stock status assessments – MEDIUM (Needed)
- Further studies on the effects of dredge weight and size on habitat disturbance and oyster catches – LOW (Needed)
- Develop a program to monitor oyster reef height, area and condition – HIGH (Ongoing)
- Estimate oyster mortality associated with relay - LOW (Needed)

- Estimate longevity and yield of oysters on cultch planting sites - HIGH (Needed)
- Develop methods to monitor abundance of the oyster population – HIGH (Pilot study in progress with the Nature Conservancy and NC State University)

FISHERY MANAGEMENT PLAN SCHEDULE RECOMMENDATION

Recommend maintaining the current timing of the next MFC scheduled review to being in July 2022. Amendment 4 of the N.C. Oyster FMP was adopted by the NCMFC in February 2017 with rule changes in effect May 1, 2017.

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TABLES

Table 1. Percentage of legal-sized oysters and status (denoted by color) by management area for the 2018-2019 season in the mechanical oyster fishery trigger sampling program. Weeks with a - represent time before sampling occurred in that area. *Signifies the area was closed to mechanical harvest by proclamation SF-8-2018 on December 13, 2018 for the remainder of the oyster season.

	Status as of week				
Management Area	11/12/2018	11/19/2018	11/26/2018	12/3/2018	12/10/2018
Neuse River	-	16.9%	5.8%	5.8%	*
Pamlico River	-	-	13.1%	16.0%	*
N. Hyde	27.0%	27.0%	17.5%	14.9%	*
N. Dare	13.0%	13.0%	23.4%	17.3%	*

Color Codes

Open

Less than 26% Trigger Tripped: Open

Two Consecutive Less Than 26% Triggers Tripped: Closed

Table 2. Classification of shellfish waters in acreage from 2008-2019 From NCDMF Shellfish Sanitation & Recreational Water Quality Section.

	Open Area		Closed Area		
Year	Approved	Conditionally Approved Open	Conditionally Approved Closed	Prohibited	Restricted
2008	1,734,192	43,281	12,788	428,739	
2009	1,734,246	43,531	12,552	428,724	
2010	1,734,938	43,054	12,552	428,414	
2011	1,734,938	43,054	12,552	428,414	
2012	1,732,902	44,632	11,834	429,664	
2013	1,733,067	44,282	11,832	429,852	
2014	1,733,118	43,849	11,739	430,363	
2015*	1,418,373	43,849	11,739	745,169	
2016	1,416,960	44,784	12,008	745,597	
2017	1,414,709	44,425	12,209	747,759	
2018	1,414,626	43,926	12,031	748,606	
2019**	1,413,906	43,148	12,836	781,036	748,606

* 314,710 acres administratively closed on 2/4/15 due to budget cuts and office closures.
** First year of use for Restricted classification.

Table 3. Summary of the NCMFC management strategies and their implementation status for Amendment 4 of the N.C. Oyster FMP adopted February 2017.

Management Strategy	Implementation Status
OYSTER MANAGEMENT	
Maintain the cost of the Shellfish License, establish a daily limit of two bushels of oysters per person with a maximum of four bushels of oysters per vessel off public bottom with the Shellfish License.	Existing proclamation authority
Increase efforts to plant and monitor cultch material.	Ongoing
Implement a 5% cull tolerance for oysters	Rule change to 15A NCAC 03K .0202 in effect on May 1, 2017
Pursue elimination of the Shellfish License for oysters only and require all oyster harvesters to have a Standard or Retired Commercial Fishing License with a shellfish endorsement to harvest commercially.	Amend G. S. 113-169.2
Allow Shellfish License holders to be eligible to acquire a Standard Commercial Fishing License after they show a history of sale of shellfish. Continue to allow commercial harvest of all other shellfish as currently allowed.	No action required; Process already in place
Status quo (Maintain the shallow bays (less than 6 feet) as defined in 15A NCAC 03R .0108)	No action required
Recommend a six-week opening timeframe for deep bays to begin on the Monday of the week prior to Thanksgiving week through the Friday after Thanksgiving. Reopen two weeks before Christmas for the remainder of the six-week season.	Existing proclamation authority; Completed in 2017-2018 season
Status quo (Maintain the 15-bushel hand/mechanical harvest limit in Pamlico Sound mechanical harvest areas outside the bays, 10-bushel hand/mechanical harvest limit in the bays and in the Mechanical Methods Prohibited area along the Outer Banks of Pamlico Sound)	Existing proclamation authority
Adopt the provisions of Supplement A – a flexible harvest limit up to 20 bushels, a trigger of 26% legal-sized oysters for closing an area to mechanical harvest and set the upper harvest limit of 20 bushels in rule (rule change required).	Existing proclamation authority and rule change to 15A NCAC 03K .0201 on May 1, 2017
Attempt to develop and ground-truth a fishery dependent metric of effort to better inform management decisions in the future	Additive to NCDMF monitoring; Working with the Nature Conservancy
PRIVATE CULTURE	
Support modification of G.S. 113-208 and G.S. 113-269 to add minimum fines for violations on shellfish leases and franchises. With minimum fines set at $500 for the first violation and $1,000 for the second violation	Amend G.S. 113-208 and G.S. 113-269
Support modification of G.S. 113-269 to include protection to all shellfish leases and franchises, not just those with water column amendments	Amend G.S. 113-269
Modify Rule 15A NCAC 03O .0114, regardless whether statute changes occur, so that a first conviction under G.S. 113-208 or G.S. 113-269 the Fisheries Director shall revoke all licenses issued to the licensee	Rule change to 15A NCAC 03O .0114 in effect on May 1, 2017
Status quo (Adhere to Regional Conditions of U.S. Army Corps of Engineers Nationwide Permit 48 with no adverse effect to submerged aquatic vegetation from shellfish leases and following measure identified in the interim)	No action required
Continue the moratorium of shellfish leases in Brunswick County	No action required
Establish a rule to support extensions for where “Acts of God” prevent lease holder from making production, with a two-year extension and only one extension allowed per term	Rule change to 15A NCAC 03O .0201 in effect on May 1, 2017

Management Strategy	Implementation Status
Allow leases returned to the state to remain delineated for a period of one year to allow the pre-existing leased bottom to be re-issued to other shellfish growers	Amend G.S. 113-202
Improve public notice of proposed lease applications on the physical lease, at fish houses, and/or through electronic notices	Ongoing
Allow a maximum of 10 acres in both mechanical methods prohibited areas and mechanical methods allowed areas	Rule change 15A NCAC 03O .0201(a)(3) in effect on May 1, 2017

FIGURES

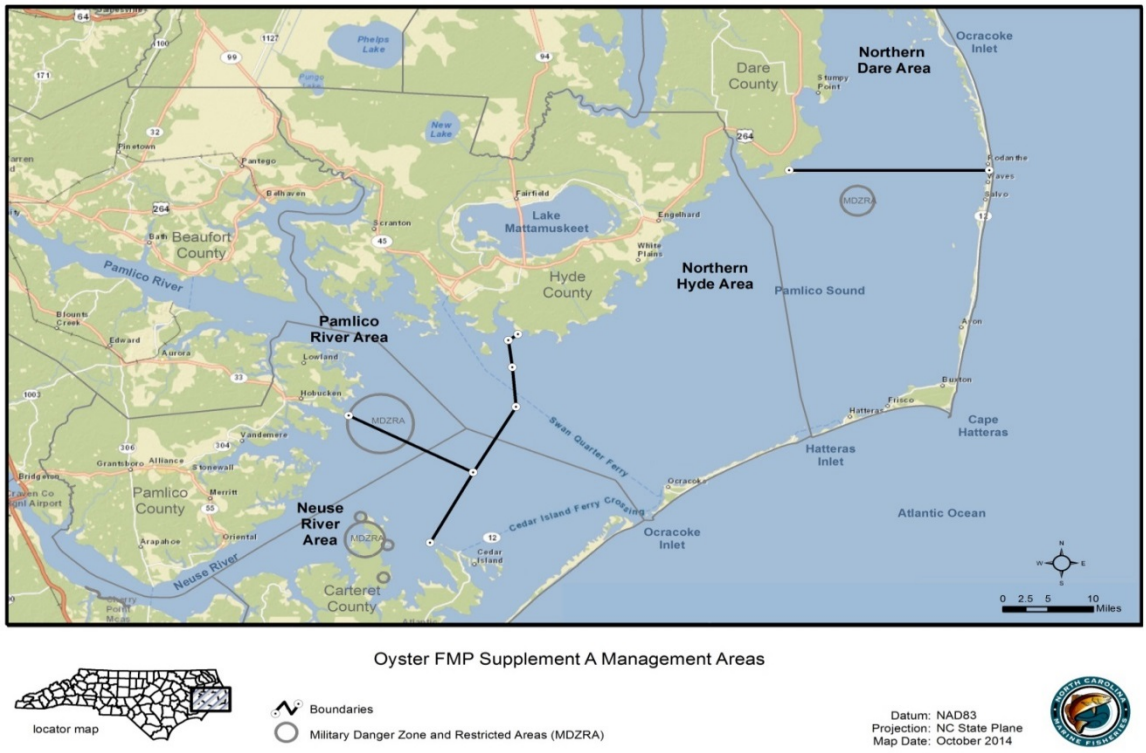

Figure 1. Mechanical harvest management areas from Amendment 4 of the Oyster Fishery Management Plan.

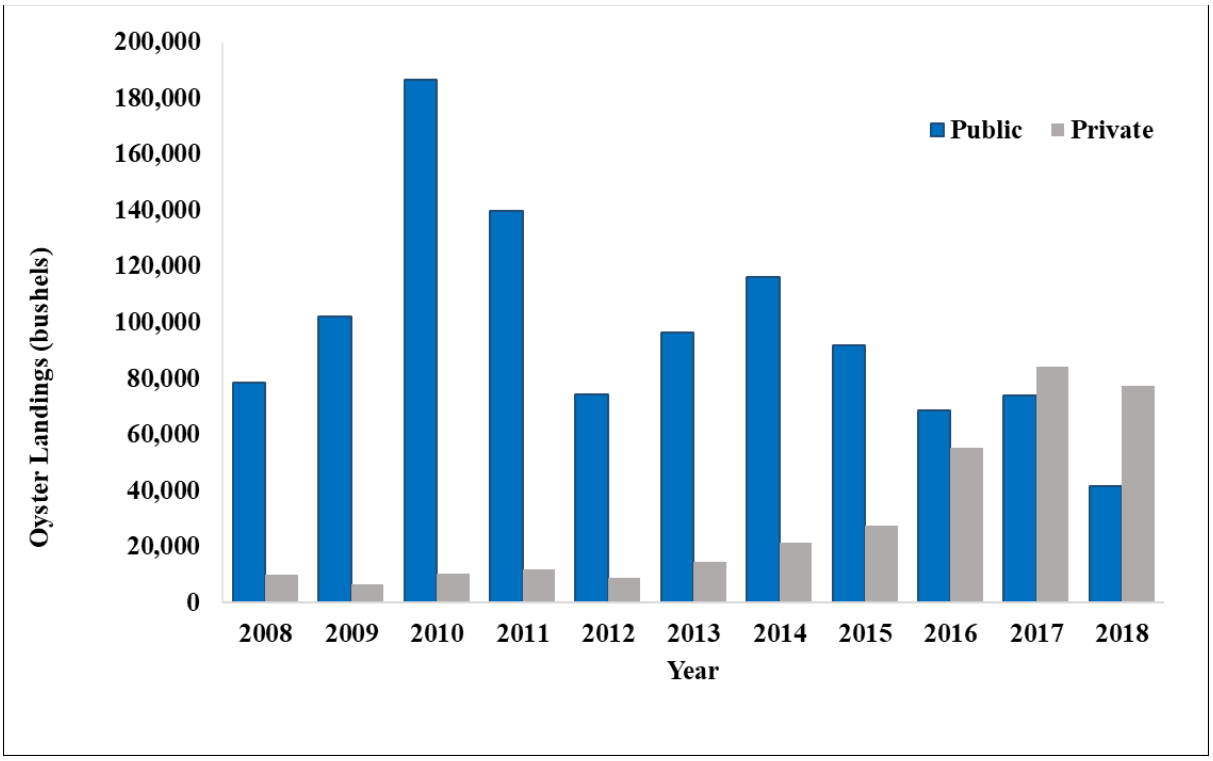

Figure 2. Annual commercial oyster landings (bushels) separated by private and public bottom in North Carolina, 2008-2018 (NCDMF Trip Ticket Program).

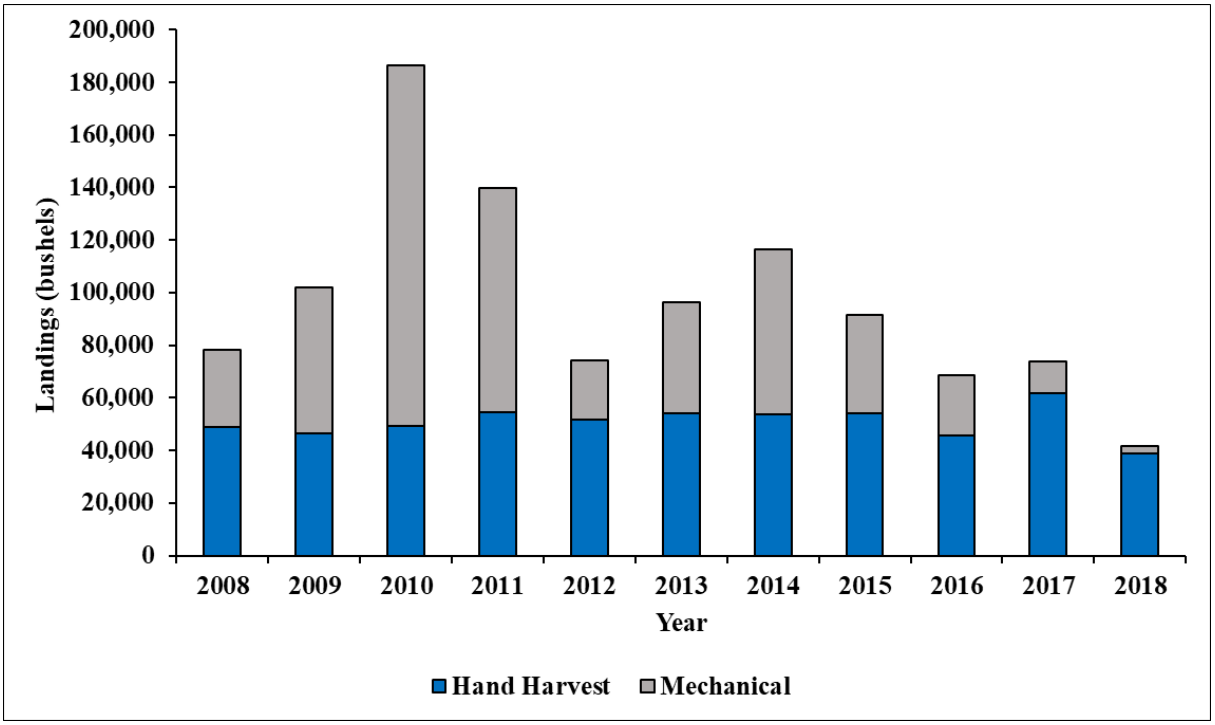

Figure 3. Annual commercial oyster landings (bushels) from public bottom separated by mechanical and hand harvest methods 2008-2018 (NCDMF Trip Ticket Program).

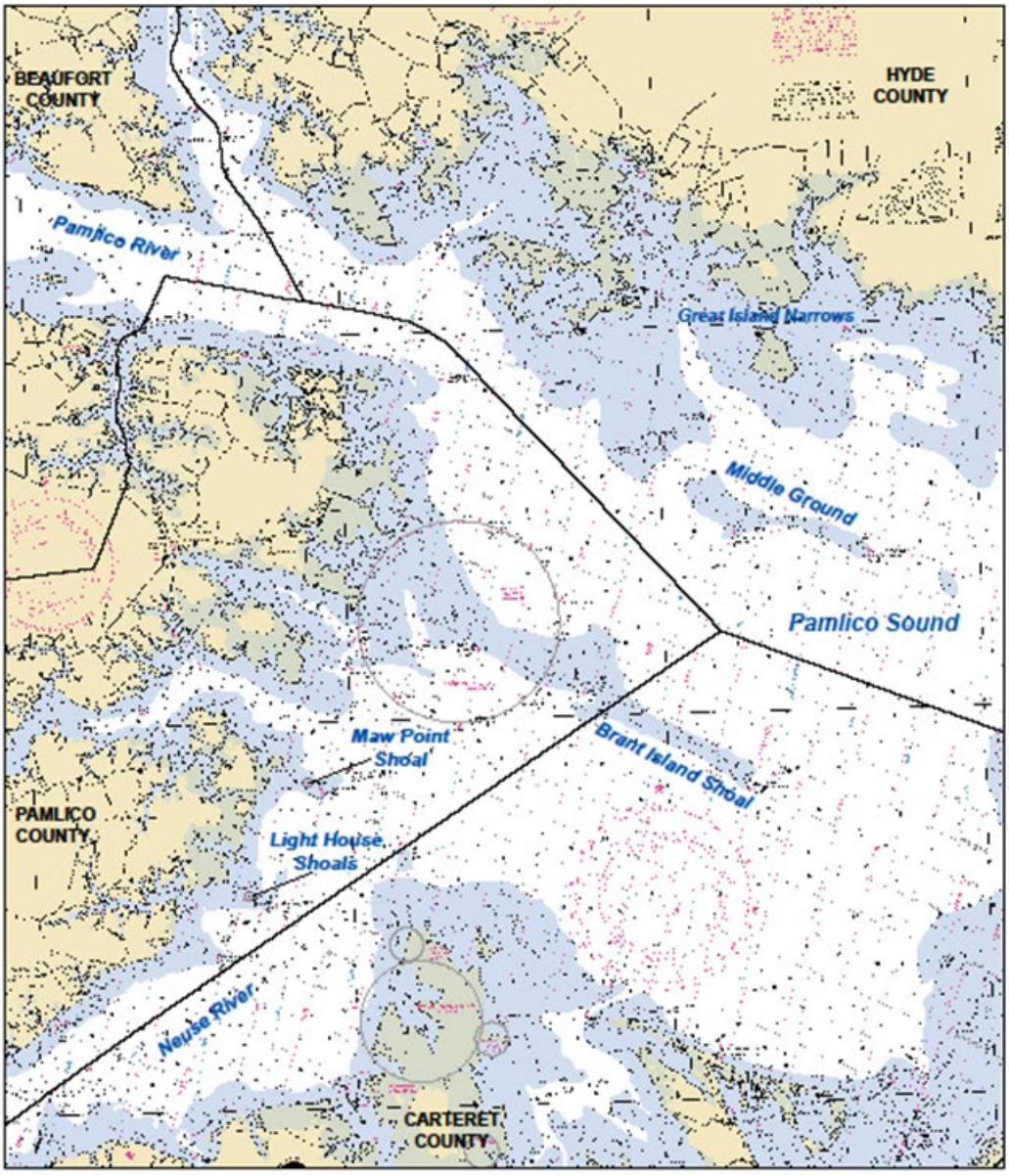

Figure 4. Map of areas referenced in the commercial landings section NCDMF Geographical Information System database).

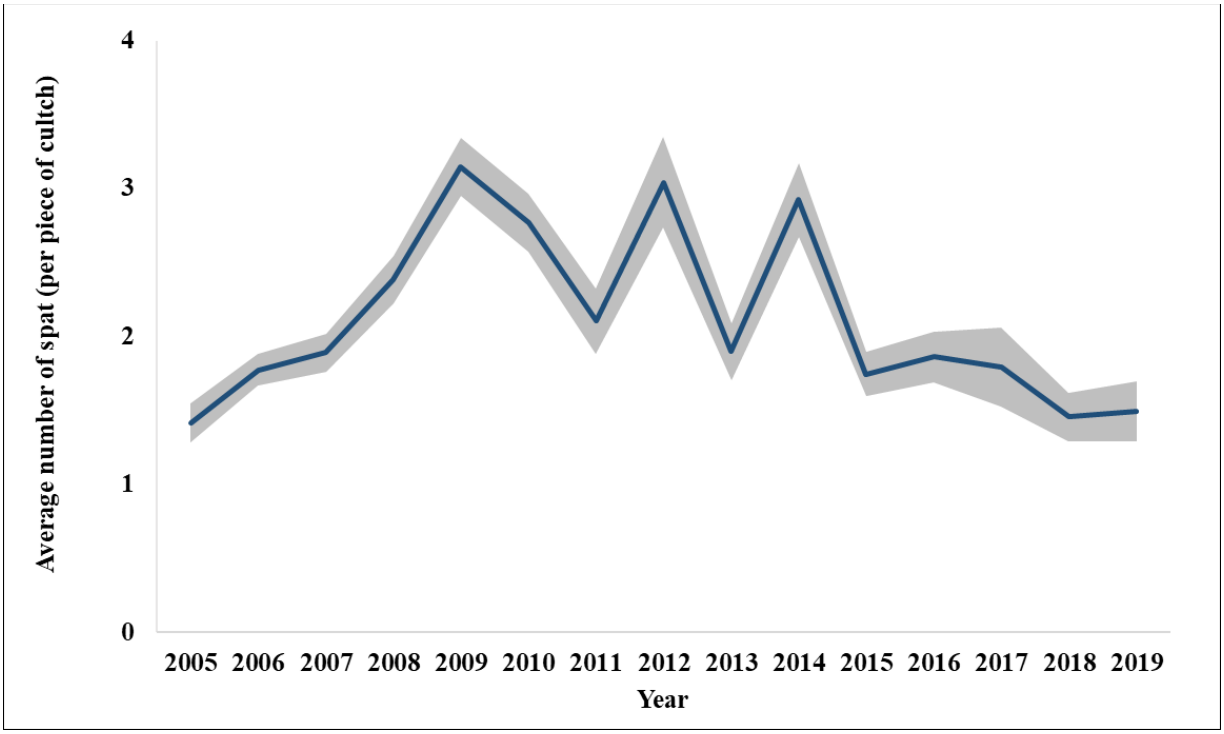

Figure 5. The annual average number of oyster spat across all sampling sites with standard error shaded in gray, 2008-2019 (NCDMF Habitat and Enhancement Section).

FISHERY MANAGEMENT PLAN UPDATE
ESTUARINE STRIPED BASS
AUGUST 2019

STATUS OF THE FISHERY MANAGEMENT PLAN

Fishery Management Plan History

Original FMP Adoption:	January 1994 May 2004
Amendments:	Amendment 1 – May 2013 Amendment 2 – In Progress
Revisions:	November 2014
Supplements:	Supplement A – February 2019
Information Updates:	None
Recommended Schedule Change:	None
Benchmark Review:	Review started in 2017
MFC Scheduled Review:	Review started in 2017

The North Carolina Marine Fisheries Commission (NCMFC) and the North Carolina Wildlife Resources Commission (NCWRC) implemented a Memorandum of Agreement in 1990 to address management of the striped bass stock in the Albemarle Sound and Roanoke River (A-R). The original Estuarine Striped Bass FMP was approved by the NCMFC in 1994 and was targeted at the continued recovery of the A-R stock, which at the time was at historically low levels of abundance and was experiencing chronic spawning failures (Laney et. al. 1993). The comprehensive plan addressed the management of all estuarine stocks of striped bass in the state, satisfying the recommendation contained in the Report to Congress for the North Carolina Striped Bass Study (U.S. Fish and Wildlife Service 1992) that such a plan be prepared.

The first North Carolina Estuarine Striped Bass FMP developed under the criteria and standards of the 1997 Fisheries Reform Act (NCDMF 2004) was approved in May 2004. The plan focused on identifying water flow, water quality, and habitat issues throughout the state, reducing discard mortality in the commercial anchored gill net fisheries, continued stocking of striped bass in the Central and Southern areas of the state, and developing creel surveys in the Tar-Pamlico, Neuse, and Cape Fear rivers to estimate recreational harvest in those systems.

Estuarine striped bass (*Morone saxatilis*) in North Carolina are currently managed under Amendment 1 to the North Carolina Estuarine Striped Bass Fishery Management Plan (FMP), its

subsequent revision (NCDMF 2014), and Supplement A. It is a joint plan between the NCMFC and the NCWRC. Amendment 1, adopted in 2013, lays out separate management strategies for the A-R stock and the Central and Southern stocks in the Tar-Pamlico, Neuse, and Cape Fear rivers. Management programs in Amendment 1 consist of daily possession limits, open and closed harvest seasons, gill net mesh size and yardage restrictions, seasonal attendance requirements, barbless hook requirements in some areas, minimum size limits, and slot limits to maintain a sustainable harvest and reduce regulatory discard mortality in all sectors. Amendment 1 also maintains the stocking regime in the Central and Southern systems (Central Southern Management Area, CSMA) and the harvest moratorium on striped bass in the Cape Fear River and its tributaries (NCDMF 2013). Striped bass fisheries in the Atlantic Ocean of North Carolina are managed under the Atlantic States Marine Fisheries Commission's (ASMFC) Amendment 6 to the Interstate FMP for Atlantic Striped Bass and subsequent addenda.

In response to the 2013 benchmark A-R striped bass stock assessment that indicated fishing mortality was above its target, the NCMFC approved a Revision to Amendment 1 in November 2014 (NCDMF 2014). The revision reduced the total allowable landings (TAL) for the A-R stock from 550,000 pounds to 275,000 pounds, split evenly between the commercial and recreational sectors. Stock assessment projections indicated a TAL of 275,000 pounds would maintain fishing mortality and spawning stock at their respective targets, providing a sustainable harvest. The Revision maintained for the CSMA the 25,000 pound commercial TAL, daily possession limits and a closed summer season to control recreational harvest, and a total harvest moratorium in the Cape Fear River and its tributaries. The Revision utilizes total allowable landings (TAL) instead of total allowable catch (TAC). The term TAC did not accurately describe the existing management strategy, because the term "catch" refers to landings and discards. Since its inception the quota used to maintain striped bass harvest at sustainable levels in the A-R and the CSMA is for landings only, not landings and discards. Discards are accounted for in the stock assessment model but are not part of the TAC.

In August 2016, the NCMFC approved a change to the FMP review schedule so that the comprehensive review of the Estuarine Striped Bass FMP would begin in July 2017 instead of July 2018 due to concerns about the high percentage of stock fish and minimal natural recruitment in the CSMA systems. Review of the plan began in 2017 and is ongoing.

On June 1, 2018, a NCWRC rule change implementing a 26-inch total length minimum size limit in the Inland Fishing Waters of the Tar-Pamlico and Neuse rivers became effective. At the November 2018 NCMFC business meeting, the division recommended development of temporary management measures to supplement the FMP providing for a no-possession provision for striped bass in the internal coastal and joint waters of the CSMA to protect important year classes of striped bass while Amendment 2 to the N.C. Estuarine Striped Bass Fishery Management Plan is developed. Supplement A to the Estuarine Striped Bass FMP was adopted by the NCMFC at their February 2019 business meeting and NCWRC in March 2019. Supplement actions in the FMP implemented March 29, 2019 consisted of the following:

- Commercial and recreational no possession measure for striped bass (including hybrids) in coastal and inland fishing waters of the CSMA (FF-6-2019). The WRC hook and line closure proclamation had the effect of suspending rules 15A NCAC 10C .0107 (l) and

10C .0314 (g). A no-possession requirement already exists for the Cape Fear River by rule.
- Additionally, consistent with Amendment 1, commercial set gill-net restrictions requiring tie-downs and distance from shore (DFS) measures will apply year-round (M-5-2019).

On March 13, 2019 the Marine Fisheries Commission held an emergency meeting that directed the division to issue a proclamation regarding gill nets, beyond what was contained in Supplement A. Proclamation (M-6-2019) implemented the following:
- Prohibits the use of ALL gill nets upstream of the ferry lines from the Bayview Ferry to Aurora Ferry on the Pamlico River and the Minnesott Beach Ferry to Cherry Branch Ferry on the Neuse River.
- Maintains tie-down (vertical net height restrictions) and distance from shore restrictions for gill nets with a stretched mesh length 5 inches and greater in the western Pamlico Sound and rivers (superseded M-5-2019).

An emergency meeting called under North Carolina General Statute section 113-221.1(d), authorizes the commission to review the desirability of directing the fisheries director to issue a proclamation. Once the commission votes under this provision to direct issuance of a proclamation, the fisheries director has no discretion to choose another management option and is bound by law to follow the commission decision. In these cases, under existing law, the decision of the commission to direct the director to issue a proclamation is final and can only be overruled by the courts.

NCDMF and NCWRC staffs continue to work collaboratively to prepare stock assessments for the CSMA and A-R stocks and in development of Amendment 2 to the NC Estuarine Striped Bass FMP.

Management Unit

There are two geographic management units and four striped bass stocks included in Amendment 1 to the North Carolina Estuarine Striped Bass FMP. The northern management unit is comprised of two harvest management areas; the Albemarle Sound Management Area (ASMA) and the Roanoke River Management Area (RRMA). The ASMA includes the Albemarle Sound and all its coastal, joint and inland water tributaries, (except for the Roanoke, Middle, Eastmost and Cashie rivers), Currituck, Roanoke and Croatan sounds and all their joint and inland water tributaries, including Oregon Inlet, north of a line from Roanoke Marshes Point across to the north point of Eagle Nest Bay in Dare county. The RRMA includes the Roanoke River and its joint and inland water tributaries, including Middle, Eastmost and Cashie rivers, up to the Roanoke Rapids Dam. The striped bass stock in these two harvest management areas is referred to as the A-R stock, and its spawning grounds are in the Roanoke River in the vicinity of Weldon, NC. Implementation of recreational and commercial striped bass regulations within the ASMA is the responsibility of the NCMFC. Within the RRMA commercial regulations are the responsibility of the NCMFC while recreational regulations are the responsibility of the NCWRC. The A-R stock is also included in the management unit of Amendment 6 to the ASMFC Interstate FMP for Atlantic Striped Bass.

The southern geographic management unit is the CSMA and includes all internal coastal, joint and contiguous inland waters of North Carolina south of the ASMA to the South Carolina state line. There are spawning stocks in each of the major river systems within the CSMA; the Tar-Pamlico, the Neuse, and the Cape Fear. These stocks are collectively referred to as the CSMA stocks. Spawning grounds are not clearly defined in these systems as access to spawning areas is influenced by river flows as well as impediments to migration. Management of striped bass within the CSMA is the sole responsibility of the NCMFC and the NCWRC and is not subject to compliance with the ASMFC Interstate FMP for Atlantic Striped Bass.

To ensure compliance with interstate requirements, North Carolina also manages the A-R striped bass stock 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 plans) and the Atlantic Coastal Fisheries Cooperative Management Act (ASMFC plans) are like the goals of the Fisheries Reform Act of 1997 to "ensure long-term viability" of these fisheries (NCDMF 2015).

Goal and Objectives

The goal of Amendment 1 to the North Carolina Estuarine Striped Bass FMP is to achieve sustainable harvest through science based decision-making processes that conserve adequate spawning stock, provide and maintain a broad age structure, and protect the integrity of critical habitats. To achieve this goal, the following objectives must be met:

1. Identify and describe population attributes, including age structure, necessary to achieve sustainable harvest.
2. Restore, improve, and protect striped bass habitat and environmental quality consistent with the Coastal Habitat Protection Plan (CHPP) to increase growth, survival and reproduction.
3. Manage the fishery in a manner that considers biological, social, and economic factors.
4. Initiate, enhance, and/or continue programs to collect and analyze biological, social, economic, fishery, habitat, and environmental data needed to effectively monitor and manage the fishery.
5. Initiate, enhance, and/or continue information and education programs to elevate public awareness of the causes and nature of issues in the striped bass stocks, habitat, and fisheries, and explain management programs.
6. Develop management measures, including regulations that consider the needs of all user groups and provide sustainable harvest.
7. Promote practices that minimize bycatch and discard mortality in recreational and commercial fisheries.

STATUS OF THE STOCK

Life History

Striped bass (*Morone saxatilis)* are an estuarine dependent species found from the lower St. Lawrence River in Canada to the west coast of Florida through the northern shore of the Gulf of Mexico to Texas. In North Carolina, the species is also known as striper, rockfish, or rock. The only stocks considered migratory are the stocks from Maine to the Albemarle Sound-Roanoke River in North Carolina. These migratory stocks are under the management authority of the ASMFC. Migratory striped bass are considered anadromous, meaning they spend most of their adult life in the waters of the estuaries and nearshore ocean, migrating to fresh water to spawn in the spring. For more southern stocks down through Florida, including the CSMA (Tar-Pamlico, Neuse, and Cape Fear stocks), striped bass are riverine, meaning they do not migrate to the ocean like northern striped bass stocks and, instead, spend their entire life in the upper estuary and riverine system.

Females in the A-R stock are 29% mature at age 3 and 97% mature ate age 4, while females in the Tar-Pamlico and Neuse rivers are 50% maturity (L50) at 2.7 years and 98% mature by age 3 (Knight 2015). The length at 50% maturity (L50) for striped bass in the A-R stock is 16.8 inches. (Boyd 2011). Female striped bass in both systems produce large quantities of eggs which are broadcast into riverine spawning areas and fertilized by mature males, age 2 and older. In the Tar-Pamlico and Neuse rivers, fecundity ranged from 223,110 eggs for an Age-3 female to 3,273,206 eggs for an Age-10 female (Knight 2015). Fertilized eggs drift with downstream currents and need 1.5 to 3 days to hatch and then continue to develop through a larval stage for several more days, eventually arriving in river mouths and the inland portions of coastal estuaries where they develop into juveniles. Striped bass require flowing, freshwater habitats to spawn successfully, allowing the eggs to remain suspended until they hatch, and to transport larvae to the nursery areas. Environmental conditions including temperature, rainfall and river flows are important factors in determining the number of juveniles produced annually. Spawning in North Carolina takes place from late March until early June. Peak spawning activity for A-R striped bass occurs when water reaches 62 to 67 degrees Fahrenheit in the Roanoke River at Weldon. Spawning grounds are not clearly defined in CSMA systems as access to spawning areas is influenced by river flows as well as impediments to migration. Recent results of a new genetics-based analysis revealed that rather than contributing minimally to the CSMA stocks of striped bass as previously thought, hatchery stocked fish were nearing 100% on the spawning grounds and in internal coastal fishing waters of the Tar-Pamlico, Neuse, and Cape Fear rivers (O'Donnell and Farrae 2017).

Striped bass are relatively long-lived and capable of attaining moderately large sizes. Fish weighing 50 or 60 pounds are not exceptional. In general, females grow larger than males with reported maximum lengths of 60 inches and 45 inches. In recent years, the oldest observed striped bass in the A-R stock was 23 years. The oldest observed striped bass within the CSMA were; Cape Fear River (7 years), Tar-Pamlico and Neuse rivers (11 years). The largest striped bass on record are two females caught in the early 1900s in Albemarle Sound which weighed 125 pounds each. Large Roanoke River striped bass (>900 mm TL) rapidly emigrate (~ 59 km/d) after spawning to distant (>1,000 km) northern ocean waters (New Jersey to Massachusetts),

where they spend their summers and migrate southward in the fall to overwintering habitats off Virginia and North Carolina and complete their migration circuit the following spring by returning to the Roanoke River to spawn. (Callihan et al. 2015). Estuarine striped bass from the A-R stock contribute minimally to the total coastal migratory stock when compared to the contributions from larger systems like the Chesapeake Bay, Delaware and Hudson rivers.

Striped bass can form large schools feeding on whatever fishes are seasonally and geographically available. They also feed on a wide variety of invertebrates. In general, oily fish such as menhaden, herrings and shads are very important prey items, but they will also readily eat spot, mullet, croaker, American eel, and various invertebrates like blue crabs.

Stock Status

A-R Stock

The 2016 A-R striped bass stock assessment update indicated the resource is not overfished or experiencing overfishing. Fishing mortality is well below the threshold and the estimate of female SSB is above its respective threshold. Terminal year (2014) estimates, especially the estimate of SSB, should be interpreted with caution as they are uncertain and associated with a bias as illustrated by the retrospective analysis. While the bias is not consistent over time, it is present and will influence terminal year estimates.

CSMA Stocks

The lack of adequate data makes it difficult to quantitatively assess the CSMA stocks regarding the overfishing and overfished stock status. The need for continued conservation management efforts are supported by the low overall abundance, minimal recruitment, uncertain levels of mortality, the absence of older fish on the spawning grounds, non-optimal environmental conditions on the spawning grounds in the spring, potential impacts from stocked juveniles and hybrid striped bass, and the high percentage of stocked fish in the population. Prior studies indicated stocked fish contributed minimally to the spawning stock; however, results of genetics-based analysis revealed stocked fish composed nearly 100% of the fish sampled from the spawning grounds and internal coastal fishing waters of the Tar-Pamlico, Neuse, and Cape Fear rivers in 2016 indicating there is extremely limited natural reproduction and survival occurring in the CSMA (O'Donnell and Farrae 2017). However, genetic analysis of fish sampled in 2017, revealed a noticeable decrease in contribution of stocked fish (Farrae and Darden 2018). In 2018, NCWRC genetics-based analysis revealed stocked fish composed of 44%, 79%, and 92% for the Tar-Pamlico, Neuse, and Cape Fear rivers, respectively (SCDNR 2018). The percent contribution of hatchery fish differs significantly between river system and area within each river. Dams blocking access to spawning habitat and low water flow associated with droughts, municipal withdrawals, and electrical power production are additional factors that potentially limit the spawning success of this species in the CSMA.

Stock Assessment

A-R Stock

The most recent A-R benchmark stock assessment (data through 2012) utilized the ASAP3 statistical catch-at-age model. This model was peer reviewed and approved for management use by an outside panel of experts and the ASMFC Atlantic Striped Bass Management Board. The model was updated in 2016 with data through 2014. The model incorporated all commercial and recreational harvest and discard data, as well as abundance data from fishery independent surveys conducted by NCDMF and NCWRC staff.

Results from the assessment update indicate the stock is not overfished and overfishing is not occurring relative to biological reference points (AR_Figures 1 and 2). Female spawning stock biomass is estimated at 2,024,583 pounds, which is above the threshold of 772,588 pounds; therefore, the stock is not considered overfished. However, caution should be used when evaluating the estimate of SSB and F in the last year of the assessment. The estimated SSB value in 2014 is the largest value in the entire time series and is likely an overestimate, based on past years of retrospective bias exhibited by the model. Subsequent assessments, incorporating additional years of data and possibly a revised stock-recruit relationship, may reduce the magnitude of this peak. (Flowers, J., et al. 2016). The A-R stock experienced a period of unusually strong recruitment (number of age-1 fish entering the population) from 1994-2001 followed by a period of lower recruitment from 2002-2013 and higher recruitment again in 2014 and 2015 (AR_Figure 1). Total stock abundance reached its peak in the late 1990s and has declined gradually since. Additionally, fishing mortality is estimated at 0.06, below the target of 0.33; therefore, overfishing is not occurring (AR_Figure 2).

CSMA Stocks

The index-based method of catch curve analysis was used to assess the status of striped bass populations in the CSMA (NCDMF 2013, Appendix 14.7). The large confidence intervals and lack of precision in the catch curve Z estimates (total mortality rate) made them unsuitable for making a stock status determination (NCDMF 2013). A benchmark stock assessment is currently underway using data from 2004 -2017. Multiple assessment techniques are being considered given the differences in life history and data sources for each system and the lack of natural recruitment in the CSMA systems. Results from each system stock assessments are expected in 2019.

STATUS OF THE FISHERY

Annual spawning success of anadromous fish and fish that spawn in or use estuaries for nursery habitat, is largely dependent upon environmental conditions, both natural and manmade. Even when female spawning stock biomass is high, poor reproductive success can occur due to unfavorable environmental conditions. This fact is important to keep in mind when discussing trends in landings data and stock abundance. For species that have long term juvenile abundance surveys, this phenomenon is evident when we observe a year with above average spawning success (termed a “strong year class”) followed by a year when practically no eggs survive to the juvenile stage (a “weak year class”). This cycle of spawning success and failure results in annual

harvests that increase and decrease depending on the abundance of the year classes available to the fishery.

Current Regulations

ASMA

Harvest in the commercial sector is limited by an annual TAL of 137,500 pounds (see the November 2014 Revision of Amendment 1 to the North Carolina Estuarine Striped Bass FMP for a thorough discussion of how the current TAL was determined). There is also an 18-inch minimum total length (TL) size limit. The commercial fishery is prosecuted as a non-directed bycatch fishery, with most landings occurring in large mesh (≥ 5-inch stretched mesh) floating gill nets during the spring American shad fishery. Pound nets and flounder nets account for the remainder of the harvest. Daily trip limits are set by proclamation. Daily reporting of the number and pounds of striped bass landed from all licensed striped bass dealers ensure the TAL is not exceeded. There is a fall harvest season from October 1 through December 31 and a spring harvest season from January 1 through April 30. The harvest season is closed from May 1 through September 30 each year. The seasons may be closed early by proclamation if the TAL is reached. There is mandatory attendance on all small mesh (< 5-inch stretched mesh) gill nets during the summer closed season to reduce discard mortality in that fishery. There are areas within the ASMA that are closed to all gill netting to further reduce undersize discards and to protect females as they enter the mouth of the Roanoke River during their spring spawning migration.

Harvest in the recreational sector is limited by an annual TAL of 68,750 pounds. The recreational sector also has an 18-inch total length minimum size limit and a two fish per person daily possession limit. The harvest seasons are the same as the commercial sector. Harvest is estimated via a creel survey designed for striped bass in the ASMA. The daily possession limit may be changed and/or seasons closed early by proclamation to ensure the TAL is not exceeded.

Check with the NCDMF for the most recent proclamation on striped bass harvest limits including trip limits and bycatch requirements.

RRMA

Commercial harvest in the RRMA is prohibited. The RRMA recreational sector also has an annual TAL of 68,750 pounds. The harvest season is open from March 1 through April 30 each year. There is an 18-inch total length minimum size limit and a no possession slot where fish between 22 and 27 inches total length may not be possessed. There is a two fish per person daily possession limit and only one of those fish may be greater than 27 inches total length. Only a single barbless hook may be used in inland waters of the RRMA upstream of the U.S. Highway 258 Bridge from April 1 – June 30.

CSMA

Commercial and recreational harvest in the CSMA is prohibited (for historical regulations see CS_Table 5). Supplement A to the Estuarine Striped Bass FMP was adopted by the NCMFC at their February 2019 business meeting and by the NCWRC in March 2019. Supplement actions in the FMP implemented March 29, 2019 consisted of the following:

- Commercial and recreational no possession measure for striped bass (including hybrids) in coastal and inland fishing waters of the CSMA (FF-6-2019). The WRC hook and line closure proclamation had the effect of suspending rules 15A NCAC 10C .0107 (l) and 10C .0314 (g). A no-possession requirement already exists for the Cape Fear River by rule.
- Additionally, consistent with Amendment 1, commercial set gill-net restrictions requiring tie-downs and distance from shore (DFS) measures will apply year-round (M-5-2019).

Commercial Landings

ASMA

Commercial landings in the ASMA have been controlled by an annual TAL since 1991 (AR_Table 1). Due to gill net mesh regulations and minimum size limits in place since 1993, most harvest consists of fish 4 to 6 years of age. From 1990 through 1997 the TAL was set at 98,000 pounds because the A-R stock was at historical low levels of abundance. The stock was declared recovered in 1997 and the TAL was gradually increased as stock abundance increased. The TAL reached its maximum level of 275,000 pounds in 2003 as the stock reached record levels of abundance.

Through 2004 the TAL was reached easily. As stock abundance started to decline, commercial landings no longer reached the annual TAL, even with increases in the number of harvest days and daily possession limits. From 2005 through 2009 landings steadily declined and averaged about 150,000 pounds, even though gill net trips remained steady during that period (AR_Figure 3).

The decline in landings during 2005-2009 was due to poor year classes produced from 2001 to 2004. An increase in landings in 2010 to over 200,000 pounds was due to the strong 2005-year class. Since 2013 landings have been reduced in part because of a shortened American shad season resulting from triggers being met in the American Shad Sustainable Fishery Plan. Most landings traditionally have come during the American shad season. Length frequency distribution in 2018 is presented in AR_Figure 4. Length at age for all commercial samples collected from 1972 through 2018 are presented in AR_Figure 5. Commercial length frequencies are represented in AR_Figure 6. Modal length increased in 1991 and has stayed steady due to the 18-inch minimum. A larger abundance of older fish was present in 2004 and a there was a decrease in modal length in 2018. Fish between 18 and 24 inches dominate the fishery.

CSMA

Commercial landings in the CSMA have been constrained by an annual TAL of 25,000 pounds since 1994. Over the past 10 years, landings have closely followed the annual TAL, except for 2008 when less than half of the TAL was landed. Since 2004 striped bass commercial landings in the CSMA have averaged 24,179 pounds and ranged from a low of 10,115 pounds in 2008 to a high of 32,479 pounds in 2004 (CS_Figure 1). In 2018, commercial landings were 20,057 pounds with a dockside value of $61,979. Most commercial landings come from the Pamlico and Pungo rivers and the Neuse and Bay rivers, with the remainder coming from the Pamlico Sound (CS_Figure 2). Since 2004 there has only been a spring harvest season, recently opening March 1 each year and closing when the TAL is reached, however due to the no possession measure

approved in Supplement A, the commercial striped bass fishery was closed in 2019 while Amendment 2 is developed.

Recreational Landings

ASMA

The recreational sector's landings in the ASMA are dominated by fish age 3 to 5 due in part to a statewide rule that prohibits possession of river herring cut bait or whole river herring over six inches in length while engaged in fishing activities, the migratory nature of larger, older fish, and general angling techniques in the ASMA. Very few anglers use the large size artificial lures or natural bait required to catch striped bass over 28 inches, so very few fish over nine or 10 years old are observed in the creel survey. Plus, these older fish make up a relatively small portion of the total overall stock abundance.

Landings in the ASMA have been controlled by a TAL since 1991 (Table 1). Starting in 1998 the TAL was split evenly between the commercial and recreational sectors. The recreational TAL increased incrementally from 29,400 pounds in 1997 to 137,500 pounds in 2003. The recreational sector reached its TAL consistently until 2002, when landings started declining. Recreational landings peaked in 2001 at 118,506 pounds. (AR_Figure 3). The harvest season increased from four days a week to seven in the fall of 2005 and the daily recreational possession limit increased from two to three fish in the fall of 2006, but landings continued to decline. Several poor year classes produced since 2001 have accounted for the decline in stock abundance and recreational harvest since 2006. The recreational limit went back down to two fish per person per day in January 2016. Harvest from 1982-2018 has averaged 45,513 pounds (13,320 fish) in the ASMA, well below the TAL of 68,750 pounds. Releases are usually greater than harvest and are dominated by fish less than the 18-inch minimum length limit. Undersized releases during the last 10 years have averaged 24,747 fish (Table 1). Length frequency distribution in 2018 is presented in AR_Figure 4. ASMA recreational length frequencies are presented in AR_Figure 7. Since 1996 the shift in abundance of younger fish is apparent with older fish still showing up in the fishery. Since 2014 the abundance of younger fish has increased likely due to the large 2014 and 2015 year classes.

RRMA

The recreational sector's landings in the RRMA are dominated by fish age 3 to 5 due to a no possession rule of fish between 22 and 27 inches total length in the RRMA, a statewide rule that prohibits possession of river herring cut bait or whole river herring over six inches in length while engaged in fishing activities, and general angling techniques in the RRMA. Very few anglers use the large size artificial lures or natural bait required to catch striped bass over 28 inches, so very few fish over nine or 10 years old are observed in the creel survey. Plus, these older fish make up a relatively small portion of the total overall stock abundance. Harvest from 1982 through 2018 has averaged 54,905 pounds (16,930 fish) in the RRMA (Table 1). Many more striped bass are caught and released by recreational anglers each year than are harvested, especially in the RRMA where concentrations of fish on the spawning grounds can be dense. Annual releases from 2005 through 2018 in the RRMA have averaged 78,197 fish (Table 1).

Landings in the RRMA followed the TAL closely through 2002. From 2003 through 2016 landings averaged 64,389 pounds, with a few noticeable low years (2003, 2008, 2013 and 2014; AR_Figure 3). The total number of fish caught per angler during the spring fishery in the RRMA can be large; catches of 100 fish per day are not uncommon, but angler catch rates can be impacted by spring water flows. The hydropower company operating the dams on the Roanoke River, along with the U.S. Army Corps of Engineers and biologists with the USFWS and NCWRC, coordinate releases to best mimic natural flow conditions during the spring spawn. However, droughts or heavy rainfall may still result in very low, i.e. 2,000-3,000 cubic feet per second (cfs) or very high, (≥20,000 cfs) flood stage flow conditions in some years. During these low or high flow years, angler success can be greatly diminished. Length frequency distribution in 2018 is presented in AR_Figure 4. RRMA recreational length frequencies are presented in AR_Figure 8. Since 2005 abundance of older fish in the recreational survey has decreased. Abundance of fish between 18 and 22 inches has stayed consistent from 2005 to 2018.

CSMA

The NCDMF started collecting recreational striped bass data in the major rivers of the CSMA in 2004. In 2018, recreational landings were 10,844 pounds, however, recreational landings have fluctuated since 2004 and have ranged from lows in 2008 and 2009 to a high of 26,973 pounds most recently in 2017 (Table 1). In recent years both the number of trips and the hours spent targeting striped bass within the CSMA have increased although there was a moderate decline observed in 2018. Since 2011, harvest in the Tar-Pamlico and Neuse rivers has been similar, ranging from 4,000 pounds to 9,000 pounds, however in 2016 and 2017 there was a sharp increase in recreational harvest (25,260 and 26,973 pounds, respectively). In 2018, recreational harvest dropped sharply by more than half of the 2016 and 2017 values (Table 1; CS_Figure 3). Harvest on the Pungo River has remained consistent at a relatively low level compared to fluctuations in the Tar-Pamlico and Neuse rivers.

Legal sized striped bass discards have increased over the past six years, more than doubling in 2017, but returning to more normal levels in 2018 (12,232 legal sized discarded fish). Fish released that were within the slot limit, have fluctuated since 2004 and have ranged from a low in 2004, 2006, and 2007 of zero fish to a high of 6,779 fish in 2016 (Table 1). In 2018, there were approximately 1,890 discarded striped bass that were within the slot limit. In 2017, mainly due to the large number of undersized striped bass available, there was more than a fivefold increase in the number of discards occurring in the fishery since 2015., However, in 2018 there was a sizeable decline back to more normal levels (34,128 under sized discarded fish; Table 1 and CS_Figure 4). Within the CSMA there is a significant catch-and-release fishery during the summer in the middle reaches of the Tar-Pamlico and Neuse rivers. Releases during the last 10 years have averaged 43,255 fish (Table 1). CSMA recreational length frequencies are presented in CS_Figure 5. In 2018, the modal length of striped bass in the recreational harvest from the Pamlico/Pungo rivers was 18 inches with few fish over 22 inches harvested (CS_ Figure 6). The modal length from the Neuse River was 19 inches with few fish over 20 inches harvested.

MONITORING PROGRAM DATA

Fishery-Dependent Monitoring

A-R Stock

The length, weight, sex, and age of the commercial harvest of striped bass has been consistently monitored through sampling at fish houses conducted by the division since 1972. Since 1994 anchored gill nets have accounted for 88 percent of the harvest in the ASMA (AR_Figure 9). Pound nets account for most of the remaining landings with minor catches coming from fyke nets, hoop nets, and pots. The mean total length from 2005 to 2018 was 22 inches (AR_Table 2).

The recreational harvest of striped bass in the ASMA and RRMA has been consistently monitored by the NCDMF since 1990 and the NCWRC since 1988 respectively. The mean total length from 2005 to 2018 was 20 inches total length for the ASMA and 20 inches total length for the RRMA (AR_Tables 3 and 4). Age data from the dependent and independent surveys are presented in AR_Table 5. The minimum and maximum age for the independent and dependent surveys are 1 and 17 years respectively with an average age of 4.

CSMA Stocks

Monitoring of the commercial fishery in the CSMA follows the same methodology as in the ASMA. There has been a commercial and recreational harvest moratorium in the Cape Fear River since 2008. Length data from the commercial harvest shows that on average striped bass in the Neuse and Bay rivers are slightly larger than fish harvested in the Pamlico and Pungo rivers (CS_Table 1). Additionally, maximum lengths are generally larger in the Neuse and Bay rivers compared to the Pamlico and Pungo rivers. In 2017, the maximum length sampled in the Neuse and Bay rivers was 47 inches compared to a maximum length of 29 inches on the Pamlico and Pungo rivers (CS_Table 1).

In 2018, the modal length of CSMA striped bass in the commercial harvest from the Pamlico/Pungo rivers was 20 inches with few fish over 25 inches harvested (CS Figure 6). In the Neuse/Bay rivers modal length was 23 inches with few fish over 27 inches harvested. CSMA commercial length frequencies are represented in CS_Figure 7 and show that striped bass are routinely harvested up to 30 inches total length, and that few fish under the 18 inch total length minimum size limit are harvested.

In North Carolina, hybrid striped bass (a cross between a striped bass and white bass; *Morone chrysops*) are commercially harvested from both the Tar-Pamlico and Neuse river systems and are not distinguished from striped bass for management purposes. Data collected on hybrid striped bass at commercial fish houses showed a peak abundance in the commercial fishery in 2014, since then the number of hybrid striped bass have steadily declined (CS_Table 1, CS_Figure 8). It is hypothesized that most of the hybrid striped bass observed in these systems originated from aquaculture facilities and escaped during flooding events. The last major flooding events in the CSMA were during Hurricane Irene in 2011 and Hurricane Florence in 2018. During Hurricane Irene river waters rose and flooded local aquaculture facilities. It was reported that tens of thousands of yearling hybrids were lost, presumably into the Pamlico River. While, it is likely that the majority of hybrids within the CSMA river systems escaped from

aquaculture facilities, it is also possible that hybridization occurs in the wild. Additional studies are needed to determine if this is occurring.

Since 2004, the CSMA recreational creel survey sampled on average 160 striped bass per year. In 2018, the creel survey measured 155 striped bass that averaged 19 inches and ranged in length from 16 to 29 inches (CS_Table 3). Age data from fishery dependent and independent surveys are presented in CS_Table 4 and CS_Figure 11. In 2016 and 2017, 570 genetic samples of stocked fish provided striped bass ages that included samples from the recreational creel survey (CS_Table 4). Figure CS_11 shows an increasing trend of size at length with a maximum age of 11 years old.

Fishery-Independent Monitoring

A-R Stock

A young-of-year (age-0) A-R striped bass juvenile abundance survey used to calculate a juvenile abundance index (JAI) was initiated by Dr. William Hassler of North Carolina State University in 1955. The NCDMF took over this critical long-term survey in 1987 at Dr. Hassler's retirement. Sampling occurs at seven fixed stations in the western Albemarle Sound from July through mid-October. Sampling gear is an 18-foot semi-balloon trawl towed for 15 minutes. Catch per unit effort is the number of striped bass captured per tow. The JAI provided by the survey is usually a reliable indicator of relative abundance and future harvest potential. Data from the survey reveal the highly variable inter-annual spawning success of striped bass. The long time-series of data also clearly shows the extended period of spawning failure that occurred when the stock was at historical levels of low abundance during the 1980s. Starting in 1993 the stock began producing successful spawns once again, due to improved water quality, agreements about water flow regimes on the Roanoke River during the spawning season, favorable environmental conditions during the spawning season, and severe management restrictions that allowed stock abundance to increase. Within an eight-year period spanning 1993-2000, the stock produced the four highest JAI values in the entire 46-year time series. The average JAI during 1993-2000 was 24.04, over three times higher than the average of the JAI prior to the stock crashing (1955-1977 JAI = 7.9; AR_Figure 10). However, from 2001 to 2010 the JAI was below average for most years, above average for only one year (2010), and several years including some back to back (2003 and 2004), which were considered spawning failures. This cycle starting in 1993 led to overall stock abundance increasing steadily through the mid-2000s to all-time highs, followed by a period of stock decline. From 2010 to 2017 the stock has seen improved annual spawning success, with above average JAI values in 2011, 2014, and 2015, with one year (2013) below the spawning failure threshold. The JAI value for 2018 was 0.43 and is below the spawning failure threshold. (AR_Figure 10).

A fall/winter fishery independent gill net survey has been conducted by the NCDMF throughout the Albemarle and Croatan sounds since the fall of 1990. The survey utilizes a stratified random sampling design, employing mesh sizes from two and one half-inch to 10-inch stretch mesh to characterize the resident and overwintering portion of the A-R stock. The survey is conducted from November through February. Catch per unit of effort is measured as the abundance of fish per 40-yard net soaked for 24 hours.

A spring survey employs the same methodology as the fall/winter survey but is conducted in the western Albemarle Sound only, near the mouth of the Roanoke River. The goal of the survey is to characterize the spawning portion of the A-R stock. The survey is conducted from March 1 through the end of May. Data from the surveys are used in the A-R stock assessment as an independent measure of stock abundance.

The independent gill net surveys do a good job of tracking relative abundance, but the trend in total abundance is often masked by the highly variable and often very large number of two- and three-year-old fish captured in the survey, so trends in total abundance are often less informative than trends in 4 to 6-year-old abundance. The trend in abundance of 4 to 6-year olds show the stock increasing in abundance through the 1990s, to a high in 1999 of about 90 fish per 100 net days for the spring survey and 72 fish in the fall/winter survey. The 4 to 6-year-old abundance has fluctuated since 2000 but has been on a general downward trend with abundance for both surveys at about 20 fish per 100 net days in 2014 (AR_Figure 11). One weakness of the gill net surveys is they collect very few older fish and under-represent the expansion of fish in the 9+ age group that has occurred since 2000. They also don't capture the decline in abundance of age 9+ fish that has occurred since the period of poor spawning success from 2001 to 2010. In 2018 the abundance of 4 to 6-year-old fish increased in the fall/winter portion of the survey and continued the downward trend during the spring.

An electrofishing survey has been conducted by the NCWRC on the spawning grounds since the spring of 1990. The survey goals are the same as the spring gill net survey but takes place on the Roanoke River in the vicinity of Weldon, the location of the fall line and historical center of spawning activity for A-R striped bass. The survey uses a stratified random sampling design. Catch per unit of effort is measured as the number of fish captured per hour of electrofishing. The survey is used in the A-R stock assessment as an independent measure of stock abundance.

The trend in total abundance from the electrofishing survey is similar to the trends of age 4 to 6 fish in the gill net surveys, increasing from low levels of abundance in the early 1990s to a peak in the early 2000s of 380 fish per hour, then decreasing since to a low in 2013 of 150 fish per hour (AR_Figure 12). The abundance of fish in 2018 was slightly higher than 2017, but still lower than the peaks in 2001, 2006 and 2008. Both surveys exhibit a few years with high inter-annual variability, but this is common with fisheries surveys in which environmental conditions affect relative abundance in the survey area and the catch efficiency of the gear. The electrofishing survey does a better job at tracking the abundance of the age 9+ group, and clearly shows the emergence of the 1993 cohort into this age group in 2002. The age 9+ group has been on a downward trend since the 2006 peak of 14 fish per hour, with the lowest catch in 2014 of just over one fish per hour (AR_Figure 13). The strong year classes produced from 1993-2000 supported the increased abundance of fish in the 9+ age group, but since the below average spawning and several years of spawning failure during 2001-2011, the abundance of the 9+ age group is declining. The oldest fish seen recently in the population is 23 years old, indicating that fishing mortality has decreased significantly since the implementation of minimum size limits and a TAL in 1990. When the survey started in 1990 fish older than seven were rarely observed in the survey. Age 9+ fish abundance from 2016 to 2018 is similar to the abundance levels seen in the early 90's.

Taken together, all the independent surveys track A-R stock dynamics well, and indicate the stock is healthy and female spawning stock biomass is adequate to produce large year classes; most recently in 2011, 2014 and 2015.

CSMA Stocks

The Fishery Independent Gill Net Survey (P915) was initiated by the NCDMF in May of 2001 in Pamlico Sound. The survey was expanded to the Pamlico, Pungo, and Neuse rivers in 2003, expanded to the Cape Fear and New rivers in 2008, and expanded into Core Sound, Bogue Sound and the White Oak River since May 2018. Due to a commercial and recreational no possession measure implemented in March 2019, fishery-independent programs like P915 will be the only source moving forward that will provide CSMA striped bass data. Samples collected from P915 on the Pamlico, Pungo, and Neuse rivers shows most striped bass were captured in the upper and middle portions of the rivers. Over the past twelve years, striped bass catch-per-unit-effort (CPUE) data shows abundance has been higher in the Pamlico/Pungo, and Neuse rivers when compared to the Cape Fear River (CS_Table 5 and CS_Figure 9). Since 2004, striped bass CPUE in the Pamlico/Pungo and Neuse rivers ranged from 0.84 to 2.66 fish per sample, whereas CPUE in the Cape Fear River ranged from 0 to 0.14 fish per sample (CS_Table 5). In 2018, striped bass CPUE in the Pamlico/Pungo and Neuse rivers was 2.26 and 1.34 fish per sample, respectively, compared to 0.03 fish per sample in the Cape Fear River (CS_Table 5; CS_Figure 9). Length frequencies from P915 are represented in CS_Figure 10. Length frequency distributions generally follow a normal bell-shaped patterns, however in 2016-2017 in the Pamlico/Pungo and 2015-2017 in the Neuse rivers there was a higher percentage of small fish that could represent the two year classes of striped bass thought to be the result of successful natural reproduction in 2014 and 2015.

In 2017, the Juvenile Anadromous Survey (P100) which was developed in the Albemarle Sound to determine relative abundance, growth and distribution of juvenile alosines and striped bass was expanded to include the Pamlico, Neuse, Cape Fear, and Northeast Cape Fear rivers. The survey employs both seines (June-July) and trawls (July-October) to monitor the status of the striped bass stocks in North Carolina in order to assess the effectiveness of management measures within the CSMA. In 2017 and 2018 young-of-year sampling in the Central Southern Management Area (CSMA) did not capture any juvenile striped bass in the Pamlico, Neuse, and Cape Fear rivers, however 24 juvenile Striped Bass were captured in the Northeast Cape Fear River in 2018.

MANAGEMENT STRATEGY

A-R Stock

Estuarine striped bass in North Carolina are managed under Amendment 1 to the North Carolina Estuarine Striped Bass FMP and subsequent revisions (see AR_Table 6). Striped bass fisheries in the Atlantic Ocean of North Carolina are managed under ASMFC's Amendment 6 to the Interstate FMP for Atlantic Striped Bass and subsequent addenda. The A-R stock is managed using biological reference points for spawning stock biomass and fishing mortality that are aimed at maintaining a sustainable harvest and adequate spawning stock biomass. Stock status is determined through a formal, peer reviewed stock assessment process that evaluates annual estimates of fishing mortality and biomass against their target and threshold values. An annual harvest quota for the A-R stock is calculated to keep these metrics below their targets. Juvenile abundance data generated from the survey is used in the A-R stock assessment as an independent

measure of stock abundance. The index is also used as a trigger. If the JAI is below 75 percent of all other values for three consecutive years, the ASMFC Striped Bass Technical Committee will make a recommendation to the ASMFC Striped Bass Management Board about possible causes and if management action is needed.

CSMA Stocks

Estuarine striped bass in North Carolina are managed under Amendment 1 to the North Carolina Estuarine Striped Bass FMP and subsequent revisions, however due to concerns about the high percentage of stock fish and minimal natural recruitment in the CSMA systems, the comprehensive review of the Estuarine Striped Bass FMP began in July 2017. Since the 2004 FMP there has been little change in the size and age distribution with few age-6 and older fish observed in any system, however age-6 and older CPUE in 2014 was the highest since the sample record began and continued an increasing trend since 2008 (Rachels and Ricks 2015). The need for continued conservation management efforts are supported by the constrained size and age distributions, low abundance, the absence of older fish in all stocks, and the high percentage of stocked fish in the population (Cushman et al. 2018; Farrae et al. 2018). Results from genetic testing of sampled fish in 2017 suggested there were two recent naturally spawned year classes and in February 2019, Supplement A to Amendment 1 to the North Carolina Estuarine Striped Bass FMP was approved instituting a recreational and commercial no-possession limit in the CSMA. The no-possession management is a temporary measure that would provide additional protection for those non-hatchery fish until Amendment 2 to the North Carolina Estuarine Striped Bass FMP is adopted. The NCDMF will use multiple stock assessment techniques to determine the overfished/overfishing status for each stock, as well as continue with drafting Amendment 2 to the North Carolina Estuarine Striped Bass FMP. Amendment 2 will determine the recovery metrics for each system.

RESEARCH NEEDS

Several research needs were identified and explored in Amendment 1 to the North Carolina Estuarine Striped Bass FMP. The bulleted items listed below outline the specific issue, the priority ranking, and the implementation status on the recommendations:

- Determine percent contribution of stocked fish on the spawning grounds -HIGH (Ongoing through NCWRC genetics study)
- Acquire life history information: maturity, fecundity, size and weight at age, egg and larval survival - HIGH. (Ongoing through CRFL funded projects. See Knight (2015) for recent publication on maturation and fecundity in the Neuse and Tar-Pamlico rivers and ongoing through NCDMF P930)
- Conduct a mark-recapture study utilizing conventional tags and telemetry approaches -HIGH (Ongoing through CRFL funded projects)
- Determine if suitable striped bass spawning conditions exist in the Tar-Pamlico, Neuse, and Cape Fear Rivers – MEDIUM (Buckley et al. 2019)

- Conduct egg abundance and egg viability studies – MEDIUM (In 2016, NCWRC initiated an anadromous ichthyoplankton survey designed to investigate egg and larval fish abundance and egg viability; In 2017, NCSU was awarded a CRFL grant to conduct research on striped bass egg yolk, egg buoyancy, and striped bass recruitment.)
- Determine extent of spawning grounds – LOW (See Rock et al. 2016 for recent publication on acoustic tagged striped bass in the CSMA)
- Improve discard estimates and discard biological characteristics from commercial fisheries – MEDIUM (Ongoing through statewide observer coverage. See Rock et al. (2016) for recent publication on improving discard estimates through NCDMF creel survey and expanded observer program)
- Obtain biological characteristics such as length, weight, age, and sex of recreational harvest – MEDIUM (Ongoing through creel surveys but could be expanded)
- Obtain biological characteristics such as length, weight, age, and sex of commercial harvest - MEDIUM (Ongoing but sampling could be increased)
- Improve discard estimates and discard biological characteristics from recreational fisheries – LOW (Ongoing through creel survey)
- Conduct delayed mortality studies for recreational and commercial gear – LOW (Ongoing for recreational fisheries)
- Conduct independent surveys that adequately capture all life stages of striped bass - HIGH (Ongoing through expansion of juvenile striped bass independent survey (P100) into the Pamlico, Neuse, Cape Fear, and Northeast Cape Fear rivers in 2017)
- Continue tagging striped bass to evaluate the possible contribution to the Atlantic Migratory stock and provide data to be used in stock assessment efforts. Develop means to better assess the tag recapture and reporting rate for use in tag-based stock assessments – HIGH (Ongoing through CRFL funded projects)
- Conduct a short-term study to determine vulnerability-at-length for survey gears – LOW (No Action)

Additional research needs were identified in Amendment 1 to the North Carolina Estuarine Striped Bass FMP, however there were no priority rankings assigned. The bulleted items listed below outlines the specific research need and the implementation status:

- Continued support and development of SHAs in NC. (Ongoing, SHAs in regions 1-3 have been designated)
- Continued protection of SHAs by the cooperating agencies once they have been designated (Ongoing)
- Work with WRC, DWQ, and others to implement management measures that will enhance water quality in areas used by striped bass (Ongoing)
- Work with American Rivers and other partners to accelerate dam removal in priority areas (Ongoing)
- Continue to protect NC coastal wetlands through the permit review process (Ongoing)
- Quantify the density and distribution of striped bass eggs, fry, and juveniles in coastal rivers to estimate potential losses to entrainment and impingement (CSMA – Ongoing through NCDMF Program 100; Buckley et al. 2019; In 2017, NCSU was awarded a CRFL grant to conduct research on striped bass egg yolk, egg buoyancy, and striped bass recruitment)

- Determine if contaminants are present in striped bass habitats and identify those that are potentially detrimental to various life history stages (Ongoing through Division of Water Quality but could be expanded. In 2017, NCSU was awarded a CRFL grant to conduct research on striped bass eggs, including evaluating for Gen X)
- Evaluate the effects of existing and future water withdrawals on water quality and quantity and fisheries habitat in coastal watersheds (No Action)
- Identify and designate anadromous fish nursery areas and how early juvenile striped bass move and are distributed in NC estuarine waters (No Action)
- Identify minimum flow requirements in the Tar-Pamlico, Neuse, and Cape Fear rivers necessary for successful spawning, egg development, and larval transport to nursery grounds (No Action)
- Evaluate the impacts/effects of reverse osmosis plants on receiving waters and aquatic resources. Short term studies conducted but there is a need for long term studies
- Verify condition of identified SHAs used by striped bass (No Action)
- Investigate abundance and spawning contribution of striped bass in the North Carolina and Virginia portions of the Blackwater, Nottoway and Meherrin rivers (Some sampling is by VADGIF and a CRFL grant is being completed that evaluated the potential spawning contribution on the Chowan and Meherrin rivers)
- Investigate striped bass use in the North Carolina portions of the Waccamaw River during the appropriate season (No Action)
- Continue to investigate the potential for passage of striped bass above Roanoke Rapids Dam (Ongoing)
- Support fish passage at Buckhorn Dam and Lock and Dam No.2 and No.3 and investigate anadromous fish utilization of the rock ladder at Lock and Dam No. 1 (Ongoing)
- Investigate the feasibility of fish passage at and improved water flows from Rocky Mount Mill Dam and Tar River Reservoir Dam (Ongoing)
- Support the removal of Milburnie Dam in Raleigh (COMPLETED-Dam removed November 2017)
- Support fish passage above the Yadkin chain of dams in North Carolina (Ongoing)
- Data on the density and distribution of striped bass eggs, fry, and juveniles in coastal rivers are needed so that potential losses to entrainment and impingement can be estimated (CSMA – Ongoing through NCDMF Program 100; Buckley et al. 2019)
- Identify effective engineering solutions to prevent entrainment and impingement of striped bass eggs, fry, and juveniles (Ongoing)
- NCDMF and NCWRC should work with DWQ and other agencies to determine and establish more stringent water quality standards in Anadromous Fish Spawning Areas (No Action)
- Apply for ITP for impacted fisheries. Completed, ITP's obtained for the estuarine gill net fishery.
- Continue gear development research to minimize species interactions (Ongoing)
- Implementation of outreach programs to inform state agencies, the public, and the commercial and recreational fishing industries about issues relating to protected species and fishery management (Ongoing)
- Methodology tested to accurately capture Atlantic Ocean striped bass harvest during summer months (Ongoing through catch card survey but compliance is uncertain)

- Increase surveys of stocked systems to determine percent contribution of wild versus stocked fish (Ongoing through NCWRC and NCDMF genetics survey)
- Determine if fish produced from system-specific parentage will increase stocking contribution to spawning populations (Ongoing through NCWRC and NCDMF genetics survey)
- Determine factors impacting survivability of stocked fish in each system (Bradley et al. 2018)
- More at-sea observations made for the gill net fishery to more accurately assess the discards from this fishery (Ongoing through NCDMF Observer Program)
- Explore improvements to NCDMF programs (Trip Ticket, Fish House sampling, fisherman surveys or logbooks) in order to acquire spatially and temporally accurate gill net gear parameters (No Action)
- Investigate the impacts of delayed mortality on striped bass captured in gill nets (No Action)
- Clarify relationships between salinity, DO, temperature and catch and release mortality rates in the ASMA and CSMA (No Action)
- Year-round creel survey in the ASMA (No Action)
- Expand tagging programs to include high reward tagging (Ongoing through CRFL funded grant)
- Conduct new analysis of relationship between JAI in Albemarle Sound and flows in Roanoke River (No Action)

FISHERY MANAGEMENT PLAN SCHEDULE RECOMMENDATION

The division is continuing with the development of Amendment 2 in conjunction with the Wildlife Resources Commission.

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TABLES – Combined

Table 1. Recreational striped bass effort, harvest and discards from the ASMA, RRMA (2005-2018), and CSMA (2004-2018).

Management Area	Year	Striped Bass Fishing Angler Trips	Striped Bass Effort Angler Hours	Number Harvested	Pounds Harvested	Striped Bass Discard (#over-creel)	Striped Bass Discard (#under-sized)	Striped Bass Discard (#legal-sized)	Striped Bass Discard (# slot-sized)	Total Discards
ASMA	2005	N/A	86,943	17,954	63,477	N/A	N/A	N/A	N/A	N/A
	2006	N/A	65,757	10,711	35,985	N/A	N/A	N/A	N/A	N/A
	2007	N/A	61,679	7,143	26,633	N/A	N/A	N/A	N/A	N/A
	2008	11,793	72,673	10,048	31,628	391	36,324	260	N/A	36,975
	2009	11,326	72,021	12,069	37,313	20	38,683	1,860	N/A	40,563
	2010	9,660	66,893	3,504	11,470	569	15,398	233	N/A	16,200
	2011	13,114	85,325	13,341	42,536	317	20,114	1,141	N/A	21,572
	2012	14,490	102,787	22,345	71,456	1,024	19,977	3,970	N/A	24,971
	2013	7,053	50,643	4,299	14,897	31	16,034	316	N/A	16,381
	2014	7,264	40,478	5,529	16,867	18	22,558	510	N/A	23,086
	2015	11,132	75,009	23,240	70,008	1,573	45,559	2,402	N/A	49,534
	2016	7,023	42,276	4,794	14,486	252	8,822	1,278	N/A	10,352
	2017	8,822	41,371	4,214	15,479	55	24,003	599	N/A	24,659
	2018	5,950	34,764	3,466	11,763	281	21,388	3,970	N/A	25,639
	Total	101,677	863,855	139,191	452,235	4,250	247,472	12,569		264,293
RRMA	2005	27,527	130,755	34,122	107,530					89,550
	2006	25,394	120,621	25,355	84,521					40,805
	2007	29,868	141,874	19,306	64,986					40,879
	2008	23,286	110,608	10,541	32,725					141,646
	2009*	25,405	120,675	23,248	69,581					135,964
	2010	24,347	125,495	22,445	72,037	Disposition of discards not available for all years.				77,882
	2011	27,311	122,876	22,102	71,561					80,828
	2012	27,151	110,982	28,847	88,539					40,772
	2013	19,539	100,391	7,718	25,197					49,148
	2014	15,960	80,256	11,058	33,717					93,471
	2015	22,827	111,419	20,031	58,962					78,401
	2016	25,036	129,132	21,260	65,218					34,753
	2017	19,688	101,565	9,899	32,569					68,693
	2018	18,280	95,447	8,741	26,797					121,969
	Total	311,620	1,602,097	264,673	550,106					1,094,761
CSMA	2004	12,782	63,791	6,141	22,958	85	11,729	1,743	0	13,557
	2005	16,414	69,370	3,832	14,965	152	15,609	1,016	77	16,854
	2006	10,611	42,066	2,481	7,352	33	12,548	2,314	0	14,895
	2007	10,971	46,655	3,597	10,794	147	21,673	1,707	0	23,527
	2008	6,621	28,413	843	2,990	2,838	11,721	3,316	91	17,966
	2009	5,642	26,611	895	3,061	7	4,471	1,769	718	6,965
	2010	6,559	25,354	1,757	5,537	29	5,200	2,401	360	7,990

Table 1. (continued).

Management Area	Year	Striped Bass Fishing Angler Trips	Striped Bass Effort Angler Hours	Number Harvested	Pounds Harvested	Striped Bass Discard (#over-creel)	Striped Bass Discard (#under-sized)	Striped Bass Discard (#legal-sized)	Striped Bass Discard (# slot-sized)	Total Discards
CSMA	2012	18,338	71,964	3,922	15,240	439	26,343	13,621	2,910	43,313
	2013	20,394	86,918	5,467	19,537	539	19,302	10,619	2,357	32,816
	2014	15,682	70,316	3,301	13,368	1,449	19,185	7,934	1,641	30,209
	2015	18,159	79,398	3,934	14,269	217	22,272	8,052	813	31,353
	2016	23,675	110,453	6,697	25,260	215	57,874	10,593	6,779	75,461
	2017	26,125	119,680	7,334	26,973	549	101,787	26,501	2,293	131,129
	2018	16,393	69,917	3,371	10,884	871	34,128	12,232	1,890	49,122
	Total	220,972	962,447	56,299	202,662	7,579	380,500	109,215	22,052	519,345

*Estimates of discards not available for the post-harvest season period.

TABLES - Albemarle-Roanoke (AR)

AR_Table 1. Striped bass commercial and recreational harvest and discards in pounds from the ASMA-RRMA, NC, 1982-2018.

Year	Harvest (lb)						Discard (lb)					Combined
	ASMA Comm.	ASMA Rec.	RRMA Comm.	RRMA Rec.	Total Harvest	TAL	ASMA Comm.	ASMA Rec.	RRMA Comm.	RRMA Rec.	Total Discards	Harvest and Discards
1982	228,004	24,098	17,369	23,693	293,164		No estimates for shaded years					293,164
1983	228,742	27,320	8,861	26,861	291,784							291,784
1984	475,641	17,181	1,703	16,892	511,417							511,417
1985	269,671	6,603	6,200	6,492	288,966							288,966
1986	172,683	18,755	50	18,440	209,928							209,928
1987	228,861	37,621	0[#]	36,989	303,471							303,471
1988	108,791	52,434	0	74,639	235,864							235,864
1989	97,061	26,857	0	32,107	156,025							156,025
1990	103,757	36,976	0	42,204	182,937							182,937
1991	108,460	30,021	0	72,529	211,010	156,800				17,048	17,048	228,058
1992	100,544	51,167	0	36,016	187,727	156,800				4,370	4,370	192,097
1993	109,475	54,835	0	45,146	209,456	156,800				11,546	11,546	221,002
1994	102,201	39,704	0	28,084	169,989	156,800	151,810			12,613	164,423	334,412
1995	89,502	30,564	0	28,884	148,950	156,800	348,255			14,539	362,794	511,744
1996	89,624	29,185	0	28,173	146,982	156,800	200,429			36,634	237,063	384,045
1997	95,671	26,724	0	28,929	151,324	156,800	120,840			55,863	176,703	328,027
1998	122,454	64,885	0	73,527	260,866	250,860	135,855			21,149	157,004	417,870
1999	155,176	60,897	0	72,966	289,039	275,946	139,043			31,513	170,556	459,595
2000	218,888	116,163	0	119,584	454,635	450,000	137,996	11,951		33,810	183,757	638,392
2001	220,227	118,533	0	112,825	451,585	450,000	92,047	10,540		29,284	131,871	583,456
2002	222,834	92,649	0	112,698	428,181	450,000	128,664	7,710		10,897	147,271	575,452

AR_Table 1. (continued).

Year	Harvest (lb) ASMA Comm.	ASMA Rec.	Discard (lb) RRMA Comm.	RRMA Rec.	Combined Total Harvest	TAL	ASMA Comm.	ASMA Rec.	RRMA Comm.	RRMA Rec.	Total Discards	Harvest and Discards
2003	266,555	51,794	0	39,170	357,519	550,000	162,115	5,278		8,598	175,991	533,510
2004	273,666	98,403	0	120,697	492,766	550,000	89,832	9,244		62,523	161,599	654,365
2005	232,645	63,477	0	107,530	403,652	550,000	45,393	3,360		34,313	83,066	486,718
2006	156,314	35,985	0	84,521	276,822	550,000	54,529	1,453		13,799	69,781	346,603
2007	173,509	26,633	0	64,986	265,128	550,000	43,475	1,914		11,330	56,719	321,847
2008	74,926	31,628	0	32,725	139,279	550,000	108,176	4,969		37,624	150,769	290,048
2009	96,134	37,313	0	69,581	203,028	550,000	32,494	5,452		29,523	67,469	270,497
2010	199,829	11,460	0	72,037	283,326	550,000	44,838	3,318		25,263	73,419	356,745
2011	134,538	42,536	0	71,561	248,635	550,000	52,741	2,870		29,409	85,020	333,655
2012	115,605	71,456	0	88,539	275,332	550,000	34,253	3,995		10,251	48,499	323,831
2013	68,338	14,897	0	25,197	108,432	550,000	29,006	3,453		15,675	48,134	156,566
2014	71,372	16,867	0	33,717	121,956	550,000	5,010	1,365		32,843	39,218	161,174
2015	113,475	70,008	0	58,962	251,651	275,000	14,982	3,458		14,552	32,992	267,805
2016	123,111	14,486	0	65,218	202,815	275,000	4,480	978		10,108	34,076	236,891
2017	75,990	15,479	0	32,569	129,713	275,000	7,018	2,331		16,593	25,942	155,655
2018	116,057	11,763	0	26,797	142,854	275,000	4,716	N/A		7,806	12,522	155,376

AR_Table 2. Striped bass total length (inches) data from commercial landings from the ASMA, NC, 2005-2018.

Year	Mean Length	Minimum Length	Maximum Length	Total Number Measured
2005	21	17	43	719
2006	22	17	44	926
2007	22	17	47	860
2008	22	18	46	547
2009	21	18	41	813
2010	21	17	48	940
2011	21	18	39	990
2012	22	18	39	648
2013	22	18	45	543
2014	23	18	43	484
2015	22	18	43	794
2016	22	18	43	604
2017	22	18	41	246
2018	20	16	41	456

AR_Table 3. Striped bass total length (inches) data from recreational landings from the ASMA, NC, 2005-2018.

Year	Mean Length	Minimum Length	Maximum Length	Total Number Measured
2005	20	16	36	1,653
2006	20	17	32	743
2007	20	17	39	412
2008	20	18	30	632
2009	20	18	42	549
2010	20	17	28	337
2011	20	18	34	979
2012	20	18	36	1,059
2013	20	18	32	527
2014	19	18	28	802
2015	20	17	30	1,523
2016	21	18	28	423
2017	21	18	32	489
2018	18	17	29	312

AR_Table 4. Striped bass total length (inches) data from recreational landings from the RRMA, NC, 2005-2018.

Year	Mean Length	Minimum Length	Maximum Length	Total Number Measured
2005	20	17	40	981
2006	20	17	39	1,059
2007	20	18	39	709
2008	19	17	35	667
2009	19	17	32	1,049
2010	20	18	28	954
2011	20	18	31	679
2012	20	17	28	688
2013	20	17	27	512
2014	19	17	30	559
2015	19	16	27	1,340
2016	20	17	29	1,133
2017	20	17	34	498
2018	20	17	28	688

AR_Table 5. Striped bass age data from dependent (commercial) and independent (independent gill net survey) surveys from the ASMA, NC, 2005-2018.

Year	Modal Age	Minimum Age	Maximum Age	Total Number Aged
2005	4	1	14	1,258
2006	5	1	14	1,262
2007	5	1	14	1,188
2008	3	1	16	1,191
2009	4	1	14	1,040
2010	5	1	17	885
2011	5	1	11	1,429
2012	2	1	14	802
2013	5	1	13	921
2014	4	2	11	728
2015	4	1	11	713
2016	5	2	12	555
2017	2	2	13	504
2018	4	1	10	674

AR_Table 6. Albemarle-Roanoke management actions taken as a result of Amendment 1 to the North Carolina Estuarine Striped Bass FMP.

Management Strategy	Implementation Status
RECREATIONAL STRIPED BASS HARVEST CLOSURE (Oregon Inlet Area/Atlantic Ocean) Status Quo – Allow the fishery to continue with catch card survey (May – Oct).	No additional regulatory action required
USE of SINGLE BARBLESS HOOKS (during Striped Bass Closed Season) Status quo (don't require barbless hooks) and continue to educate anglers on ethical angling practices, with the additional recommendation to include mortality statistics associated with various handling techniques when possible.	Increase angler education about proper angling and handling techniques to reduce discard mortality
ALBEMARLE SOUND MANAGEMENT AREA (Southern Boundary Line Adjustment) Support the necessary rule changes to create a new boundary point.	Rule change: 15A NCAC 03J .0209; 03R .0112; and 03R .0201
CASHIE RIVER (Change in Joint and Coastal Waters Boundary Line) Support the necessary rule changes to create a new boundary point.	Rule change 15A NCAC 03Q .0202
ALBEMARLE SOUND MANAGEMENT AREA and ROANOKE RIVER MANAGEMENT AREA STRIPED BASS MANAGEMENT MEASURES Status Quo with the current management measures in the ASMA and RRMA. Status Quo with the current management measures in the ASMA and RRMA. Status Quo for ASMA and RRMA management measures maintain the following: Biological Reference Points $F_{Target} = 0.25$ $F_{Threshold} = 0.29$ A-R stock has been managed with a Total Allowable Catch (TAC^2) since 1990	No additional regulatory action required

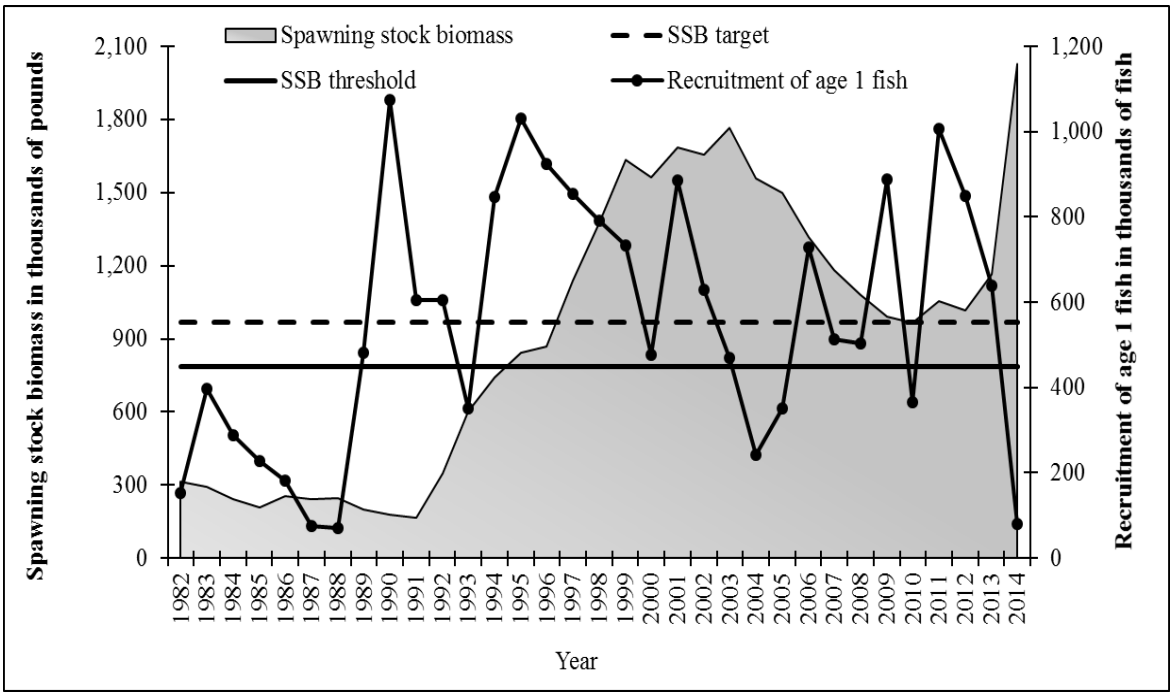
AR_Table 6. (continued).

Management Strategy	Implementation Status
Maintain current TAC[2] of 550,000 lb.	
The TAC[2] will continue to be split evenly between commercial and recreational sectors	
ASMA commercial TAC[2] = 275,000 lb.	
ASMA recreational TAC[2] = 137,500 lb.	
RRMA recreational TAC[2] = 137,500 lb.	
ASMA Commercial Harvest (TAC[2] = 275,000 lb.)	
18 in TL minimum size limit (ASMFC compliance requirement)	
Continue to operate as a bycatch fishery	
Spring season, anytime between Jan 1 – Apr 30	
Fall Season, anytime between Oct 1 – Dec 31	
Daily trip limits for striped bass	
Maintain gill net mesh size and yardage restrictions	
Maintain seasonal and area closures	
Maintain attendance requirements for small mesh nets (mid – May through late November)	
ASMA Recreational Harvest (TAC[2] = 137,500 lb.)	
18 in TL minimum size limit	
Daily creel limit (can be adjusted as necessary to keep harvest below the TAC[2])	
Open 7 days a week all season (can be adjusted as necessary to keep harvest below the TAC[2])	
Spring season, anytime between Jan 1 – Apr 30	
Fall season, anytime between Oct 1 – Dec 31	
RRMA Recreational Harvest (TAC[2] = 137,500 lb.)	
18 in TL minimum size limit	
Protective slot (no harvest): 22-27 in TL	
2 fish daily creel, only one of which can be greater than 27 in TL	
Harvest season in entire river opens on March 1 and closes on April 30 by rule since 2008	
Single barbless hook regulation from April 1 – June 30 in Inland waters above the US 258 Bridge	
Management of TACs[2] for ASMA and RRMA	

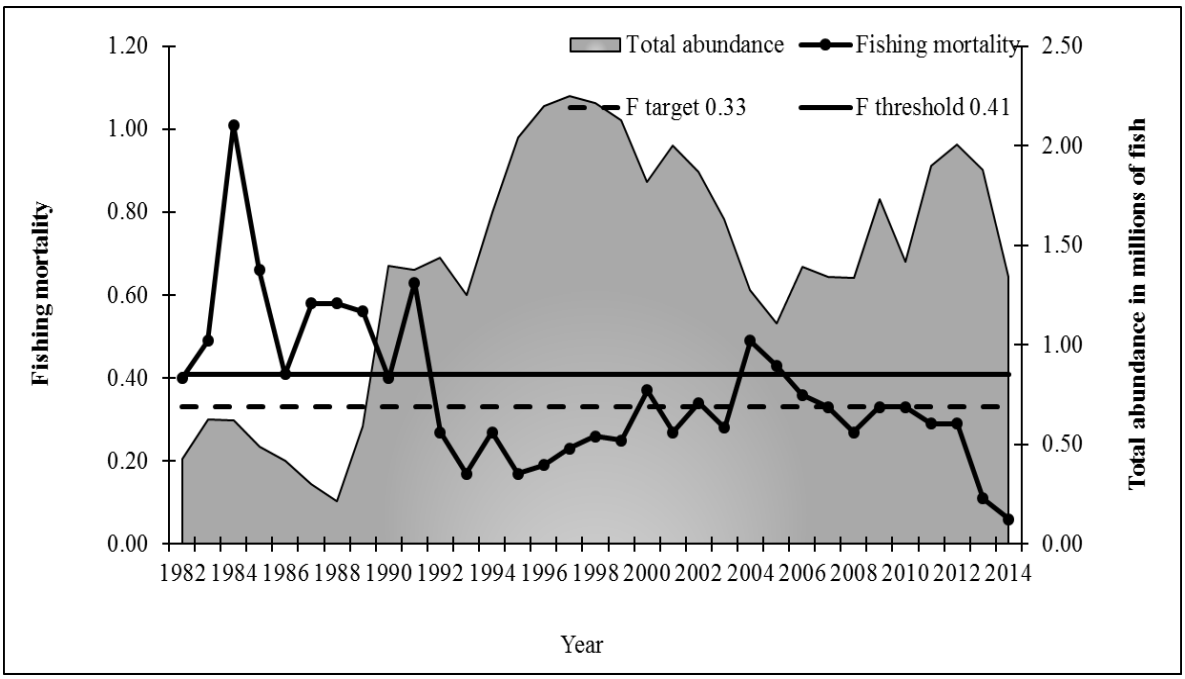
AR_Table 6. (continued).

Management Strategy	Implementation Status
Short-term Overages: if the harvest point estimate exceeds the total TAC2 by 10% in a single year, overage is deducted from the next year and restrictive measures implemented in the responsible fishery(ies) Long-term Overages: five-year running average of harvest point estimate exceeds the five-year running average of the total TAC[2] harvest by 2%, the responsible fishery exceeding the harvest limit will be reduced by the amount of the overage for the next five years. Should the target F be exceeded, then restrictive measures will be imposed to reduce F to the target level	
PROCLAMATION AUTHORITY For the ASMA, RRMA, and CSMA STRIPED BASS STOCKS: It should also be noted that under the provisions of this FMP the NCDMF Director and the NCWRC Chief of Inland Fisheries will maintain the ability to establish seasons, authorize or restrict fishing methods and gear, limit quantities taken or possessed, and restrict fishing areas as deemed necessary to maintain a sustainable harvest.	No additional regulatory action required

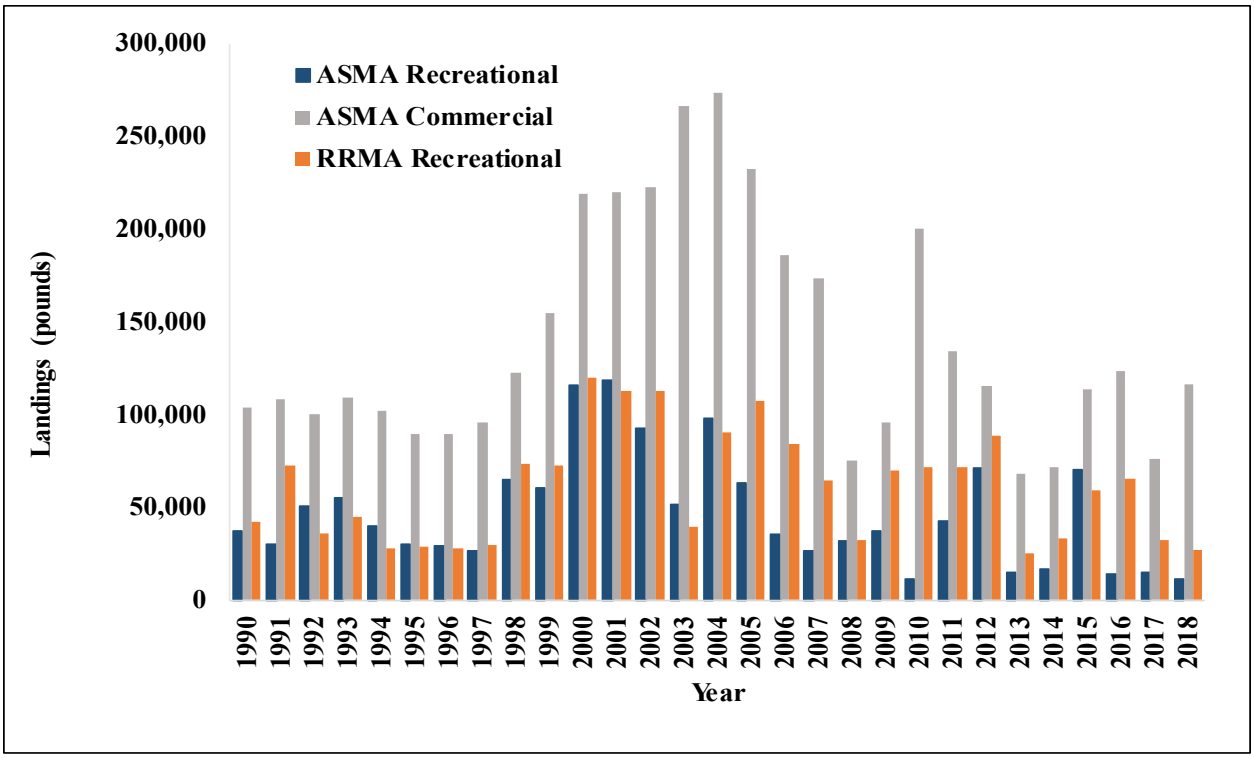
FIGURES - AR



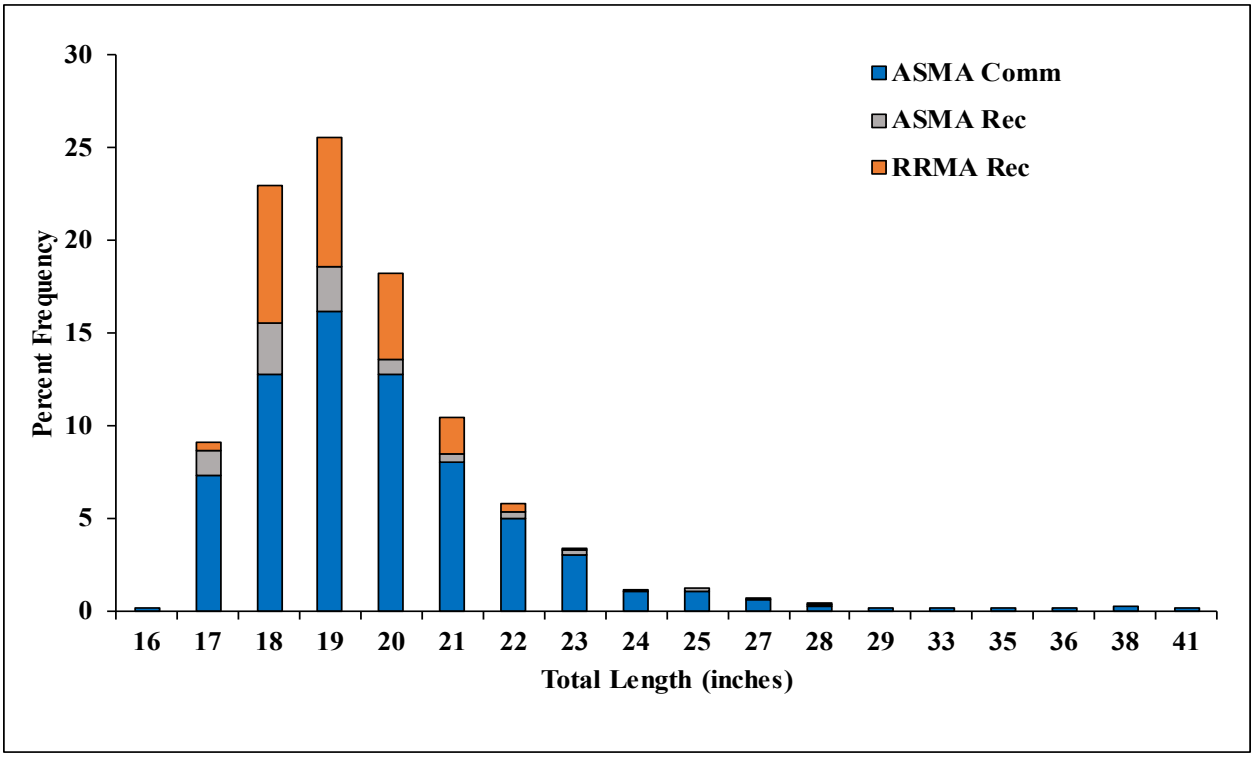
AR_Figure 1. Albemarle-Roanoke striped bass female spawning stock biomass and recruitment (abundance of age-1), 1982-2014. Source: Stock Status Update of Albemarle Sound-Roanoke River Striped Bass, 2016.



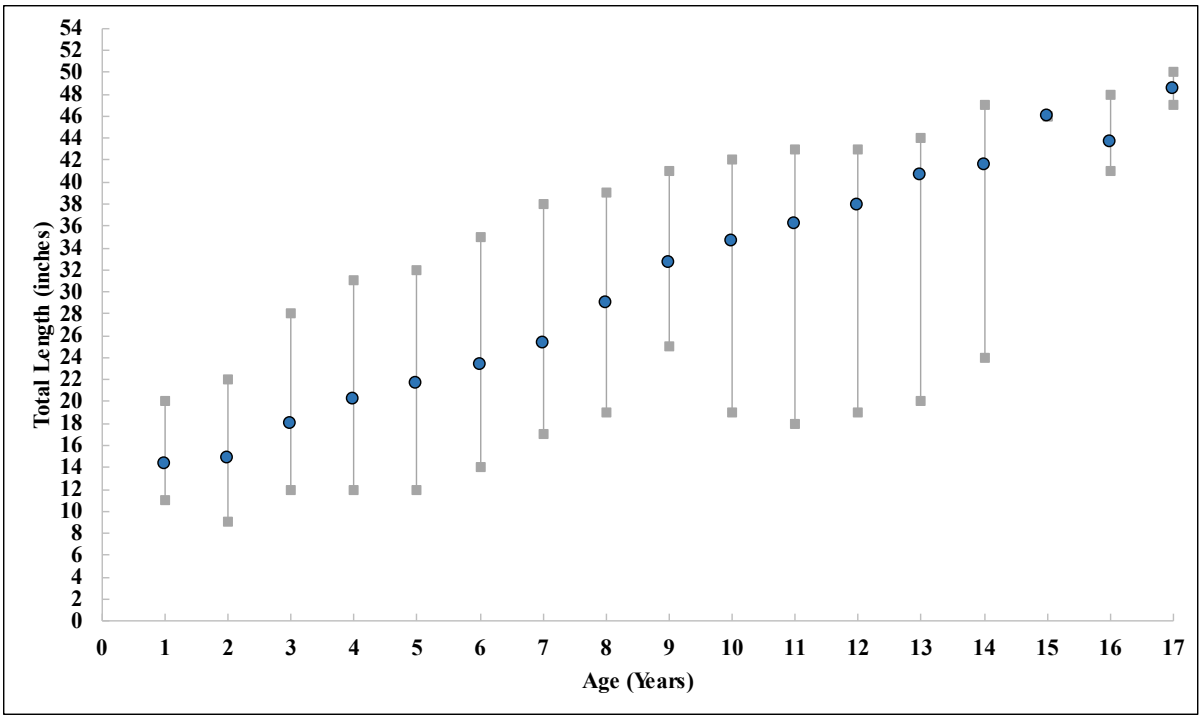
AR_Figure 2. Albemarle-Roanoke striped bass total stock abundance and fishing mortality, 1982-2014. Source: Stock Status Update of Albemarle Sound-Roanoke River Striped Bass, 2016.



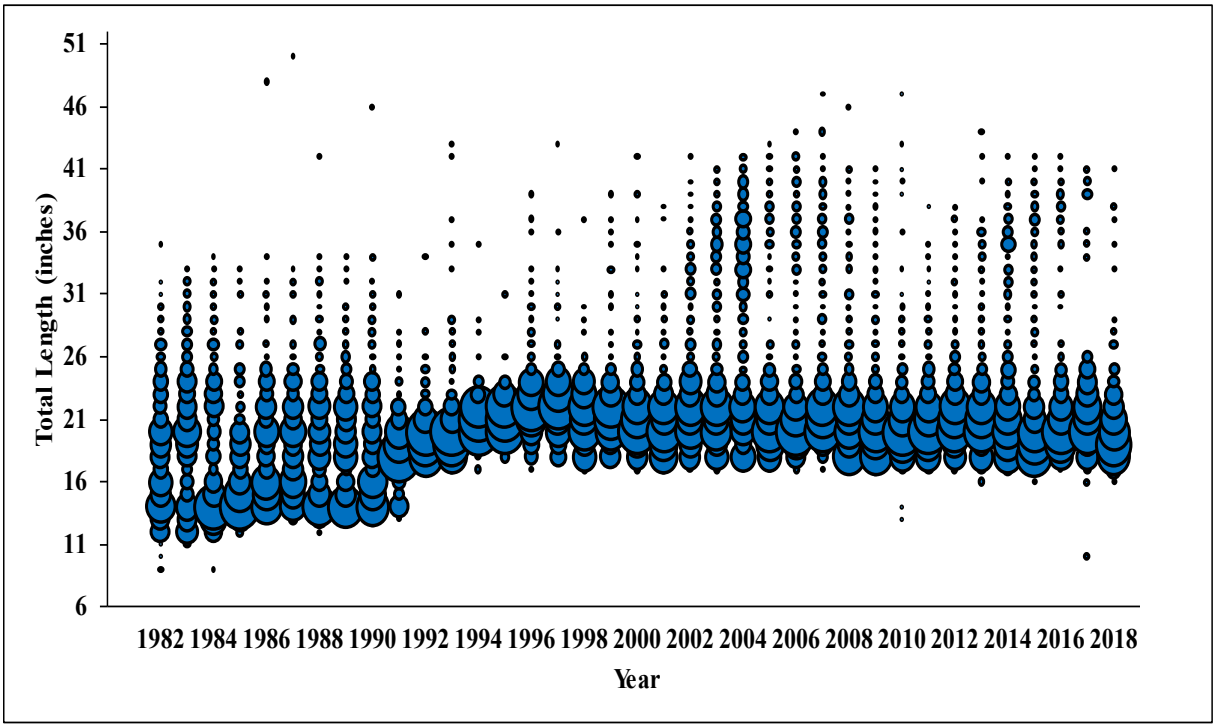
AR_Figure 3. ASMA Rec., ASMA Comm. and RRMA Rec. striped bass landings, NC, 1990-2018.



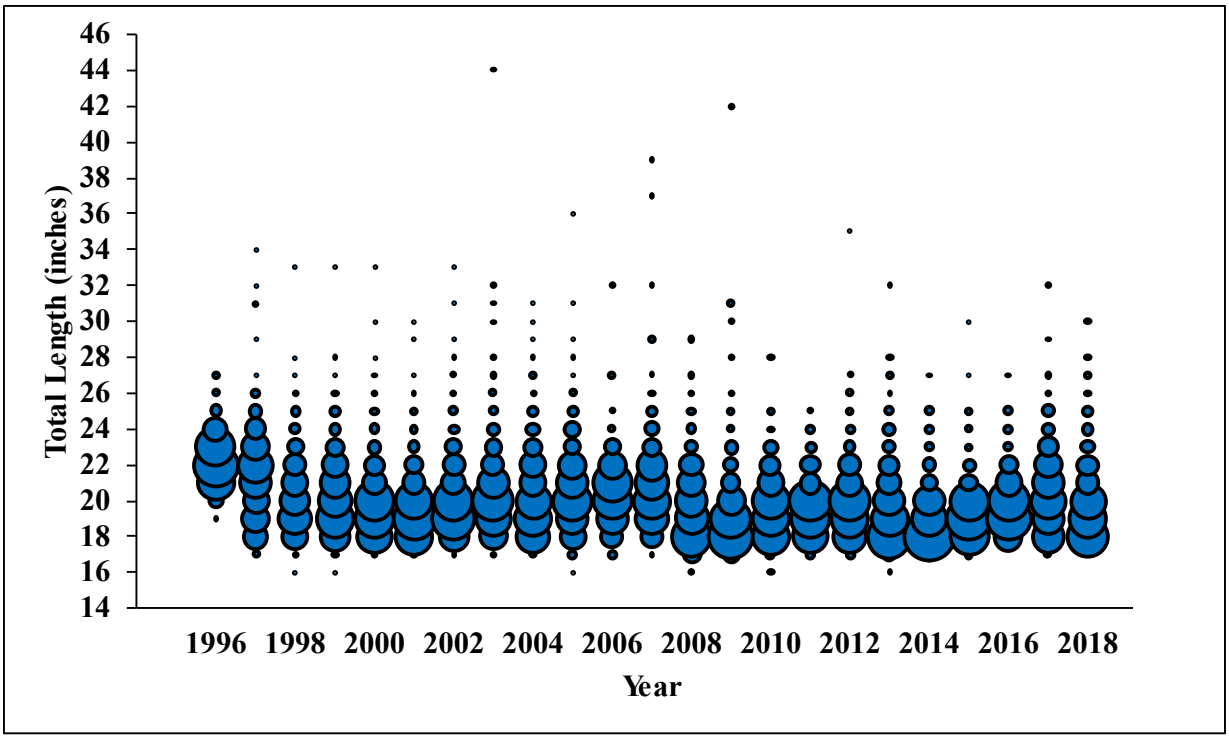
AR_Figure 4. ASMA Rec., ASMA Comm. and RRMA Rec. length frequency distribution from striped bass harvested in 2018.



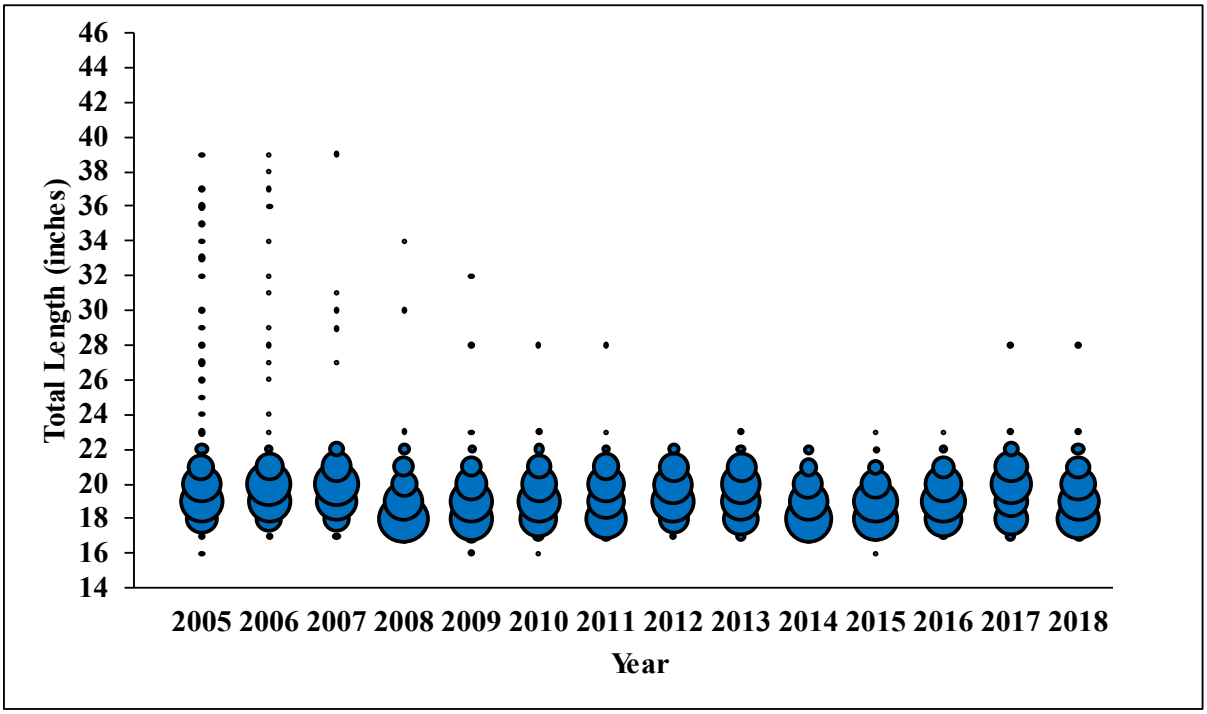
AR_Figure 5. Striped bass length at age based on all commercial samples collected from 1972 to 2018. Blue circles represent the mean size at a given age while the grey squares represent the minimum and maximum observed size for each age.



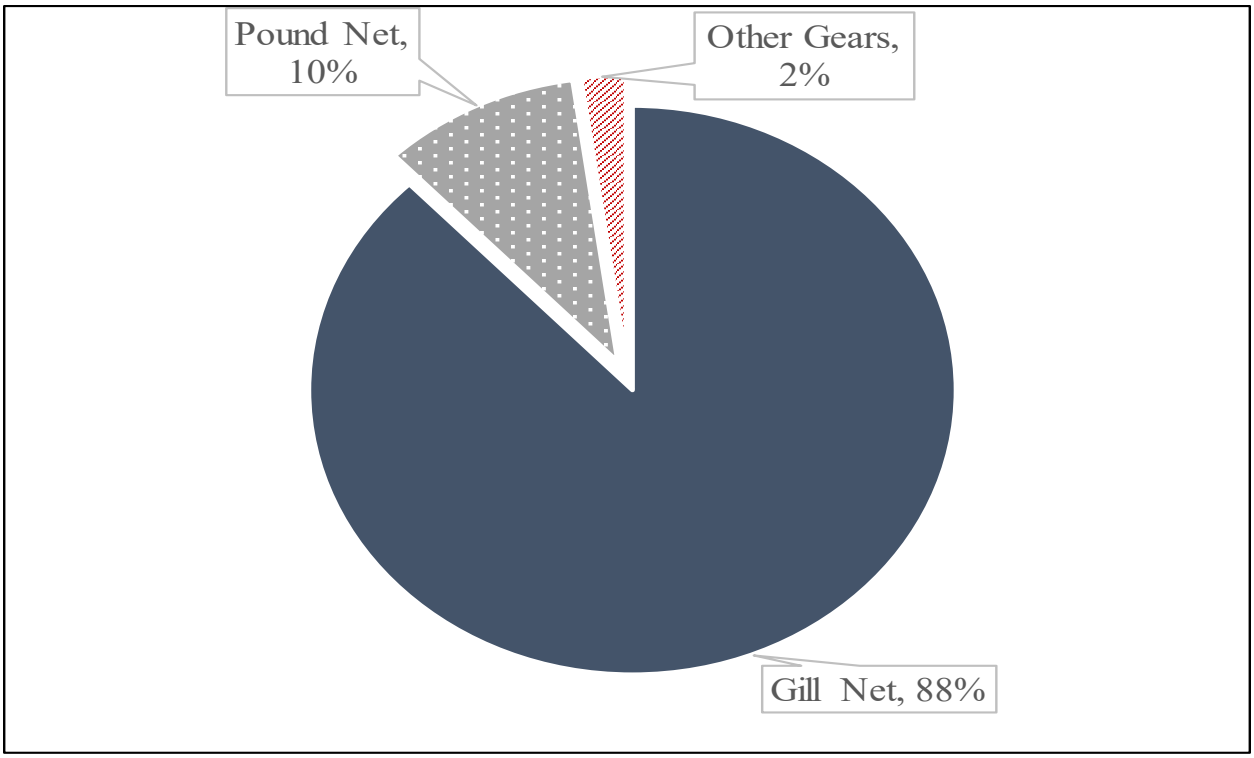
AR_Figure 6. Commercial length frequency (total length, inches) of striped bass harvested in the ASMA, NC, 1982 to 2018. Bubble size represents the proportion of fish at length.



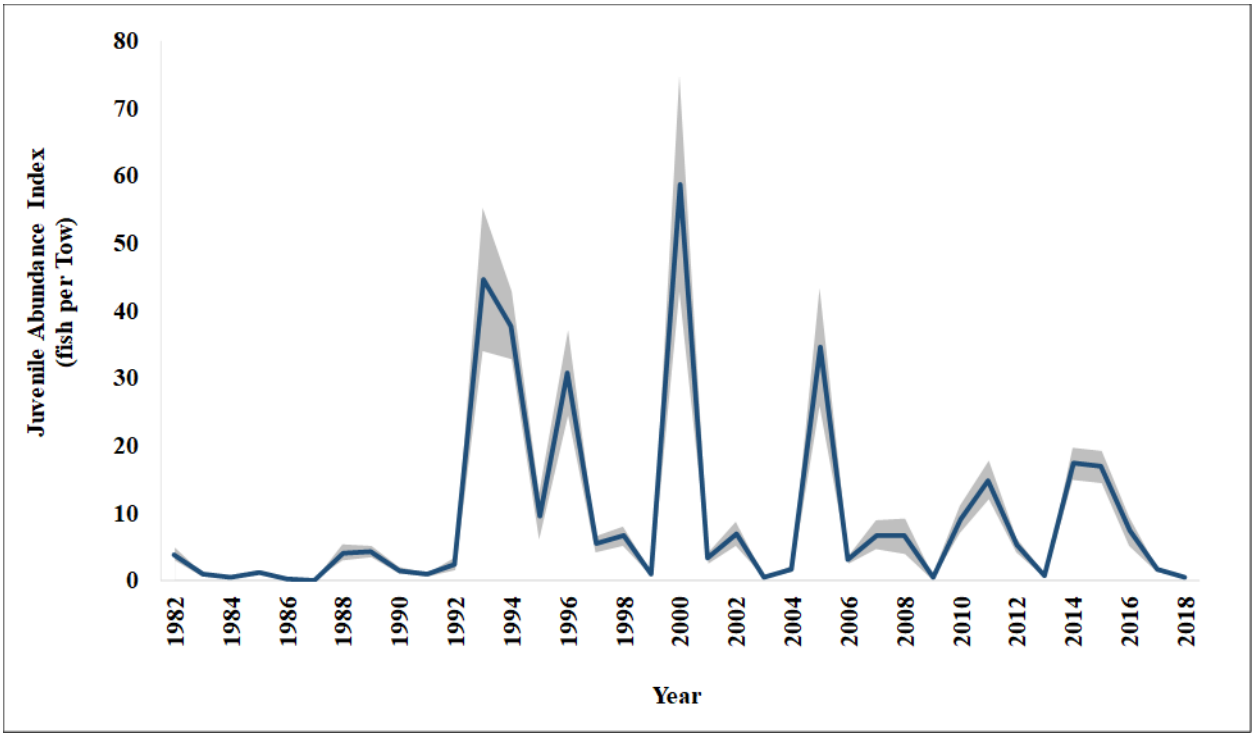
AR_Figure 7. Recreational length frequency (total length, inches) of striped bass harvested in the ASMA, NC, 1996-2018. Bubble size represents the proportion of fish at length.



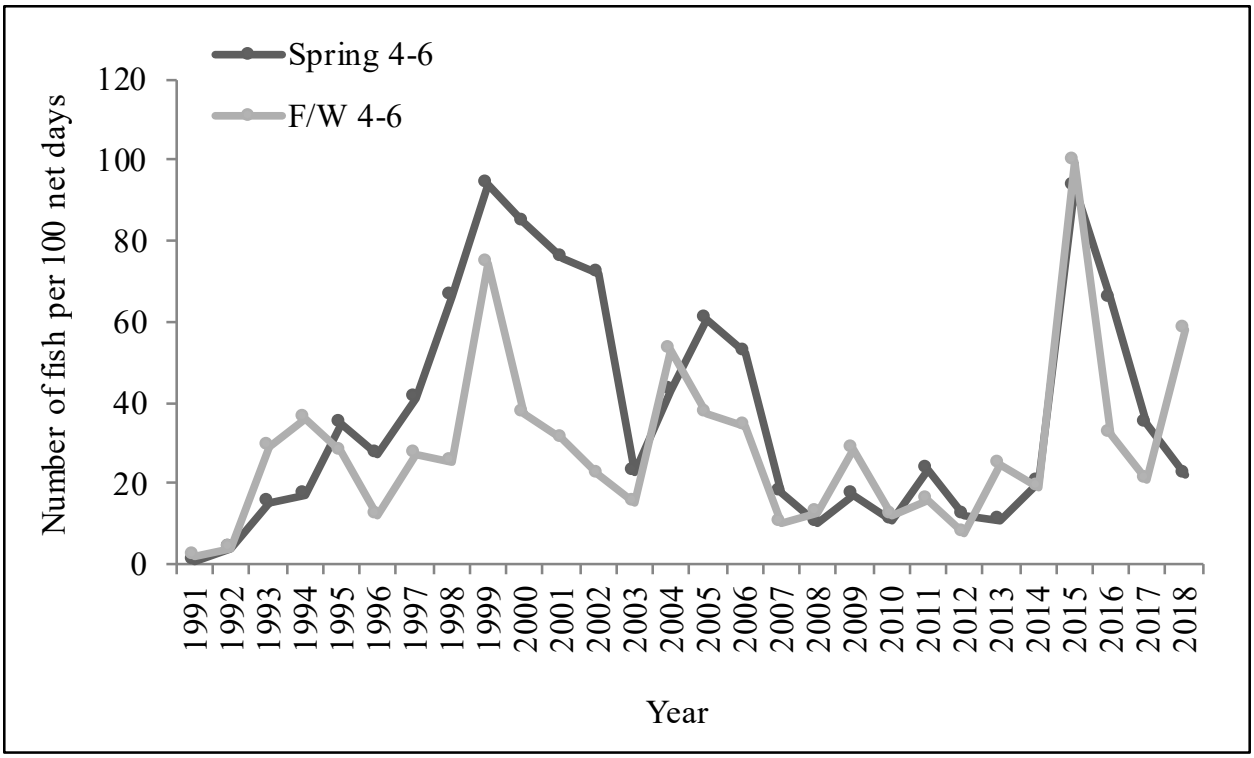
AR_Figure 8. Recreational length frequency (total length, inches) of striped bass harvested in the RRMA, NC, 2005-2018. Bubble size represents the proportion of fish at length.



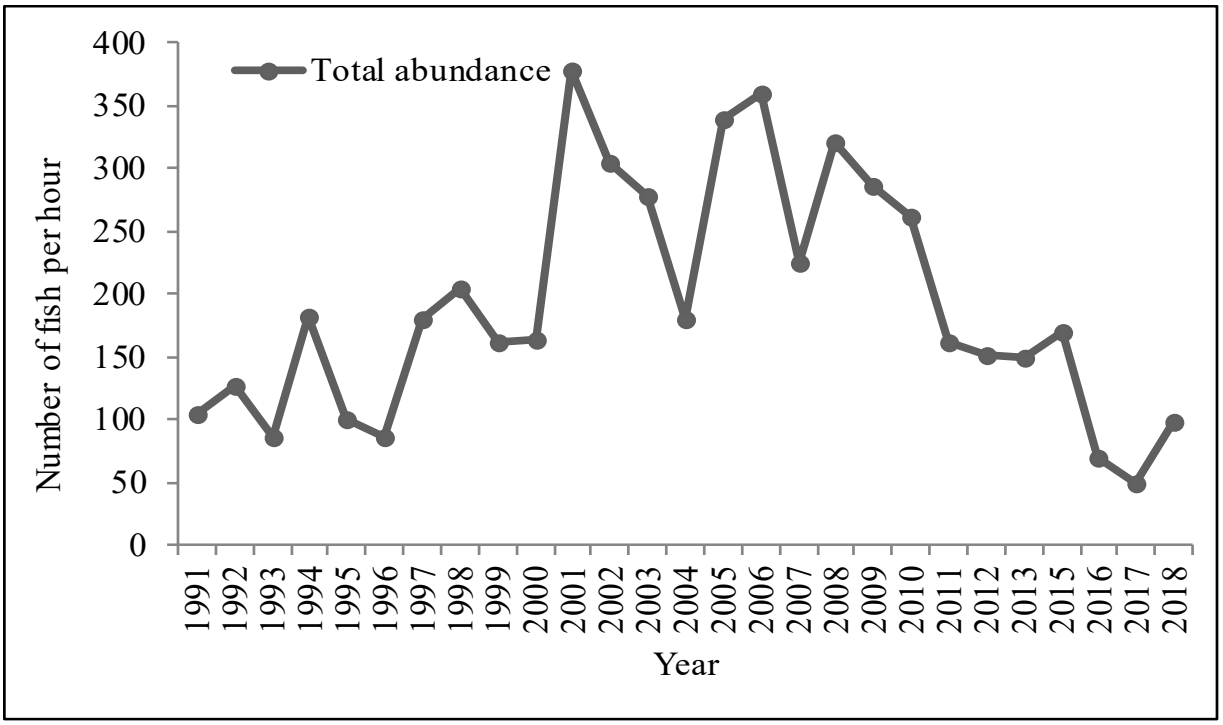
AR_Figure 9. Commercial striped bass landings broken out by major gears in the ASMA, NC, 1994-2018.



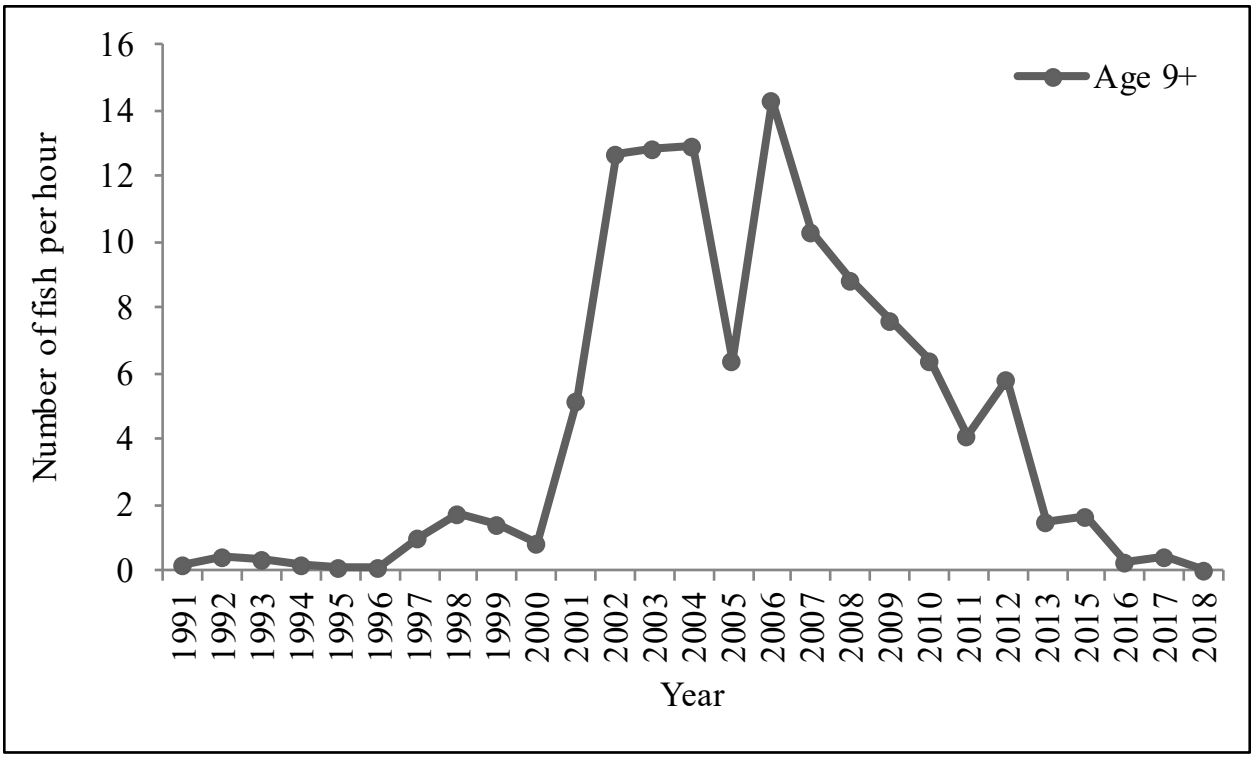
AR_Figure 10. Juvenile abundance index (JAI) of Albemarle-Roanoke striped bass from the NCDMF juvenile trawl survey, western Albemarle Sound, NC, 1982-2018.



AR_Figure 11. Relative abundance of age 4-6 Albemarle-Roanoke striped bass from the NCDMF fall/winter and spring independent gill net surveys, Albemarle Sound area, NC, 1991-2018.



AR_Figure 12. Relative abundance of Albemarle-Roanoke striped bass from the NCWRC spawning grounds electrofishing survey, Roanoke River at Weldon, NC, 1991-2018.



AR_Figure 13. Relative abundance of age 9+ Albemarle-Roanoke striped bass from the NCWRC spawning grounds electrofishing survey, Roanoke River at Weldon, NC, 1991-2018.

TABLES - Central-Southern (CS)

CS_Table 1. Striped bass length data (TL - inches) from CSMA commercial harvest, 2000-2018. All lengths and numbers (N) of fish sampled are for striped bass, no length data are presented for hybrid striped bass other than the percent sampled.

	Pamlico / Pungo R.					Neuse / Bay R.				
	Length (mm)				% Hybrid Striped Bass in Samples	Length (mm)				% Hybrid Striped Bass in Samples
Year	Mean	Min	Max	N		Mean	Min	Max	N	
2000	23	20	35	126	1.6	25	22	31	5	0.0
2001	23	21	26	116	8.7	25	23	31	12	0.0
2002	24	19	39	96	31.4	25	19	29	31	0.0
2003	23	18	37	173	39.9	24	19	37	19	5.0
2004	24	20	42	131	34.2	25	19	37	74	1.3
2005	23	20	37	127	9.3	24	20	36	70	1.4
2006	22	18	37	119	17.4	24	19	36	144	0.7
2007	22	19	33	112	4.3	22	19	27	63	4.5
2008	22	18	43	84	4.5	23	19	44	39	0.0
2009	22	19	31	99	1.0	22	18	31	85	2.3
2010	22	19	26	194	4.4	23	19	32	263	4.0
2011	23	18	27	284	2.4	23	19	42	195	0.0
2012	24	15	30	254	9.6	24	19	29	96	1.0
2013	25	18	40	225	12.8	25	18	39	301	3.2
2014	22	18	39	52	89.7	24	20	38	56	47.7
2015	24	19	40	97	74.6	24	19	44	97	21.8
2016	24	17	29	257	29.2	23	19	28	78	14.3
2017	24	19	31	151	12.2	24	19	50	97	4.0
2018	23	19	32	76	5.0	24	18	38	163	2.4

CS_Table 2. Striped bass length data (total length - inches) from CSMA recreational harvest, 2004-2018.

Year	Mean Total Length	Minimum Total Length	Maximum Total Length	Total Number Measured
2004	22	17	32	430
2005	22	18	32	318
2006	22	18	30	132
2007	22	17	30	129
2008	21	18	26	50
2009	21	17	24	95
2010	21	18	26	74
2011	21	18	28	140
2012	21	18	28	153
2013	20	17	28	169
2014	21	18	30	115
2015	21	16	27	106
2016	20	18	33	144
2017	20	17	30	202
2018	19	16	29	155

CS_Table 3. CSMA striped bass otolith and genetic age data from fishery dependent (commercial and recreational creel survey) and independent (independent gill net survey) surveys from the, 2004-2018. *2018 striped bass otolith and genetic ages are not available.

	Modal Age		Minimum Age		Maximum Age		Total Number Aged	
Year	otolith	genetic	otolith	genetic	otolith	genetic	otolith	genetic
2004	3	-	1	-	11	-	50	0
2005	2	-	1	-	9	-	78	0
2006	3	-	1	-	9	-	111	0
2007	3	-	1	-	9	-	86	0
2008	3	-	1	-	8	-	103	0
2009	4	-	1	-	6	-	37	0
2010	5	-	1	-	9	-	154	0
2011	3	-	2	-	6	-	56	0
2012	3	-	1	-	7	-	205	0
2013	3	-	1	-	8	-	156	0
2014	3	-	1	-	11	-	172	0
2015	3	-	1	-	9	-	113	0
2016	2	3	1	2	8	6	38	323
2017	2	4	1	1	9	7	98	247
2018*	-	-	-	-	-	-	-	-

CS_Table 4. Annual weighted CPUE of striped bass (number of individuals per sample), total number of striped bass collected, and the number of gill net samples (N) in the Pamlico, Pungo, and Neuse rivers, 2004-2018. The Percent Standard Error (PSE) represents a measure of precision. *In 2005, fewer stations were sampled due to a gasoline shortage as a result of Hurricane Katrina. + Sampling in the Cape Fear and New rivers began in 2008.

	Pamlico and Pungo Rivers				Neuse River				Cape Fear and New Rivers+			
Year	CPUE	No. of Striped Bass	N	PSE	CPUE	No. of Striped Bass	N	PSE	CPUE	No. of Striped Bass	N	PSE
2004	1.2	184	160	16	1.04	158	160	26				
2005	2.66	396	152*	14	1.37	200	152*	23				
2006	2.38	371	160	17	1.74	268	160	17				
2007	1.57	241	160	22	1.16	177	160	19				
2008	1.61	249	160	21	1.25	193	161	23	0.04	3	84	100
2009	1.18	182	160	16	0.9	142	160	26	0.03	3	119	67
2010	2.11	329	160	17	2.02	311	160	23	0.01	1	120	100
2011	2.15	328	160	20	2.14	325	160	18	0.04	4	120	50
2012	0.94	143	160	20	0.84	127	160	20	0.03	3	120	67
2013	1.41	215	160	18	0.98	149	160	24	0.02	2	120	50
2014	1.43	217	160	16	1.82	273	160	20	0	0	120	-
2015	1.14	173	160	18	1.65	251	160	18	0.14	15	120	36
2016	1.16	178	160	14	1.17	178	160	14	0.11	12	120	45
2017	1.21	186	160	17	1.41	218	160	16	0.08	9	120	50
2018	2.26	346	160	21	1.34	204	160	19	0.03	3	113	67

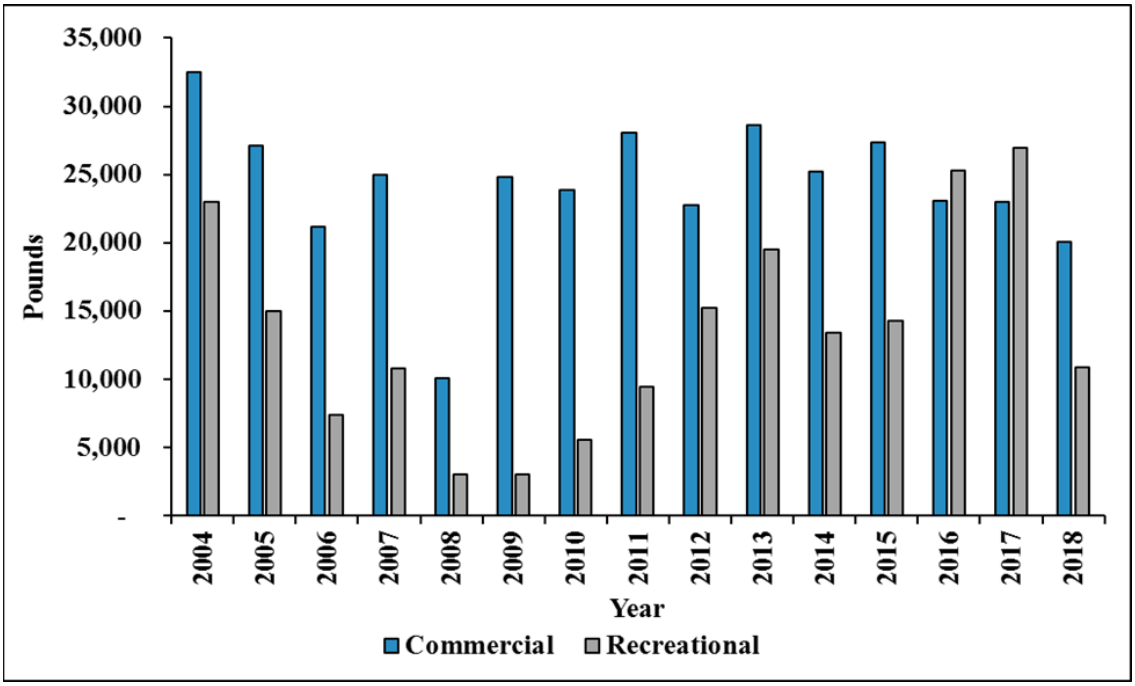
CS_Table 5. Central-Southern management actions taken as a result of Amendment 1 to the North Carolina Estuarine Striped Bass FMP.

Management Strategy	Implementation Status
STRIPED BASS STOCKING (Coastal Rivers) Status quo and research needs – Goal of 100,000 Phase II striped bass stocked annually per CSMA system (Tar-Pamlico, Neuse, and Cape Fear) with 3,000 stocked fish tagged annually in each system.	No additional regulatory action required
DISCARD MORTALITY (CSMA Commercial Gill Net Sets)Status Quo – continue the gill net requirement for tie downs and restricting gill net from within 50 yards of shore proclamation.	No additional regulatory action required
HOOK and LINE as COMMERCIAL GEAR in ESTUARINE STRIPED BASS FISHERIES Status Quo (don't allow hook and line as commercial gear) and support the necessary rule changes for adaptive management.	Rule change 15A NCAC 03M .0201 and 03M .0202[1]
CENTRAL SOUTHERN MANAGEMENT AREA STRIPED BASS MANAGEMENT MEASURES Status Quo with the addition of instituting a pound for pound payback provision for the commercial harvest TAC[2].	No additional regulatory action required
Status Quo for CSMA management measures maintain the following:	
CSMA Recreational Harvest (Coastal, Joint, and Inland waters) Unified season Oct 1 – Apr 30 2 fish daily creel limit 18 in TL minimum size limit Protective slot (no harvest) 22 – 27 in TL (joint and inland waters only) Harvest moratorium for Cape Fear River and its tributaries	
CSMA Commercial Harvest (Coastal and Joint waters)	

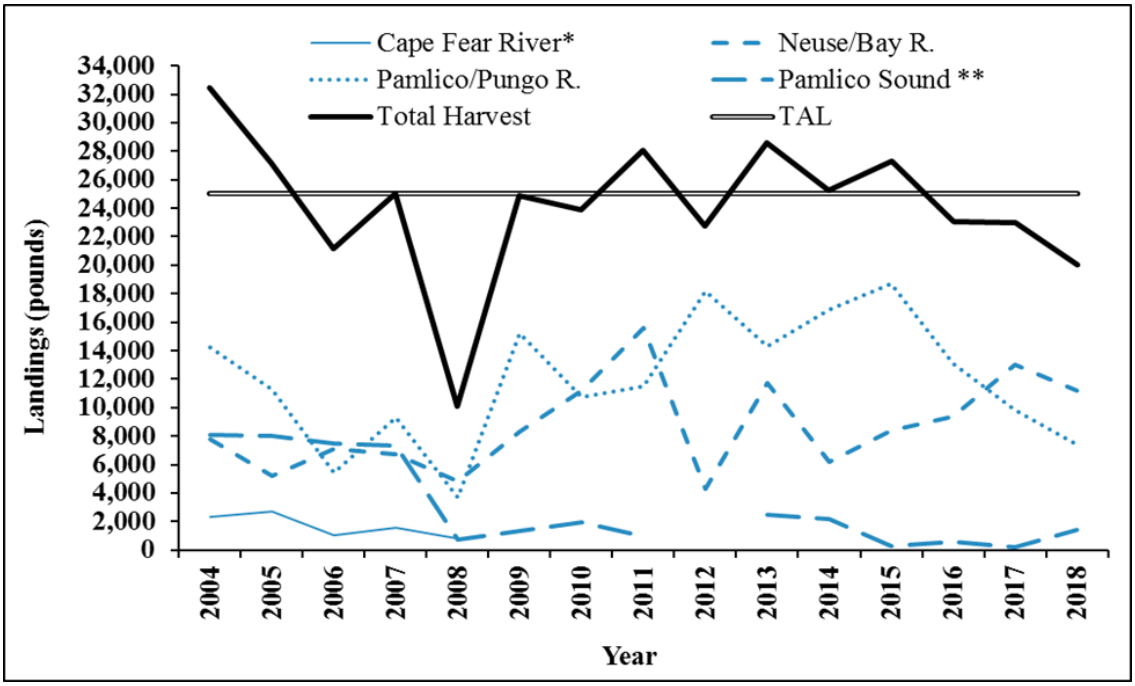
CS_Table 5. (continued).

Management Strategy	Implementation Status
TAC[2] of 25,000 lb. and commercial fishery, excluding Pamlico Sound, is not a bycatch fishery 18 in TL minimum size limit 10 fish or less trip limit Spring season only, anytime between Jan 1 – Apr 30 Gill net mesh size restrictions and yardage limits 18 in TL minimum size limit Discards – maintain existing gill net tie-down and distance from shoreline (DFS) measures implemented by proclamation. Harvest moratorium for Cape Fear River and its tributaries	
PROCLAMATION AUTHORITY For the ASMA, RRMA, and CSMA STRIPED BASS STOCKS: It should also be noted that under the provisions of this FMP the NCDMF Director and the NCWRC Chief of Inland Fisheries will maintain the ability to establish seasons, authorize or restrict fishing methods and gear, limit quantities taken or possessed, and restrict fishing areas as deemed necessary to maintain a sustainable harvest.	No additional regulatory action required

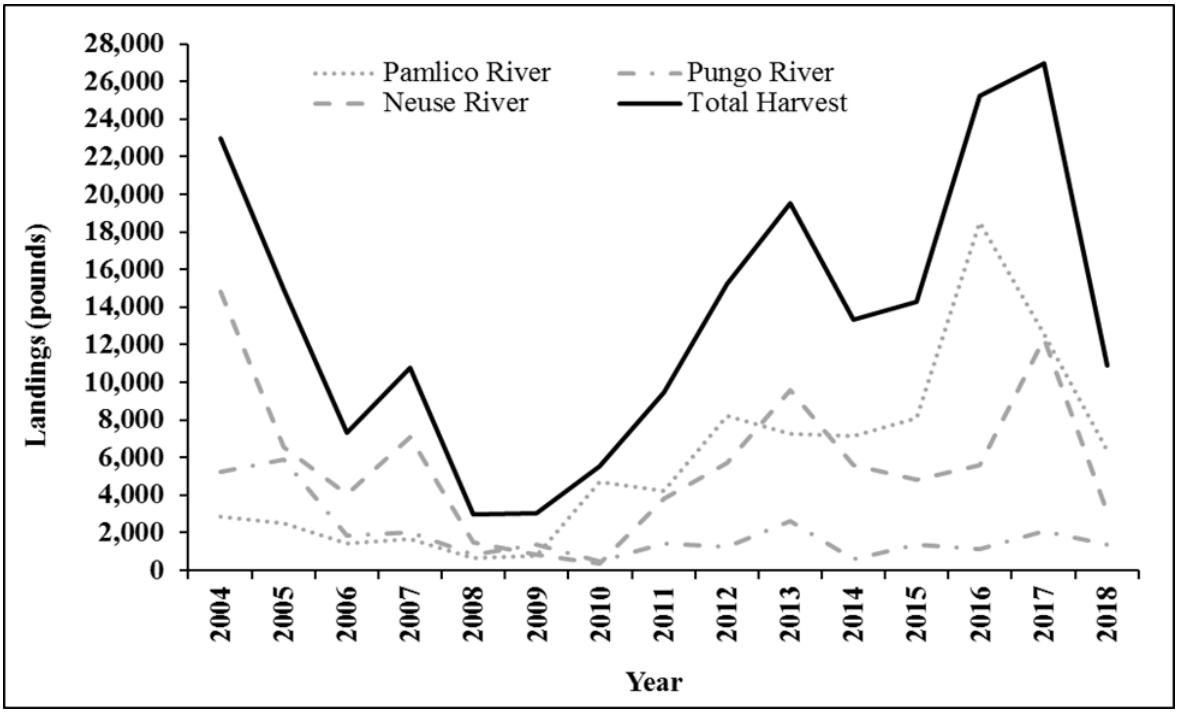
FIGURES - CS



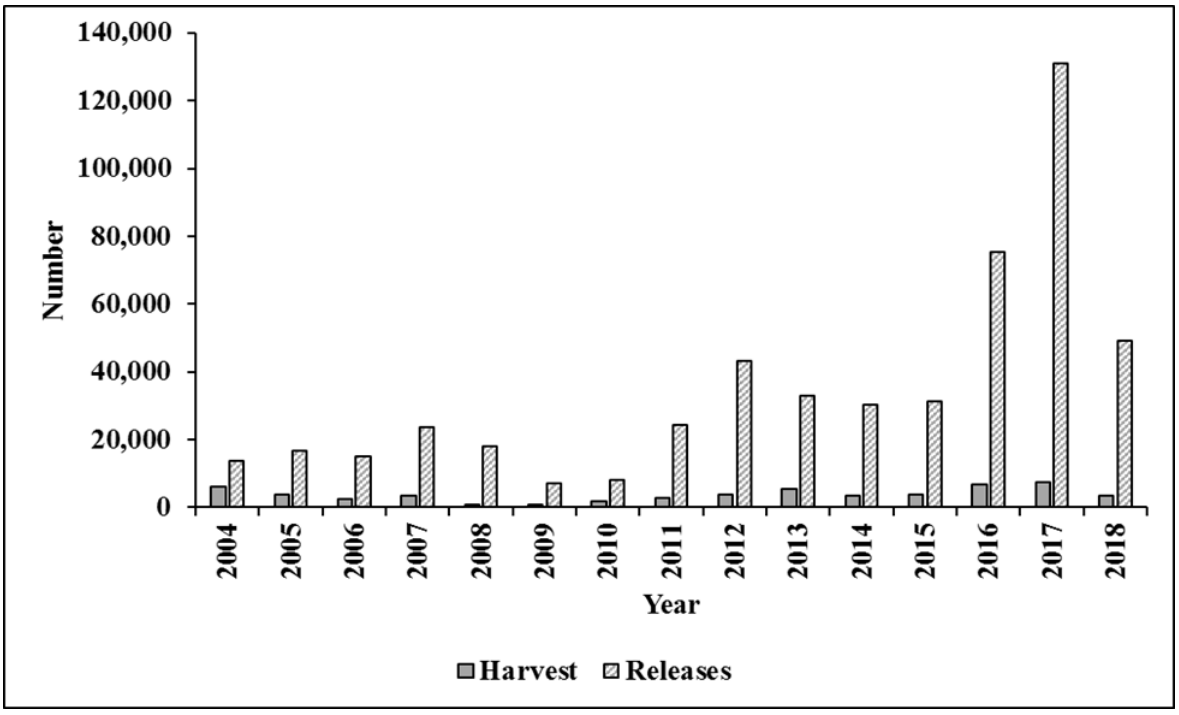
CS_Figure 1. Annual commercial and recreational CSMA striped bass harvest in pounds, 2004-2018.



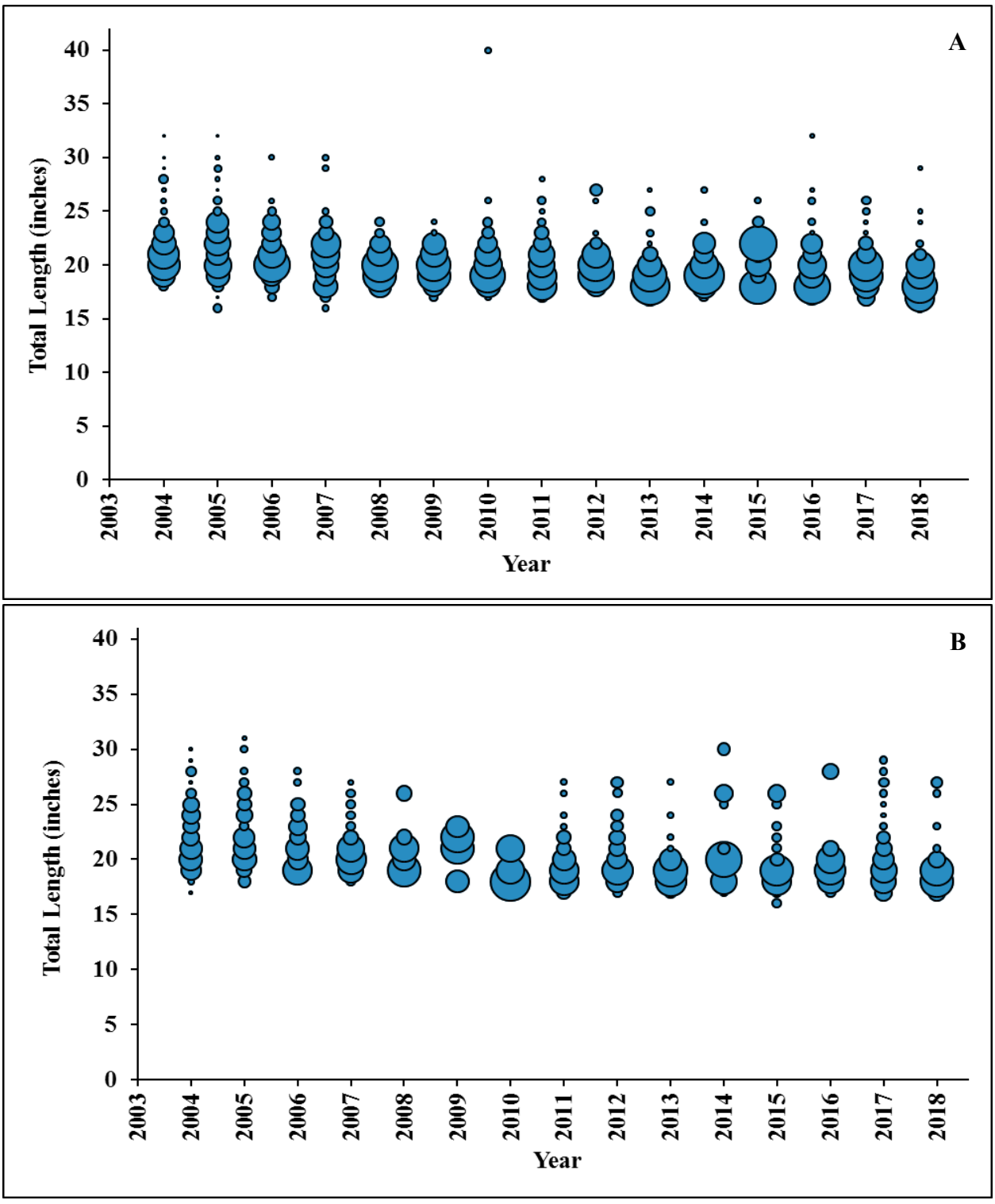
CS_Figure 2. Commercial striped bass harvest by system, and the TAL in the CSMA, 2004-2018. *There has been a harvest moratorium in the Cape Fear River since 2009. **Landings data for the Pamlico Sound in 2012 are confidential.



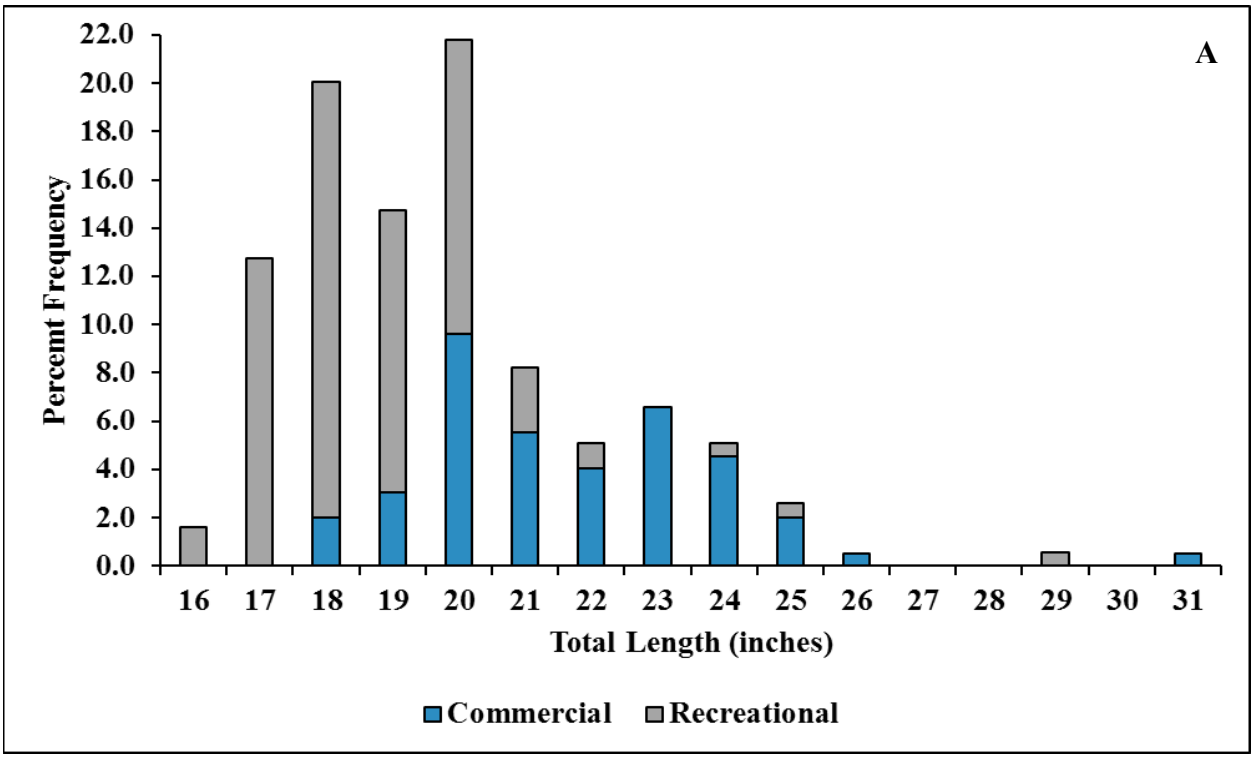
CS_Figure 3. Recreational striped bass harvest in the Pamlico, Pungo and Neuse rivers, 2004-2018.

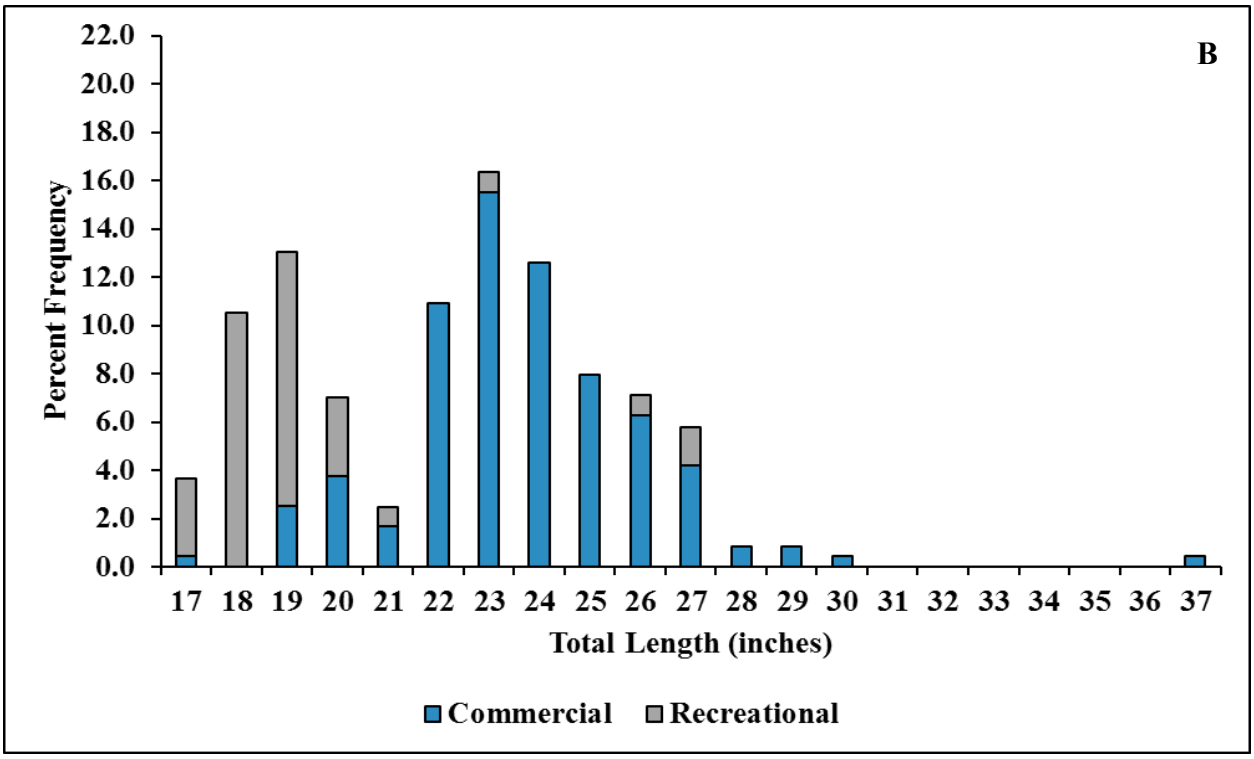


CS_Figure 4. Annual recreational catch (released and/or harvested) of striped bass in the CSMA, 2004-2018.

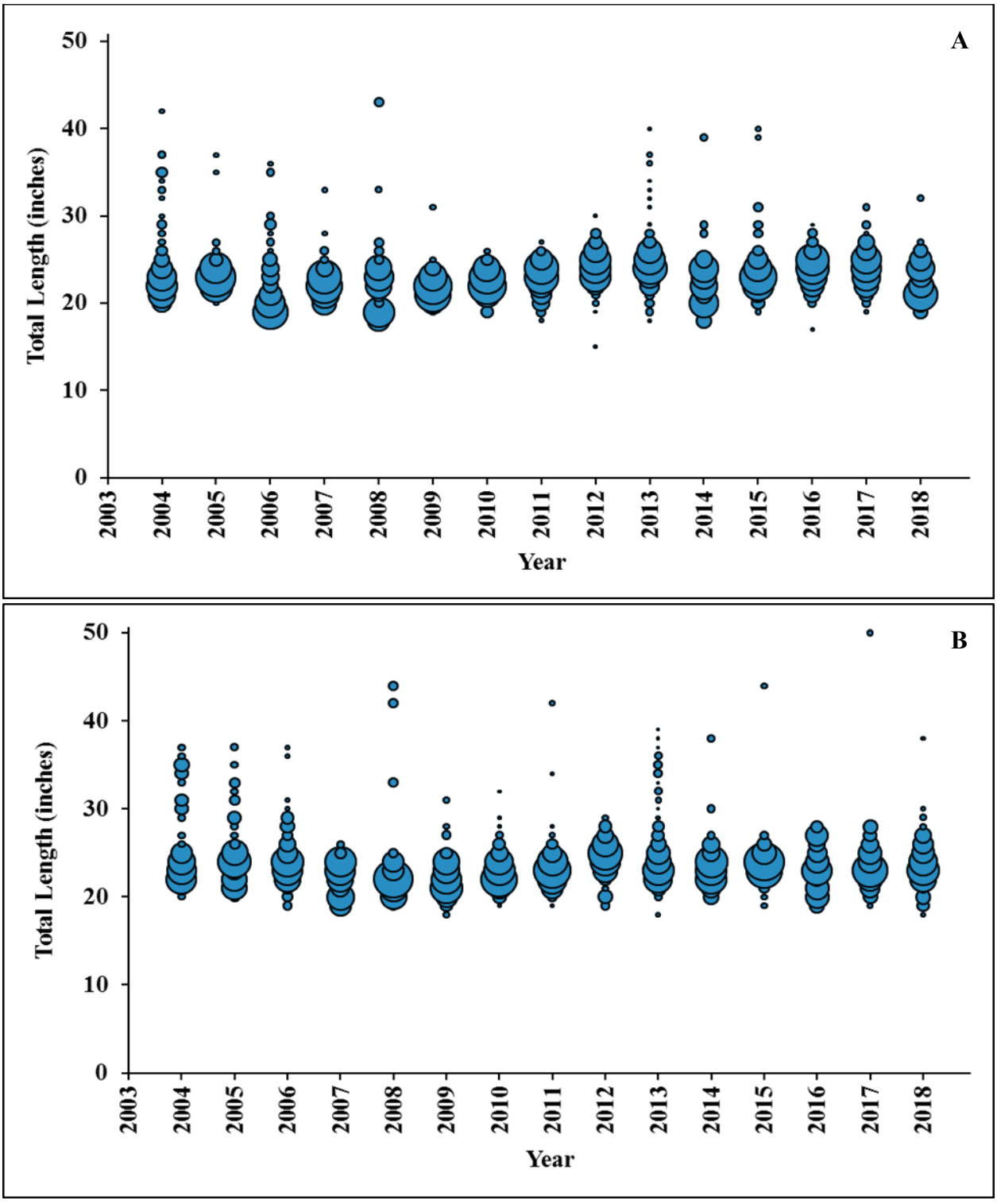


CS_Figure 5. Recreational length frequency of CSMA striped bass harvested in the Pamlico/Pungo rivers (A), and the Neuse River (B), 2004-2018. Bubble size represents the proportion of fish at length.

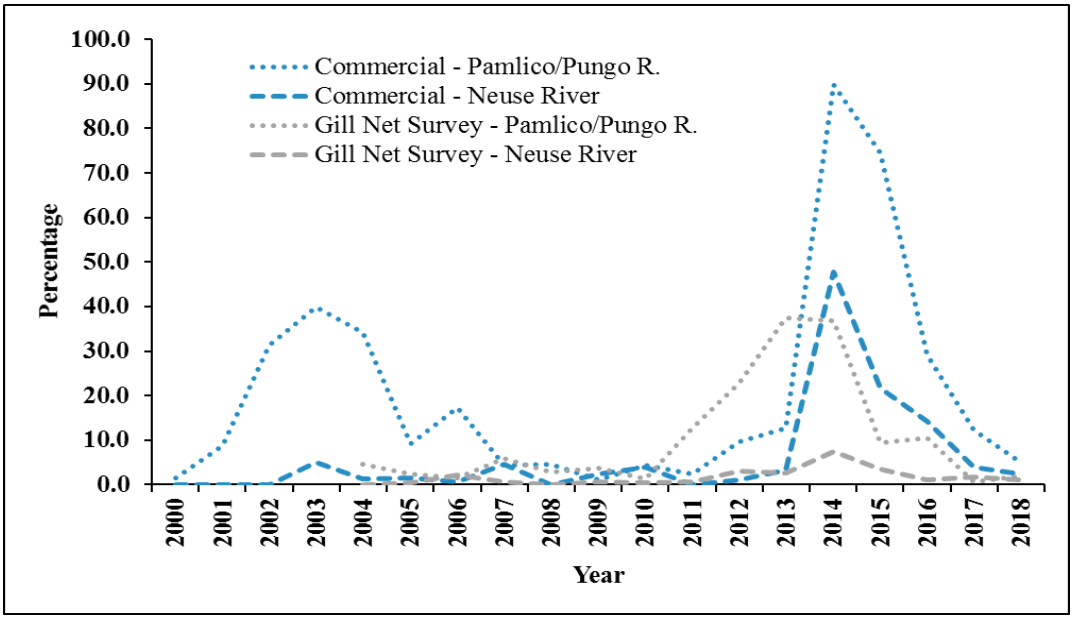




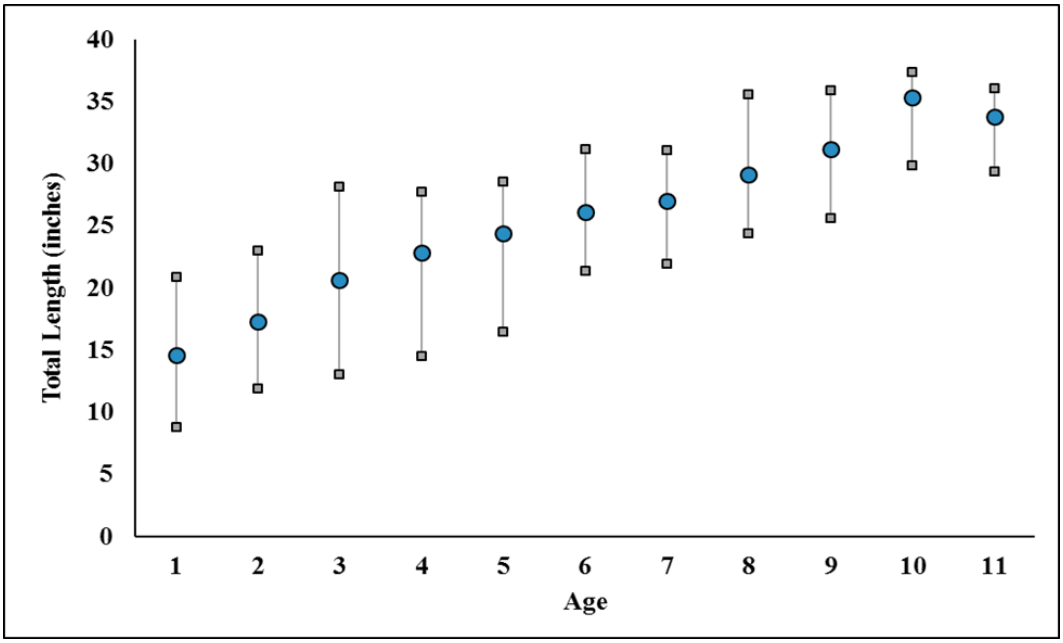
CS_Figure 6. Commercial and recreational length frequency distributions from CSMA striped bass harvested in 2018 from the Pamlico/Pungo rivers (A) and the Neuse/Bay rivers (B).



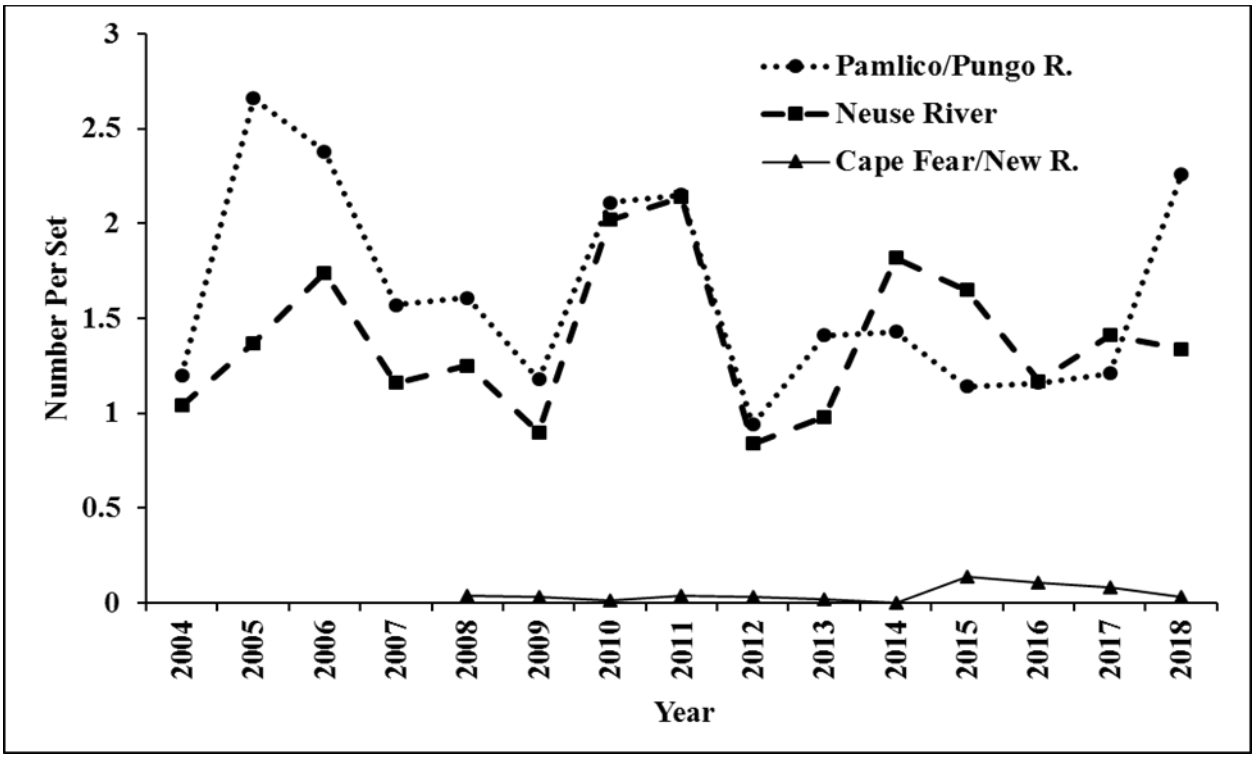
CS_Figure 7. Commercial length frequency of CSMA striped bass landed in the Pamlico/Pungo rivers (A), and the Neuse/Bay rivers (B) from 2004-2018. Bubble size represents the proportion of fish at length.



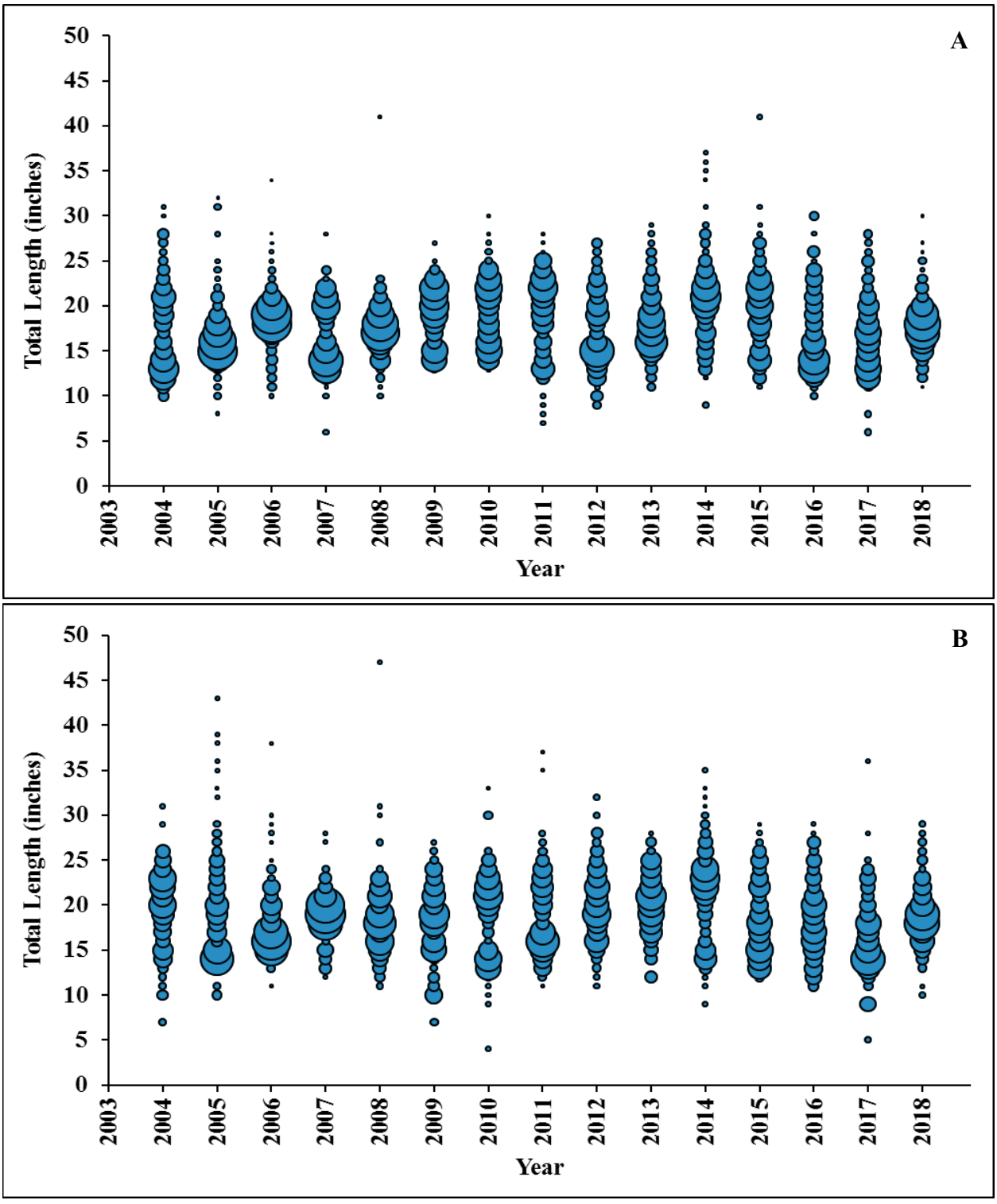
CS_Figure 8. Percentage of CSMA hybrid striped bass in commercial fish house samples (Pamlico/Pungo and Neuse/Bay rivers, 2000-2018) and in the Fisheries Independent Gill Net Survey (Pamlico/Pungo and Neuse rivers, 2004-2018).



CS_Figure 9. CSMA striped bass length at age based on otolith and genetic age samples collected from 2004 to 2017 (2018 striped bass otolith and genetic age data are not available). Blue circles represent the mean size at a given age while the grey squares represent the minimum and maximum observed size for each age.



CS_Figure 10. Annual indices of adult abundance of CSMA striped bass in the Fisheries Independent Gill Net Survey for the Pamlico/Pungo and Neuse rivers (2004-2018) and the Cape Fear/New rivers (2008-2018).



CS_Figure 11. Length frequency of CSMA striped bass captured in the Fisheries Independent Gill Net Survey in the Pamlico/Pungo rivers (A), and the Neuse River (B) from 2004-2018. Bubble size represents the proportion of fish at length.

FISHERY MANAGEMENT PLAN UPDATE
HARD CLAM
AUGUST 2019

STATUS OF THE FISHERY MANAGEMENT PLAN

Fishery Management Plan History

Original FMP Adoption:	August 2001
Amendments:	Amendment 1 – June 2008 Amendment 2 – February 2017
Revisions:	None
Supplements:	None
Information Updates:	None
Recommended Schedule Change:	None
Next MFC Scheduled Review:	July 2022

The 2001 N.C. Hard Clam Fishery Management Plan (FMP) recommendations included adding a new mechanical clam harvest area in Pamlico Sound and rotating openings in this area with northern Core Sound, decreasing the daily harvest limit for mechanical harvest in Core Sound, changing some of the lease requirements, increasing relay of clams, and increasing funding for Shellfish Sanitation (NCDMF 2001).

The N.C. Hard Clam FMP Amendment 1, adopted in 2008 recommended the hard clam fishery from public bottom continue harvesting at current daily limits, eliminating the mechanical clam harvest rotation in Pamlico Sound, instituting a resting period in the northern Core Sound mechanical clam harvest area, and developing sampling programs to collect information necessary for the completion of a hard clam stock assessment (NCDMF 2008). Amendment 1 also endorsed several changes to the shellfish lease program to increase the accountability of the leaseholders and to improve public acceptance of the program.

The N.C. Hard Clam FMP Amendment 2, adopted by the N.C. Marine Fisheries Commission (NCMFC) in February 2017 recommended maintaining status quo on recreational harvest limits, eliminating mechanical harvest in Pamlico Sound by rule, instituting shading requirements for harvesters from April 1 to September 30, implementing modifications to shellfish lease provisions, and adding to convictions of theft on shellfish leases and franchises to the types of violations that could result in license suspension or revocation.

Management Unit

Includes the hard clam (*Mercenaria mercenaria*) and its fisheries in all waters of coastal North Carolina.

Goal and Objectives

The goal of N.C. Hard Clam FMP is to manage hard clam stocks in a manner that achieves sustainable harvest and protects its ecological value. To achieve this goal, it is recommended that the following objectives be met:

1. Protect the hard clam stock from overfishing, while maintaining levels of harvest at sustained production, providing sufficient opportunity for both recreational and commercial hard clamming, and aquaculture.
2. Identify, develop, and promote research to improve the understanding of hard clam biology, ecology, population dynamics, and aquaculture practices.
3. Initiate, enhance, and continue studies to collect and analyze economic, social, and fisheries data needed to effectively monitor and manage the hard clam fishery.
4. Identify, develop and promote efficient hard clam harvesting practices while protecting habitat.
5. Promote the protection, restoration, and enhancement of habitats and water quality so that the production of hard clams is optimized.
6. Consider the socioeconomic concerns of all hard clam resource user groups, including market factors.
7. Promote public awareness regarding the status and management of the North Carolina hard clam stock.

STATUS OF THE STOCK

Life History

Hard clams (*Mercenaria mercenaria*) are mostly estuarine-dependent, filter-feeding shellfish found in sandy and vegetated bottoms from Prince Edward Island, Canada to the Yucatan Peninsula, Mexico. Spawning occurs from May through November when water temperatures are between 68 degrees and 86 degrees Fahrenheit. The larvae go through several stages before settling onto a suitable bottom. During the juvenile stages, hard clams tend to be dominantly male and then become either male or female as they mature into adults. Sexual maturity is reached in hard clams when individuals reach a certain size, and the timing is therefore dependent on the rate of growth. Growth rates are highly variable because of temperature, food availability, and genetic disposition. Legal size (one inch thick) is typically reached at age 3 in North Carolina, with the oldest individual known living to 46 years.

Stock Status

The status of the hard clam stock in North Carolina is unknown due to the paucity of data available to assess the population, therefore benchmark reference values could not be determined for the stock (NCDMF 2017). Amendment 2 of the FMP recommends the status continue to be

defined as unknown due to the continued lack of data needed to conduct a reliable assessment of the stock.

The statutory obligation to manage hard clams according to sustainable harvest cannot be met until the appropriate data are collected. While landings records reflect population abundance to some extent, the relationship is confounded by changes in harvest effort and efficiency.

Stock Assessment

Data limitations prevent the North Carolina Division of Marine Fisheries (NCDMF) from conducting a hard clam stock assessment and calculating sustainable harvest. Currently, the only data available for the stock in most areas are the commercial landings and associated effort. For this reason, the current assessment focused on trends in catch rates in the commercial hard clam fishery from 1994 through 2013 (NCDMF 2017). Commercial landings of clams are considered a biased index of population size. Fisheries-dependent data are often not proportional to population size due to a number of caveats (e.g. area closures and market fluctuations) and should be interpreted with caution if the interest is relative changes in the population.

The North Carolina commercial hard clam fishery is subject to trip limits, which could bias catch rates (Mike Wilberg, University of Maryland Center for Environmental Science, personal communication; John Walter, National Oceanic and Atmospheric Administration Fisheries, personal communication); that is, the trip limits can affect the amount of catch that is observed per unit effort, preventing the true value of the variable from being observed. A censored regression approach was applied to calculate an unbiased index of relative abundance using data collected from a fishery with trip limits. Preliminary analysis found that for years in which greater than or equal to 50% of transactions equaled or exceeded the trip limit in a particular water body, the censored regression produced nonsensical results. For this reason, such years were removed from those water bodies where this occurred. (Note: this was only an issue for mechanical harvest data)

Data were obtained from the North Carolina Trip Ticket Program for 1994 through 2013. Catch rates were estimated for both hand harvest and mechanical harvest in each of the major water bodies from which hard clams are harvested, and where sufficient data were available (see previous paragraph). Hand harvest occurs year-round and is summarized by calendar year. The majority of mechanical harvest occurs from December through March with some harvest occasionally allowed during other times of the year in specific areas; therefore, mechanical harvest is summarized by fishing year (December through March). Only landings from public bottom were examined because planting of seed clams, grow-out availability, and market demand often artificially drives landings from private leases. Fisheries-dependent catch rates were expressed as numbers harvested per transaction. Catch rates were consistently higher for mechanical harvest than for hand harvest.

There were significant increasing trends over time detected in eight areas for hand harvest: Bogue Sound, Core Sound, Inland Waterway, New River, Newport River, North River/Back Sound, Shallotte River, and White Oak River. A significant decreasing trend was found in the hand harvest catch rates in Pamlico Sound. The remaining water bodies showed no trend in hand

harvest catch rates over time. The Intercoastal Waterway, New River, Newport River, North River/Back Sound, and Stump Sound demonstrated significantly increasing trends in mechanical harvest catch rates over time. No trends were detected in Bogue Sound, Core Sound, or White Oak River catch rates for mechanical harvest.

Trends observed in fishery-dependent indices must be interpreted with strong caveats. In order for a fisheries-dependent index to be proportional to abundance, fishing effort must be random with respect to the distribution of the population and catchability must be constant over space and time. Other factors affecting the proportionality of fishery-dependent indices to stock size include changes in fishing power, gear selectivity, gear saturation and handling time, fishery regulations, gear configuration, fishermen skill, market prices, discarding, vulnerability and availability to the gear, distribution of fishing activity, seasonal and spatial patterns of stock distribution, change in stock abundance, and environmental variables. Many agencies, such as the NCDMF, do not require fishermen to report records of positive effort with zero catch; lack of these "zero catch" records in the calculation of indices can introduce further bias.

STATUS OF THE FISHERY

Current Regulations

Hard clams cannot be taken from any public or private bottom in areas designated as prohibited (polluted) by proclamation except for special instances for: Shellfish Management Areas (NCMFC Rule 15A NCAC 03K .0103), with a permit for planting shellfish from prohibited areas (NCMFC Rule 15A NCAC 03K .0104), and for the depuration of shellfish (NCMFC Rule 15A NCAC 03K .0107). Hard clams cannot be taken between the hours of sunset and sunrise of any day. Beginning in April 2014, time and temperature control measures were initiated for hard clams to prevent post-harvest growth of naturally-occurring bacteria that can cause serious illness in humans.

Public Bottom

The minimum size limit for hard clams is one-inch thickness (shell width). Daily commercial harvest limits on public bottom are no more than 6,250 hard clams (25 bags at 250 clams per bag) per fishing operation in any coastal fishing waters regardless of the harvest methods employed. Size, daily harvest limits, and season and area limitations do not apply in some situations on public bottom for: 1) temporary openings made on the recommendation of shellfish sanitation; and 2) maintenance dredging operations, where waste of the hard clam resource is apparent due to these activities and Shellfish Sanitation deem the area safe from public health risks.

The daily hand harvest limit on public bottom is 6,250 hard clams and the fishery is open year-round. Rakes no more than 12 inches in width or weighing no more than six pounds can be used to take hard clams in any live oyster bed, in any established bed submerged aquatic vegetation or in an established bed of salt water cordgrass.

The public mechanical hard clam harvest season can occur from December 1 through March 31, and is opened by proclamation to only very specific locations. The mechanical harvest season usually begins the second Monday in December and extends through the week of March 31st. Harvest is allowed only from 7:30 a.m. to 4:00 p.m. on Monday through Friday until before the Christmas holiday and then Monday through Wednesday after December 25th for the remainder of the open harvest season.

Internal waters that can open to public mechanical hard clam harvest can only be in areas in Core and Bogue sounds, Newport, North, White Oak and New rivers and the Intracoastal Waterway north of "BC" Marker at Topsail Beach which have been opened at any time from January, 1979, through September, 1988. Public hard clam mechanical daily harvest limits vary by waterbody. In some instances, mechanical harvest areas are rotated (alternately open and close) with other areas (Table 1). The White Oak River, New River, and the Intracoastal Waterway of Onslow and Pender counties (Marker 65 to the BC Marker at Banks Channel) are fished mainly with escalator dredges and are rotated on a yearly basis with maximum daily limits of 6,250 hard clams (25 bags at 250 hard clams per bag) per operation. The mechanical harvest area from Marker 72A to the New River Inlet is opened annually with a maximum daily harvest limit of 6,250 hard clams. The maximum daily harvest of 3,750 hard clams is allowed in North River, Newport River, and Bogue Sound (Table 1). Since 2008, upon adoption of Amendment 1 to the Hard Clam FMP, Core Sound has been divided into two areas and the northern area is open every other year while the southern portion is opened annually. Each area in Core Sound has a daily harvest limit of 5,000 hard clams per operation.

Recreational harvest limits from public bottom are 100 hard clams per person per day and no more than 200 hard clams per vessel. Hard clams can only be taken by hand for recreational purposes.

Private Bottom

Leases and franchises in internal waters must adhere to the minimum one-inch thick size limit for the sale of hard clams for consumption. There is no daily maximum harvest limit applied to the taking of hard clams from private bottom in internal waters. Public bottom must meet certain criteria in order to be deemed suitable for leasing for shellfish cultivation and there are specific planting, production, and marketing standards for compliance to maintain a shellfish lease or franchise. Also, there are management practices that must be adhered to while the lease is in operation, such as: marking poles and signs, spacing or markers, and removal of markers when the lease is discontinued.

Possession and sale of hard clams by a hatchery or aquaculture operation, and purchase and possession of hard clams from a hatchery or aquaculture operation are exempt from the daily harvest limit and minimum size restrictions. The possession, sale, purchase and transport of such hard clams must be in compliance with the Aquaculture Operation Permit. Leases that use the water column must also meet certain standards as outlined in G.S. 113-202.1 in order to be deemed suitable for leasing and aquaculture purposes.

There is a specific application process to obtain a lease and a public comment process that is required before a shellfish lease is granted, allowing any member of the public to protest the issuance of a lease. Owners of shellfish leases and franchises must provide annual production reports to the NCDMF. Failure to furnish production reports can constitute grounds for termination. Cancellation proceedings will begin for failure to meet production requirements and interfering with public trust rights. Corrective action and appeal information is given prior to lease termination A lease may be transferred to a new individual before the contract terms ends, however there are specific requirements to do so.

Commercial Landings

Hard clam harvest has fluctuated historically, often in response to changes in demand, improved harvesting, and increases in polluted shellfish area closures. Since 2007 about 90% (2007-2016 combined estimates) (NCDMF 2017) of the total commercial hard clam harvest come from public bottom in North Carolina. It is assumed that trends in hard clam landings from both sources (private and public bottom) combined can be attributed to changes in hard clam landings from public bottom since they make up the largest component to the overall harvest. Adverse weather conditions (i.e., hurricanes, heavy rain events) can impact the annual landings. One of the greatest environmental impacts to clam harvest occurred in 1987-1988 due to red tide. The red tide bloom caused the closure of over 361,000 acres of public bottoms to shellfish harvest from November 1987 to May 1988. These closures affected 98% of the clam harvesting areas, and had its greatest impact on the clam fishermen. The dinoflagellate responsible for the red tide, *Karenia brevis*, produced a neurotoxin, which was concentrated in shellfish, making them unfit for consumption. Eleven hurricanes have made landfall in North Carolina since 1996 (http://www.nc-climate.ncsu.edu). Freshwater runoff after storm events often increase shellfish harvest area closures and causes a reduction in hard clam harvest effort for short term periods. Hard clams are a live product that must go to market relatively quickly after harvest. Competition with hard clams grown in private culture from other states is also a known contributor to reduced market demand for wild harvested hard clams since a more consistent product can be provided from private grow out facilities.

Annual average hard clam landings from 1994-2018 was 25.2 million clams (Figure 1). Annual landings in 2018 were the lowest in the 25-year period at 10.5 million clams. This significant decrease from previous years was likely due to a major hurricane affecting coastal North Carolina in September 2018. There has been a steady decline in commercial landings since the early 2000s. The landings during the last ten years are roughly half of the peak seen in 1994-2001.

Hand Harvest Fishery

Hand harvest is a year-round fishery and has average landings of 22.1 million clams a year (1994-2018) (Figure 2; NCDMF 2017). Most hand harvest for clams occurs in the spring and summer when warm water is conducive to wading. Annual hand harvest for hard clams has declined steadily over the 25-year time series to its lowest level of 9.5 million clams in 2018 (Figure 2; NCDMF 2017).

Mechanical Harvest Fishery

Hard clam landings from using mechanical methods has average landings of 2.3 million clams each fishing year (1994-2018) (Figure 2). The mechanical clam harvest season usually has the highest landings at the beginning of the fishing season in December and declines as the season progresses. Landings outside of the usual mechanical clam harvest season are from temporary openings for the maintenance of channels and temporary openings in Core Creek when bacteriological levels are at acceptable levels to harvest clams. Hard clam landings and trips fluctuate from fishing year to fishing year and appear to be greatly influenced by harvest from the New River mechanical harvest area. Since 1994, when the public mechanical harvest area of New River is open, 48 to 97%of the total mechanical harvest landings are from this area (NCDMF 2017).

Private Culture

The NCDMF administers the shellfish lease program whereby state residents may apply to lease estuarine bottom and water columns for the commercial production of shellfish. The NCDMF does not differentiate between clam, oyster, bay scallop, and mussel leases; allowing shellfish growers to grow out multiple species simultaneously or as their efforts and individual management strategy allows. For the period of 1994-2018, roughly 35% of all private culture operations harvested only clams (NCDMF 2017).

Private enterprise has provided roughly 10.8% of the total commercial hard clam harvest in North Carolina between 1994 and 2018 (Figure 3). The annual average hard clam landings from 1994 to 2018 from private production were 2.4 million clams. In 2018, harvest from private culture was 1.0 million clams, the lowest in the 25-year times series.

Recreational Landings

The recreational harvest of hard clams in North Carolina does not require a fishing license, and due to this the total amount of recreational landings cannot be estimated and remains unknown. However, a mailout survey has been used since 2010 to estimate harvest from Coastal Recreational Fishing License holders. This population of recreational harvesters makes up an unknown proportion of total recreational harvest, but still provides insight into catch rates, harvest trends, and scale of harvest. In 2010, surveys were only mailed out November and December, so harvest and effort estimates are very low (Table 2). Harvest and catch rate have seen a decline since 2013 (Figure 4). In 2018 recreational harvest was less than one quarter the average since 2011. This is most likely due to Hurricane Florence in September 2018 which caused widespread shellfish closures.

MONITORING PROGRAM DATA

Fishery-Dependent Monitoring

Sampling of commercial catches of hard clams has been ongoing in the Southern District, Morehead City Office since 1998. Additional sampling of other areas followed later as funding became available for expansion.

The number of hard clam shell lengths from fishery dependent sources from 1999 through 2018 ranged from 304 in 2005 to 10,670 in 2011 (Table 3). Mean shell length has ranged from 35 mm (1.2 inches) in 2004 to 40 mm (1.6 inches) in 2008, 2017, and 2018, with a minimum shell length of 20 mm (0.8 inch) to a maximum shell length of 82 mm (3.2 inches) for clams measured at the fish house (Table 3).

In 2018, the modal shell length of hard clams caught in the commercial fishery was 38 mm (Figure 5). The modal shell length has been increasing since 2014.

Fishery-Independent Monitoring

A fisheries-independent monitoring program (Program 640) in Core Sound to provide baseline data on hard clam abundance and gather environmental information. In the future, it may be possible to expand this sampling into other areas to evaluate the entire population. Thirty randomly selected stations are sampled each year within three strata. The three designated strata were: Shellfish Mapping Strata (ST), Known Fishing Areas (FA), and Closed Shellfish Areas (CA). Sampling is performed at each station location within each stratum using small patent tongs on a 25-ft flat bottom boat. The patent tongs have an opening of 0.51 square meters. Samples are by station and three samples at each station are taken.

Very few hard clams are caught in this program due to the nature of the gear and random stratified sampling design. The Catch per Unit Effort (CPUE) or number of clams per station has ranged annually from 0.27 clams per station in 2018 to 1.27 clams per station in 2009 (Table 4). No trend is apparent from this sampling, but it is considered a short time series with only 11 years of data (Figure 6).

MANAGEMENT STRATEGY

There are no management triggers or methods to track stock abundance, fishing mortality, or recruitment between benchmark reviews from the current FMP. Landings and effort have decreased over time. There are no data to track the recreational fishery.

Amendment 2 was adopted in February 2017 with rule changes in effect May 1, 2017. The selected management strategies of the Marine Fisheries Commission from Amendment 2 for hard clams taken from public bottom included:

- removing the Pamlico Sound mechanical clam harvest areas in rule no longer in use
- taking latitude/longitude coordinates of the poles marking the open mechanical clam harvest area in New River

For private culture of hard clams, the preferred management options in draft Amendment 2 included:

- adding convictions for theft of shellfish from leases or franchises to the list of convictions that may result in revocation of fishing licenses to implement stronger deterrents to shellfish theft and intentional aquaculture gear damage
- clarifying how production and marketing rates are calculated for shellfish leases and franchises to meet minimum production requirements

- expanding the maximum proposed lease size to 10 acres in all areas
- specifying criteria that allow a single extension period for shellfish leases of no more than two years per contract period to meet production and marketing requirements in the case of unforeseen circumstances, and reorganize the rules for improved clarity.

Amendment 2 also recommended implementing shading requirements for clams on a vessel, during transport to a dealer, or storage on a dock from June through September.

See Table 5 for Marine Fisheries Commission selected management options under Amendment 2.

RESEARCH NEEDS

The specific research recommendations from Amendment 2, with its priority ranking are provided below. The prioritization of each research recommendation is designated either a HIGH, MEDIUM, or LOW standing. A low ranking does not infer a lack of importance but is either already being addressed by others or provides limited information for aiding in management decisions. A high ranking indicates there is a substantial need, which may be time sensitive in nature, to provide information to help with management decisions. Proper management of the hard clam resource cannot occur until some of these research needs are met, the research recommendations include:

- Support all proposed implementation actions under the priority habitat issue on sedimentation in the CHPP – HIGH (Ongoing)
- Improve the reliability for estimating recreational shellfish harvest – HIGH (Incomplete)
- Survey commercial shellfish license holders without a record of landings to estimate hard clam harvest from this group – MEDIUM (Incomplete)
- Determine the consequences to hard clams from impacts to habitat due to harvest practices – LOW (Incomplete)
- Develop regional juvenile and adult abundance indices – HIGH (Incomplete)
- Complete socioeconomic surveys of recreational clam harvesters – MEDIUM (Incomplete)
- Continue to complete socioeconomic surveys of commercial clam fishermen – LOW (Incomplete)
- Support collaborative research to more efficiently track bacterial sources for land-based protection and restoration efforts – MEDIUM (Ongoing)
- Quantify the relationship between water quality parameters and the cumulative effect of shoreline development units - MEDIUM (Incomplete)
- Investigate impacts of clam trawls and escalator dredges on sandy bottom environments – LOW (Incomplete)
- Investigate the effects of mechanical harvest on clam recruitment and clam mortality in the mechanical harvest areas – MEDIUM (Incomplete)

FISHERY MANAGEMENT PLAN SCHEDULE RECOMMENDATION

Recommend maintaining the current timing of the Benchmark Review set to begin in July 2022.

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TABLES

Table 1. Current daily mechanical hard clam harvest limits by water body. Season can only be opened from December 1 through March 31 by proclamation.

Waterbody	Daily harvest limit (number of clams)	Additional information
Northern Core Sound	5,000	Rotates one year open and one year closed opposite the open/close rotation of the New River
Southern Core Sound	5,000	Limit reduced from 6,250 in 2001. Open annually
North River	3,750	Open annually
Newport River	3,750	Open annually
Bogue Sound	3,750	Open annually
White Oak River	6,250	Rotates one year open and one year closed opposite the open/close rotation of the New River
New River	6,250	Rotates one year open and one year closed opposite the open/close rotation of the White Oak River and the ICW in the Onslow/Pender counties areas
New River Inlet	6,250	Open annually from Marker 72A to the New River Inlet
ICW Onslow/Pender counties area	6,250	Intracoastal Waterway (maintained marked channel only) from Marker #65, south of Sallier's Bay, to Marker #49 at Morris Landing. All public bottoms within and 100 feet on either side of the Intracoastal Waterway from Marker #49 at Morris Landing to the "BC" Marker at Banks Channel. Open every other year when the New River is closed.

Table 2. Estimated number of trips, number of clams harvested, and catch rate (clams per trip) per year of Coastal Recreational Fishing License holders, 2010-2018. * denotes partial year of sampling

Year	Number Trips	Clam Harvest	Catch Rate
2010*	528	8731	18.4
2011	6,350	127,597	22.9
2012	6,726	146,151	27.3
2013	8,644	191,842	26.2
2014	6,325	162,656	28.8
2015	7,637	166,419	27.4
2016	8,456	84,199	12.3
2017	3,435	75,171	21.8
2018	2,362	26,769	11.3

Table 3. Observed annual mean, minimum and maximum shell length (mm) of hard clams measured from commercial catches at the dealer, 1999 – 2018.

Year	Mean Shell Length	Min Shell Length	Max Shell Length	Total Number measured
1999	37	22	76	3,999
2000	35	24	72	2,137
2001	38	23	80	3,265
2002	36	22	56	1,900
2003	36	21	56	836
2004	38	24	55	1,212
2005	38	27	82	304
2006	39	25	74	1,540
2007	38	25	63	1,405
2008	40	24	67	1,383
2009	37	25	69	1,859
2010	37	22	63	5,358
2011	37	20	67	10,670
2012	36	22	64	5,851
2013	37	21	65	4,750
2014	35	22	66	7,444
2015	35	21	66	6,216
2016	36	23	62	6,454
2017	40	24	65	3,420
2018	40	25	64	1,946

Table 4. Independent hard clam sampling (Program 640) annual estimates of catch per unit effort (CPUE=Number of clams per station) and their standard deviations, 2007 to 2018 for Core Sound.

Year	Total number of stations	Number of stations with zero catch	Number of clams	CPUE (Number of clams/station)	Standard deviation
2007	30	22	20	0.67	1.54
2008	31	24	12	0.39	0.80
2009	30	15	38	1.27	1.82
2010	30	19	22	0.73	1.36
2011	30	26	14	0.47	2.03
2012	30	17	21	0.70	1.21
2013	30	25	16	0.53	1.53
2014	30	24	21	0.70	1.78
2015	30	22	15	0.50	0.50
2016	30	22	16	0.53	0.23
2017	30	22	35	1.17	2.57
2018	30	23	8	0.27	0.52

Table 5. Summary of the Marine Fisheries Commission selected management strategies from Amendment 2 of the N.C. Hard Clam Fishery Management Plan.

Management strategies	Implementation status
MANAGEMENT OF PUBLIC BOTTOM	
1. Status quo (Continue the daily harvest limit for recreational purposes at 100 clams per person per day not to exceed 200 per clams per vessel per day)	No action required
2. Status quo (Maintain management of the mechanical clam harvest in existing areas from Core Sound south to Topsail Sound, including modifications to the mechanical clam harvest lines to exclude areas where oyster habitat and SAV habitat exist based on all available information)	No action required
3. Remove the Pamlico Sound mechanical clam harvest areas in rule no longer in use	Rule change to 15A NCAC 03K .0302 in effect May 1, 2017
4. Take latitude/longitude coordinates of the poles marking the open mechanical clam harvest area boundary in the New River, still with the flexibility to move a line to avoid critical habitats	Completed in 2015
5. Allow mechanical clam harvesters to have access to the bottom before maintenance dredging occurs	No action required
6. Status quo (Maintain current definitions and enforcement of hand harvest methods)	No action required

Management strategies	Implementation status
7. Allow Shellfish License holders to be eligible to acquire a Standard Commercial Fishing License after they show a history of sale of shellfish. Continue to allow commercial harvest of all other shellfish (clams included) as currently allowed	No action required
PRIVATE CULTURE	
1. Support modification of G.S. 113-208 and G.S. 113-269 to add minimum fines for violations on shellfish leases and franchises. With minimum fines set at $500 for the first violation and $1,000 for the second violation	Amend G.S. 113-208 and G.S. 113-269
2. Support modification of G.S. 113-269 to include protection to all shellfish leases and franchises, not just those with water column amendments	Amend G.S. 113-269
3. Modify Rule 15A NCAC 03O .0114, regardless whether statute changes occur, so that a first conviction under G.S. 113-208 or G.S. 113-269 the Fisheries Director shall revoke all licenses issued to the licensee	Rule change to 15A NCAC 03O .0114 in effect May 1, 2017
4. Status quo (Adhere to Regional Conditions of USACE NWP48 with no adverse effect to SAV from shellfish leases and following measure identified in the interim)	No action required
5. Continue the moratorium of shellfish leases in Brunswick County	No action required
6. Establish a rule to support extensions for where “Acts of God” prevent lease holder from making production, with a two year extension and only one extension allowed per term	Rule change 15A NCAC 03O .0201 in effect on May 1, 2017
7. Allow leases returned to the state to remain delineated for a period of one year to allow the pre-existing leased bottom to be re-issued to other shellfish growers	Amend G.S. 113-202
8. Improve public notice of proposed lease applications on the physical lease, at fish houses, and/or through electronic notices	Ongoing
9. Allow a maximum of ten acres in both mechanical methods prohibited areas and mechanical methods allowed areas	Rule change 15A NCAC 03O .0201(a)(3) in effect on May 1, 2017
ENVIRONMENT AND PUBLIC HEALTH	
1. Implement shading requirements for clams on a vessel, during transport to a dealer, or storage on a dock during June through September. These requirements would be implemented as a public health protection measure under 15A NCAC 03K .0110 by proclamation annually.	Existing proclamation authority, implemented beginning April 1, 2017

FIGURES

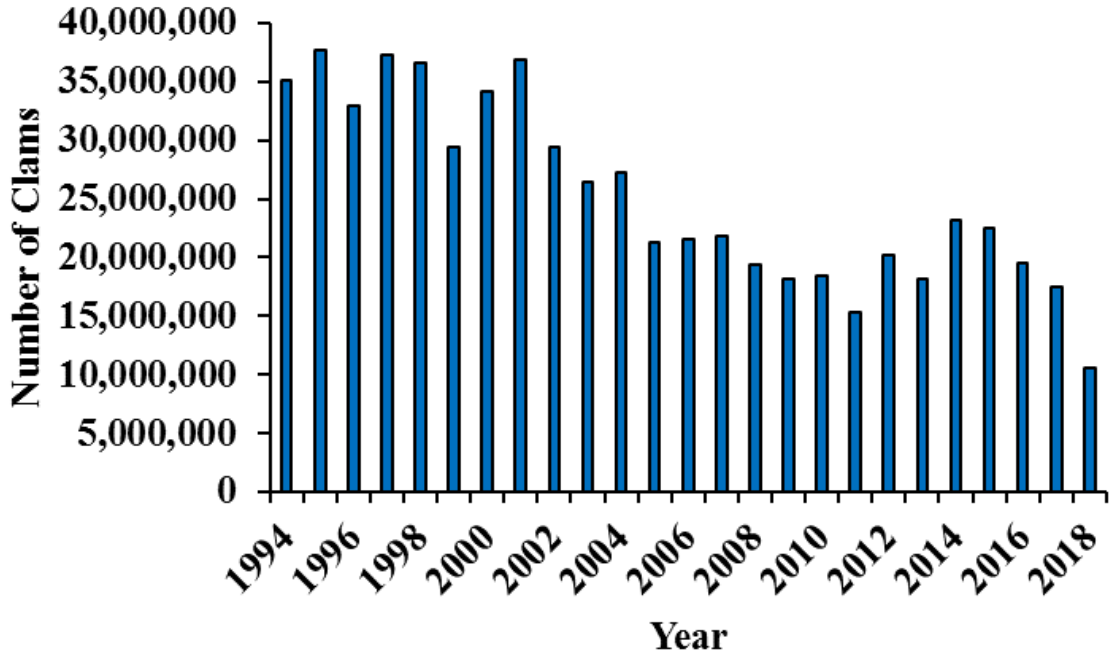

Figure 1. Annual commercial (1994-2018) hard clam landings (number of clams) from private and public bottom in North Carolina.

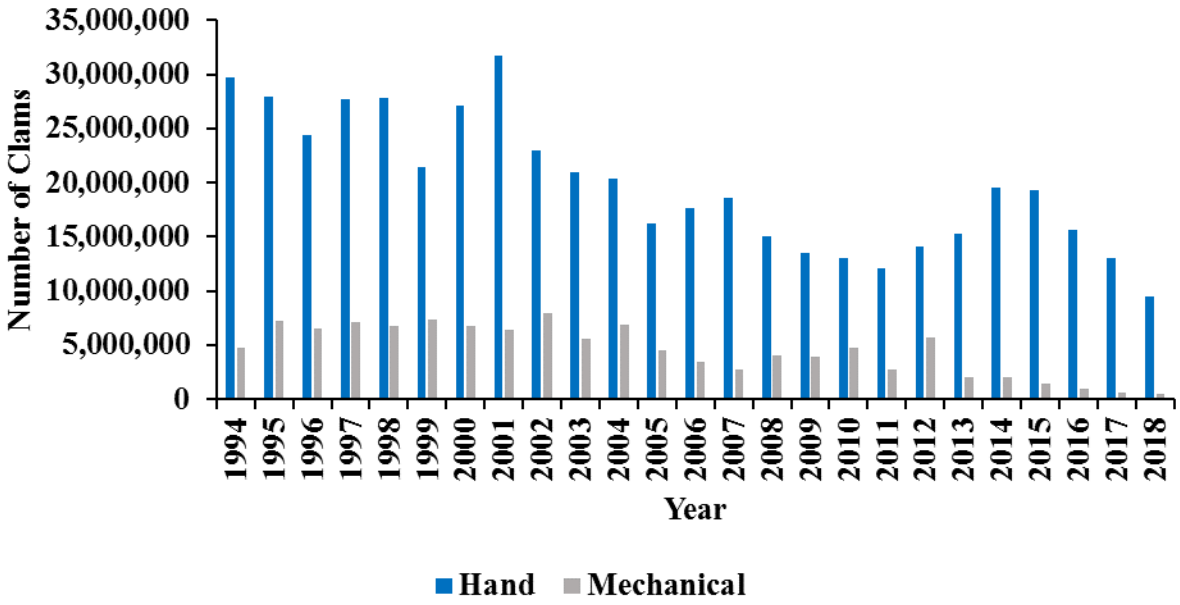

Figure 2. Annual hard clam landings (Number of clams) from hand and mechanical harvest in North Carolina, 1994 - 2018.

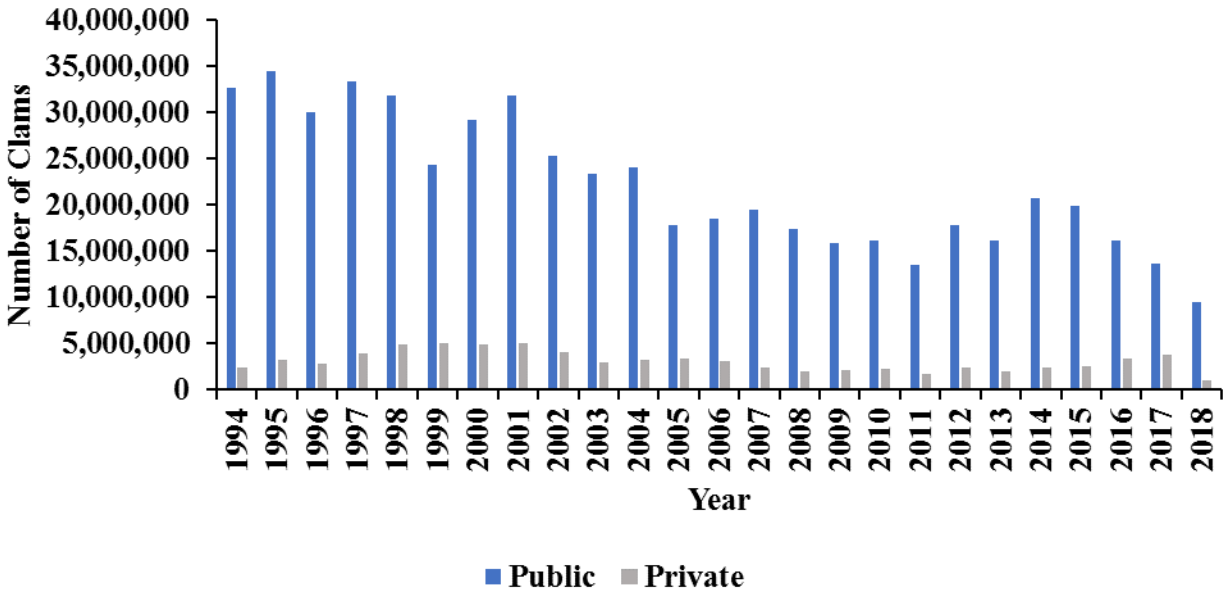

Figure 3. Annual hard clam landings (Number of clams) from private and public bottom, 1994 - 2018.

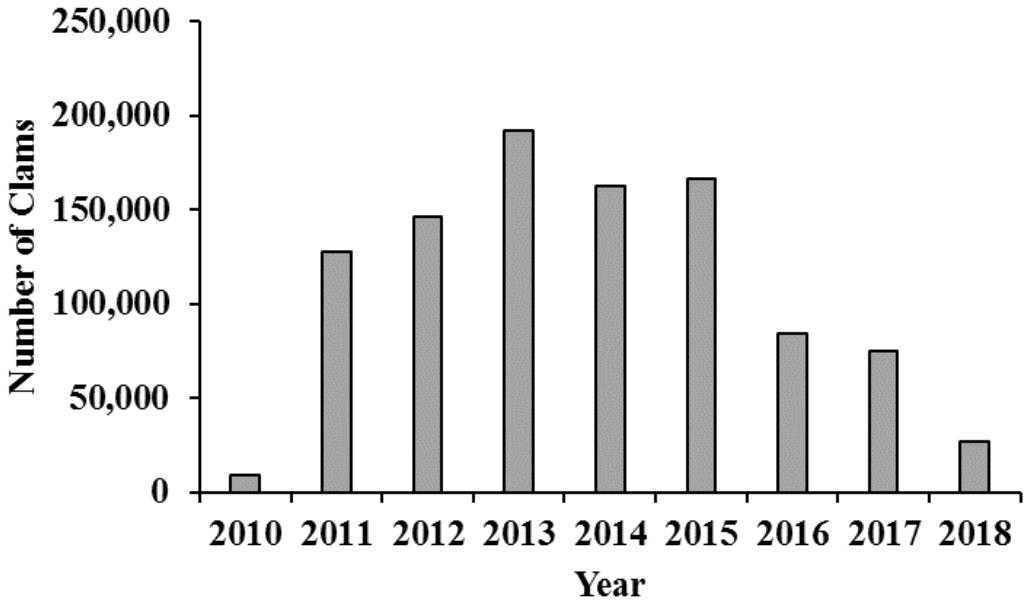

Figure 4. Annual recreational (2010-2018) hard clam landings (number of clams) from private and public bottom in North Carolina. Data from 2010 represent a partial year of sampling.

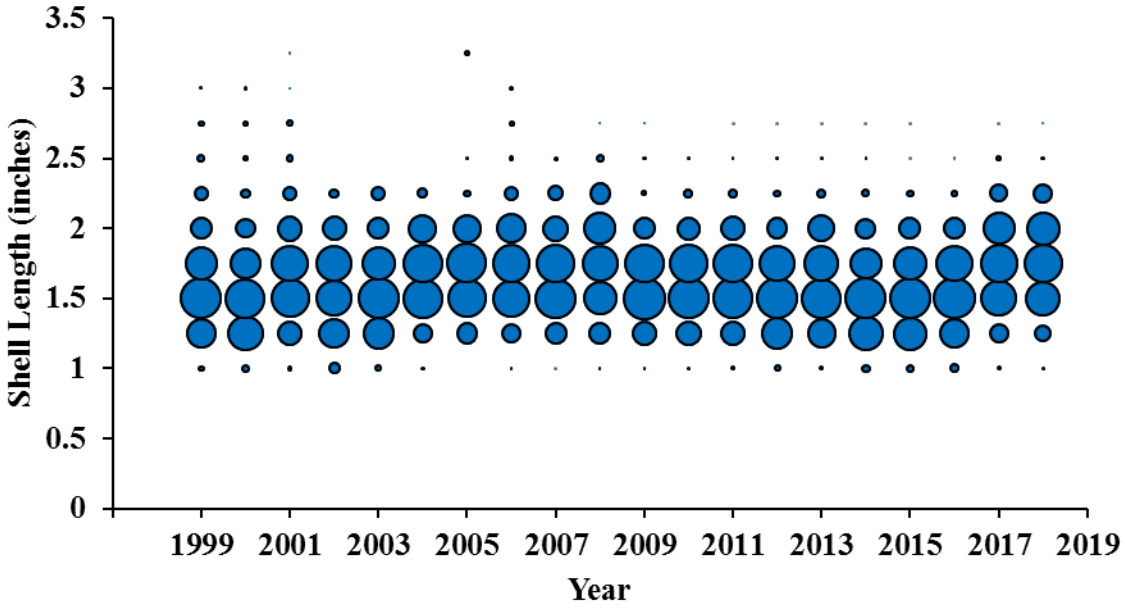

Figure 5. Length frequency (shell length, inches) of hard clams harvested from 1999 to 2018. Bubble represents the proportion of clams at length.

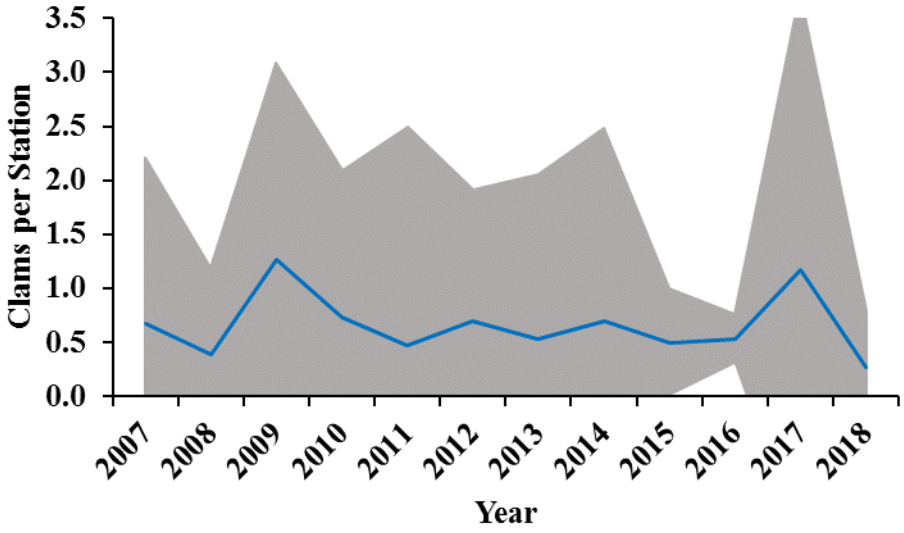

Figure 6. Annual catch per unit effort (Number of clams per stations) of hard clams in Core Sound from the independent sampling program 640, 2007 - 2018.

FISHERY MANAGEMENT PLAN UPDATE
KINGFISHES
AUGUST 2019

STATUS OF THE FISHERY MANAGEMENT PLAN

Fishery Management Plan History

Original FMP Adoption:	November 2007
Amendments:	None
Revisions:	None
Supplements:	None
Information Updates:	November 2015
Recommended Schedule Change:	None
Next MFC Scheduled Review:	July 2020

The original 2007 Kingfish Fishery Management Plan (FMP) developed management strategies that ensure a long-term sustainable harvest for recreational and commercial fisheries of North Carolina. The plan established the use of trend analysis and management triggers to monitor the viability of the stock. The N.C. Marine Fisheries Commission (NCMFC) also approved a rule which included proclamation authority for the North Carolina Division of Marine Fisheries (NCDMF) director the flexibility to impose restrictions on season, areas, quantity, means and methods, or size of kingfish (NCMFC Rule 15A NCAC 03M .0518), if needed. An Information Update was completed for the Kingfish FMP in November of 2015. The best available data and techniques used for the trend analysis and management triggers were refined and modified to better assess population trends as part of this FMP Information Update.

Management Unit

The North Carolina Kingfish FMP includes the three species of kingfishes (southern *Menticirrhus americanus*, Gulf *M. littoralis*, and northern *M. saxiatlis*) in all coastal fishing waters of North Carolina. Southern kingfish is designated as the indicator species for this assemblage. The management unit identified in this plan does not encompass the entire unit stock range for any of the three species of kingfishes inhabiting North Carolina. This is the primary reason that a quantified state-specific stock assessment could not be conducted and further, why a regional stock assessment approach is recommended as the most appropriate mechanism for determining the stock status and the long-term viability of this stock (NCDMF 2007).

Goal and Objectives

The goal of the 2007 Kingfish Fishery Management Plan is to determine the health of the stock and ensure the long-term sustainability for the kingfishes stock in North Carolina (NCDMF 2007). To achieve this goal, it is recommended that the following objectives be met:

1. Develop an objective management program that provides conservation of the resource and sustainable harvest in the fishery.
2. Ensure that the spawning stock is of sufficient capacity to prevent recruitment overfishing.
3. Address socio-economic concerns of all user groups.
4. Restore, improve, and protect critical habitats that affect growth, survival, and reproduction of the North Carolina stock of kingfishes.
5. Evaluate, enhance, and initiate studies to increase our understanding of kingfishes' biology and population dynamics in North Carolina.
6. Promote public awareness regarding the status and management of the North Carolina kingfishes stock.

STATUS OF THE STOCK

Life History

Three species of kingfishes occur in North Carolina: southern (*Menticirrhus americanus*), Gulf (*M. littoralis*), and northern kingfishes (*M. saxatilis*). Kingfish refers to a single species while kingfishes refers to multiple species. Kingfishes are demersal (live near and feed on the bottom) members of the drum family. Southern kingfish is the most abundant kingfish species from North Carolina to the east coast of Florida and Gulf of Mexico with a range extending as far as Cape May, New Jersey southward to Buenos Aires, Argentina. Northern kingfish is the most abundant kingfish species from Massachusetts to North Carolina, with a range extending from the Gulf of Maine into the Gulf of Mexico. Gulf kingfish is the most abundant kingfish species in the surf zone south of Cape Hatteras, North Carolina, and has a range extending from Virginia to Rio Grande, Brazil. The northern and southern kingfishes prefer mud or sand-mud bottom types while Gulf kingfish prefer the sandy bottoms of the surf zone. Kingfishes move from estuarine and nearshore ocean waters to deeper offshore waters as water temperature cools. Spawning takes place in the ocean from April to October. The kingfishes have several regional names including sea mullet, king whiting, king croaker, sea mink, roundhead, hard head, whiting, hake, Carolina whiting, and Virginia mullet.

Stock Status

The stock of kingfish is unassessed, thus overfishing/overfished status cannot be determined. However, results from the trend analysis suggests there are no concerns with the stock and no need for management at this time. A coast-wide stock assessment is a high research priority that needs to be addressed before biological reference points relative to overfished and overfishing can be determined.

Stock Assessment

The 2007 Kingfish FMP selected the use of trend analysis with management triggers as the management strategy to monitor the viability of the kingfish stock in North Carolina (NCDMF 2007). During the review of the 2007 Kingfish FMP as part of the 2015 FMP Information Update, best available data and techniques used for the trend analysis and management triggers were refined and modified to better assess population trends. The trend analysis incorporates management triggers to alert NCDMF and NCMFC to the potential need for management action based on stock conditions. The activation of any two management triggers (regardless of trigger category) two years in a row warrants further evaluation of the data and potential management action. The analysis is updated each year and all trends relative to management triggers are provided as part of this annual update. Current management triggers are based on fishery independent indices of abundance for Young-of-Year (YOY), adult fish, the proportion of catch greater than size at 50% maturity (L_{50}) and a relative fishing mortality index. YOY fish includes new fish that enter the population that year. L_{50} is the length at which 50% of the adult population is sexually mature and ready to spawn.

A formal quantitative stock assessment is not available for kingfish in North Carolina; therefore, no determination can be made relative to an overfishing or overfished status. Prior attempts at a stock assessment during the 2007 FMP development were not successful, primarily due to limited data. From these prior attempts, all reviewers noted a lack of migration (mixing) data to determine the movement patterns of kingfishes along North Carolina and the entire Atlantic coast. A regional (multi-state) stock assessment approach is likely needed to best determine the stock status for kingfish along the Atlantic coast including North Carolina. In 2008 and 2014, Atlantic States Marine Fisheries Commission (ASMFC) South Atlantic Board met to consider regional management by reviewing data on kingfishes. However, due to no major concerns with kingfish stocks, it was decided no further action was necessary. As a result, kingfish management in North Carolina continues to fall solely within the framework of the state FMP process.

STATUS OF THE FISHERY

Current Regulations

For shrimp or crab trawls, there is a three-hundred-pound trip limit for kingfishes south of Bogue Inlet from December 1 through March 31 (NCMFC Rule 15A NCAC 03J .0202 (5)). No other harvest limits are in place specific to kingfish in any other fisheries.

Commercial Landings

Commercial landings for kingfishes include southern, northern, and Gulf kingfishes combined. Landings have fluctuated historically, but have been on an increasing trend since 2011. However, the 2018 landings decreased 58% from 2017 (Figure 1). The vast majority of kingfishes landed are from the ocean gill net fishery. The average landings from 2009 to 2018 were 721,930 pounds. Harvest of kingfishes is seasonal with peak landings in April and November. Peaks in landings coincide with seasonal movements of kingfishes along the Atlantic coast.

Recreational Landings

Recreational fishing activity is monitored through the Marine Recreational Information Program. In this report, estimates across all years have been updated and are now based on the MRIP new Fishing Effort Survey-based calibrated estimates. For more information on MRIP methodology changes see https://www.fisheries.noaa.gov/topic/recreational-fishing-data.

Recreational landings for kingfish include southern, northern, and Gulf kingfishes. Total recreational landings had been on an increasing trend from 1983 – 2014. In 2015, 2016 and 2017, recreational landings declined, with 2017 having the lowest landings since 1999. In 2018 recreational landings increased 80% from 2017 (Figure 1). Most kingfishes are landed from the ocean and the majority of the fish are caught from man-made structures, such as piers, jetties, or bridges, or from beaches. A smaller portion of kingfishes are caught in estuarine waters of the state and the majority of those fish are harvested by anglers fishing from private vessels. Recreational harvest of kingfishes is also seasonal with the majority of fish harvested during the spring and the fall, and lowest during the summer. Most of the recreational catch consists of kingfish from 8 to 12 inches (Figure 12).

MONITORING PROGRAM DATA

Fishery-Dependent Monitoring

Kingfishes are sampled from a variety of commercial fishery surveys, including the estuarine long haul, ocean trawl, pound net, ocean gill net, estuarine gill net and ocean beach seine fisheries in N.C. A total of 30,939 kingfishes were measured from 2009 to 2018 (25,855 southern, 2,747 northern and 2,337 Gulf; Table 1; Figure 9). Mean length for southern kingfish ranged from 11.4 to 12.1 inches, with a minimum of 6.5 inches and a maximum of 22.0 inches. Mean length for northern kingfish ranged from 12.4 to 13.4 inches, with a minimum of 6.9 inches and a maximum of 17.7 inches. Mean length for Gulf kingfish ranged from 12.2 to 13.2 inches with a minimum of 6.1 inches and a maximum of 18.3 inches.

Recreational lengths are collected as part of Marine Recreational Informational Program (MRIP) by recreational port agents. A total of 7,493 kingfishes were measured from 2009 to 2018 (5,331 southern, 231 northern and 1,931 Gulf; Table 2). Mean length for southern kingfish ranged from 10.4 to 11.7 inches, with a minimum of 6.1 inches and a maximum of 19.9 inches. Mean length for northern kingfish ranged from 9.2 to 13.2 inches, with a minimum of 6.2 inches and a maximum of 16.0 inches. Mean length for Gulf kingfish ranged from 10.2 to 12.1 inches, with a minimum of 5.9 inches and a maximum of 18.2 inches. The length composition and modal length of kingfish caught in the commercial fishery has been stable from 1989 to 2018 (Figure 11).

Fishery-Independent Monitoring

Fishery-independent data are collected through the NCDMF Pamlico Sound Survey (Program 195), the Southeast Area Monitoring and Assessment Program – South Atlantic (SEAMAP-SA) Coastal Survey and the NCDMF Independent Gill Net Survey (Program 915). The Pamlico

Sound Survey catches the most kingfishes of any of the NCDMF fishery independent sampling programs, and the majority of those are southern kingfishes. This survey has been running uninterrupted since 1987. From 1991 to present, the Pamlico Sound Survey has been conducted during the middle two weeks in June and September. The stations sampled are randomly selected from strata based upon depth and geographic location. Tow duration is 20 minutes at 2.5 knots using the R/V Carolina Coast pulling double rigged demersal mongoose trawls. The sample area covers all of Pamlico Sound and its bays, as well as Croatan Sound up to the Highway 64 Bridge, the Pamlico River up to Blounts Bay, the Pungo River up to Smith Creek, and the Neuse River up to Upper Broad Creek. However, most kingfish are caught in Pamlico Sound proper, and very few from the Neuse, Pamlico, and Pungo rivers. The September portion of the Pamlico Sound Survey is used to calculate a YOY index of relative abundance because there are more southern kingfish collected in the fall, and more YOY are present in the catch at this time. The relative index derived from Programs 195 survey was calculated using a stratified generalized linear model (GLM) approach. The Program 195 YOY relative abundance index peaked in 2009, but has been on a decreasing trend since 2013, and remained low in 2018 (Figure 2; Table 4).

The Southeast Area Monitoring and Assessment Program-South Atlantic (SEAMAP-SA) Coastal Survey is conducted by the South Carolina Department of Natural Resources-Marine Resources Division, and provides long-term fishery independent data on the distribution and relative abundance of coastal species (Cowen and Zimney 2016). Stations are randomly selected from a pool of stations in each stratum, and sampled using paired mongoose-type Falcon trawls with tow times of 20 minutes. SEAMAP-SA Coastal Survey cruises are conducted each year in spring (mid-April to the end of May), summer (mid-July to mid-August), and fall (the first of October to mid-November). The summer portion of SEAMAP-SA Coastal Survey is used to calculate an adult index of abundance and the fall portion of SEAMAP-SA Coastal Survey is used as a young of year index of abundance. The indices derived from the SEAMAP-SA Coastal Survey were computed using standard (non-stratified) GLMs. After a peak in 2012, the SEAMAP-SA Coastal Survey adult index of relative abundance has been on a declining trend, which continued in 2018 (Figure 3; Table 4). The YOY index of relative abundance increased to well above the average in 2015 and has since returned to approximately the average in 2018 (Figure 4; Table 4).

The Independent Gill Net Survey is designed to characterize the size and age distribution for key estuarine species in Pamlico Sound and its major river tributaries. Sampling began in Pamlico Sound in 2001 and was expanded to the current sampling area (including tributaries) in 2003. Each array of nets consists of floating gill nets in 30-yard segments of 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, and 6.5-inch stretched mesh, for a total of 240 yards of nets. Catches from an array of gill nets comprise a single sample; two samples (one shallow, one deep) totaling 480 yards of gill net are completed each trip. Gill nets are typically deployed within an hour of sunset and fished the following morning. Efforts are made to keep all soak times within 12 hours. Gill net sets are determined using a random stratified survey design, based on area and water depth. The L_{50} management trigger is based on a conservative proportion of adults in the population. This is the length at which 50% of the population is mature. For southern kingfish, this is 8.25 inches (210 mm) in length. One of the data sources for this management trigger comes from the Independent Gill Net Survey and has been stable over the time series (Figure 5).

Table 3 summarizes the age data for kingfishes (southern, northern, and Gulf), collected from 2009 through 2018. The majority of kingfish age samples came from Independent Gill Net Survey (Program 915), followed by the commercial ocean gill net fishery. Southern kingfish ages ranged from 0 to 7 years old. Northern kingfish ages ranges from 0 to 4 years old. Gulf kingfish ages ranged from 0 to 6 years old. The modal ages ranged from 1 to 3 years for southern and Gulf kingfishes, and northern kingfish.

MANAGEMENT STRATEGY

The 2007 Kingfish FMP selected the use of trend analysis and management triggers as the management strategy to monitor the viability of the kingfish stock in North Carolina (NCDMF 2007). A second management strategy promotes work to enhance public information and education. The trend analysis and management triggers are updated annually and results are presented to the NCMFC as part of the annual FMP Update. The trend analysis incorporates triggers to alert managers to the potential need for management action based on stock conditions. The activation of any two management triggers two years in a row (regardless of category) warrants further data evaluation and potential management action. The NCMFC will be notified should this criterion be met. The Pamlico Sound Survey, the Independent Gill Net Survey and the SEAMAP-SA Coastal Survey data are currently used for management triggers for kingfishes in North Carolina.

The L_{50} management trigger is based on a conservative proportion of adults in the population. This is the length at which 50% of the population is mature. For southern kingfish, this is 8.25 inches (210 mm) in length. Data sources for this management trigger come from three fisheries-independent surveys; the summer component of the SEAMAP-SA Coastal Survey, the July-September component of independent gill net survey, and the June component of the Pamlico Sound Survey.

Relative *F* is a simple method for estimating trends in *F* (Sinclair 1998). It is estimated as catch (commercial landings plus recreational harvest) divided by a fisheries-independent index of relative abundance. Here, catch (commercial landings plus recreational harvest) was divided by the SEAMAP-SA Coastal Survey spring index (Onslow, Raleigh, and Long bays, inner—shallow—strata) of relative abundance, given that the majority of catch occurs in the spring.

The kingfish management triggers are summarized as follows:

<u>Biological Monitoring</u>
Proportion of adults ≥ length at 50% maturity (L_{50}) for NCDMF Program 195 June (Figure 6)
Proportion of adults ≥ L_{50} for NCDMF Program 915 (Figure 5)
Proportion of adults ≥ L_{50} for SEAMAP-SA Coastal Survey summer (Figure 7)
→ If the proportion of adults ≥ L_{50} falls below 2/3 of the average proportion of adults ≥ L_{50} for the time series, then the trigger will be considered tripped.

<u>Fisheries-Independent Surveys—Juvenile and Adult</u>
NCDMF Program 195 September index of YOY relative abundance (Figure 2)
SEAMAP-SA Coastal Survey summer index of adult relative abundance (Figure 3)

SEAMAP-SA Coastal Survey fall index of YOY relative abundance (Figure 4)
→ If a fisheries-independent survey falls below 2/3 of the average abundance for the time series (through 2017), then the trigger will be considered tripped.

Other
Relative fishing mortality rate (*F*) (Figure 8)
→ If relative *F* rises above the average +1/3 of relative *F* for the time series (through 2017), the trigger will be considered tripped.

A summary of the various management triggers by year is provided in Table 4. Bold values indicate years when a particular management trigger was activated. In 2018, one management trigger was activated and only one trigger (the YOY index from the fall portion of SEAMAP Survey) was below the management trigger threshold. No action is required at this time.

RESEARCH NEEDS

The division reviewed and prioritized the research recommendations during the 2015 FMP Information Update (NCDMF 2015). The prioritization of each research recommendation is designated as a high, medium, or low priority. A low ranking does not infer a lack of importance but is either already being addressed by others or provides limited information for aiding in management decisions. A high ranking indicates there is a substantial need, which may be time sensitive in nature, to provide information to help with management decisions. Proper management of the kingfishes resource cannot occur until some of these research needs are met. The research recommendations include:

- Conduct a coast-wide stock assessment of southern kingfish along the Atlantic Coast including estimation of biological reference points for sustainable harvest – HIGH (No action)
- Validate YOY and adult indices used in trend analysis – HIGH (UNCW has conducted seine surveys in the ocean to determine trends for all three species)
- Develop a fisheries-independent survey in the ocean for juvenile and adult kingfishes – HIGH (No action)
- Collect observer data from commercial fishing operations to estimate at-sea species composition of the catch, discard rates, and lengths – HIGH (NCDMF has observers collecting data at sea for the shrimp fishery, flounder gill net fishery and other fisheries)
- Improve recreational data collection, particularly the species composition of discards, discard rates and associated biological data – HIGH (Steps have been taken to improve sampling in recreational fisheries, including a carcass collection program)
- Improve dependent commercial data collection of more sample sizes for life history information – MEDIUM (NCDMF ageing study collects kingfish for life history data)
- Evaluate and potentially expand the NCDMF fishery-independent gill net survey to provide data on species composition, abundance trends, and population age structure by including additional areas of North Carolina's estuarine and nearshore ocean waters – MEDIUM (No action)
- Continue bycatch reduction device studies in the shrimp trawl fishery to decrease bycatch – MEDIUM (Ongoing research through NCDMF and various federal agencies)

- Determine stock structure using genetics of kingfishes along North Carolina and the Atlantic Coast – LOW (Grant approved for UNCW and NCDMF to use genetic markers to delineate the population structure)
- Develop tagging study to estimate natural and fishing mortality, to investigate stock structure, and to understand movement patterns – HIGH (No action)
- Collect histological data to develop maturity schedule with priority to southern kingfish – HIGH (NCDMF currently collecting histology samples in order to validate and update maturity schedules)
- Conduct an age validation study with priority to southern kingfish – HIGH (No action)
- Conduct study to estimate fecundity with priority to southern kingfish – MEDIUM (No action)
- Conduct study to identify spawning areas with priority for southern kingfish – MEDIUM (No action)
- Sample inlets and river plumes to determine the importance of these areas for kingfishes and other estuarine-dependent species – LOW (Sampling in the nearshore ocean through N.C. Adult Fishery Independent Survey was initiated in 2008 but discontinued in 2015. Gill net sampling in Cape Fear, New, Neuse, Pamlico, and Pungo rivers continues)
- Determine the effects of beach re-nourishment on kingfishes and their prey – LOW (Grant approved for UNCW to investigate effects of beach renourishment)
- Conduct a study to investigate how tidal stages and time of day influence feeding in kingfishes – LOW (No action)
- Increase the sample size of surveyed participants in the commercial kingfish fishery to better determine specific business characteristics and the economics of working in the fishery – LOW (NCDMF conducted a study of CRFL holders in 2009/2010)
- Update information on the participants in the recreational kingfish fishery – LOW (Socioeconomic study was conducted by NCDMF on piers)

FISHERY MANAGEMENT PLAN SCHEDULE RECOMMENDATION

The NCDMF recommends maintaining the current schedule for the review to begin in July 2020.

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TABLES

Table 1. Summary of length data (fork length, inches) sampled from the kingfish commercial fishery, 2009 - 2018.

Southern Kingfish

Year	Mean Length	Minimum Length	Maximum Length	Total Number Measured
2009	11.5	6.9	16.5	3,909
2010	11.6	6.7	22.0	2,466
2011	11.7	8.1	18.1	2,102
2012	11.5	7.0	17.0	2,947
2013	12.1	6.5	16.1	1,390
2014	11.9	8.3	20.9	2,880
2015	11.9	7.7	15.8	3,286
2016	12.0	7.1	17.2	3,107
2017	11.6	7.9	16.1	2,504
2018	11.4	6.8	16.1	1,264

Northern Kingfish

Year	Mean Length	Minimum Length	Maximum Length	Total Number Measured
2009	12.4	6.9	15.9	314
2010	12.6	9.0	16.0	189
2011	12.7	8.6	17.0	275
2012	12.8	7.8	17.5	370
2013	13.1	8.6	16.0	815
2014	13.4	9.5	16.7	216
2015	12.7	10.0	16.6	100
2016	12.4	8.8	17.0	227
2017	13.3	9.8	17.4	177
2018	13.9	9.7	17.7	64

Gulf Kingfish

Year	Mean Length	Minimum Length	Maximum Length	Total Number Measured
2009	12.4	8.4	16.0	305
2010	12.5	10.2	16.2	136
2011	13.2	6.1	17.9	314
2012	12.6	9.2	16.0	151
2013	12.9	8.3	17.4	470
2014	12.2	8.6	15.5	182
2015	12.7	9.2	16.3	168
2016	12.4	8.1	18.3	193
2017	12.3	9.4	16.7	257
2018	12.5	9.0	18.0	161

Table 2. Summary of length data (fork length, inches) sampled from the kingfish recreational fishery, 2009 - 2018.

Southern Kingfish

Year	Mean Length	Minimum Length	Maximum Length	Total Number Measured
2009	10.9	6.3	18.1	689
2010	11.2	6.3	16.3	968
2011	11.0	7.2	16.5	583
2012	10.9	6.1	16.1	828
2013	10.4	6.1	15.8	370
2014	11.7	7.8	19.9	383
2015	10.7	6.4	18.7	258
2016	11.2	7.8	16.5	490
2017	11.0	7.8	15.4	472
2018	11.5	7.8	15.2	290

Northern Kingfish

Year	Mean Length	Minimum Length	Maximum Length	Total Number Measured
2009	10.6	8.6	15.1	19
2010	11.1	8.7	15.4	20
2011	12.2	7.1	16.0	70
2012	11.3	8.3	15.1	58
2013	10.9	6.2	14.8	26
2014	11.2	9.3	13.5	2
2015	10.9	8.5	14.1	7
2016	10.8	7.9	11.8	3
2017	13.2	9.8	14.4	24
2018	9.2	6.4	13.1	2

Gulf Kingfish

Year	Mean Length	Minimum Length	Maximum Length	Total Number Measured
2009	10.2	7.2	16.9	203
2010	10.8	5.9	18.2	363
2011	11.9	7.5	16.9	223
2012	10.4	6.4	17.2	406
2013	10.4	6.0	17.2	180
2014	11.5	6.5	17.2	203
2015	11.3	8.5	16.0	63
2016	10.7	6.9	14.1	81
2017	12.1	7.5	15.8	126
2018	11.6	6.5	17.0	83

Table 3. Kingfish age data collected from all sources (commercial and recreational fisheries and fishery independent sampling programs) combined, 2009 - 2018.

Southern Kingfish

Year	Modal Age	Minimum Age	Maximum Age	Total Number Aged
2009	2	2	5	15
2010	2	1	5	163
2011	2	0	6	243
2012	1	1	6	228
2013	2	1	5	298
2014	3	0	5	269
2015	2	0	5	353
2016	1	0	7	530
2017	2	0	6	413
2018	1	0	7	308

Northern Kingfish

Year	Modal Age	Minimum Age	Maximum Age	Total Number Aged
2009	1	1	3	14
2010	2	1	3	4
2011	2	0	4	115
2012	1	0	3	17
2013	2	1	3	26
2014	2	2	2	1
2015	2	0	2	40
2016	1	1	4	49
2017	2	1	3	13
2018	3	3	3	1

Gulf Kingfish

Year	Modal Age	Minimum Age	Maximum Age	Total Number Aged
2009	-	-	-	0
2010	3	3	3	1
2011	2	1	6	28
2012	1	0	4	98
2013	1	1	4	44
2014	2	1	4	38
2015	2	0	4	78
2016	1	0	5	116
2017	2	0	5	167
2018	2	0	6	95

Table 4. Summary of management trigger organized by category. Bold indicates values that activate a trigger.

	BIOLOGICAL MONITORING			FISHERIES-INDEPENDENT SURVEYS			OTHER
	Proportion of Adults >= L50			YOY Indices		Adult Index	Relative *F*
Year	Program 195 June	Program 915 July-September	SEAMAP Summer	Program 195 September	SEAMAP Fall	SEAMAP Summer	Relative *F*
1987	0.611			**0.86**			
1988	0.450			**0.22**			
1989	**0.300**		0.585	**1.32**	6.30	**3.41**	67,901
1990	0.563		0.488	**1.35**	6.60	17.70	**305,648**
1991	0.667		0.863	**1.90**	**4.70**	18.30	107,162
1992	0.429		0.663	**0.75**	**1.78**	6.80	109,121
1993	0.543		**0.354**	**0.23**	**1.92**	**6.70**	**268,584**
1994	0.794		0.815	**0.65**	5.70	**1.78**	**450,576**
1995	0.440		0.444	**1.80**	**1.44**	**4.67**	149,528
1996	0.872		0.697	**0.24**	5.60	**2.46**	**172,560**
1997	0.589		**0.367**	**0.24**	**1.10**	**5.99**	83,659
1998	1.000		0.732	**0.19**	6.1	**2.47**	54,363
1999	0.920		0.569	**1.11**	7.20	13.20	124,682
2000	0.733		0.918	3.68	**3.40**	**4.90**	**324,589**
2001	0.660	0.983	**0.303**	2.60	**2.72**	11.60	117,159
2002	0.704	0.978	0.922	**1.84**	5.80	**5.81**	110,959
2003	0.872	0.978	0.693	5.40	**2.60**	10.20	30,979
2004	0.513	0.971	**0.300**	2.37	6.10	19.40	34,545
2005	0.594	0.971	0.552	**1.68**	**3.80**	9.40	39,849
2006	0.541	0.980	0.392	7.82	**3.10**	11.60	57,803
2007	**0.343**	0.976	0.468	4.70	**4.40**	**3.72**	**174,234**
2008	0.488	0.978	0.611	9.94	**4.60**	**1.89**	133,516
2009	0.586	1.000	**0.357**	4.49	**1.43**	8.20	**178,712**
2010	0.529	0.983	0.641	**1.73**	**4.30**	**6.19**	91,015
2011	0.432	1.000	**0.372**	7.38	15.80	10.30	127,485
2012	0.511	1.000	**0.283**	3.34	**3.90**	29.20	34,803
2013	0.659	0.947	0.528	9.79	5.30	18.60	32,764
2014	0.422	0.982	0.502	5.87	**4.90**	19.10	108,961
2015	0.534	0.981	0.527	4.52	93.00	17.50	46,684
2016	**0.358**	0.950	**0.349**	2.82	9.50	14.50	14,224
2017	0.503	0.958	0.661	2.43	6.81	10.26	7,145
2018	0.639	1.000	0.448	3.09	**2.48**	9.33	27,767
Threshold	<0.392	<0.652	<0.385	<2.0	<5.2	<6.8	>159,421
Total Years	32	18	30	32	30	30	30
Years Trigger Activated	3	0	8	16	16	12	7

Table 5. Summary of the N.C. Marine Fisheries Commission management strategies and their implementation status for the 2007 Kingfish Fishery Management Plan.

Management Strategy	**Implementation Status**
Fisheries Management	
The proposed management strategy for kingfishes in North Carolina is to 1) maintain a sustainable harvest of kingfishes over the long-term and 2) promote public education. The first strategy will be accomplished by developing management triggers based on the biology of kingfishes, landings of kingfishes, independent surveys, and requesting a stock assessment of kingfishes be conducted by Atlantic States Marine Fisheries Commission (ASMFC). The second strategy will be accomplished by the NCDMF working to enhance public information and education.	Accomplished
Recommend ASMFC conduct a coast-wide stock assessment on sea mullet.	ASMFC determined a stock assessment for the kingfishes was not necessary due to the positive trends in SEAMAP southern kingfish CPUE.
Endorse additional research to reduce bycatch in the shrimp trawl fishery, primarily shrimp trawl characterization studies involving at-sea observers and investigations into fish excluder devices with a higher success rate for reducing the harvest and retention of kingfish in shrimp trawls.	Ongoing
Implement rule giving NCDMF director proclamation authority to manage kingfish.	Accomplished. Rule 15A NCAC 3M .0518 in effect since October 1, 2008
Habitat and Water Quality	
The NCDCM should continue promoting the use of shoreline stabilization alternatives that maintain or enhance fish habitat. That includes using oyster cultch or limestone marl in constructing the sills (granite sills do not attract oyster larvae).	Endorsed through the Coastal Habitat Protection Plan (CHPP)
To ensure protection of kingfish nursery areas, fish-friendly alternatives to vertical stabilization should be required around primary and secondary nursery areas.	Endorsed through the CHPP
The location and designation of nursery habitats should be continued and expanded by the NCDMF.	Endorsed through the CHPP
No trawl areas and mechanical harvest prohibited areas should be expanded to include recovery/restoration areas for subtidal oyster beds and SAV.	Endorsed through the CHPP
Expansion and coordination of habitat monitoring efforts is needed to acquire data for modeling the location of potential recovery/restoration sites for oysters and SAV.	Endorsed through the CHPP
Any proposed stabilization project threatening the passage of kingfish larvae through coastal inlets should be avoided.	Endorsed through the CHPP
All coastal-draining river basins should be considered for NSW classification because they all deliver excess nutrients to coastal waters, regardless of flushing rate.	Endorsed through the CHPP
Efforts to implement phase II stormwater rules must be continued.	Endorsed through the CHPP
The EEP process should be extended to other development projects.	Endorsed through the CHPP
Reduce sediment and nutrient loading by addressing multiple sources, including: • improvement and continuation of urban and agricultural BMPs, • more stringent sediment controls on construction projects, and • implementation of additional buffers along coastal waters.	Endorsed through the CHPP

FIGURES

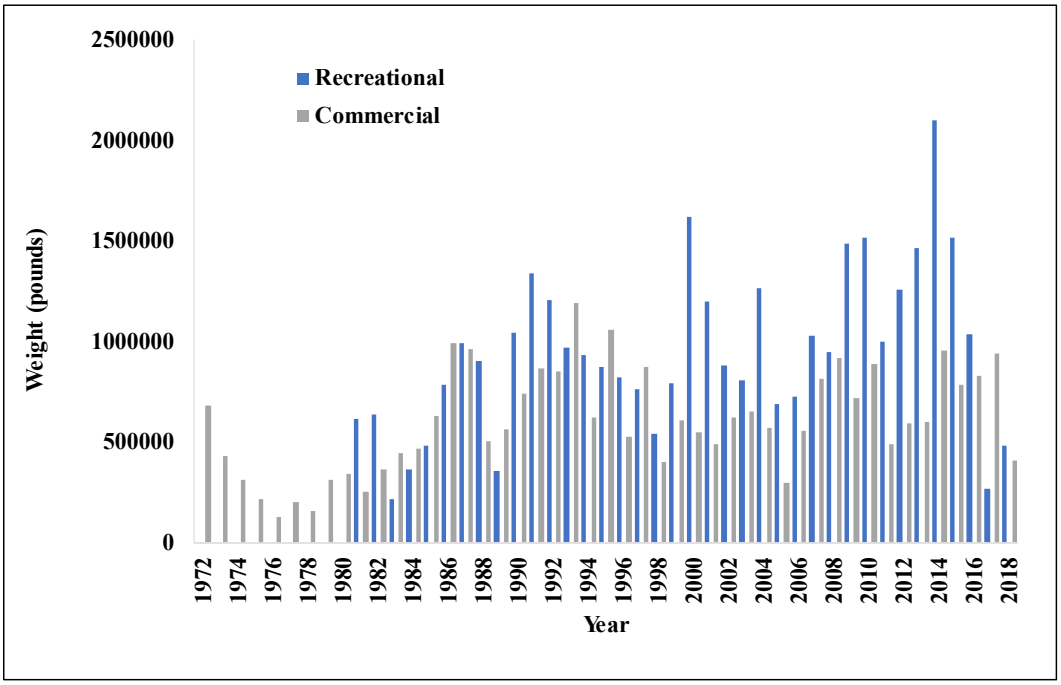

Figure 1. Commercial and recreational landings of kingfishes (southern, northern, and Gulf combined), 1972 - 2018.

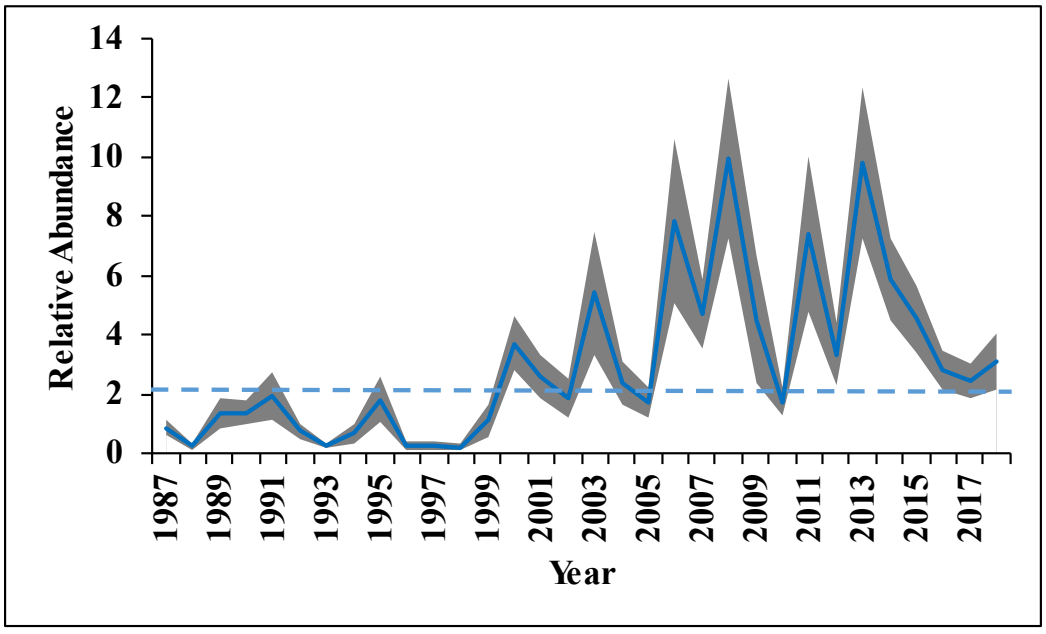

Figure 2. Annual index of relative YOY abundance for southern kingfish derived from the September component of the NCDMF Program 195 survey (excluding strata from the Neuse, Pamlico, and Pungo rivers), 1987–2018. Dotted line represents 2/3 of the average of the time series.

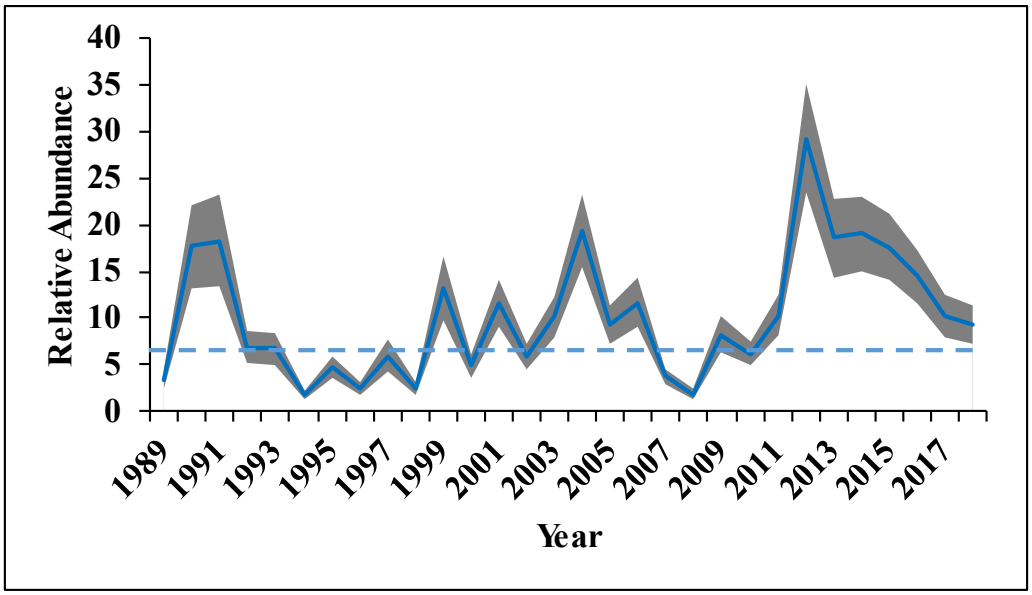

Figure 3. Annual index of relative adult abundance for southern kingfish derived from the summer component of the SEAMAP-SA Coastal Survey (Onslow, Raleigh, and Long bays, inner—shallow—strata), 1989–2018. Dotted line represents 2/3 of the average of the time series.

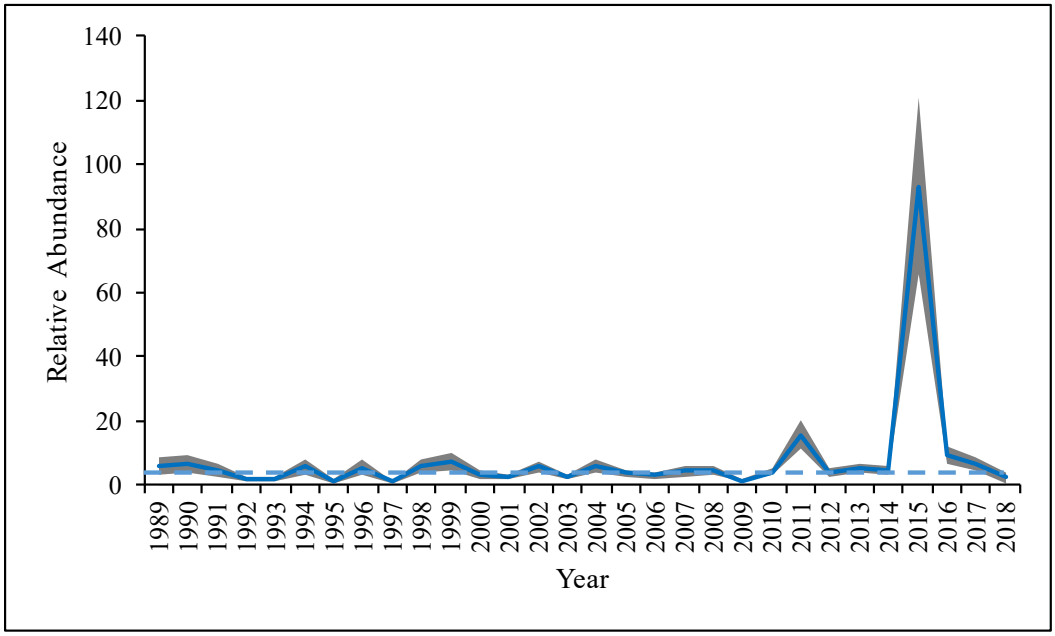

Figure 4. Annual index of relative YOY abundance for southern kingfish derived from the fall component of the SEAMAP-SA Coastal Survey (Onslow, Raleigh, and Long bays, inner—shallow—strata), 1989–2018. Dotted line represents 2/3 of the average of the time series.

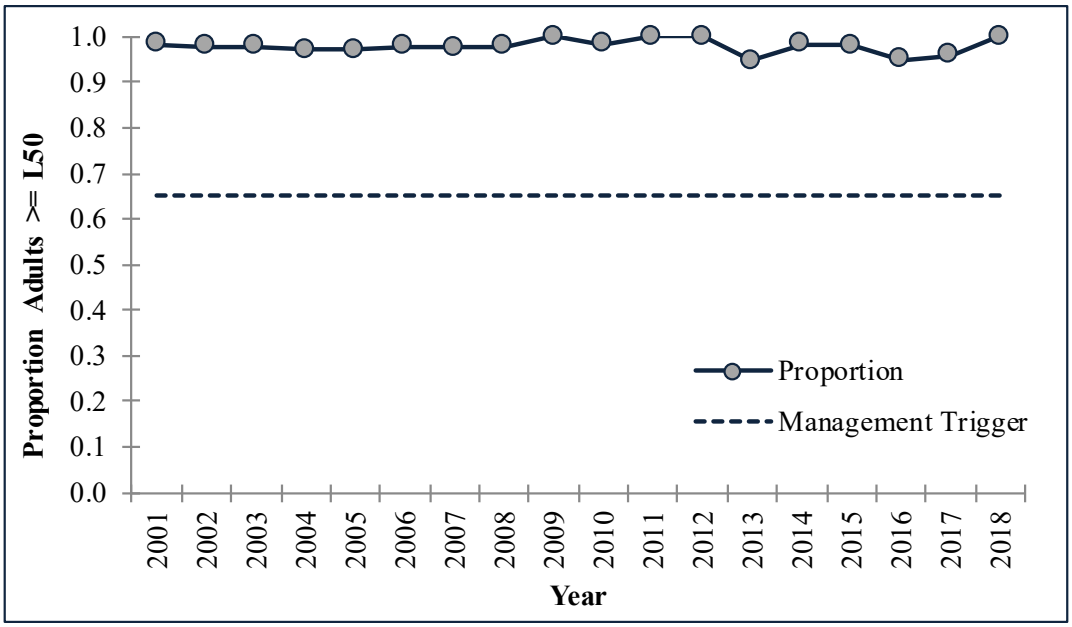

Figure 5. Annual proportions of adults (southern kingfish) greater than or equal to the length at 50% maturity occurring in the July through September component of the NCDMF Program 915 survey (Pamlico Sound, deep strata only), 2001–2018. Dotted line represents 2/3 of the average of the time series.

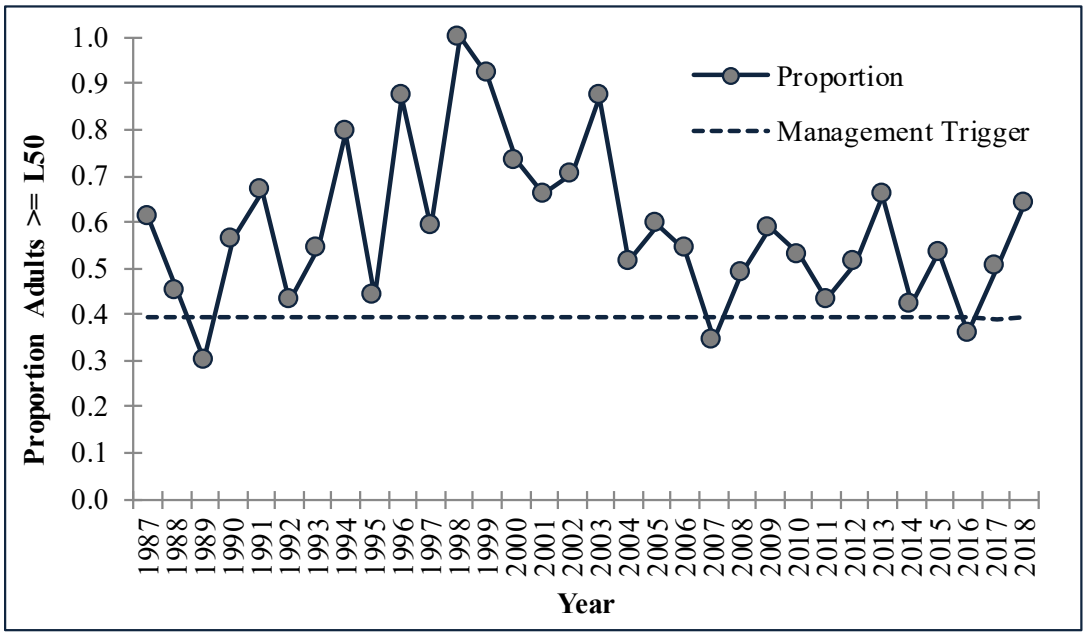

Figure 6. Annual proportions of adults (southern kingfish) greater than or equal to the length at 50% maturity occurring in the June component of the NCDMF Program 195 survey (excluding strata from the Neuse, Pamlico, and Pungo rivers), 1987–2018. Dotted line represents 2/3 of the average of the time series.

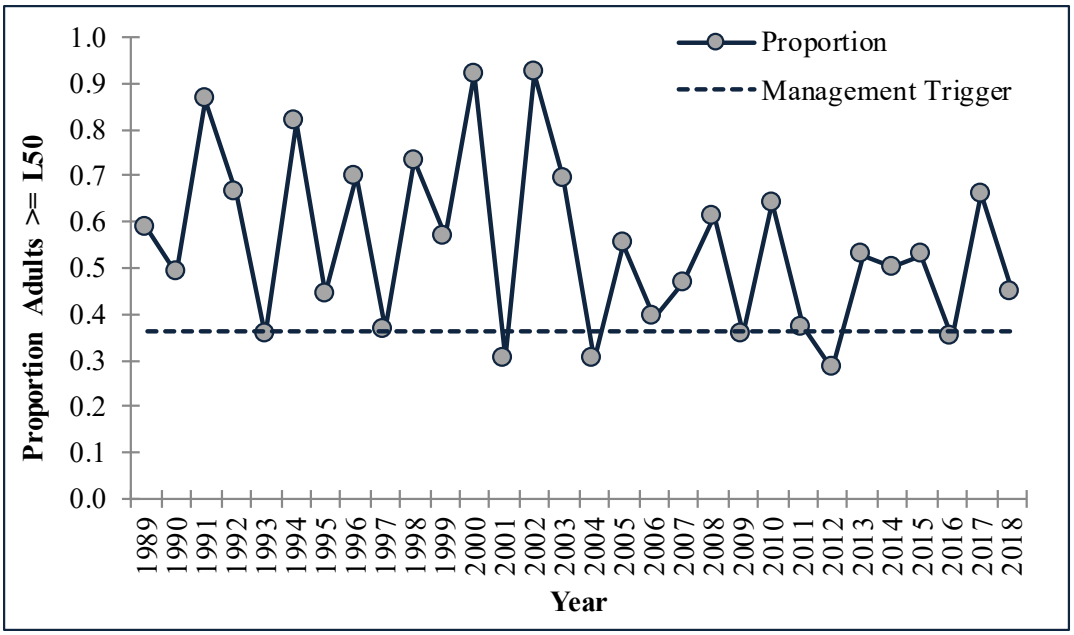

Figure 7. Annual proportions of adults (southern kingfish) greater than or equal to the length at 50% maturity occurring in the summer component of the SEAMAP-SA Coastal Survey (Onslow, Raleigh, and Long bays, inner—shallow—strata), 1989–2018. Dotted line represents 2/3 of the average of the time series.

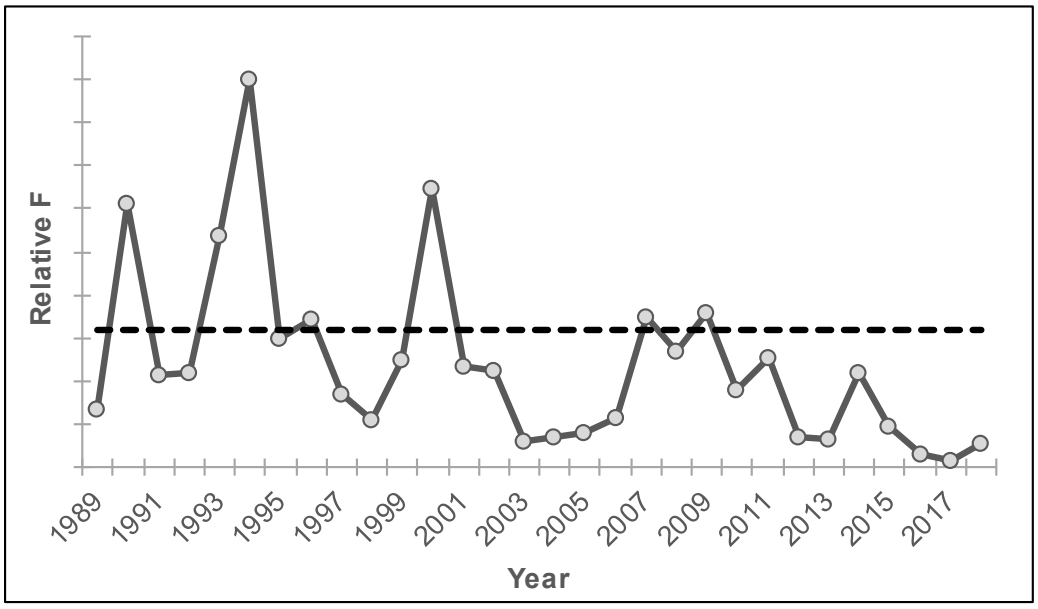

Figure 8. Relative *F*, as estimated as catch (commercial and recreational) divided by the SEAMAP-SA Coastal Survey spring index (Onslow, Raleigh, and Long bays, inner—shallow—strata) of relative abundance, 1989-2018. Dotted line represents 2/3 of the average of the time series.

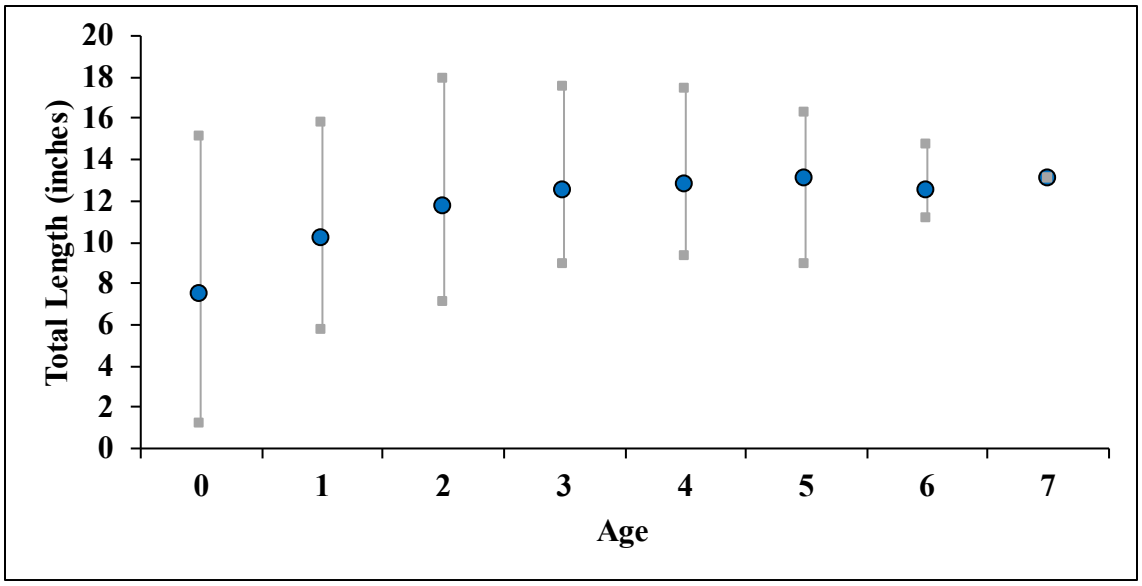

Figure 9. Kingfish length at age based on all samples collected, 1997 - 2018. Blue circles represent the mean size at a given age while the grey squares represent the minimum and maximum observed for each age.

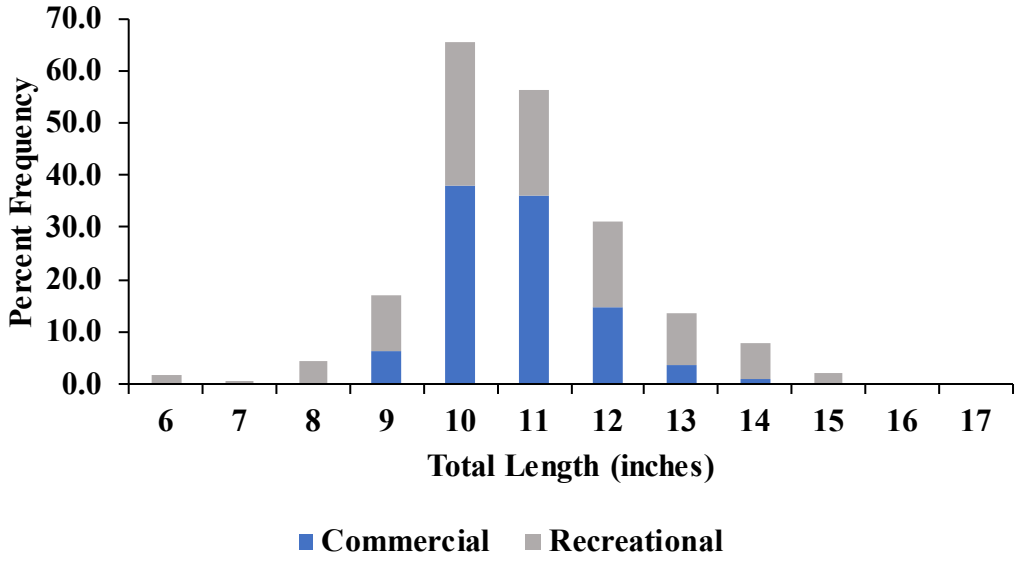

Figure 10. Commercial and recreational length frequency distribution of Kingfish harvested in 2018.

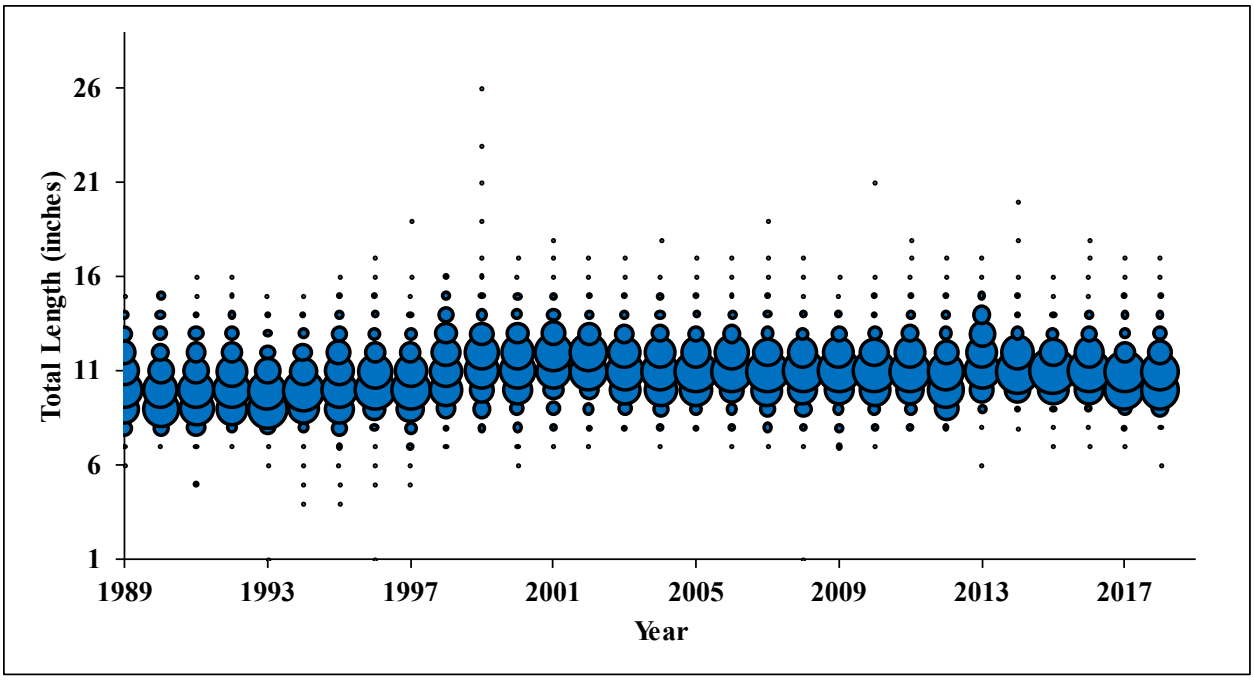

Figure 11. Commercial length frequency of Kingfish harvested, 1989-2018. Bubble represents the proportion of fish at length.

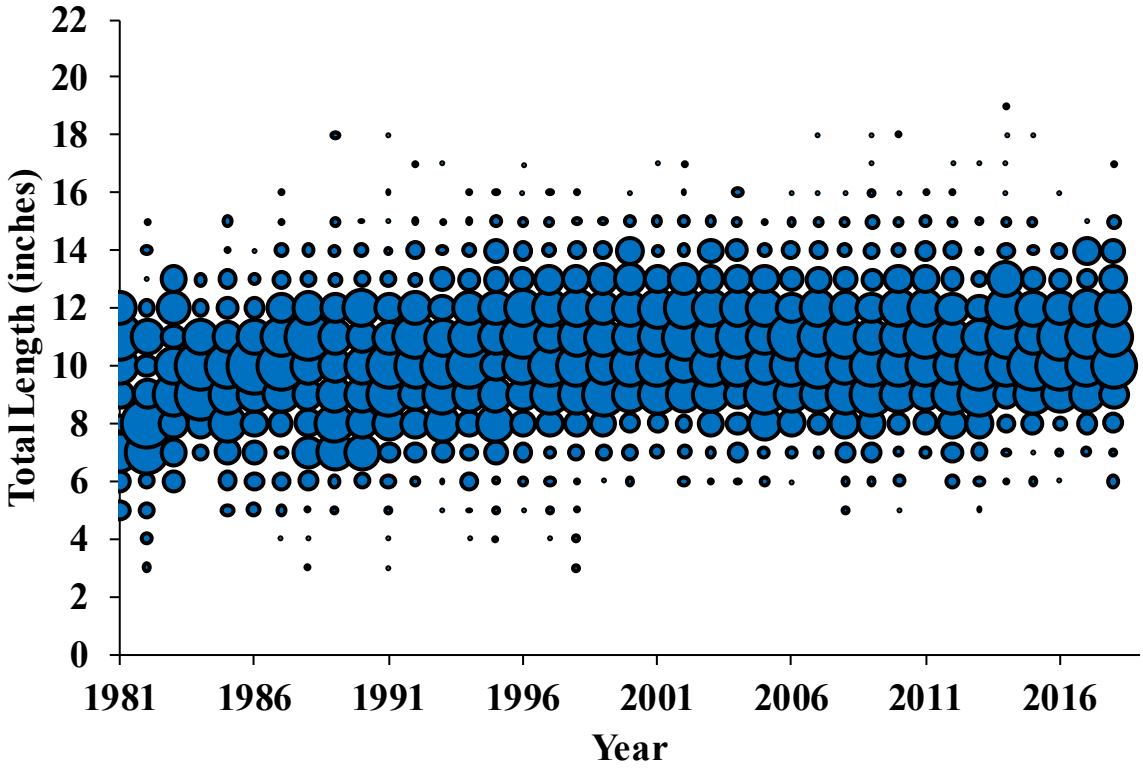

Figure 12. Recreational length frequency of Kingfish harvested, 1981-2018. Bubble represents the proportion of fish at length.

FISHERY MANAGEMENT PLAN UPDATE
RED DRUM
AUGUST 2019

STATUS OF THE FISHERY MANAGEMENT PLAN

Fishery Management Plan History

Original FMP Adoption:	March 2001
Amendments:	Amendment 1 – November 2008
Revisions:	None
Supplements:	None
Information Updates:	None
Recommended Schedule Change:	None
Benchmark Review:	Completed February 2017
Next MFC Scheduled Review:	July 2022

Red drum (*Sciaenops ocellatus*) in North Carolina are currently managed under Amendment 1 to the North Carolina Red Drum Fishery Management Plan (FMP) (NCDMF 2008). When Amendment 1 was developed, the 2007 stock assessment indicated that overfishing was not occurring in North Carolina (Takade and Paramore 2007). As a result, no new harvest restrictions for either the commercial or recreational fisheries were required when this amendment was adopted in 2008. Amendment 1 implemented regulations to reduce the impact of discard mortality. These included requiring circle hooks along with fixed weights and short leaders in the summer adult red drum recreational fishery in Pamlico Sound and further expanded the gill net attendance requirements that were originally implemented as part of the original 2001 North Carolina Red Drum FMP (NCDMF 2001).

Prior to Amendment 1, restrictive harvest measures due to overfishing were implemented through the 2001 North Carolina Red Drum FMP. These measures were first implemented in October of 1998, as interim measures, while the full plan was developed. Harvest restrictions included: restricting all harvest of red drum to fish between 18 and 27 inches total length (previously allowed one fish over 27 inches); implemented a one fish recreational bag limit (previously five fish bag limit); implemented a daily trip limit for the commercial fishery that is set by the North Carolina Division of Marine Fisheries (NCDMF) director (previously no daily limit); and maintained the existing 250,000-pound annual commercial cap. The trip limit was designed to reduce harvest and to deter targeting of red drum commercially. The original FMP also implemented seasonal small mesh gill net attendance requirements to reduce discard

mortality of red drum. The North Carolina Red Drum FMP was approved in March of 2001 and maintained all the interim measures. Stock assessments conducted since the implementation of the 2001 FMP have all indicated that management measures have been effective at preventing overfishing (Takade and Paramore 2007, SAFMC 2009, ASMFC 2017).

In addition to the state FMP, red drum in North Carolina also fall under Amendment 2 to the Atlantic States Marine Fisheries Commission (ASMFC) Red Drum FMP (ASMFC 2002). Adopted in 2002, Amendment 2 required all states to implement management measures projected to result in a 40% static spawning potential ratio (sSPR). Each state was required to implement these measures no later than January of 2003. Further, the plan also continues to require that states maintain management strategies that ensure that overfishing is not occurring and that optimum yield (OY) in the red drum fishery can be obtained. Amendment 2 compliance requirements to the states include:

- Implementing bag and size limits projected by bag and size limit analysis to achieve the minimum 40% sSPR.
- Establishing a maximum size limit of 27 inches or less in all red drum fisheries.
- Maintaining current or more restrictive commercial fishery regulations.
- Requires any commercial cap overages from one fishing year to be subtracted from the subsequent year's commercial cap.

The management measures already in place through the 2001 North Carolina Red Drum FMP were deemed sufficient to meet all the requirements of Amendment 2 to the ASMFC plan. Since that time, both the 2009 and 2017 assessments for red drum have indicated that the 40% static spawning potential ratio continues to be met or exceeded (SAFMC 2009, ASMFC 2017). Therefore, the ASMFC, to date, has continued with the current management strategy developed under Amendment 2.

To ensure compliance with interstate requirements, North Carolina also includes red drum as part of 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 plans) and the Atlantic Coastal Fisheries Cooperative Management Act (ASMFC plans) are like the goals of the Fisheries Reform Act of 1997 to "ensure long-term viability" of these fisheries (NCDMF 2015).

Management Unit

The Amendment 1 to the North Carolina Red Drum FMP applies to all joint and coastal waters throughout North Carolina, while the interjurisdictional plan through ASMFC applies to all states from Florida to Maine. Under the ASMFC plan, the management unit for red drum along the Atlantic coast is divided into a northern and southern stock. North Carolina and all areas north along the Atlantic coast represent the northern stock.

Goal and Objectives

The goal of Amendment 1 to the North Carolina Red Drum FMP is to prevent overfishing in the red drum stocks by allowing the long-term sustainable harvest in the red drum fishery. To achieve these goals, the FMP lists the following objectives:

1. Achieve and maintain a minimum overfishing threshold where the rate of juvenile escapement to the adult stock is sufficient to maintain the long-term sustainable harvest in the fishery.
2. Establish a target spawning potential ratio to provide the optimum yield from the fishery in order to maintain a state FMP that is in compliance with the requirements of the ASMFC Red Drum FMP.
3. Continue to develop an information program to educate the public and elevate their awareness of the causes and nature of problems in the red drum stock, its habitat and fisheries, and explain the rationale for management efforts to solve these problems.
4. Develop regulations that while maintaining sustainable harvest from the fishery, considers the needs of all user groups and provides adequate resource protection.
5. Promote harvest practices that minimize the mortality associated with regulatory discards of red drum.
6. In a manner consistent with Coastal Habitat Protection Plan, restore, improve and protect essential red drum habitat and environmental quality to increase growth, survival, and reproduction of red drum.
7. Improve our understanding of red drum population dynamics and ecology through the continuation of current studies and the development of better data collection methods, as well as, through the identification and encouragement of new research.
8. Initiate, enhance, and continue studies to collect and analyze the socio-economic data needed to properly monitor and manage the red drum fishery.

STATUS OF THE STOCK

Life History

Red drum are estuarine dependent members of the drum family that includes Atlantic croaker, spot, black drum, weakfish and spotted sea trout. Ranging from Florida to Massachusetts along the Atlantic coast, red drum are most abundant from Virginia to Florida. Red drum, also called channel bass, are common throughout the coastal waters of North Carolina and is the state's saltwater fish. Large red drum (up to 90 pounds) inhabit the coastal waters throughout the year, are often observed in the surf during the spring and fall seasons and commonly found in the Pamlico Sound during the summer months. Spawning takes place in the fall around coastal inlets and in Pamlico Sound. Larval and juvenile red drum use various shallow estuarine habitats in coastal sounds and rivers during the first few years of life. Upon maturity (age 4 and around 32 inches in length), red drum move out of the estuaries to join the adult spawning stock in the ocean. Red drum are a long-lived species commonly reaching ages in excess of 40 years. The oldest red drum recorded was taken in North Carolina and was 62 years old. Red drum are

opportunistic feeders and diet can shift with changes in age and habitat. Various types of small crabs and shrimp make up a large portion of juvenile red drum diets; while crabs and shrimp continue to make up a portion of the adult diet, adults will also frequently eat various fish species.

Stock Status

The new 2017 benchmark stock assessment indicates that the red drum stock in North Carolina is not experiencing overfishing (ASMFC 2017). The overfished status remains undetermined due to uncertainty in the adult stock size estimates.

Stock Assessment

Only the overfishing and not the overfished status can currently be determined for red drum. The threshold (below which the stock is experiencing overfishing) and the target fishing mortality rates correspond to those rates that achieve 30% and 40% static spawning potential ratio. Static spawning potential ratio is a measure of spawning stock biomass survival rates when fished at the current years' fishing mortality rate relative to the spawning stock biomass survival rates if no fishing mortality was occurring. An assessment was last completed by the ASMFC in 2017. Based on the results of this assessment the static spawning potential ratio was at or above target levels (Figure 1). Management measures have effectively controlled fishing mortality to a level sufficient to meet management targets. It is critical to note that reaching the target is only the first step in maintaining this fishery. For the red drum stock to be considered healthy and viable, the 40% static spawning potential ratio must be maintained continuously over time. Increases in the harvest rates (relaxation of current regulations) of red drum should only be allowed if those increases are not anticipated to lower the static spawning potential ratio below the management goal (40%). Reviewer comments from the most recent stock assessment provide caution that relaxation of current regulations, particularly those that increase fishing mortality on adult red drum, could quickly lead to an overfishing status (ASMFC 2017).

STATUS OF THE FISHERY

Current Regulations

All harvest is limited to red drum between an 18-inch total length minimum size and 27-inch total length maximum size for both the recreational and commercial fisheries. The recreational bag limit is one fish per day. A daily commercial bycatch allowance and an annual cap of 250,000 pounds, with payback of any overage, constrain the commercial harvest. The commercial annual cap is monitored from September 1 to August 31. Within a fishing year, 150,000 pounds is allocated to the period between September 1 and April 30 and the remainder is allocated to the period of May 1 to August 31. Check with the NCDMF for the most recent proclamation on red drum harvest limits including trip limits and bycatch requirements.

Commercial Landings

North Carolina's commercial landings in 2018 were 144,464 pounds; below 2017 landings (186,907 pounds) and 10-year mean (154,209 pounds; Table 1 and Figure 2). Since 1989, landings have fluctuated but have generally been constrained by commercial harvest cap of 250,000 pounds. Gill nets have traditionally dominated the harvest of red drum in the commercial fishery. In 2018, gill nets accounted for 89% of the commercial landings (Figure 4).

Amendment 2 to the North Carolina Red Drum FMP maintained the 250,000-pound annual cap in the commercial fishery, but shifted the commercial fishing year to September 1 through August 31. Since that time, North Carolina's commercial landings during this fishing year have averaged 146,941 pounds. The 2007/2008, 2009/2010 and 2013/2014 fishing years had overages (Table 2). All overages were deducted from the following year's cap allowance. The 2017/2018 fishing year resulted in 198,401 pounds of red drum landings, well below the 250,000-pound annual cap.

Recreational Landings

Recreational fishing activity is monitored through the Marine Recreational Information Program. In this report, estimates across all years have been updated and are now based on the MRIP new Fishing Effort Survey-based calibrated estimates. For more information on MRIP methodology changes see https://www.fisheries.noaa.gov/topic/recreational-fishing-data. Recreational landings in 2018 were 1,452,358 pounds; above the 2008-2017 10-year average (1,126,775 pounds) and very near 2017 landings (1,475,852 pounds; Table 1 and Figure 2). Releases totaled 1,729,260 fish in 2018; slightly below the ten-year average of 1,982,133 fish but well above the time-series average of 1,011,018 (Table 1). Recreational releases have increased over time averaging around 250,000 releases per year for the period of 1989 to 1998 compared to nearly 2 million releases per year in the most recent 10-year period (2009-2018).

The NCDMF offers award citations for exceptional catches of red drum. Red drum captured and released that measure greater than 40 inches total length are eligible for an award citation. Since 1991, award citations for red drum have been steadily increasing from just over 300 awarded in 1991 to a time-series high of 2,884 awarded in 2018 (Figure 3).

MONITORING PROGRAM DATA

Fishery-Dependent Monitoring

Commercial fishing activity is monitored through fishery dependent sampling conducted by the NCDMF since 1982. Data collected in this program allow the size and age distribution of red drum to be characterized by gear/fishery. Predominant fisheries for red drum include estuarine gill nets, long haul seine/swipe nets, pound nets, and beach haul seines. Over the past decade gill nets have been the dominant gear used for red drum accounting for >90% of the overall harvest. In 2018, 89% of the red drum harvest was taken in gill nets, followed by pound nets with 9% (Figure 4). In all, 561 red drum, primarily from set gill nets, were measured from the commercial fishery in 2018 (Table 3). The average size was 23 inches fork length. Average size has varied little over time ranging from 17 to 23 inches fork length since 1989. Due to the slot limit of 18 to 27 inches' total

length, red drum harvested in both the commercial and recreational fishery are of similar size (Figure 5). In the commercial fishery, a shift in the size of harvest is apparent between 1991 and 1992, when the minimum size limit was increased from 14 to 18 inches (Figure 6). Additionally, as the harvest of larger fish was disallowed during the 1990's, fish above 27 inches are now rarely observed. With the current slot limit on harvest for both the commercial and recreational fisheries, nearly all landings consist of age-1 and age-2 fish. Similar to the commercial fishery, average size varies little from year to year in the recreational fishery (Table 4; Figure 7). Harvest of red drum over 27 inches was eliminated in 1998, although occasional larger fish are still sometimes observed in the recreational harvest (Figure 7). In 2018, the average size recreational fish harvested was 23 inches fork length. From 1989 to 2017 this range varied little (17 to 23 inches fork length).

Fishery-Independent Monitoring

The NCDMF has conducted a juvenile red drum seine survey on an annual basis since 1991. The seine survey provides an index of abundance for juvenile (age-0) red drum with sampling occurring from September through November. The relative abundance of juvenile red drum is highly variable with both high and low abundance occurring in recent years (Figure 8). In 2018, 1,146 juvenile red drum were taken in 111 seine samples for an overall state mean catch per unit effort (CPUE) of 10.32 red drum per haul. The 2018 overall mean CPUE was higher than 2017 (2.72) and well above the long term average of the survey of 10.32 (Figure 8). Information gathered from this survey is currently used as an input parameter in the ASMFC Atlantic coast red drum stock assessment.

A fishery independent gill net survey was initiated by the NCDMF in May of 2001. The survey uses a stratified random sampling scheme designed to characterize the size and age distribution for key estuarine species in Pamlico Sound. By continuing a long-term database of age composition and developing an index of abundance for red drum this survey will help managers assess the red drum stocks without relying solely on commercial and recreational fishery dependent data. The overall red drum CPUE was 1.38 red drum per set in 2018, lower than the time series average of 2.78 (Figure 9). The survey is currently used in the ASMFC Atlantic coast red drum stock assessment as an annual index of relative abundance for age-1 and age-2 red drum.

North Carolina initiated an adult red drum longline survey in 2007 that has operated continuously since. The primary objective of the survey is to provide a fisheries independent index of abundance for adult red drum occurring in North Carolina. From July through October, a standardized, stratified random sample design is employed. A standard sample consists of 1,500 meters of mainline set with 100 gangion placed at 15 meter intervals (100 hooks/set). Soak times are approximately 30 minutes. All random sampling takes place in Pamlico Sound. During the 2018 season, 388 red drum were captured out of 70 stratified random sets (5.54 red drum per set) which is slightly above the time series average of 4.94 red drum per set (Figure 10). Red drum ranged from 29 to 48 inches fork length with most being >40 inches in length. Sampling is scheduled to continue in 2019 and this survey is used in the ASMFC red drum stock assessment.

In order to describe the age structure of harvest and indices, red drum age structures are collected from various fishery independent (scientific surveys) and dependent (fisheries) sources throughout the year. In 2018, 594 red drum were collected ranging in age from 0 to 42 years

(Table 5). The majority of red drum collected from harvest (18 to 27 inches total length) are ages 1 to 3. Red drum over 27 inches are protected by no harvest in North Carolina, a measure designed to protect the spawning portion of the population. Red drum in North Carolina are long-lived with the oldest red drum being aged at 62 years. Growth in length is rapid for the first several years of life and then slows as fish reach maturity (100% mature by age 4 and 32 inches total length). Beyond age-4, the relationship of length and age for red drum is less predictable with much overlap in age for a given length (Figure 11).

MANAGEMENT STRATEGY

Red drum in North Carolina are managed under Amendment 1 to the North Carolina Red Drum FMP and Amendment 2 to the ASMFC Red Drum FMP. Both plans have an identical management threshold (overfishing) and management target (30% and 40% static spawning potential ratio). Stock status is determined by a formal, peer reviewed stock assessment. Amendment 2 to the ASMFC Red Drum FMP requires specific compliance criteria, including harvest restrictions designed to achieve the management target. Any changes to harvest that deviate from those options provided in this plan must be approved by the ASMFC South Atlantic Board. Amendment 1 to the North Carolina Red Drum FMP maintained measures for compliance and also implemented measures to reduce losses from discards in both the recreational and commercial fisheries (Table 6).

RESEARCH NEEDS

The following management and research needs are summarized from Amendment 1 to the North Carolina Red Drum FMP (status of need provided in parenthesis).

- Assess the size distribution of recreational discards (needed).
- Improved catch and effort data for the red drum recreational fishery, particularly for the fishery that occurs at night (needed).
- Development of independent surveys to monitor both the sub-adult and adult red drum populations. (ongoing through NCDMF gillnet and longline surveys).
- Continued life history studies for age and growth. Additional work needed to update maturity schedule and collect diet information specific to North Carolina (age and growth ongoing through NCDMF; maturity through NCDMF; recent diet work through NCSU).
- Identification of spawning areas in North Carolina (studies conducted for Pamlico Sound, additional work needed).
- Characterize the adult recreational fishery with regard to tackle, geographic location, bait, water temperature, seasonality, hook types, etc. (needed).
- Obtain discard estimates from the commercial fisheries including information on size and disposition (ongoing through NCDMF observer program, recent expanded coverage).
- Collect data to determine the catch rates of red drum and targeted species with regard to distance from shore in the gill net fishery (needed, some data through Fishery Resource Grants and NCDMF Independent Gill Net Survey)
- Conduct a comprehensive study of gill net fishers including information on species targeted, gear characteristics and areas fished (needed, valuable ongoing data from fish house sampling and commercial observer program).

- Conduct studies to explore ways to reduce red drum regulatory discards with commercial gear while allowing the retention of targeted species (needed).
- Conduct additional research to determine the release mortality of red drum captured in gill nets (needed).
- Economic analysis of the adult red drum fishery (needed).
- Improved social and economic data collection on the recreational and commercial fishery, including information on current conflicts and potential for future conflicts in these fisheries (needed).
- Determine juvenile habitat preference and examine if recruitment is habitat limited (needed; study conducted by UNCW).
- Examine ecological use and importance of shell bottom to red drum (Needed; some work through CRFL by UNC).
- Identify coastal wetlands and other habitats utilized by juvenile red drum and assess relationship between changes in recruitment success and changes in habitat conditions (needed).
- Assess cumulative impact of large-scale beach nourishment and inlet dredging on red drum and other demersal fish that use the surf zone (needed).
- Determine location and significance of spawning aggregation sites throughout the coast (needed).
- Determine if navigational dredging between August and October significantly impacts spawning activity (needed).
- Determine if designation of spawning areas is needed, and if specific protective measures should be developed (needed).

FISHERY MANAGEMENT PLAN SCHEDULE RECOMMENDATION

The management program currently in place for red drum has resulted in a stock that has met ongoing management targets. Therefore, the division recommended and the Marine Fisheries Commission accepted the 2016 annual FMP update as the formal review of Amendment 1 to the North Carolina Red Drum FMP. All management strategies that have led to management targets being met will be maintained as outlined in both the state FMP and the ASMFC FMP. Stock conditions will be monitored and reported through each subsequent annual FMP update and the Marine Fisheries Commission will continue to have the option to modify the review schedule annually. The next scheduled formal review of this plan will begin in July 2022.

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Takade, H and L Paramore. 2007. Stock Status of the Northern Red Drum Stock. North Carolina Division of Marine Fisheries. In-House Report, 60 pp.

TABLES

Table 1. Red drum recreational harvest and number released (Marine Recreational Information Program) and commercial harvest (North Carolina Trip Ticket Program) for 1989-2018. All weights are in pounds.

	Recreational				
	Numbers		Weight (lb)		
Year	Landed	Released	Landed	Commercial Weight (lb)	Total Weight (lb)
1989	234,788	15,246	718,961	274,356	993,317
1990	98,374	46,812	261,688	183,216	444,904
1991	111,787	336,524	345,911	96,045	441,956
1992	48,099	140,866	233,100	128,497	361,597
1993	107,235	442,230	538,175	238,099	776,274
1994	72,245	185,906	349,317	142,169	491,486
1995	151,145	373,695	692,063	248,122	940,185
1996	90,177	97,663	391,364	113,338	504,702
1997	22,829	426,993	98,079	52,502	150,581
1998	164,693	388,288	843,571	294,366	1,137,937
1999	151,062	633,951	701,002	372,942	1,073,944
2000	127,165	443,747	655,251	270,953	926,204
2001	57,929	538,370	290,901	149,616	440,517
2002	127,559	1,515,679	571,102	81,370	652,472
2003	73,202	215,277	359,181	90,525	449,706
2004	58,543	369,326	245,163	54,086	299,249
2005	103,275	967,892	470,914	128,770	599,684
2006	127,412	1,042,564	569,699	169,206	738,905
2007	157,577	818,037	789,430	243,658	1,033,088
2008	112,938	1,510,133	523,607	229,809	753,416
2009	214,317	1,238,158	1,028,339	200,296	1,228,635
2010	179,828	1,670,693	835,143	231,828	1,066,971
2011	156,484	587,369	737,853	91,980	829,833
2012	152,005	4,939,534	648,342	66,519	714,861
2013	520,758	1,892,171	2,214,045	371,949	2,585,994
2014	324,303	1,086,967	1,674,595	90,650	1,765,245
2015	143,876	1,308,072	567,730	80,397	648,127
2016	169,195	3,203,452	633,496	77,101	710,597
2017	353,716	2,165,656	1,475,852	186,907	1,662,759
2018	299,577	1,729,260	1,452,358	144,464	1,596,822
Average	157,070	1,011,018	671,168	170,124	867,332

Table 2. North Carolina's annual commercial harvest based on a fishing year beginning September 1 and ending August 31. September 1 fishing year began through FMP in 2001/2002 fishing year.

Fishing Year	Landings (lb)	Annual Cap
2001/2002	61,504	250,000
2002/2003	105,704	250,000
2003/2004	70,175	250,000
2004/2005	61,838	250,000
2005/2006	159,379	250,000
2006/2007	172,166	250,000
2007/2008	326,211	250,000
2008/2009*	134,161	173,789
2009/2010	275,924	250,000
2010/2011**	126,185	224,142
2011/2012	94,298	250,000
2012/2013	134,372	250,000
2013/2014	262,756	250,000
2014/2015***	140,887	237,244
2015/2016	64,159	250,000
2016/2017	109,878	250,000
2017/2018	198,401	250,000
Average	146,941	

*adjusted to pay back overage in 2007/2008 fishing year
**adjusted to pay back overage in 2009/2010 fishing year
*** adjusted to pay back overage in 2013/2014 fishing year

Table 3. Red drum length (fork length, inches) data from commercial fish house samples, 1989-2018.

Year	Mean Fork Length	Minimum Fork Length	Maximum Fork Length	Total Number Measured
1989	22	11	51	123
1990	17	13	46	511
1991	18	12	48	183
1992	23	11	49	311
1993	23	16	45	602
1994	23	12	41	142
1995	22	16	31	496
1996	23	16	26	120
1997	20	10	37	272
1998	19	12	37	1,082
1999	21	13	30	1,008
2000	22	16	31	725
2001	22	17	28	419
2002	21	13	30	483
2003	21	17	28	387
2004	22	16	28	326
2005	21	14	28	811
2006	22	14	29	1,258
2007	22	16	31	1,502
2008	23	13	29	1,206
2009	22	14	35	1,166
2010	22	14	31	1,134
2011	22	17	31	646
2012	21	16	28	359
2013	21	12	27	1,664
2014	23	18	28	444
2015	23	17	28	429
2016	21	16	27	681
2017	21	17	28	672
2018	23	12	28	561

Table 4. Red drum length (fork length, inches) data from Marine Recreational Information Program recreational samples, 1989-2018.

Year	Mean Fork Length	Minimum Fork Length	Maximum Fork Length	Total Number Measured
1989	19	13	44	101
1990	17	15	39	73
1991	18	11	42	101
1992	22	17	43	42
1993	22	10	41	117
1994	23	12	40	90
1995	22	18	29	240
1996	21	14	30	114
1997	20	9	44	30
1998	22	15	42	534
1999	23	15	27	199
2000	23	18	26	130
2001	23	17	26	73
2002	21	18	29	86
2003	22	19	26	52
2004	21	18	27	38
2005	22	18	26	48
2006	22	14	30	79
2007	22	17	27	71
2008	22	16	27	90
2009	23	18	28	136
2010	21	11	27	193
2011	22	17	29	147
2012	22	14	41	132
2013	21	17	28	333
2014	23	17	28	316
2015	22	14	27	95
2016	20	12	28	102
2017	21	8	27	288
2018	23	17	28	206

Table 5. Summary of red drum age samples collected from both dependent (commercial and recreational fisheries) and independent (surveys) sources from 1989-2018.

Year	Modal Age	Minimum Age	Maximum Age	Total Number Aged
1989	1	0	56	312
1990	1	0	52	345
1991	1	0	48	259
1992	1	0	56	440
1993	1	0	62	428
1994	1	0	41	297
1995	1	0	47	482
1996	1	0	54	383
1997	1	0	56	465
1998	1	0	31	612
1999	1	0	26	530
2000	1	0	17	470
2001	1	0	41	466
2002	1	0	24	361
2003	1	0	28	262
2004	1	0	25	342
2005	1	0	34	484
2006	1	0	32	641
2007	1	0	37	495
2008	1	0	35	574
2009	1	0	36	644
2010	1	0	37	516
2011	1	0	38	256
2012	1	0	39	605
2013	1	0	41	721
2014	1	0	41	560
2015	1	0	42	428
2016	1	0	38	653
2017	1	0	39	726
2018	1	0	42	594

Table 6. Management action taken as a result of Amendment 1 to the N.C. Red Drum FMP.

MANAGEMENT STRATEGY	OUTCOME
Adult harvest limits: Status quo (no harvest over 27 inches TL)	No action required
Recreational targeting of adult red drum: It is unlawful to use any hook larger than 4/0 from July 1 through September 30 in the internal coastal fishing waters of Pamlico Sound and its tributaries south of the Albemarle Sound Management Area as defined in 15A NCAC 03R .0201 and north of a line beginning at a point 34° 59.7942' N - 76° 14.6514' W on Camp Point; running easterly to a point at 34° 58.7853' N - 76° 09.8922' W on Core Banks while using natural bait from 7:00 p.m. to 7:00 a.m. unless the terminal tackle consists of: A circle hook defined as a hook with the point of the hook directed perpendicularly back toward the shank, and with the barb either compressed or removed. A fixed sinker not less than two ounces in weight, secured not more than six inches from the fixed weight to the circle hook. (also continued education on fishing methods that minimize risk to fish). During July through September, unlawful to use J-hooks larger than 4/0 while fishing natural bait in Pamlico Sound and its tributaries.	Rule change implemented 15A NCAC 03J .0306
Recreational bag and size limits: Status quo (one fish per day between 18 and 27 inches TL)	No action required

MANAGEMENT STRATEGY	OUTCOME
Commercial limits: Trip Limit and Bycatch Provision Status quo (7 fish trip limit with 50% bycatch provision). Director retains authority to modify trip limit and bycatch provision as needed.	Implemented by proclamation
Allow the possession of up to 3 fish while engaged in fishing without requiring that they be subject to the bycatch provision. Upon landing/sale all red drum possessed would be subject to bycatch provision.	
Commercial Cap: Continue 250,000 lb annual cap monitored from September 1 to August 31. Implement a split season on the annual commercial cap, capping the period of September 1 to April 30 at 150,000 lb and conserving the remaining portion of the cap for the period of May 1 to August 31. Unused cap in period one would be available for period two. Any annual commercial harvest limit that is exceeded one year will result in the poundage overage being deducted from the subsequent year's commercial harvest limit.	Rule change implemented 15A NCAC 03M .0501
Estuarine gill net discarded bycatch of red drum: Small Mesh Attendance (<5" stretch mesh) Year-round Attendance Expand year-round attendance within 200 yards of shore to include the area of the lower Neuse out to the mouth of the river.	Rule change implemented 15A NCAC 03R .0112
Seasonal Attendance Modify the seasonal attendance requirements for small mesh gill nets (currently May 1 to October 31) to include the period of May 1 through November 30 in the following locations: a) All primary and permanent secondary nursery areas and modified no-trawl areas	Rule change implemented 15A NCAC 03J .0103 & 15A NCAC 03R .0112

MANAGEMENT STRATEGY	OUTCOME
b) Within 200 yards of any shoreline for the areas of Pamlico, Pungo, Neuse and Bay Rivers and bays c) Within 50 yards of any shoreline in the areas of Pamlico and Core Sound south to the NC/SC line d) Area Core Sound and south is excluded from 50 yard shoreline attendance requirement during October and November	
Modification to current small mesh seasonal attendance area along the Outer Banks (i.e. modified no-trawl area)	Rule change implemented 15A NCAC 03R .0112
Large Mesh (>5" stretch mesh) Require all unattended large mesh gill nets to be set a minimum of 10 feet from any shoreline from June through October	Rule change implemented 15A NCAC 03J .0103
The use of gigs, gaffs or spears to take red drum: Continue to prohibit and move Proclamation FF-40-2001 into rule	Rule change implemented 15A NCAC 03M .0501

FIGURES

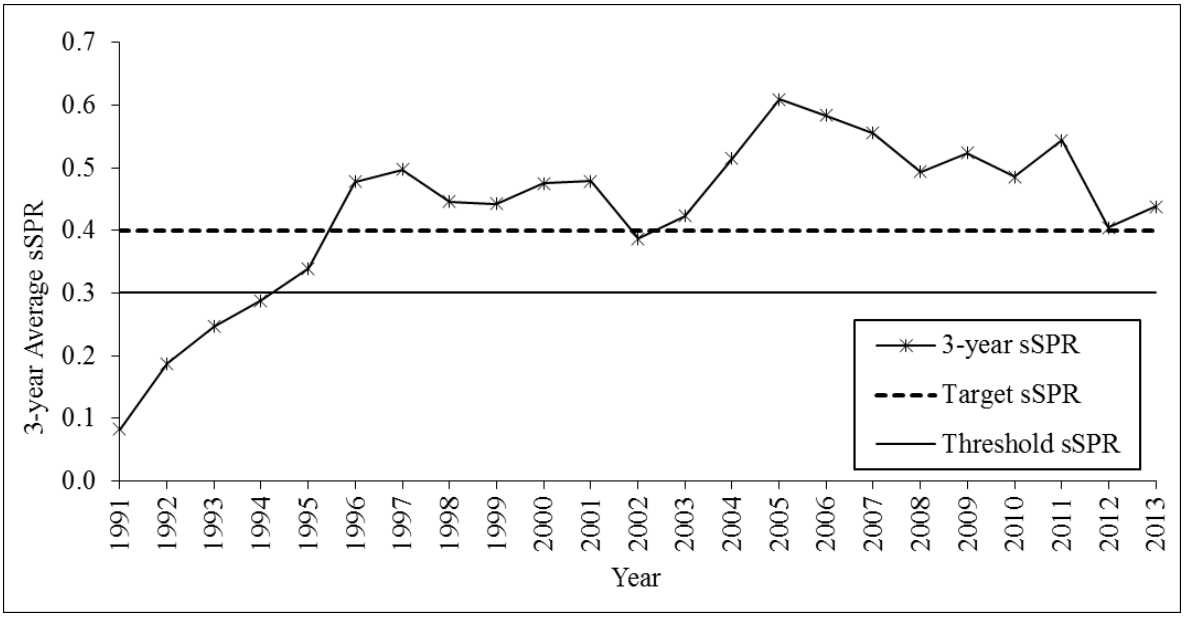

Figure 1. Northern region (North Carolina north) red drum estimates of three-year average static spawning potential ratios (sSPR). Three-year average includes current and previous two year's sSPR estimates. The dashed line shows the 30% overfishing threshold and the solid line shows the 40% target sSPR.

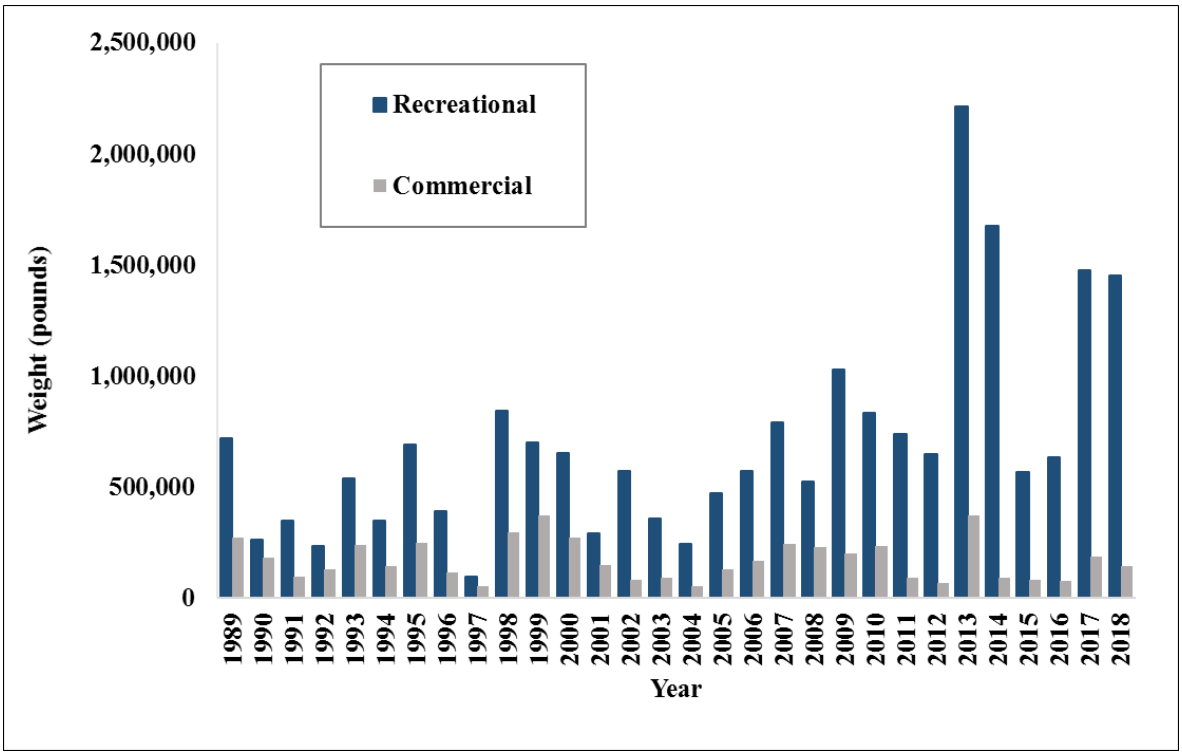

Figure 2. Annual commercial and recreational landings in pounds for red drum in North Carolina from 1989 to 2018.

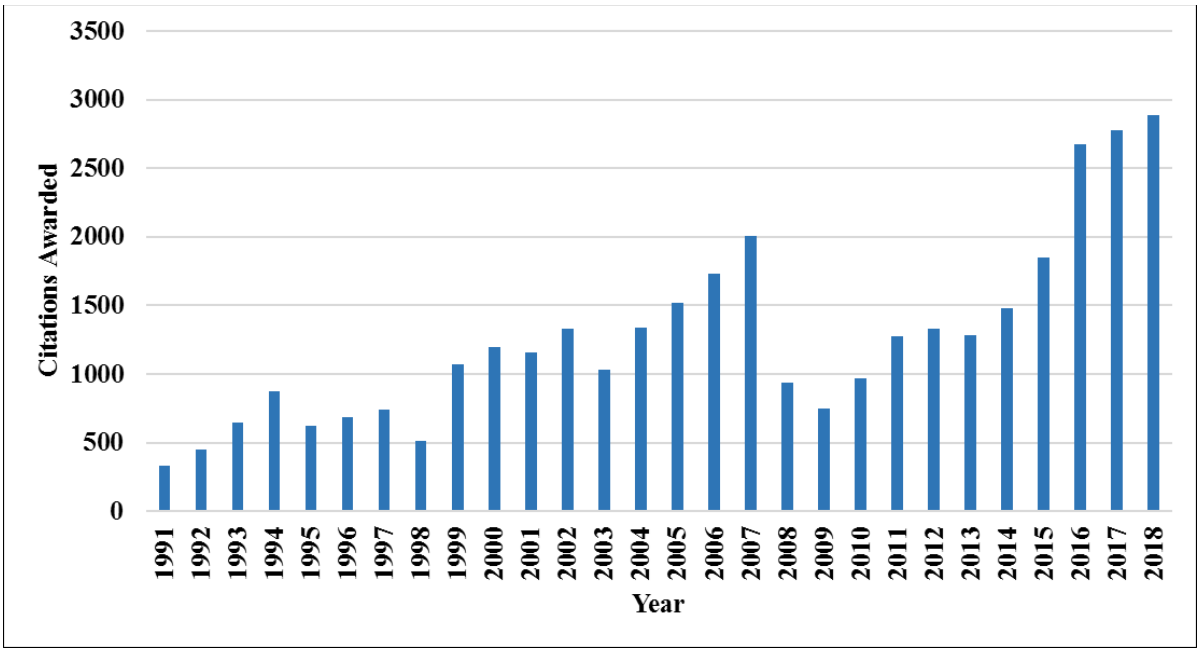

Figure 3. North Carolina Saltwater Fishing Tournament citations awarded for red drum from 1991 to 2018. Citations are awarded for red drum greater than 40 inches total length. Prior to 1998 citations were awarded for either a red drum released (≥40 inches total length) or harvested (≥40 pounds). Since 1998, all citations are for released fish only.

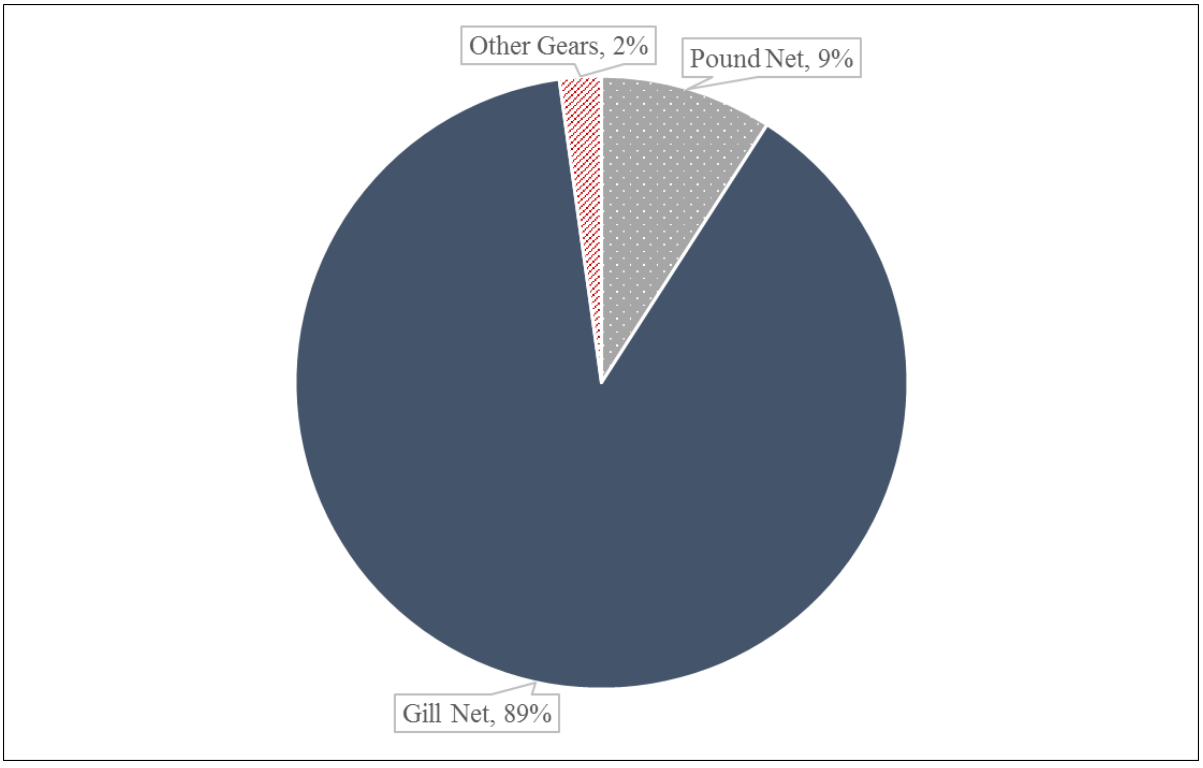

Figure 4. Red drum commercial harvest in 2018 by gear type.

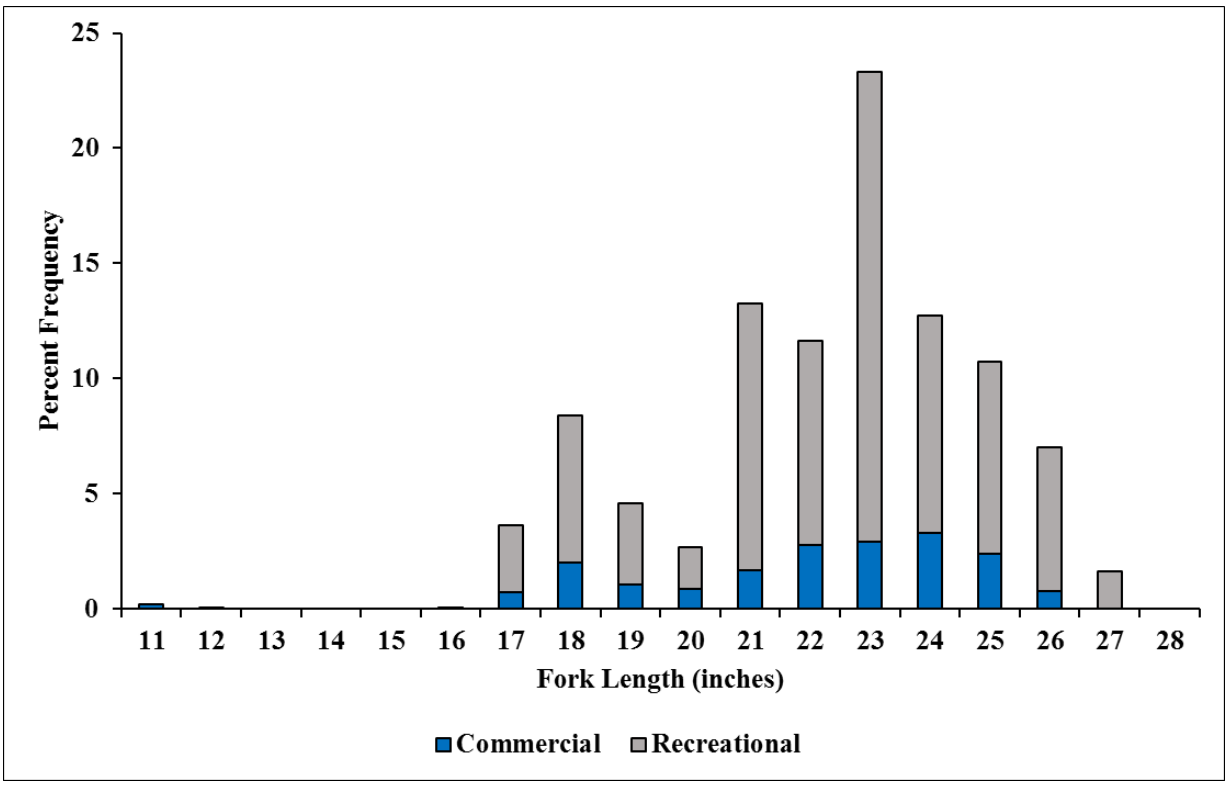

Figure 5. Commercial and recreational length frequency distribution from red drum harvested in 2018.

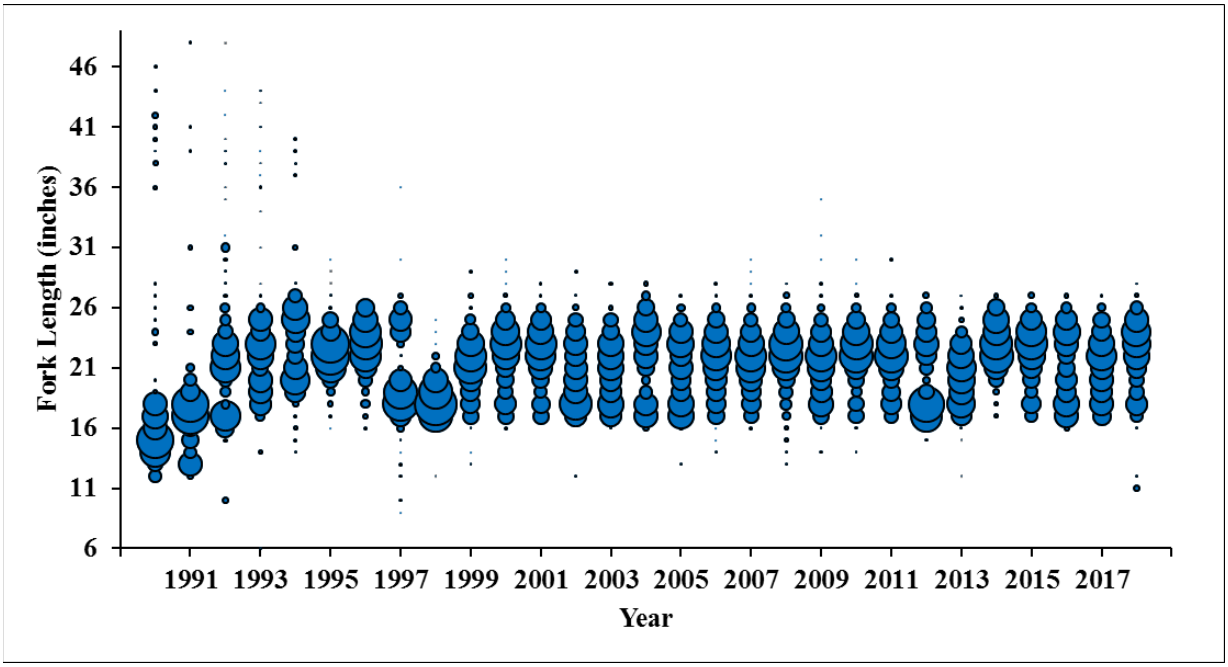

Figure 6. Commercial length frequency (fork length, inches) of red drum harvested from 1990 to 2018. Bubbles represent fish harvested at length and the size of the bubble is equal to the proportion of fish at that length.

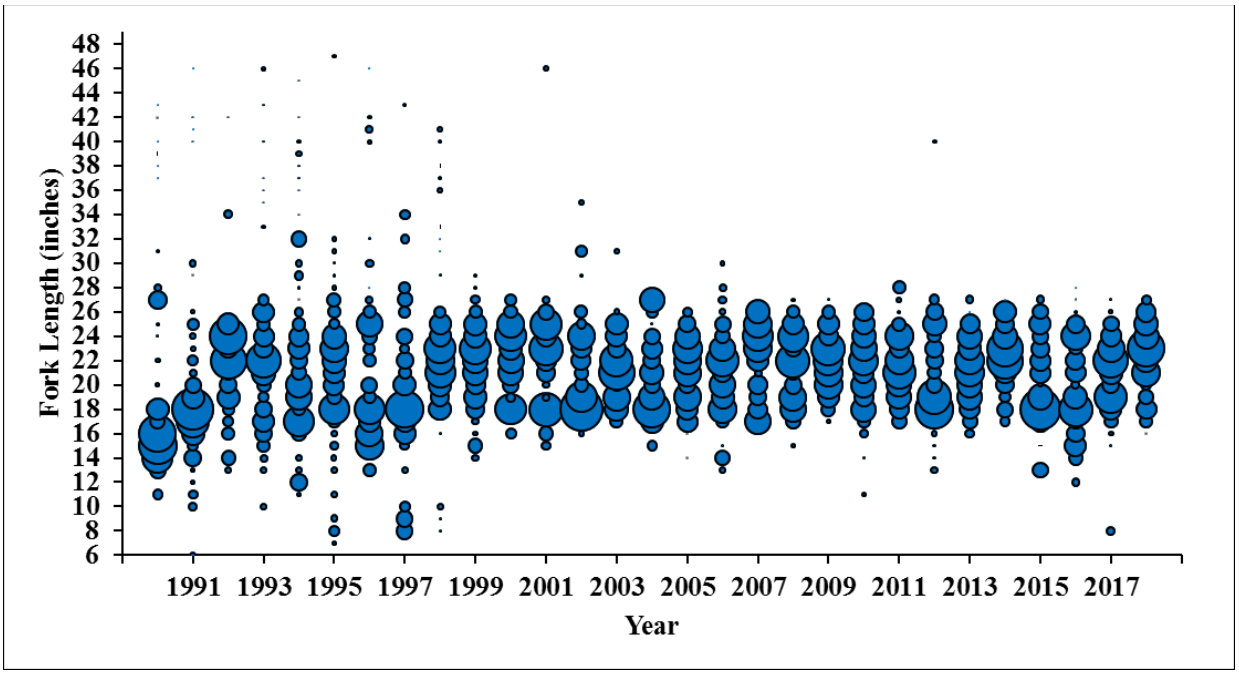

Figure 7. Recreational length frequency (fork length, inches) of red drum harvested from 1990 to 2018. Bubbles represent fish harvested at length and the size of the bubble is equal to the proportion of fish at that length.

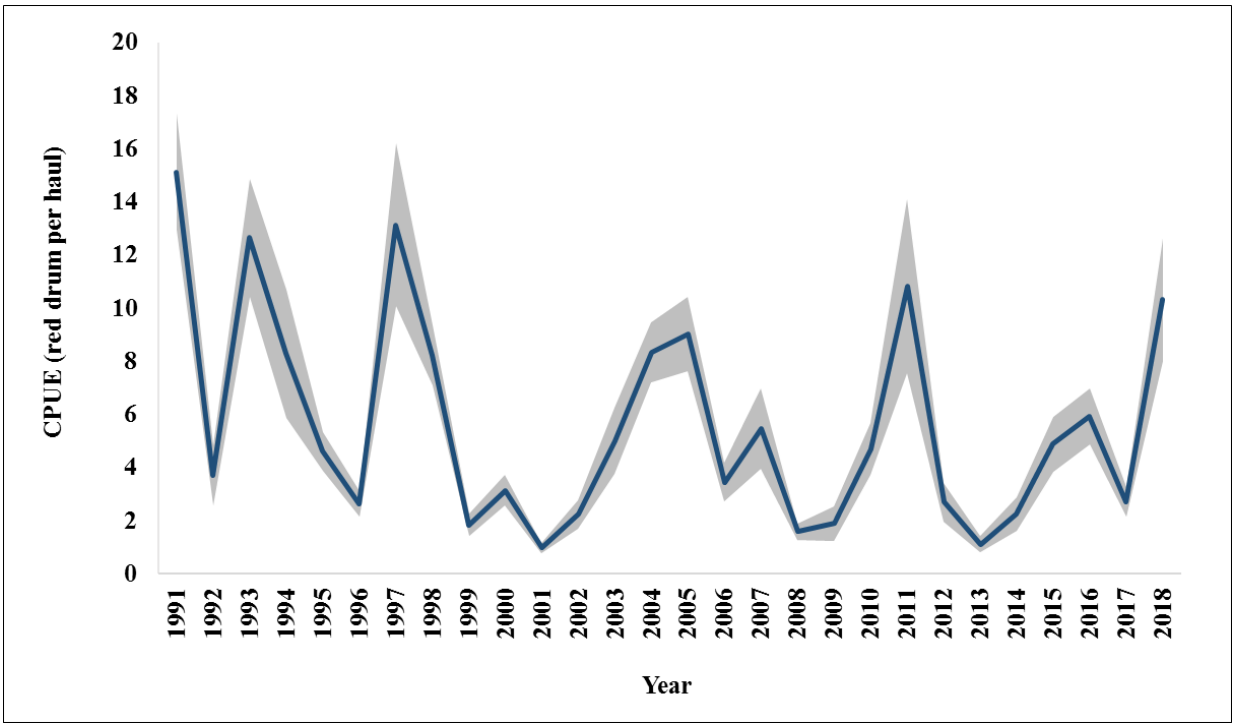

Figure 8. The annual juvenile (age-0) abundance index with standard error shaded in gray from the North Carolina Red Drum Juvenile Seine Survey for the period of 1991-2018.

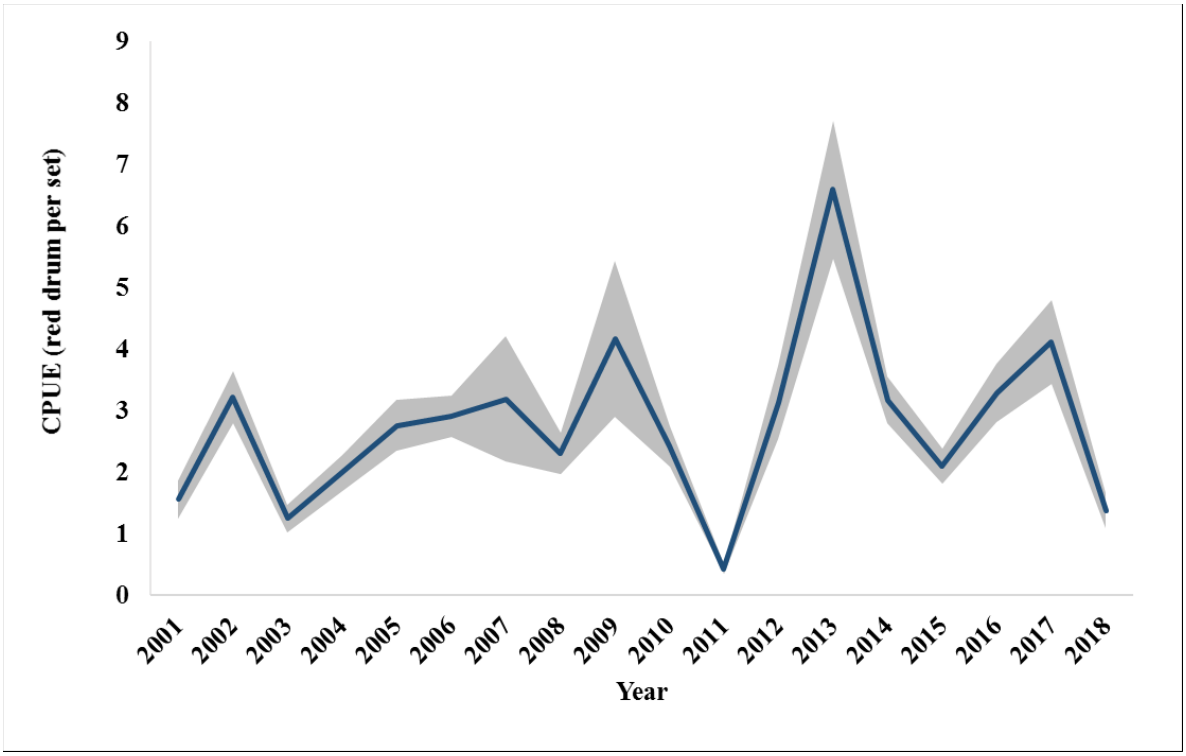

Figure 9. Annual weighted red drum CPUE (number captured ages combined) with standard shaded in gray from the North Carolina Pamlico Sound Independent Gill Net Survey from 2001-2018.

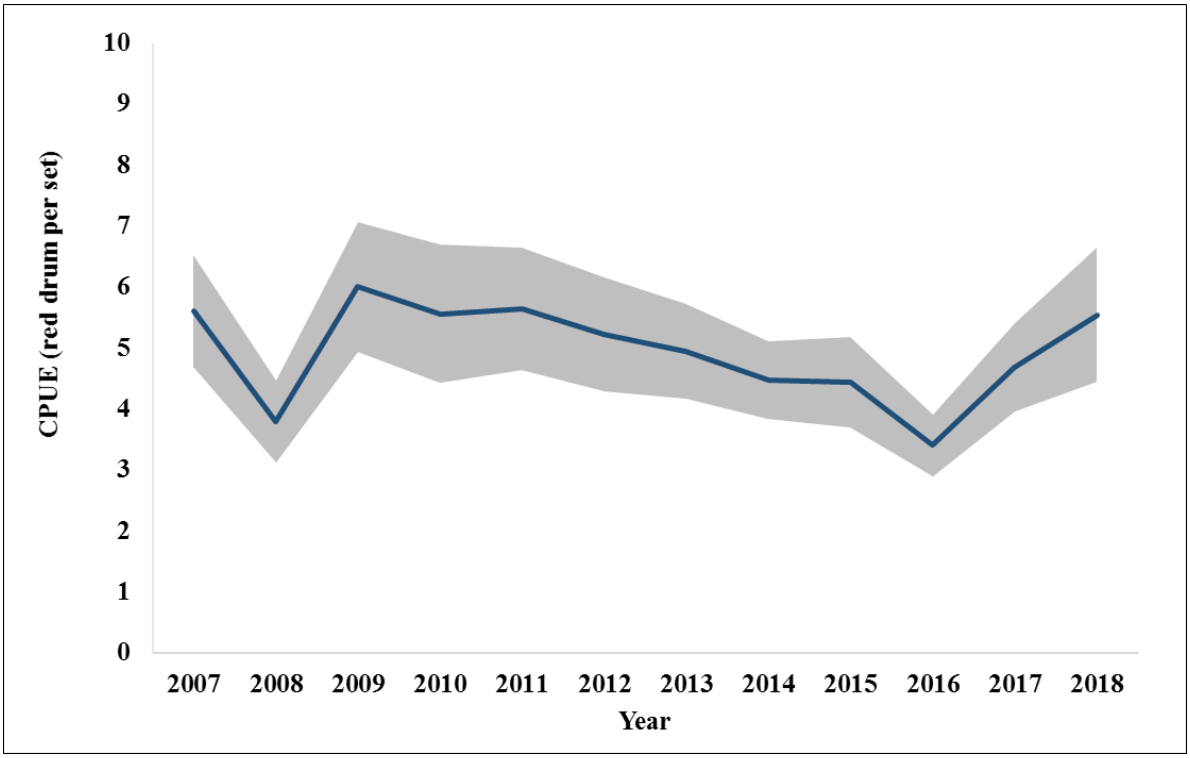

Figure 10. Annual adult red drum CPUE (number captured for ages combined) with standard error shaded in gray from the North Carolina Red Drum Longline Survey from 2007-2018.

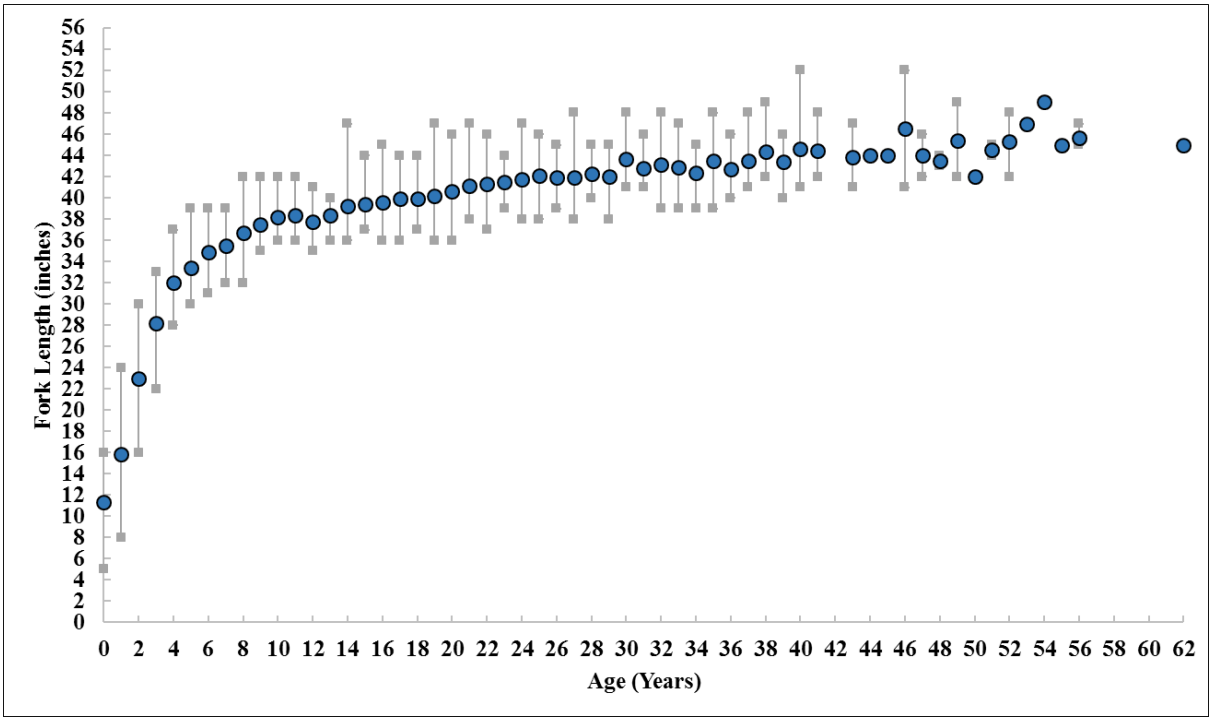

Figure 11. Red drum length at age based on all age samples collected from 1983 to 2018. Blue circles represent the mean size at a given age while the grey squares represent the minimum and maximum observed size for each age.

FISHERY MANAGEMENT PLAN UPDATE
RIVER HERRING
AUGUST 2019

STATUS OF THE FISHERY MANAGEMENT PLAN

Fishery Management Plan History

Original FMP Adoption:	February 2000
Amendments:	Amendment 1 – September 2007 Amendment 2 – May 2015
Revisions:	None
Supplements:	None
Information Updates:	None
Recommended Schedule Change:	None
Next Benchmark Review:	May 2025
Next MFC Scheduled Review:	July 2020

In North Carolina blueback herring (*Alosa aestivalis*) and alewife (*Alosa peseudoharengus*), collectively known as river herring, are managed under Amendment 2 to the North Carolina River Herring Fishery Management Plan (FMP) for River Herring. The original North Carolina River Herring FMP adopted February of 2000, focused on issues pertaining to stock conditions (overfished and recruitment overfishing), habitat degradations, and research/monitoring expansion to provide assessment data and socioeconomic data (NCDMF 2000). Amendment 1 to the North Carolina River Herring FMP implemented a no-harvest provision for commercial and recreational fisheries of river herring in coastal waters of the state, effective in 2007 (NCDMF 2007). This was a result of the North Carolina Division of Marine Fisheries (NCDMF) 2005 stock assessment of river herring (data through 2003) that determined blueback herring and alewife were overfished and overfishing was occurring, there was minimal recruitment with continued declines in abundance for both species, and high fishing mortality rates (Grist 2005). Additional management strategies included gear restrictions and stock recovery indicators (based on blueback herring). It also included a 7,500 pounds limited research set-aside harvest to be used for data collection and to provide product to local herring festivals. The NCDMF Director allocated a maximum of 4,000 pounds to be used for this discretionary harvest season by permitted fishermen, which occurred in the Chowan River Herring Management Area around Easter week each year. Additional outcomes of Amendment 1 included implementing monitoring programs, endorsing additional research on predation, restoration, impediments, bycatch and supporting spawning area habitat protection.

Amendment 2 to the North Carolina River Herring FMP was finalized in 2015 with three issues: 1) eliminating the discretionary river herring harvest season and permit since it was not serving the intended purposes of providing biological data for stock analysis and local product; 2) moving the Albemarle Sound/Chowan River Herring Management Areas to 15A NCAC 03R .0202, which corrected a reference and corrected the boundary of the Cashie River Anadromous Fish Spawning Area, and 3) removing alewife and blueback herring from exceptions in the Mutilated Finfish Rule 15A NCAC 03M .0101 (NCDMF 2015a).

Due to the Rules Review Committee receiving at least 10 letters requesting legislative review (pursuant to G.S. 150B), a portion of the third issue to prohibit possession of river herring (alewife and blueback herring) greater than six inches aboard a vessel or while engaged in fishing from the shore or a pier underwent legislative review during the 2016 spring short session. Since a bill was not introduced specifically disapproving the rule, the rule was effective June 13, 2016 in the River Herring Rule 15A NCAC 03M .0513.

In addition to the state FMP, North Carolina river herring also are managed through Amendment 2 of the Atlantic States Marine Fisheries Commission (ASMFC) Interstate FMP for Shad and River Herring. Adopted in 2009, Amendment 2 requires management measures from the ASMFC be adopted by North Carolina as the minimum standard for the fishery, while the North Carolina plan can adopt additional measures (ASMFC 2009). Additionally, Amendment 2 requires that states and jurisdictions develop sustainable FMPs in order to maintain a commercial and/or recreational river herring fishery past January 2012.

To ensure compliance with interstate requirements, North Carolina also manages river herring 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 plans) and the Atlantic Coastal Fisheries Cooperative Management Act (ASMFC plans) are like the goals of the Fisheries Reform Act of 1997 to “ensure long-term viability” of these fisheries (NCDMF 2015b).

Management Unit

Blueback herring (*Alosa aestivalis*) and alewife (*Alosa pseudoharengus*) management authority lies with the ASMFC. Responsibility for management action in the Economic Exclusive Zone (EEZ), located from 3 to 200 miles from shore, lies with the Secretary of Commerce through the Atlantic Coastal Fisheries Cooperative Management Act in the absence of a federal FMP. The NCDMF also has a state FMP in place for statewide management of river herring.

Goal and Objectives

The goal of Amendment 2 to the North Carolina River Herring FMP is to restore the long-term viability of the river herring population. To achieve this goal, the plan adopts the following objectives:

1. Identify and describe population attributes necessary to sustain long-term stock viability.
2. Protect, restore, and enhance spawning and nursery area habitats.
3. Initiate, enhance, and/or continue programs to collect and analyze biological, social, economic, fishery, and environmental data needed to effectively monitor and manage the river herring fishery.
4. Promote education and public information to help the public understand the causes and nature of problems in the river herring stocks, its habitats and fisheries, and the rationale for management efforts to solve these problems.

The goal of Amendment 2 to the ASMFC Interstate FMP for Shad and River Herring (River Herring Management) is to protect, enhance, and restore east coast migratory spawning stocks of alewife and blueback herring in order to achieve stock restoration and maintain sustainable levels of spawning stock biomass. To achieve this goal, the plan adopts the following objectives:

1. Prevent further declines in river herring (alewife and blueback herring) abundance.
2. Improve our understanding of bycatch mortality by collecting and analyzing bycatch data.
3. Increase our understanding of river herring fisheries, stock dynamics and population health through fishery-dependent and independent monitoring, in order to allow for evaluation of management performance.
4. Retain existing or more conservative regulations for American shad and hickory shad.
5. Promote improvements in degraded or historic alosine critical habitat throughout the species' range.

STATUS OF THE STOCK

Life History

River herring is a collective term for alewife and blueback herring. River herring are anadromous fish, meaning they migrate from the ocean, through inlets into coastal bays and sounds and ascend into freshwater rivers and streams to spawn. Alewife spawn in rivers, lakes, and tributaries from northeastern Newfoundland to South Carolina, but are most abundant in the Mid-Atlantic and the Northeast. Blueback herring prefer to spawn in swift flowing rivers and tributaries from Nova Scotia to northern Florida but are most numerous in waters from the Chesapeake Bay south. Mature alewife (ages 3 to 8) and blueback herring (ages 3 to 8) migrate rapidly downstream after spawning. Juveniles remain in tidal freshwater nursery areas in spring and early summer but may also move upstream with the encroachment of saline water. As water temperatures decline in the fall, juveniles move downstream to more saline waters. Little information is available on the life history of juvenile and adult river herring after they emigrate to the sea and before they mature and return to freshwater to spawn.

Adult river herring feed primarily on zooplankton (small, often microscopic animals floating in the water column) although they may also feed on fish eggs, crustacean eggs, insects and insect eggs, and small fish in some areas and in larger individuals. In general, alewife are larger than blueback herring of the same age and with each species females are larger than males. Total length for either species in North Carolina rarely exceeds 12 inches.

Stock Status

An Atlantic coast-wide stock assessment update for river herring was completed in August 2017, with data through 2015, by the Atlantic States Marine Fisheries Commission. Results indicate that river herring remain depleted and at near historic lows on a coast-wide basis (ASMFC 2017). The North Carolina portion of the coast-wide stock assessment is for the Chowan River blueback herring stock only, due to the long-term data available for this area. River herring in other parts of the state are currently listed as unknown by the ASMFC due to the lack of data for these systems. The stock assessment update found that, although the North Carolina stock in the Chowan River was not experiencing overfishing (harvesting from a stock at a rate greater than the stock's reproductive capacity to replace fish removed through harvest) due to the harvest moratorium, the stock still remains overfished. The factors leading to this recommendation of stock status remain largely unchanged since the 2012 stock assessment, despite a fishing pressure that is negligible. The spawning stock biomass (SSB) for blueback herring, a stock status indicator, remains 12% of the amount necessary to replace itself in the complete absence of fishing (Figure 1).

Stock Assessment

The ASMFC stock assessment update used a forward-projecting, age-structured statistical catch-at-age model for the Chowan River blueback herring stock. The stock assessment incorporated blueback herring data from total in-river catches, age compositions, length compositions and a fisheries-independent juvenile index to estimate age-3 abundance and mortality rates, from 1972 to 2015. Based on the 2015 fishing mortality rate and female spawning stock biomass estimates, the Chowan River blueback herring population is overfished but over-fishing is not occurring. Estimates of fishing mortality have been close to zero since the moratorium. Juvenile abundance is well below the target of 60 fish per haul with no increasing pattern evident. The percentage of repeat spawners varied from 2007 through 2010, remaining below the target of 10%, but has exceeded the target since 2011 to the highest level in 22 years of 16.8% in 2015. The SSB for blueback herring has been increasing since 2010, but still remains at approximately 12% of the target of 3.9 million pounds.

It is worthy to note the importance physical habitat and water quality play in the recovery of the river herring stocks in North Carolina and coast-wide (NCDMF 2009). In North Carolina, considerable habitat area has been lost through wetland drainage, stream channelization and conversion to other uses. Some streams are blocked by dams, storm debris, and other physical barriers. Migration and spawning may be affected by the replacement of small road bridges and culverts. Oxygen consuming wastes are discharged into several streams and practices to control non-point discharges are inadequate causing nuisance algal blooms, fish kills, and fish diseases over the years. The NCMDF initiated a survey of culverts and obstructions following

Amendment 1 to the 2000 River Herring FMP. The list created from the survey has resulted in the replacement of failing culverts and prioritized others for replacement or repair.

STATUS OF THE FISHERY

Current Regulations

In 2007, Amendment 1 to the North Carolina River Herring FMP implemented a no-harvest provision for commercial and recreational fisheries of river herring in coastal waters. The North Carolina River Herring FMP Amendment 2, adopted by the North Carolina Marine Fisheries Commission (NCMFC) in May 2015, eliminated the discretionary river herring harvest season and permit, removed alewife and blueback herring from exceptions in the Mutilated Finfish Rule, and prohibited the possession of river herring (blueback herring and alewife) greater than six inches aboard a vessel or while engaged in fishing from the shore or a pier.

Commercial Landings

North Carolina landings of river herring from 1972 through the mid-1980s peaked at 11.5 million pounds (Table 1 and Figure 2). Most landings occurred in the Chowan River and Albemarle Sound system. River herring landings declined sharply starting in 1986, prior to the implementation of regulations specific to river herring, first implemented in 1995. Amendment 1 implemented a no-harvest provision in 2007, allowing only for a limited discretionary harvest to provide local herring to festivals and continue NCDMF data collection from commercial fisheries. Table 2 includes information on landings data from 2007 through 2014 when the limited research set-aside season was prosecuted before being eliminated under Amendment 2 in 2015.

Recreational Landings

There is currently no recreational fishery for river herring per the no harvest provision outlined in Amendment 1. Formerly, most river herring caught recreationally were likely used for personal consumption or for bait. For the years leading up to the 2007 harvest closure, the extent of river herring harvest for personal consumption and bait in coastal North Carolina is unknown.

MONITORING PROGRAM DATA

Fishery-Dependent Monitoring

Commercial fishing activity is monitored through fishery-dependent sampling conducted by the NCDMF since 1972 in the Chowan River. The dominant gears for river herring were gill nets and pound nets. In 2007, the no-harvest provision essentially eliminated commercial landings. However, the Chowan River Pound Net survey was implemented in 2008, for the 2009 sampling year, to provide estimates of commercial catch-per-unit effort (CPUE), percent of repeat spawners, and age and sex data for alewife and blueback herring.

Table 3 and Table 4 describe the mean, minimum and maximum length data for blueback herring and alewife from 1972 to 2018. In 2018, a total of 1,232 blueback herring and 1,360 alewife were measured from the Chowan River pound net survey. The overall average size of blueback herring was 9 inches fork length and 9.25 inches fork length for alewife. Variation in modal, minimum, and maximum ages throughout the fishery-dependent monitoring is described in Table 5 for blueback herring and Table 6 for alewife, with little variation across the time-series. Figure 3 and Figure 4 illustrate the overall length at age (mean, minimum, and maximum) for blueback herring and alewife from all age samples collected at any given age from 1972 to 2018.

The NCDMF has monitored river herring repeat spawning since 1972 (Table 7 and Figure 5). Percent repeat spawners for blueback herring from the Chowan River spawning stock is one of the stock recovery indicators identified in Amendment 1. The Chowan River blueback herring spawning stock should contain at least 10% repeat spawners (percent of the spawning stock that have spawned more than once). Since 2011, percentages of blueback herring have increased to levels above the restoration target, with the exception of 2017. For alewife percentages have been above the restoration target since 2007, with the exception of 2014.

Total pound net effort (operable nets per week), estimated total river herring catch (pounds), and CPUE for the Chowan River Pound Net Survey (Table 8) shows a downward trend through 2012 followed by an increasing trend through 2017. In 2018, approximately 47% of the estimated total river herring catch were blueback herring, based on the weekly subsample of river herring from the survey.

Fishery-Independent Monitoring

The NCDMF has conducted an annual juvenile (age-0) seine survey for river herring since 1972. The seine survey has been conducted twice a month, at eleven fixed sites, in the Albemarle Sound-Chowan River area from June to October. Only the first pull from each month is used to calculate the index of abundance for juvenile river herring. Juvenile index of abundance of blueback herring is one of the stock recovery indicators identified in Amendment 1. The blueback herring juvenile index should exceed the three-year moving average 60-fish per haul. The relative annual abundance of juvenile blueback herring has remained well below the target of 60-fish per haul since the mid-1980's (Figure 6). Due to the low numbers of juvenile alewife caught across the time series, these data have not been used for management and are only shown here as an illustration of the trend in abundance (Figure 7). In 2018 overall mean CPUE was 0.02 for blueback herring and 3.0 for alewife, well below the restoration target.

Adult river herring are monitored using the NCDMF Albemarle Sound Independent Gill Net Survey (IGNS). The Albemarle Sound IGNS began collecting biological data on adult river herring in 1991, but did not start collecting aging structures until 2004. The survey uses a stratified random sampling scheme designed to characterize the size and age distribution for key estuarine species in the Albemarle Sound. River herring CPUE has been calculated from the Albemarle Sound IGNS since 1991. Blueback herring and alewife CPUE from the 2.5 and 3.0 inch stretched mesh (combined), January through May, 1991 to 2018 are shown in Table 9 and Figure 8. Catch of both species has increased since 2012.

Table 10 and Table 11 describe the mean, minimum and maximum length data for alewife and blueback from 1991 to 2018. In 2018, a total of 1,764 blueback herring and 1,950 alewife were measured from the Albemarle Sound IGNS. The overall average size of blueback herring was 9.50 inches fork length and 9.25 inches fork length for alewife. Variation in modal, minimum, and maximum ages throughout the fishery-dependent monitoring is described in Table 12 for blueback herring and Table 13 for alewife, with little variation since aging began in 2004. Figure 9 and Figure 10 illustrate the overall length at age (mean, minimum, and maximum) for blueback herring and alewife from all age samples collected at any given age from 2004 to 2018.

MANAGEMENT STRATEGY

Amendment 1 to the North Carolina River Herring FMP implemented four stock recovery indicators to evaluate stock status. Under Amendment 2 to the North Carolina River Herring FMP, the plan development team determined that only three of the stock recovery indicators were necessary and decided that the term stock status indicator was more appropriate, using blueback herring as the indicator species. The three stock status indicators were adopted by the North Carolina River Herring FMP plan development team, each based on a three-year moving average. The plan development team recommended using the first two stock status indicators (juvenile abundance and repeat spawners) as a trigger for doing a stock assessment earlier than 10 years. If a three-year moving average of each of the indicators was above the threshold, it would trigger the need for a new stock assessment, which would determine the third stock status indicator. The third stock status indicator sets the threshold that determines when the river herring fishery will re-open.

1. Catch per unit effort (CPUE) of 60 young-of-the-year per haul in the Albemarle Sound juvenile abundance survey.
2. Ten percent repeat spawners observed in fishery-dependent pound net samples.
3. Spawning stock biomass (SSB) of 30% unfished SSB, estimated in stock assessment model.

Collectively, these indices represent *minimal* stock rebuilding goals for the recovery of river herring stocks in the Albemarle Sound and Chowan River. In the 2012 stock assessment ASMFC recommended a ten-year interval between stock assessments (ASMFC 2012). The plan development team recommended using the first two stock status indicators (juvenile abundance and repeat spawners) as a trigger for doing a stock assessment earlier than 10 years. If a three-year moving average of the first two indicators was above the threshold, it would trigger the need for a new stock assessment, which would determine the third stock status indicator.

The stock status indicator for percent repeat spawners of blueback herring has exceeded the target of 10% since 2011, except for 2017. The increase in the percent repeat spawners is a positive sign, which means that the current management strategy is working. Juvenile abundance has remained well below the target since the early 1990s. Spawning stock biomass will need to continue to increase enough to see results in the juvenile index before the fishery could reopen.

RESEARCH NEEDS

The NCMFC implemented a series of management strategies under North Carolina River Herring FMP Amendment 2. These management strategies and their implementation status are listed in Table 13. On an annual basis the ASMFC publishes a prioritized list of research needs for American shad and river herring in the Review of the Atlantic States Marine Fisheries Commission Fishery Management Plan for Shad and River Herring (ASMFC 2018). For more information on research needs for American Shad please see: http://www.asmfc.org/uploads/file/5bc76a1dShad_RiverHerringFMPReview_2018.pdf.

FISHERY MANAGEMENT PLAN SCHEDULE RECOMMENDATION

Pertaining to the current FMP schedule, the plan development team recommended using the first two stock status indicators (juvenile abundance and repeat spawners) as a trigger for doing a stock assessment earlier than 10 years. If a three-year moving average of each of the indicators was above the threshold, it would trigger the need for a new stock assessment, which would determine the third stock status indicator. It is recommended the review schedule for river herring remain the same.

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TABLES

Table 1. Commercial harvest in pounds of river herring in North Carolina, 1972-2006, all waterbodies combined. Commercial harvest prohibited in 2007.

Year	Commercial Weight (lb)
1972	11,237,143
1973	7,925,898
1974	6,209,542
1975	5,952,067
1976	6,401,360
1977	8,523,813
1978	6,607,153
1979	5,119,150
1980	6,218,523
1981	4,753,723
1982	9,437,703
1983	5,868,332
1984	6,516,109
1985	11,548,278
1986	6,814,323
1987	3,194,975
1988	4,191,211
1989	1,491,077
1990	1,157,625
1991	1,575,378
1992	1,723,178
1993	916,235
1994	644,334
1995	453,984
1996	529,503
1997	334,809
1998	521,930
1999	443,494
2000	332,336
2001	306,761
2002	174,860
2003	199,716
2004	188,541
2005	250,021
2006	109,847

Table 2. Harvest landings and value of discretionary river herring harvest season in North Carolina, 2008-2014.

Year	# of Permits Issued	Quota (lb/permit/period)	Harvest (lb)	Value ($)
2008	13	250	1,292	775
2009	27	125	643	836
2010	30	125	1,765	1,765
2011	23	150	1,611	1,611
2012	18	150	678	678
2013	12	150	743	743
2014	27	150	989	1,319

Table 3. Length (fork length, inches) data of blueback herring sampled from the Chowan River commercial fisheries, 1972-2018. *In 2007 a no-harvest provision went into effect and the Chowan River Pound Net survey began in 2009.

Year	Mean Fork Length	Minimum Fork Length	Maximum Fork Length	Total Number Measured
1972	9.75	7.00	11.50	2,564
1973	9.75	5.50	11.50	2,208
1974	9.75	7.25	11.50	1,622
1975	9.50	6.00	11.00	2,428
1976	9.75	8.25	11.25	1,564
1977	9.75	5.50	11.75	1,425
1978	10.00	8.25	11.75	1,342
1979	10.00	8.25	12.25	1,218
1980	10.00	8.25	11.50	1,229
1981	10.00	8.50	12.00	1,469
1982	9.75	8.75	11.50	851
1983	9.50	8.25	11.25	482
1984	9.25	7.75	11.25	450
1985	9.50	8.50	11.25	388
1986	9.50	7.25	10.75	347
1987	9.50	8.00	11.00	318
1988	9.25	8.00	11.25	314
1989	9.25	8.25	10.75	273
1990	9.25	8.00	10.75	275
1991	9.25	8.00	11.00	357
1992	9.25	8.00	10.75	368
1993	9.25	7.50	10.50	160
1994	8.75	8.00	10.75	84
1995	9.25	8.25	10.50	322
1996	9.50	8.00	11.25	626
1997	9.50	8.00	11.25	625
1998	9.25	6.00	11.00	1,361
1999	9.50	7.75	11.00	720
2000	9.00	7.75	11.00	1,213
2001	9.25	7.75	10.75	667
2002	9.25	8.00	10.75	338
2003	9.00	7.50	10.50	304
2004	9.00	7.75	10.25	245
2005	9.00	7.75	10.75	305
2006	8.75	7.75	10.00	156
2007*	9.00	7.75	10.75	231
2008*	8.75	7.50	11.00	928
2009*	9.00	7.75	10.50	546
2010*	8.75	7.50	10.25	833
2011*	9.00	7.50	10.50	500
2012*	9.00	7.00	10.50	412
2013*	9.00	7.75	10.75	492
2014*	8.50	7.50	10.25	691
2015*	8.75	7.75	10.75	589
2016*	8.75	7.75	11.00	456
2017*	9.00	7.50	10.25	528
2018*	9.00	7.75	10.50	1,232

Table 4. Length (fork length, inches) data of Alewife sampled from the Chowan River commercial fisheries, 1972-2018. In 2007 a no-harvest provision went into effect and the Chowan River Pound Net survey began in 2009.

Year	Mean Fork Length	Minimum Fork Length	Maximum Fork Length	Total Number Measured
1972	10.25	6.25	12.25	1,337
1973	10.00	7.75	12.25	1,471
1974	9.00	5.75	11.25	616
1975	9.75	7.75	12.00	2,440
1976	9.75	8.25	12.00	2,029
1977	10.00	5.00	12.25	2,024
1978	10.25	7.75	11.50	997
1979	10.00	7.75	11.50	1,143
1980	10.00	8.50	12.25	551
1981	9.75	8.50	11.25	1,052
1982	9.75	8.50	12.00	752
1983	9.75	8.00	11.00	457
1984	9.75	8.75	11.75	351
1985	9.75	8.25	11.00	272
1986	9.25	8.25	11.00	203
1987	9.25	8.00	11.50	389
1988	9.50	8.00	10.75	312
1989	9.50	8.25	10.75	262
1990	9.50	8.00	11.00	194
1991	9.50	7.75	11.25	502
1992	9.25	7.75	11.00	300
1993	8.50	7.50	10.00	183
1994	8.50	8.00	9.00	2
1995	9.75	8.75	10.25	41
1996	9.50	8.50	10.50	42
1997	9.50	8.75	10.75	47
1998	9.50	7.75	11.00	55
1999	9.25	8.25	10.00	6
2000	9.25	7.75	10.50	798
2001	9.50	8.25	10.75	835
2002	9.75	7.75	10.75	963
2003	9.50	7.75	11.50	1,004
2004	9.50	8.00	11.25	720
2005	9.50	7.75	11.25	539
2006	9.50	7.75	12.25	553
2007	9.00	7.75	11.00	45
2008	9.00	7.50	11.25	1,872
2009*	9.25	7.75	10.75	1,000
2010*	9.50	8.00	11.00	822
2011*	9.75	8.00	11.25	806
2012*	9.75	7.50	11.25	641
2013*	9.25	7.75	13.00	854
2014*	9.25	8.00	11.50	1,037
2015*	9.25	8.00	11.00	998
2016*	9.25	7.75	11.25	773
2017*	9.25	7.75	14.00	1,336
2018*	9.25	7.75	11.25	1,360

Table 5. Blueback Herring aging data collected from North Carolina fishery-dependent monitoring, 1972-2018.

Year	Modal Age	Minimum Age	Maximum Age	Total Number Aged
1972	5	2	8	1,215
1973	5	3	8	1,092
1974	4	3	8	920
1975	4	3	8	951
1976	4	3	9	862
1977	5	3	8	767
1978	4	3	7	694
1979	5	3	8	942
1980	5	3	8	1,079
1981	5	3	9	794
1982	4	3	9	478
1983	4	3	8	314
1984	4	3	8	283
1985	5	3	7	249
1986	5	3	7	230
1987	4	3	7	208
1988	4	3	7	201
1989	4	3	6	184
1990	4	2	7	189
1991	4	2	7	242
1992	4	3	7	220
1993	5	2	8	112
1994	4	3	7	71
1995	5	3	7	192
1996	5	3	7	279
1997	4	3	7	180
1998	5	2	7	462
1999	5	3	7	389
2000	4	3	9	512
2001	5	3	7	311
2002	5	3	7	164
2003	5	3	7	147
2004	4	3	6	130
2005	4	3	6	162
2006	4	3	5	86
2007	5	3	6	143
2008	4	3	7	474
2009	4	3	7	251
2010	4	3	7	247
2011	4	3	6	175
2012	4	3	7	189
2013	5	3	7	217
2014	4	3	7	198
2015	4	3	7	184
2016	4	3	8	226
2017	5	3	7	250
2018	4	3	6	272

Table 6. Alewife aging data collected from North Carolina fishery-dependent monitoring, 1972-2018.

Year	Modal Age	Minimum Age	Maximum Age	Total Number Aged
1972	4	3	9	783
1973	4	3	9	721
1974	4	2	7	417
1975	4	2	9	842
1976	4	3	7	853
1977	5	3	8	759
1978	4	3	8	736
1979	4	3	8	701
1980	5	3	8	492
1981	5	4	8	532
1982	4	3	7	444
1983	4	3	7	295
1984	4	3	7	248
1985	5	3	7	195
1986	4	3	6	146
1987	4	3	7	266
1988	4	2	6	228
1989	4	3	7	179
1990	4	2	7	153
1991	5	3	7	319
1992	5	2	8	242
1993	4	2	7	130
1994	4	4	4	2
1995	5	4	6	40
1996	4	3	7	41
1997	4	3	7	18
1998				
1999	3,6	3	6	6
2000	5	3	7	300
2001	5	3	7	369
2002	5	3	7	341
2003	4	2	7	350
2004	5	2	7	318
2005	5	3	7	253
2006	4	3	7	260
2007	4	3	6	30
2008	5	4	8	588
2009	5	3	7	342
2010	6	3	7	277
2011	6	3	8	211
2012	6	3	8	259
2013	5	2	7	308
2014	4	2	6	328
2015	4	3	7	206
2016	4	3	8	311
2017	5	3	7	346
2018	4	3	7	375

Table 7. Blueback herring and alewife percent (%) repeat spawners from the Chowan River pound net survey 1972-2018. Blueback herring percent repeat spawner is a stock status indicator.

	Percent (%)	
Year	Blueback Herring	Alewife
1972	22	15
1973	17	14
1974	18	4
1975	6	10
1976	11	8
1977	9	5
1978	6	8
1979	16	9
1980	19	18
1981	48	29
1982	11	1
1983	14	2
1984	7	34
1985	10	12
1986	16	4
1987	22	
1988	11	6
1989	4	9
1990	12	17
1991	31	21
1992	26	48
1993	12	5
1994	5	
1995	6	8
1996	13	29
1997	15	29
1998	7	
1999	13	67
2000	14	8
2001	9	13
2002	13	38
2003	16	30
2004	9	20
2005	13	15
2006	0	9
2007	9	10
2008	5	14
2009	3	14
2010	6	41
2011	12	27
2012	13	29
2013	14	11
2014	13	5
2015	17	18
2016	16	20
2017	7	33
2018	11	31

Table 8. River herring total pound net effort, estimated catch and catch per unit effort for the Chowan River pound net survey 2009-2018.

Year	Total Effort (# of Active Sets)	Total RH (lbs)	Total CPUE
2009	217	89,245	411.3
2010	260	71,532	275.1
2011	286	74,485	260.4
2012	315	18,415	58.5
2013	238	27,396	115.1
2014	271	45,619	168.3
2015	253	49,560	195.9
2016	228	77,372	339.4
2017	231	137,374	594.7
2018	276	86,605	313.8
Total	257.5	67,760	273.2

Table 9. January-May adult river herring catch per unit effort (2.5 and 3.0 inch stretch mesh) from the North Carolina Albemarle Sound independent gill net survey 1991-2018.

Alewife					Blueback Herring				
Year	Effort	Sum	CPUE	PSE	Year	Effort	Sum	CPUE	PSE
1991	472	222	0.47	16	1991	472	4,817	10.21	15
1992	548	1,056	1.93	18	1992	548	3,197	5.83	13
1993	558	139	0.25	27	1993	558	1,838	3.29	16
1994	527	93	0.18	22	1994	527	638	1.21	20
1995	517	207	0.40	17	1995	517	2,672	5.17	19
1996	512	150	0.29	59	1996	512	1,514	2.96	17
1997	521	64	0.12	19	1997	521	3,338	6.41	17
1998	506	64	0.13	16	1998	506	2,364	4.67	17
1999	536	281	0.52	42	1999	536	2,600	4.85	16
2000	525	938	1.79	15	2000	525	4,039	7.69	15
2001	498	1,380	2.77	11	2001	498	2,534	5.09	15
2002	505	321	0.64	11	2002	505	1,457	2.89	17
2003	552	310	0.56	13	2003	552	2,312	4.19	15
2004	504	379	0.75	12	2004	504	1,674	3.32	17
2005	503	267	0.53	12	2005	503	1,617	3.21	20
2006	526	1,060	2.02	11	2006	526	2,361	4.49	12
2007	511	3,310	6.48	11	2007	511	1,566	3.06	14
2008	499	1,282	2.57	10	2008	499	833	1.67	17
2009	452	1,050	2.32	10	2009	452	1,011	2.24	15
2010	419	1,144	2.73	14	2010	419	669	1.60	16
2011	418	466	1.11	14	2011	418	465	1.11	17
2012	355	348	0.98	13	2012	355	307	0.86	18
2013	363	1,246	3.43	18	2013	363	1,642	4.52	16
2014	402	2,810	6.99	15	2014	402	1,077	2.68	18
2015	443	2,013	4.54	11	2015	443	2,470	5.58	20
2016	460	2,369	5.15	11	2016	460	2,802	6.09	15
2017	451	1,677	3.72	10	2017	451	2,373	5.26	15
2018	377	2,805	7.44	19	2018	377	3,054	8.10	14

Table 10. Length (fork length, inches) data of blueback herring sampled from North Carolina Albemarle Sound independent gill net survey from 1991-2018.

Year	Mean Fork Length	Minimum Fork Length	Maximum Fork Length	Total Number Measured
1991	9.75	6.50	13.25	2,315
1992	9.75	8.00	11.75	2,140
1993	9.75	7.50	13.25	1,334
1994	9.75	8.25	13.25	555
1995	9.50	6.50	11.25	1,324
1996	9.50	5.75	13.25	1,090
1997	9.25	5.00	12.75	1,530
1998	9.50	8.00	11.25	1,231
1999	9.50	6.50	13.75	1,917
2000	9.50	8.25	11.25	2,740
2001	9.50	6.50	11.50	1,862
2002	9.75	5.50	11.00	1,339
2003	9.50	7.75	11.75	1,924
2004	9.50	8.25	17.25	1,157
2005	9.25	5.75	11.50	1,039
2006	9.25	7.25	13.25	1,790
2007	9.25	8.00	10.75	1,204
2008	9.25	4.75	10.75	697
2009	9.25	5.25	11.00	815
2010	9.25	7.75	12.25	609
2011	9.25	7.25	13.75	445
2012	9.50	8.00	10.75	295
2013	9.00	7.75	11.50	1,163
2014	9.25	7.75	13.00	799
2015	9.25	8.00	13.50	1,206
2016	9.50	4.25	11.25	1,555
2017	9.50	8.00	13.25	1,433
2018	9.50	8.00	12.75	1,764

Table 11. Length (fork length, inches) data of alewife sampled from North Carolina Albemarle Sound independent gill net survey from 1991-2018.

Year	Mean Fork Length	Minimum Fork Length	Maximum Fork Length	Total Number Measured
1991	10.00	5.75	12.00	235
1992	10.00	8.50	13.75	860
1993	9.50	8.00	13.25	143
1994	9.25	8.50	11.00	99
1995	9.50	6.75	11.50	211
1996	9.75	4.50	13.50	102
1997	10.00	8.25	13.75	64
1998	9.75	7.75	11.50	64
1999	9.00	8.00	13.75	226
2000	9.25	8.25	11.25	1,436
2001	9.75	5.25	17.75	1,933
2002	10.00	8.00	11.00	477
2003	9.75	7.75	11.25	551
2004	9.75	8.00	14.00	388
2005	9.50	8.00	11.25	274
2006	9.25	8.00	13.50	1,006
2007	9.25	4.50	12.75	2,343
2008	9.50	6.25	12.00	1,221
2009	9.50	5.75	11.75	1,000
2010	9.75	8.00	13.75	1,036
2011	10.00	8.00	11.75	493
2012	10.25	7.75	12.00	363
2013	9.25	7.75	13.50	1,004
2014	9.50	8.00	13.75	1,930
2015	9.75	4.50	12.50	1,786
2016	9.75	7.75	13.00	2,042
2017	9.75	7.75	12.75	1,531
2018	9.25	7.75	12.00	1,950

Table 12. Blueback herring aging data collected from North Carolina Albemarle Sound independent gill net survey, 2004-2018.

Year	Modal Age	Minimum Age	Maximum Age	Total Number Aged
2004	4	3	6	98
2005	4	2	7	174
2006	4,5	3	7	213
2007	5	3	7	173
2008	4,5	4	7	45
2009	4,5	4	7	72
2010	4	3	5	45
2011	4	3	6	100
2012	4	3	8	80
2013	3	2	7	107
2014	3	2	5	40
2015	4	3	6	139
2016	5,6	3	7	157
2017	5	3	7	176
2018	4	3	7	228

Table 13. Alewife aging data collected from North Carolina Albemarle Sound independent gill net survey, 2004-2018.

Year	Modal Age	Minimum Age	Maximum Age	Total Number Aged
2004	4	3	6	106
2005	5	3	7	148
2006	4,5	3	7	283
2007	4	3	8	266
2008	5	4	7	96
2009	5	2	7	125
2010	6	4	7	122
2011	5	3	8	137
2012	6	3	8	129
2013	4	2	6	168
2014	4	3	6	110
2015	5	3	7	263
2016	5	3	7	173
2017	5	3	8	249
2018	4	3	8	331

Table 14. Summary of the N.C. Marine Fisheries Commission management strategies and their implementation status for Amendment 2 of the River Herring Fishery Management Plan

Management Strategy	Implementation Status
Eliminate the discretionary river herring harvest season and permit	Existing proclamation authority
Moving the Albemarle Sound/Chowan River Herring Management Areas to correct boundary reference for the Cashie River Anadromous Fish Spawning Area	15A NCAC 03R .0202
Remove alewife and blueback herring from the Mutilated Finfish Rule	15A NCAC 03M .0101
Prohibit possession of alewife and blueback herring greater than six inches aboard a vessel or while engaged in fishing from the shore or a pier.	15A NCAC 03M .0513

FIGURES

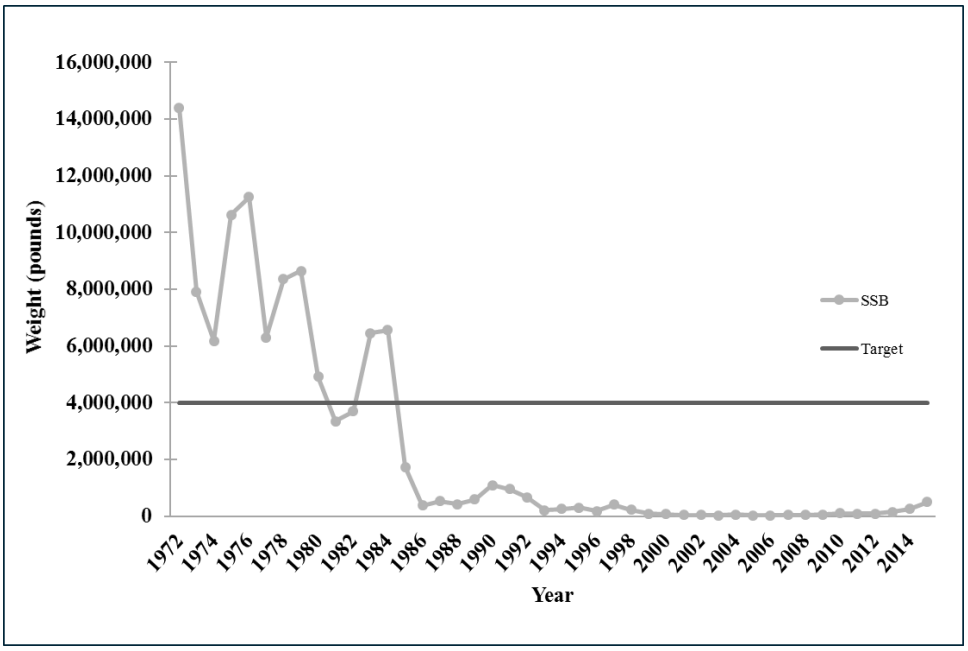

Figure 1. Annual estimate of blueback herring spawning stock biomass (SSB) in pounds for the Chowan River blueback herring stock, 1972-2015 (ASMFC 2017). Stock status indicator.

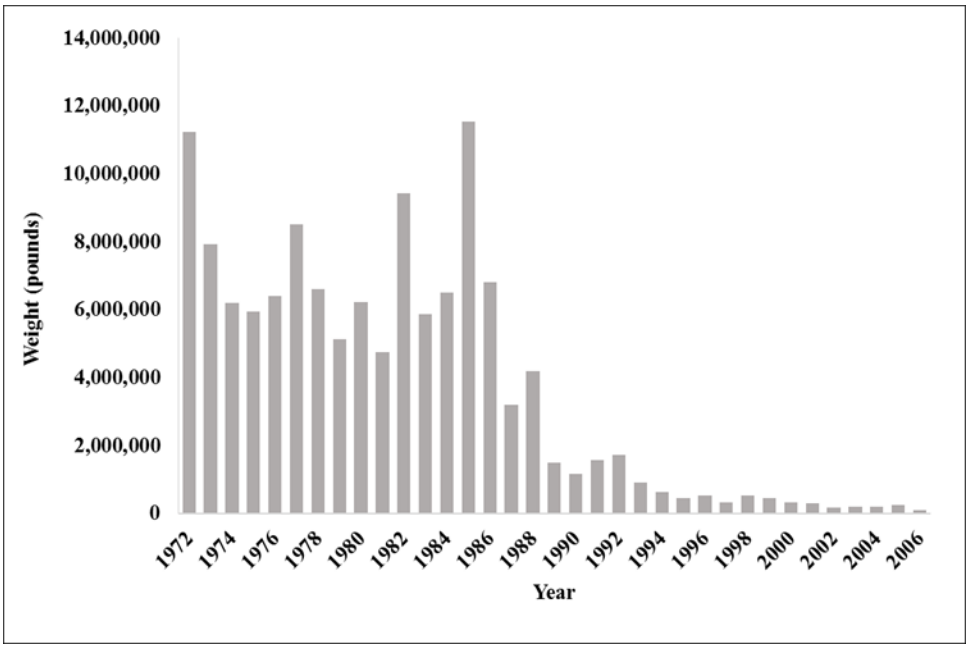

Figure 2. Commercial harvest in pounds of river herring (blueback herring and alewife combined) in North Carolina from 1972-2006, all waterbodies combined.

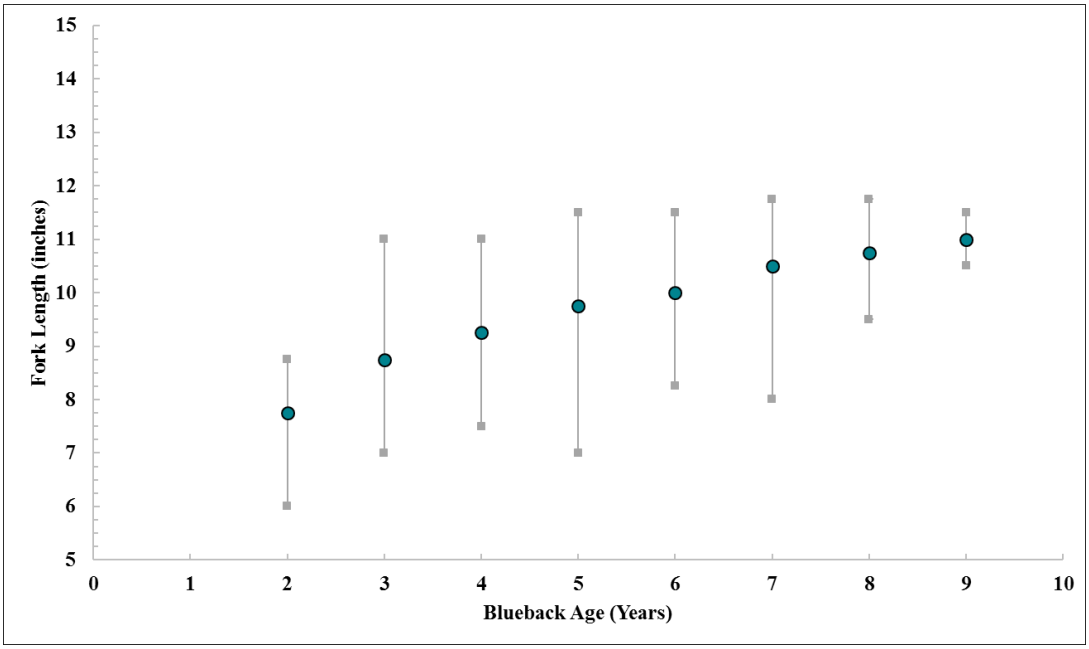

Figure 3. Blueback herring length at age from all age samples collected from fishery-dependent monitoring, 1972-2018. Blue circles represent the mean size at a given age while the gray squares represent the minimum and maximum observed size for each age.

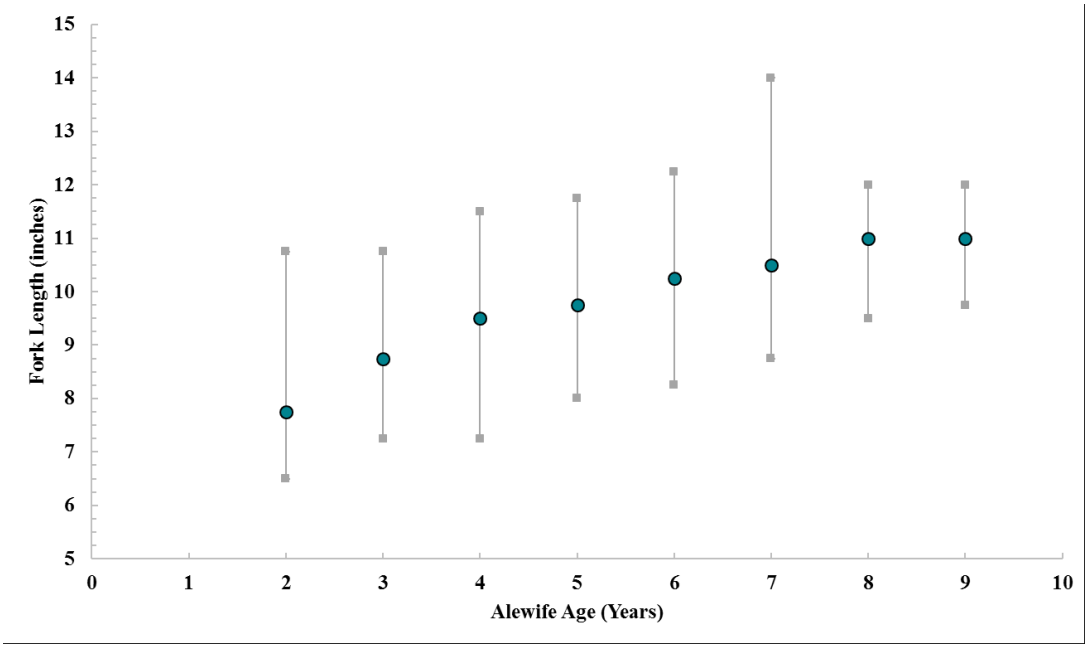

Figure 4. Alewife length at age from all age samples collected from fishery-dependent monitoring, 1972-2018. Blue circles represent the mean size at a given age while the gray squares represent the minimum and maximum observed size for each age.

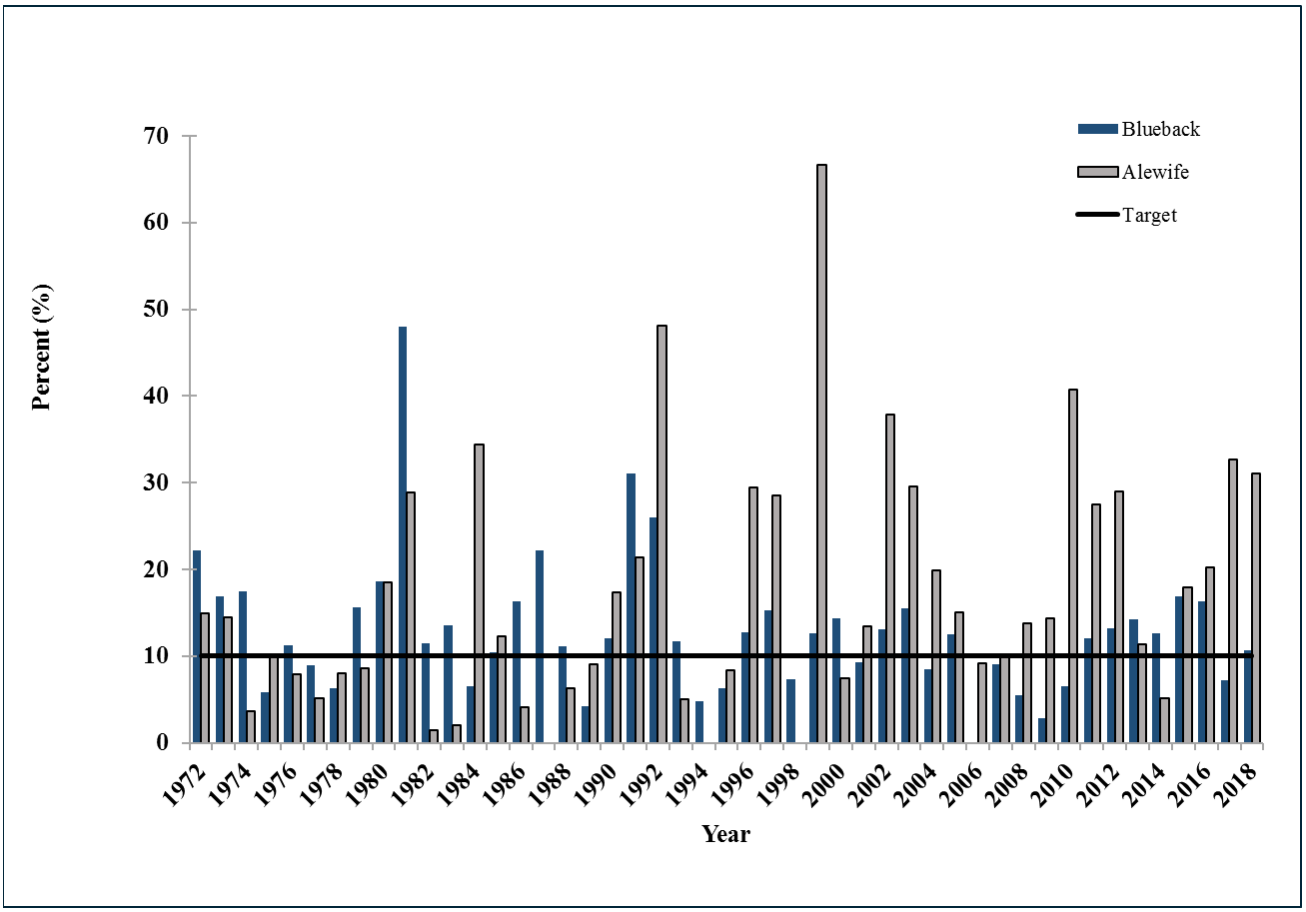

Figure 5. Percent of repeat spawners (blueback herring and alewife) in the Chowan River Pound Net Survey, 1972-2018. Blueback herring percent repeat spawner is a stock status indicator.

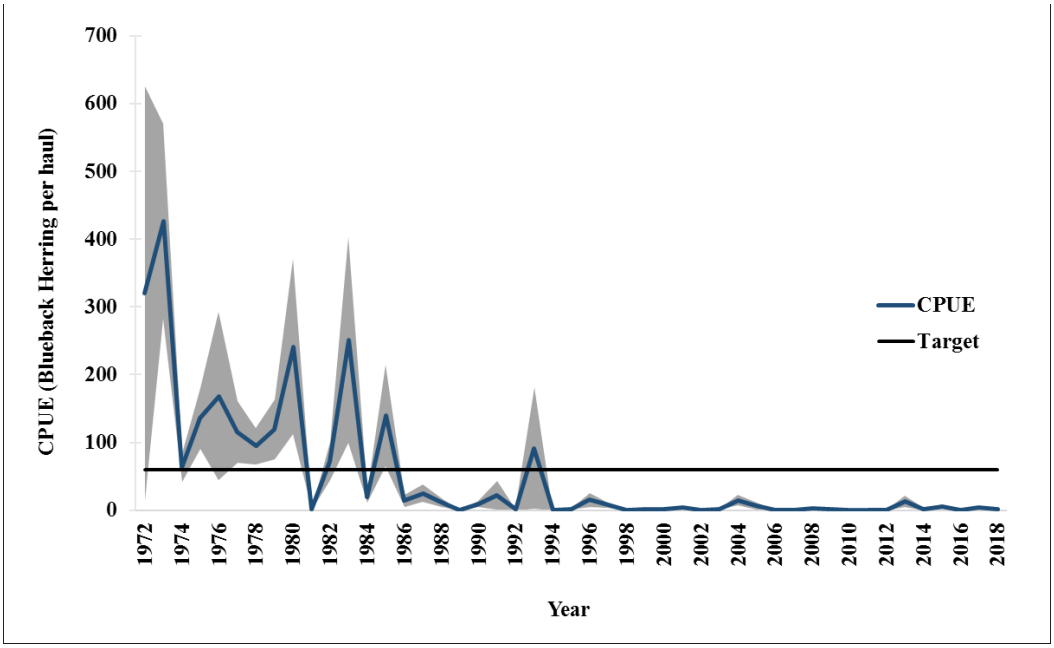

Figure 6. Blueback herring annual juvenile (age-0) abundance index from the NCDMF Albemarle Sound juvenile survey, 1972-2018. Stock status indicator.

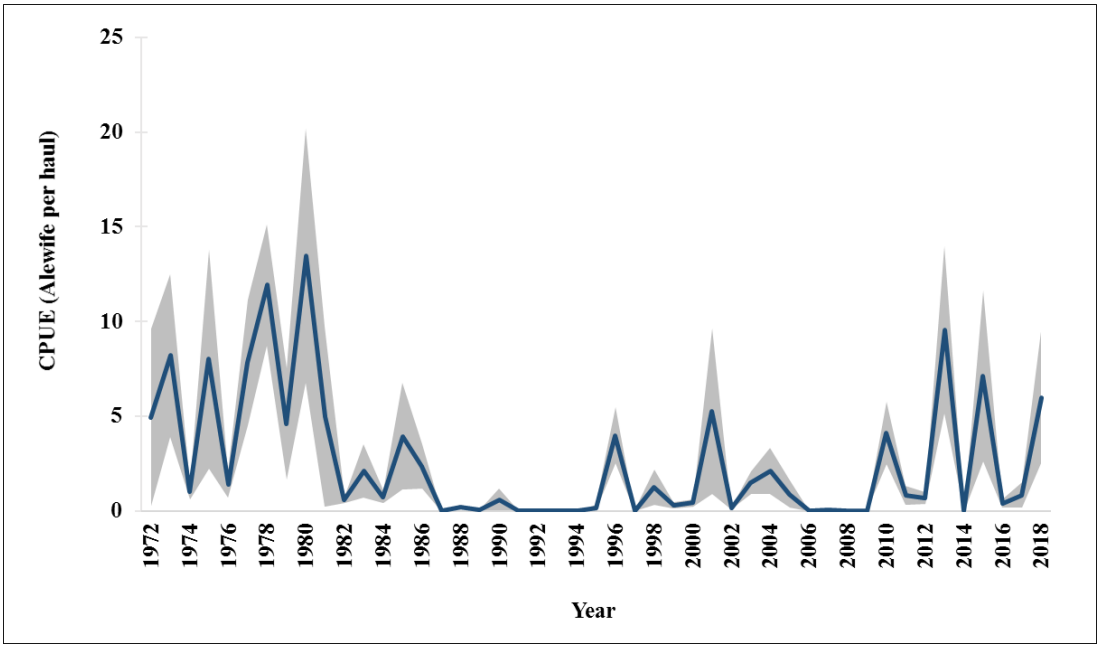

Figure 7. Alewife annual juvenile (age-0) abundance index from the NCDMF Albemarle Sound juvenile survey, 1972-2018.

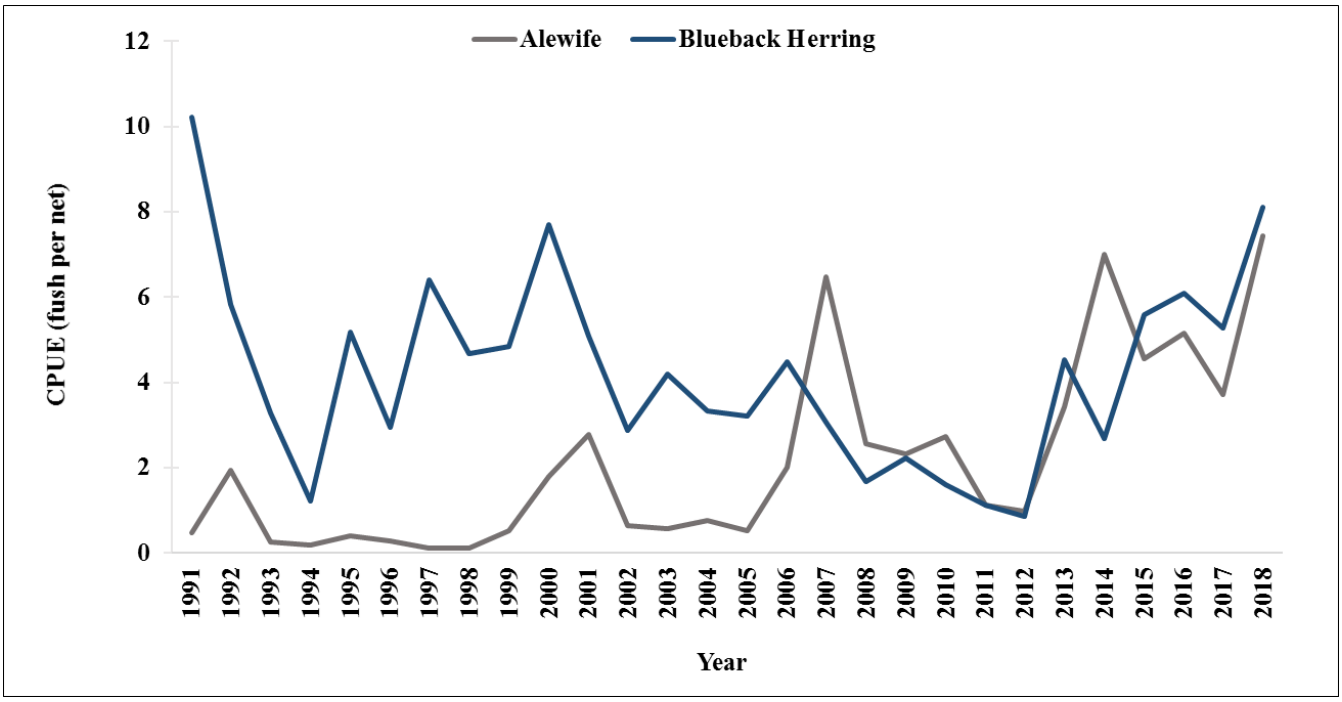

Figure 8. January-May adult river herring CPUE (2.5 and 3.0 inch stretch mesh) from the North Carolina Albemarle Sound independent gill net survey 1991-2018.

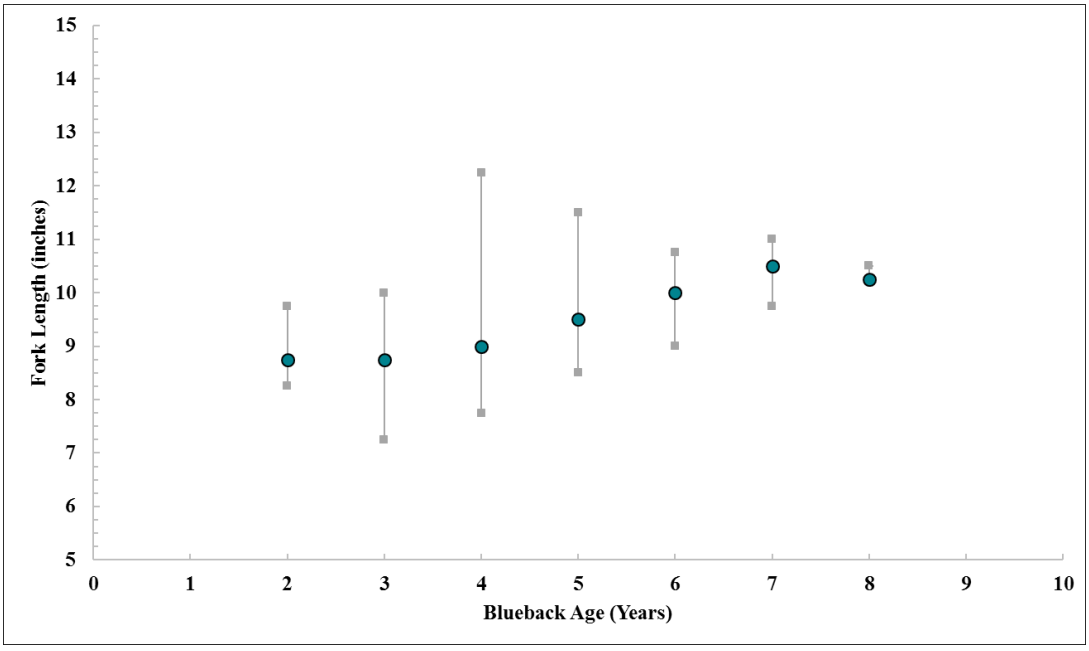

Figure 9. Blueback herring length at age from all age samples collected from North Carolina Albemarle Sound independent gill net survey, 2004-2018. Blue circles represent the mean size at a given age while the gray squares represent the minimum and maximum observed size for each age.

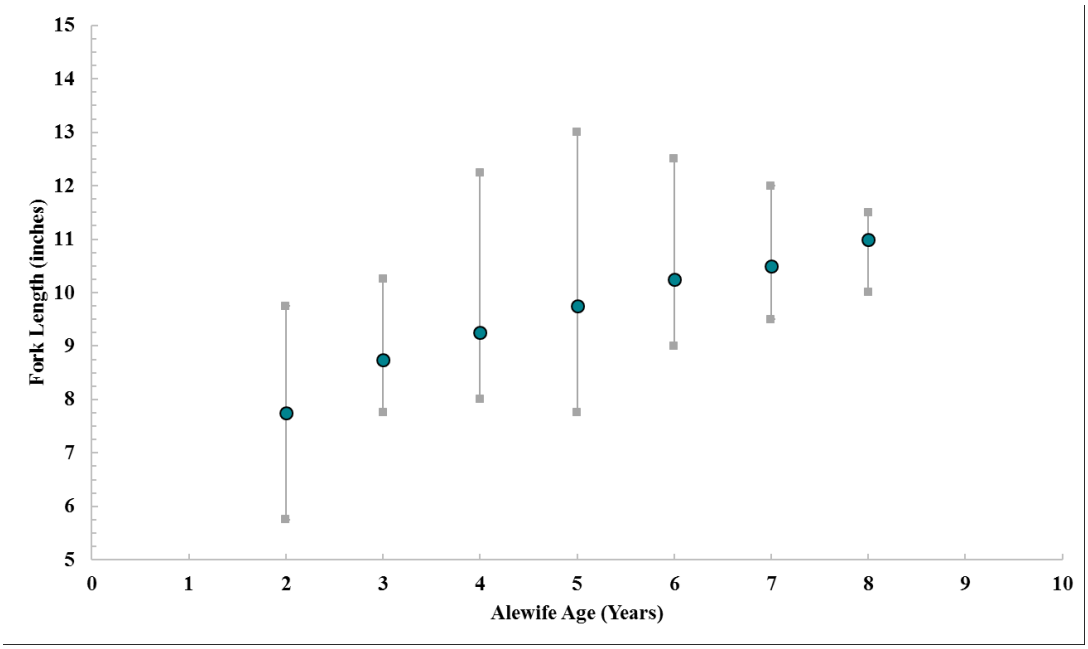

Figure 10. Alewife length at age from all age samples collected from North Carolina Albemarle Sound independent gill net survey, 2004-2018. Blue circles represent the mean size at a given age while the gray squares represent the minimum and maximum observed size for each age.

FISHERY MANAGEMENT PLAN UPDATE
SHEEPSHEAD
AUGUST 2019

STATUS OF THE FISHERY MANAGEMENT PLAN

Fishery Management Plan History

Original FMP Adoption: N/A

Amendments: N/A

Revisions: N/A

Supplements: N/A

Information Updates: N/A

Recommended Schedule Change: N/A

Next MFC Scheduled Review: N/A

Sheepshead (*Archosargus probatocephalus*) was initially managed as part the South Atlantic Fishery Management Council's (SAFMC) Snapper Grouper Fishery Management Plan (FMP). The plan restricted recreational anglers to an aggregate 20 fish bag limit; there was no commercial trip limit, and neither sector had a size limit. In state waters, North Carolina deferred to the Council and the same regulations were followed. In April 2012, sheepshead was officially removed from the SAFMC's snapper grouper management complex through the Comprehensive Annual Catch Limit Amendment (Amendment 25; SAFMC 2011). Subsequently, North Carolina's proclamation authority for the management of the species was invalidated since sheepshead was no longer part of the North Carolina Fishery Management Plan for Interjurisdictional Fisheries or a Council managed species. In November 2012, the N.C. Marine Fisheries Commission (NCMFC) requested that a rule be developed for sheepshead; and in November 2013, approved the rule (15A NCAC 03M .0521) that specifies the Director's proclamation authority, including the ability to implement size, bag, and trip limits, as well as season and gear restrictions. In July 2014, N.C. Division of Marine Fisheries (NCDMF) began developing potential management measures for sheepshead to present to the NCMFC. In 2015, the Commission implemented new regulations that included size, bag, and trip limits in order to prevent overharvest, as well as to allow a greater number of individuals to spawn before being harvested. There currently is no state or federal FMP for sheepshead.

Management Unit

North Carolina manages sheepshead in state coastal waters (internal and 0 to 3 miles in Atlantic Ocean).

Goal and Objectives

None

STATUS OF THE STOCK

Life History

Sheepshead are a relatively large and long-lived member of the porgy family that ranges from Nova Scotia, Canada to Florida and the Gulf of Mexico south to the Atlantic coast of Brazil. They are generally found year-round in North Carolina's coastal waters ranging from inshore brackish waters to offshore rocky bottom. Juveniles are associated with shallow vegetated habitat as well as hard structures that offer protection. As sheepshead grow larger, they move to more typical adult habitat including oyster reefs, rocks, pilings, jetties, piers and wrecks. Migration patterns based on mark recapture studies have not documented large scale north-south movements. Movement instead tends to be towards inlets during the fall and winter when adult sheepshead migrate to ocean waters to spawn.

Sheepshead are omnivores, meaning they eat plant material as well as animals (barnacles, crabs, oysters). Sheepshead grow quickly up to age 6, and then their growth slows. After their first year, sheepshead average 10 inches, at which less than 50% of the individuals are sexually mature. Most sheepshead mature at age 2 (12 inches fork length) and all sheepshead are mature by ages 3 to 5 (14 inches fork length). In North Carolina, sheepshead commonly attain a length of 20 to 25 inches with weights ranging from 5 to 15 pounds. The maximum reported age in North Carolina is 30 years.

Stock Status

The Division is continuing to collect data from recreational, commercial, and independent sampling efforts to estimate trends in abundance of sheepshead; age structure, maturity, and other biological information is also being collected.

Stock Assessment

Currently, there is not a stock assessment for sheepshead in North Carolina. A coast-wide stock assessment (from Virginia through the east coast of Florida) is being developed by a doctoral candidate at North Carolina State University. The assessment is expected to be complete in 2020.

STATUS OF THE FISHERY

Current Regulations

In 2015, the NCMFC implemented a 10-inch fork length (FL) minimum size limit for both recreational and commercial fisheries. There is a recreational bag limit of 10 fish per person per day or per trip (if a trip occurs over more than one calendar day). Commercial fishing operations are limited to 300 pounds per trip with two exceptions; gig and spear operations are limited to 10

fish per person per day or trip (if a trip occurs over more than one calendar day), and pound net operations are exempt from the commercial trip limits.

Commercial Landings

Commercial landings of sheepshead in North Carolina are available from 1950 to the present. However, monthly landings were not available until 1974. North Carolina instituted mandatory reporting of commercial landings through their Trip Ticket Program, starting in 1994. Landings information collected since 1994 is considered the most reliable. Landings have fluctuated from year to year, ranging from 9,782 pounds in 1981 to 180,225 pounds in 2013. In 2018, 90,291 pounds of sheepshead were landed in the commercial fishery (Table 1; Figure 1).

Sheepshead are primarily caught as bycatch in several of North Carolina's commercial fisheries (i.e., gill nets, pound nets, haul seines). Estuarine gill nets and pound nets have made up greater than 50% of the landings for most of the time series. A targeted spear fishery has developed in the last seven years, and the gig fishery has also become more popular in this time. While the long haul fishery used to account for up to 20% of the landings, in the last several years landings from this fishery have accounted for less than 1% of the harvest. In 2018, the majority (84%) of the commercial landings came from pound nets (56%) and estuarine gill nets (28%); an additional 10% was landed by spears and gigs, combined (Figure 2).

Recreational Landings

The recreational fishery tends to be more of a targeted fishery compared to the commercial. This fishery is primarily a hook and line fishery, but the species is becoming a favorite of spear fishermen. Recreational harvest estimates are available from 1981 to the present. Recreational fishing activity is monitored through the Marine Recreational Information Program. In this report, estimates across all years have been updated and are now based on the MRIP new Fishing Effort Survey-based calibrated estimates. For more information on MRIP methodology changes see https://www.fisheries.noaa.gov/topic/recreational-fishing-data.

Recreational harvest accounted for 84% of North Carolina's total harvest (pounds) from 2009-2018, and 89% of the 2018 harvest (Table 1). Like the commercial catch, landings have fluctuated from year to year, with a low of 19,285 pounds harvested in 1983 and a high of 1,456,396 pounds in 2007 (Table 1; Figure 1). In 2018, 735,738 pounds of sheepshead were landed recreationally.

The NCDMF offers award citations for exceptional catches of sheepshead. Harvested sheepshead that weigh greater than eight pounds are eligible for an award citation. Since 1991, approximately 2,000 citations for sheepshead have been issued. From 1991 through 2007 the number of award citations remained under 50 citations per year. From 2007 through 2014 the number of award citations increased steadily, but have decreased in recent years (Figure 3).

MONITORING PROGRAM DATA

Fishery-Dependent Monitoring

Commercial fishing activity is monitored through fishery dependent sampling programs conducted by NCDMF. Data collected in these programs allow the size and age distribution of sheepshead to be characterized by gear and fishery. In 2018, 666 lengths were measured at fish houses or on the water, the majority of which came from the estuarine gill net, spear, and pound net fisheries. The mean size of commercial caught sheepshead was 14 inches FL (Table 2). This has varied from year to year (10 to 20 inches FL), with the average and minimum sizes being smaller when there was no size limit.

Similar to the commercial fishery, average size varies little from year to year in the recreational fishery (Table 3). In 2018, the average size recreational sheepshead was 13 inches FL (Table 3). In both fisheries, sublegal fish (<10 inches FL) are still being harvested (Tables 2 and 3). This is most likely due to fishermen being unaware of changes in regulations, and/or confusing sheepshead and black drum regulations. While the size limits differ, black drum are measured for total length and sheepshead for FL.

Fishery-Independent Monitoring

A fishery independent gill net survey was initiated by the NCDMF in May of 2001. The survey utilizes a stratified random sampling scheme designed to characterize the size and age distribution for key estuarine species in Pamlico Sound. By continuing a long-term database of age composition and developing an index of abundance for sheepshead this survey will help managers assess the sheepshead stocks without relying solely on commercial and recreational fishery dependent data. The overall sheepshead Catch per Unit Effort (CPUE; number of sheepshead per set) was 0.41 in 2018, 50% above the time series CPUE (Table 4; Figure 7).

In order to describe the age distribution of the harvest and indices, sheepshead age structures are collected from various fishery independent and dependent sources throughout the year. Otolith collection for sheepshead is relatively new; though there are samples going back to 2008, collection of sheepshead otoliths was not made a sampling priority until 2013. The majority of sheepshead collected were ages 2 to 6 (Table 5). In 2018, 227 sheepshead were collected ranging in age from 0 to 30. The age-length relationship is hard to predict as there is overlap in age for a given length (Figure 8).

MANAGEMENT STRATEGY

See Table 6 for current management strategies and implementation status for sheepshead.

RESEARCH NEEDS

- Conduct spawning area surveys HIGH- (Needed; some work to be done by CMAST through CRFL)

- Develop a tagging program to determine migration patterns as well as juvenile and adult abundance indices for use in the development of a stock assessment model to determine sustainability. The program should include methods to estimate tag retention, reporting rate, and tagging-induced mortality- HIGH (Needed)
- Continue monitoring of recreational and commercial catches- MEDIUM (Ongoing)
- Collect ageing structures, update maturity schedule- MEDIUM (Ongoing)
- Collect age and sex information from recreational and commercial fisheries- MEDIUM (Ongoing)

LITERATURE CITED

SAFMC (South Atlantic Fishery Management Council). 2011. Comprehensive Annual Catch Limit (ACL) Amendment (Amendment 25 to the Fishery Management Plan for the Snapper Grouper Fishery of the South Atlantic Region). South Atlantic Fishery Management Council, 4055 Faber Place, Ste 201, North Charleston, S.C. 29405. (Available online at: https://www.dropbox.com/s/iz8wn5vec36hpis/CompACLAm_101411_FINAL.pdf?dl=0)

TABLES

Table 1. Recreational harvest (number of fish released and weight) and releases (number of fish; MRIP) and commercial harvest (weight in pounds; Atlantic Coastal Cooperative Statistics Program and N.C. Trip Ticket Program) of sheepshead from North Carolina, 1981-2018. All weights are in pounds.

	Recreational				
	Numbers		Weight (lb)	Commercial	Total
Year	Landed	# Released	Landed	Weight (lb)	Weight (lb)
1981	83,626	12,772	262,503	9,782	272,285
1982	61,765		183,768	13,922	197,690
1983	5,930		19,285	28,224	47,509
1984	21,156		32,152	36,267	68,419
1985	12,691		42,573	61,190	103,763
1986	132,061	8,283	399,925	97,355	497,280
1987	52,061	70,117	172,377	81,101	253,478
1988	152,971	7,766	50,046	63,400	113,446
1989	136,175	17,747	243,496	56,940	300,436
1990	103,041	18,679	161,180	68,029	229,209
1991	67,277	34,505	154,193	52,611	206,804
1992	206,241	48,565	434,509	47,526	482,035
1993	221,442	51,981	289,634	57,884	347,518
1994	92,098	31,965	197,128	83,789	280,917
1995	157,769	39,779	407,729	91,198	498,927
1996	77,750	12,798	256,911	82,290	339,201
1997	209,662	55,258	308,381	50,414	358,795
1998	151,473	109,454	209,825	60,184	270,009
1999	255,885	124,676	758,153	60,895	819,048
2000	355,192	94,963	780,622	88,459	869,081
2001	183,781	66,594	654,527	64,522	719,049
2002	181,197	68,317	781,567	57,434	839,001
2003	294,989	85,877	983,640	53,361	1,037,001
2004	86,554	40,263	453,372	82,009	535,381
2005	87,504	65,863	340,227	53,259	393,486
2006	137,312	90,502	445,182	57,481	502,663
2007	433,872	334,014	1,456,396	77,173	1,533,569
2008	503,666	172,604	1,007,914	89,726	1,097,640
2009	362,439	299,221	577,311	132,390	709,701
2010	327,223	190,823	966,467	157,631	1,124,098
2011	196,844	78,821	522,896	120,976	643,872
2012	346,609	269,226	797,963	109,881	907,844
2013	784,747	391,809	1,220,357	180,225	1,400,582
2014	185,267	224,062	389,583	173,376	562,959
2015	181,554	160,447	520,382	124,827	645,209
2016	149,085	212,471	375,328	93,513	468,841
2017	282,480	910,841	810,633	128,269	938,902
2018	343,772	524,967	735,738	90,291	826,029
Average	236,763	160,903	477,517	88,219	662,927

Table 2. Sheepshead length (fork length, inches) data from commercial fish house samples, 1982-2018.

Year	Mean Fork Length	Minimum Fork Length	Maximum Fork Length	Total Number Measured
1982	10	3	24	13
1983	18	8	24	25
1984	20	11	24	8
1985	10	3	13	3
1986	19	15	23	19
1987	16	8	24	53
1988	16	3	22	29
1989	14	3	23	42
1990	16	8	25	162
1991	15	6	23	124
1992	13	3	22	86
1993	13	4	22	107
1994	16	10	22	22
1995	15	5	23	164
1996	15	9	22	122
1997	16	8	24	97
1998	12	6	24	313
1999	13	8	24	461
2000	14	9	27	642
2001	15	8	22	296
2002	13	8	23	382
2003	14	9	24	406
2004	16	8	23	294
2005	17	9	25	415
2006	16	8	24	445
2007	14	7	24	826
2008	13	7	24	1,366
2009	12	6	23	1,388
2010	13	7	24	1,684
2011	15	9	24	1,246
2012	13	7	37	1,157
2013	13	7	24	1,282
2014	14	7	23	1,294
2015	15	8	24	982
2016	15	9	24	886
2017	14	9	23	333
2018	14	8	23	666

Table 3. Sheepshead length (fork length, inches) data from Marine Recreational Information Program samples, 1981-2018.

Year	Mean Fork Length	Minimum Fork Length	Maximum Fork Length	Total Number Measured
1981	18	9	20	13
1982	17	8	21	29
1983	19	15	20	3
1984	11	10	13	2
1985	13	13	13	1
1986	15	7	29	29
1987	15	7	23	70
1988	2	6	25	85
1989	13	7	21	76
1990	11	7	22	93
1991	12	5	23	83
1992	13	8	23	54
1993	11	6	22	176
1994	13	7	21	179
1995	14	7	22	174
1996	15	9	26	79
1997	11	6	24	134
1998	11	6	23	191
1999	15	7	29	187
2000	13	8	24	239
2001	16	10	30	132
2002	17	10	23	56
2003	15	8	26	96
2004	17	9	24	54
2005	16	9	23	34
2006	15	7	24	55
2007	15	7	24	118
2008	12	7	21	108
2009	11	7	21	159
2010	14	8	26	221
2011	14	7	25	160
2012	13	6	23	254
2013	11	6	24	351
2014	13	8	25	99
2015	14	9	23	134
2016	14	8	25	106
2017	14	4	22	272
2018	13	9	23	386

Table 4. Annual weighted sheepshead Catch Per Unit Effort (Number per set, all ages combined) from the North Carolina Pamlico Sound Independent Gill Net Survey, 2001-2018. N=number of samples; CPUE=Catch per unit effort; SE=Standard Error; PSE=Proportional Standard Error.

Year	N	CPUE	SE	PSE
2001	237	0.13	0.06	46
2002	320	0.14	0.04	29
2003	320	0.08	0.02	25
2004	320	0.13	0.03	23
2005	304	0.08	0.02	25
2006	320	0.08	0.02	25
2007	320	0.11	0.03	27
2008	320	0.11	0.03	27
2009	320	0.30	0.05	17
2010	320	0.18	0.04	22
2011	298	0.16	0.06	38
2012	308	0.12	0.03	25
2013	308	0.30	0.07	23
2014	308	0.45	0.09	20
2015	306	0.26	0.06	23
2016	308	0.20	0.04	20
2017	308	0.44	0.10	23
2018	308	0.41	0.11	27

Table 5. Summary of sheepshead age samples collected from both dependent (commercial and recreational) and independent (survey) sources, 2008-2018.

Year	Modal Age	Minimum Age	Maximum Age	Total Number Aged
2008	2	2	8	10
2009	--	3	25	5
2010	6	3	18	10
2011	4	3	10	14
2012	1	1	26	8
2013	2	1	22	162
2014	3	1	24	243
2015	4	1	24	140
2016	5	0	29	211
2017	2	1	28	262
2018	2	0	30	227

Table 6. Summary of management strategies and their implementation status for sheepshead.

Management Strategy	Implementation Status
HARVEST MANAGEMENT	
Implement a size limit, recreational bag limit, and commercial trip limit by June 1, 2015	Proclamation authority through Rule 15A NCAC 03M .0521 (FF-28-2015)

FIGURES

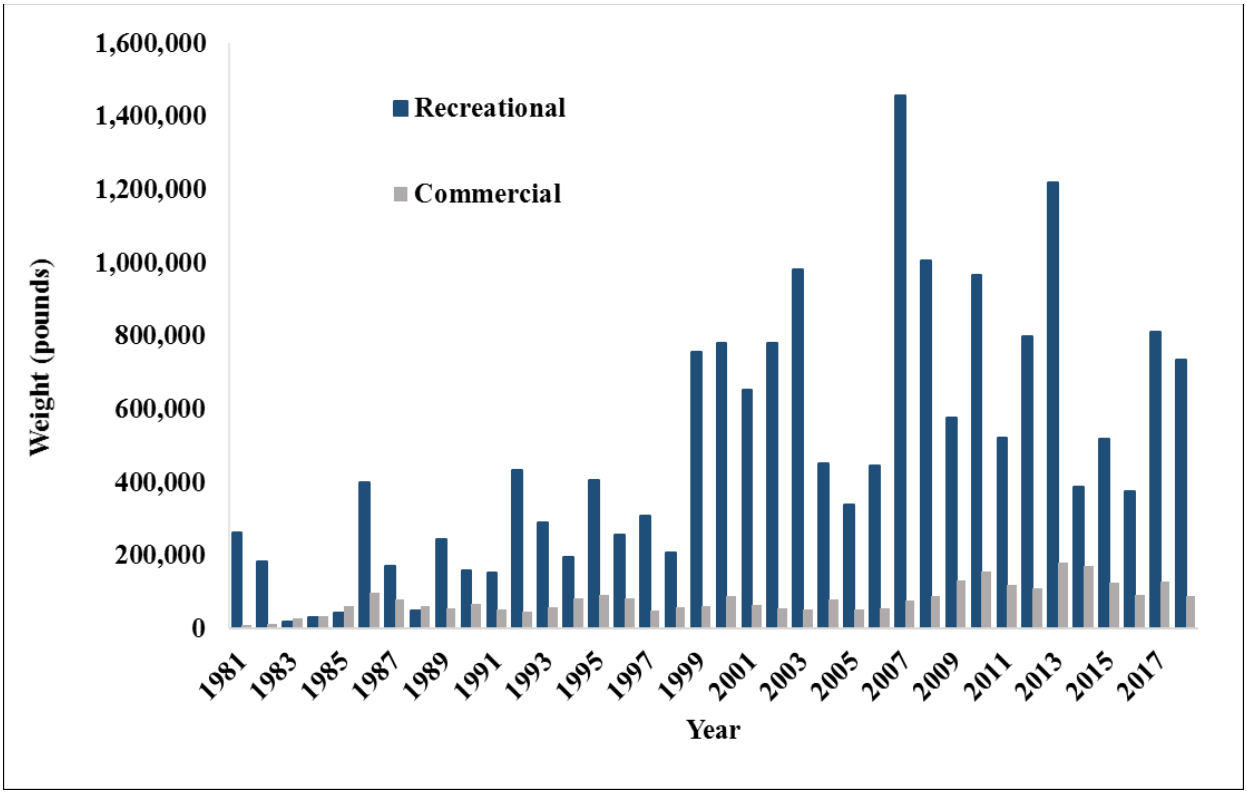

Figure 1. Annual commercial (Atlantic Coastal Cooperative Statistics Program and N.C, Trip Ticket Program) and recreational (MRIP) landings in pounds for sheepshead in North Carolina from 1981 to 2018.

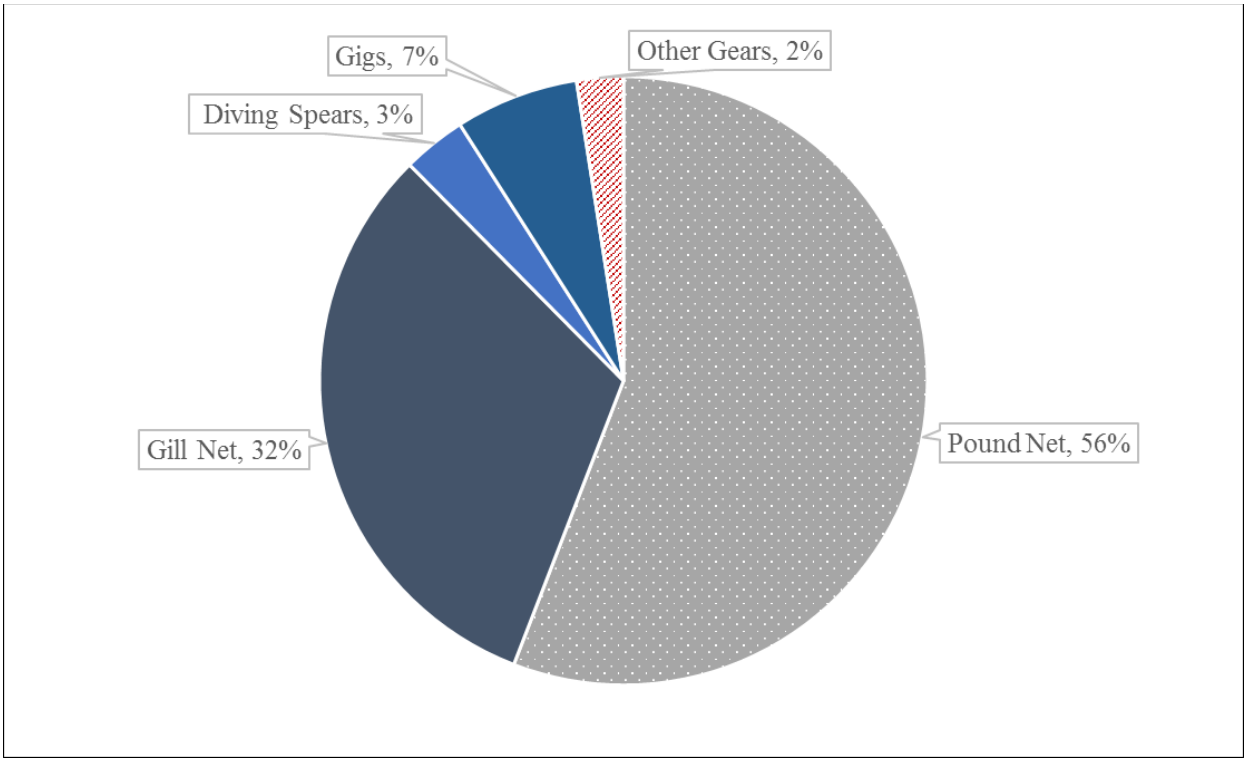

Figure 2. Commercial harvest in 2018 by gear type. Other gears include trawls, long haul seines, fyke nets, crab pots, and hook-and-line.

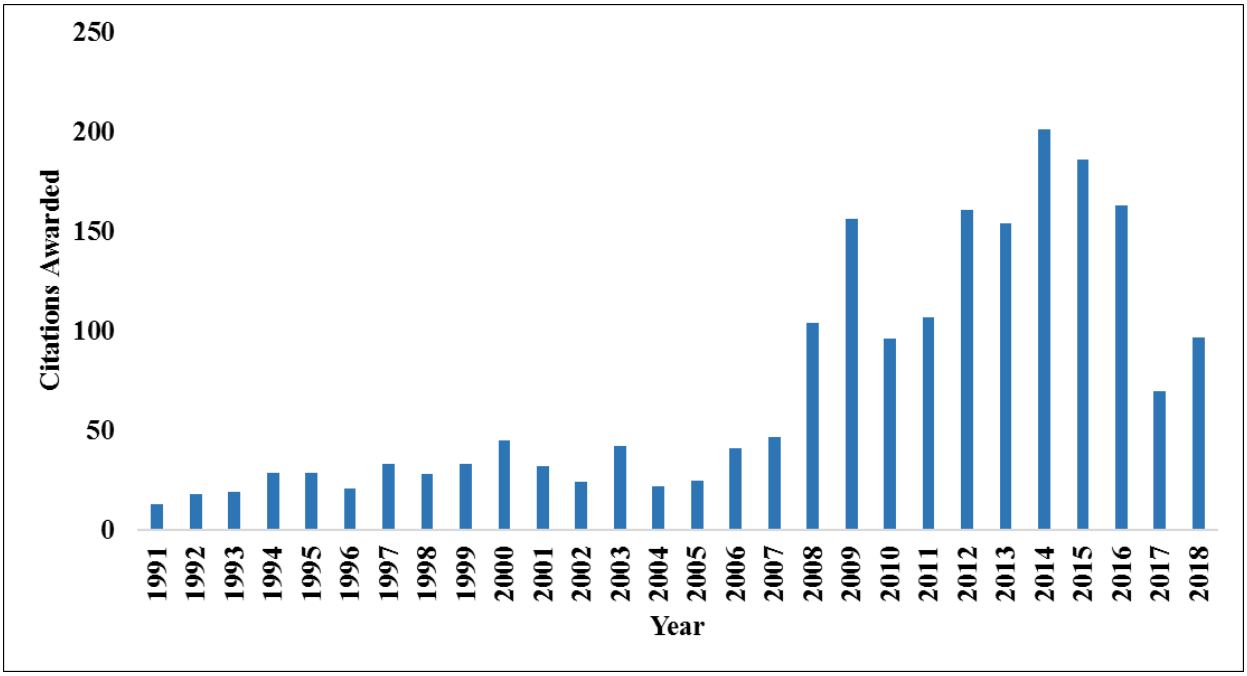

Figure 3. North Carolina Saltwater Fishing Tournament citations awarded for sheepshead from 1991 to 2018.

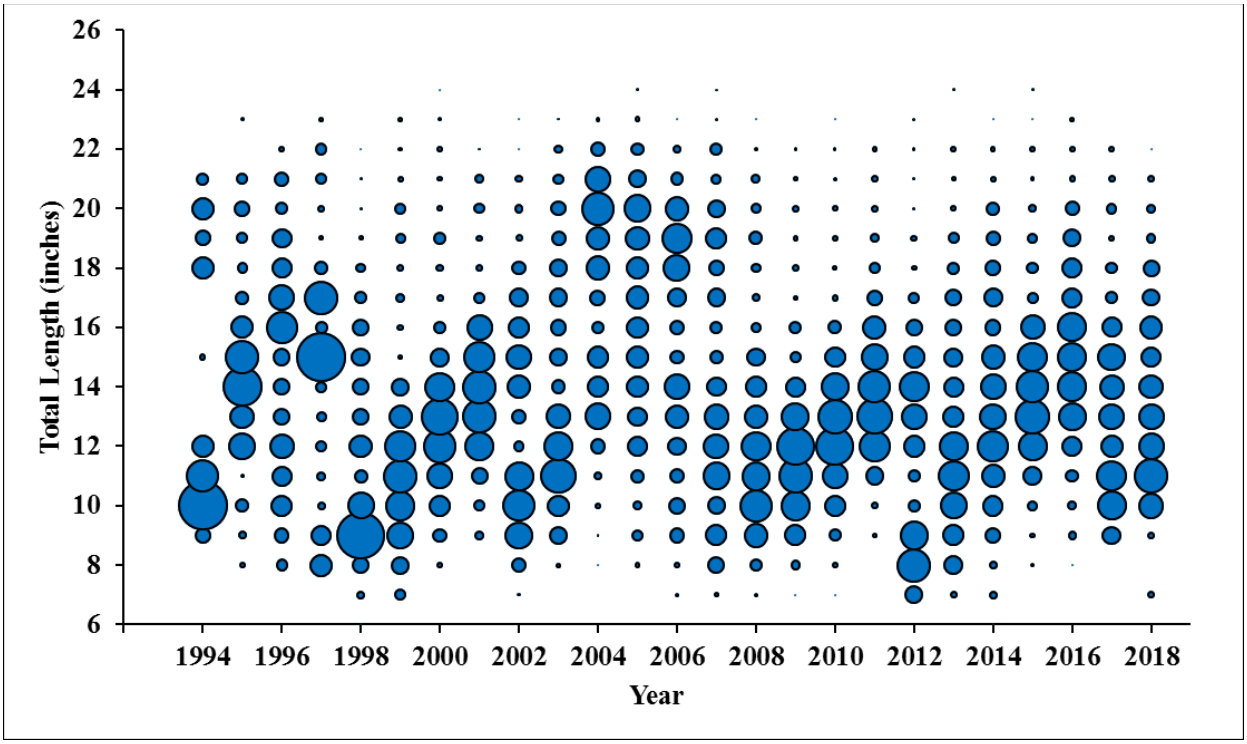

Figure 4. Commercial length frequency (fork length, inches) of sheepshead harvested from 1994 to 2018. Bubbles represent fish harvested at length and the size of the bubble is equal to the proportion of fish at that length.

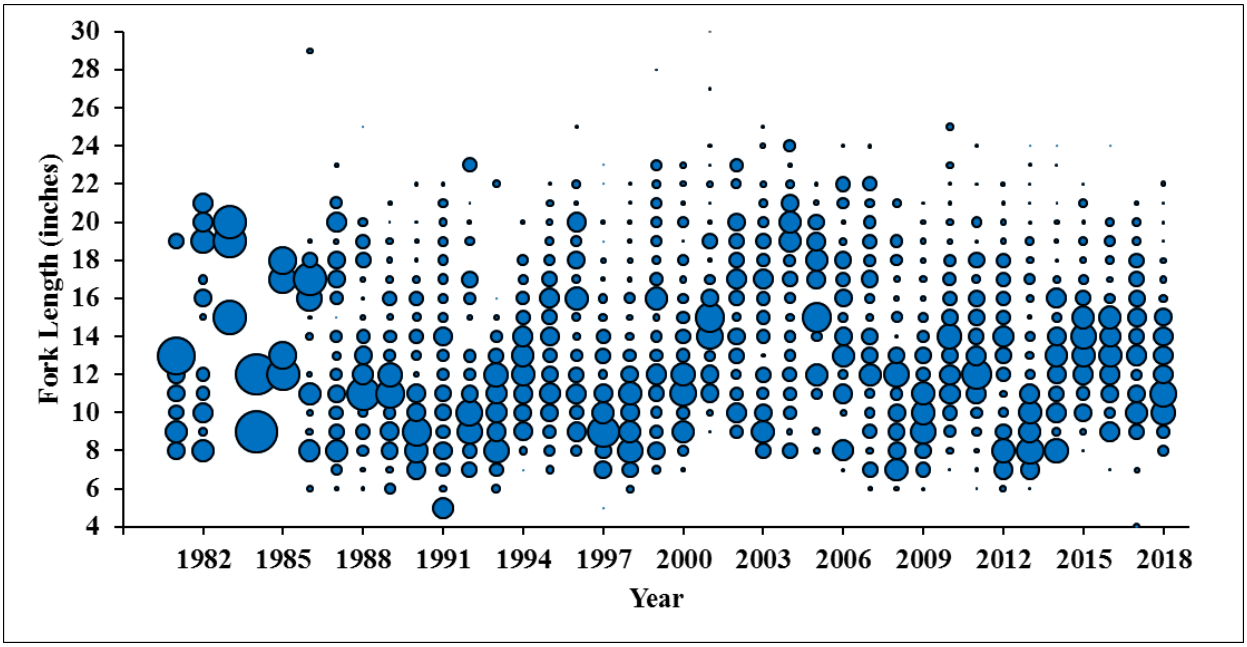

Figure 5. Recreational length frequency (fork length, inches) of sheepshead harvested from 1981 to 2018. Bubbles represent fish harvested at length and the size of the bubble is equal to the proportion of fish at that length.

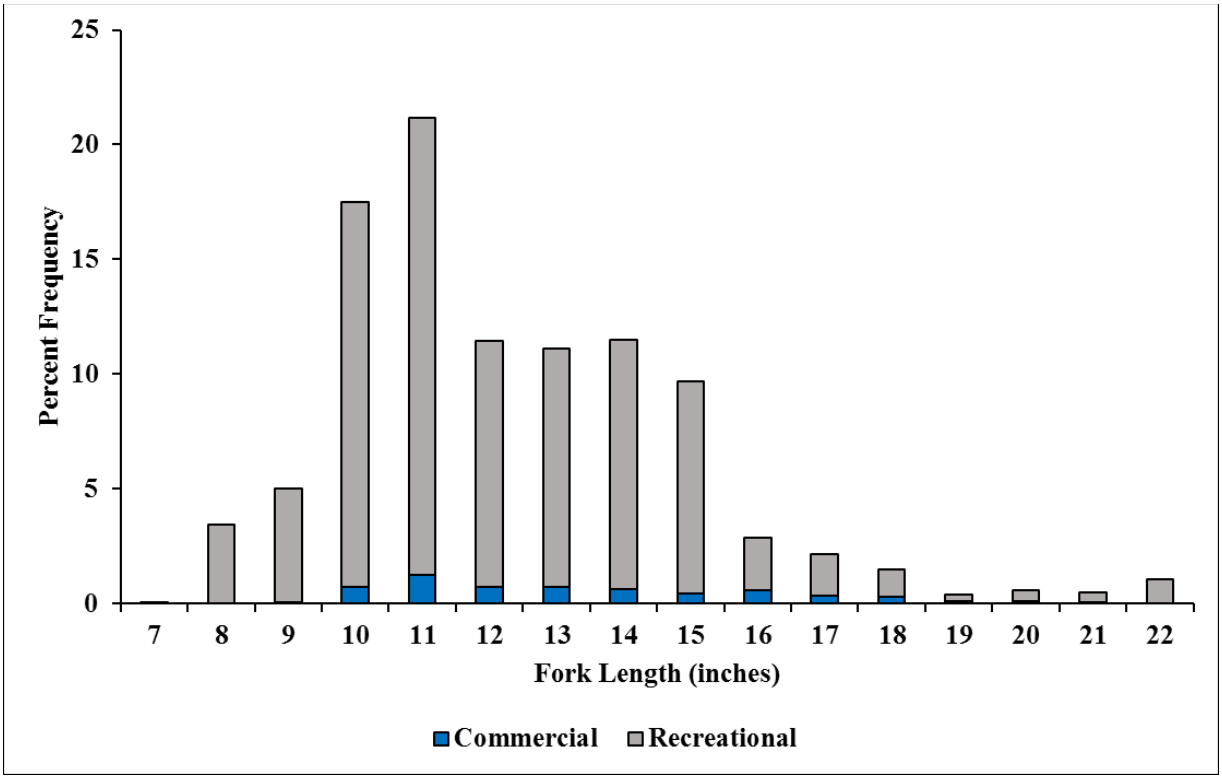

Figure 6. Commercial and recreational length frequency distribution from sheepshead harvested in 2018.

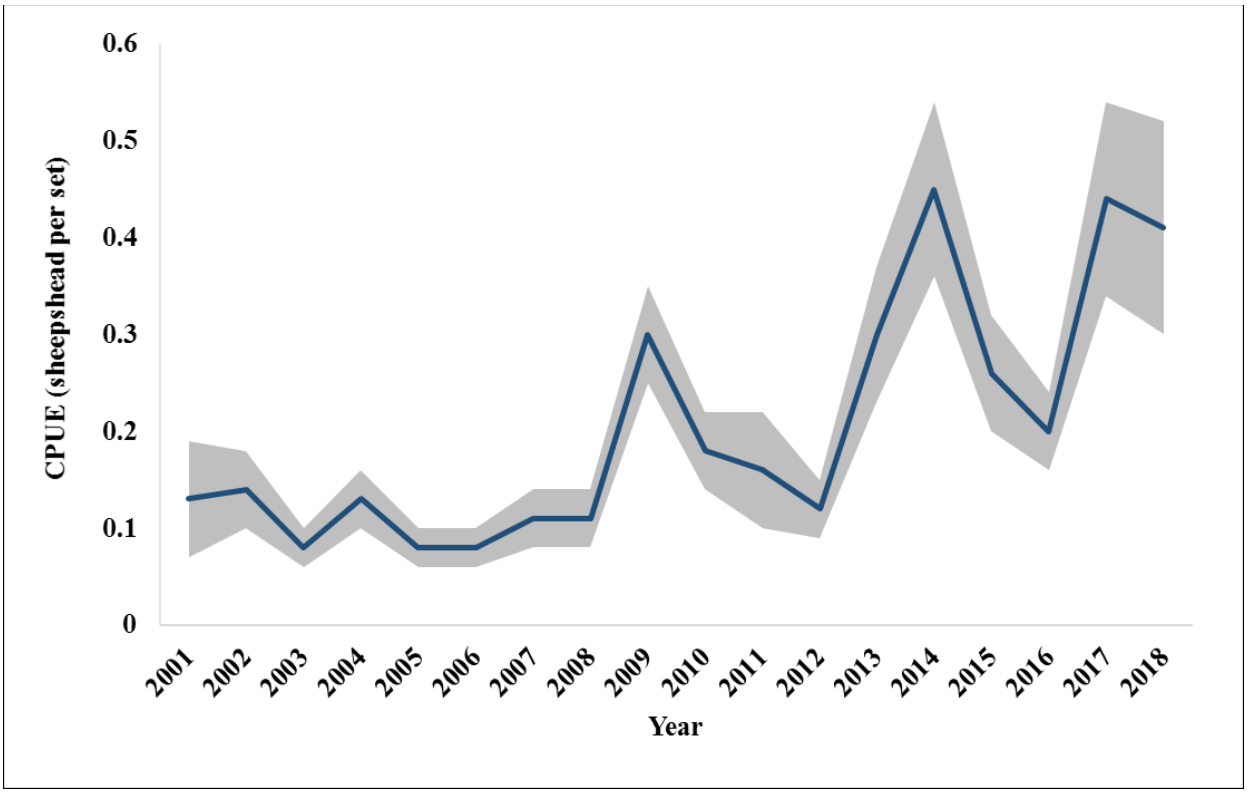

Figure 7. Annual index of abundance of sheepshead in the NCDMF Pamlico Sound Independent Gill Net Survey, 2001-2018.

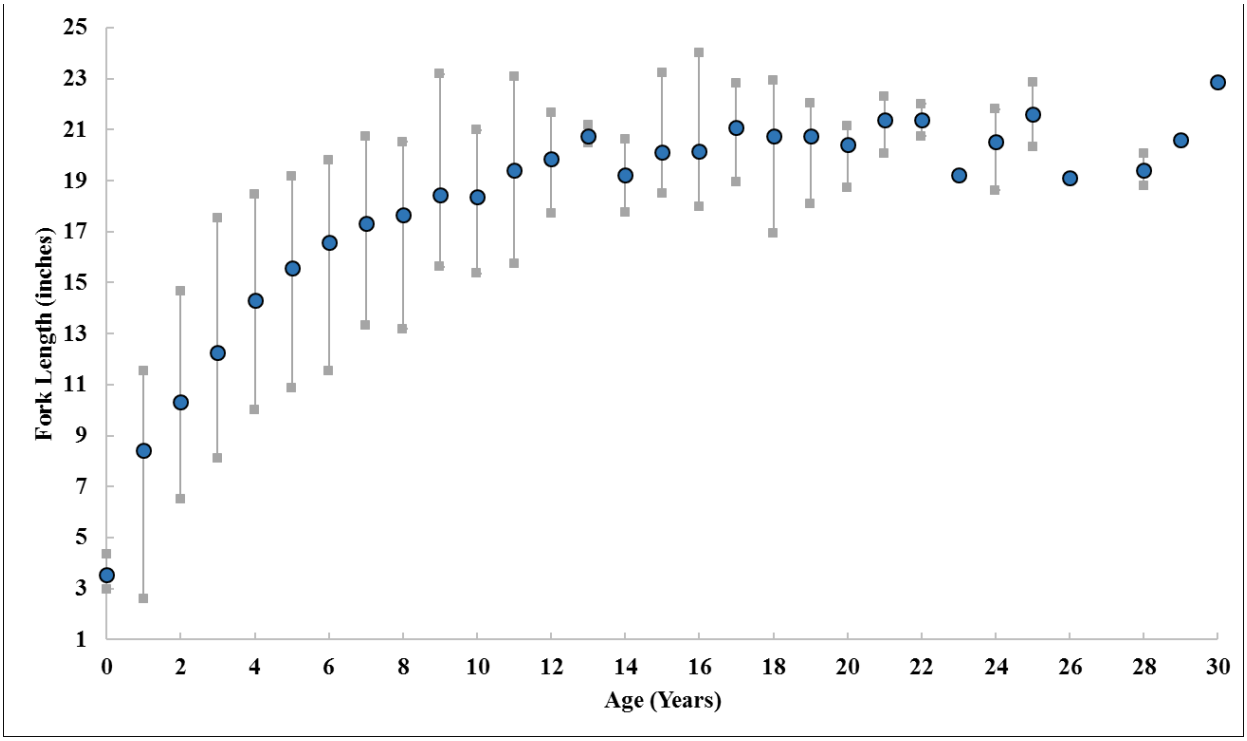

Figure 8. Sheepshead length at age based on all age samples collected from 2008 to 2018. Blue circles represent the mean size at a given age while the grey squares represent the minimum and maximum observed size for each age.

FISHERY MANAGEMENT PLAN UPDATE
SHRIMP
AUGUST 2019

STATUS OF THE FISHERY MANAGEMENT PLAN

Fishery Management Plan History

Original FMP Adoption:	April 2006
Amendments:	Amendment 1 – February 2015
Revisions:	Revision 1 to Amendment 1 – May 2018
Supplements:	None
Information Updates:	None
Recommended Schedule Change:	None
Next MFC Scheduled Review:	July 2019

The N.C. Shrimp Fishery Management Plan (FMP) was approved in April 2006 by the N.C. Marine Fisheries Commission (NCMFC; NCDMF 2006). The plan included a 90-foot headrope limit in some internal waters, allowed skimmer trawls as a Recreational Commercial Gear License (RCGL) gear and made recommendations on the minimum shrimp size at which some water bodies open to trawling. The plan also closed some areas in the state to protect habitats and juvenile finfish and established a 48-quart (heads-on) recreational limit. A restriction on the use of shrimp trawls above the Highway 172 Bridge over New River took effect in 2010 and this area above the bridge is now limited to skimmer trawls only. This strategy was codified into rule through Amendment 1.

Amendment 1 was adopted in February 2015 and was limited in scope to bycatch issues in the commercial and recreational fisheries (NCDMF 2015). It recommended a wider range of certified bycatch reduction devices (BRD) to choose from, and the requirement of two BRDs in shrimp trawls and skimmer trawls beginning June 1, 2015 (SH-2-2015). It increased the daily harvest limit for cast nets in closed areas. Amendment 1 also established a maximum combined headrope length of 220 feet in all internal coastal waters where there were no existing maximum combined headrope requirements, allowing for a phase-out period until January 1, 2017. Shrimp trawling was also prohibited, effective May 1, 2015 in the Intracoastal Waterway channel from the Sunset Beach Bridge to the South Carolina line, including the Shallotte River, Eastern Channel and lower Calabash River, to protect small shrimp. Amendment 1 also permitted a live bait shrimp fishery to allow live bait fishermen with a permit to fish until 12:00 p.m. (noon) on Saturdays; effective May 1, 2017.

An industry workgroup was formed to test gear modifications to reduce bycatch, to the extent practicable, with a 40% target reduction in the shrimp trawl fishery. In 2015, five experimental gear combinations were tested during the summer on large vessels in the Pamlico Sound. During the summer and fall of 2016, four additional gear combinations were tested on large vessels in the Pamlico Sound. In the final year of the study, 2017, three gear combinations were tested on both small and large vessels in the Atlantic Ocean and the Pamlico Sound. Gear combinations with larger tailbag mesh sizes (>one and one half-inches), reduced TED grid size (3-inch), and larger fisheyes were found to significantly reduce finfish bycatch. Four of the 12 gear combinations tested met or exceeded the 40% target reduction in finfish bycatch while also minimizing shrimp loss (Brown et al. 2017, 2018). Overall, finfish bycatch reductions ranged from 4.5 to 57.2%. Differences in shrimp catch between the control and experimental nets ranged from a 16.2% loss to a 9.9% gain. Results from the industry workgroup testing as well as the workgroup recommendation were presented to the NCMFC at its May 2018 business meeting. At this meeting the commission voted to require fishermen to use one of four gear combinations tested by the workgroup that achieved at least 40% finfish bycatch. These gears were found to reduce finfish bycatch by 40.1 to 57.2%. The new gear configurations will be required in all shrimp trawls, except skimmer trawls, used in inside waters where up to 220 feet of combined headrope is allowed (Pamlico Sound and portions of the Pamlico, Bay, and Neuse rivers); effective July 1, 2019. The commission also voted to continue the shrimp industry workgroup and explore funding options for more studies, to survey fishermen to determine what bycatch reduction devices the shrimp trawl industry currently uses, and to begin development of Amendment 2 to the Shrimp Fishery Management Plan.

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.

Management Unit

The management unit includes the three major species of shrimp: brown (*Farfantepenaeus aztecus),* pink (*F. duorarum*), and white (*Litopenaeus setiferus*) and its fisheries in all coastal fishing waters of North Carolina, which includes the Atlantic Ocean offshore to three miles.

Goal and Objectives

The goal of the N.C. Shrimp Fishery Management Plan is to utilize a management strategy that provides adequate resource protection, optimizes the long-term commercial harvest, maximizes social and economic value, provides sufficient opportunity for recreational shrimpers, and

considers the needs of all user groups. To achieve this goal, it is recommended that the following objectives be met:

1. Minimize waste and enhance economic value of the shrimp resource by promoting more effective harvesting practices.
2. Minimize harvest of non-target species of finfish and crustaceans and protected, threatened, and endangered species.
3. Promote the protection, restoration, and enhancement of habitats and environmental quality necessary for enhancing the shrimp resource.
4. Maintain a clear distinction between conservation goals and allocation issues.
5. Reduce conflicts among and within user groups, including non-shrimping user groups and activities.
6. Encourage research and education to improve the understanding and management of the shrimp resource.

STATUS OF THE STOCK

Life History

There are three shrimp species that make up the shrimp fishery in North Carolina. They are the brown shrimp, *Farfantepenaeus aztecus*, pink shrimp, *F. duorarum* and white shrimp, *Litopenaeus setiferus*. The lifecycle of these three species are similar in that the adults spawn offshore and eggs are hatched into free-swimming larvae. These larvae develop through several stages into post-larvae. Once post-larval shrimp enter the estuaries, growth is rapid and is dependent on salinity and temperature. As the shrimp increase in size, they migrate from the upper reaches of small creeks to deeper saltier rivers and sounds. By late summer and fall, they return to the ocean to spawn. The maximum life span of shrimp can range from 16 to 24 months and may reach a size of 7 to 11 inches.

Stock Status

Population size is regulated by environmental conditions, and while fishing reduces the population size over the season, fishing is not believed to have any impact on subsequent year class strength unless the spawning stock has been reduced below a minimum threshold level by environmental conditions. Because of high fecundity and migratory behavior, the three species are all capable of rebounding from a very low population size in one year to a large population size in the next, provided environmental conditions are favorable.

Stock Assessment

Estimates of population size are not available but since the fishery is considered an annual crop and fished at near maximum levels, annual landings are probably a good indication of relative abundance. Annual variations in catch are presumed to be due to a combination of prevailing environmental conditions, fishing effort, and the effects of changes in the economics of the fishery.

STATUS OF THE FISHERY

Current Regulations

General Rules

- Channel net is defined as a net used to take shrimp which is anchored or attached to the bottom at both ends or with one end anchored or attached to the bottom and the other end attached to a boat [15A NCAC 03I .0101(3)(b)].
- Headrope is defined as a support structure for the mesh or webbing of a trawl that is nearest to the water surface when in use [15A NCAC 03I .0101(3)(i)].
- Nursery areas are defined as areas in which for reasons such as food, cover, bottom type, salinity, temperature and other factors, young finfish and crustaceans spend the major portion of their initial growing season [15A NCAC 03I .0101(4)(f)].
- Military danger zones and restricted areas are designated in 15A NCAC 03R .0102 and are enforced by the appropriate federal agency [15A NCAC 03I .0110(a)].
- Maps or charts showing the boundaries of areas identified by rule or in proclamations are available for inspection [15A NCAC 03I .0121(a)].
- The NCDMF shall mark boundaries with signs insofar as may be practical. No removal or relocation of signs shall have the effect of changing the classification or affect the applicability of any rule pertaining to that body of water [15A NCAC 03I .0121(b)].

Rules Specific to Commercial Nets, Pots, Dredges, and Other Fishing Devices

- It is unlawful to use or set a fixed or stationary net in the Intracoastal Waterway where it may be a hazard to navigation, block more than two-thirds of any natural or manmade waterway, in the middle third of any marked navigation channel [15A NCAC 03J .0101(1), (2), and (3)].
- It is unlawful to possess aboard a vessel while using a trawl in internal waters more than 500 pounds of finfish from December 1 through February 28 and 1,000 pounds of finfish from March 1 through November 30 [15A NCAC 03J .0104(a)].
- It is unlawful to use trawls nets in internal coastal waters from 9:00 p.m. on Friday through 5:00 p.m. on Sunday, except for the areas described in the next bullet [15A NCAC 03J .0104(b)(1)].
- It is unlawful to use trawl nets from December 1 through February 28 from one hour after sunset to one hour before sunrise in portions of the Pungo, Pamlico, Bay, Neuse, and New rivers [15A NCAC 03J .0104(b)(5)(A), (B), (C), (D), and (E)].
- It is unlawful to use trawl nets in Albemarle Sound and its tributaries [15A NCAC 03J .0104(b)(3)].
- The Director may by proclamation, require bycatch reduction devices or codend modifications in trawl nets to reduce the catch of finfish that do not meet size limits or are unmarketable as individual foodfish by reason of size [15A NCAC 03J .0104(d)].
- It is unlawful to use trawl nets in designated pot areas opened to the use of pots by 15A NCAC 03J .0301(a)(2) within an area bound by the shoreline to the depth of six feet [15A NCAC 03J .0104(b)(6)].
- It is unlawful to use shrimp trawls for the taking of blue crabs in internal waters, except that it shall be permissible to take or possess blue crabs incidental to commercial shrimp trawling provided that the weight of the crabs shall not exceed 50% of the total weight of

the combined crab and shrimp catch; or 300 pounds, whichever is greater [15A NCAC 03J .0104(f)(2)].

- It is unlawful to use shrimp trawls for recreational purposes unless the trawl is marked with a pink buoy on the tailbag [15A NCAC 03J .0104(e)].
- The Fisheries Director may, by proclamation, close any area to trawling for specific time periods in order to secure compliance with this rule [15A NCAC 03J .0104(g)].
- It is unlawful to use a channel net until the Director specifies by proclamation when and where channel nets and other fixed nets for shrimping can be used [15A NCAC 03J .0106(a)(1)].
- It is unlawful to set a channel net without yellow light reflective tape on the staffs, stakes and buoys [15A NCAC 03J .0106(a)(2)].
- Channel nets cannot be set with any portion of the set within 50 feet of the center line of the Intracoastal Waterway (ICW) channel or in the middle third of any navigation channel marked by the Corps of Engineers or the Coast Guard. Fishermen must attend channel nets by being no more than 50 yards from the set at all times [15A NCAC 03J .0106(a)(3), (4), and (5)].
- The maximum corkline length of a channel net that can be used or possessed is 40 yards. No channel net, net buoys or stakes can be left in coastal waters from December 1 through March 1. From March 2 through November 30, cables and any attached buoy must be connected together with non-metal line when not attached to the net. Metallic floats or buoys to mark sets are unlawful [15A NCAC 03J .0106(b), (c), (d), and (e)].
- Channel nets must be properly marked with yellow light reflective tape and the owner's identification on each buoy. Identification includes one of the following: owner's N.C. motorboat registration number or the U.S. vessel documentation number or owner's last name and initials. Channel nets, anchor lines or buoys are not to be used in any way that constitutes a hazard to navigation [15A NCAC 03J .0106(f) and (g)].
- It is unlawful to use channel nets to take blue crabs in internal waters, except that it shall be permissible to take or possess blue crabs incidental to channel net operations provided that the weight of the crabs does not exceed 50% of the total weight of crab and shrimp or 300 pounds, whichever is greater [15A NCAC 03J .0106(h)(1)(A) and (B)].
- The Director may, by proclamation, close any area to channel net use for specific time periods in order to secure compliance with the above bullet [15A NCAC 03J .0106(h)(2)].
- It is unlawful to use nets from June 15 through August 15 in the waters of Masonboro Inlet or in the ocean within 300 yards of the beach between Masonboro Inlet and a line running 138° through the water tank on the northern end of Wrightsville Beach, a distance parallel with the beach of 4,400 yards. It is unlawful to use trawls within one-half mile of the beach between the Virginia line and Oregon Inlet [15A NCAC 03J. 0202(1) and (2)].
- It is unlawful to use a trawl with a mesh length less than four inches in the body and three inches in the extension and on and three-fourths inches in the cod end or tail bag from the west side of Beaufort Inlet Channel to the shore off Salter Path within a half mile of shore [15A NCAC 03J .0202(3)].
- From December 1 through March 31 it is unlawful to possess finfish caught incidental to shrimp and crab trawling in the Atlantic Ocean unless the weight of the combined catch of shrimp and crabs exceeds the weight of finfish; except that crab trawlers working south of Bogue Inlet may keep up to 300 pounds of kingfish, regardless of their shrimp or crab catch weight [15A NCAC 03J .0202(5)].

- It is unlawful to use shrimp trawls in all waters west of a line beginning at the southeastern tip of Baldhead Island at a point 33^0 50.4833'N – 77^0 57.4667 W; running southerly in the Atlantic Ocean to a point 33^0 46.2667'N – 77^0 56.4000 W from 9:00 p.m. through 5:00 a.m. [15A NCAC 03J .0202(8)].
- It is unlawful to use trawl nets upstream of the Highway 172 Bridge in New River from 9:00 p.m. through 5:00 a.m. when opened by proclamation from August 15 through November 30 (15A NCAC 03J .0208).
- It is unlawful to use any commercial fishing gear in the Southport Boat Harbor, Brunswick County and to use any commercial fishing gear in the Progress Energy Intake Canal between the fish diversion screen and the Brunswick nuclear power plant (15A NCAC 03J .0206 and .0207).
- It is unlawful to use shrimp pots with mesh lengths smaller than one and one-fourth inches stretch or five-eighths inch bar [15A NCAC 03J .0301(e)].
- It is unlawful to use pots with leads or leaders to take shrimp. Leads are defined as any fixed or stationary net or device used to direct fish into any gear [15A NCAC 03J .0301(l)].
- In Dare County, commercial fishing gear may not be used within 750 feet of licensed fishing piers when opened to the public. Commercial fishing gear may not be used in the Atlantic Ocean off of portions of Onslow, Pender, and New Hanover counties during specified time frames [15A NCAC 03J .0402(a)(1)(A)(ii), (a)(2)(A), (a)(2)(B)(i) and (ii), (a)(3)(A), (a)(3)(B)(i) and (iii), (a)(4)].
- Shrimp pound net set is defined as a pound net set constructed of stretch mesh equal to or greater than one and one-fourth inches and less than or equal to two inches [15A NCAC 03J .0501(a)(6)].
- A permit is required to deploy a pound net set and must be operational for a minimum of 30 consecutive days during the permit period. Each pound required the permittee's identification on a sign attached to a stake at the permitted ends of each set at all times. They must have yellow light reflective tape or yellow light reflective devices on each pound and have a marked navigational opening at least 25 feet wide at the end of every third pound and marked with yellow light reflective tape or yellow light reflective devices [15A NCAC 03J .0501(b) and (c)].
- It is unlawful to use a RCGL shrimp pound net unless it is marked by attaching to the offshore lead, one hot pink floating buoy. The owner shall be identified on the buoy by engraving the gear owner's current boat registration number or the owners U.S. vessel documentation name. Each shrimp pound must be set a minimum of 100 yards from a RCGL pound net set or 300 yards from an operational permitted shrimp pound net set [15A NCAC 03J .0501(d)(1) and (2)].
- It is unlawful within 30 days of abandonment of a permitted pound net set to fail to remove all stakes and associated gear from coastal fishing waters [15A NCAC 03J .0501(g)].
- Pound net permit applications, renewals and transfers are to comply with the permitting procedures and requirements for obtaining all NCDMF-issued permits. Application process, criteria for the granting of the permit, operational requirements and other elements of the shrimp pound net set permits are found in 15A NCAC 03J .0502, .0503, .0504, and .0505.

Rules Specific to Shrimp

- It is unlawful to take shrimp with nets until the Director opens the season in various waters by proclamation (15A NCAC 03L .0101).

Proclamations may specify any hours of day or night or both and any other conditions appropriate to manage the fishery. Some areas never open to shrimping, some areas are open year round, and some areas open and close throughout the year dependent upon shrimp movement and their size. Open areas to trawling are considered the shrimp open areas for all other gears including cast nets. All proclamations beginning with SH identify the open and closed areas and are found here throughout the year: http://portal.ncdenr.org/web/mf/proclamations-current.

- It is unlawful to take shrimp by any method from 9:00 p.m. on Friday through 5:00 p.m. on Sunday except in the Atlantic Ocean or with the use of fixed and channel nets, hand seines, shrimp pots and cast nets [15A NCAC 03L .0102].
- It is unlawful to take shrimp with mesh lengths less than one and one-half inches in trawls, one and one-fourth inches in fixed nets, channel nets, float nets, butterfly nets and hand seines [15A NCAC 03L .0103(a)(1) and (2)].
- It is unlawful to take shrimp with a net constructed in a manner as to contain an inner our outer liner of any mesh size. Net material used as chafing gear shall be no less than four inches mesh length [15A NCAC 03L .0103(b)].
- It is unlawful to take shrimp with trawls which have a combined headrope of greater than 90 feet in internal coastal waters except in Pamlico Sound, Pamlico River downstream of Pamlico Point/ Willow Point and Neuse River downstream of Winthrop Point/Windmill Point [15A NCAC 03L .0103(c)(1), (2), and (3)].
- It is unlawful to use a shrimp trawl in the Pungo River, upstream of Wades Point/Abel Bay, Pamlico River upstream of the entrance to Goose Creek/Wades Point and Neuse River upstream of Cherry Point/Wilkerson Point 15A [NCAC 03L .0103(d)].
- It is unlawful to possess more than 48 quarts, heads-on or 30 quarts heads-off of shrimp per person per day or per vessel per day for recreational purposes [15A NCAC 03L .0105(1)].
- It is unlawful to take or possess shrimp taken from any area closed to the taking of shrimp except for two quarts per person per day may be taken with a cast net in a closed area [15A NCAC 03L .0105(2)].
- It is unlawful to use trawls in the crab spawning sanctuaries from March 1 through August 31 [15A NCAC 03L .0205(a)].
- It is unlawful to use a trawl net in any primary or permanent secondary nursery area [15A NCAC 03N .0104, and .0105(a)].
- Special secondary nursery areas may be opened to shrimp and crab trawling from August 16 through May 14 [15A NCAC 03N .0105(b)].
  Special secondary nursery areas open by proclamation and vary in their open time periods within the August 16 through May 14 window. They are opened once the finfish amount has declined to reduce bycatch.

Recreational Licenses and Limits

- RCGL gear includes one shrimp trawl with a headrope not exceeding 26 feet in length per vessel, five shrimp pots, skimmer trawls, not exceeding 26 feet in total combined width and one shrimp pound net with each lead 10 feet or less in length and with a minimum lead net mesh of 1 ½ inches and enclosures constructed of net mesh of 1 ¼ inches or greater and with all dimensions being 36 inches or less. Attendance is required at all times for shrimp pounds [15A NCAC 03O .0302(a)(2), (3), (7), and (8)].
- It is unlawful for a RCGL holder to use pots, including shrimp pots unless each pot is

marked by attaching one hot pink floating buoy; the buoy should be engraved with the gear owners boat registration number or U.S. vessel documentation name [15A NCAC 03J .0302(a)(1) and (2)].

- It is unlawful to possess more than 48 quarts, heads-on, or 30 quarts, heads-off, of shrimp per person per day or per vessel per day [15A NCAC 03L .0105].
- It is unlawful to possess more than 48 quarts, heads-on, or 30 quarts, heads-off, of shrimp when only one person aboard a vessel possesses a valid RCGL and recreational commercial fishing equipment [15A NCAC 03O .0303(e)].
- It is unlawful to possess more than 96 quarts, heads on or 60 quarts, heads-off, of shrimp if more than one person aboard a vessel possesses a valid RCGL and recreational commercial fishing equipment [15A NCAC 03O .0303(f)].

Turtle Excluder Device Requirements

- It is unlawful to use a shrimp trawl that does not conform with the federal requirements for Turtle Excluder Devices (TEDs) [15A NCAC 03L .0103(g)].
- It is unlawful to trawl for shrimp in the Atlantic Ocean without TEDs within one nautical mile of shore from Browns Inlet to Rich's Inlet without a valid permit to waive the requirement to use TEDs in the Atlantic Ocean when allowed by proclamation from April 1 through November 30. It is unlawful to tow more than 55 minutes from April 1 through October 31 and 75 minutes from November 1 through November 30. It is unlawful to not fully empty the contents of each net after each tow. It is unlawful to refuse to take observers. It is unlawful to fail to report any sea turtle captured [15A NCAC 03O .0503(d)(1), (2), (3), (4), and (5)].

Federal Regulations

- 33 CFR 334.410 through 334.450
  These rules designate prohibited and restricted military areas, including locations within North Carolina coastal fishing waters, and specify activities allowed in these areas.
- 50 CFR 223.206 - Exceptions to prohibitions relating to sea turtles.
  The incidental taking of sea turtles in the shrimp trawl fishery is exempted from section 9 of the Endangered Species Act if conservation regulations are followed and include the installation of National Oceanic and Atmospheric Administration (NOAA) Fisheries approved TEDs and alternative tow times for skimmer trawls, pusher-head trawls and butterfly trawls.
- 50 CFR 223.207 – Approved TEDs
  This lists NOAA Fisheries approved TEDs such as the single-grid hard TEDs, hooped hard TEDs, special hard TEDs and soft TEDs, along with materials and gear specifications. Testing protocols for TEDs are also included in this rule.
- 50 CFR 229.7 – Monitoring of incidental mortalities
  This requires that fishermen who participate in a Category I or II fishery are required to accommodate an observer onboard your vessel(s) up on request
- 50 CFR 622, Appendix D – Approved Bycatch Reduction Devices (BRDs)
  This lists NOAA Fisheries approved BRDs and provides technical specifications for the construction and subsequent legal enforcement of these BRDs.

Rules implemented in Amendment 1 to the N.C. Shrimp Fishery Management Plan on May 1, 2015

- Modify the definition of mesh length to apply to diamond-mesh and square-mesh nets in support of a management strategy to require an additional bycatch reduction device in skimmer and otter trawls, which can include a square-mesh T-90 panel [15A NCAC 03I .0101(3)(n)].
- Codify an existing management strategy prohibiting the use of trawl nets, except skimmer trawls, upstream of the N.C. 172 Bridge over the New River in Onslow County to continue reducing bycatch [15A NCAC 03J .0208(a) and (b)].
- Clarify the Division of Marine Fisheries Director's proclamation authority for shrimp harvest restrictions [15A NCAC 03J .0104(g)].
- Establish a maximum combined headrope length of 220 feet in all internal coastal waters where there is no existing maximum combined headrope requirements, allowing for a phase-out period until Jan. 1, 2017 [15A NCAC 03L .0103(d)(1), (2), and (3)].
- Allow cast-netting of shrimp in all areas otherwise closed to shrimping and increasing the harvest limit in these areas to four quarts, heads-on, or 2 ½ quarts, heads-off [15A NCAC 03L .0105(2)].
- Prohibit shrimp trawling in the Intracoastal Waterway channel from the Sunset Beach Bridge to the South Carolina line, including the Shallotte River, Eastern Channel and lower Calabash River, to protect small shrimp [15A NCAC 03R .0114(4), (5), (6), and (7)].
- Establish a Permit for Weekend Trawling for Live Shrimp to allow live bait fishermen with a permit to fish until 12:00 p.m. (noon) on Saturdays [15A NCAC 03J .0104(b)(1)(B), 03L .0102(1), (2), and (3), and 03O .0503(k)(1), (2), and (3)].

Commercial Landings

Landings in the North Carolina shrimp fishery vary from year to year and are dependent primarily on environmental conditions. Environmental factors, especially severity of winter temperatures, and salinity can have a major influence on the yearly harvest. North Carolina's shrimp fishery is unusual in the southeast because all three species are taken here and most of the effort occurs in internal waters. While South Carolina, Georgia, and Florida allow limited inside waters shrimping, much of their fisheries are conducted in the Atlantic Ocean and white shrimp comprise most of their harvest (NCDMF 2015).

Commercial activity occurs in all waters. The shrimp fishery in the northern portion of the state is conducted in Pamlico, Croatan, and Roanoke sounds and Pamlico, Pungo, Bay, and Neuse rivers. The otter trawl is the predominant gear used in this portion of the state. The shrimp fishery in the central coastal area of the state occurs in Core Sound, North River, Newport River, Bogue Sound, and White Oak River. A variety of methods are used to catch shrimp including trawls, skimmer trawls, channel nets, shrimp pounds, and cast nets. Trawls are used on all three species in both the estuary and the ocean with two-seam trawls used for brown and pink shrimp and four-seam and tongue trawls for white shrimp, which tend to swim higher in the water column and will jump to the surface when disturbed. Most trawling in the central portion of the state is conducted at night. Channel nets are popular around Harkers Island in the Straits and North River while skimmer trawling is very popular in Newport River and New River.

In the southern portion of the state, the fishery is characterized by a large number of small boats fishing internal waters (primarily the Intracoastal Waterway, New, and Cape Fear rivers) and larger vessels fishing the Atlantic Ocean primarily off New River, Carolina Beach, and Brunswick County. Many of the small boats are fished by individuals who shrimp part-time or for personal consumption. Use of gears other than trawls has increased primarily in the area from New River to Rich's Inlet. Channel, float, and butterfly nets make use of tidal currents to push shrimp into the nets and offer the advantages of less fuel consumption and less bycatch than traditional shrimp trawls. Channel nets are fished extensively in the areas around New River and Topsail inlets. To shrimp with a “float net”, fishermen attach large floats to the doors and top lines of trawls to make the net fish up in the water column and are pulled slowly forward to harvest shrimp that are migrating to the inlets at night. Butterfly nets use this same harvest strategy but are attached to a metal frame and are held stationary in the water column to capture shrimp as the current carries them into the net. Skimmer trawls have become more popular around New River and Topsail Sound. These alternative gears are employed very little in areas south of Rich's Inlet, however tidal conditions seem favorable for their use. Cast nets and seines are also used to harvest shrimp to provide live shrimp for the commercial bait fishery.

Landings provided by the trip ticket program are combined for the three shrimp species (Figure 1). Total landings from 1994 to 2018 have averaged 7,345,451 pounds per year. In 2018, 9,729,526 pounds of shrimp were landed. Total landings decreased 30% from 2017 to 2018; likely a result of Hurricane Florence (9/17/18). In 2018, the majority (82%) of the harvest occurred in estuarine waters, with the remainder occurring in the Atlantic Ocean (less than 3 miles from shore). Landings in the ocean decreased 59% in 2018 and were below the times series average (Figure 3). Annual shrimping effort (number of trips) has fluctuated with shrimp abundance, but it appears to have gradually declined since 1994 (NCDMF 2015). This is due to a number of things including cheaper imported shrimp prices, increasing fuel prices, and fishermen retiring out of the industry. Landings in 2005 were lowest on record, likely from several reasons; many large trawlers remained scalloping instead of shrimping because prices were high and the days at sea were extended (NCDMF 2015). Hurricanes Katrina (8/29/05) and Rita (9/4/05) hit the Gulf coast, negatively affecting the fishing industry. Shrimp breading operations in the Gulf shut down with only one operational in September and some North Carolina shrimpers could not sell their product (NCDMF 2015). The number of trips has increased slightly since 2014; however, decreased 2% from 2017 to 2018 (Figure 2).

Recreational Landings

Shrimp are harvested recreationally throughout the state by otter trawls, skimmer trawls, seines, cast nets, shrimp pots and shrimp pounds with specific gear limitations. Since July 1, 1999, anyone wishing to harvest shrimp recreationally with commercial gear is required to purchase a Recreational Commercial Gear License (RCGL). The RCGL is an annual license that allows recreational fishermen to use limited amounts of commercial gear to harvest seafood for their personal consumption. Seafood harvested under this license cannot be sold. Fishermen using this license are held to recreational size and possession limits, gear marking and gear limit and configuration requirements. Many of the species taken by recreational users of commercial gear are included in fisheries management plans. Until 2002, the influence that RCGL holders may have on these species was unknown. Two surveys were used to collect information from RCGL

holders; a socioeconomic survey, conducted in 2001, 2004, and 2007, and a catch and effort survey conducted monthly from 2002 through 2008. Both surveys were terminated in 2008 due to budget constraints. RCGL holders harvested an average of 52,352 pounds of shrimp a year from 2002 to 2008 (NCDMF 2015). The highest landings occurred in 2002 (101,766 pounds), followed by 2008 (54,359 pounds) and 2003 (50,961 pounds). Recreational landings of shrimp are currently unknown since this survey was discontinued in 2008.

MONITORING PROGRAM DATA

Fishery-Dependent Monitoring

Currently, the only data available for the stock in all areas are the commercial landings and associated effort from the Trip Ticket Program. No fishery dependent monitoring program exists for shrimp.

Fishery-Independent Monitoring

The Estuarine Trawl Survey (Program 120) is a fishery-independent multispecies monitoring program that has been ongoing since 1971 in the months of May and June. One of the key objectives of this program is to provide a long-term data base of annual juvenile recruitment for economically important species. This survey samples fixed stations, a set of 104 core stations with additional stations as needed. The core stations are sampled from western Albemarle Sound south through the South Carolina border each year without deviation two times in the months of May and June. This survey targets juvenile finfish, blue crabs, and penaeid shrimp. A two-seam 10.5 foot headrope trawl with a one fourth-inch mesh in the body and one eighth-inch mesh in the tailbag is used. A one-minute tow is conducted covering a distance of 75 yards. All species taken are sorted, identified, and a total number is recorded for each species. For target species, a subset of at least 30 to 60 individuals is measured. Environmental data are collected, including salinity, dissolved oxygen, temperature, wind speed, and direction.

Trends in the annual brown shrimp catch per unit effort (CPUE) measured as the number of brown shrimp per station in Program 120 sampling shows fluctuations from year to year (Figure 4). The annual brown shrimp CPUE increased 77% from 2017 to 2018 (Table 2; Figure 4). The proportional standard error was below 20 in all but three years from 1988 to 2018 (Table 2). A PSE of “20” and less was established by the Atlantic Coast Cooperative Statistics Program (ACCSP) as a standard when considering the precision of a given metric. The margin of error for the annual brown shrimp CPUE is low, therefore providing greater confidence in the samples as an expression to the population (Table 2).

As indicated in the stock status section, annual landings are a good indication of relative abundance of shrimp in the coastal fishing waters of North Carolina. Estimates of recruitment calculated from the annual brown shrimp CPUE can also be used to determine year class strength. Trends in overall shrimp landings from June and July, months were brown shrimp predominately make up the harvest, show similar trends as the Program 120 data (Figure 5). Currently, there are no juvenile indices for white and pink shrimp in North Carolina.

MANAGEMENT STRATEGY

The management strategy for the shrimp fisheries in North Carolina is to continue to: 1) optimize resource use over the long-term, and 2) minimize waste. The first strategy is accomplished by protection of critical habitats, and gear and area restrictions to protect the stock. Minimization of waste is accomplished by gear modifications, bycatch reduction devices, area closures, and harvest restrictions.

There are no management triggers or methods to track stock abundance, fishing mortality, or recruitment between benchmark reviews from the current FMP. Landings and effort have decreased over time (NCDMF 2015). There are no data to track the recreational fishery.

Amendment 1 was adopted in February 2015 and was limited in scope to bycatch issues in the commercial and recreational fisheries. The management strategy for this amendment recommended a wider range of certified bycatch reduction devices to choose from, the requirement of two bycatch reduction devices in shrimp trawls and skimmer trawls (beginning June 1, 2015), and increased the daily harvest limit for cast nets in closed areas. Amendment 1 also established a maximum combined headrope length of 220 feet in all internal coastal waters where there is no existing maximum combined headrope requirements, allowing for a phase-out period until January 1, 2017. Shrimp trawling was also prohibited, effective May 1, 2015 in the Intracoastal Waterway channel from the Sunset Beach Bridge to the South Carolina line, including the Shallotte River, Eastern Channel and lower Calabash River, to protect small shrimp. With the adoption of the Amendment 1, the Marine Fisheries Commission further directed the division to develop a live bait permit to allow permitted fishermen to fish until 12:00 p.m. (noon) on Saturdays.

An industry workgroup was formed as a management strategy through Amendment 1, to test gear modifications to reduce bycatch, to the extent practicable, with a 40% target reduction in the shrimp trawl fishery. At its May 2018 business meeting, the Marine Fisheries Commission voted to require fishermen to use one of four gear combinations tested by the workgroup that achieved at least 40% finfish bycatch. The new gear configurations will be required in all shrimp trawls, except skimmer trawls, used in inside waters where up to 220 feet of combined headrope is allowed (Pamlico Sound and portions of the Pamlico, Bay and Neuse rivers); effective July 1, 2019. The commission also voted to continue the shrimp industry workgroup and explore funding options for more studies, to survey fishermen to determine what bycatch reduction devices the shrimp trawl industry currently uses, and to begin development of Amendment 2 to the Shrimp Fishery Management Plan. The information paper titled “Shrimp Fishery Management Plan (FMP) Amendment 1: Consideration of Gear Modifications to Reduce Bycatch in the North Carolina Shrimp Trawl Fishery” serves as a Revision to Amendment 1 to the North Carolina Shrimp Fishery Management Plan to document the management strategy changes and rationale. All other management strategies contained in Amendment 1 will remain in place until another Revision, Supplement, or Amendment to the N.C. Shrimp Fishery Management Plan occurs.
See Table 3 for the specific management strategies implemented as part of Amendment 1.

RESEARCH NEEDS

The N.C. Marine Fisheries Commission selected research strategies and implementation status are provided in Table 3. Proposed research needs and status of need is provided in parenthesis from Amendment 1 include:

- Continue to conduct bycatch characterization work across all strata (for example: dominant species, season, areas, vessel type, number of nets/rigs, headrope length) - HIGH (ongoing through NCDMF)
- Initiate/increase state monitoring and reporting on the extent of unutilized bycatch and fishing mortality on fish less than age-1 in the shrimp trawl fishery - HIGH (needed)
- Continue to develop and test methods to reduce bycatch in the commercial and recreational shrimp trawl fisheries - HIGH (ongoing in commercial shrimp trawl fishery through NCDMF and the industry workgroup)
- Obtain mortality (immediate and post-harvest) estimates of culled (active and passive) bycatch from gears used in the recreational and commercial shrimp fisheries - HIGH (needed)
- Continue to develop standard protocol for bycatch estimations - HIGH (ongoing at NCDMF with collaborative efforts with other agencies and researchers)
- Continue to define and quantify the intensity, duration and spatial scale of trawling effort in N.C. estuaries - HIGH (ongoing through NCDMF)
- Determine species interactions and predator/prey relationships for prominent shrimp trawl bycatch - HIGH (needed)
- Determine how the resuspension of sediment, siltation, and non-point source pollution from adjacent land use practices impacts trends in shrimp abundance and habitat degradation - HIGH (needed)
- Determine the spatial and biological characteristics of submerged aquatic vegetation that maximize their ecological value to shrimp for restoration and conservation purposes - HIGH (ongoing through the Coastal Habitat Protection Plan)
- Effort data needs to be collected to provide estimates based on actual time fished (or number of tows), rather than number of trips - HIGH (needed)
- Improve accuracy of self-reported license gear survey data, or investigate other means of accurately obtaining shrimp fleet characteristic - HIGH (needed)
- Examine how sedimentation, hydrologic alterations, and environmental conditions affect the abundance of brown shrimp (Farfantepenaeus aztecus) in southeastern North Carolina - HIGH (needed)
- Conduct research to quantify the number of protected species interactions with the shrimp fishery - MEDIUM (ongoing through NCDMF)
- Continue to develop and test methods to reduce interactions with protected species in the commercial and recreational shrimp trawl fisheries – MEDIUM (ongoing work being conducted by NOAA)
- Initiate sampling to investigate if additional areas currently open to shrimping need changes to their habitat designations - MEDIUM (needed)
- Evaluate the effectiveness and efficiency of the current sampling protocol used to manage shrimp - MEDIUM (needed)

- Continue to map and quantify the habitat structure and sediment types in North Carolina estuaries - MEDIUM (ongoing through NCDMF)
- Continue to measure the effects of trawling on sediment size distribution and organic carbon content – MEDIUM (needed)
- Expand current social and economic surveys to specifically collect information on shrimp fishermen - MEDIUM (needed)
- Continue to determine the extent of recreational shrimp harvest that is occurring. This group primarily use cast nets to take shrimp either for bait or personal consumption - MEDIUM (needed)
- Continue to support research to determine the status of protected species along the N.C. coast to better anticipate and prevent interactions (for example: migration patterns and habitat utilization) - LOW (ongoing support continued to provide information as interactions with protected species occurs)
- Continue to investigate the impact of tiger shrimp in North Carolina. waters - LOW (research conducted through NOAA)
- Initiate research to determine the impacts of endocrine disrupting chemicals (EDCs) on the various life stages of shrimp - LOW (needed)

FISHERY MANAGEMENT PLAN SCHEDULE RECOMMENDATION

Recommend maintaining the current timing of the next MFC scheduled review. Amendment 1 of the N.C. Shrimp FMP was adopted in February 2015 with rule changes in effect May 1, 2015 and May 1, 2017.

LITERATURE CITED

Brown, K.B., B. Price, L. Lee, S. Baker, and S. Mirabilio. 2017. An evaluation of bycatch reduction technologies in the North Carolina shrimp trawl fishery. North Carolina Department of Environment and Natural Resources, Division of Marine Fisheries, Morehead City, NC. 40 pp.

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NCDMF (North Carolina Division of Marine Fisheries). 2006. North Carolina Shrimp Fishery Management Plan. North Carolina department of Environment and Natural Resources. North Carolina Division of Marine Fisheries. Morehead City, NC. 384 pp.

NCDMF (North Carolina Division of Marine Fisheries). 2015. North Carolina Shrimp Fishery Management Plan. Amendment 1. North Carolina department of Environment and Natural Resources. North Carolina Division of Marine Fisheries. Morehead City, NC. 519 pp.

TABLES

Table 1. Harvest (pounds) and pounds per trip of shrimp (three species combined) by RCGL gear from 2002 through 2008 (NCDMF 2015).

Year	Pounds	Pounds/trip
2002	101,766	19.1
2003	50,961	18.5
2004	43,698	9.3
2005	32,542	13.4
2006	49,362	20.3
2007	33,778	15.2
2008	54,359	22.3
Mean	52,352	16.8

Table 2. Program 120 annual sampling for brown shrimp from core stations in May and June combined. Number of samples (stations), brown shrimp arithmetic catch per unit effort (CPUE) as the number of shrimp per station, standard error, standard deviation, coefficient of variation (CV), minimum number caught at a station, maximum number caught at a station, total number caught, and proportional standard error (PSE), 1988-2018.

Year	Number of stations	CPUE (No. shrimp/tow)	Standard error	Standard deviation	CV	Minimum number per station	Maximum number per station	Total number of shrimp	PSE
1988	209	21.2	3.2	46.3	218.0	0	348	4,440	15
1989	207	29.2	5.4	77.7	265.8	0	775	6,050	18
1990	206	44.2	6.8	98.0	222.0	0	1,094	9,098	15
1991	207	48.6	5.4	77.2	158.9	0	520	10,055	11
1992	210	25.8	5.0	72.9	282.2	0	664	5,428	19
1993	205	23.8	4.4	62.3	262.0	0	348	4,876	18
1994	205	29.9	4.3	61.4	205.2	0	459	6,134	14
1995	208	38.6	5.7	82.5	213.7	0	615	8,032	15
1996	207	34.8	6.4	91.9	264.2	0	696	7,199	18
1997	207	25.6	6.2	89.8	350.5	0	856	5,304	24
1998	208	13.0	2.8	40.0	306.7	0	369	2,712	21
1999	206	49.7	7.5	108.3	218.1	0	675	10,233	15
2000	209	56.8	7.1	102.1	179.8	0	759	11,865	12
2001	209	42.8	6.3	91.0	212.6	0	717	8,947	15
2002	208	59.7	6.9	99.4	166.5	0	793	12,414	12
2003	208	31.2	4.3	62.3	199.9	0	563	6,484	14
2004	208	24.9	4.0	57.6	231.1	0	334	5,185	16
2005	208	23.2	4.4	62.8	270.8	0	551	4,820	19
2006	208	25.9	3.4	49.7	191.9	0	308	5,383	13
2007	208	18.5	1.9	27.2	147.2	0	170	3,845	10
2008	208	95.7	13.4	193.9	202.6	0	1,718	19,908	14
2009	208	60.3	8.2	117.7	195.3	0	1,001	12,540	14
2010	208	75.2	13.2	190.0	252.5	0	1,622	15,651	18
2011	208	52.2	7.4	106.8	204.7	0	930	10,852	14
2012	208	40.1	4.3	61.5	153.2	0	343	8,347	11
2013	208	27.5	4.4	63.3	229.8	0	459	5,726	16
2014	208	35.0	4.5	64.5	184.3	0	409	7,276	13
2015	208	103.8	25.9	373.2	359.6	0	5,053	21,587	25
2016	208	19.9	3.2	46.8	235.0	0	319	4,146	16
2017	208	18.9	3.6	52.0	274.5	0	467	3,940	19
2018	208	33.6	5.5	79.0	235.2	0	714	6,985	16

Table 3. The N.C. Marine Fisheries Commission selected management strategies, and implementation status to reduce bycatch as mandated by Amendment 1.

Management Strategy	Implementation Status
Status quo (continue to prohibit otter trawls in the New River special secondary nursery area above the Highway 172 Bridge).	Rule change implemented May 1, 2015; 15A NCAC 03J .0208
Allow hand cast netting of shrimp in all closed areas and increase the limit to four quarts, with heads on per person.	Rule change implemented May 1, 2015; 15A NCAC 03L .0105
Status quo on a license requirement to fish a cast net for shrimp.	No action required
Upon federal adoption of TEDs in skimmer trawls, the division will support the federal requirement.	No action required
Establish a permitted live shrimp bait fishery and for DMF to craft the guidelines and permit fees after reviewing permitted operations in other states, and to allow live bait fishermen with a permit to fish until 12 p.m. (noon) on Saturday.	Rule change implemented May 1, 2017; 15A NCAC 03J .0104, 03L .0102, 03O .0105, 03O .0503
Allow any federally certified BRD in all internal and offshore waters of NC.	Existing proclamation authority; Proclamation issued with complete list of BRDs, SH-2-2015
Update the scientific testing protocol for the state's BRD certification program.	Plans to update the testing protocols to use the federal standards.
Convene a stakeholder group to initiate industry testing of minimum tail bag mesh size, T-90 panels, skylight panels, and reduced bar spacing in TEDs to reduce bycatch to the extent practicable with a 40% target reduction. • Upon securing funding, testing in the ocean and internal waters will consist of three years of data using test nets compared to a control net with a Florida fish eye, a federally approved TED and a 1.5-inch mesh tail bag. • Results should minimize shrimp loss and maximize reduction of bycatch of finfish. Promising configurations will be brought back to the commission for consideration for mandatory use. • The stakeholder group may be partnered with the division and Sea Grant. • Members should consist of fishermen, net/gear manufacturers and scientific/gear specialists.	Stakeholder group convened in 2015 and industry testing completed in 2017. Results presented to MFC in May 2018. Proclamation issued for Pamlico Sound and portions of the Pamlico, Bay, and Neuse rivers (where up to 220 feet of combined headrope is allowed) requiring the use of gear combinations tested by the workgroup that achieve at least 40% finfish bycatch, effective July 1, 2019, SH-3-2019, http://portal.ncdenr.org/web/mf/proclamation-sh-03-2019 Plans to continue shrimp industry workgroup and explore funding options for more studies.
Require either a T-90/square mesh tailbag or other applications of square mesh panels (e.g., skylight panel), reduced bar spacing in a TED, or another federal or state certified BRD in addition to existing TED and BRD requirements in all skimmer and otter trawls.	Existing proclamation authority Rule change required in 15A NCAC 03I .0101 to modify definition of mesh length; Rule change implemented May 1, 2015. Proclamation issued for second BRD requirement to begin on June 1, 2015, SH-2-2015,

Management Strategy	Implementation Status
	http://portal.ncdenr.org/web/mf/proclamation-sh-02-2015
Status quo on effort management (no change in season, weekend, or night time fishing).	No action required
In order to put a cap on fleet capacity as a management tool, establish a maximum combined headrope length of 220 feet in all internal coastal waters where there is no existing maximum combined headrope requirements with a two-year phase out period.	Rule change implemented May 1, 2015; 15A NCAC 03L .0103
Prohibit shrimp trawling in the IWW channel from Sunset Beach to the SC state line, including Eastern Channel, lower Calabash River and Shallotte River.	Rule change implemented May 1, 2015; 15A NCAC 03R .0114
Establish a permitted live bait shrimp fishery and allow live bait fishermen with a permit to fish until 12 p.m. (noon) on Saturday	Rule change implemented May 1, 2017; 15A NCAC 03O .0503

FIGURES

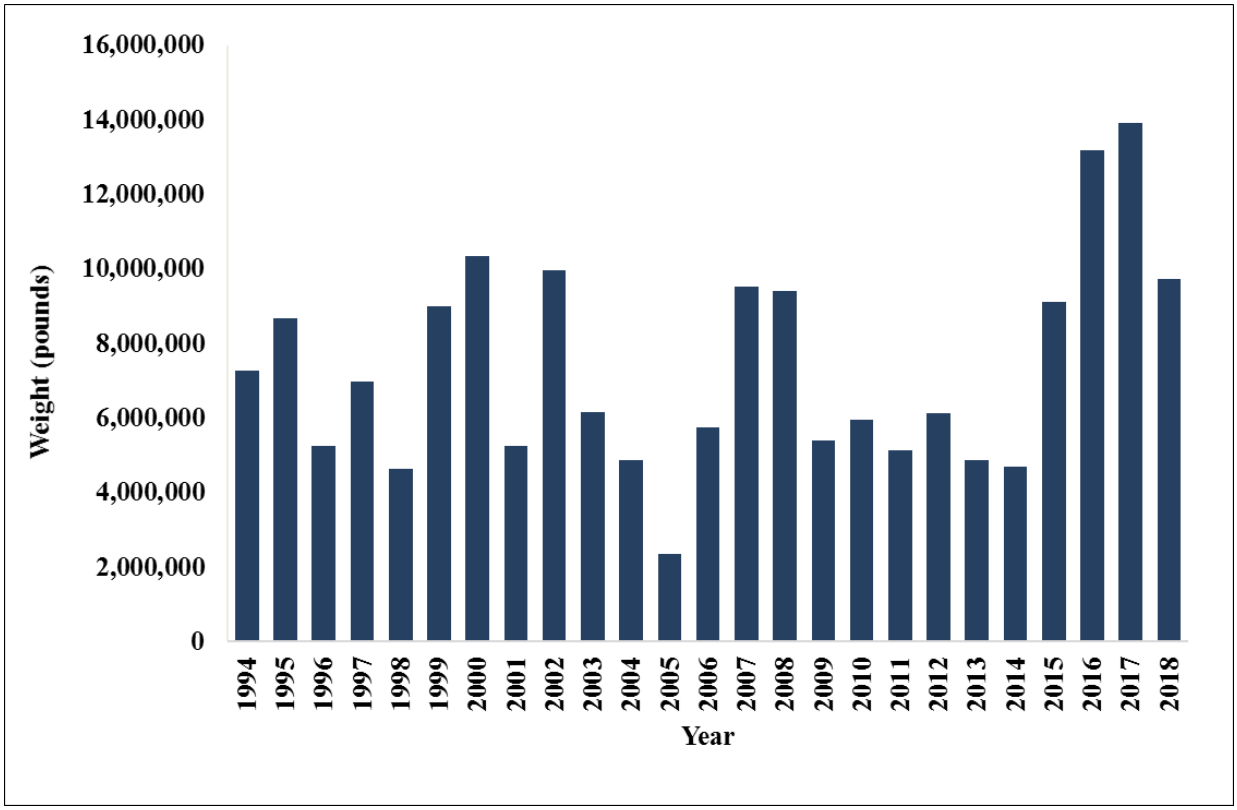

Figure 1. Annual commercial shrimp landings (pounds) from all three shrimp species combined in North Carolina, 1994-2018. Data from the NCDMF Trip Ticket Program.

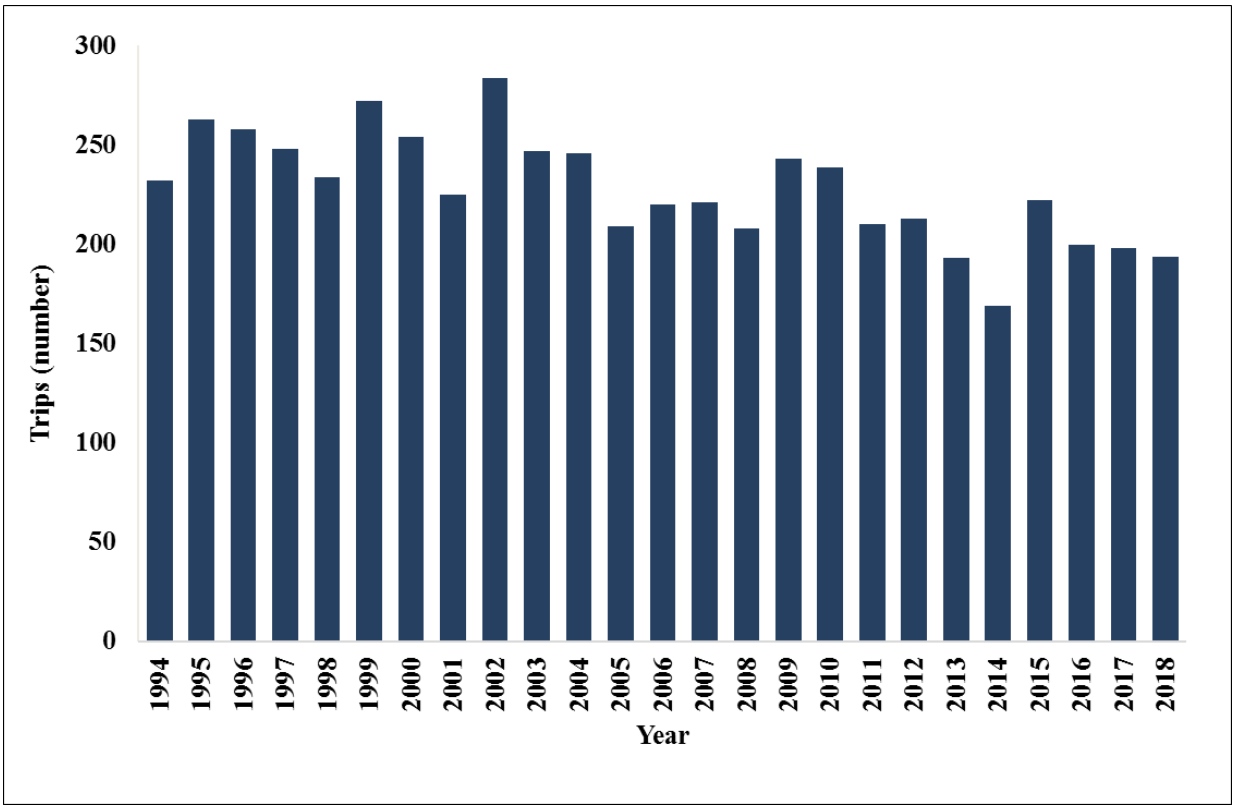

Figure 2. Annual number of commercial trips reported for all three species combined in inside and ocean waters, 1994-2018. Data from the NCDMF Trip Ticket Program.

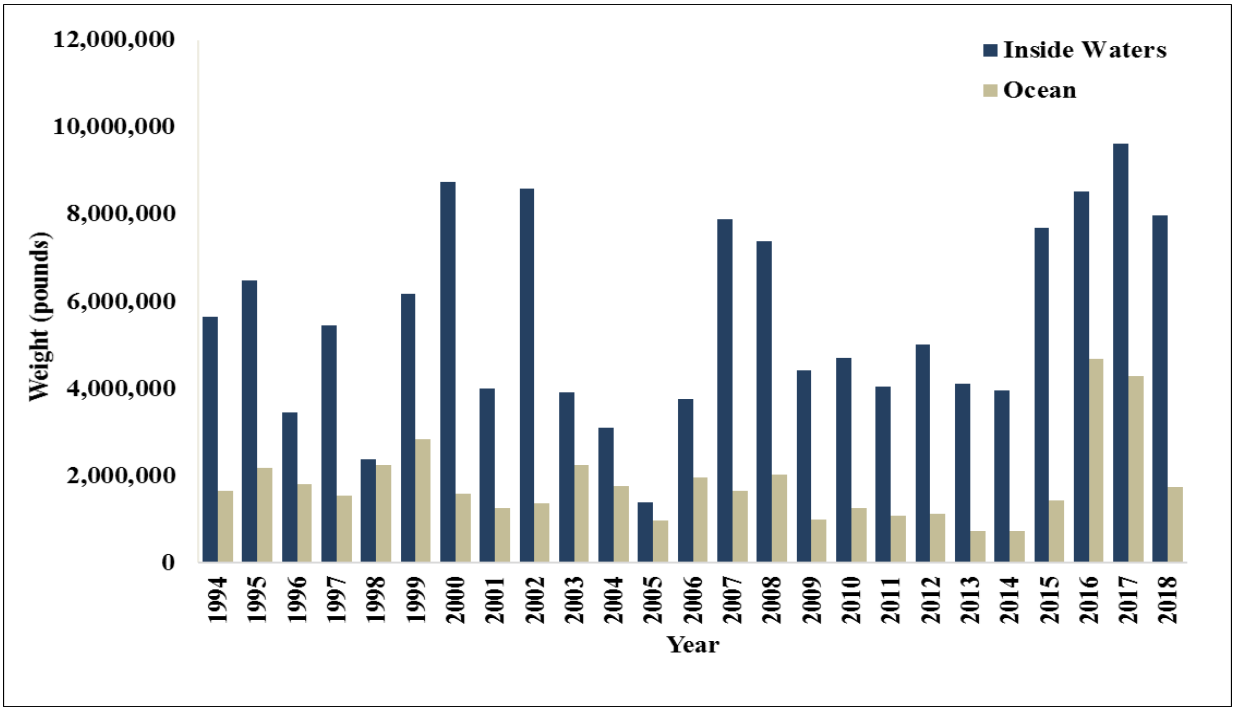

Figure 3. Annual commercial shrimp landings (pounds) by area from all three shrimp species combined in North Carolina, 1994-2018. Data from the NCDMF Trip Ticket Program.

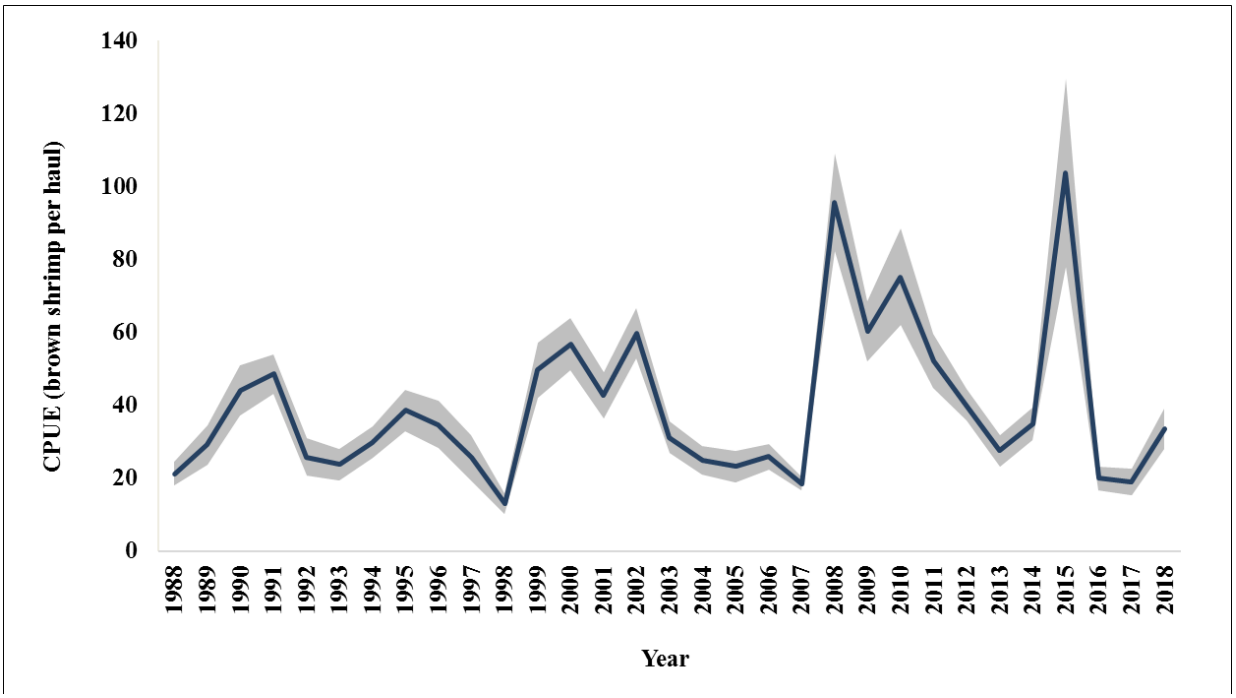

Figure 4. Annual catch per unit effort (CPUE; number of shrimp per station) of brown shrimp from Program 120 estuarine trawl survey, 1988-2018. Shaded area represents standard error.

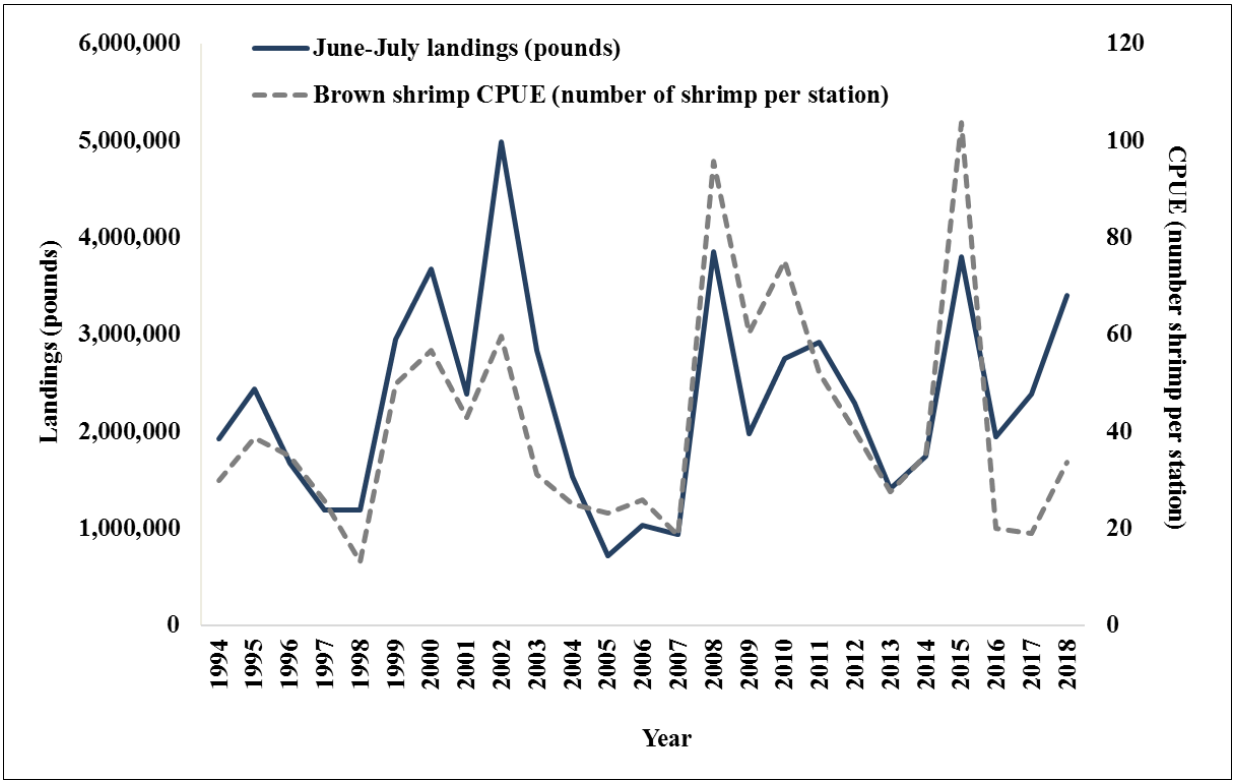

Figure 5. Comparison of shrimp commercial shrimp landings in the months of June and July to the brown shrimp Program 120 catch per unit effort (number of shrimp per station), 1994-2018.

FISHERY MANAGEMENT PLAN UPDATE
SOUTHERN FLOUNDER
AUGUST 2019

STATUS OF THE FISHERY MANAGEMENT PLAN

Fishery Management Plan History

Original FMP Adoption:	February 2005
Amendments:	Amendment 1 – February 2013
Revisions:	None
Supplements:	Supplement A to the 2005 FMP – February 2011 Supplement A to Amendment 1 – November 2015
Information Updates:	None
Recommended Schedule Change:	None
MFC Scheduled Review:	Review started in 2017

A five-year review of the N.C. Southern Flounder Fishery Management Plan (FMP) began January 2018, immediately following a peer review workshop evaluating the 2018 stock assessment. At the end of the peer review workshop, the Southern Flounder Review Panel accepted the pooled-sex run of the ASAP model presented at the Review Workshop as a valid basis of management for at least the next five years, with the expectation that the model will be updated with data through 2017 to provide the best, most up to date estimate of stock status for management. The reviewers also noted that management advice based on the 2015 terminal year would be out of date by the time it could be implemented and that expected changes to recreational catch estimates (MRIP) should be incorporated into the assessment model and management response.

During 2018, the southern flounder stock assessment sub-committee updated all necessary data inputs for the ASAP model. The pooled-sex model was updated with data through 2017 including incorporating the new MRIP estimates that were available, Results indicate the stock was overfished and overfishing was still occurring. Analyses that provided projections of reductions to fishing mortality necessary to end overfishing and to determine what reductions would be necessary to rebuild the spawning stock biomass and end the overfished status were completed. The plan development team continues to work through the development of Amendment 2 to the Southern Flounder FMP in conjunction with the Southern Flounder FMP Advisory Committee.

Until Amendment 2 is approved by the MFC, management of southern flounder falls under Amendment 1 and Supplement A to Amendment 1. Actions to achieve sustainable harvest in Amendment 1 include: 1) accept management measures to reduce protected species interactions as the management strategy for achieving sustainable harvest in the commercial southern flounder fishery; 2) increase the recreational minimum size limit to 15 inches and decrease the creel limit to six fish. Amendment 1 also set new sustainability benchmarks at 25% Spawning Potential Ratio (SPR) (threshold) and 35% SPR (target).

Supplement A to Amendment 1 was approved at the November 2015 NCMFC meeting. Management actions approved include: increasing the minimum commercial size limit to 15 inches, increasing the minimum mesh size for gill nets to six-inch stretched mesh (ISM), closing the commercial gill net and recreational fisheries on October 15, closing the commercial gig fishery once the pound net fishery closes, a 38% reduction to the pound net fishery based on the 2011-2015 average landings, and to increase the escape panels in flounder pound nets to five and three-quarters inch. All management actions were effective January 1, 2016. However, an injunction was granted in October 2016 stopping the Division from enacting some of the management actions. The recreational closure on October 15, the commercial closure of the gig fishery, and the 38% reduction in pound net landings based on the 2011-2015 average did not occur.

Management Unit

The Amendment 1 and Supplement A to Amendment 1 to the North Carolina Fishery Management Plan management unit was defined as North Carolina coastal and joint waters. However, due to increased information relative to genetic identification and tagging studies the unit stock for the 2018 stock assessment was changed to include all waters from North Carolina through the East coast of Florida.

Goal and Objectives

Until the goals and objectives of Amendment 2 are approved by the MFC, the goals and objectives of Amendment 1 remain. The goal of Amendment 1 to the North Carolina Southern Flounder FMP is to end overfishing and rebuild the spawning stock for long-term sustainable harvest and maintain the integrity of the stock. To achieve this goal, the following objectives must be met:

1. Ensure that the spawning stock biomass of southern flounder is adequate to produce recruitment levels necessary to increase spawning stock biomass and expand age distribution.
2. Implement management measures that will achieve sustainable harvest.
3. Promote harvesting practices that minimize bycatch.
4. Continue to develop an information program to educate the public and elevate their awareness of the causes and nature of problems in the southern flounder stock, its habitat and fisheries, and explain the rationale for management efforts to sustain the stock.
5. Address social and economic concerns of all user groups, including issues such as user conflicts.

6. Promote the protection, restoration, and enhancement of habitats and environmental quality for the conservation of the southern flounder population.
7. Initiate, enhance, and/or continue studies to improve the understanding of southern flounder population ecology and dynamics.
8. Initiate, enhance, and/or continue studies to collect and analyze the socio-economic data needed to properly monitor and manage the southern flounder fishery.

STATUS OF THE STOCK

Life History

Southern flounder *(Paralichthys lethostigma)* are a bottom dwelling species of the left eyed flounder family found in the Atlantic Ocean and estuaries from northern Mexico to Virginia. This species is one of three commonly caught left eyed flounder in North Carolina; Southern flounder, Gulf flounder (*Paralichthys albigutta*), and summer flounder (*Paralichthys dentatus*). This species supports important commercial and recreational fisheries along the U.S. South Atlantic and Gulf coasts and are particularly important to fisheries in North Carolina. The biological unit stock for southern flounder inhabiting North Carolina waters may include fish from other southern states based on evidence from tagging and genetic studies, as well as differences in aging structures, which indicate one single unit stock of southern flounder from North Carolina to Florida. Evidence also suggests some adult southern flounder return to the estuaries after spawning in the ocean, while others remain in the ocean. Tagged fish are typically recaptured south of original tagging locations and often in other states once in the ocean. Limited data from South Carolina and Georgia tagging programs suggest a low probability of adult movement from South Carolina or Georgia to North Carolina waters.

Data collected from fall fisheries by the North Carolina Division of Marine Fisheries suggests that with the onset of maturity, fish of both sexes migrate out of inlets to ocean waters in the fall. Southern flounder can produce approximately 3 million eggs per female in multiple spawning events in a season, and spawning is thought to take place between November and April. Larval southern flounder pass through inlets within 30 to 45 days of hatching and settle throughout the sounds and rivers in the winter and early spring. Nearly half of female flounder are thought to be mature by ages 1 and 2 (at approximately 16 inches). Fish collected in the ocean tend to be larger and older with females attaining larger sizes. The largest southern flounder observed in North Carolina was a 33 inch long female and a 20 inch long male. The maximum observed age was 9 for a female and 9 for a male; southern flounder captured in North Carolina represent the oldest ages observed throughout the species' range.

Juvenile and adult southern flounder are bottom dwelling and typically feed by camouflaging themselves and ambushing their prey with a quick upward lunge. Southern flounder diets switch to fish when they are between 3 and 4 inches long. Adult southern flounder feed almost exclusively on other fish, but will consume shrimp as well.

Stock Status

Following the recommendation of the peer review panel, the southern flounder working group recommended that the stock size threshold and target be defined in terms of Spawning Stock Biomass (SSB) associated with the fishing mortality target and threshold. Based on the results of

the January 2018 stock assessment, the probability that fishing mortality in 2015 is above the threshold value of 0.46 is 53%, whereas there is a 95% chance the fishing mortality in 2015 is above the target value of 0.31. The probability that the SSB in 2015 is below the threshold or target value (3,984 and 5,411 mt, respectively) is 100%. Therefore, the current status of the southern flounder stock is overfished and overfishing is occurring.

Stock Assessment

The 2009 stock assessment used a statistical catch-at-age model run using the Age Structured Assessment Program (Takade 2009). Results showed the stock to be overfished with overfishing occurring throughout the time series. These were the most recent assessment results included in Amendment 1. The 2014 Southern Flounder Stock Assessment used a statistical catch-at-age model run using Stock Synthesis (NCDMF 2015). Upon review of the assessment, external peer reviewers and the NCDMF determined the model could not fully account for stock mixing during spawning, nor quantify migration of southern flounder to and from North Carolina waters. Consequently, the assessment was not accepted for determining stock status. As a result, a multistate southern flounder stock assessment was developed and included data and expertise of state agency staff from North Carolina. South Carolina, Georgia, and Florida, as well as researchers from the University of North Carolina at Wilmington and Louisiana State University. The multistate assessment was an attempt to further address the geographical distribution of the unit stock and was peer reviewed in December 2017. This assessment used a statistical catch-at-age model run using the Age Structured Assessment Program (Lee et. al. 2018). The Southern Flounder Review Panel accepted the pooled-sex run of the ASAP model presented at the Review Workshop and was approved as a valid basis of management for at least the next five years, with the expectation that the model will be updated with data through 2017 to provide the best, most up to date estimate of stock status for management. The reviewers also noted that management advice based on the 2015 terminal year would be out of date by the time it could be implemented and that expected changes to recreational catch estimates (MRIP) should be incorporated into the assessment model and management response. During 2018, the southern flounder stock assessment sub-committee updated all necessary data inputs for the ASAP model. The pooled-sex model was updated with data through 2017 including incorporating the new MRIP estimates that were available, results indicate the stock was overfished and overfishing was still occurring. Analyses that provided projections of reductions to fishing mortality necessary to end overfishing and to determine what reductions would be necessary to rebuild the spawning stock biomass and end the overfished status were completed.

STATUS OF THE FISHERY

Current Regulations

Commercial: 15-inches total length (TL) minimum size limit from internal waters and 14-inches TL minimum size limit from ocean waters, 6 ISM minimum mesh size for gill nets, closed season in internal waters from December 1-31; no trip limits in internal waters and a 100 pound trip limit in ocean waters unless the individual has a License to Land Flounder from the Atlantic Ocean.

Recreational: 15-inches TL minimum size limit, four-fish creel limit from all joint and coastal waters, and year-round season.

At the NCMFC's November 2015 business meeting they adopted a supplement to the FMP which instituted several new rule changes effective January 1, 2016. Please check the NCDMF's website for a summary of the actions http://portal.ncdenr.org/web/mf/nr-50-2015-mfc-flounder.

Commercial Landings

All landings reported as caught in inshore waters are considered to be southern flounder by the NCDMF Trip Ticket Program. Most southern flounder landings are from gill nets and pound nets, although gigs and other inshore gears (e.g., trawls) catch flounder in smaller numbers. Historically, pound nets were the dominant gear but landings from gill nets were higher in 1994-2013 (Figure 1). Peak commercial landings occurred in 1994 (Table 1). Since 1994, pound net landings decreased greatly, while gill net landings remained relatively high until 2010. Decreases in gill net landings from 2010 to 2012 were mainly due to lower landings in the Albemarle Sound. The Sea Turtle Settlement Agreement (2010) added regulations to gill nets in portions of the state, resulting in lower effort in many areas, however, the Albemarle Sound was mostly unaffected by these regulations. The Albemarle Sound is typically where the majority of southern flounder gill net harvest occurs. In 2013, gill net harvest increased greatly in the Albemarle Sound, but decreased in Pamlico Sound and Core Sound; pound net landings also increased greatly in 2013. Since 2014, gill net harvest has decreased in all areas of the state, especially in the Albemarle Sound due to widespread gill net closures to avoid catches of red drum and closures due to protected species interactions. Pound net harvest surpassed gill net harvest 2014 through 2018 (Figure 1). Gig harvest of southern flounder has generally increased, especially since 2010. Harvest by other commercial gears has generally decreased to its lowest point in 2018 and currently makes up a small portion of commercial harvest. Commercial harvest is the highest in fall months.

Trends in commercial trips have generally followed landings trends (Figure 2). Trips include the number of trip ticket records with landings reported; some trips may represent more than one day of fishing. The majority of trips that harvest flounder are from gill nets. Gill net trips have been variable around a decreasing trend since 2010. Pound net trips were decreasing until 2002, since they have been variable on a lower level. Gigging trips have been variable around an increasing trend since 2010.

Recreational Landings

Recreational fishing activity is monitored through the Marine Recreational Information Program. In this report, estimates across all years have been updated and are now based on the MRIP new Fishing Effort Survey-based calibrated estimates. For more information on MRIP methodology changes see https://www.fisheries.noaa.gov/topic/recreational-fishing-data.

Recreational harvest of southern flounder is mainly by hook and line and gigs, with a small amount of harvest by spearfishing or Recreational Commercial Gear License (RCGL) gears. NCDMF does not have information on long-term trends of the gig fishery. This is because the

Marine Recreational Information Program (MRIP) rarely encounters gig fishermen. A DMF mail-based survey of gigging that began in 2010 indicates the gig harvest from 2010-2018 averaged 10% of the recreational harvest (with hook and line harvest making up the remainder). Hook and line harvest can be split into ocean and inshore harvest, with most southern flounder harvested inshore (Figure 3). Hook and line harvest peaked in 2010 (Table 1). Recreational harvest is highest during summer months.

Trends in recreational trips are somewhat difficult to interpret because they represent all *paralichthid* flounder species commonly caught in North Carolina (southern, summer and Gulf). This is because anglers simply report targeting 'flounder' rather than a particular species of flounder. Trips can be defined in several ways, but in this document all trips that harvested or released any *paralichthid* flounder species were included. Trends in trips and harvest are roughly similar throughout most of the time-series, but trips have been declining since 2013 while harvest has been variable. (Figure 4).

MONITORING PROGRAM DATA

Fishery-Dependent Monitoring

Commercial fishing activity is monitored through fishery-dependent sampling conducted by the division since 1982. Data collected in this program allow the size and age distribution of southern flounder to be characterized by gear and fishery. Several NCDMF sampling programs collect biological data on commercial and recreational fisheries that catch southern flounder. The primary programs that collect length and age data for harvested southern flounder include: 461 (gill net and seine), 476 (gig and spear), 432 (pound net) and 437 (long haul seine). Programs 466 and 570 collect length data on harvested and discarded flounder. Other commercial sampling programs focusing on fisheries that do not target southern flounder rarely collect biological data. The NCDMF sampling of the recreational fishery through the MRIP collects length data on southern flounder. The NCDMF mail-based gigging survey collects harvest data for the recreational gig fishery, but does not collect length or age data. Age data from the recreational fishery are collected mainly via voluntary angler donations through the NCDMF Carcass Collection Program.

There were no clear trends in commercial length and age data from 2005 to 2018 (Table 2). In 2018, 49% of southern flounder were harvest by pound nets, followed by gill nets (40%), gigs (10%), and other gear accounted for 1% (Figure 5). Commercial age data for 2018 are not available at this time. Annual mean lengths were fairly consistent; however, an increase in mean length was observed due to the changes in minimum commercial size regulation, increasing to 15-inches (Table 1; Figure 6).

There were no clear trends in recreational length and age data from 2005 to 2018 (Table 3). Recreational age data for 2018 are not available at this time. Annual mean lengths collected through age sampling programs were consistent and 2017 was similar to previous years where 17 inches was the mean length as seen 12 of the last 14 years. MRIP length requency data show harvest of smaller fish has declined as changes to minimum size limits has occurred (Table 3; Figure 7).

Fishery-Independent Monitoring

Several NCDMF independent sampling programs collect biological data on southern flounder. The primary surveys that collect length data for southern flounder and that were evaluated as indices of abundance in recent stock assessments were: 120 (Estuarine Trawl Survey), 195 (Pamlico Sound Survey), 135 (Albemarle Sound Independent Gill Net Survey and 915 (Pamlico Sound and Rivers Independent Gill Net Surveys). Age data primarily is collected in Program 915, although the other three surveys do collect age data. Methodology for analyzing trends in catch-per-unit-effort (CPUE) for each survey changed with the 2018 stock assessment when generalized linear models (GLMs) were used to calculate relative yearly abundance index values. These indices were not updated for this report, as an update to the stock assessment is under way and final GLM values have not been finalized. As a result, nominal CPUE values have been include in this report.

There were no clear trends in fishery-independent length and age data from 2005 to 2018 (Table 4). Independent age data for 2018 are not available at this time. Annual mean lengths were fairly consistent and 2016 had the second largest mean length in the time-series. However, the number of fish measured in 2016 was the lowest of any year from 2005 to 2017.

Data collected by Program 915 were used for an index of general (juvenile and adult) abundance in the January 2018 stock assessment. The survey is designed to characterize the size and age distribution for key estuarine species in Pamlico Sound and its major river tributaries. Sampling began in Pamlico Sound in 2001 and was expanded to the current sampling area (including tributaries) in 2003. Each array of nets consists of floating gill nets in 30-yard segments of 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, and 6.5-inch stretched mesh, for a total of 240 yards of nets. Catches from an array of gill nets comprise a single sample; two samples (one shallow, one deep) totaling 480 yards of gill net are completed each trip. Gill nets are typically deployed within an hour of sunset and fished the following morning. Efforts are made to keep all soak times within 12 hours. All gill nets are constructed with a hanging ratio of 2:1. Gill net sets are determined using a random stratified survey design, based on area and water depth. Each region is overlaid with a one-minute by one-minute grid system (equivalent to one square nautical mile) and delineated into shallow (less than six feet) and deep (greater than six feet) strata. Deep strata were not included in data analysis for this report. Sampling in Pamlico Sound is divided into two regions: Region 1, which includes areas of eastern Pamlico Sound adjacent to the Outer Banks from southern Roanoke Island to the northern end of Portsmouth Island; and Region 2, which includes Hyde County bays from Stumpy Point Bay to Abel's Bay and adjacent areas of western Pamlico Sound. Each of the two regions is further stratified into four similar sized areas, denoted by either Hyde or Dare and numbers one through four. The rivers are divided into four areas in the Neuse River, three areas in the Pamlico River, and one area for the Pungo River. Although the survey is conducted in all months except January, only July-September data were used to analyze CPUE trends because these months had the peak catches of southern flounder. The survey was expanded to include areas in the southern portion of the state in 2008, but these data were not analyzed for the index due to the short time-series. The abundance index for Program 915 peaked in 2010 and the low point was in 2016 for the time-series analyzed (2003-2018) and has a decreasing trend (Table 5; Figure 8) with the last four years all below the time series average.

Data collected by Program 135 was not used as an index of general (juvenile and adult) abundance in the January 2018 stock assessment but continues to provide an additional data source to monitor trends in the population. Beginning in 1990, Program 135 has conducted gill net sets in waters of Albemarle Sound. The survey was designed to monitor the striped bass population. The survey follows a random stratified design, stratified by geographic area. This survey divides the Albemarle region into six sample zones that are further subdivided into one-mile square quadrants with an average of 22 quadrants per zone. Four arrays of twelve meshes (2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 6.5, 7.0, 8.0, 10.0-inch stretch) of gill nets are set in each quadrant by the fishing crew, two arrays are sinking gill nets and two are floating. One unit of effort is defined as each 40-yard net fished for 24 hours. The abundance index for Program 135 peaked in 1992 and the low points were in 2011, 2016, 2017, and 2018 for the time-series analyzed (1991-2018; Table 5; Figure 9). The CPUE for each of the last five years have all been below the servies average.

Data collected by Program 120 were used for a Juvenile Abundance Index (JAI) in the January 2018 stock assessment. The Estuarine Trawl Survey (Program 120) is a fishery-independent multispecies monitoring program that has been ongoing since 1971 in the months of May and June. One of the key objectives of this program is to provide a long-term data base of annual juvenile recruitment for economically important species. This survey samples fixed stations, a set of 104 core stations with additional stations as needed. The core stations are sampled from western Albemarle Sound south through the South Carolina border each year without deviation one sample for each station each month during the months of May and June. This survey targets juvenile finfish, blue crabs, and Penaeid shrimp. A two-seam 10 and one-half foot headrope trawl with a one-fourth inch mesh in the body and one-eighth inch mesh in the tailbag is used. A one-minute tow is conducted covering a distance of 75 yards. All species collected are sorted, identified, and a total number is recorded for each species. For target species, a subset of at least 30 to 60 individuals is measured. Environmental data is collected, including salinity, dissolved oxygen, temperature, wind speed and direction. Data from this survey were used to produce a southern flounder JAI from 1991 to 2018. The JAI for Program 120 peaked in 1996 and the low point was in 2016 for the time-series analyzed (1991-2018) and shows a variable trend (Table 5; Figure 10) with each of the last 5 years being below the time series average.

Data collected by Program 195 were not used as a JAI in the January 2018 stock assessment but continues to provide an additional data source to monitor trends in the population. Program 195 conducts trawls using a random-stratified survey design in waters of Pamlico Sound and major river tributaries in June and September. Only data from September were used for the JAI in the 2014 stock assessment. Stations are randomly selected from strata based upon depth and geographic location. Randomly selected stations are optimally allocated among the strata based upon all previous sampling in order to provide the most accurate abundance estimates (PSE <20). Tow duration is 20 minutes; using double rigged demersal mongoose trawls (9.1m headrope, 1.0m X 0.6m doors, 2.2-cm bar mesh body, 1.9-cm bar mesh cod end and a 100-mesh tailbag extension. Data from this survey were used to produce a southern flounder JAI from 1991 to 2018. The JAI for Program 195 peaked in 1996 and the low point was in 1998 for the time-series analyzed (1991-2018; Table 5; Figure 11). However, annual CPUE for three of the last four years has been above the time series average.

In order to describe the age structure of harvest and indices, southern flounder age structures are collected from various fishery independent (scientific surveys) and dependent (fisheries) sources throughout the year. In 2017, 1,178 southern flounder were aged ranging in age from 0 to 7 years (Tables 2-4). Growth in length is rapid for the first year of life and then slows. The relationship of length and age for southern flounder is unpredictable with much overlap in age for a given length (Figure 12).

MANAGEMENT STRATEGY

Until Amendment 2 is approved for management by the MFC, Southern flounder are managed under Amendment 1 and Supplement A to Amendment 1 to the Southern Flounder FMP, adopted in February 2013. Amendment 1 established the threshold SPR of 25% and the target SPR of 35% and implemented management measures for the commercial and recreational fisheries (Table 6). Actions to achieve sustainable harvest in Amendment 1 include: 1) accept management measures to reduce protected species interactions as the management strategy for achieving sustainable harvest in the commercial southern flounder fishery; 2) increase the recreational minimum size limit to 15 inches and decrease the creel limit to six-fish. Since the adoption of Amendment 1, the 2014 Southern Flounder Stock Assessment was completed. Upon review of the assessment, external peer reviewers and the NCDMF determined the model could not fully account for stock mixing during spawning and quantify migration of southern flounder to and from North Carolina waters. Consequently, the assessment was not accepted for determining stock status. Due to concerns for the health of the stock based on abundance trends and the percentage of immature fish in the harvest, in February 2015 the NCMFC requested a supplement be developed for reducing harvest in the southern flounder fishery.

Supplement A to Amendment 1 was approved at the November 2015 MFC business meeting. Management actions approved included: 1) increasing the minimum commercial size limit to 15 inches; 2) increasing the minimum mesh size for gill nets to 6 ISM; 3) closing the commercial gill net and recreational fisheries on October 15; 4) closing the commercial gig fishery once the pound net fishery closes, a 38% reduction to the pound net fishery based on the 2011-2015 average landings; and 5) an increase to five and three-quarter inch escape panels. All management actions were effective January 1, 2016. However, an injunction was granted in October 2016, preventing the NCDMF from enacting some of the management actions. The commercial gill net and recreational closure on October 15, the commercial closure of the gig fishery, and monitoring the 38% reduction in pound net landings based on the 2011-2015 average did not occur.

RESEARCH NEEDS

The management strategies and implementation status from Amendment 1 and Supplement A of the N.C. Southern Flounder FMP can be found in Table 6. The following research recommendations were included in Amendment 1; status of need is provided in parentheses:

- Investigate the feasibility of a quota as a management tool for the commercial southern flounder fishery (underway).

- Annual survey of the recreational gig fishery (mail-based survey underway, dockside survey still needed).
- Further research on southern flounder that remain in the ocean after the spawning season (tagging studies underway, but other studies may be needed).
- Determine the exact locations of spawning aggregations of southern flounder in the ocean (tagging studies underway, but other studies may be needed).
- Continued otolith microchemistry research to gain a better understanding of ocean residency of southern flounder (more research needed).
- Tagging study of southern flounder in the ocean to gain a better understanding of migration patterns into the estuaries (underway).
- Update the southern flounder maturity schedule (completed).
- Fishery dependent sampling of the commercial spear fishery for flounder in the ocean (some sampling done under NCDMF sampling, but more may be needed).
- Harvest estimates and fishery dependent sampling of the recreational spear fishery for flounder in the ocean (not done except what MRIP encounters).
- Increased fish house sampling of the Currituck Sound flounder gill net and pound net fisheries (sampling has increased, more may be needed).
- Increased at-sea observer trips with gill netters and pound netters in Currituck Sound (underway for gill nets, pound net observing needed).
- Reestablish a RCGL survey to obtain harvest, discard, and effort information (needed).
- Establish an at-sea observer program of the RCGL fishery (needed).
- Formulate a bycatch estimate of southern flounder from crab pots (more research needed).
- Further research on degradable materials to determine which material works best in a given water body and how other parameters, such as microbial activities and the effects of light penetration impact degradation rates and performance of the crab pot (progress unknown).
- Further research on flatfish escapement devices that minimize undersized flounder bycatch and maximize the retention of marketable blue crabs (needed).
- Further research on factors that impact release mortality of southern flounder in the recreational hook and line fishery (more research needed).
- Research on deep hooking events of different hook types and sizes on southern flounder (needed)
- Population dynamics research for all Atlantic protected species (some research completed, more is needed).
- Continued gear research in the design of gill nets and pound nets to minimize protected species interactions (some research completed, more may be needed).
- Development of alternative gears to catch southern flounder (some research completed, more may be needed).
- Further research on the size distribution of southern flounder retained in pound nets with 5.75-inch and 6-inch escape panels (some research completed, more is needed).
- Research on the species composition and size distribution of fish and crustaceans that escape pound nets through 5.75-inch and 6-inch escape panels (some research completed, more is needed).
- Coast-wide at-sea observations of the flounder pound net fishery (needed).
- Discard mortality estimates of southern flounder from pound nets (needed).

- Continue at-sea observations of the large mesh gill net fishery, especially outside of the PSGNRA, including acquiring biological data on harvest and discards (underway).
- Increase the number of large mesh gill net catches sampled in areas such as Albemarle Sound and the Newport River (sampling has increased, more may be needed).

Research recommendations from the January 2018 stock assessment:

- Develop a survey that will provide estimates of harvest and discards for the recreational gig fisheries in North Carolina, South Carolina, Georgia, and Florida
- Conduct sampling of the commercial and recreational ocean spear fishery harvest and discards
- Develop a survey that will estimate harvest and discards from commercial gears used for recreational purposes
- Develop a survey that will provide estimates of harvest and discards from gears used to capture southern flounder for personal consumption
- Improve estimates of the B2 component (catches, lengths, and ages) for southern flounder from the MRIP
- Collect additional discard data (ages, species ratio, lengths, fates) from other gears (in addition to gill nets) targeting southern flounder (pound net, gigs, hook-and-line, trawls)
- Develop and implement consistent strategies for collecting age and sex samples from commercial and recreational fisheries and fisheries-independent surveys to achieve desired precision for stock assessment
- Complete an age validation study using known age fish
- Implement a tagging study to estimate emigration, movement rates, and mortality rates throughout the stock's range
- Expand, improve, or add inshore and offshore surveys of southern flounder to develop indices for future stock assessments
- Expand, improve, or add fisheries-independent surveys of the ocean component of the stock
- Collect age and maturity data from the fisheries-independent SEAMAP Trawl Survey given its broad spatial scale and potential to characterize offshore fish
- Conduct studies to better understand ocean residency of southern flounder
- Determine locations of spawning aggregations of southern flounder
- Develop protocol for archiving and sharing data on gonads for microscopic observation of maturity stage of southern flounder for North Carolina, South Carolina, Georgia, and Florida
- Examine the variability of southern flounder maturity across its range and the effects this may have on the assessment model
- Investigate how environmental factors (wind, salinity, temperatures, or oscillations) may be driving the stock-recruitment dynamics for southern flounder
- Promote data sharing and research cooperation across the South Atlantic southern flounder range (North Carolina, South Carolina, Georgia, and Florida)
- Consider the application of areas-as-fleets models in future stock assessments given the potential spatial variation (among states) in fishery selectivity and fleet behavior in the southern flounder fishery
- Consider the application of a spatial model to account for inshore and ocean components of the stock as well as movements among states

The peer review panel concluded that the working group's research recommendations were appropriate and endorsed all of them. In addition to identifying some research needs as high priority, the peer review panel offered the following additional research recommendations:

- Conduct studies to quantify fecundity and fecundity-size/age relationships in Atlantic southern flounder
- Work to reconcile different state-level/regional surveys to better explain differences in trends
- Develop a recreational CPUE (e.g., from MRIP intercepts or the Southeast Regional Headboat Survey if sufficient catches are available using a species guild approach to identify trips, from headboat logbooks, etc.) as a complement to the more localized fishery independent indices
- Explore reconstructing historical catch and catch-at-length data prior to 1989 to provide more contrast in the removals data
- Study potential species interactions among *Paralichthid* flounders to explain differences in population trends where they overlap

FISHERY MANAGEMENT PLAN SCHEDULE RECOMMENDATION

At its August 2015 business meeting the NCMFC approved the FMP schedule that maintained the timeline for a scheduled review of the southern flounder FMP to begin in 2018.
At its Aug. 18, 2016 business meeting, the NCMFC approved a motion to begin the review of the FMP as soon as a valid stock assessment is available. A coast-wide stock assessment for southern flounder, including data from North Carolina, South Carolina, Georgia, and Florida, was completed in January 2018 with an update completed in January 2019. This update was a necessary result of an external peer review of the January 2018 stock assessment conducted in December 2017.

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TABLES

Table 1. Southern flounder recreational harvest and number released (Marine Recreational Information Program) and commercial harvest (North Carolina Trip Ticket Program) for 1989-2018. All weights are in pounds.

	Recreational				
	Numbers		Weight (lb)		
Year	Landed	Released	Landed	Commercial Weight (lb)	Total Weight (lb)
1989	119,047	125,192	199,850	3,225,955	3,425,805
1990	138,106	152,895	216,960	2,560,459	2,777,419
1991	257,319	791,778	489,865	4,163,374	4,653,239
1992	115,329	433,576	219,720	3,145,020	3,364,740
1993	83,811	370,372	127,860	4,272,368	4,400,228
1994	168,237	562,915	323,869	4,878,609	5,202,478
1995	127,106	459,800	271,703	4,166,966	4,438,669
1996	173,400	449,876	339,228	3,807,009	4,146,237
1997	209,038	873,901	560,323	4,076,793	4,637,116
1998	96,124	411,939	205,569	3,952,729	4,158,298
1999	78,321	209,956	184,969	2,933,331	3,118,300
2000	326,712	942,560	607,053	3,205,792	3,812,845
2001	304,791	990,335	567,568	3,522,136	4,089,704
2002	366,671	1,415,247	789,539	3,436,753	4,226,292
2003	293,793	860,052	621,985	2,198,503	2,820,488
2004	347,492	1,537,924	827,593	2,454,577	3,282,170
2005	298,307	997,132	675,856	1,870,754	2,546,610
2006	352,942	1,287,601	761,069	2,287,823	3,048,892
2007	279,916	1,075,735	572,064	2,083,043	2,655,107
2008	349,860	2,532,079	807,867	2,602,390	3,410,257
2009	329,117	1,889,921	692,704	2,396,240	3,088,944
2010	556,812	2,835,142	1,149,899	1,689,557	2,839,456
2011	388,647	2,087,604	942,373	1,247,450	2,189,823
2012	290,035	2,434,621	701,698	1,646,137	2,347,835
2013	374,215	2,357,529	869,223	2,186,391	3,055,614
2014	209,228	1,856,280	447,337	1,673,511	2,120,848
2015	249,166	1,709,189	558,303	1,202,952	1,761,255
2016	299,273	2,178,145	695,713	899,932	1,595,645
2017	221,321	1,988,000	451,126	1,394,906	1,846,032
2018	217,805	1,002,753	495,289	903,055	1,398,344

Table 2. Southern flounder total length (inches) and age data for NCDMF commercial fishery sampling programs (includes harvest and some discard information).

Year	Mean Length	Minimum Length	Maximum Length	Total Measured	Modal Age	Minimum Age	Maximum Age	Total Aged
2005	16	2	31	28,972	2	0	7	83
2006	16	5	31	39,572	3	0	6	80
2007	16	4	29	23,768	2	0	5	94
2008	16	1	28	39,302	2	0	7	212
2009	16	4	28	33,403	2	1	6	34
2010	16	5	29	27,176	2	1	5	33
2011	16	5	30	32,000	3	1	6	90
2012	16	4	30	29,865	2	0	6	38
2013	16	1	32	33,776	1	1	5	245
2014	16	1	28	26,354	2	0	4	408
2015	16	2	30	19,717	1	0	5	330
2016	17	6	27	14,712	0	0	4	246
2017	17	3	30	14,775	0	0	5	418
2018	17	2	27	8,962	NA	NA	NA	NA

Table 3. Southern flounder total length (inches) and age data for NCDMF recreational fishery sampling.

Year	Mean Length	Minimum Length	Maximum Length	Total Measured	Modal Age	Minimum Age	Maximum Age	Total Aged
2005	17	13	26	202	3	1	6	112
2006	16	10	31	343	3	1	6	188
2007	17	14	24	220	2	1	8	137
2008	17	13	27	311	3	1	6	79
2009	17	12	26	306	2	1	4	45
2010	17	11	28	754	2	1	7	127
2011	17	14	26	478	2	1	6	91
2012	18	14	30	400	2	1	6	57
2013	17	13	27	390	3	1	5	47
2014	17	14	26	199	2	1	7	42
2015	17	14	24	177	3	1	6	36
2016	17	14	25	225	2	0	5	123
2017	17	14	26	215	2	0	7	140
2018	17	13	27	276	NA	NA	NA	NA

Table 4. Southern flounder total length (inches) and age data for NCDMF fishery-independent sampling programs.

Year	Mean Length	Minimum Length	Maximum Length	Total Measured	Modal Age	Minimum Age	Maximum Age	Total Aged
2005	8	0	25	3,769	2	0	4	516
2006	9	0	23	3,560	3	0	4	539
2007	7	0	22	3,812	1	0	5	513
2008	10	0	27	4,270	1	0	5	816
2009	10	1	27	3,230	1	0	5	414
2010	9	1	23	4,168	1	0	5	1,072
2011	12	1	28	2,604	1	0	6	720
2012	10	1	26	4,878	1	0	3	1,112
2013	9	1	27	3,534	1	0	6	678
2014	9	1	25	2,339	1	0	3	802
2015	9	1	24	2,133	1	0	3	463
2016	11	2	30	1,426	1	0	3	404
2017	9	1	22	2,238	1	0	3	620
2018	9	0	24	2,123	NA	NA	NA	NA

Table 5. Annual nominal abundance index values for southern flounder as catch per unit effort and standard error (SE) in N.C. Division of Marine Fisheries independent surveys (programs 120, 195, 135 and 915). Indices for programs 120 and 195 are considered juvenile (young-of-year) abundance indices.

Year	P915 Index	P915 SE	P135 Index	P135 SE	P195 Index	P195 SE	P120 Index	P120 SE
1991			0.17	0.01	0.6	0.2	1.13	0.17
1992			0.18	0.02	4.83	1.3	2.49	0.30
1993			0.15	0.01	3.81	1.1	2.93	0.38
1994			0.08	0.01	3.33	1.2	1.79	0.24
1995			0.11	0.01	2.83	0.7	1.69	0.24
1996			0.03	0	9.65	2.0	7.82	0.95
1997			0.1	0.01	3.1	0.8	2.74	0.29
1998			0.08	0.01	0.37	0.1	0.90	0.15
1999			0.04	0	1.91	0.5	2.49	0.30
2000			0.05	0.01	0.77	0.2	3.74	0.43
2001			0.1	0.01	0.82	0.3	4.38	0.46
2002			0.14	0.01	3.28	1.5	4.49	0.56
2003	3.41	0.35	0.03	0	2.94	0.8	6.31	1.01
2004	3.11	0.34	0.09	0.01	1.28	0.2	3.89	0.46
2005	2.64	0.25	0.08	0.01	3.25	1.0	3.05	0.38
2006	1.84	0.29	0.13	0.01	1	0.3	2.63	0.33
2007	1.44	0.17	0.16	0.01	1.07	0.3	3.64	0.39
2008	2.97	0.35	0.17	0.01	0.94	0.5	2.40	0.33
2009	2.04	0.27	0.12	0.01	1.28	0.3	1.93	0.26
2010	3.57	0.46	0.05	0.01	1.14	0.3	5.03	0.66
2011	2.33	0.35	0.02	0	0.6	0.2	1.09	0.19
2012	2.22	0.22	0.08	0.01	4.44	1.9	3.07	0.39
2013	2.57	0.24	0.1	0.01	1.05	0.3	2.64	0.33
2014	1.81	0.19	0.05	0	0.64	0.2	1.86	0.30
2015	1.32	0.23	0.04	0	2.46	0.4	1.67	0.27
2016	1.14	0.15	0.02	0	0.73	0.3	0.53	0.11
2017	1.34	0.15	0.02	0	6.02	2.2	1.03	0.16
2018	1.51	0.18	0.02	0	2.94	1.0	1.34	0.18

Table 6. Management action taken as a result of Amendment 1 and Supplement A to the Southern Flounder FMP.

MANAGEMENT STRATEGY	OUTCOME
Commercial: Accept management measures to reduce protected species interactions as the management strategy for achieving sustainable harvest in the commercial southern flounder fishery. Specific minimum measures for the flounder gill net fishery are provided in Issue Paper 10.1.1 (page 129). Recreational: Increase the minimum size limit to 15 inches and decrease the creel limit to six fish-20.2% harvest reduction	Commercial: No Action Required Recreational: Proclamation FF-29-2011 (refer to Supplement A to the 2005 FMP)
Status quo and address research recommendations	No Action Required
Status quo (implement mediation and proclamation authority to address user conflicts with large mesh gill nets)	No Action Required
Status quo (200-yard minimum distance between pound nets and gill nets)	No Action Required
Status quo and address research recommendations	No Action Required
Status quo and expand research on flatfish escape devices and degradable panels under commercial conditions to other parts of the state	No Action Required
Status quo and expand research on factors impacting the release mortality of southern flounder and on deep hooking events of different hook types and sizes	No Action Required
• Request funding for state observer program • Apply for Incidental Take Permit for large mesh gill net fishery • Continue gear development research to minimize protected species interactions	No Action Required
Status quo minimum mesh size for escape panels (5.5-inch stretched mesh) and recommend further research on 5.75-inch stretched mesh escape panels	No Action Required
Status quo minimum mesh size (5.5 inches stretched mesh)	No Action Required
Increase minimum mesh size to harvest southern flounder to 6.0-inch stretched mesh Increase minimum size limit for commercial fisheries to 15 inches	Proclamation FF-3-2016 (refer to Supplement A to Amendment 1 of the 2005 FMP)
Increase minimum mesh size for escape panels to 5.75-inch stretched mesh	Proclamation M-34-2015 (refer to Supplement A to Amendment 1 of the 2005 FMP)
Reduce daily bag limit for recreational harvest of southern flounder from 6 fish to 4 fish	Proclamation FF-4-2017 (refer to Addendum XXVIII to ASMFC Summer Flounder, Scup, Black seabass FMP)

FIGURES

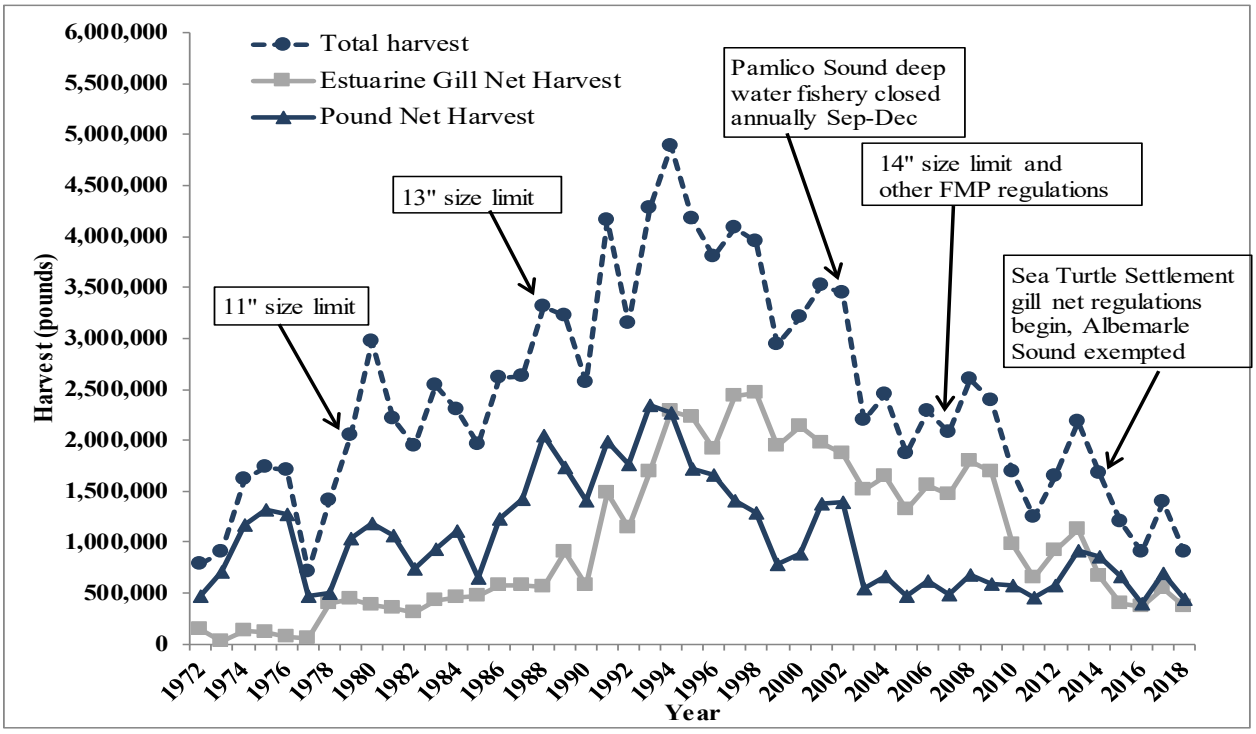

Figure 1. Southern flounder harvest (pounds) for total commercial fishery and top two gears (gill nets and pound nets) from N.C. Trip Ticket Program 1972-2018 with major fishery regulation changes.

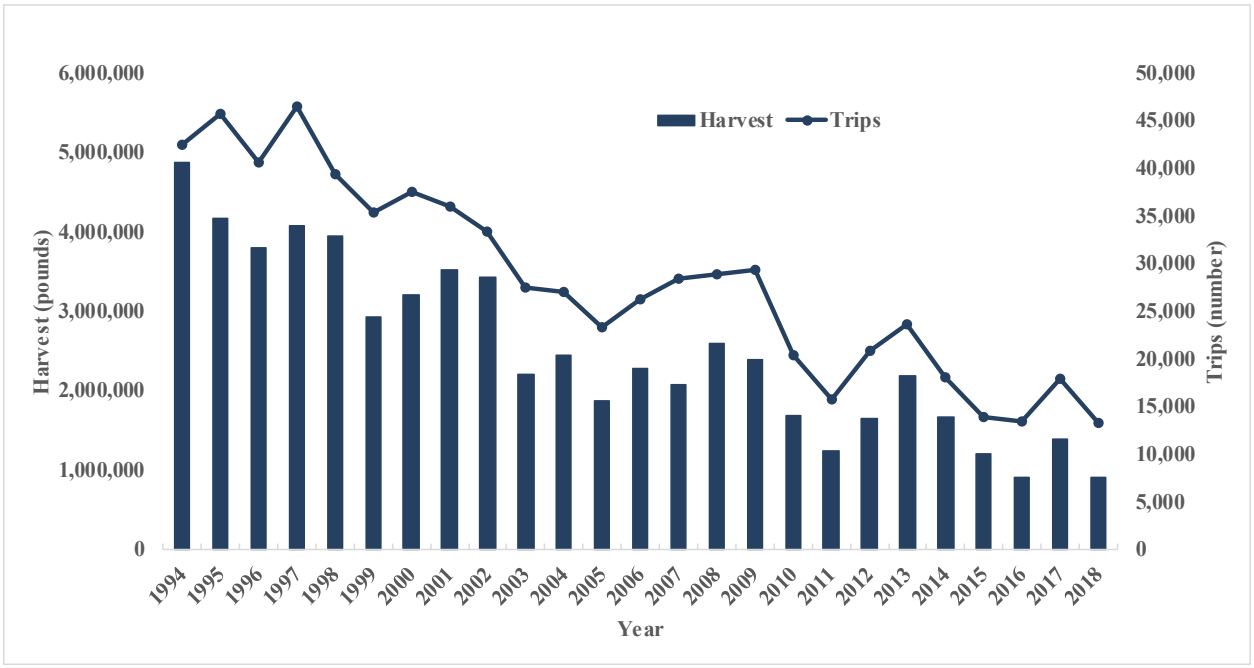

Figure 2. Southern flounder commercial trips (numbers) and harvest (pounds) from N.C. Trip Ticket Program, 1994-2018.

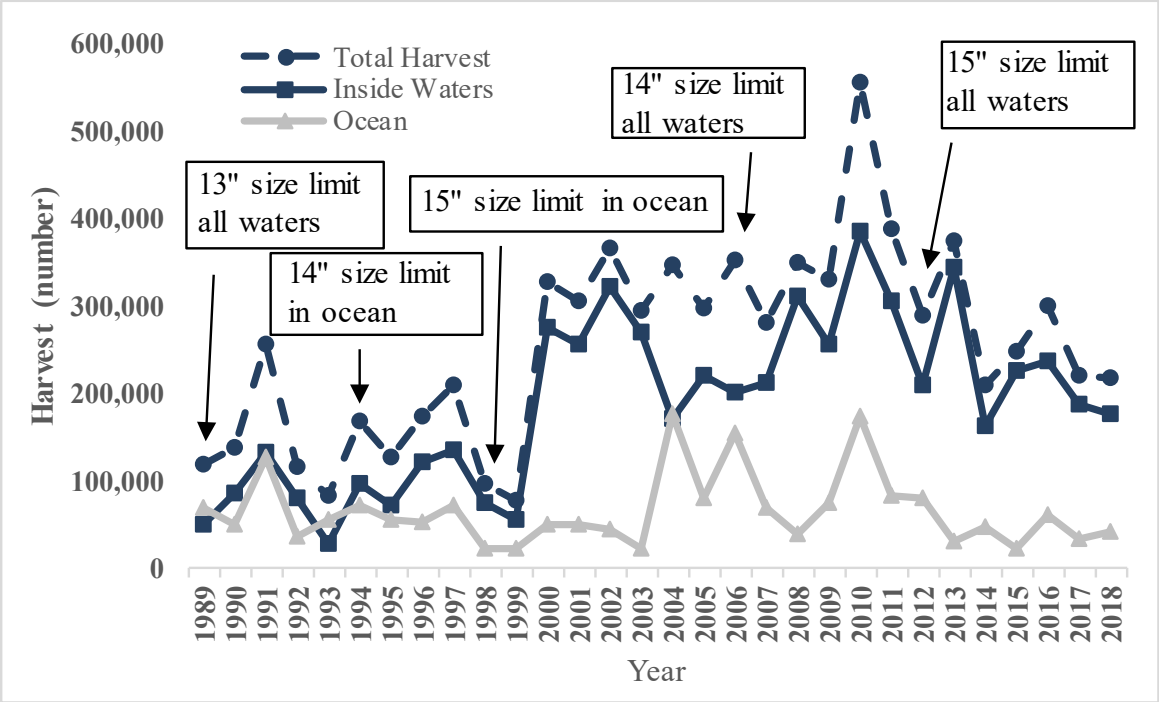

Figure 3. Southern flounder recreational hook and line harvest in numbers of fish from MRIP data 1989-2018 and major fishery regulation changes.

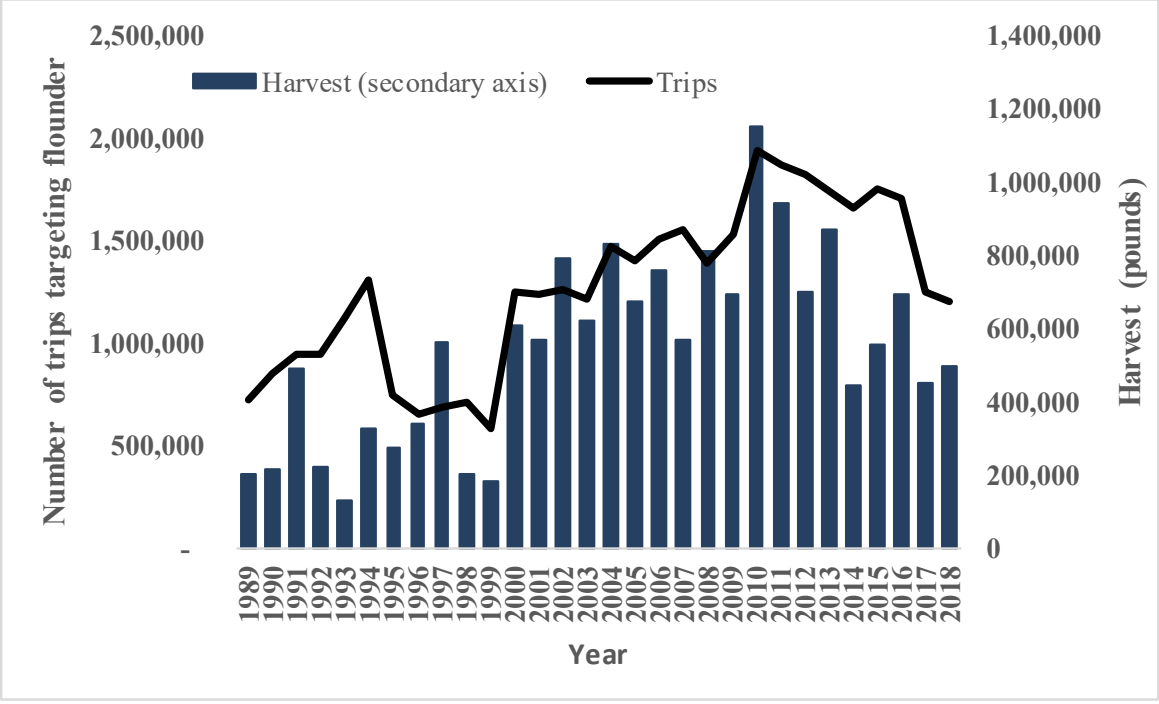

Figure 4. Recreational hook and line harvest (in numbers of fish) and all trips that harvested or released paralichthid flounder species, from MRIP data 1992-2018. Data from prior to 2004 were calibrated to align with MRIP estimates post-2004.

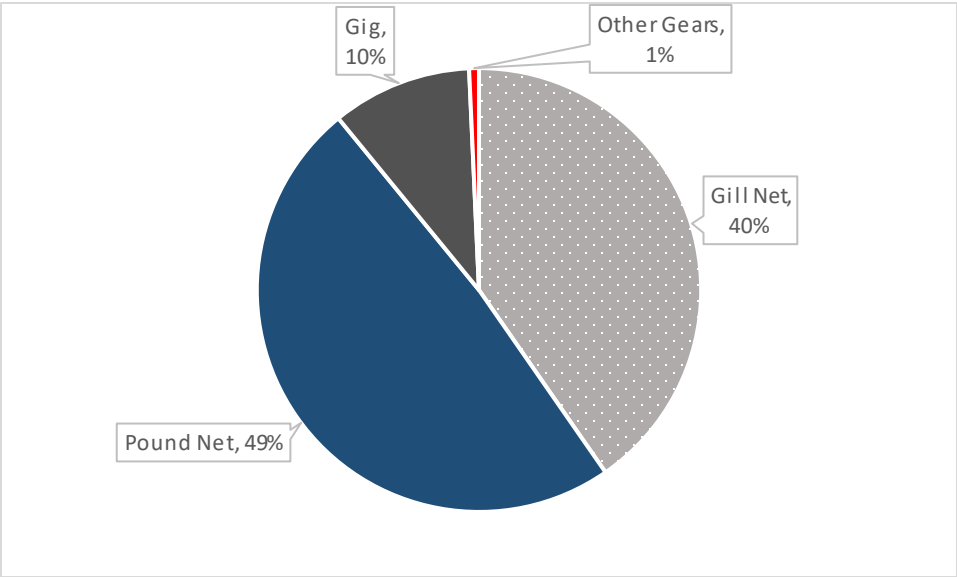

Figure 5. Commercial harvest of southern flounder in 2018 by gear type.

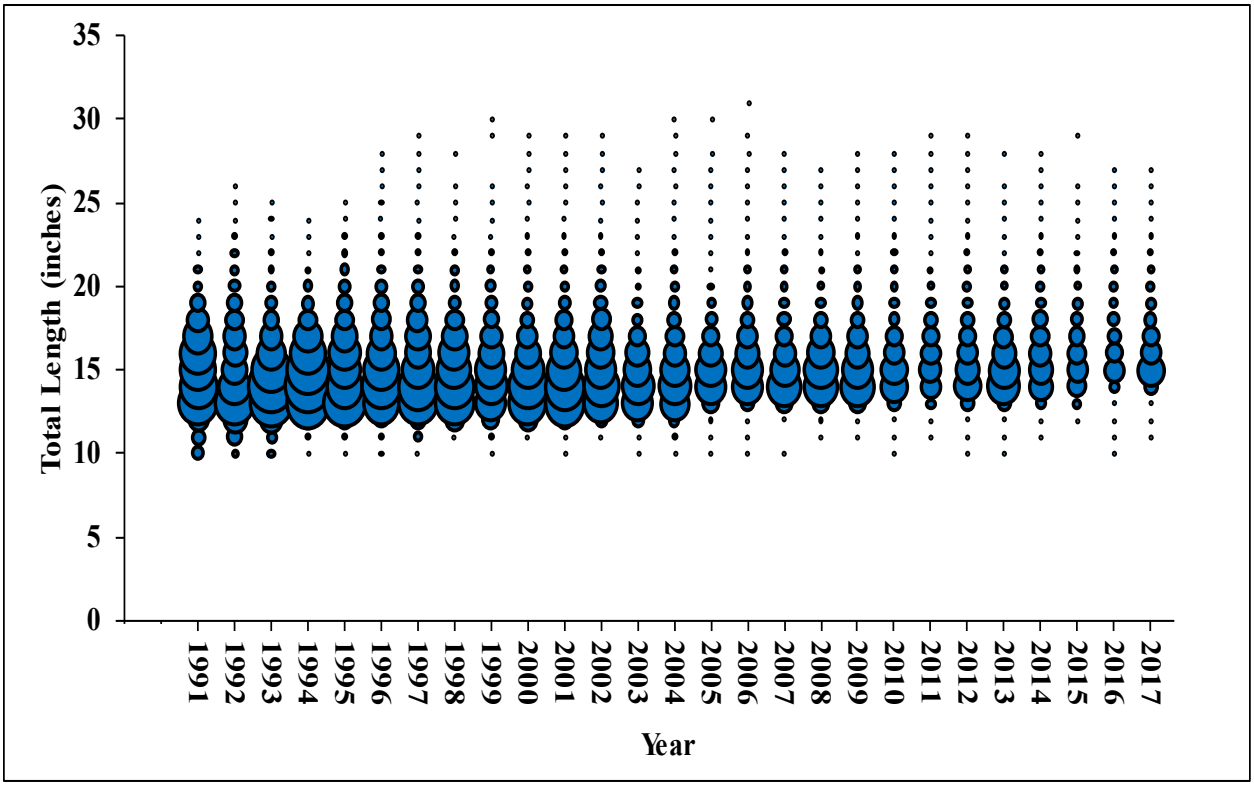

Figure 6. Commercial length frequency (total length, inches) of southern flounder harvested from 1991 through 2017. Bubbles represent fish harvested at length and the size of the bubble is equal to the proportion of fish at that length.

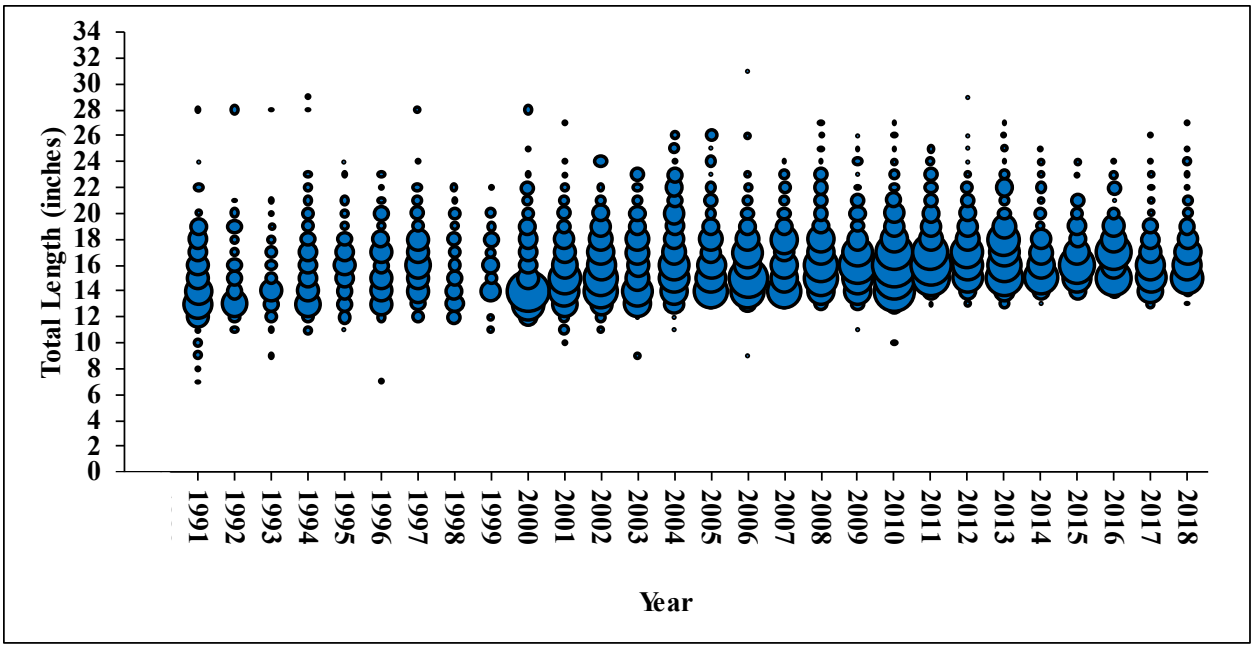

Figure 7. Recreational length frequency (total length, inches) of southern flounder harvested in North Carolina from MRIP, 1991 through 2018. Bubbles represent fish harvested at length and the size of the bubble is equal to the proportion of fish at that length.

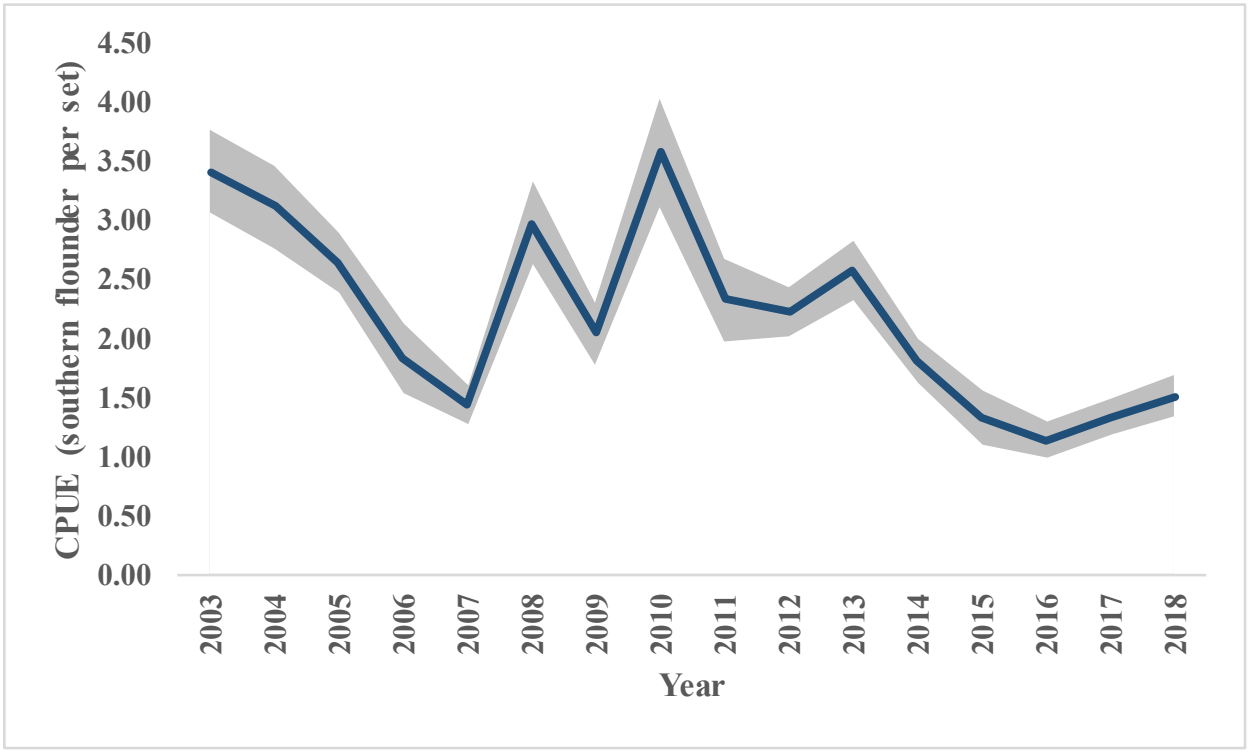

Figure 8. Annual nominal abundance index values for southern flounder (juveniles and adults) caught in the Pamlico Sound Independent Gill Net Survey (P915).

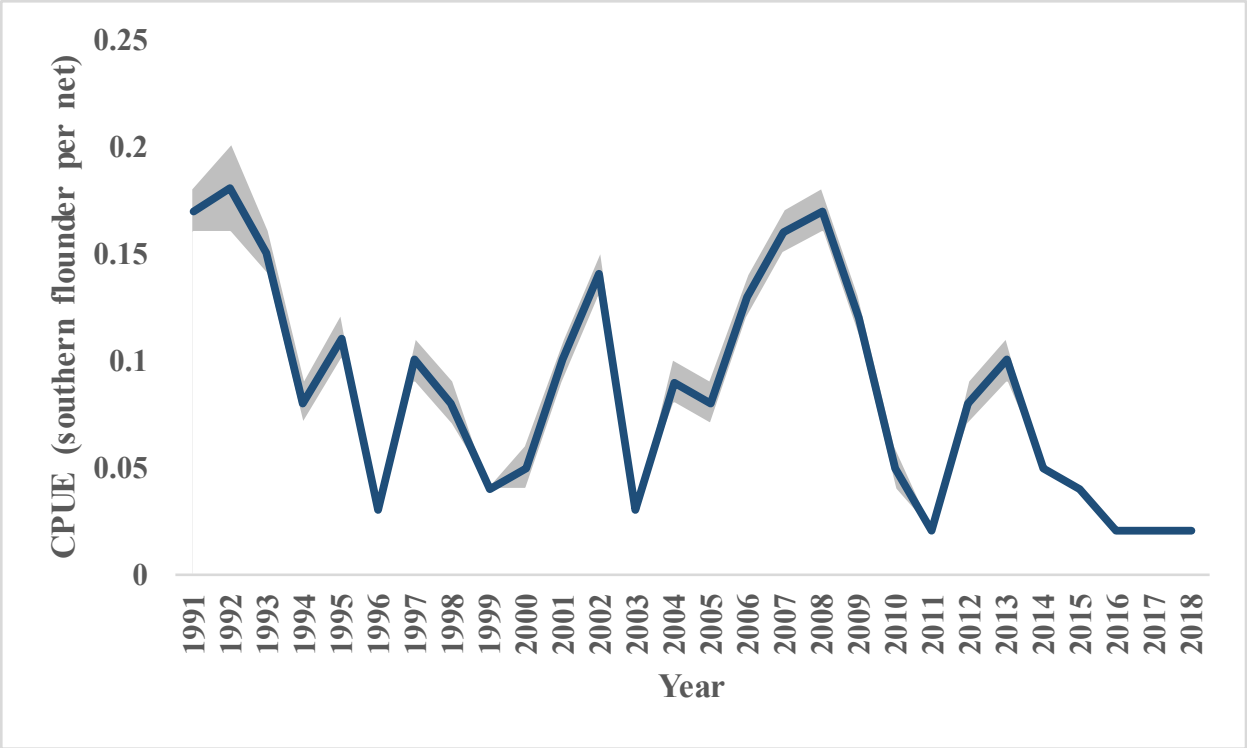

Figure 9. Annual nominal abundance index values for southern flounder (juveniles and adults) caught in the Striped Bass Independent Gill Net Survey (P135).

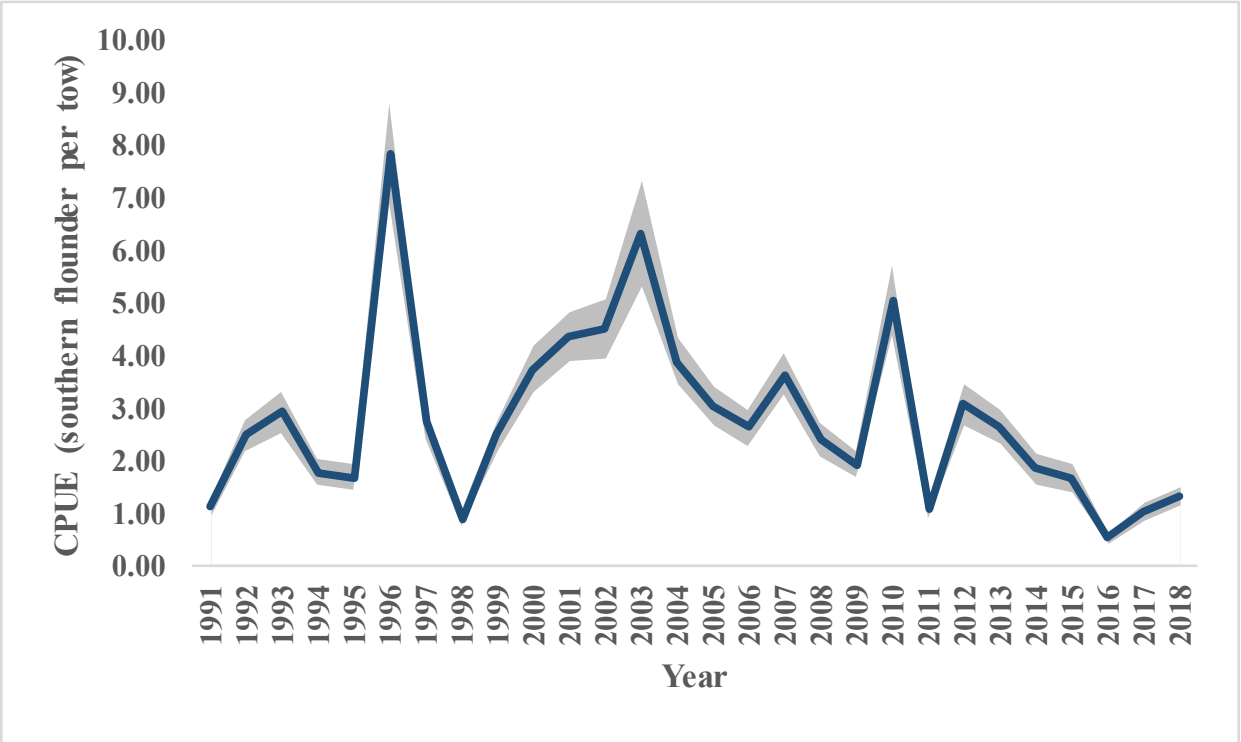

Figure 10. Annual nominal abundance index values for southern flounder (juveniles and adults) caught in the Estuarine Trawl Survey (P120).

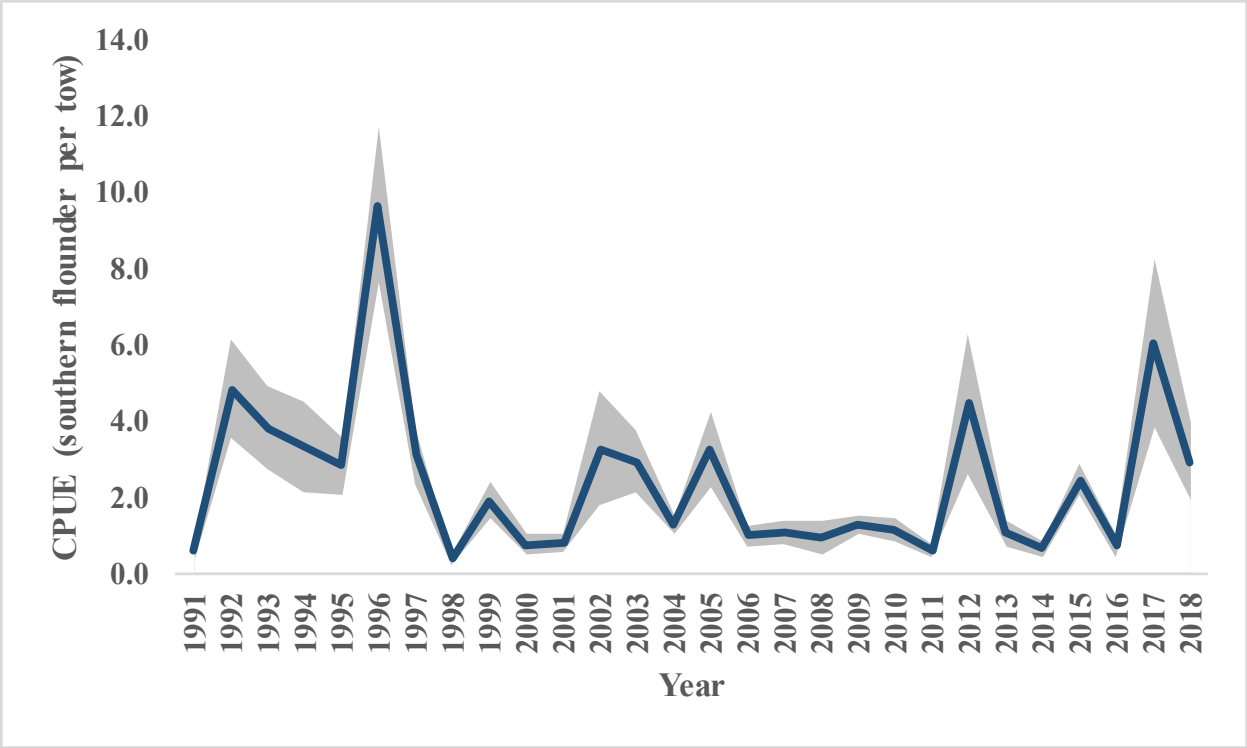

Figure 11. Annual nominal abundance index values for southern flounder (juveniles and adults) caught in the Pamlico Sound Survey (P195).

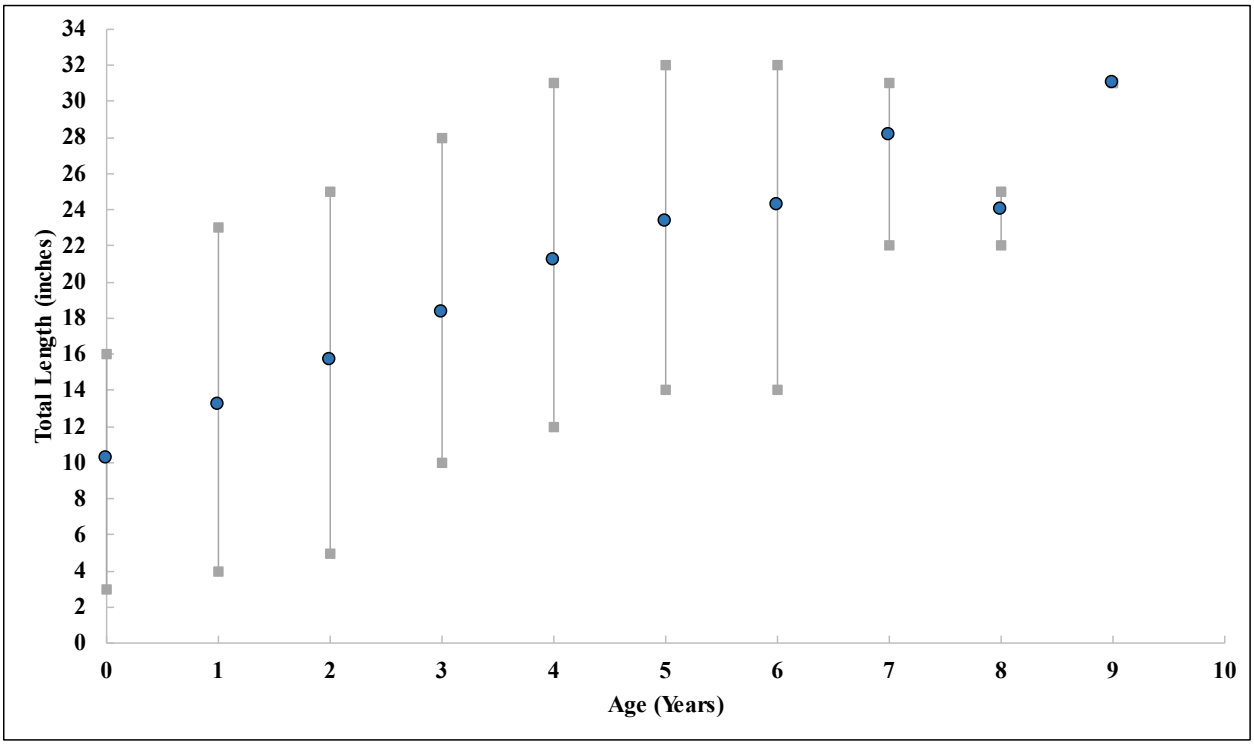

Figure 12. Southern flounder length at age based on all age samples collected from 1991 through 2017. Blue circles represent the mean size at a given age while the grey squares represent the minimum and maximum observed size for each age.

FISHERY MANAGEMENT PLAN UPDATE
SPOTTED SEATROUT
AUGUST 2019

STATUS OF THE FISHERY MANAGEMENT PLAN

Fishery Management Plan History

Original FMP Adoption:	February 2012
Amendments:	None
Revisions:	None
Supplements:	Supplement A to the 2012 FMP – February 2014
Information Updates:	None
Recommended Schedule Change:	None
MFC Scheduled Review:	Review started in 2019

Spotted seatrout *(Cynoscion nebulosus)* are managed under the authority of two state and one interstate fishery management plans (FMP). The North Carolina Marine Fisheries Commission (NCMFC) currently manages spotted seatrout under the North Carolina Spotted Seatrout FMP (NCDMF 2012) and Supplement A to the 2012 FMP (NCDMF 2014a). Supplement A maintains short–term measures in the spotted seatrout fishery (40% reduction at 14-inch total length minimum size) to address several sources of uncertainty in the 2009 stock assessment through acquisition and assessment of additional data. This supplement examined sources of uncertainty in the assessment, the rationale for not implementing on schedule the North Carolina Spotted Seatrout FMP February 2014 management measures, and presented possible interim management measures. At the February 2014 NCMFC meeting the commission voted to maintain short-term management measures in the spotted seatrout fishery (Proclamation FF-38-2014: 14-inch minimum size, 75-fish commercial trip limit with weekend closures in joint waters except in Albemarle and Currituck sounds; Proclamation FF-39-2014: 14-inch minimum size, four-fish recreational bag limit). These measures will remain in effect until an amendment is completed.

As required in the approved 2012 FMP, a stock assessment was completed on schedule (2014-2015), peer reviewed, approved for management, and was presented to the NCMFC at its May 2015 business meeting. A new benchmark stock assessment will begin in 2019. The North Carolina Division of Marine Fisheries (NCDMF) is on schedule to review the current state FMP for spotted seatrout beginning in 2019 and determine if changes to management are needed through the FMP amendment process.

The Atlantic States Marine Fisheries Commission (ASMFC) manages spotted seatrout in all Atlantic States who have a declared interest in the species. In addition to the state FMP, the ASMFC manages spotted seatrout under the Omnibus Amendment to the Interstate Fishery Management Plans for Spanish Mackerel, Spot, and Spotted Seatrout (ASMFC 2011). The goals for the Omnibus Amendment are to bring the FMPs for the three species under the authority of the ASMFC Interstate Fishery Management Program Charter, and bringing compliance requirements to each state. Because the intent of the Omnibus amendment was to bring the ASMFC spotted seatrout FMP into compliance with the new ASMFC charter, management measures were not adjusted and the identified objectives and compliance requirements to the states of the Omnibus Amendment are the same as Amendment 1 to the ASMFC spotted seatrout FMP (ASMFC 1990) and are as follows:

- Manage the spotted seatrout fishery restricting catch to mature individuals (12-inch minimum size).
- Manage the spotted seatrout stock to maintain sufficiently-high spawning stock biomass (20% SPR).
- Develop research priorities that will further refine the spotted seatrout management program to maximize the biological, social, and economic benefits derived from the spotted seatrout population.

To ensure compliance with interstate requirements, North Carolina also manages this species 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 plans) and the Atlantic Coastal Fisheries Cooperative Management Act (ASMFC plans) are like the goals of the Fisheries Reform Act of 1997 to "ensure long-term viability" of these fisheries (NCDMF 2015).

Management Unit

The management unit for the North Carolina Spotted Seatrout FMP (NCDMF 2012) includes all spotted seatrout within the coastal and joint waters of North Carolina. The unit stock, or population unit, for North Carolina's assessment of spotted seatrout include all spotted seatrout caught in North Carolina and Virginia. Virginia landings were included in the stock assessment of spotted seatrout because of the high rate of mixing observed between North Carolina and Virginia.

Goal and Objectives

The goal of the North Carolina Spotted Seatrout FMP (NCDMF 2012) is to determine the status of the stock and ensure long-term sustainability for the spotted seatrout stock in North Carolina. To achieve this goal, it is recommended that the following objectives be met:

1. Develop an objective management program that provides conservation of the resource and sustainable harvest in the fishery.
2. Ensure the spawning stock is of sufficient capacity to prevent recruitment-overfishing.
3. Address socio-economic concerns of all user groups.
4. Restore, improve, and protect important habitats that affect growth, survival, and reproduction of the North Carolina spotted seatrout stock.
5. Evaluate, enhance, and initiate studies to increase understanding of spotted seatrout biology and population dynamics in North Carolina.
6. Promote public awareness regarding the status and management of the North Carolina spotted seatrout stock.

STATUS OF THE STOCK

Life history

Spotted seatrout range from Massachusetts to southern Florida and the Bahamas on the U.S. Atlantic Coast and continue through the Gulf of Mexico to the Yucatan Peninsula, Mexico (Murphy et al. 2006). They inhabit shallow coastal and estuarine waters throughout their range and are considered a euryhaline species (Deaton et al. 2010). In North Carolina, the current state record was recorded at 12.3 pounds in 1961. The maximum reported age of spotted seatrout is 9 years in North Carolina for both male and female fish (NCDMF 2012). Most spotted seatrout in North Carolina are mature by age 1 and 7.9 inches for males and 9.6 inches for females. All males are mature at 12 inches and females at 15 inches. Spawning in North Carolina occurs from April to October with peak spawn around May (Burns 1996). Spawning occurs within the first few hours after sunset (Luczkovich et al. 1999) and a single fish is capable of spawning multiple times (batch spawners) throughout the season. In Florida, it has been observed that during peak spawning, spotted seatrout older than 3 years old may spawn every two days while younger fish may spawn as frequently as every four days (Roumillat and Brouwer 2004). Estimates of the number of eggs a female can produce in a year from the Southeast and Gulf Coasts vary, based on size and age and range, from 3 million to 20 million per year (Nieland et al. 2002; Roumillat and Brouwer 2004; Murphy et al. 2011).

Stock Status

The 2014 North Carolina spotted seatrout stock assessment (NCDMF 2014b) indicated that the spotted seatrout stock in North Carolina and Virginia is not overfished and overfishing in not occurring. Reference points (SSB and F) for determining stock status were calculated from the assessment using the SPR thresholds (20% SPR) and targets (30%SPR) defined in the spotted seatrout FMP (NCDMF 2012). The model estimated $SSB_{20\%}$ at 394 metric tons and $SSB_{30\%}$ at 623 metric tons with a model terminal year (2012) SSB estimate of 2,513,270 pounds. Based on these results, the stock is not currently overfished ($SSB_{2012} < SSB_{20\%}$) and has not been overfished during the 1991 to 2012 time period (Figure 1). Fishing mortality reference points estimated from the model were $F_{20\%}$ at 0.656 and $F_{30\%}$ at 0.422 with a terminal year estimate of F at 0.401, close to the F target, but still below, suggesting that overfishing is not occurring ($F_{2012} < F_{20\%}$; Figure 2).

Stock Assessment

The 2014 assessment of the spotted seatrout in North Carolina and Virginia was conducted using a Stock Synthesis model that incorporated data collected from commercial and recreational fisheries, two fishery-independent surveys, and a tagging study (NCDMF 2014b). This approach differs from the previous NCDMF assessment of spotted seatrout, which was applied to data available from 1991 through 2008. The previous assessment used the ASAP2 statistical catch-at-age model and data more limited in both area and time. The previous model relied primarily upon fishery-dependent data, one fishery-independent index, and included age data only from the North Carolina portion of the stock.

The Stock Synthesis model has been thoroughly vetted through the stock assessment community and peer reviewed literature. The time period used for the assessment was 1991 through 2012 and relied on expanded fishery-independent data sources, including age data from the Virginia portion of the stock, a juvenile abundance index, and tag-return data from research conducted by North Carolina State University (Ellis 2015). The fishing year was changed from a calendar year to a biological year (defined as March 1 through February 28 or 29) to allow the model to incorporate cold stun mortalities within a single fishing year instead of across two calendar years. The maximum age was decreased from 12 years (previous assessment) to nine as the 12-year maximum was based on scale ages not otoliths. Only ages derived from otoliths were used in the current assessment.

Tagging data from Ellis' (2015) study was included in the model but did not have a significant influence on results. Multiple model configurations were attempted to account for varying natural mortality ranging from direct tagging estimates to estimates based on water temperature correlations: however, no model configuration incorporating varying natural mortality would produce results (converge). Ellis' (2015) data did provide further evidence of the highs and lows associated with spotted seatrout natural mortalities and the need for a custom model that can incorporate these highly variable mortality rates. The NCDMF recognized the need to develop a model that will accept variable natural mortality estimates. Developing a custom model that can incorporate variable natural mortality was added as a research recommendation and the NCDMF will continue to investigate this during the next benchmark assessment.

The results of this assessment suggest the age structure of the spotted seatrout stock has been expanding during the last decade. However, an abrupt decline is evident in the model's estimate of recruitment after 2010, although this is not mirrored in the empirical survey data. Spawning stock biomass (SSB) increased to its maximum in 2007 but has since declined to close to the time series average. In 2012, estimated SSB was 2,513,270 pounds, which is greater than the currently defined threshold for assessing whether the stock is overfished (SSB30%=868,621 pounds; Figure 1). Fishing mortality has varied without apparent trend, but periods of high fishing mortality seem to coincide with the decline in spawning stock biomass and may be attributed to cold stun events. The 2012 estimate of fishing mortality was 0.40, which is less than the fishing mortality threshold (F20%=0.66), indicating that the stock is not experiencing overfishing; however, the 2012 estimate of fishing mortality (0.40) is very near the target fishing mortality of F30%=0.42 (Figure 2).

A benchmark stock assessment for spotted seatrout will begin in 2019 coinciding with the scheduled plan review.

STATUS OF THE FISHERY

Current Regulations

The NCDMF currently allows the recreational harvest of spotted seatrout seven days per week with a minimum size limit of 14-inches total length (TL) and a daily bag limit of four fish. The commercial harvest is limited to a daily limit of 75 fish with a minimum size limit of 14-inches TL). It is unlawful for a commercial fishing operation to possess or sell spotted seatrout for commercial purposes taken from Joint Fishing Waters of the state from midnight on Friday to midnight on Sunday each week; the Albemarle and Currituck sounds are exempt from this weekend closure. In the event of a catastrophic cold stun, the NCDMF has the authority to close the fishery until the following spawning period. In 2018, the spotted seatrout commercial and recreational fishery was closed from January 5 through June 15 by proclamation due to a coast-wide cold stun event.

Commercial Landings

Annual landings have been variable throughout the time series (Table 1; Figure 3). Commercial landings in 2018 (128,922 pounds) declined by 57% compared to the previous year (299,911 pounds; Table 1; Figure 3). This sharp decline in commercial landings is most likely due to the fishery closure from January through mid-June. During the early to mid-1990s, landings in the ocean and estuarine areas were more similar than in the remainder of the time series (1995-2018) in which estuarine landings have dominated. The primary gear of harvest are estuarine gill nets (set, drift, and run around).

Recreational Landings

Recreational fishing activity is monitored through the Marine Recreational Information Program. In this report, estimates across all years have been updated and are now based on the MRIP new Fishing Effort Survey-based calibrated estimates. For more information on MRIP methodology changes see https://www.fisheries.noaa.gov/topic/recreational-fishing-data.

Recreational harvest of spotted seatrout estimated by MRIP (Type A + B1) in 2018 was 658,555 pounds (PSE = 18.4%) and 449,473 fish (PSE = 18.6%), much lower than the time series averages of 1,423,709 pounds and 920,763 fish (Table 1; Figure 3). Estimated recreational releases in 2018 (15,245,249 fish) were well above the time series average of 2,847,400 fish (Table 1).

The North Carolina Saltwater Fishing Tournament recognizes anglers for landing and/or releasing fish of exceptional size or rarity by issuing citations that document the capture for the angler. Citations awarded through the North Carolina Saltwater Fishing Tournament for spotted seatrout have varied by year throughout the time series, averaging 325 citations (Table 2; Figure 4). The number of awarded citations in 2018 decreased from the previous year from 464 to 198. The number of release citations (fish over 24 inches that are released) awarded also decreased from

previous year's count, but comprised the largest percent of the spotted seatrout citations (37%) since spotted seatrout release citations began in 2008 (Table 2).

MONITORING PROGRAM DATA

Fishery-Dependent Monitoring

Commercial fish houses are sampled monthly to provide length, weight, and age data. This information is used to characterize the commercial fishery for stock assessments and to monitor trends in the size and age of fish being removed from the stock. The average sizes of fish landed by the commercial fishery are typically larger than the recreational fishery and is primarily driven by the larger maximum size observed in the commercial landings (Table 3; Figure 5). The number of fish sampled by division staff at commercial fish houses has varied over time due to annual variability in landings of the fishery, however; mean, minimum, and maximum lengths of spotted seatrout have not varied much between years for the commercial fishery (Table 3; Figure 6). The bulk of spotted seatrout landings by the commercial fishery come from the ocean and estuarine gill net fishery (96%) with gigs (1%) and all other gears (3%) accounting for the rest.

Recreational catch is almost exclusively hook-and-line with few fish being landed by gigs. The average size of fish measured from the recreational fishery has been increasing from 2010 to 2017, most likely due to the increase in the minimum size limit from 12-inches to 14-inches in late 2009 (Table 3; Figure 7). However, the average size of fish caught by the recreational fishery in 2018 was 15.7 inches, which is a decline from the 2010-2017 average size of 17.0 inches. A majority (40%) of the spotted seatrout sampled in 2018 were at the minimum size limit of 14 inches (Figure 5). The maximum size of spotted seatrout in 2018 was 23.3 inches, a decrease of 1.6 inches over the eight-year average. This decrease observed in average size caught and maximum size caught in 2018 may be at least partially due to the cold stun event that occurred in January 2018, which caused high spotted seatrout mortality coast-wide in North Carolina.

Fishery-Independent Monitoring

The NCDMF utilizes numerous independent monitoring programs to provide indices of juvenile (Program 120) and adult (Program 915) abundance to include in stock assessments. Program 120, the North Carolina Estuarine Trawl Survey, is a fishery independent multispecies monitoring program that has been ongoing since 1971 in the months of May, June and July. One of the key objectives of this program is to provide a long-term database of annual juvenile recruitment for economically important species. This survey samples a fixed set of 104 core stations with additional stations as needed. The core stations are sampled from western Albemarle Sound south to the South Carolina border each year without deviation two times in the months of May and June. An additional set of 27 spotted seatrout juvenile stations in Pamlico Sound and its major tributaries were added in 2004, and are sampled during the months of June and July. Data from the seatrout specific stations are used to generate an index of relative abundance of age zero spotted seatrout, calculated as a Catch Per Unit Effort (CPUE) or the average number of fish per tow. The resulting CPUE index for the time series is variable with no significant trends in CPUE and peaks in 2006, 2008, 2012, 2013, and 2018 suggesting relatively

higher recruitment in those years (Figure 8). The Program 120 CPUE in 2018 was 2.98, which was above the time series average of 2.19. Spikes in the juvenile index are often observed in years after severe cold stun events.

The NCDMF started a fishery independent gill net survey (Program 915) in 2001 to generate a long-term database of age composition and to develop indices of abundance for numerous commercial and recreationally important finfish species, including spotted seatrout. The survey utilizes a stratified random sampling scheme of multi-mesh gill nets designed to characterize the size and age distribution for key estuarine species in Pamlico Sound and help managers assess the spotted seatrout stocks without relying solely on commercial and recreational fishery dependent data. Three regions that encompass most of the estuarine waters in North Carolina are sampled monthly from February to December. Pamlico Sound stations include waters on the backside of the barrier islands and the bays of Hyde and Dare counties. CPUE from Pamlico Sound has remained relatively steady, with a time series high in 2017 and a slight decrease in 2018 (Figure 9). Central river stations that include Pamlico, Pungo and Neuse rivers have had an overall declining trend in CPUE since 2012, with CPUE in 2018 the lowest since 2005 (Figure 10). Spotted seatrout CPUE in the Cape Fear and New rivers has declined in the past two years, reaching the second lowest CPUE in 2018 since sampling began in 2008 (Figure 11). The declines in CPUE of spotted seatrout observed in 2018 in all areas sampled by P915 is most likely due to mortality from the coast-wide January 2018 cold stun event.

Spotted seatrout age samples are collected from numerous NCDMF fishery independent and dependent sources. To date, a total of 17,770 otoliths from spotted seatrout have been aged since 1991 (Table 4). With the exception of 2003, the minimum age of sampled spotted seatrout has been age zero for every year the NCDMF has recorded this information. Maximum ages have varied every year and has ranged from age five to age nine. Modal ages, which give an indication of the age of the largest cohort in the fishery, has mostly been age one. Spotted seatrout length-at-age was summarized based on all available age data (1991-2018; Figure 12). Average growth of spotted seatrout slows down around age-4, but fish as large as 24 inches have the potential to be young of the year (age-0), demonstrating the species' fast growth.

MANAGEMENT STRATEGY

Reduce F to maintain a 20% spawning potential ratio which will increase the likelihood of sustainability through an expanded age structure and an increase in the spawning stock biomass. This strategy should provide a greater cushion for the population that would likely lead to faster recovery of the population after cold stun events, which can lead to mass mortalities in the winter months potentially affecting the number of mature fish available to spawn the following spring. Consider revising reference points after the stock is reassessed in the next plan review based on the response of the population to the management measures selected in the initial FMP. The Director will maintain authority to intervene in the event of a catastrophic cold stun event and do what is necessary in terms of temporary closures by waterbody (Table 5 and 6).

RESEARCH NEEDS

The following research needs were compiled from those listed in the 2012 North Carolina Spotted Seatrout FMP. Improved management of spotted seatrout is dependent upon research needs being met. Research needs are not listed in order of priority.

- Develop a juvenile abundance index to gain a better understanding of a stock recruitment relationship – (ongoing, using program 120 since 2004)
- Research the feasibility of including measures of temperature or salinity into the stock recruitment relationship – (not completed)
- Determine batch fecundity estimates for North Carolina spotted seatrout – (not conducted)
- Size specific fecundity estimates for North Carolina spotted seatrout – (not conducted)
- Area specific spawning surveys could help in the delineation of area specific closures to protect females in spawning condition – (not completed)
- Investigation of the relationship of temperature with both adult and juvenile mortality – (started in 2015, monitoring temperatures in over wintering habitat of spotted seatrout: CRFL project 2F40-F024)
- Incorporate cold stun event information into the modeling of the population – (unsuccessfully attempted using stock synthesis model, will be investigated further during next benchmark stock assessment)
- Estimate or develop a model to predict the impact of cold stun events on local and statewide spotted seatrout abundance – (unsuccessfully attempted using stock synthesis model, will be investigated further during next benchmark stock assessment).
- Obtain samples (length, age, weight, quantification) of the cold stun events as they occur – (obtained samples in 2001, 2014, and 2015; length, weight, sex, age; unable to quantify extent of kills)
- Define overwintering habitat requirements of spotted seatrout – (not conducted)
- Determine factors that are most likely to influence the severity of cold stun events in North Carolina, and separate into low and high salinity areas – (Tim Ellis and the spotted seatrout Plan Development Team worked on this but were unable to incorporate into models; Ellis et. al (2017))
- Investigate the distribution of spotted seatrout in nursery and non-nursery areas – (not completed)
- Further research on the possible influences of salinity on release mortality of spotted seatrout – (ongoing; CRFL project 2F40-F017, evaluation of tagging and discard mortality component)
- Survey of fishing effort in creeks with conflict complaints – (not completed)
- Determine targeted species in nursery areas and creeks with conflict complaints – (not completed)
- Microchemistry, genetic, or tagging studies are needed to verify migration patterns, mixing rates, or origins of spotted seatrout between North Carolina and Virginia – (Tim Ellis data (2008-2013); CRFL project 2F40-F017, NC Multi Species Tagging Study 2014 – present; NCSU study CRFL grant 2F40-F022)
- Tagging studies to verify estimates of natural and fishing mortality – (Tim Ellis data (2008-2013); CRFL project 2F40-F017, NC Multi Species Tagging Study 2014 – present)

- Tagging studies to determine if there are localized populations within the state of North Carolina (e.g., a southern and northern stock) – (Tim Ellis data (2008-2013); CRFL project 2F40-F017, NC Multi Species Tagging Study 2014 - present)
- A longer time series and additional sources of fishery-independent information – (longer series available as well as Program 915 survey for rivers and southern portion of state)
- Increased observer coverage in a variety of commercial fisheries over a wider area – (ongoing)
- Expand nursery sampling to include SAV bed sampling in high and low salinity areas during the months of July through September – (not completed)
- Evaluate the role of shell hash and shell bottom in spotted seatrout recruitment and survival, particularly where SAV is absent – (not completed)
- Evaluate the role of SAV in the spawning success of spotted seatrout – (not completed)

FISHERY MANAGEMENT PLAN SCHEDULE RECOMMENDATIONS

The Marine Fisheries Commission approved the 2017 FMP schedule in August 2017, which included a schedule change for spotted seatrout to begin in 2019, two years later than originally planned. This was due to staff workload for the review of the Southern Flounder Fishery Management Plan, the early review of the Estuarine Striped Bass Fishery Management plan, and the unscheduled review of the Blue Crab and Shrimp Fishery Management Plans. The review started in July 2019.

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TABLES

Table 1. Recreational harvest (number of fish released and weight in pounds) and releases (number of fish) and commercial harvest (weight in pounds) of spotted seatrout from North Carolina for the period 1991 - 2018.

	Recreational				
	Numbers		Weight (lb)		
Year	Landed	# Released	Landed	Commercial Weight (lb)	Total Weight (lb)
1991	988,049	719,372	1,360,530	660,662	2,021,192
1992	908,233	476,405	1,390,746	526,271	1,917,017
1993	569,327	542,137	857,720	449,886	1,307,606
1994	798,937	601,148	1,207,520	412,358	1,619,878
1995	863,057	764,503	1,221,065	574,296	1,795,361
1996	575,357	1,028,974	699,078	226,580	925,658
1997	779,611	480,093	1,025,110	232,497	1,257,607
1998	702,274	351,114	1,125,898	307,671	1,433,569
1999	1,080,411	1,168,909	1,878,913	546,675	2,425,588
2000	728,906	645,107	1,095,729	376,574	1,472,303
2001	499,556	1,210,336	659,893	105,714	765,607
2002	746,908	1,829,880	957,824	175,555	1,133,379
2003	388,715	903,292	515,678	181,462	697,140
2004	560,834	934,206	728,027	130,961	858,988
2005	1,517,647	3,744,921	1,695,036	129,855	1,824,891
2006	1,444,778	2,722,351	2,034,469	312,624	2,347,093
2007	1,241,296	3,558,110	1,998,275	374,722	2,372,997
2008	1,372,973	4,509,440	2,114,130	304,430	2,418,560
2009	1,857,890	5,369,092	2,878,160	320,247	3,198,407
2010	630,748	8,034,670	1,277,174	202,647	1,479,821
2011	723,502	7,486,377	1,353,388	75,239	1,428,627
2012	1,602,836	4,967,987	2,720,028	265,016	2,985,044
2013	1,107,957	4,312,436	1,881,881	367,648	2,249,529
2014	725,086	3,950,447	1,451,592	242,245	1,693,837
2015	249,260	4,883,109	430,579	128,762	559,341
2016	978,624	6,533,887	1,724,492	254,590	1,979,082
2017	1,217,834	5,151,510	2,157,198	299,911	2,457,109
2018	449,473	15,245,249	658,555	128,922	787,477
Average	903,931	3,290,181	1,396,382	296,929	1,693,311

Table 2. Total number of awarded citations for spotted seatrout (>24 inches total length for release or > five pounds landed) from the North Carolina Saltwater Fishing Tournament for the time period 1991-2018.

Year	Total Citations	Release Citations[+]	% Release
1991	185		0
1992	203		0
1993	12		0
1994	237		0
1995	483		0
1996	132		0
1997	125		0
1998	332		0
1999	695		0
2000	511		0
2001	518		0
2002	353		0
2003	328		0
2004	378		0
2005	290		0
2006	686		0
2007	1,000		0
2008	428	5	1
2009	434	14	3
2010	168	16	10
2011	37	3	8
2012	143	5	3
2013	162	21	13
2014	197	18	9
2015	176	16	9
2016	214	44	21
2017	464	81	17
2018	198	73	37

[+] Spotted seatrout release citations (fish released greater than 24 inches total length) began in 2008.

Table 3. Mean, minimum, and maximum lengths (fork length, inches) of spotted seatrout measured from the commercial and recreational fisheries for the period 1991-2018.

Year	Commercial				Recreational			
	Mean Length	Minimum Length	Maximum Length	Total Number Measured	Mean Length	Minimum Length	Maximum Length	Total Number Measured
1991	14.4	7.7	28.7	1,207	15.1	4.9	31.9	745
1992	16.0	8.4	27.9	1,791	15.6	5.1	24.2	543
1993	16.3	8.5	29.7	1,898	15.7	9.3	25.0	485
1994	15.6	7.0	29.1	1,224	16.0	10.6	24.0	1,076
1995	17.1	8.5	29.1	2,728	15.6	8.5	31.6	853
1996	16.0	7.0	27.6	748	14.6	8.9	24.3	307
1997	14.9	8.1	29.9	4,155	15.3	8.9	23.1	622
1998	14.5	8.0	29.9	4,698	16.4	11.0	36.5	551
1999	15.6	7.6	30.2	6,167	16.4	11.6	26.8	699
2000	17.5	6.0	30.7	2,901	15.6	11.3	25.2	330
2001	16.3	7.6	30.7	1,595	14.8	11.5	26.0	326
2002	16.1	8.0	28.9	3,897	14.9	11.8	24.8	283
2003	17.2	9.5	29.6	2,305	14.6	9.9	25.0	130
2004	16.6	9.0	27.9	2,676	15.3	8.9	22.5	294
2005	16.8	8.5	27.5	2,429	14.2	8.7	25.2	664
2006	16.3	8.9	29.3	6,493	15.5	10.1	25.9	706
2007	17.3	9.6	31.0	8,455	15.9	10.8	27.7	521
2008	17.0	7.3	30.3	5,877	15.6	11.5	26.5	790
2009	16.7	5.4	29.5	6,631	16.0	9.1	26.0	779
2010	17.5	11.4	30.9	4,060	17.5	12.4	24.8	336
2011	16.6	8.8	27.8	1,274	17.0	12.3	24.2	638
2012	16.5	7.4	31.1	4,822	16.5	13.0	24.1	939
2013	16.7	8.7	28.5	6,144	16.8	10.1	23.5	865
2014	17.3	5.5	28.3	3,321	17.6	13.1	26.0	381
2015	18.3	8.9	30.9	2,676	16.9	12.8	25.0	154
2016	17.3	9.4	31.7	3,025	16.8	13.0	25.2	647
2017	17.6	7.6	32.9	3,066	17.0	11.6	25.8	864
2018	17.2	10.5	28.0	1,180	15.7	9.3	23.3	274

Table 4. Modal age, minimum age, maximum age, and number aged for spotted seatrout collected through NCDMF sampling programs from 1991 through 2018.

Year	Modal Age	Minimum Age	Maximum Age	Total Number Aged
1991	1	0	7	679
1992	1	0	6	572
1993	1	0	6	645
1994	1	0	9	688
1995	1	0	5	623
1996	1	0	6	734
1997	1	0	6	710
1998	1	0	9	765
1999	1	0	6	869
2000	1	0	7	566
2001	1	0	5	425
2002	1	0	7	713
2003	1	1	7	405
2004	1	0	6	598
2005	1	0	5	727
2006	1	0	8	970
2007	2	0	8	702
2008	1	0	7	616
2009	2	0	6	660
2010	1	0	6	623
2011	1	0	6	421
2012	1	0	5	593
2013	2	0	5	635
2014	1	0	7	530
2015	2	0	5	448
2016	1	0	5	456
2017	1	0	7	881
2018	1	0	5	516

Table 5. Summary of the NCMFC management strategies and their implementation status for the 2012 N.C. Spotted Seatrout FMP.

Management Strategy	Implementation Status
50% reduction in harvest needed, six fish bag limit, 14-inch minimum size limit, and weekend closure for commercial gears year round (no possession on weekends).	Accomplished; Proclamation authority
A maximum of two fish over 24 inches for recreational fishermen	Proclamation authority
The small mesh gill net attendance requirement is extended to include weekends, December through February	Accomplished
Development of a mutual aid agreement between NCDMF Marine Patrol and WRC Wildlife Enforcement Officers for Inland fishing waters	Accomplished
Move forward with the mediation policy process to resolve conflict between spotted seatrout fishermen	Conflict resolution process established under Rule 15A NCAC 03I .0122.
Remain status quo with the assumption that the Director will intervene in the event of a catastrophic event and do what is necessary in terms of temporary closures by water body	Repealed Rule 15A NCAC 03M .0504 and used proclamation authority in 15A NCAC 03M .0512; Beginning in May 2017 re-established spotted seatrout Rule 15A NCAC 03M .0522 due to ASMFC considering retiring Interstate Spotted Seatrout FMP
More extensive research on cold stun events by NCDMF, Universities, etc.	Ongoing

Table 6. Summary of the NCMFC management strategies and their implementation status for Supplement A to the 2012 N.C. Spotted Seatrout FMP adopted in 2014.

Management Strategy	Implementation Status
2014: 14-inch minimum size limit, four recreational bag limit, 75 fish commercial trip limit, no gill nets in joint waters on weekends, unlawful for a commercial operation to possess or sell spotted seatrout taken from joint waters on weekends.	Proclamation authority
2014: 14-inch minimum size limit, three fish recreational bag limit with a December 15- January 31 closure, 25 fish commercial trip limit (no closure)	Delay in management strategy
If a cold stun occurs close spotted seatrout harvest through June 1 and retain four fish recreational bag limit and 75 fish commercial trip limit	Proclamation authority
Revisit the Spotted Seatrout FMP in three years to determine if sustainable harvest measures are working	On schedule to begin July 2017*

* The NCMFC approved the 2017 FMP schedule in August 2017, which included a schedule change for spotted seatrout to begin in 2019, two years later than originally planned.

FIGURES

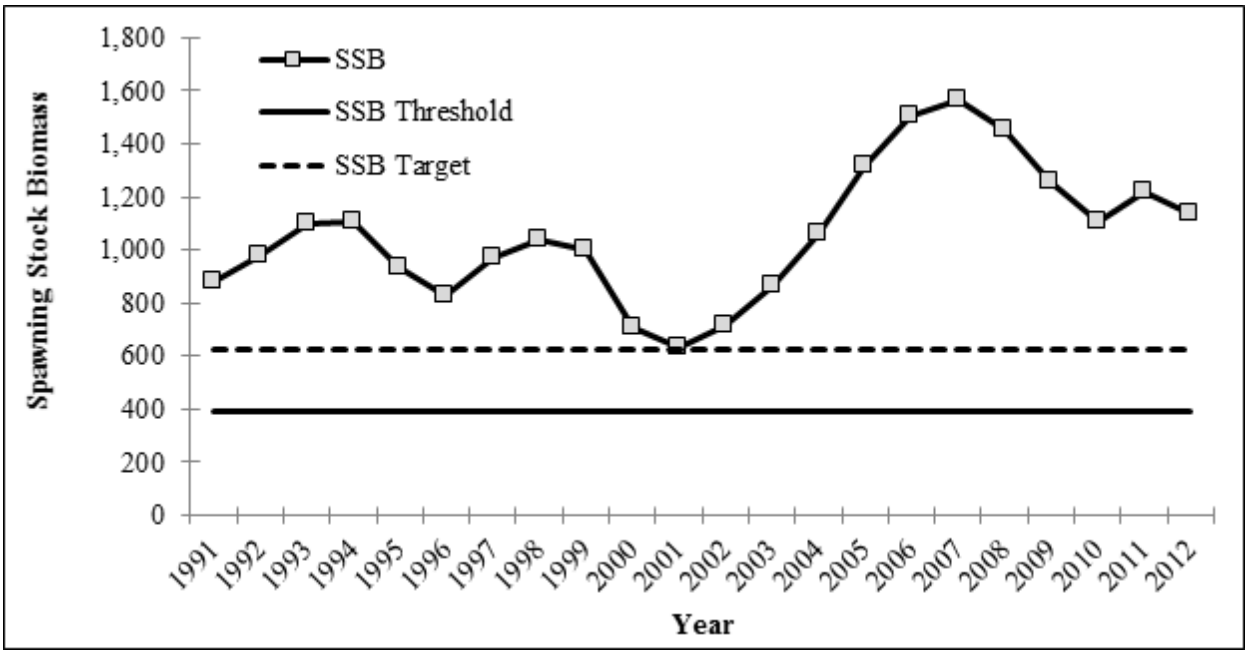

Figure 1. Annual predicted spawning stock biomass compared to estimated $SSB_{Threshold}$ ($SSB_{20\%}$) and SSB_{Target} ($SSB_{30\%}$), 1991-2012. 2012 is the terminal year for the last spotted seatrout stock assessment (NCDMF 2014).

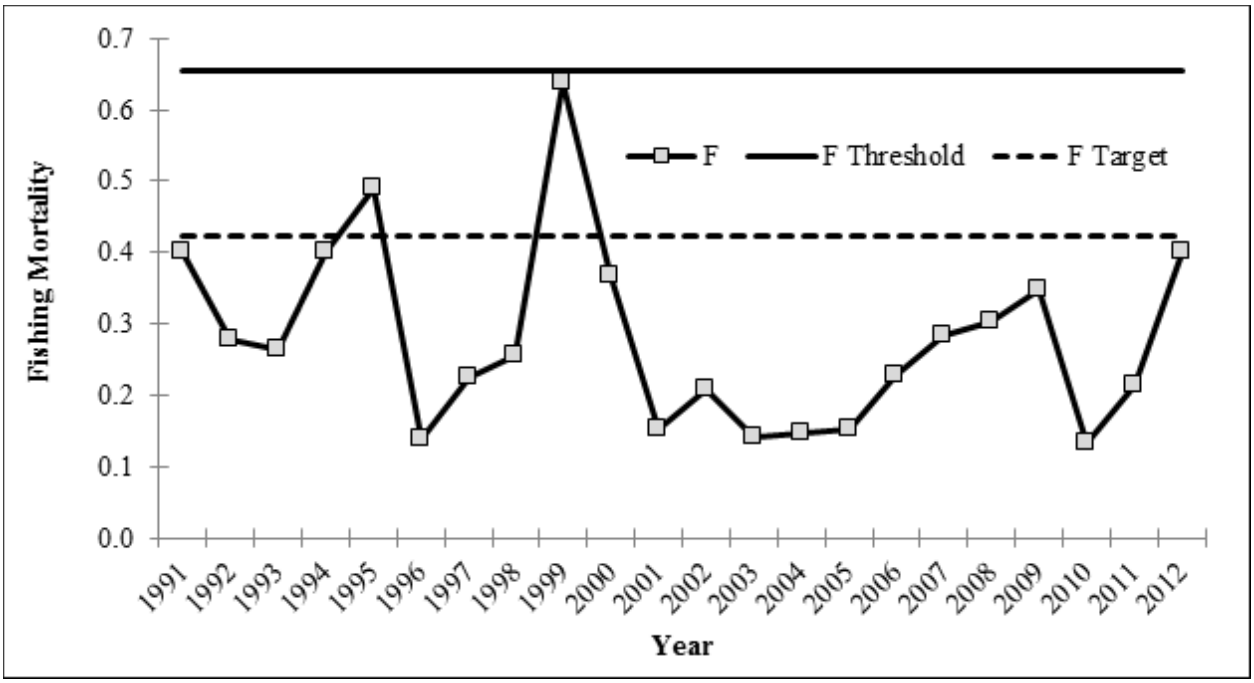

Figure 2. Annual predicted fishing mortality rates (numbers-weighted, ages 1–4) compared to estimated $F_{\text{Threshold}}$ ($F_{20\%}$) and F_{Target} ($F_{30\%}$), 1991-2012. 2012 is the terminal year for the last spotted seatrout stock assessment (NCDMF 2014).

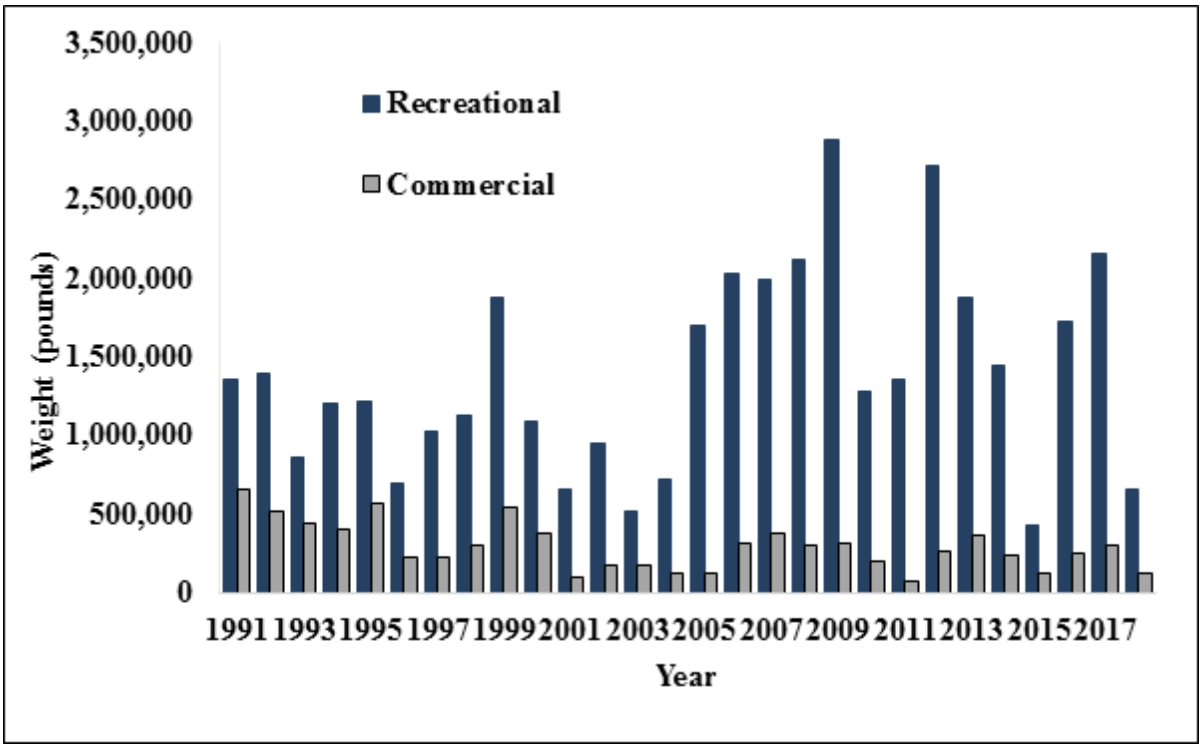

Figure 3. Commercial landings (pounds) reported through the North Carolina Trip Ticket Program and recreational landings (Type A + B1; pounds) and releases (Type B2; number of fish) estimated from the Marine Recreational Information Program survey for North Carolina from 1991 - 2018.

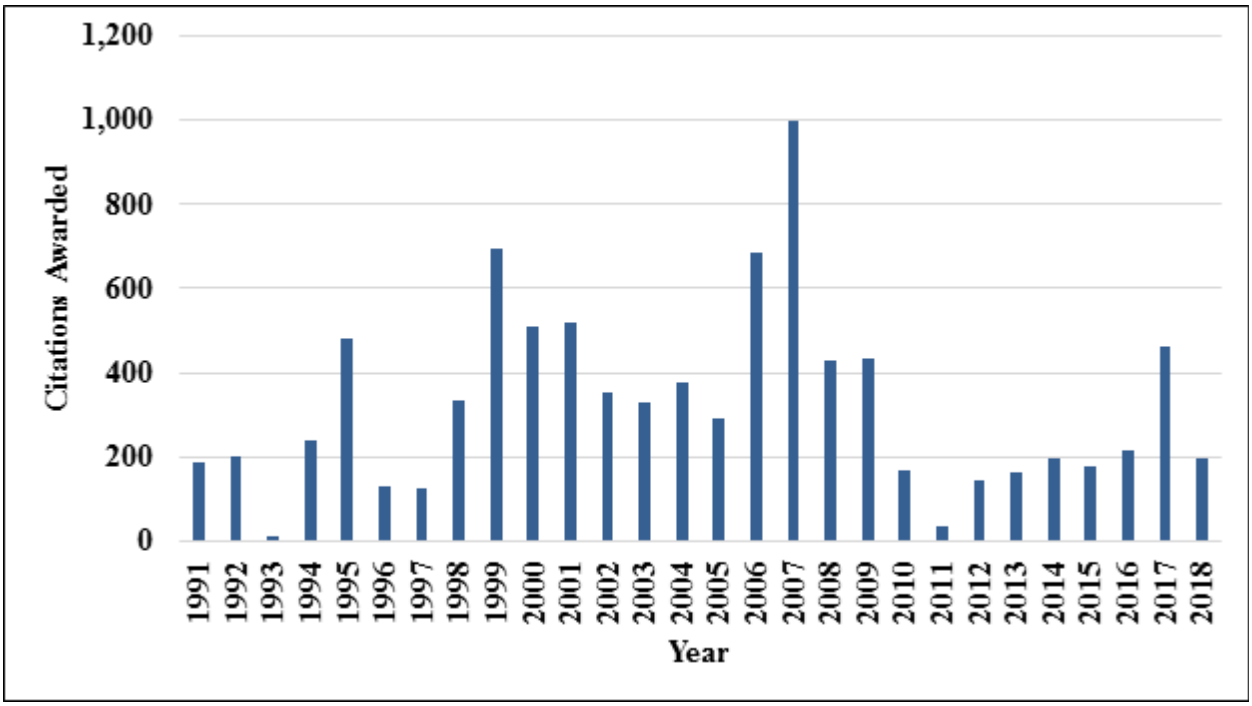

Figure 4. North Carolina Saltwater Fishing Tournament citations awarded for spotted seatrout from 1991 to 2018. Citations are awarded for spotted seatrout >24 inches total length for release or > five pounds landed.

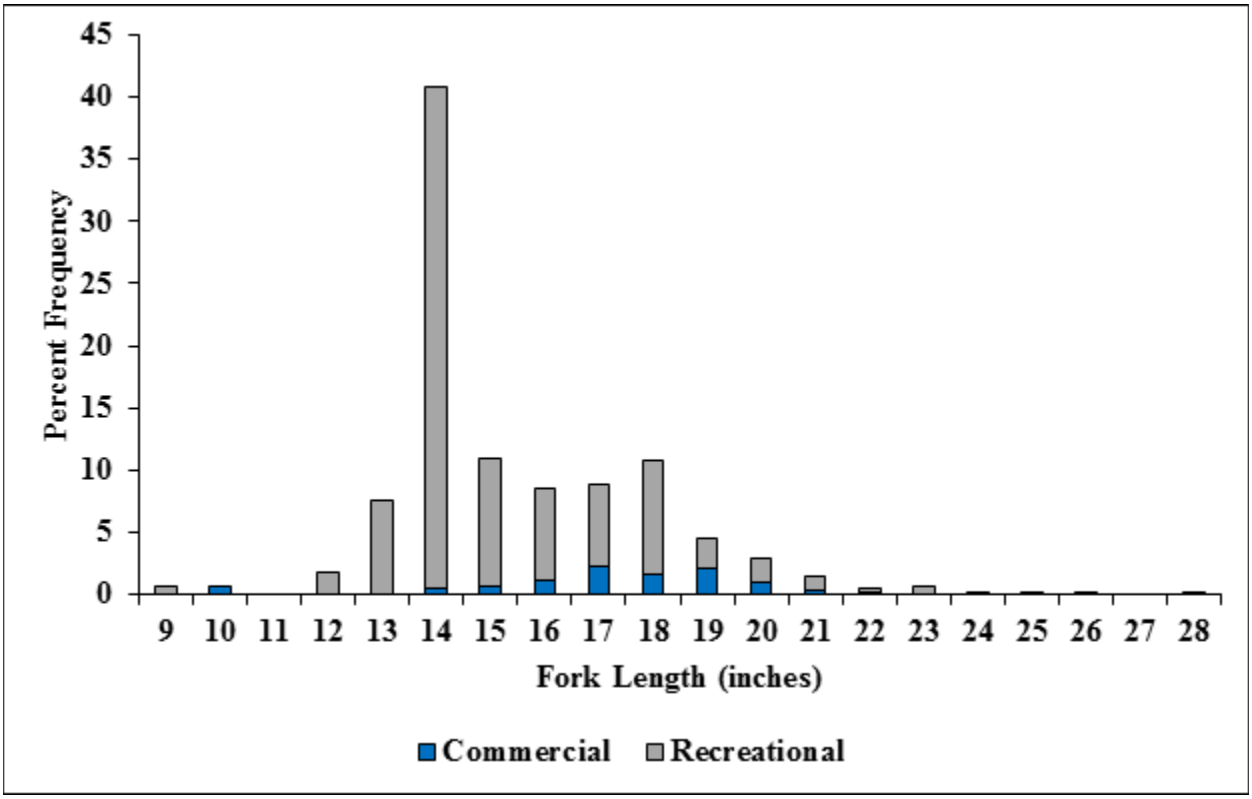

Figure 5. Commercial and recreational length frequency distribution from spotted seatrout harvested in 2018.

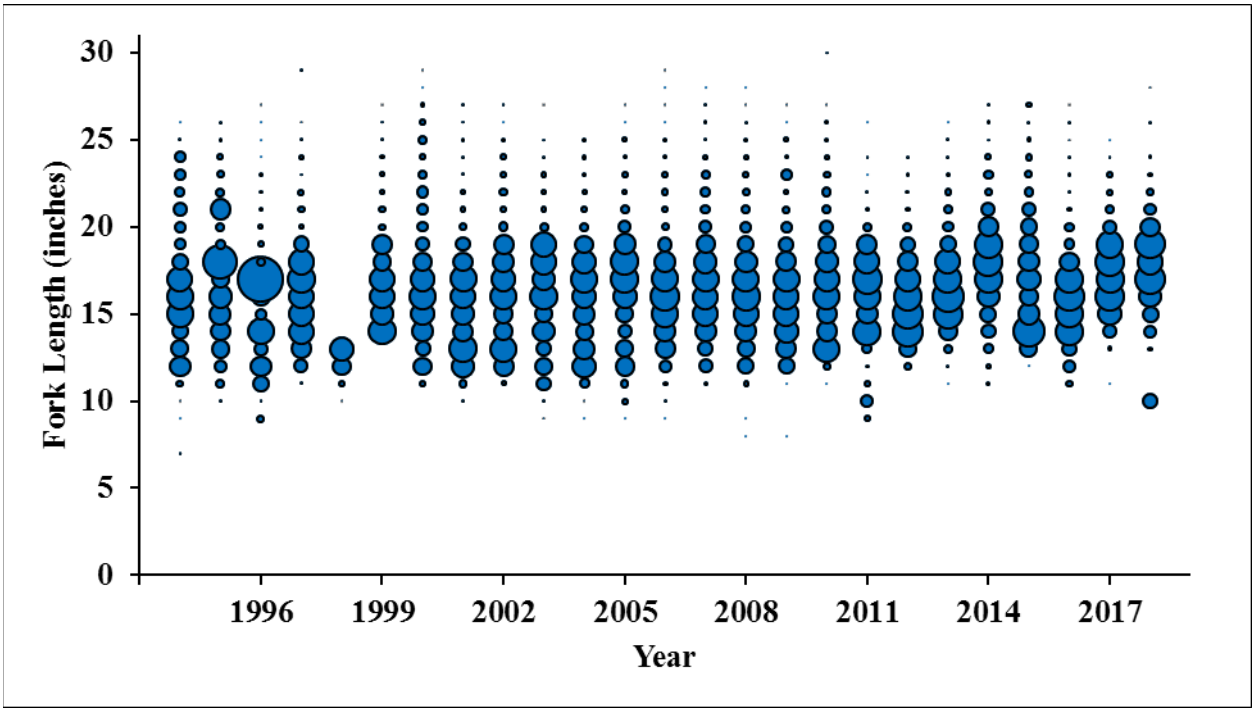

Figure 6. Commercial length frequency (fork length, inches) of spotted seatrout harvested from 1994 to 2018. Bubbles represent fish harvested at length and the size of the bubble is equal to the proportion of fish at that length.

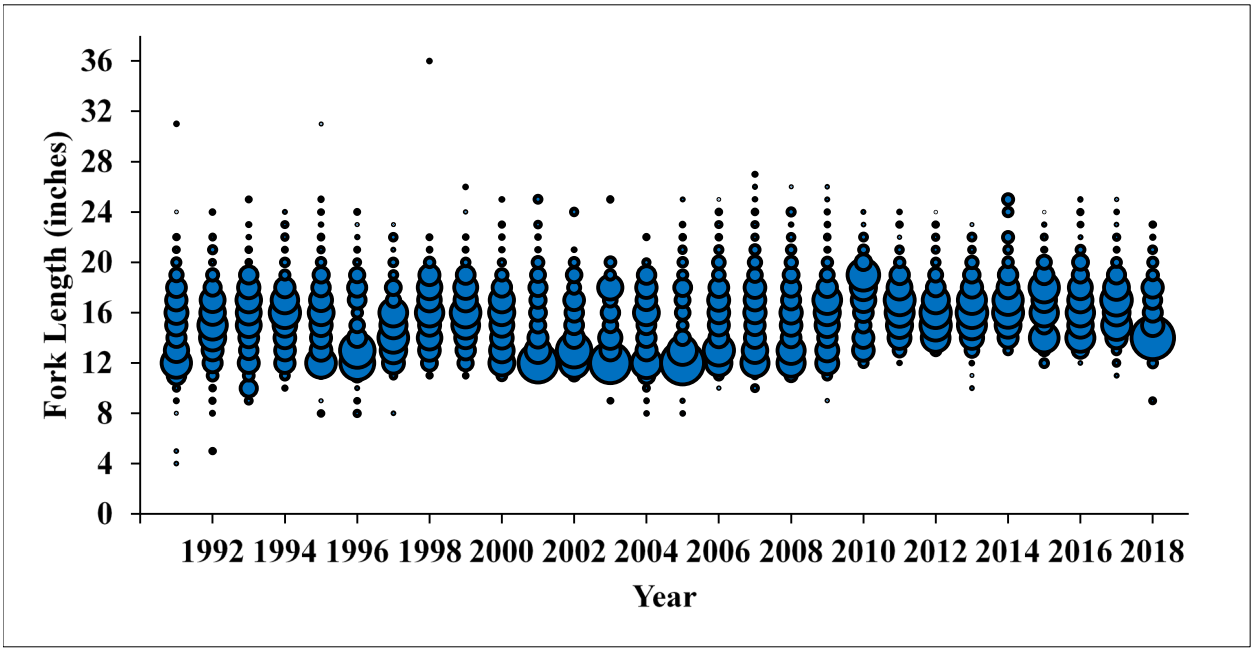

Figure 7. Recreational length frequency (fork length, inches) of spotted seatrout harvested from 1991 to 2018. Bubbles represent fish harvested at length and the size of the bubble is equal to the proportion of fish at that length.

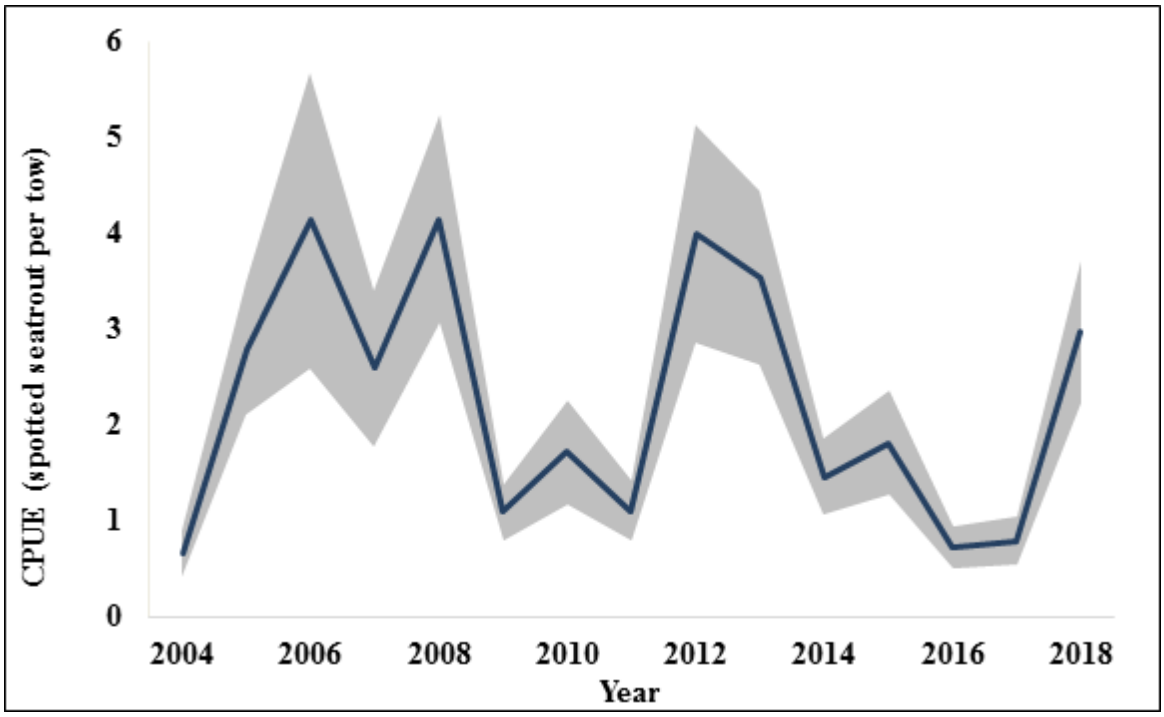

Figure 8. Catch per unit effort (CPUE; fish per-tow) from the North Carolina Estuarine Trawl Survey (Program 120) during June and July, 2004-2018. Error bars represent ± 1 standard error.

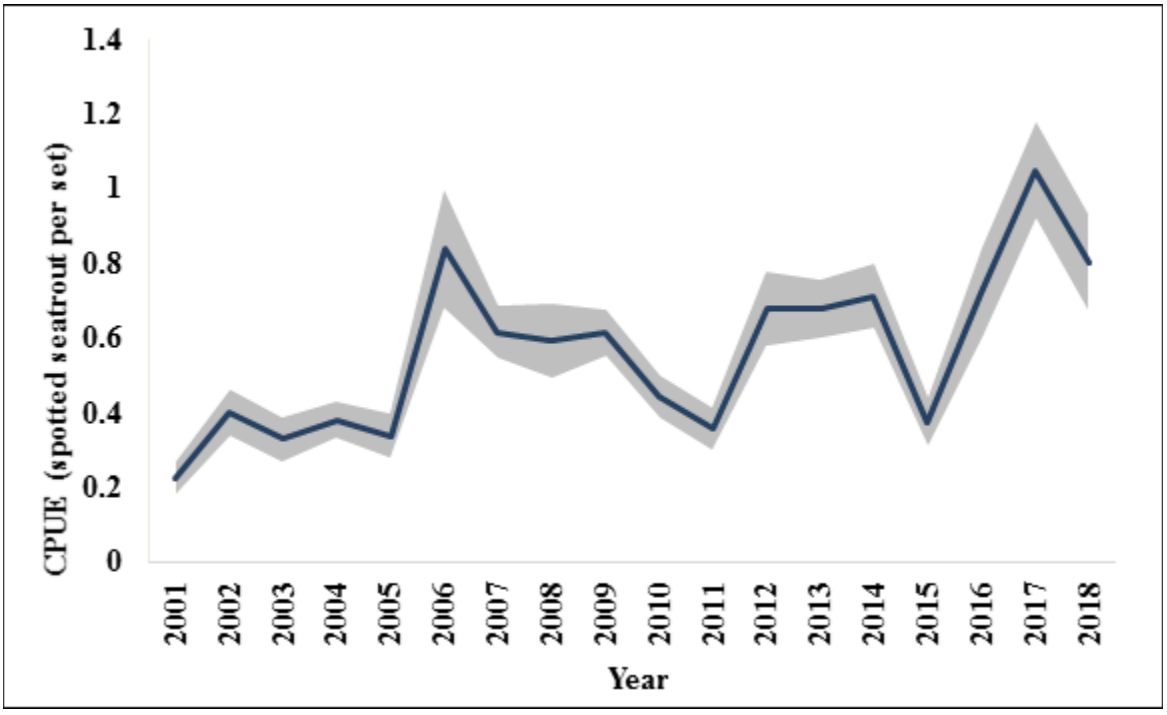

Figure 9. Catch per unit effort (CPUE; fish per station set) of spotted seatrout collected from Program 915 in Pamlico Sound, 2001 - 2018. Error bars represent ± 1 standard error.

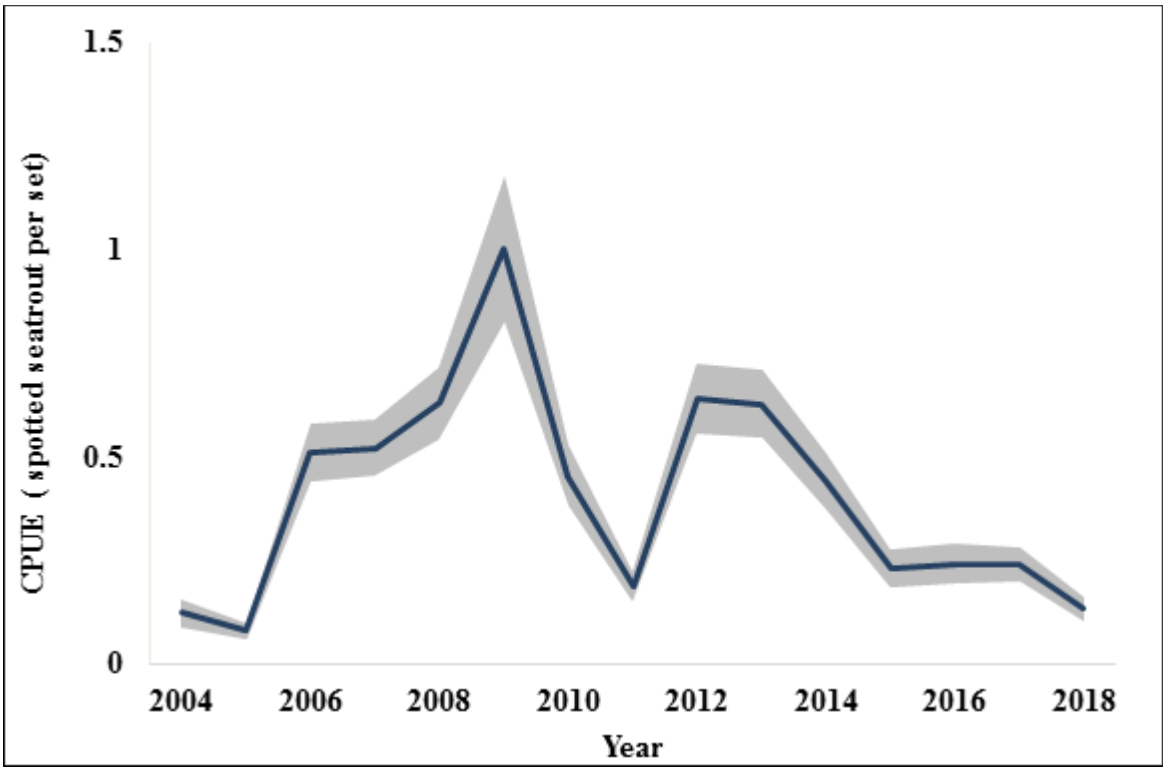

Figure 10. Catch per unit effort (CPUE; fish per station set) of spotted seatrout collected from Program 915 in Pungo, Pamlico, and Neuse rivers, 2004 - 2018. Error bars represent ± 1 standard error.

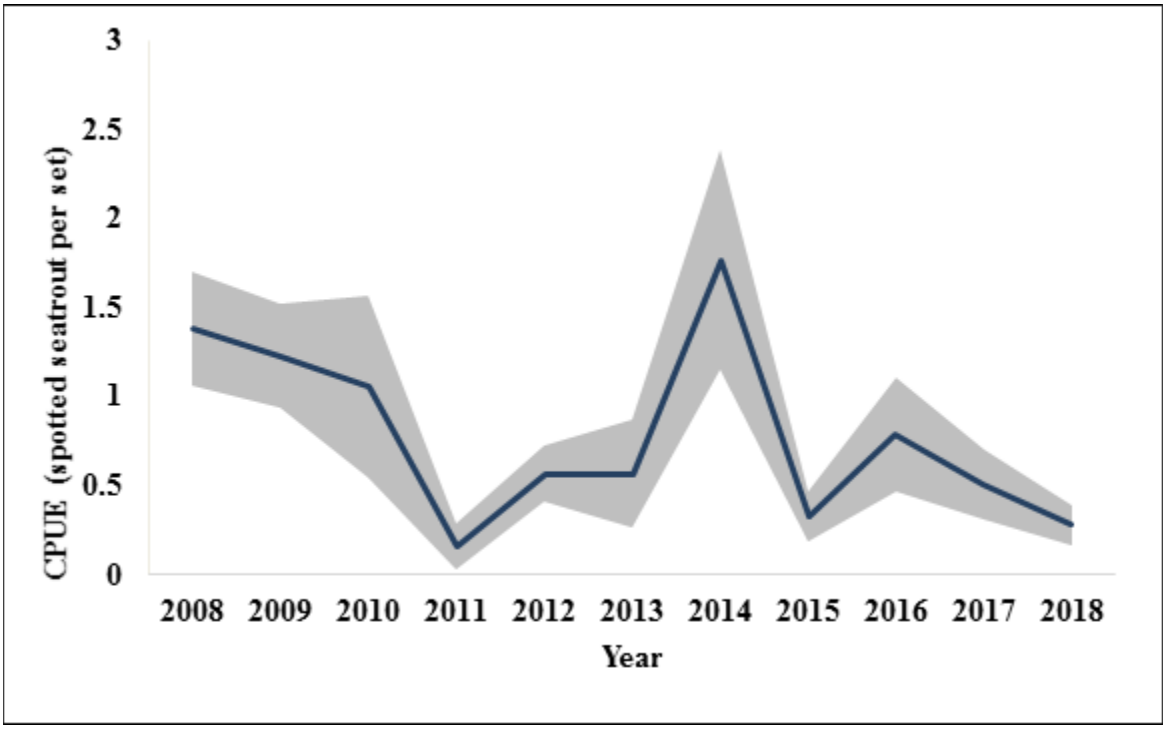

Figure 11. Catch per unit effort (CPUE; fish per station set) of spotted seatrout collected from Program 915 in New and Cape Fear rivers, 2008 - 2018. Error bars represent ± 1 standard error.

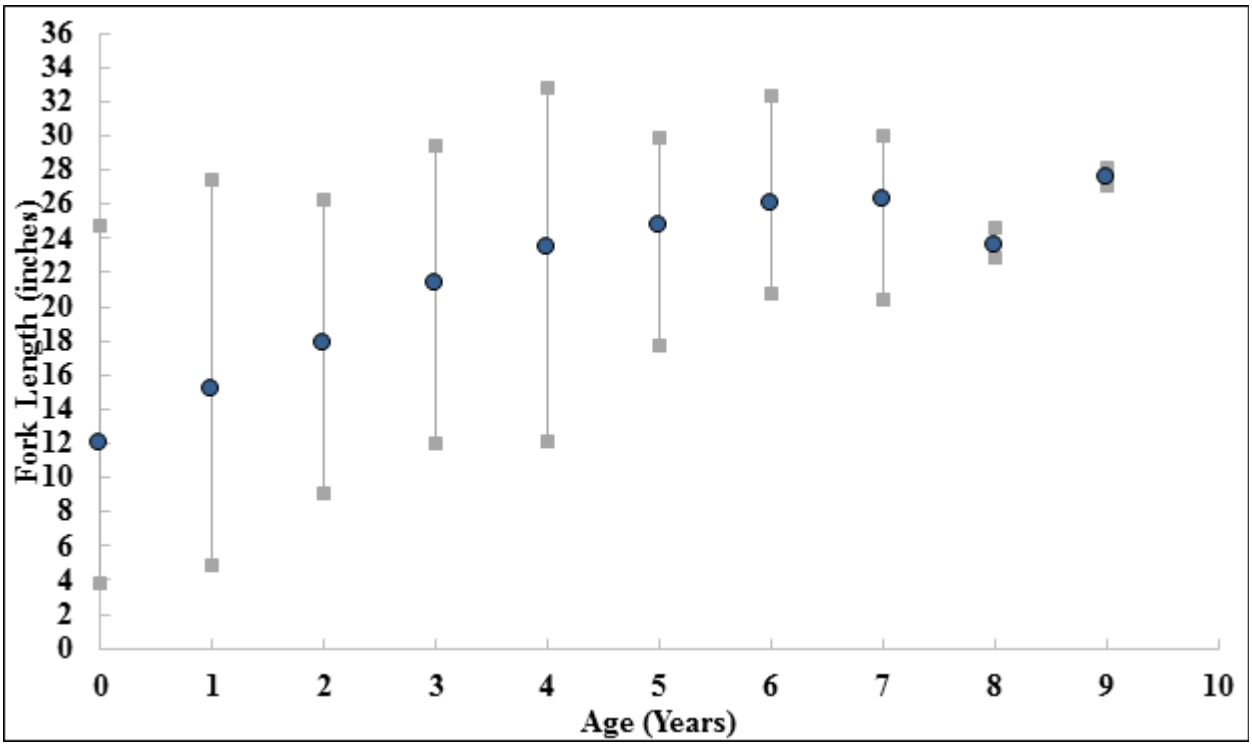

Figure 12. Spotted seatrout length at age based on all age samples collected from 1991 to 2018. Blue circles represent the mean size at a given age while the grey squares represent the minimum and maximum observed size for each age.

FISHERY MANAGEMENT PLAN UPDATE
STRIPED MULLET
AUGUST 2019

STATUS OF THE FISHERY MANAGEMENT PLAN

Fishery Management Plan History

Original FMP Adoption:	April 2006
Amendments:	Amendment 1 – November 2015
Revisions:	None
Supplements:	None
Information Updates:	None
Recommended Schedule Change:	None
Next MFC Scheduled Review:	July 2020

The North Carolina Striped Mullet Fishery Management Plan (FMP) was adopted in April 2006. The management plan established minimum and maximum commercial landings triggers of 1.3 and 3.1 million pounds (NCDMF 2006). If annual landings fall below the minimum trigger, the North Carolina Division of Marine Fisheries (NCDMF) would determine whether the decrease in landings is attributed to stock decline, decreased fishing effort, or both. If annual landings exceed the maximum trigger, NCDMF would determine whether harvest is sustainable and what factors are driving the increase in harvest. The Striped Mullet FMP established a daily possession limit of 200 mullets (white and striped in aggregate) per person per day in the recreational fishery.

Amendment 1 to the FMP was adopted in November 2015 and the subsequent rules were implemented in April 2016. Amendment 1 resolved issues with Newport River gill net attendance, mitigated known user group conflicts, updated the management framework and updated minimum and maximum commercial landings triggers to 1.13 and 2.76 million pounds (NCDMF 2015). Amendment 1 maintains the 200 mullet possession limit per person in the recreational fishery.

Commercial landings in 2016 were 965,198 pounds, which is below the minimum landings trigger of 1.13 million pounds (Figure 1). As required by the FMP, the NCDMF initiated data analysis in July 2017 to determine whether the decrease was attributed to a stock decline, decreased fishing effort, or both. The NCDMF presented the findings from preliminary analysis and recommendations to the North Carolina Marine Fisheries Commission (NCMFC) during its November 2017 business meeting. It was determined by the NCDMF that no management

actions were necessary at that time, but a more comprehensive analysis with data through 2017 was needed.

The NCDMF presented results of their comprehensive analysis at the February 2018 NCMFC business meeting and concluded that the stock had likely declined since completion of the 2013 stock assessment which had a terminal year of 2011. The NCDMF recommended updating the 2013 stock assessment model to include data through 2017 prior to taking management action. As an assessment update, there were no changes to model parameters and peer review was not required, as the configuration of the model that previously passed peer review was maintained. Results of the stock assessment indicated overfishing was not occurring through 2017.

Subsequent management options were developed by the NCDMF and presented to the Finfish, Southern, and Northern advisory committees in July 2018 to receive input prior to finalizing the NCDMF recommendation. Recommendations were then presented to the NCMFC at its August 2018 business meeting. The NCDMF and the advisory committees recommended that no management action be taken since the stock assessment update indicated overfishing was not occurring. The NCDMF would, however, continue to monitor trends in the commercial fishery and fishery independent indices. The recommendation was approved by the NCMFC.

Review of the 2018 commercial landings indicated neither the maximum or minimum triggers had been exceeded.

Management Unit

Coastal and joint waters of North Carolina.

Goal and Objectives

The goal of Amendment 1 to the North Carolina Striped Mullet FMP is to manage the striped mullet fishery to preserve the long-term viability of the resource, maintain sustainable harvest, maximize social and economic value, and consider the needs of all user groups. The following objectives will be used to achieve this goal:

1. Use a management strategy that provides for conservation of the striped mullet resource and promotes sustainable harvest while considering the needs of all user groups.
2. Promote the protection, enhancement, and restoration of habitats and water quality necessary for the striped mullet population.
3. Minimize conflict among user groups, including non-fishing user groups and activities.
4. Promote research to improve the understanding of striped mullet population dynamics and ecology to improve management of the striped mullet resource.
5. Initiate, enhance, and/or continue studies to collect and analyze the socio-economic data needed to properly monitor and manage the striped mullet fishery.
6. Promote public awareness regarding the status and management of the North Carolina striped mullet stock.

STATUS OF THE STOCK

Life History

Striped mullet are found in a wide range of depths and habitats, but primarily inhabit freshwater to estuarine environments until migrating to the ocean to spawn in the fall (Able and Fahay 1998; Pattillo et al. 1999; Cardona 2000; Whitfield et al. 2012). Striped mullet serve as an ecological link between some of the smallest aquatic organisms and the highest-level predators in the marine food chain. Striped mullet feed on microorganisms such as bacteria and single-celled algae found on aquatic plants, in mud, silt, and sand and in decaying plant material (Odum 1968; Moore 1974; Collins 1985a; Larson and Shanks 1996; Torras et al. 2000). In turn, striped mullet are prey to top predators such as birds, fish, sharks and porpoises (Breuer 1957; Thomson 1963; Collins 1985a; Barros and Odell 1995; Fertl and Wilson 1997). Striped mullet are highly fecund (upwards of 4 million eggs for a large female; Bichy 2000) and spawn in large aggregations near inlets to offshore areas (Collins and Stender 1989). Length at 50% maturity for males occurs at 11.1 inches fork length and for females at 12.8 inches fork length (Bichy 2000). Spawning individuals have been reported from September to March; however, peak spawning activity occurs from October to early December (Bichy 2000).

Stock Status

The most recent assessment of the North Carolina striped mullet stock was completed in 2017 utilizing data from 1994-2017 (NCDMF 2018). The 2017 stock assessment is an update to the 2013 benchmark stock assessment (NCDMF 2013). Results of the stock assessment indicate spawning stock biomass increased from 2003 through 2007 but declined through 2017. Recruitment also declined in the latter portion of the time series, though a slight increase was observed in 2017. Fishing mortality (F) had little variation for most of the time series with a slight increase in 2017. Despite this increase, F in the terminal year ($F_{2017} = 0.13$) was below both the fishing mortality target ($F_{35\%} = 0.40$) and threshold ($F_{25\%} = 0.57$). Based on the assessment results, the stock was not undergoing overfishing in 2017. A poor stock-recruit relationship resulting in unreliable biomass based reference points prevented determining if the stock was overfished.

Stock Assessment

The striped mullet stock was modeled using Stock Synthesis text version 3.24f (Methot 2000, 2012; Methot and Wetzel 2013), which was also used to calculate reference points (NCDMF 2018). The Stock Synthesis model incorporates information from multiple fisheries and surveys and both length and age composition data. The structure of the model allows for a wide range of model complexity depending upon available data. The strength of the model is that it explicitly models both the dynamics of the population and the processes by which one observes the population and its fisheries. That is, the comparison between the model and the data is kept close to the natural basis of the observations, instead of manipulating the observations into the format of a simpler model. Another important advantage is the model allows for (and estimates) selectivity patterns for each fishing fleet and survey.

STATUS OF THE FISHERY

Current Regulations

There are no size restrictions, but as of July 1, 2006 there is a 200 mullet (white and striped aggregate) daily possession limit per person in the recreational fishery and the mutilated finfish rule was modified to exempt mullet used as bait.

Commercial Landings

Historically, beach seines and gill nets are the two primary gear types used in the striped mullet commercial fishery, with most commercial landings prior to 1978 coming from the beach seine fishery. Gill nets replaced seines as the dominant commercial gear type in 1979. Because the commercial fishery primarily targets striped mullet roe, the fishery is seasonal with the highest demand and landings occurring in the fall when large schools form during their spawning migration to the ocean. Striped mullet are targeted commercially using runaround gill nets in the estuarine waters of North Carolina with most landings occurring in the fall. The striped mullet beach seine fishery primarily occurs in conjunction with the Bogue Banks stop net fishery. The stop net fishery has operated under fixed seasons and net and area restrictions since 1993. Stop nets are limited in number (four), length (400 yards), and mesh sizes (minimum eight inches outside panels, six inches middle section). Stop nets are only permitted along Bogue Banks (Carteret County) in the Atlantic Ocean from October 1 to November 30. However, the stop net season was extended to include December 3 to December 17 in 2015 due to minimal landings of striped mullet (Proclamation M-28-2015). Due to the schooling nature of striped mullet the beach seine fishery has the potential to be, and historically has been, a high volume fishery with thousands of pounds landed during a single trip.

Since 1972, commercial landings have ranged from a low of 965,198 pounds in 2016 to a high of 3,063,853 pounds in 1993 (Table 1; Figure 1). From 2003 to 2009 landings were stable between 1,598,617 and 1,728,607 pounds before increasing to 2,082,832 pounds in 2010. Landings fluctuated annually between 1.5 and 2.0 million pounds from 2010-2014 before declining significantly in 2015 and again in 2016 dropping below the minimum commercial landings trigger established by Amendment 1. Commercial landings in 2018 were 1,312,117 pounds, which is 182,117 pounds above the minimum commercial landings trigger.

Recreational Landings

Recreational fishing activity is monitored through the Marine Recreational Information Program. In this report, estimates across all years have been updated and are now based on the MRIP new Fishing Effort Survey-based calibrated estimates. For more information on MRIP methodology changes see https://www.fisheries.noaa.gov/topic/recreational-fishing-data.

The federal Marine Recreational Information Program (MRIP) is primarily designed to sample anglers who use rod and reel as the mode of capture. Since most striped mullet are caught with cast nets for bait, striped mullet recreational harvest data are imprecise. In addition, angler misidentification between striped mullet and white mullet is common and bait mullet are usually

released by anglers before visual verification by creel clerks is possible. As such, mullets are not identified to the species level in the MRIP data (Catch Type B). Because of imprecise estimates, MRIP data are not considered a reliable source for estimates of recreational striped mullet harvest and catch.

In October 2011, NCDMF began a mail survey to develop catch and effort estimates for recreational cast net and seine use. The mail survey was established as a direct response to a lack of precision in MRIP estimates for difficult to sample or overlooked recreational fisheries and activities. The survey does not distinguish between striped and white mullet and all data should be interpreted with caution because the ratio of striped mullet to white mullet in the recreational catch will differ between seasons and areas of the state. Recreational cast net effort directed toward mullet is generally highest from July through October and decreased significantly between 2017 and 2018 (Table 2). Mullet harvest and total catch is also highest from July through October and decreased significantly between 2017 and 2018. Number of releases decreased between 2017 and 2018. In addition to decreases, estimates in 2018 were also more uncertain (PSE >50) compared to previous years. Declines and increased uncertainty are likely the result of Hurricane Florence which caused major damage to much of the North Carolina coast in September 2018.

Striped mullet 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 and the minimal contributions from RCGL to overall harvest. From 2002 through 2008 an average of 41,512 pounds of striped mullet were harvested per year using a RCGL (Table 3).

MONITORING PROGRAM DATA

Fishery-Dependent Monitoring

The total number of striped mullet measured in fishery dependent programs between 1994 and 2018 ranged from 123 to 13,212 annually, with the lowest number measured in 1996 (Table 4). Mean length varied little, generally falling between 12.0 and 14.5 inches fork length (FL), with the lowest mean length occurring in 1997 (12.8 inches FL). Minimum and maximum lengths generally fell within a small range, though in 1994 and 1996 maximum length was below 20.0 inches, while maximum length in other years ranged from 20.0 to 28.0 inches (Table 4).

From 1994 through 2018 the size range of striped mullet captured in the commercial fishery as determined from commercial fish house samples ranged from 5.0 to 28.0 inches FL (Figure 2). Modal length generally falls between 12.0 and 14.0 inches, and in recent years fewer small striped mullet have been present in the catch. In all years there are few striped mullet over 18.0 inches present in the catch.

Fishery-Independent Monitoring

Modal age was two in all years except 1996, 1999, 2001, and 2003 when the modal age was one, and in 2017 when modal age was 1-2 (Table 5). Minimum age was zero in every year except 2010 when the minimum age was one. Maximum age ranged from six in 1996, 2012, 2014, and

2015 to 15 in 2017. From 2005 through 2008 the maximum age was 10, in 2009 the maximum age was 13, in 2011 the maximum age was 14 and in 2018 the maximum age was 10. There is significant overlap in length at age for striped mullet (Figure 3). Striped mullet grow quickly from age 0 to age 2 with growth slowing after age 3.

The striped mullet electrofishing survey also known as Program 146 (P146) was initiated in 2003 to produce a fisheries-independent index of relative abundance for striped mullet. Twelve sampling stations were established among four sites (three stations per site) in the Neuse River and its tributaries. Each station is sampled once per month from January through April and from October through December. To provide the most relevant index from the striped mullet electrofishing survey, data were limited to those collected during January through April when striped mullet are most abundant in the Neuse River. Since the survey primarily catches adults, juveniles were excluded from analysis. A sample represents all the fish collected over a 500 m transect. Striped mullet catch-per-unit-effort (CPUE) was stable at approximately 100 fish per sample from 2005 through 2009 before peaking in 2011 (Figure 4). Standard errors in 2010 and 2011 are large because most fish came from a few samples. CPUE dropped significantly in 2012, potentially due to hurricanes, before increasing to near the time series average in 2013 and 2014. CPUE declined in 2015 to approximately 45 fish per sample, declined again in 2016 to 20 fish per sample and remained low in 2017 at 26 fish per sample. CPUE increased to 91 fish per sample in 2018 which is above the time series average (80.5 fish per sample).

From 2004 through 2017, the size of striped mullet captured during the January to April portion of P146 sampling generally ranged from 4.0 to 21.0 inches FL (juveniles excluded; Figure 5). In most years modal length was between 10.0 to 12.0 inches FL. From 2014 through 2017 modal length increased but overall size distribution truncated. However, in 2018 there was some increase in the distribution of lengths.

The fishery-independent gill net survey, also known as Program 915 (P915), has sampled in Hyde and Dare Counties since 2001 and the Neuse, Pamlico, and Pungo rivers since 2003. Sampling in the Cape Fear and New rivers began in 2008 and sampling in Carteret County began in 2018. To provide the most relevant striped mullet index from the survey, data were limited to samples from shallow river areas (Pamlico, Pungo and Neuse rivers) during October-November where and when most striped mullet occur. The survey primarily catches adults, so juveniles were excluded from analysis. From 2004-2014 CPUE generally fluctuated between 7.0 and 16.0 striped mullet per sample (Figure 6). CPUE dropped significantly in 2015 to 3.7 and then again in 2016 to a time series low of 3.1 striped mullet per sample. CPUE remained low in 2017 at 3.4 fish per sample but increased to 5.8 striped mullet per sample in 2018.

From 2004 through 2018 the size of striped mullet captured during the October-November portion of P915 sampling in the Pamlico and Neuse rivers generally ranged from 8.0 to 25.0 inches FL (juveniles excluded; Figure 7). Modal length generally ranged from 12.0 to 14.0 inches but began to decline in 2011 and declined further in 2018. Few striped mullet less than 10.0 inches or greater than 15.0 inches are captured in this survey.

In October 1990, the NCDMF initiated the striped bass independent gill net survey, also known as Program 135 (P135). The survey was designed to monitor the striped bass population in the

Albemarle Sound and Roanoke River but also encounters striped mullet. To provide the most relevant striped mullet index from P135, data were limited to those collected from 2.5-inch to 5.5-inch mesh sizes during November through February (fall-winter) when and where the majority of striped mullet occur. Since the survey primarily catches adults, juveniles were excluded from analysis. Data were also limited to those collected in less than 10 feet of water because these samples covered most of the water column. CPUE averaged 2.0 fish per set from 1990-2008 (Figure 8). Standard errors in 2013, 2014 and 2015 are large because most fish came from a few samples. CPUE increased to 10.5 in 2010 and spiked at 15.2 and 12.9 fish per set in 2014 and 2015. CPUE dropped significantly in 2016 and no striped mullet were caught during the survey in 2017. In 2018, CPUE increased to 2.1 fish per set.

From 1990 through 2018 modal length of striped mullet captured in P135 sampling generally ranged from 10.0 to 15.0 inches FL with a range of sizes captured (juveniles excluded; Figure 9). Modal length has fluctuated, increasing in recent years while length distribution has truncated.

MANAGEMENT STRATEGY

The management strategy for the striped mullet fisheries in North Carolina is to: 1) optimize resource utilization over the long-term; 2) reduce user group conflicts; and 3) promote public education. The first strategy will be accomplished by protecting critical habitats and monitoring stock status. To address user group conflicts, a rule change was made to limit how much of a waterway may blocked by runaround, drift, or other non-stationary gill nets. Specific user group conflicts will continue to be dealt with on a case-by-case bases and management actions will be implemented to address specific fishery related problems. Issues addressed in formulating Amendment 1 of the management plan for North Carolina's striped mullet fishery included: 1) resolution of the Newport River gill net attendance and 2) user group conflicts, and 3) updating the management framework for the N.C. striped mullet stock. See Table 6 for a summary of management strategies and outcomes.

Minimum and maximum landings triggers of 1.13 and 2.76 million pounds have been established to monitor the striped mullet fishery. If landings fall below the minimum landings trigger or exceed the maximum landings trigger the NCDMF will determine if a new stock assessment and/or interim management action is needed.

RESEARCH NEEDS

The following research needs were compiled from those listed in Amendment 1.

- Initiate a fishery independent adult striped mullet survey in the Core and Bogue sound areas where approximately 20% of the striped mullet harvest occurs – HIGH (independent gill net survey will began in 2018)
- Develop a reliable fisheries independent index of juvenile abundance – HIGH (Needed)
- Initiate a tagging study to provide estimates of stock size, fishing mortality, and natural mortality that are not dependent on assumptions about steepness – HIGH (Needed)

- Increase the number of age samples from both fisheries dependent and fisheries independent sources – MEDIUM (Ongoing)
- Investigate how catchability of striped mullet by NCDMF Program 146 is affected by variations in salinity and conductivity and expand survey to other coastal rivers and tributaries – MEDIUM (Needed)
- Initiate a study to estimate fecundity and update the current maturity schedule microscopically – MEDIUM (Ongoing)
- Initiate a survey to estimate RCGL landings of striped mullet to estimate recreational landings, as well as social and economic elements of the striped mullet fishery – MEDIUM (Ongoing through NCDMF)
- Increase sampling of the commercial bait mullet cast net fishery to improve estimates of striped mullet and white mullet harvest – LOW (Needed)
- Restart fishery independent cast net sampling to improve estimates of the proportion of striped mullet and white mullet in this fishery – LOW (Needed)
- Analyze the data from the CRFL recreational cast net and seine survey to better characterize the recreational striped mullet fishery, including the social and economic elements – LOW (Needed)
- Improve recreational fisheries statistics provided by the Marine Recreational Information Program (MRIP) or some other program to reliably characterize the magnitude and length and age structure of recreational fisheries losses – LOW (Ongoing)
- Initiate a plankton survey covering all inlets to determine inlet use by striped mullet – LOW (Needed)
- Explore the NOAA Bridge Net Survey as a possible larval/juvenile abundance index for striped mullet – LOW (Ongoing)
- Investigate the disappearance of males from the population after age three – LOW (Needed)
- Initiate an acoustic tagging study to determine spatial and temporal variations in habitat use throughout the state to help provide better indices for stock assessments – LOW (Needed)
- Implement public outreach on waste reduction of striped mullet in the commercial and recreational fisheries – LOW (Needed)
- Consider sex specific selectivity curves in future modeling work – LOW (Needed)

FISHERY MANAGEMENT PLAN SCHEDULE RECOMMENDATION

Striped mullet commercial landings in 2018 were 1,312,117 pounds, which is above the minimum and below the maximum commercial landings triggers established in Amendment 1. In addition, the 2018 striped mullet stock assessment update indicated overfishing was not occurring through 2017 (NCDMF 2018). Therefore, it is recommended to maintain the timing of the MFC scheduled review “as is” on the current FMP schedule, but continue to closely monitor trends in commercial landings and fishery independent indices.

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TABLES

Table 1. Commercial landings of striped mullet in North Carolina, 1972-2018.

Year	Pounds	Year	Pounds
1972	1,176,918	1996	1,756,863
1973	1,092,620	1997	2,442,657
1974	2,137,502	1998	2,218,108
1975	1,952,748	1999	1,460,850
1976	2,071,741	2000	2,829,086
1977	1,834,935	2001	2,317,655
1978	1,752,233	2002	2,596,304
1979	1,767,955	2003	1,629,314
1980	2,215,532	2004	1,598,617
1981	1,293,902	2005	1,620,394
1982	1,492,179	2006	1,728,607
1983	1,068,014	2007	1,668,804
1984	1,688,522	2008	1,675,859
1985	1,486,583	2009	1,685,615
1986	1,932,190	2010	2,082,832
1987	2,590,360	2011	1,627,894
1988	3,060,829	2012	1,859,587
1989	2,062,147	2013	1,549,157
1990	2,994,604	2014	1,828,351
1991	1,467,448	2015	1,247,044
1992	1,820,494	2016	965,337
1993	3,063,853	2017	1,366,338
1994	1,726,242	2018	1,312,117
1995	2,298,446		

Table 2. Number of trips, number of mullet harvested, number of mullet released, and total number of mullet caught in the recreational cast net fishery estimated from the NCDMF mail survey with associated percent standard error (PSE) by wave, 2012-2018. Estimates with a PSE value greater than 50 are shaded in gray.

Year	Wave	Total Effort	PSE Effort	Total Harvest	PSE Harvest	Total Releases	PSE Releases	Total Catch	PSE Catch
2012	Jan/Feb	10,484	22.1	23,346	32.8	9,050	42.3	32,395	32.4
	Mar/Apr	9,734	19.8	17,055	32	3,931	57.2	20,986	31.8
	May/Jun	20,903	12.5	84,180	25.7	26,845	32.9	111,025	23.9
	Jul/Aug	29,725	13.8	107,409	23.7	64,453	29.6	171,862	21.3
	Sep/Oct	29,810	11.3	135,318	19.9	72,941	16	208,259	15.5
	Nov/Dec	21,094	15.9	24,484	38	31,774	26.5	56,258	26
	Total	121,751	6.2	391,792	11.6	208,993	12.5	600,785	9.9
2013	Jan/Feb	12,635	18.6	26,244	51.4	6,668	39.1	32,911	46.4
	Mar/Apr	8,642	24.1	6,915	69.5	2,741	56.4	9,656	52.2
	May/Jun	24,541	11.8	25,409	40.4	21,957	30.5	47,366	29.9
	Jul/Aug	41,197	11.3	210,888	23.4	121,012	21.7	331,900	20.1
	Sep/Oct	25,277	16.6	33,918	46	39,065	26.1	72,983	31
	Nov/Dec	25,666	15.3	37,667	27.3	34,740	30.9	72,407	23.8
	Total	137,959	6.4	341,039	16.7	226,183	14.1	567,223	13.7
2014	Jan/Feb	5,036	25.7	4,886	82.2	744	70.9	5,631	73.7
	Mar/Apr	15,247	19.7	11,284	53.1	1,563	69.2	12,847	50.7
	May/Jun	28,343	13.1	39,438	33.2	22,465	23.6	61,903	24.4
	Jul/Aug	42,572	12	37,774	36.9	56,604	20.4	94,378	22.2
	Sep/Oct	63,250	12.7	82,343	23.2	146,886	17.3	229,229	16
	Nov/Dec	24,174	14.6	29,518	29.6	24,946	25.6	54,464	21.2
	Total	178,623	6.6	205,243	14.5	253,209	11.9	458,453	10.6
2015	Jan/Feb	6,554	26	11,172	52.5	2,884	54.8	14,056	48.2
	Mar/Apr	13,338	18.8	9,870	40.8	5,880	33.6	15,751	35.3
	May/Jun	49,792	12.2	103,793	22.9	48,774	26.3	152,567	19.5
	Jul/Aug	63,706	10.6	149,016	20	133,629	20.5	282,645	16.1
	Sep/Oct	37,938	11	32,683	30	39,298	19.8	71,981	18.2
	Nov/Dec	24,264	17.7	34,817	36.7	34,672	25.5	69,489	25.2
	Total	195,592	6.1	341,350	12.5	265,137	12.6	606,488	10.1
2016	Jan/Feb	11,400	28.3	.	.	73	100	73	100
	Mar/Apr	13,803	20.5	15,411	49.5	1,238	63.5	16,649	46.2
	May/Jun	35,478	14.4	28,748	37	40,159	31.4	68,907	26.6
	Jul/Aug	51,299	11.8	140,659	29.5	112,351	22	253,010	19.8
	Sep/Oct	41,928	11.9	42,855	26.5	29,109	20.7	71,964	19.7
	Nov/Dec	33,813	16.7	43,571	46.4	33,017	32.2	76,588	37.9
	Total	187,721	6.5	271,245	18.4	215,947	14.3	487,192	13.2
2017	Jan/Feb	6,178	25.3	5,722	65.1	994	70.9	6,716	63.1

Year	Wave	Total Effort	PSE Effort	Total Harvest	PSE Harvest	Total Releases	PSE Releases	Total Catch	PSE Catch
	Mar/Apr	17,512	15.9	20,607	35.7	13,568	30.5	34,175	30.9
	May/Jun	36,167	13.4	64,209	35.4	54,339	22.3	118,548	24.6
	Jul/Aug	55,330	13.7	92,670	23.6	95,611	18.8	188,281	17.5
	Sep/Oct	40,032	13.8	93,323	21.7	54,989	25.8	148,312	19.6
	Nov/Dec	27,478	14.4	44,132	29.9	28,040	27.3	72,172	24.3
	Total	182,697	6.7	320,662	12.8	247,543	11.3	568,205	10.2
2018	Jan/Feb	4,121	30.4	1,124	100.0	450	70.5	1,574	86.8
	Mar/Apr	10,108	22.4	645	77.2	4,560	43.1	5,205	39.0
	May/Jun	32,380	14.2	19,922	39.8	13,295	29.4	33,217	32.2
	Jul/Aug	13,097	19.0	.	.	15,913	30.4	15,913	30.4
	Sep/Oct	11,832	71.1	17,170	100.0	56,912	85.8	74,082	70.4
	Nov/Dec	20,890	16.3	34,353	31.6	20,987	23.6	55,340	22.7
	Total	92,428	11.78	73,215	29.83	112,117	44.15	185,331	29.72

Table 3. North Carolina RCGL survey estimates of the number of striped mullet harvested, pounds harvested, number released, and total number caught. The RCGL survey was conducted from 2002-2008, funding was discontinued in 2009.

Year	Number Harvested	Pounds Harvested	Number Released	Total Number
2002	66,305	64,213	6,549	72,854
2003	28,757	24,774	3,514	32,270
2004	34,736	35,947	2,875	37,611
2005	35,888	36,314	3,492	39,380
2006	38,175	37,385	5,352	43,527
2007	35,472	40,168	7,449	42,921
2008	51,465	51,785	9,207	60,672

Table 4. Mean length, minimum length, maximum length (fork length, inches), and total number of striped mullet measured from North Carolina commercial fish house samples, 1994-2018.

Year	Mean Length	Minimum Length	Maximum Length	Number Measured
1994	13.0	6.1	19.1	302
1995	14.5	9.3	21.6	255
1996	13.5	10.0	18.5	123
1997	12.8	9.2	22.8	2,048
1998	13.1	8.6	25.4	1,600
1999	13.4	8.7	23.9	1,759
2000	13.4	8.3	23.5	7,522
2001	14.1	8.1	20.9	5,726
2002	13.2	5.9	21.3	10,989
2003	13.2	6.3	24.5	7,170
2004	13.1	7.6	24.4	12,778
2005	13.5	7.8	22.6	10,270
2006	13.7	7.8	22.2	12,108
2007	13.5	7.1	27.5	12,141
2008	14.1	8.4	24.1	13,212
2009	14.1	8.0	22.4	8,241
2010	13.9	8.1	22.7	10,991
2011	13.9	6.5	22.1	7,750
2012	14.0	7.9	22.2	12,833
2013	14.2	8.3	24.3	8,535
2014	13.8	7.7	24.0	6,517
2015	14.2	8.1	24.9	5,923
2016	14.3	8.9	24.1	5,661
2017	14.2	7.8	28.6	4,480
2018	14.5	8.3	22.5	4,111

Table 5. Modal age, minimum age, maximum age and total number of striped mullet aged from fishery independent and fishery dependent sampling, 2004-2018. Age data from 2018 is considered preliminary.

Year	Modal Age	Minimum Age	Maximum Age	Number Aged
1996	1	0	6	163
1997	2	0	7	344
1998	2	0	7	717
1999	1	0	8	753
2000	2	0	10	1,122
2001	1	0	11	705
2002	2	0	7	625
2003	1	0	13	765
2004	2	0	9	1,142
2005	2	0	10	654
2006	2	0	10	685
2007	2	0	10	699
2008	2	0	10	771
2009	2	0	13	349
2010	2	1	8	748
2011	2	0	14	633
2012	2	0	6	873
2013	2	0	7	850
2014	2	0	6	855
2015	2	0	6	770
2016	2	0	8	956
2017	1-2	0	15	695
2018*	2	0	10	763

Table 6. Summary of management strategies.

MANAGEMENT STRATEGY	Implementation Status
Establish minimum and maximum commercial landings triggers of 1.13 and 2.76 million pounds.	Amendment 1, 2015.
Establish minimum and maximum commercial landings triggers of 1.3 and 3.1 million pounds.	Striped Mullet Fishery Management Plan, 2006.
Implement a recreational harvest limit of 200 mullet per person, per day – currently there are no bag restrictions for mullet.	Striped Mullet Fishery Management Plan, 2006. MFC Rule April 2006 adoption 15ANCAC 03M.0502 (a), (b)
Modify mutilated finfish rule to exempt mullet when used as bait.	Striped Mullet Fishery Management Plan, 2006. 15ANCAC 03M.0101

FIGURES

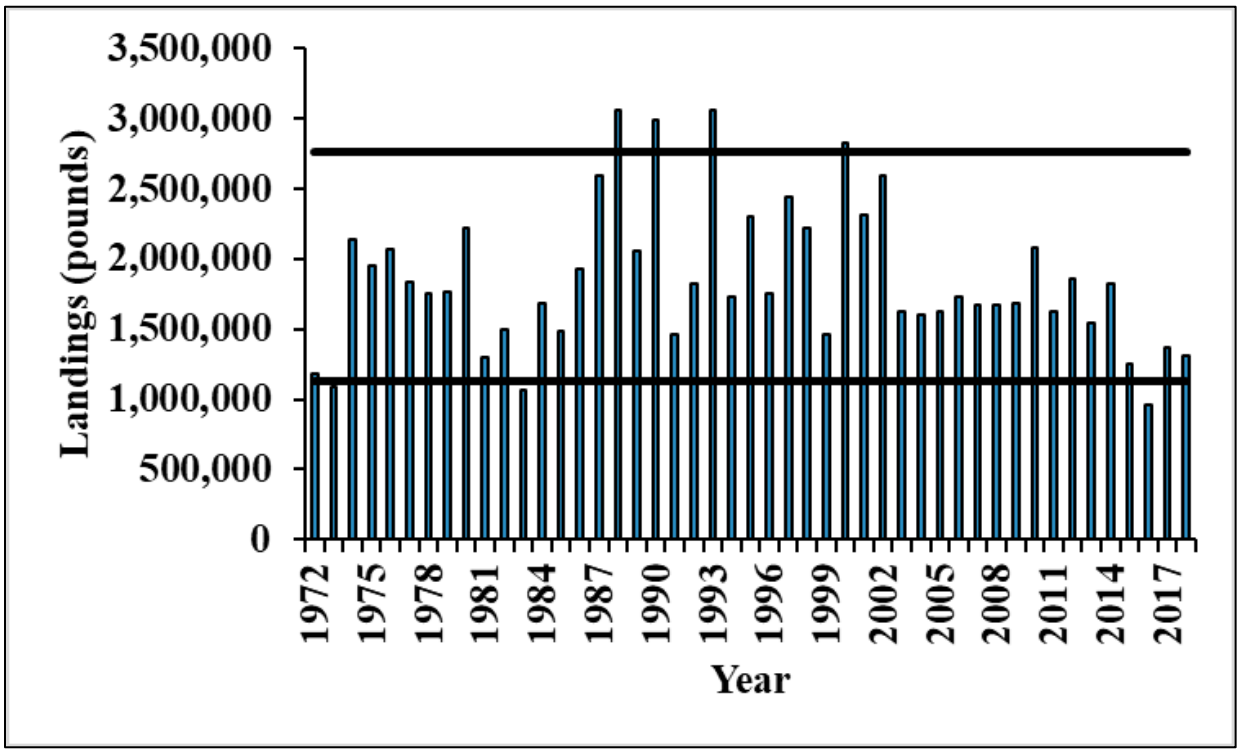

Figure 1. Commercial landings of striped mullet, 1972-2018. Solid lines represent upper (2.76 million lb.) and lower (1.13 million lb.) landings limits that would trigger a closer examination of data. Landings limits were changed from upper and lower limits of 3.1 million and 1.3 million pounds by Amendment 1 in November 2016 (NCDMF 2014).

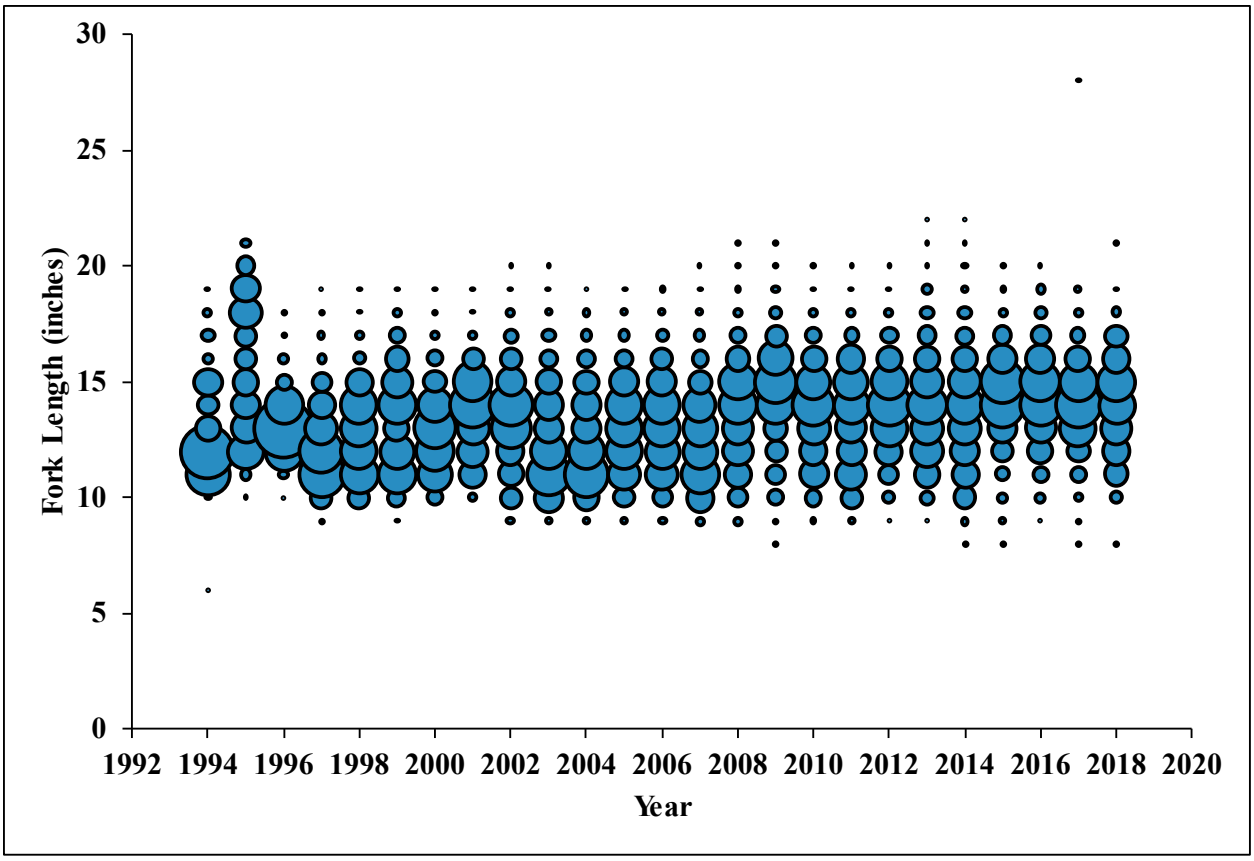

Figure 2. Commercial length-frequency (fork length, inches) of striped mullet harvested in the commercial fishery based on NCDMF fish house sampling, 1994-2018. Bubble represents the proportion of fish at length.

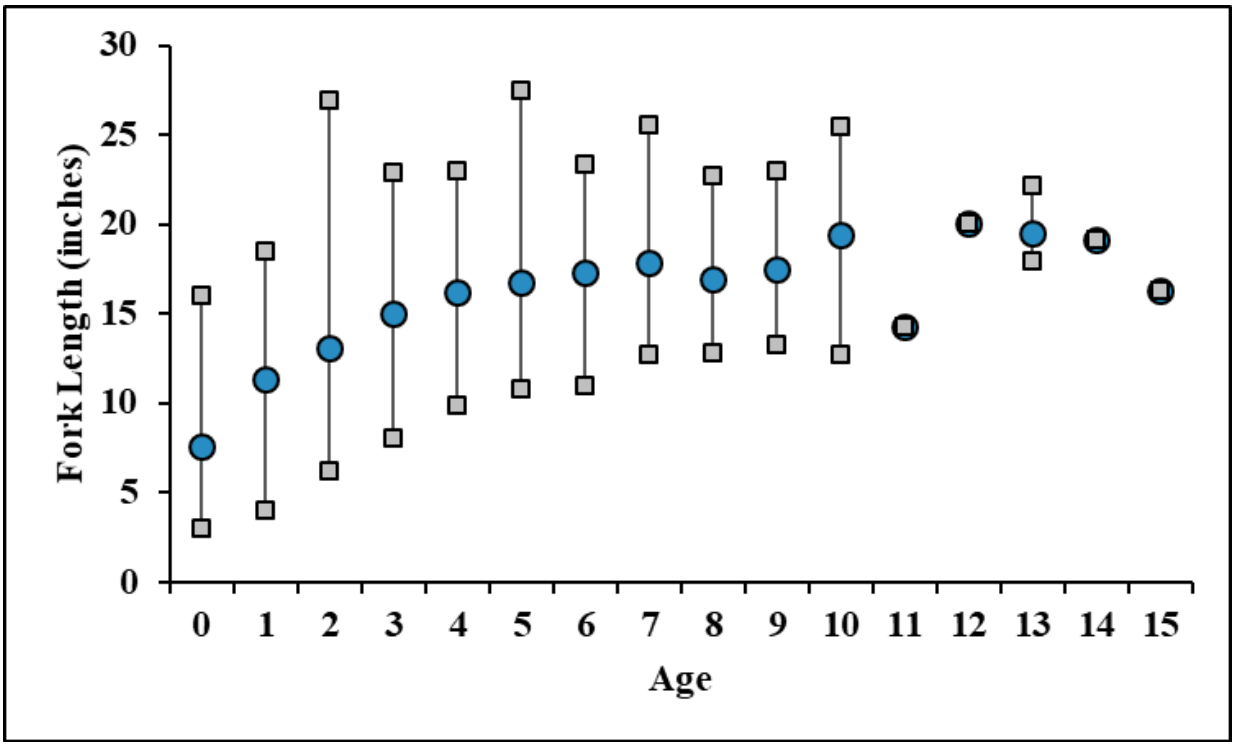

Figure 3. Striped mullet length at age based on all age samples collected from 1996 to 2018. Blue circles represent mean size at a given age and the grey squares represent the minimum and maximum observed size for each age. Data from 2018 is considered preliminary.

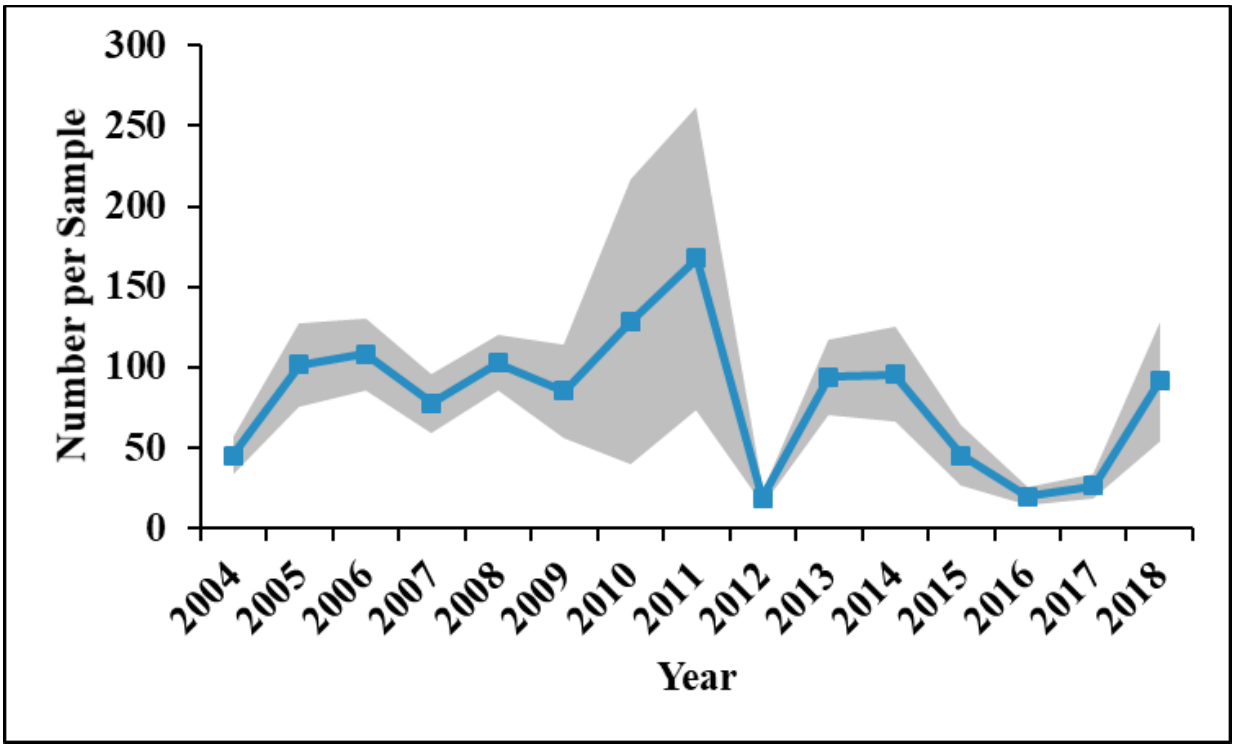

Figure 4. Number of striped mullet per sample (500 m sampling session) from the striped mullet electrofishing survey (P146), 2004-2018. To provide the most relevant index, data were limited to those collected during January through April. The shaded area represents standard error.

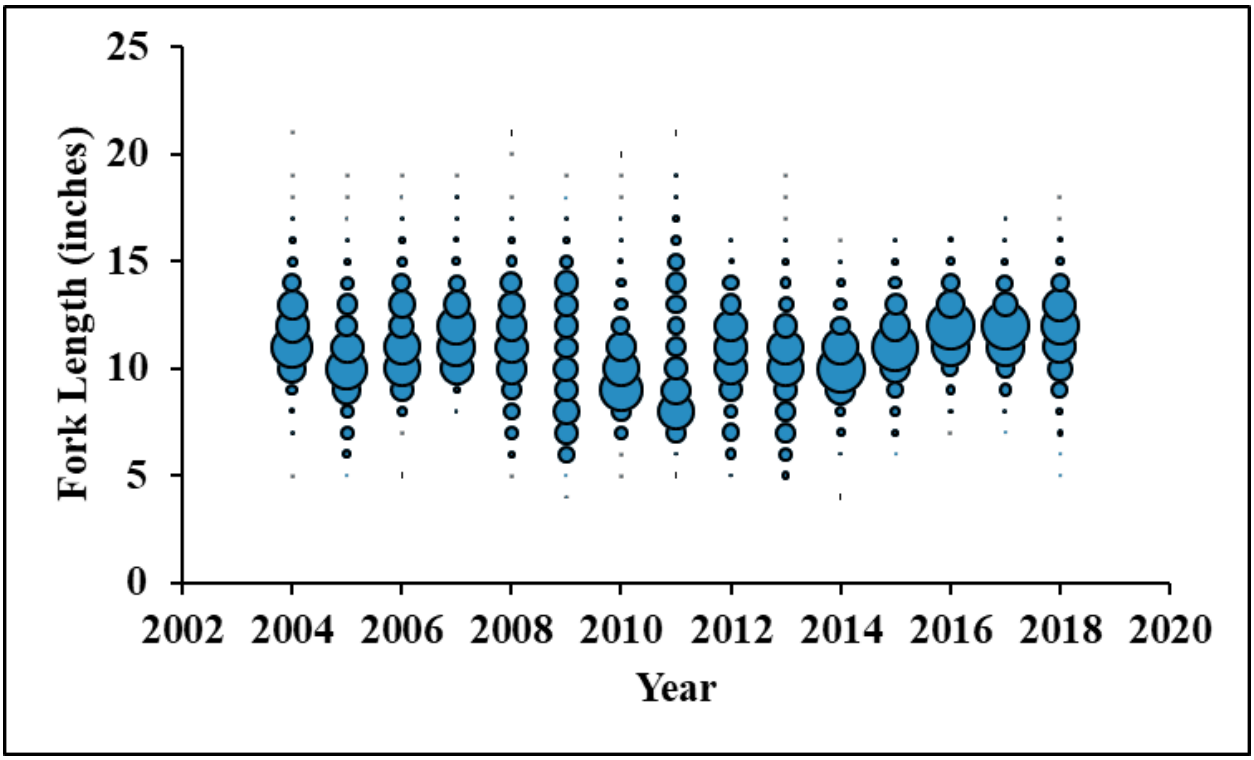

Figure 5. Length frequency (fork length, inches) of striped mullet from the striped mullet electrofishing survey (P146), 2004-2018. Lengths include striped mullet collected during January-April.

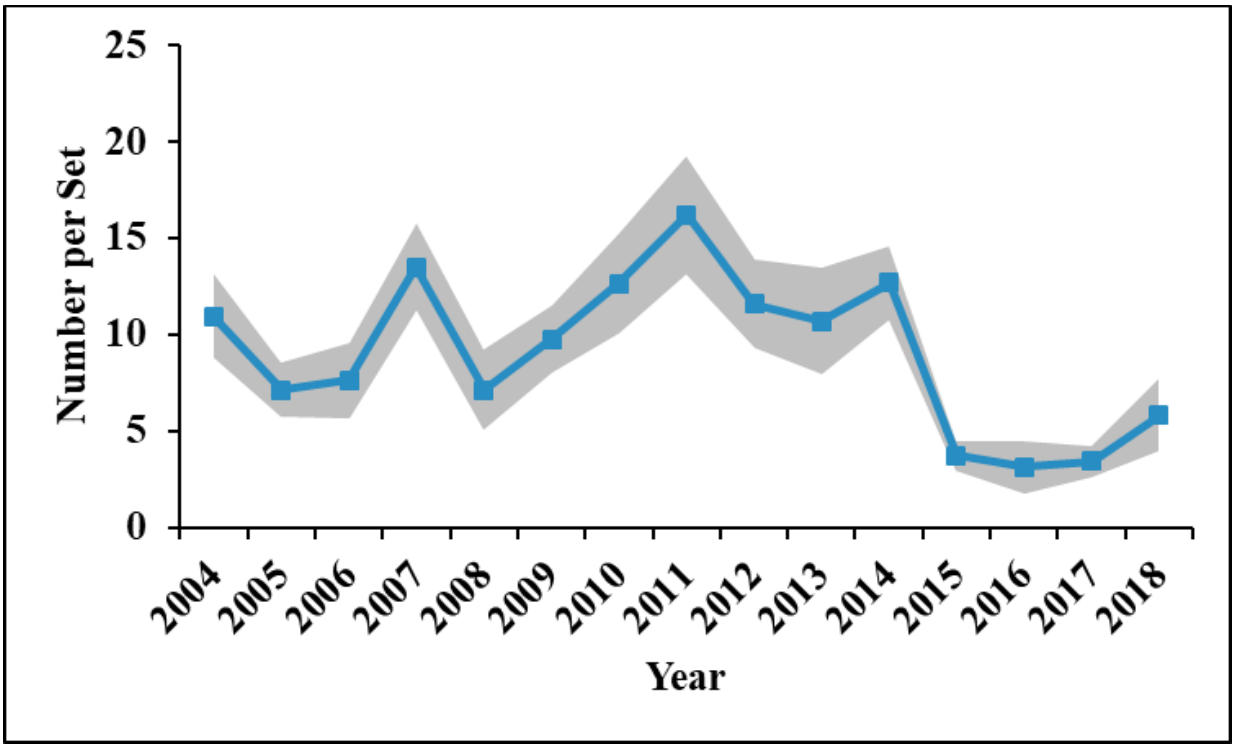

Figure 6. CPUE (number/set) of striped mullet from the independent gill net survey (P915), 2004-2018. To provide the most relevant index, only shallow river (Neuse, Pamlico, Pungo) samples collected during October-November were included. The shaded area represents standard error.

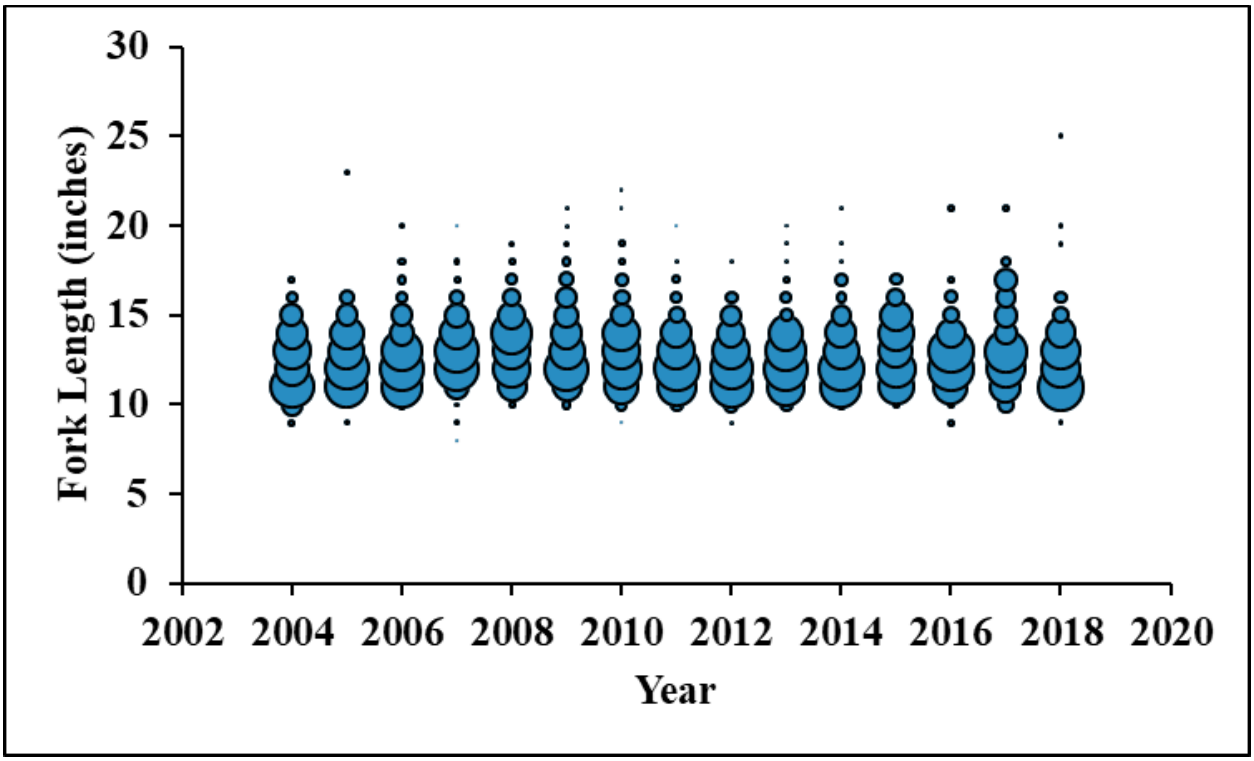

Figure 7. Length-frequency (fork length, inches) of striped mullet from the independent gill net survey (P915), 2004-2018. Lengths include striped mullet from shallow river (Neuse, Pamlico, Pungo) samples collected during October-November.

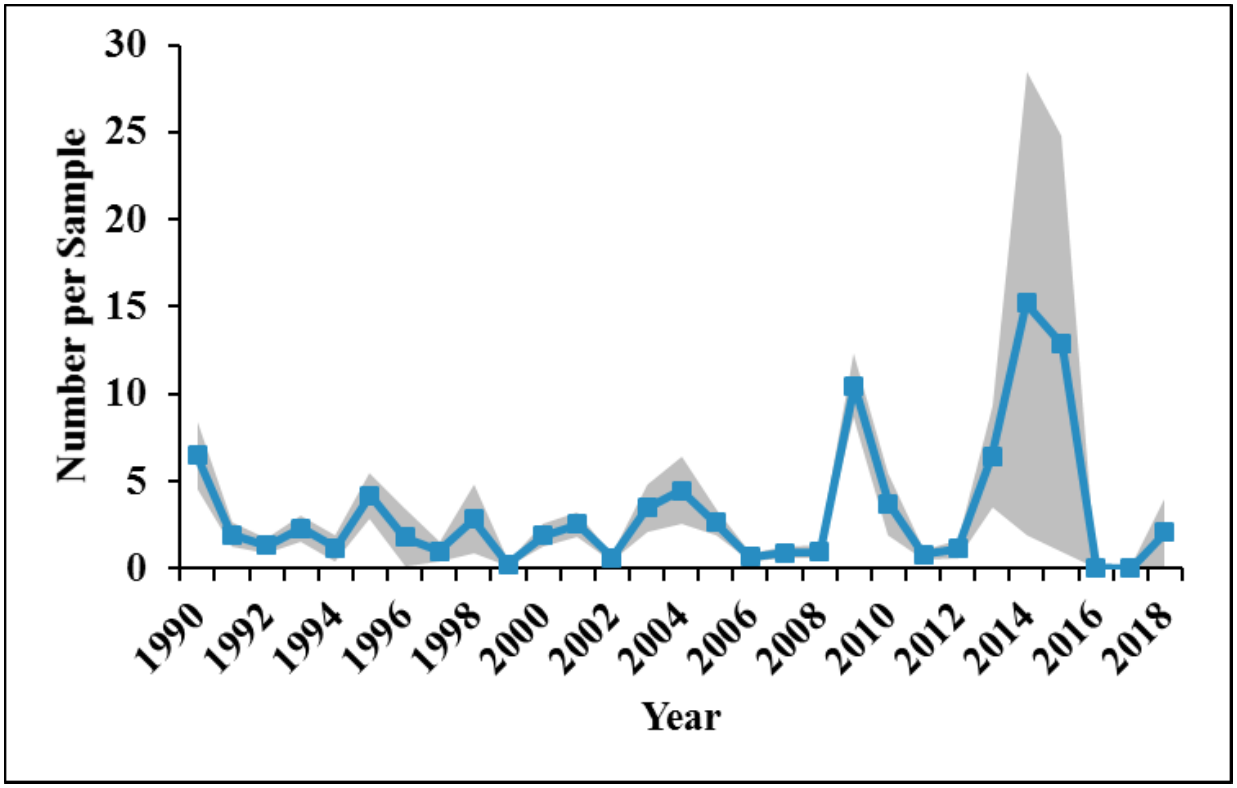

Figure 8. CPUE (number/set) of striped mullet from the striped bass independent gill net survey (P135), 1990-2018. To provide the most relevant striped mullet index data were limited to those collected from 2.5-inch to 5.5-inch mesh sizes during November through February (fall-winter) in less than 10 feet of water.

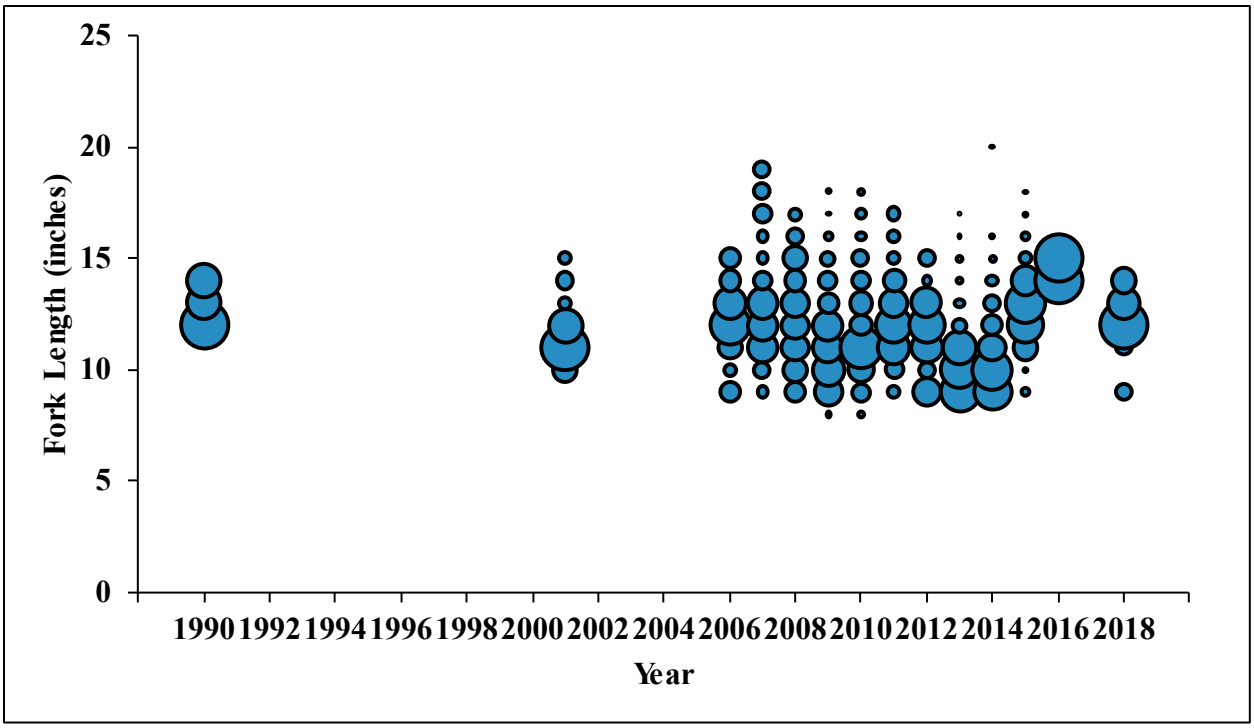

Figure 9. Length-frequency (fork length, inches) of striped mullet from the fall-winter portion of the striped bass independent gill net survey (P135), 1990-2018. In some years no striped mullet were captured or no lengths were recorded.

FISHERY MANAGEMENT PLAN UPDATE
AMERICAN SHAD
AUGUST 2019

STATUS OF THE FISHERY MANAGEMENT PLAN

Fishery Management Plan History

Original FMP Adoption:	October 1985
Amendments:	Amendment 1 (April 1999) Amendment 3 (February 2010)
Revisions:	Technical Addendum 1 (February 2000) Addendum I (August 2002)
Supplements:	Supplement (October 1988)
Information Updates:	None
Next Benchmark Review:	ASMFC started 2018/final results summer 2020

The first Atlantic States Marine Fisheries Commission (ASMFC) Fishery Management Plan (FMP) for Shad and River Herrings was adopted in 1985. The FMP did not require any specific management approach or monitoring programs within the management unit, asking only that states provide annual summaries of restoration efforts and ocean fishery activity. It specified four management objectives: regulate exploitation, improve habitat accessibility and quality, initiate programs to introduce alosine stocks into historic waters, and recommend and support research programs. The 1988 Supplement (ASMFC 1988) reassessed the research priorities identified in the original 1985 plan and created a new listing of research priorities.

Amendment 1 (ASMFC 1999) reported that the majority of American shad (*Alosa sapidissima*) stocks were not overfished, but almost all were believed to be at or near historically low levels. Therefore, Amendment 1 required increased annual reporting requirements on juveniles, adult spawning stocks, annual fishing mortality, and habitat. A fishing mortality threshold (overfishing) was defined as a reference point of F_{30}. A fishing mortality rate of F_{30} will result in 30% of the maximum spawning potential in the female component of an unfished population. Amendment 1 also implemented the phase-out of the ocean intercept fishery for American shad (effective in 2005). Eliminating the North Carolina ocean intercept fishery was important to controlling harvest to specific river origins.

Technical Addendum 1 (ASMFC 2000) modified several technical errors and provided clarification of several monitoring requirements in Amendment 1.
Addendum I (ASMFC 2002) changed the conditions for marking hatchery-reared alosines. The addendum clarifies the definition and intent of *de minimis* status for the American shad fishery. It

also further modifies and clarifies the fishery independent and fishery-dependent monitoring requirements of Technical Addendum 1.

The ASMFC coast-wide stock assessment completed in 2007 found that American shad stocks were at all-time lows and did not appear to be recovering to acceptable levels. Therefore, under ASMFC's Amendment 3 to the Interstate FMP for Shad and River Herring, individual states were required to develop Implementation Plans (ASMFC 2010). Implementation Plans consisted of two parts: 1. Review and update of the fishing/recovery plans required under Amendment 1 for the stocks within their jurisdiction; and 2. Habitat plans. North Carolina submitted a fishing/recovery plan that meets the requirements of Amendment 3 and is known as the North Carolina American Shad Sustainable Fishery Management Plan (SFMP) (NCDMF 2011).

To ensure compliance with interstate requirements, North Carolina also manages this species 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 plans) and the Atlantic Coastal Fisheries Cooperative Management Act (ASMFC plans) are like the goals of the Fisheries Reform Act of 1997 to "ensure long-term viability" of these fisheries (NCDMF 2015).

Management Unit

The management units for American shad are all the migratory American shad stocks of the Atlantic coast of the United States. American shad and hickory shad management authority lies with the ASMFC and is coordinated by Atlantic coastal states from Maine through Florida through approved Sustainable Fishery Management Plans for American Shad. Responsibility for management action in the Economic Exclusive Zone (EEZ), located from three to 200 miles from shore, lies with the Secretary of Commerce through the Atlantic Coastal Fisheries Cooperative Management Act (ACFCMA) in the absence of a federal FMP.

Goal and Objectives

Migratory stocks of American shad have been managed under the ASMFC since 1985. These species are currently managed under Amendment 3 (American shad) and Amendment 1 (American and hickory shad (*Alosa mediocris*) to the ASMFC FMP, Technical Addendum 1, and Addendum I. Because of the scarcity of data on hickory shad populations, the ASMFC member states decided to focus Amendment I on American shad regulations and monitoring programs. However, the amendment requires states to initiate fishery-dependent monitoring programs for hickory shad while recommending continuance of current fishery-independent programs for these species. The goal of Amendment 3 is to protect, enhance, and restore Atlantic coast migratory stocks and critical habitat of American shad in order to achieve levels of spawning

stock biomass that are sustainable, can produce a harvestable surplus, and are robust enough to withstand unforeseen threats. To achieve this goal, the plan adopts the following objectives:

1. Maximize the number of juvenile recruits emigrating from freshwater stock complexes.
2. Restore and maintain spawning stock biomass and age structure to achieve maximum juvenile recruitment.
3. Manage for an optimum yield harvest level that will not compromise Objectives 1 and 2.
4. Maximize cost effectiveness to the local, state, and federal governments, and the ASMFC associated with achieving Objectives 1 through 3.

STATUS OF THE STOCK

Life History

American shad are anadromous fish, meaning they spend most of their adult lives at sea, only returning to freshwater in the spring to spawn. Shad young leave their home river within the first year and will spend the next few years at sea, schooling in large numbers with shad from other regions and feeding on plankton, small fish, and crustaceans. Upon reaching maturity, at about age 4, they return to the streams they were born in to spawn. Males or "buck shad" return first, followed by females or "roe shad." They spawn usually at night or during overcast days. In the southern range (Cape Fear River to Florida), females release as many as 700,000 eggs during the spawning season, but both males and females normally die after spawning. In the northern range, females typically release 300,000 eggs or less during the spawning season; however, most shad will return to spawn in the following years, with some shad living up to 10 years.

Stock Status

The most recent coast-wide stock assessment of American shad stated that populations in the Albemarle Sound and Roanoke River are stable and low, whereas a determination of stock status could not definitively be assigned for the Tar/Pamlico, Neuse and Cape Fear rivers due to limited information (ASMFC 2007).

Stock Assessment

The last coast-wide stock assessment for American shad was completed in 2007, which found that stocks are currently at all-time lows and do not appear to be recovering. Recent declines in stock abundance were reported for Maine, New Hampshire, Rhode Island and Georgia, and for the Hudson (NY), Susquehanna (PA), James (VA) and Edisto (SC) Rivers. Low and stable stock abundance was indicated for Massachusetts, Connecticut, Delaware, Chesapeake Bay, the Rappahannock River (VA) and some South Carolina and Florida stocks. The Potomac River stock has shown rebuilding in recent years of the stock assessment. For North Carolina the stock assessment found that American shad populations in the Albemarle Sound and Roanoke River are stable and low, whereas a determination of stock status could not definitively be assigned for the Tar-Pamlico, Neuse and Cape Fear rivers due to limited information (ASMFC 2007). It should be noted that areas south of Albemarle Sound form a zone where stocks transition from iteroparity (spawns multiple times over the course of its lifetime) to semelparity (spawns once before death), which can also impact the ability to determine stock status.

Primary causes for stock decline were identified, including overfishing, pollution and habitat loss due to dam construction. A peer review panel recommended that current restoration actions should be reviewed and new ones should be identified and applied, and suggested considering a reduction of fishing mortality, enhancement of dam passage and mitigation of dam-related fish mortality, stocking and habitat restoration.

The ASMFC has not conducted a coast-wide assessment of hickory shad. The benchmark stock assessment for American shad, currently in progress, will use data through 2017 and is scheduled for completion Summer 2020.

STATUS OF THE FISHERY

Current Regulations

The NCMFC enacted a rule in 1995, which established a closed season for American shad and hickory shad. It is unlawful to take these species by any method except hook-and-line from April 15 through December 31. The ocean intercept fishery for American shad was closed to all harvest January 1, 2005 (ASMFC 2002).

In the Albemarle, Croatan, Roanoke, and Currituck sounds and tributaries (Albemarle Sound Management Area; ASMA), floating gill nets of 5.25-inch stretch mesh (ISM) to 6.5 ISM, were limited to 1,000 yards and can only be utilized from March 3 through March 24 and must be fished at least once during a 24-hour period (no later than noon each day). The western portion of Albemarle Sound near the mouth of the Roanoke River (including Roanoke, Cashie, Middle and Eastmost Rivers) is closed to gill netting year-round. The large mesh gill net restrictions were imposed for striped bass conservation but also provided measures of protection for American shad. Gill nets of less than 3.25 ISM were not allowed due to the river herring closure. Gill nets with a mesh length of 3.25 - 4.00 ISM could not exceed 800 yards and were allowed the entire spring. Attendance for small mesh gill nets (3.0 – 4.0 ISM) was required May 18 – November 20. The ASMA was closed to all gill nets except for 3.0 – 4.0 ISM run-around, strike, drop, and drift gill nets until the area was opened September 1, 2015. Gill net attendance was removed in this area on November 20.

Since May 2016, in other areas outside of the ASMA (excluding the Cape Fear River), a statewide rule limits the amount of large mesh (4.0-inch and greater) gill net set in internal Coastal Fishing Waters to no more than 2,000 yards per vessel. A prior version of the rule (3,000 yards maximum) was suspended for most internal Coastal waters as a result of sea turtle conservation measures to institute no more than 2,000 yards per vessel of 4.0–6.5-inch gill net in the Tar-Pamlico and Neuse river systems in earlier years. Additionally, in certain sections of the Tar-Pamlico and Neuse rivers, gill nets with a mesh size less than five inches must be attended at all times. Also, it is unlawful to use any gill nets in Joint Fishing Waters from midnight on Friday to midnight on Sunday each week (except for portions of Albemarle and Currituck sounds). These existing gill net measures have likely reduced American Shad harvest since they have remained in effect since the spring 2012 fishing season and remain in effect indefinitely.

In the Cape Fear River there are different gill net restrictions than described above for the Tar-Pamlico and Neuse river systems (i.e. mesh lengths, spacing, set/retrieval days and times). Large mesh gill nets (4.0-6.5-inch) are prohibited in the Cape Fear River (north of the Railroad Bridge) and Northeast Cape Fear River (north of I-40 bridge) north of Wilmington, NC. In other parts of the Cape Fear River, large mesh gill nets can be set in lengths no greater than 100 yards and must have at least a 25-yard space between each individual length of net. Only single overnight sets are allowed; nets can be set one hour prior to sunset and must be retrieved within one hour of sunrise, with no sets allowed Friday, Saturday or Sunday evenings, and the maximum yardage allowed is a 1,000-yard limit per vessel. It is unlawful to use gill nets of any mesh size on weekends in the Cape Fear system. This measure will remain in effect indefinitely.

Commercial Landings

North Carolina's commercial landings in 2018 were 53,878 pounds; well below 2017 landings (90,868 pounds) and the lowest annual total since the implementation of the Albemarle Sound Management Area reduced season in 2014 (Table 1 and Figure 1). Landings show a decreasing trend until 2013 when average landings leveled off with the implementation of the American Shad SFMP. Commercial harvest is sporadic and cyclical and annual trends show these changes. Figure 2 describes that landings break down by the four areas of the state, as stated in the American Shad SFMP. The Albemarle Sound area accounts for approximately 69% of total state landings in 2018.

Recreational Landings

Recreational fishing activity is monitored through coordination with the North Carolina Wildlife Resources Commission (WRC) and the NCDMF, methods were developed to conduct recreational creel surveys on the Roanoke, Tar, Neuse, and Cape Fear rivers starting in 2012, except for Cape Fear River which started in 2013. Recreational landings for American shad are minimal throughout the Albemarle Sound/Roanoke River due to limited to no effort focused on American shad in this system. The bulk of the North Carolina recreational fishery occurs in the Cape Fear River system where substantial effort is targeted on American shad with an estimated annual harvest of 5,366 fish in 2018 (Table 2).

MONITORING PROGRAM DATA

Fishery-Dependent Monitoring

Commercial fishing activity is monitored through fishery-dependent sampling conducted by the NCDMF since 1972, with a sampling gap from 1994 to 2000 due to funding. Data collected in this program allow the size and age distribution of American Shad to be characterized by sex (female and male). The predominant fishery for American shad are estuarine gill nets and harvest is primarily focused on female American Shad, as they are harvested for their roe (eggs). In 2018, gill nets accounted for greater than 95% of the commercial landings (Figure 3).

A total of 388 females and 53 males were measured from the commercial fishery in 2018 (Table 3 and Table 4). The average size of female American Shad was 17 inches fork length and male

was 15 inches fork length in 2018, which has decreased over time for both females and males (Figure 4 and Figure 5). Variation in modal, minimum, and maximum ages throughout the fishery-dependent monitoring is described in Table 5, for both sexes combined. The modal age has increased over the time series, while the minimum and maximum ages have remained relatively unchanged. Figure 6 and Figure 7 illustrate the American Shad length at age (mean, minimum, and maximum) for females and males from all age samples collected at any given age from 1972 to 2018.

Fishery-Independent Monitoring

The NCDMF does not have a dedicated juvenile (age-0) survey for American Shad, but does conduct a juvenile anadromous seine survey that intercepts American Shad. The seine survey, originally designed for juvenile river herring [Blueback Herring (*Alosa aestivalis*) and Alewife (*Alosa peseudoharengus*)], has been conducted twice a month, at eleven fixed sites in the Albemarle Sound/Chowan River area from June to October since 1972. Only the first pull from each month is used to calculate the index of abundance for juvenile Blueback Herring and Alewife, with the same method also used for American Shad (Figure 8). Due to the low numbers of juvenile American Shad caught across the time series, these data have not been used for management and are only shown here as an illustration of the trend in abundance.

Adult American shad are monitored using the NCDMF Albemarle Sound Independent Gill Net Survey (IGNS) and North Carolina Wildlife Resources Commission (NCWRC) electrofishing surveys to estimate female catch per unit effort (CPUE) and relative fishing mortality in the Albemarle Sound/Roanoke River area. In other areas of the state, NCWRC conducts electrofishing surveys to estimate abundance and the relative fishing mortality. These data are incorporated into the North Carolina SFMP for American Shad described in more detail in the Management Strategy section.

The Albemarle Sound IGNS began collecting biological data on adult American Shad in 2000, sex was not recorded until 2004. The survey uses a stratified random sampling scheme designed to characterize the size and age distribution for key estuarine species in the Albemarle Sound. American Shad intercepted by NCDMF IGNS surveys outside to the Albemarle Sound/Roanoke River area are biologically sampled and reported annually to the ASMFC, due to low numbers of catch a CPUE is not estimated. In 2018, the Albemarle Sound IGNS overall American Shad CPUE (female and male combined) was 0.08 fish per unit of effort (Figure 9).

A total of 76 females and 80 males were measured from the NCDMF fishery-independent monitoring (Table 6 and Table 7) from all areas of the state. The average size of female American Shad is 16 inches fork length and male is 15 inches fork length. Variation in modal, minimum, and maximum ages throughout the fishery-independent sampling is described in Table 8, for both sexes combined. The modal age has fluctuated over the time series, while the minimum and maximum ages have remained relatively stable. Figure 10 and Figure 11 illustrate the American Shad length at age (mean, minimum, and maximum) for females and males from all age samples collected from the fishery-independent monitoring at any given age from 2000 to 2018.

MANAGEMENT STRATEGY

Shad are managed under Amendment 3 to the ASMFC Interstate FMP for Shad and River Herring. The Amendment requires states and jurisdictions to develop sustainable fishery management plans, which are reviewed by the ASMFC Technical Committee and approved by the ASMFC Shad and Herring Management Board, in order to maintain commercial and recreational fisheries past January 2013. The ASMFC requires that these plans be re-evaluated every five years to update and modify sustainable management measures. The first NCDMF American Shad SFMP, effective in 2013 through 2017, identified sustainability parameters for four regions of the state: Albemarle Sound/Roanoke River, Tar/Pamlico, Neuse, and Cape Fear River systems. Sustainability parameters are based on the female portion of the stock because the commercial fishery targets roe shad; roe landings can account for as much as 90% of the total American shad landings in a year. The second NCDMF American Shad SFMP, approved October 2017 for 2018 through 2022, maintained the original sustainability parameters of relative fishing mortality (*F*) and abundance indices, but relative *F* will now be computed by dividing commercial landings by a hind cast 3-year average of a survey index. The previous plan used a centered 3-year average. Proposed thresholds for sustainability parameters are fixed using available survey data through 2017 and will remain fixed during the next 5-year management period.

The NCDMF American Shad SFMP is updated annually in September by the American Shad Work Group, which consists of biologists from the NCDMF and the NCWRC, and the next year's season is determined. Annual updates were completed for all areas to determine if any sustainability parameters were exceeding the thresholds. The Tar/Pamlico, Neuse, and Cape Fear River systems have not exceeded any of the thresholds that have required management changes.

Albemarle Sound/Roanoke River:

The Albemarle Sound/Roanoke River system has three sustainability parameters: female CPUE based on the NCDMF Albemarle Sound IGNS, CPUE based on the NCWRC electrofishing survey, and female relative fishing mortality (*F)* computed by dividing commercial landings by a hind cast 3-year average of the NCDMF IGNS index. As written in the SFMP, exceeding the female CPUE based on Albemarle Sound IGNS or the female relative *F* parameters for three consecutive years will trigger management action. The female CPUE based on the NCWRC electrofishing survey will be used in conjunction with a second index for triggering management action.

The Albemarle Sound/Roanoke River system exceeded two thresholds, the female CPUE index based on the NCWRC electrofishing survey and the female relative fishing mortality (*F*), during the 2013 commercial fishing season. These parameters exceeding the threshold required management actions to be implemented for the 2014 fishing season. In February 2014, the American Shad Work Group chose to reduce the American shad commercial season in the Albemarle Sound/Roanoke River to March 3-24 to reduce overall commercial landings. The 2015, 2016, 2017, and 2018 commercial fishing season continued with the same seasonal dates and updates of sustainability parameters indicate that no thresholds are being exceeded. The recreational season is open year-round. Recreational fishermen can possess 10 American shad

and hickory shad, in the aggregate, per person per day taken by hook-and-line or for recreational purposes and only one of the 10 shad may be an American shad.

Figure 12 shows the female CPUE based on the NCDMF Albemarle Sound IGNS. Figure 13 shows the CPUE based on the NCWRC electrofishing survey. Figure 14 shows the female relative *F* based on commercial landings and a hind cast three-year average of the NCDMF IGNS index.

Tar/Pamlico system:

The Tar/Pamlico system has two sustainability parameters: female CPUE based on the NCWRC electrofishing survey, and female relative *F* based on the NCWRC electrofishing survey. The NCDMF American shad SFMP set the commercial and recreational seasons and recreational possession limit in 2013. The commercial season is open from February 15 to April 14. The recreational season is open year-round. Recreational fishermen can possess 10 American shad and hickory shad, in the aggregate, per person per day taken by hook-and-line or for recreational purposes.

Figure 15 shows the female CPUE based on the NCWRC electrofishing survey and figure 16 shows the female relative *F* based on the NCWRC electrofishing survey.

Neuse system:

The Neuse River system has two sustainability parameters: female CPUE based on the NCWRC electrofishing survey, and female relative *F* based on the NCWRC electrofishing survey. The NCDMF American shad SFMP set the commercial and recreational seasons and recreational possession limit in 2013. The commercial season is open from February 15 to April 14. The recreational season is open year-round. Recreational fishermen can possess 10 American shad and hickory shad, in the aggregate, per person per day taken by hook-and-line or for recreational purposes and only one of the 10 shad may be an American shad.

Figure 17 shows the female CPUE based on the NCWRC electrofishing survey and figure 18 shows the female relative *F* based on the NCWRC electrofishing survey.

Cape Fear River system:

The Cape Fear River system has two sustainability parameters: female CPUE based on the NCWRC electrofishing survey, and female relative *F* based on the NCWRC electrofishing survey. The NCDMF American shad SFMP set the commercial and recreational seasons and recreational possession limit in 2013. The commercial season is open from February 20 to April 11. The recreational season is open year-round. Recreational fishermen can possess 10 American shad and hickory shad, in the aggregate, per person per day taken by hook-and-line or for recreational purposes and only five of the 10 shad may be an American shad.

Figure 19 shows the female CPUE based on the NCWRC electrofishing survey and figure 20 shows the female relative *F* based on the NCWRC electrofishing survey.

The 2018 update of the SFMP sustainability parameters throughout the state demonstrated that all the parameters were within the sustainable targets, with the exception of the Tar/Pamlico system female CPUE (no management action triggered).

All Other Internal Coastal and Joint Fishing Waters

For all other internal coastal and joint fishing waters not included under a sustainability parameter in the NCDMF American Shad SFMP the following commercial and recreational measures were established. The commercial season is open from February 15 to April 14. The recreational season is open year-round. Recreational fishermen can possess 10 American shad and hickory shad, in the aggregate, per person per day taken by hook-and-line or for recreational purposes.

RESEARCH NEEDS

On an annual basis the ASMFC publishes a prioritized list of research needs for American Shad and river herring in the Review of the Atlantic States Marine Fisheries Commission Fishery Management Plan for Shad and River Herring (ASMFC 2018). For more information on research needs for American Shad please see http://www.asmfc.org/uploads/file/5bc76a1dShad_RiverHerringFMPReview_2018.pdf.

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TABLES

Table 1. Commercial harvest in pounds of American shad in North Carolina from 1972-2018, all waterbodies combined.

Year	Commercial Weight (lb)
1972	468,484
1973	321,000
1974	368,833
1975	241,240
1976	167,190
1977	120,201
1978	402,017
1979	277,818
1980	199,206
1981	351,500
1982	407,034
1983	380,897
1984	382,331
1985	190,044
1986	279,142
1987	111,860
1988	111,567
1989	52,997
1990	30,833
1991	29,037
1992	38,020
1993	12,544
1994	110,975
1995	205,867
1996	199,638
1997	219,526
1998	327,556
1999	131,617
2000	297,990
2001	151,075
2002	274,657
2003	395,251
2004	270,245
2005	189,462
2006	184,710
2007	298,597
2008	118,855
2009	167,114
2010	232,326
2011	203,755
2012	235,795
2013	257,348
2014	191,302
2015	95,966
2016	62,245
2017	90,868
2018	53,878

Table 2. American shad commercial and recreational landings and releases (recreational only) in numbers and pounds for the Central Southern Management Areas (CSMA), 2012*-2018.

	Neuse River			Tar-Pamlico River			Cape Fear River		
	Recreational		Commercial	Recreational		Commercial	Recreational		Commercial
Year	Harvest (N)	Released (N)	Landings (lb)	Harvest (N)	Released (N)	Landings (lb)	Harvest (N)	Released (N)	Landings (lb)
2012	1,017	655	23,976	959	4,396	12,936			10,333
2013	1,388	2,771	17,320	2,603	10,180	9,776	20,519	34,902	24,888
2014	413	998	11,358	168	1,314	18,769	7,453	11,025	46,148
2015	94	137	2,990	1,006	3,917	3,346	4,136	6,388	25,039
2016	252	1,423	2,568	1,051	2,820	765	10,244	11,388	12,937
2017	519	2,591	11,451	898	2,217	4,384	1,352	2,669	10,778
2018	112	358	3,987	685	2,767	1,580	5,366	7,924	14,931

*Creel survey began in 2012.

Table 3. Length (fork length, inches) data of female American shad sampled from the commercial fisheries throughout North Carolina, 1972-2018.

Year	Mean Fork Length	Minimum Fork Length	Maximum Fork Length	Total Number Measured
1972	19	14	22	244
1973	18	14	21	345
1974	18	15	21	177
1975	18	15	21	774
1976	18	14	23	404
1977	18	14	20	515
1978	18	14	20	554
1979	18	10	22	691
1980	18	14	21	367
1981	19	16	21	374
1982	18	13	21	247
1983	18	12	21	464
1984	19	15	21	613
1985	19	15	23	561
1986	19	15	23	419
1987	19	14	21	360
1988	18	15	22	607
1989	18	15	23	470
1990	18	15	23	156
1991	18	13	20	330
1992	18	15	20	299
1993	17	15	22	220
2000	17	14	20	836
2001	17	13	20	711
2002	18	13	20	794
2003	18	13	22	545
2004	18	12	22	727
2005	17	13	21	847
2006	17	14	20	667
2007	17	12	20	785
2008	17	14	20	740
2009	17	12	22	702
2010	17	12	20	948
2011	17	15	19	1,103
2012	17	15	21	1,169
2013	18	15	21	1,363
2014	18	13	20	870
2015	18	14	20	678
2016	17	15	20	396
2017	17	15	22	456
2018	17	14	20	388

Table 4. Length (fork length, inches) data of male American shad sampled from the commercial fisheries throughout North Carolina, 1972-2018.

Year	Mean Fork Length	Minimum Fork Length	Maximum Fork Length	Total Number Measured
1972	17	13	19	285
1973	16	12	20	365
1974	15	13	18	225
1975	16	12	20	466
1976	16	12	20	392
1977	16	11	19	253
1978	16	11	22	470
1979	16	13	20	533
1980	16	12	19	429
1981	16	13	19	486
1982	16	11	19	367
1983	16	13	21	630
1984	16	12	19	608
1985	16	13	19	475
1986	16	12	19	348
1987	16	12	19	299
1988	16	11	20	422
1989	16	12	18	346
1990	16	13	19	204
1991	16	12	19	248
1992	16	12	19	232
1993	15	12	19	153
2000	16	13	20	315
2001	15	11	20	130
2002	16	13	21	352
2003	16	10	20	284
2004	16	8	19	239
2005	15	7	18	160
2006	15	11	20	192
2007	15	12	18	216
2008	15	5	20	152
2009	15	12	18	213
2010	15	12	18	199
2011	15	12	18	159
2012	16	10	19	353
2013	15	11	19	175
2014	15	11	18	120
2015	16	12	18	124
2016	15	13	18	50
2017	15	12	17	58
2018	15	13	18	53

Table 5. Aging data (male and female combined) collected from North Carolina American shad commercial fisheries, 1972-2018.

Year	Modal Age	Minimum Age	Maximum Age	Total Number Aged
1972	5	3	9	465
1973	4	3	8	656
1974	4	3	7	389
1975	5	2	9	1138
1976	5	4	9	664
1977	5	3	7	585
1978	6	3	7	953
1979	5	4	9	1060
1980	6	4	9	685
1981	6	4	9	528
1982	5	3	9	328
1983	5	3	9	626
1984	5	3	9	707
1985	5	3	8	624
1986	5	4	9	475
1987	5	4	9	403
1988	5	4	9	604
1989	5	3	8	238
1990	6	3	9	233
1991	5	4	8	321
1992	5	4	9	295
1993	5	4	9	221
2000	5	3	7	401
2001	5	3	8	423
2002	5	3	8	580
2003	6	3	8	543
2004	5	3	8	645
2005	5	3	8	477
2006	6	3	8	499
2007	6	3	8	439
2008	6,7	3	9	447
2009	7	4	10	431
2010	6	3	9	453
2011	6	3	8	403
2012	5	3	8	526
2013	7	3	9	449
2014	7	3	9	418
2015	7	4	8	406
2016	7	4	8	280
2017	7	4	9	382
2018	7	3	8	278

Table 6. Length (fork length, inches) data of female American shad sampled from North Carolina independent sampling programs from 2000-2018.

Year	Mean Fork Length	Minimum Fork Length	Maximum Fork Length	Total Number Measured
2000	18	14	20	74
2001	17	15	21	198
2002	18	14	20	144
2003	18	15	20	161
2004	18	15	20	149
2005	18	15	20	106
2006	17	15	20	52
2007	17	14	18	35
2008	16	13	19	45
2009	17	16	19	22
2010	17	15	19	83
2011	17	15	19	14
2012	17	14	19	59
2013	17	13	19	73
2014	17	16	19	28
2015	17	16	18	18
2016	17	13	18	19
2017	17	14	19	65
2018	16	12	19	76

Table 7. Length (fork length, inches) data of male American shad sampled from North Carolina independent sampling programs from 2000-2018.

Year	Mean Fork Length	Minimum Fork Length	Maximum Fork Length	Total Number Measured
2000	16	13	19	173
2001	15	13	18	84
2002	15	12	18	135
2003	16	12	19	87
2004	17	12	19	14
2005	15	13	17	30
2006	15	13	18	14
2007	15	13	17	34
2008	14	12	17	33
2009	15	13	17	18
2010	15	12	16	40
2011	15	14	17	12
2012	15	13	17	23
2013	15	13	16	34
2014	15	14	16	11
2015	15	14	16	3
2016	15	15	16	7
2017	15	11	17	57
2018	15	12	18	80

Table 8. American Shad aging data (male and female combined) collected from North Carolina independent sampling programs from 2000-2018.

Year	Modal Age	Minimum Age	Maximum Age	Total Number Aged
2000	5	3	7	247
2001	5	3	7	282
2002	4	3	8	279
2003	6	3	8	248
2004	6	3	8	163
2005	5	3	7	136
2006	4	3	8	66
2007	4	4	7	69
2008	5	3	8	78
2009	6	4	8	40
2010	6	3	8	123
2011	6	3	8	26
2012	6	4	8	82
2013	5	3	8	107
2014	6	4	7	39
2015	6,7	3	7	21
2016	6	3	8	26
2017	6	3	8	122
2018	5	3	8	146

FIGURES

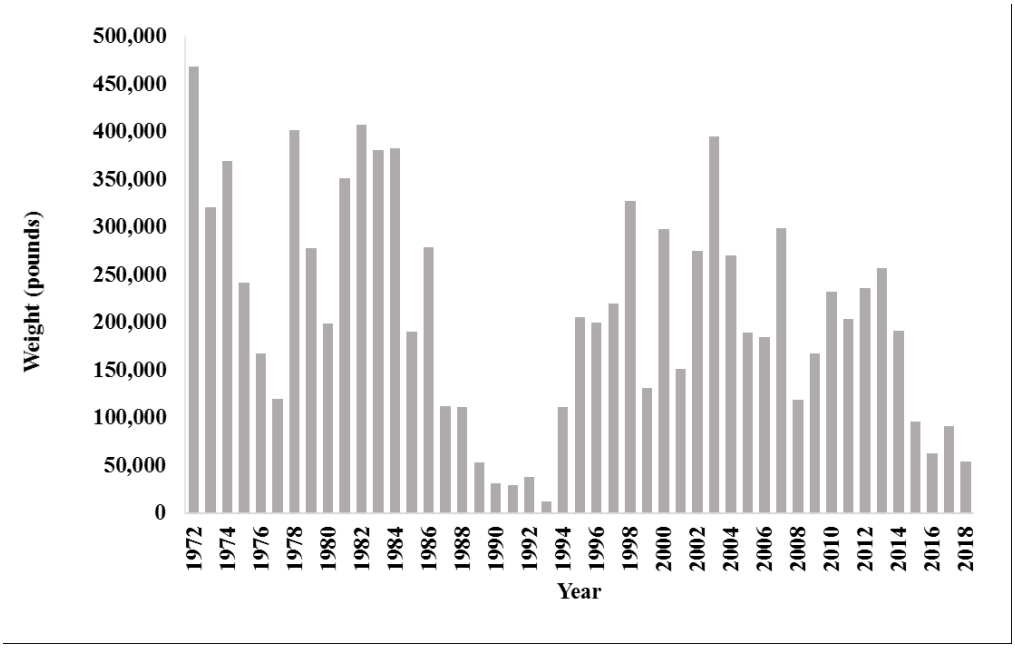

Figure 1. Commercial harvest in pounds of American shad in North Carolina from 1972-2018, all waterbodies combined.

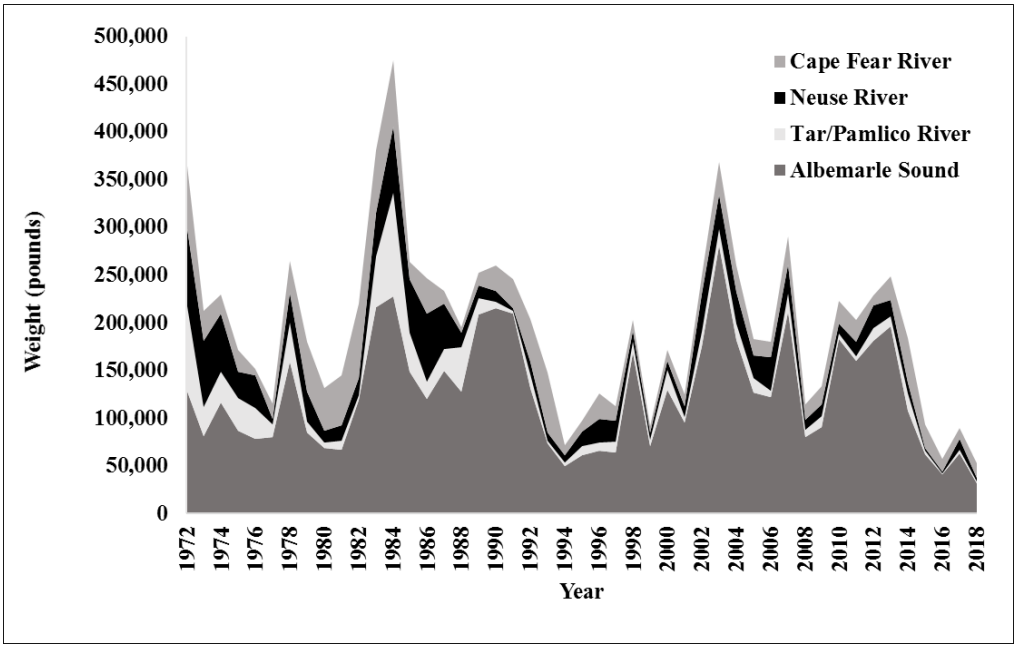

Figure 2. Landings of American shad in North Carolina by major waterbody from 1972-2018.

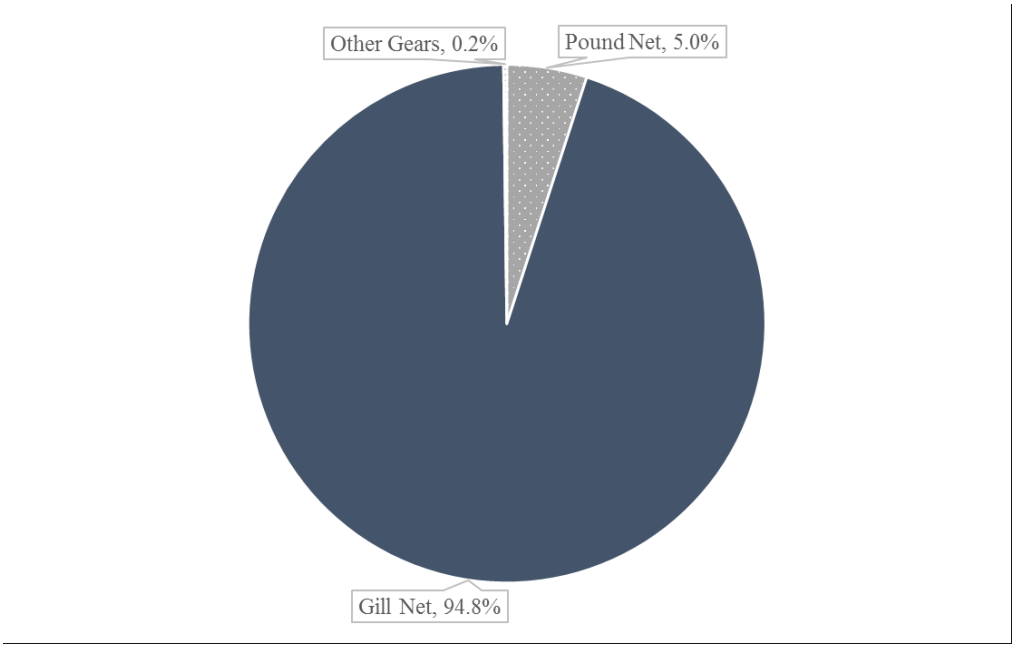

Figure 3. Commercial harvest of American Shad in 2018 by percent gear type.

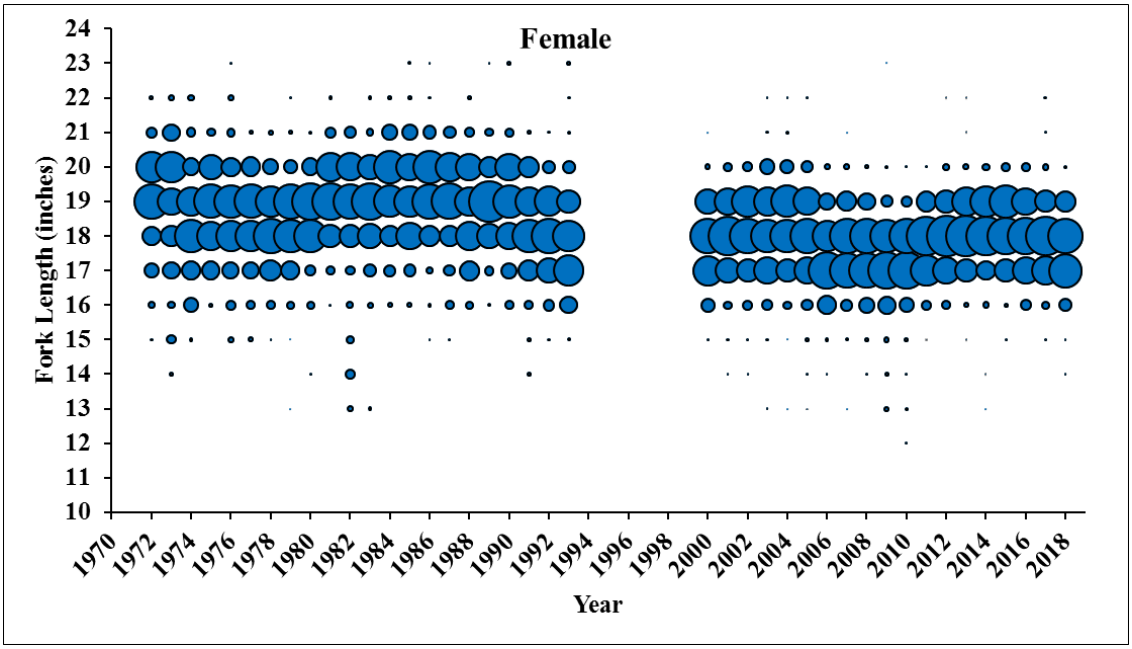

Figure 4. Commercial length frequency (fork length, inches) of female American Shad harvested from 1972-2018. Bubbles represent fish harvested at length and the size of the bubble is equal to the proportion of fish measured at that length.

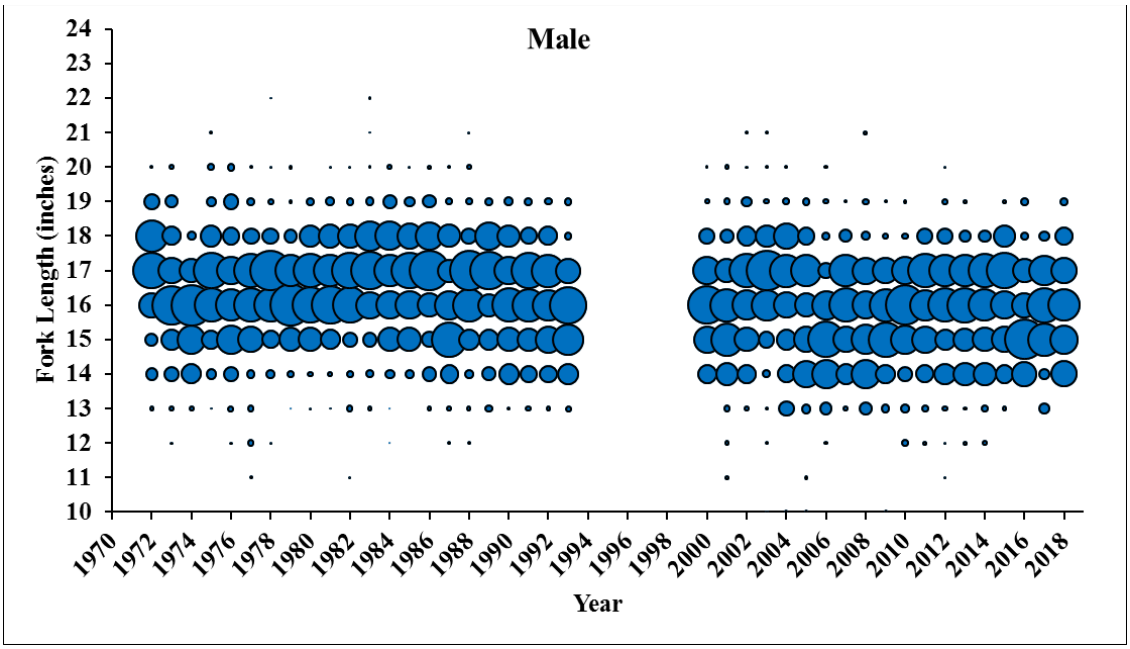

Figure 5. Commercial length frequency (fork length, inches) of male American Shad harvested from 1972-2018. Bubbles represent fish harvested at length and the size of the bubble is equal to the proportion of fish measured at that length.

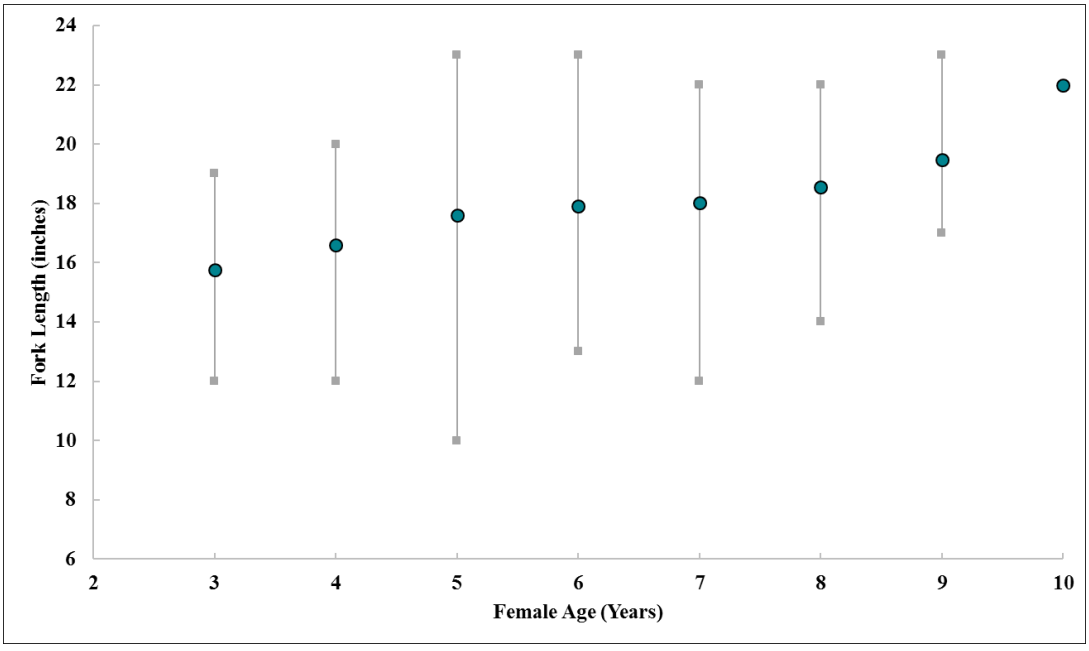

Figure 6. Female American Shad length at age from all age samples collected from commercial fisheries, 1972-2018. Blue circles represent the mean size at a given age while the gray squares represent the minimum and maximum observed size for each age.

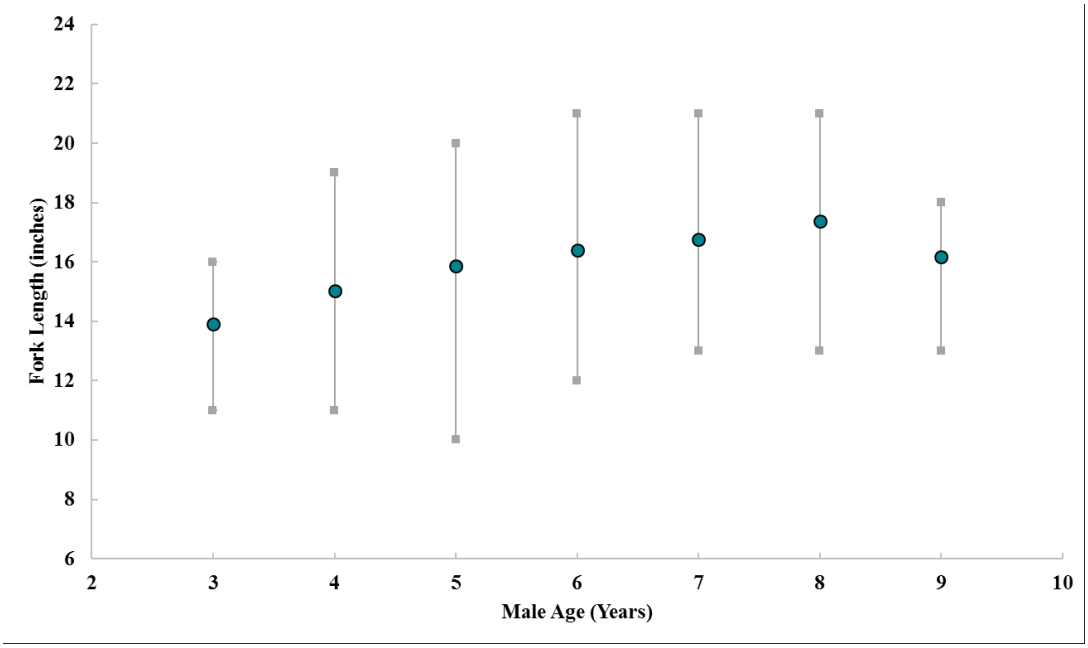

Figure 7. Male American Shad length at age from all age samples collected from commercial fisheries, 1972-2018. Blue circles represent the mean size at a given age while the gray squares represent the minimum and maximum observed size for each age.

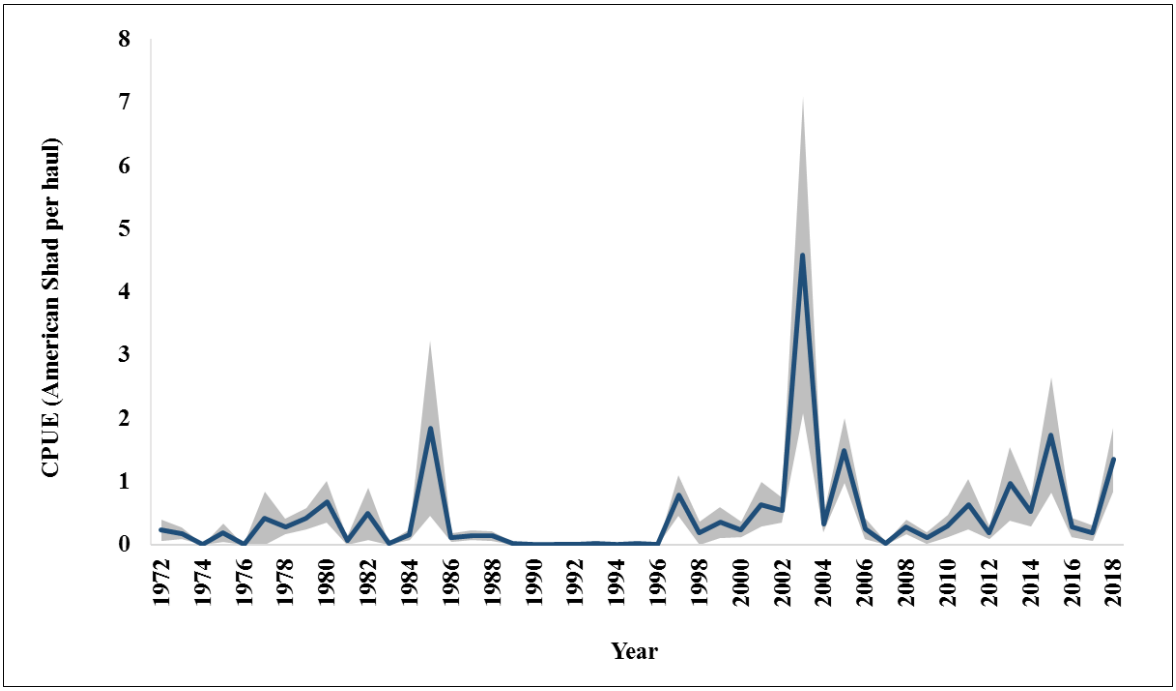

Figure 8. American Shad annual juvenile (age-0) abundance index with standard error shaded in gray from the North Carolina Albemarle Sound juvenile survey, 1972-2018.

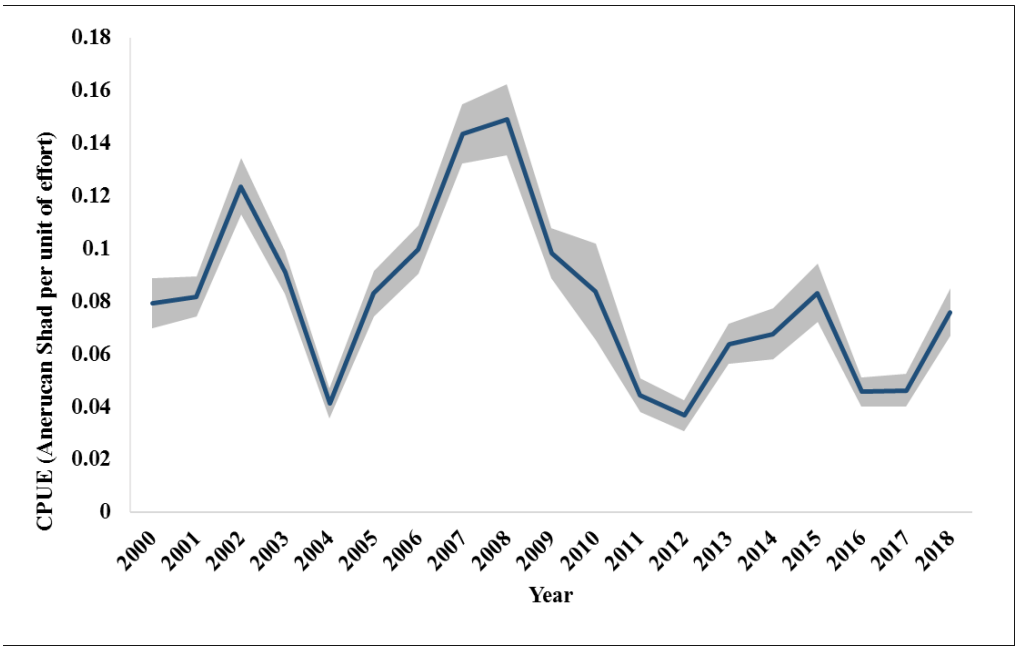

Figure 9. January-May adult American Shad CPUE (all mesh sizes, number captured, ages combined) with standard error shaded in gray from the North Carolina Albemarle Sound independent gill net survey 2000-2018.

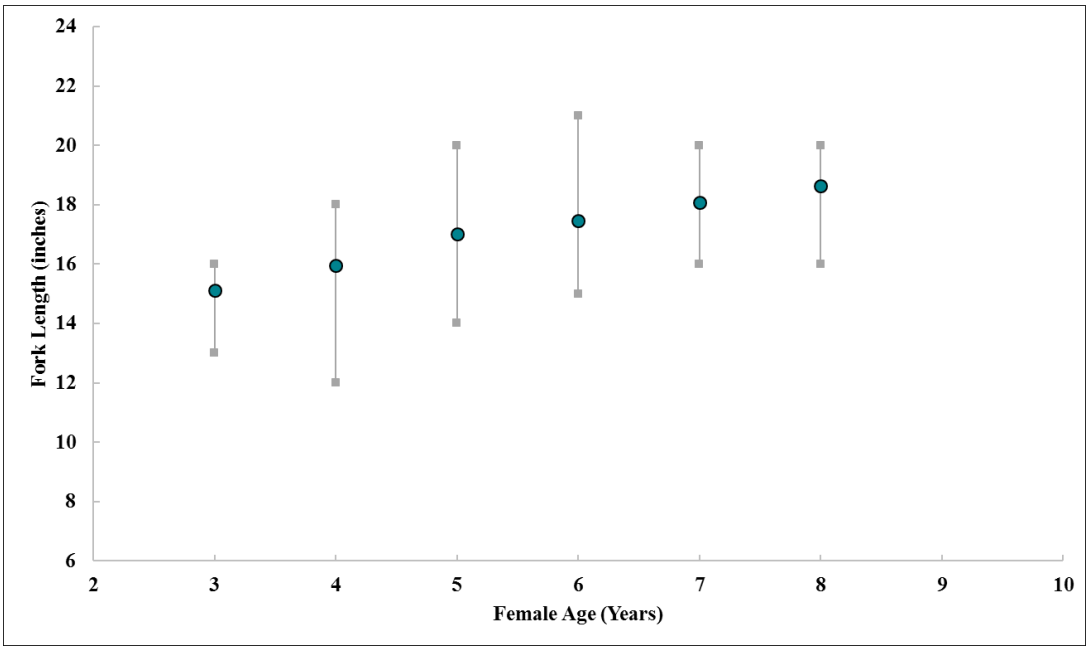

Figure 10. Female American Shad length at age from all age samples collected from North Carolina independent gill net surveys, 2000-2018. Blue circles represent the mean size at a given age while the gray squares represent the minimum and maximum observed size for each age.

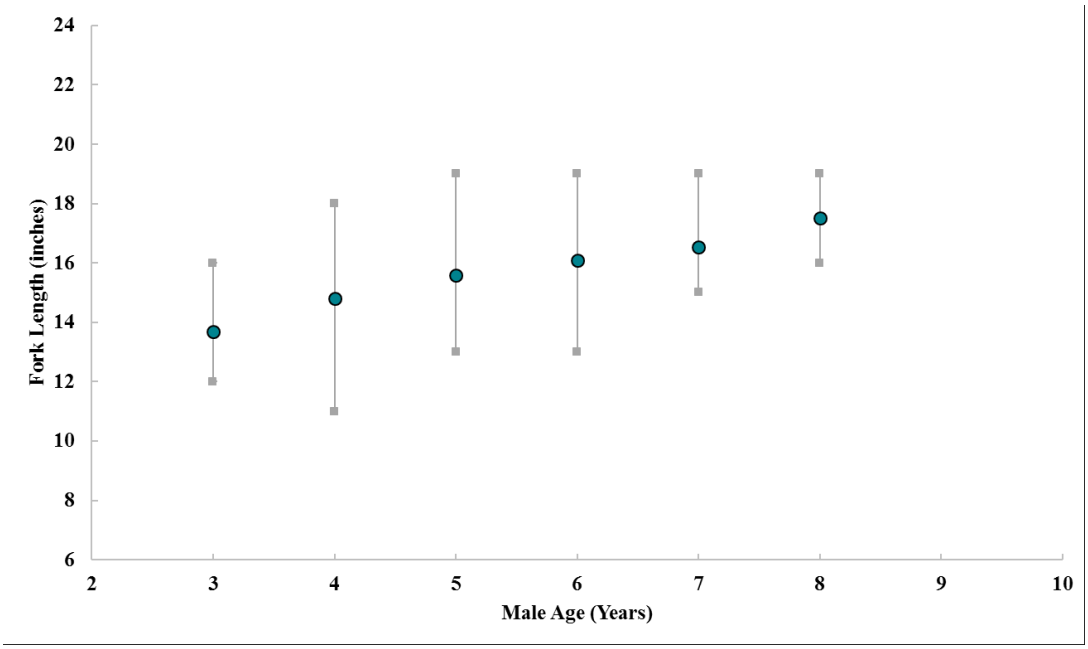

Figure 11. Male American Shad length at age from all age samples collected from North Carolina independent gill net surveys, 2000-2018. Blue circles represent the mean size at a given age while the gray squares represent the minimum and maximum observed size for each age.

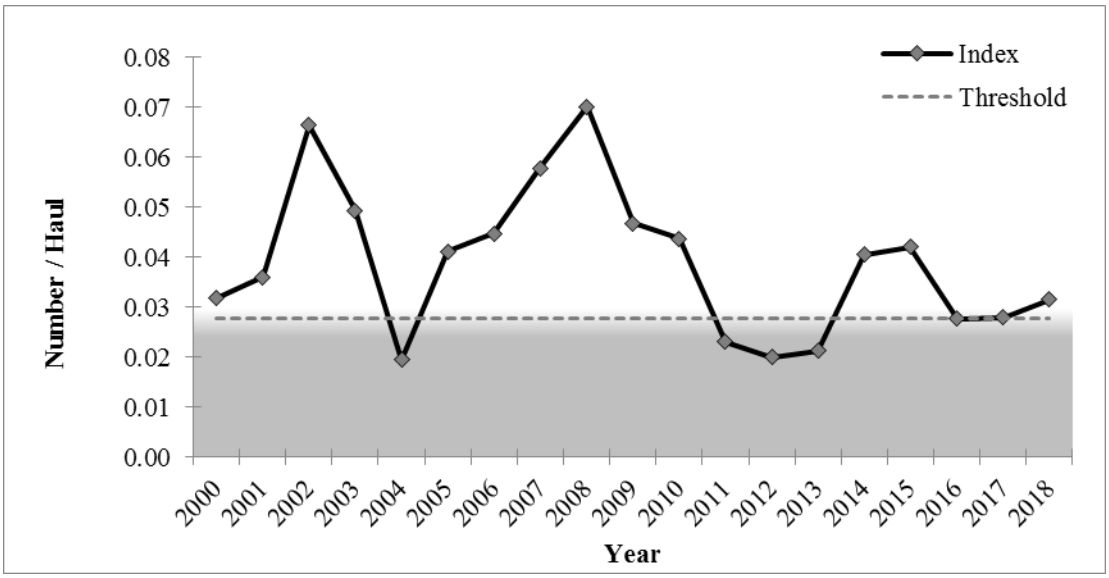

Figure 12. Albemarle Sound/Roanoke River sustainability parameter for female CPUE in the NCDMF IGNS, 2000-2018. Grey areas represent a parameter exceeding the threshold.

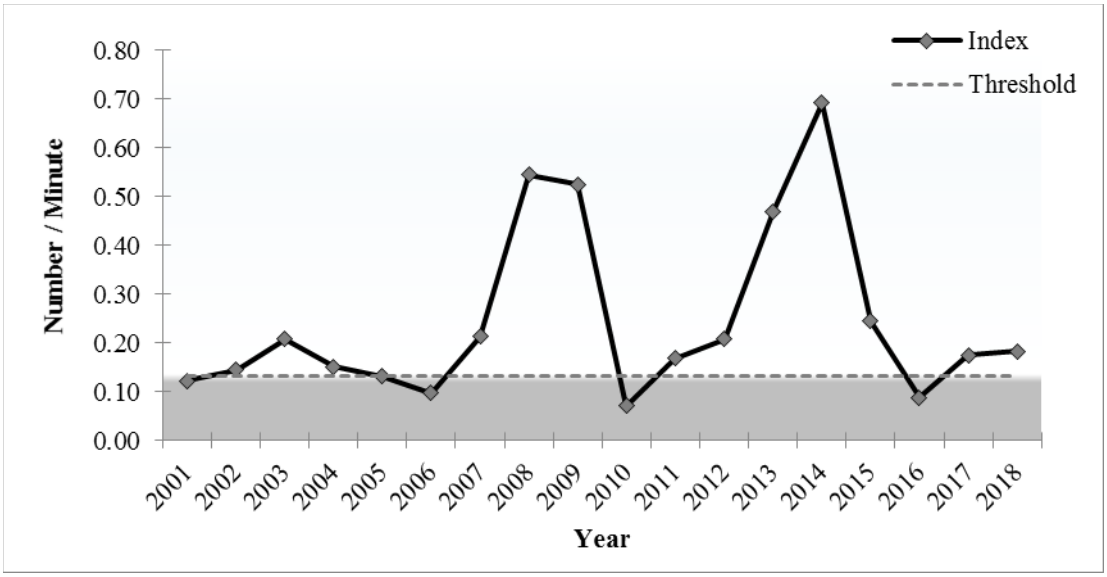

Figure 13. Albemarle Sound/Roanoke River sustainability parameter for female CPUE in NCWRC electrofishing survey, 2001-2018. Grey areas represent a parameter exceeding the threshold.

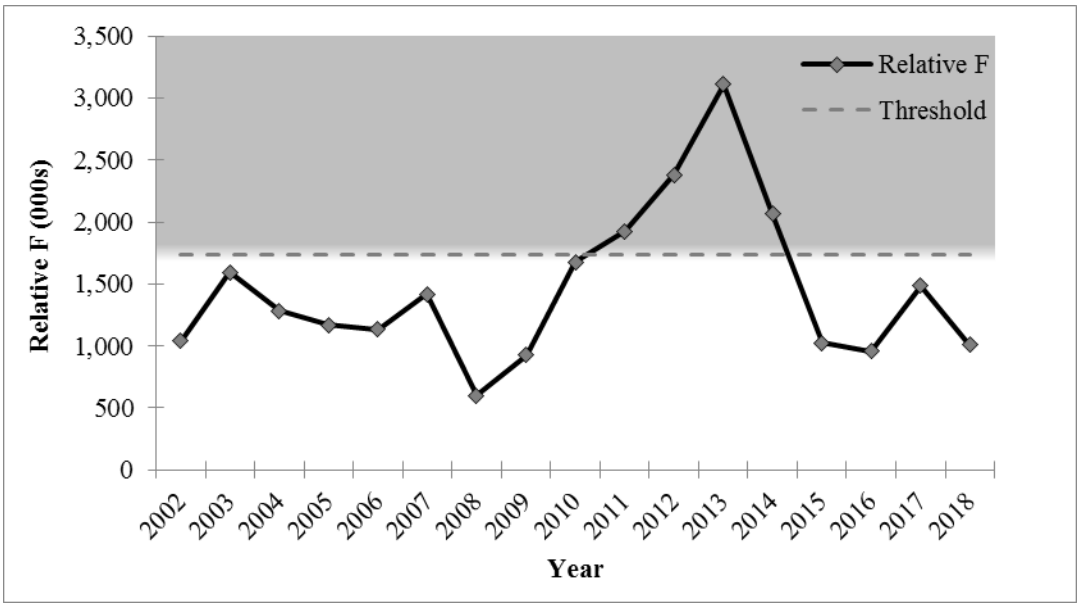

Figure 14. Albemarle Sound/Roanoke River sustainability parameter for female relative *F* in the NCDMF IGNS, 2002-2018. Grey areas represent a parameter exceeding the threshold.

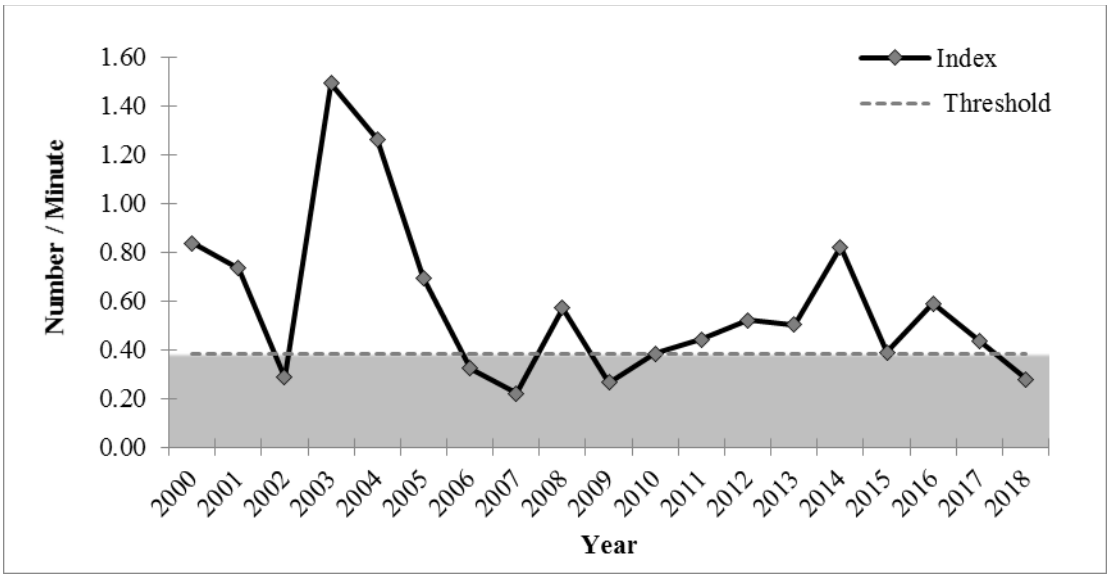

Figure 15. Tar/Pamlico River system sustainability parameter for female CPUE in NCWRC electrofishing survey, 2000-2018. Grey areas represent a parameter exceeding the threshold.

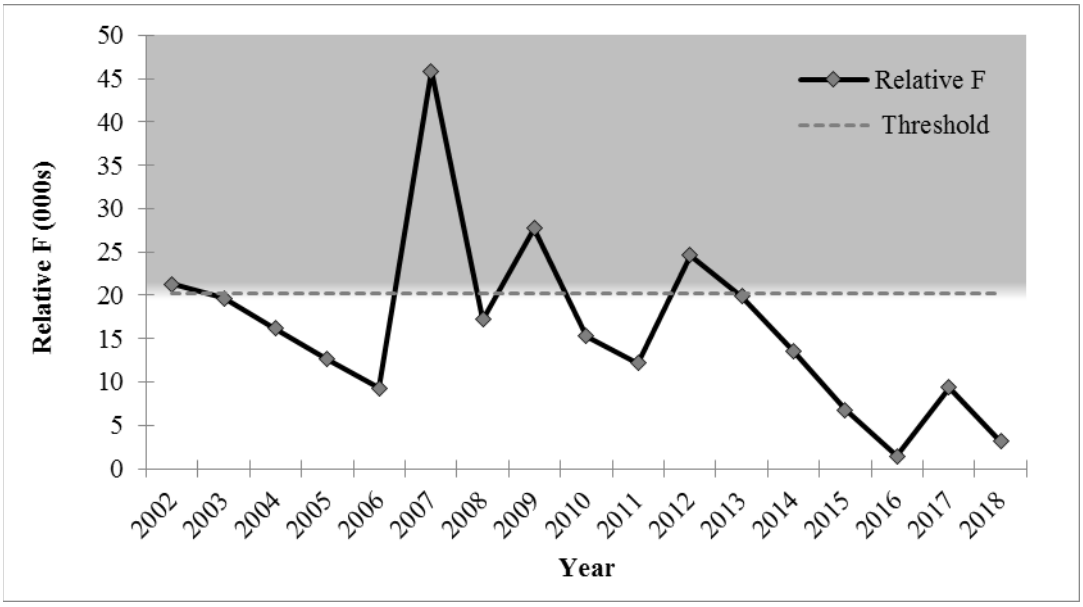

Figure 16. Tar/Pamlico River system sustainability parameter for female relative *F* in NCWRC electrofishing survey, 2002-2018. Grey areas represent a parameter exceeding the threshold.

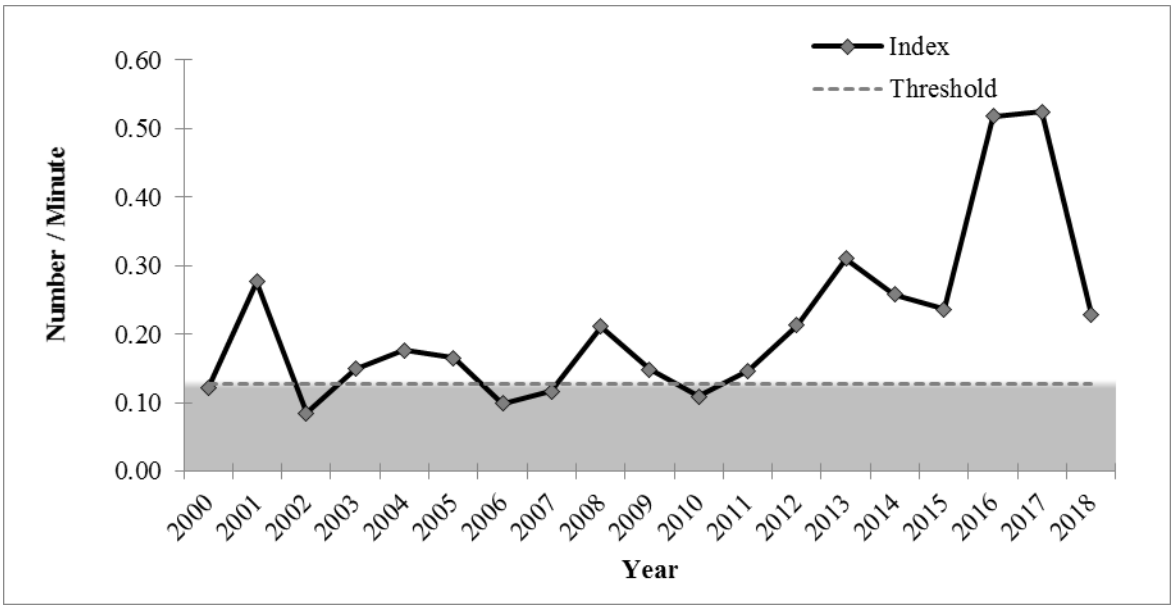

Figure 17. Neuse River system sustainability parameter for female CPUE in NCWRC electrofishing survey, 2000-2018. Grey areas represent a parameter exceeding the threshold.

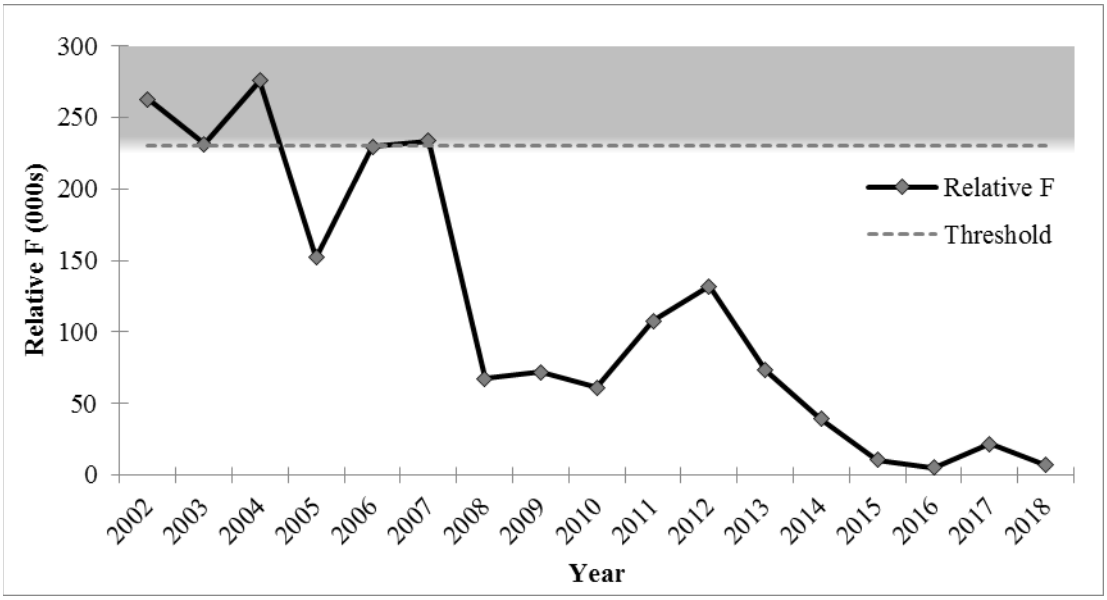

Figure 18. Neuse River system sustainability parameter for female relative *F* in NCWRC electrofishing survey, 2002-2018. Grey areas represent a parameter exceeding the threshold.

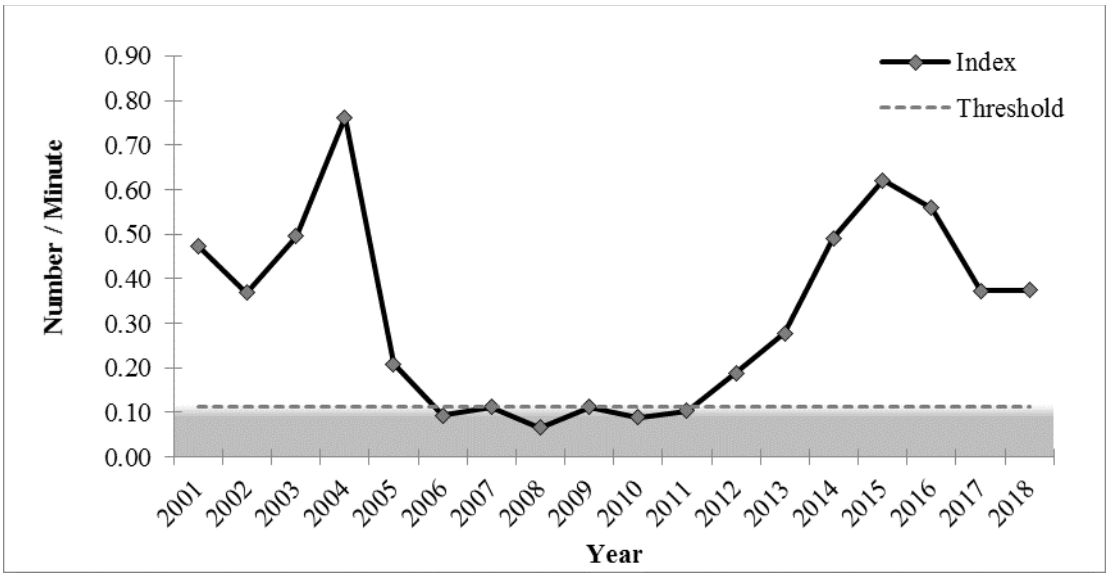

Figure 19. Cape Fear River system sustainability parameter for female CPUE in NCWRC electrofishing survey, 2001-2018. Grey areas represent a parameter exceeding the threshold.

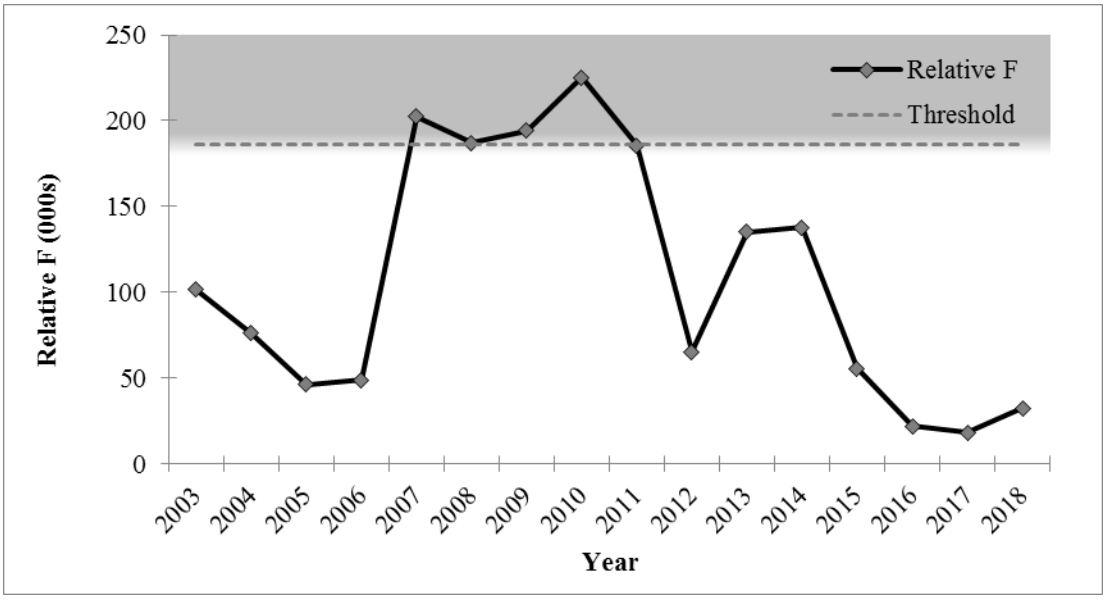

Figure 20. Cape Fear River system sustainability parameter for female relative *F* in NCWRC electrofishing survey, 2003-2018. Grey areas represent a parameter exceeding the threshold.

FISHERY MANAGEMENT PLAN UPDATE
ATLANTIC CROAKER
AUGUST 2019

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
Revisions:	None
Supplements:	None
Information Updates:	None
Benchmark Review:	Completed May 2017

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%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% 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., National Marine Fisheries Service (NMFS) 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.

A benchmark stock assessment was completed in 2017 but was not accepted for use in management by a peer review panel (ASMFC 2018, 2017). The review panel did not, however, identify any major problems in the fishery that would require immediate management action. The TLA will continue to be used to guide management decisions between stock assessments. Recommendations for a revised TLA were presented to the Board in February 2018 and were further considered for use in management in August 2018. Because adoption of the revised TLA would trigger management action, the Board requested member states to solicit public input on potential management measures before taking action. In May 2019, the Board reviewed input from the states and initiated an addendum to the Atlantic croaker FMP to incorporate the revised TLA and redefine the management response.

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:

1. Manage the fishing mortality rate to provide adequate spawning potential to sustain long-term abundance of the population.
2. Manage the stock to maintain the spawning stock biomass above the target biomass levels and restrict fishing mortality to rates below the threshold.
3. Develop a management program for restoring and maintaining essential habitat.
4. 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. 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).

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% 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 2018, 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, 2018).

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, 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.

Management was not triggered in 2017 since both the harvest and abundance population characteristics were not above the 30% threshold for the 2015-2017 time period (ASMFC 2018; Figures 1-3). However, the harvest index has generally indicated a declining trend while the adult abundance index has generally indicated an increasing or stable trend. 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. Recommendations for a revised TLA framework were presented to the Board in February 2018 and in May 2019 the Board initiated an addendum to the Atlantic croaker FMP to incorporate the revised TLA.

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 2018). 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 2018 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 6,709,999 pounds from 1989 through 2018 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). 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 fishing activity is monitored through the Marine Recreational Information Program. In this report, estimates across all years have been updated and are now based on the MRIP new Fishing Effort Survey-based calibrated estimates. For more information on MRIP methodology changes see https://www.fisheries.noaa.gov/topic/recreational-fishing-data. From 1989 through 2018 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). Some of the harvest decline in 2018 can likely be attributed to Hurricane Florence, which hit the North Carolina coast in September of that year. From 1989 through 2018, the number of releases averaged 4,109,289 individuals, with 4,311,368 releases in 2018.

The number of Atlantic croaker measured during MRIP sampling has generally remained stable since 1998 (Table 2). Mean total length (TL) in 2018 was 8.9 inches and has fluctuated little since 1989. Similarly, minimum and maximum TL have also fluctuated little since 1989, though maximum TL has declined recently. In 2018, modal length in the recreational harvest was 9.0 inches TL and only a few fish harvested were over 10.0 inches (Figure 6). The recreational fishery did harvest Atlantic croaker between 5.0 and 7.0 inches TL which are size classes that 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. Minimum TL ranged from 3.0 inches to 7.4 inches. Maximum TL ranged from 15.2 inches to 20.0 inches. Scrap samples are included in calculations of mean, minimum and maximum length.

In 2018, modal length in the commercial fishery was 9.0 inches TL and only a few fish harvested were over 10.0 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 scrap samples) generally increased from 1993 through the early 2000's but has been contracting and declining since (Figure 8).

Fishery Independent Monitoring

The number of Atlantic croaker aged in North Carolina from 1996 through 2018 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 nine from 2011-2018. 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 2018 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 declined to 137 individuals per tow in 2018, which is an 88% decrease from the 2017 JAI. The 2017 JAI was the second highest value in the time series and the 2018 JAI was the 15th lowest value in the time series. The mean JAI over the 32-year time series is 341 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 2017 since both population characteristics (harvest and abundance) were not above the 30% threshold for the 2015-2017 time period. Recommendations for a revised TLA were presented to the Board in February 2018 and were further considered for use in management in August 2018. Because adoption of the revised TLA would trigger management action, the Board requested member states to solicit public input on potential management measures before taking any action. In May 2019, the Board reviewed input from the states and initiated an addendum to the Atlantic croaker FMP to incorporate the revised TLA and redefine the management response. See Table 6 for 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 coast-wide and state specific research recommendations have been identified and ranked through the ASMFC FMP and stock assessment process and include (ASMFC 2018, 2017):

- 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 coast-wide 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)

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TABLES

Table 1. Atlantic croaker recreational harvest and number released (Marine Recreational Information Program) and commercial harvest (North Carolina Trip Ticket Program), 1989-2018. 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
Mean	1,358,803	4,109,289	536,119	6,884,702	7,246,118

Table 2. Total number measured, mean, minimum, and maximum length (inches) of Atlantic croaker measured by MRIP sampling in North Carolina, 1989-2018.

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	626	8.4	5.1	15.5
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

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, 1994-2018. Scrap 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

Table 5. Total number aged, modal, minimum, and maximum age of Atlantic croaker in North Carolina from fishery dependent and fishery independent sampling, 1996-2018. Includes otolith ages only.

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

Table 6. Summary of management strategies and needs.

Management Strategy	**Implementation Status**
Establish Traffic Light method for monitoring the stock in non-assessment years	Addendum 2 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

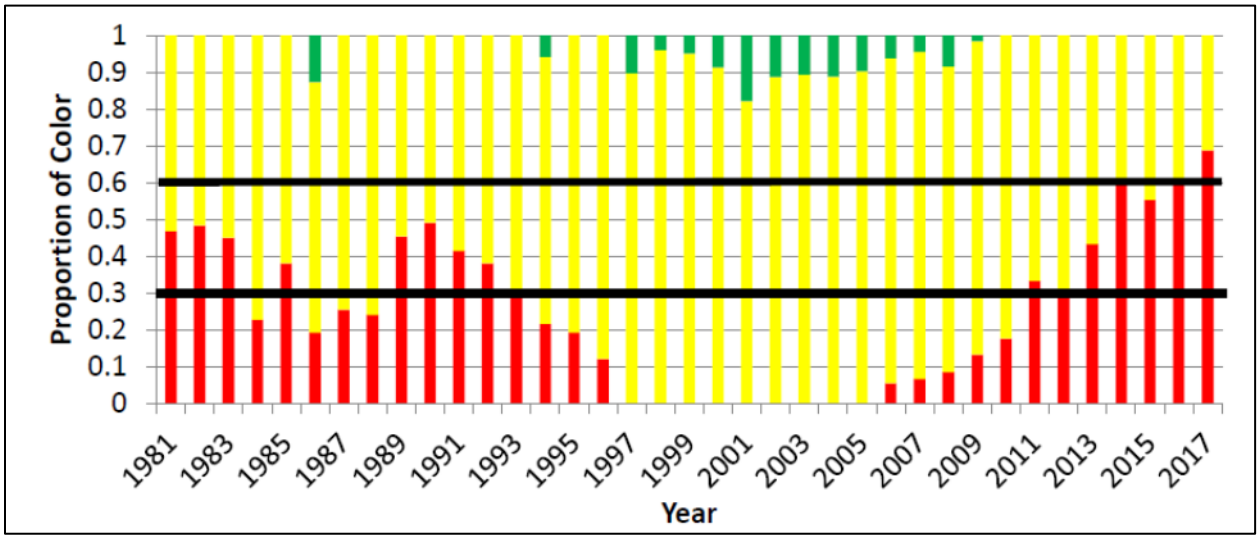

Figure 1. Annual color proportions for the harvest composite Traffic Light Analysis of Atlantic croaker recreational and commercial landings, 1981-2017 (ASMFC 2018). Bottom black line is the 30% threshold and top black line is the 60% threshold for management action. The reference period is 1996-2008.

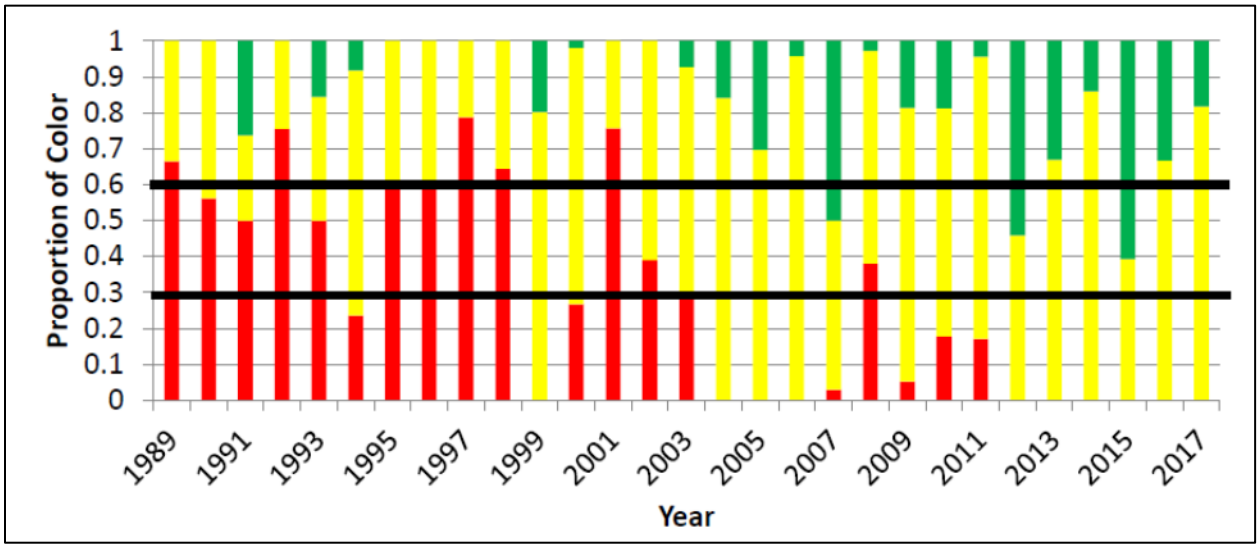

Figure 2. Annual color proportions for the adult Atlantic croaker Traffic Light Analysis composite characteristic index (NMFS and SEAMAP surveys), 1989-2017 (ASMFC 2018). Bottom black line is the 30% threshold and top black line is the 60% threshold for management action. The reference period is 1996-2008.

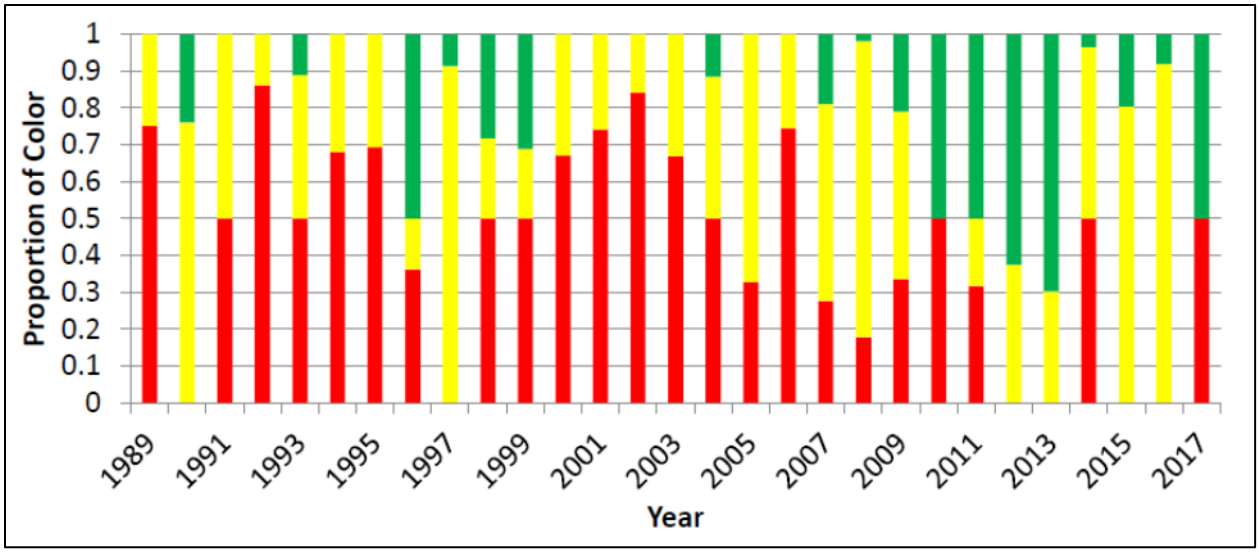

Figure 3. Annual color proportions for the juvenile Atlantic croaker Traffic Light Analysis composite characteristic index (Pamlico Sound Survey and Virginia Institute of Marine Science Survey), 1989-2017 (ASMFC 2018). Reference period is 1996-2008. Juvenile index does not trip management action.

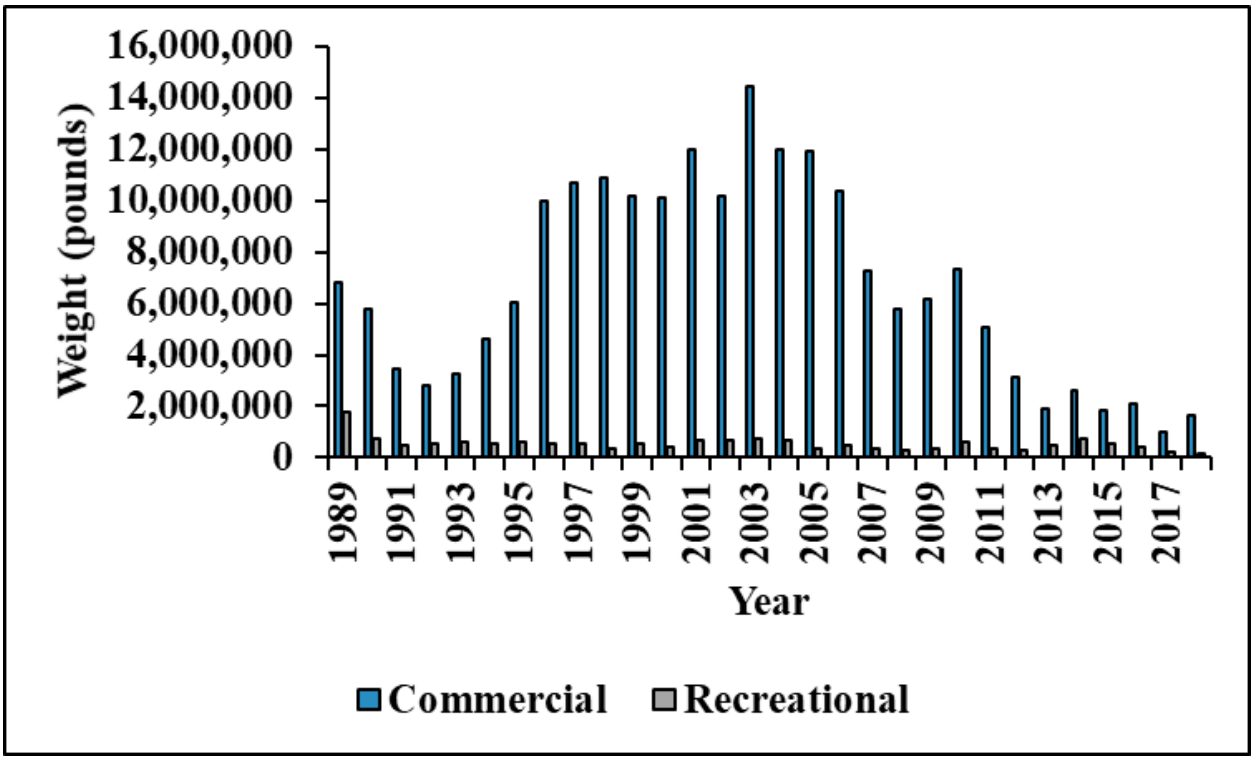

Figure 4. Annual commercial (1989-2018) and recreational (1989-2018) landings in pounds for Atlantic croaker in North Carolina.

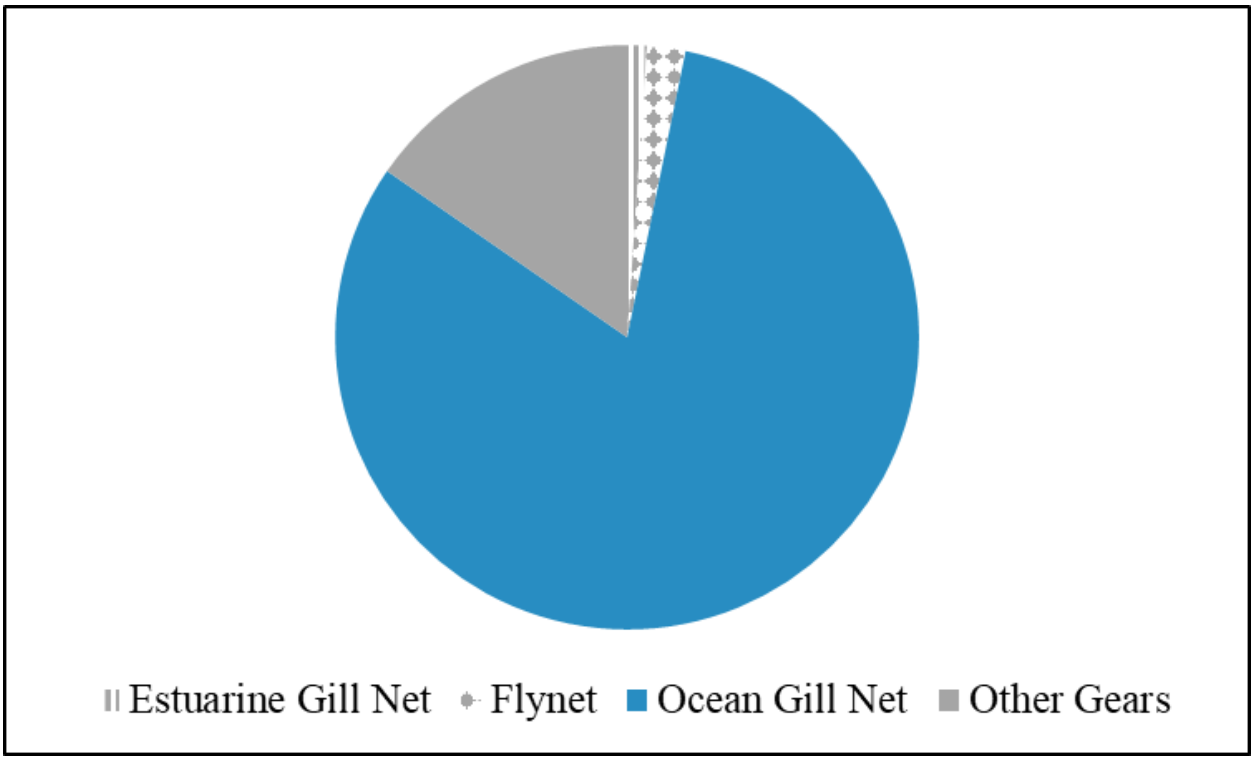

Figure 5. Commercial harvest of Atlantic croaker by gear, 2018. Other gears include flounder trawls, haul seines and pound nets.

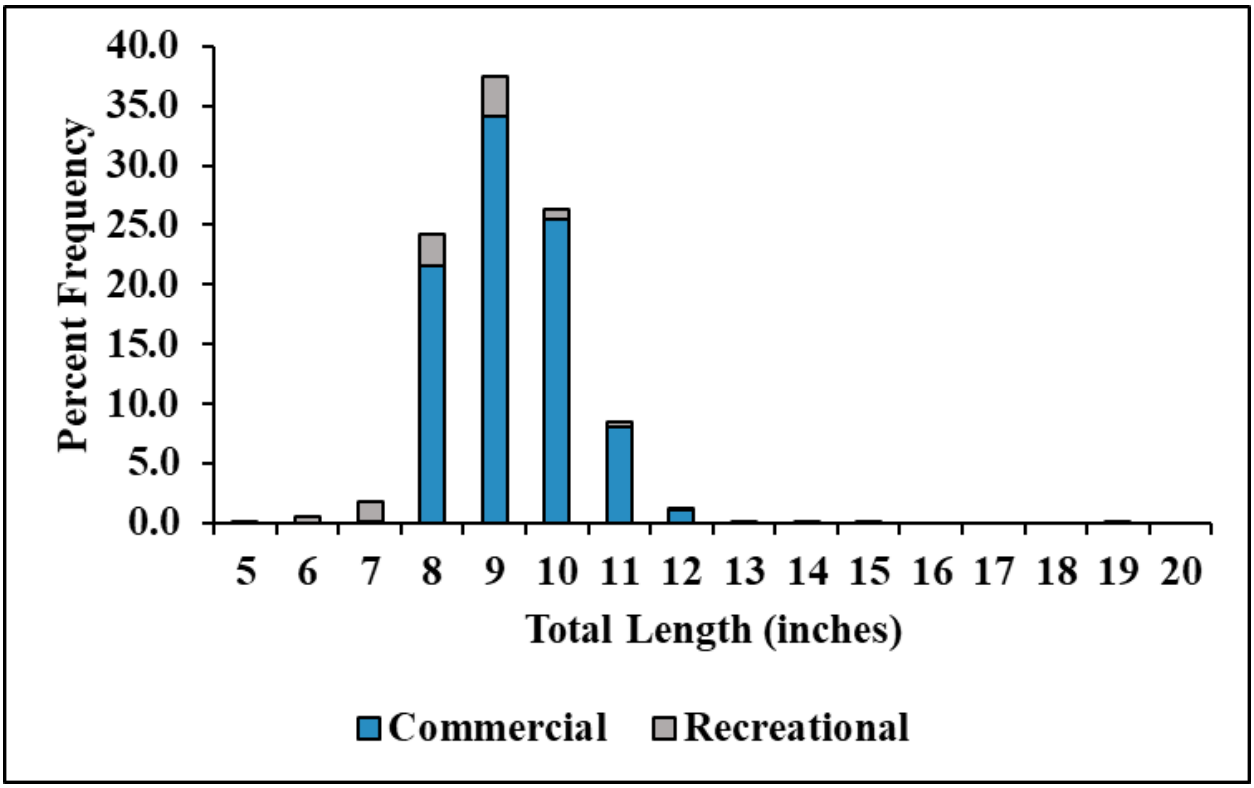

Figure 6. Commercial and recreational length frequency distribution from Atlantic croaker harvested in 2018.

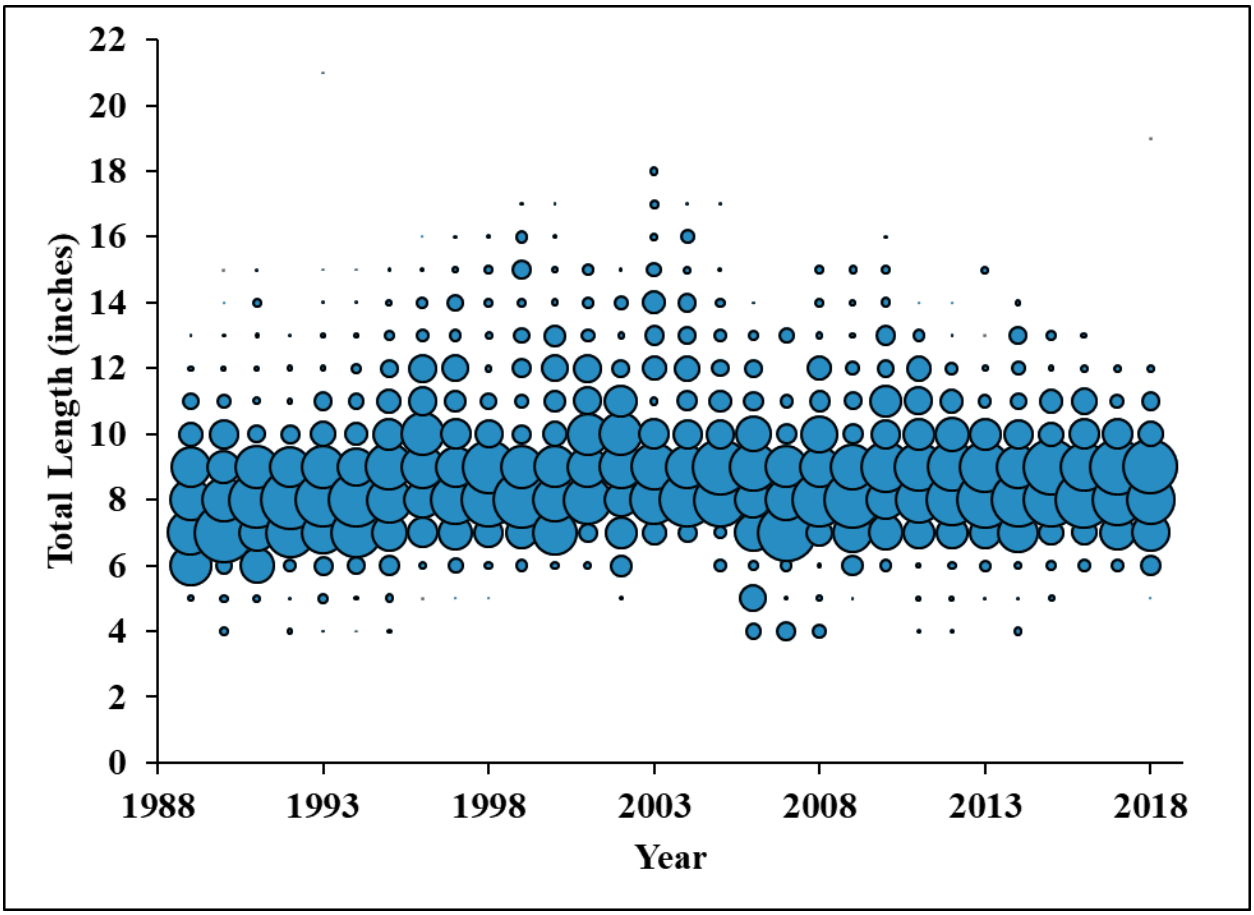

Figure 7. Recreational length frequency (total length, inches) of Atlantic croaker harvested from 1989-2018. Bubble represents the proportion of fish at length.

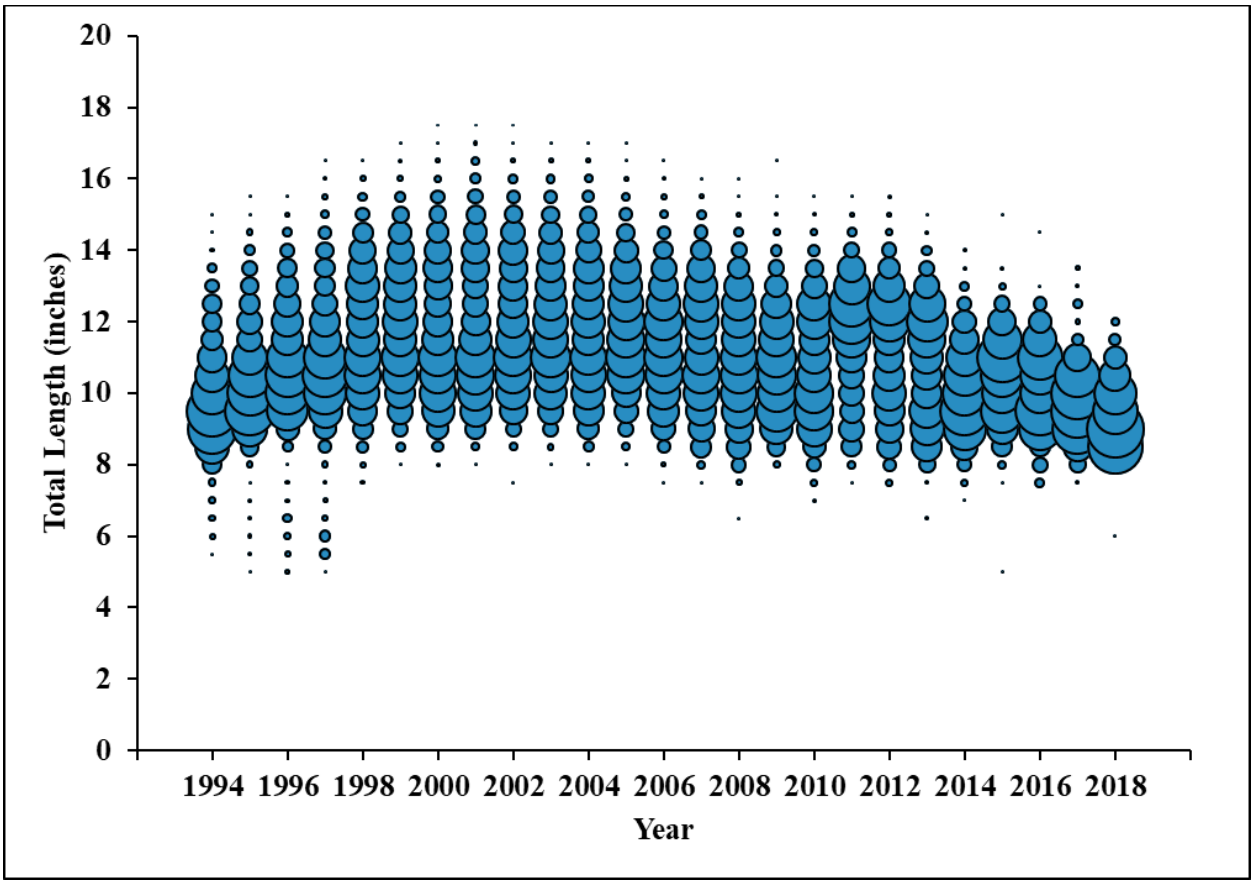

Figure 8. Commercial length frequency (total length, inches) of Atlantic croaker harvested from 1994-2018. Bubble represents the proportion of fish at length. Scrap samples not included.

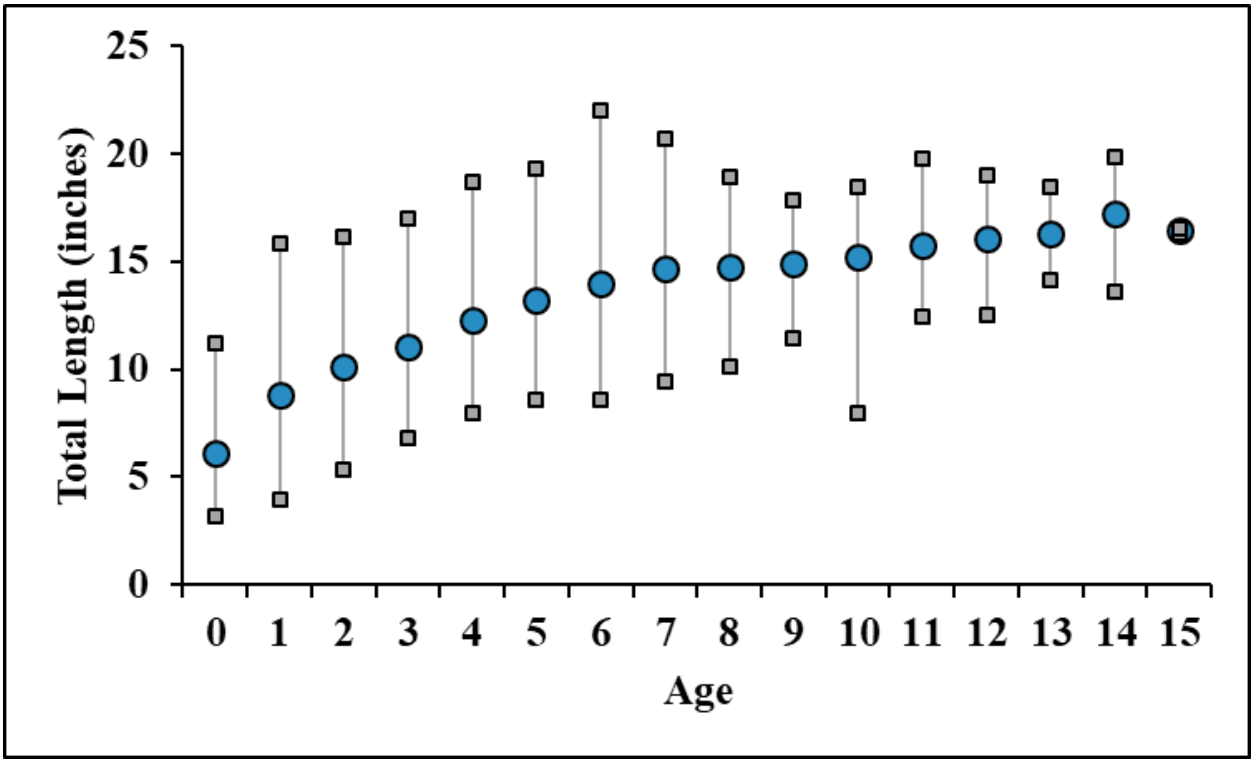

Figure 9. Atlantic croaker length at age based on all age samples collected from 1996 to 2018. Blue circles represent the mean size at a given age while the grey squares represent the minimum and maximum observed size for each age.

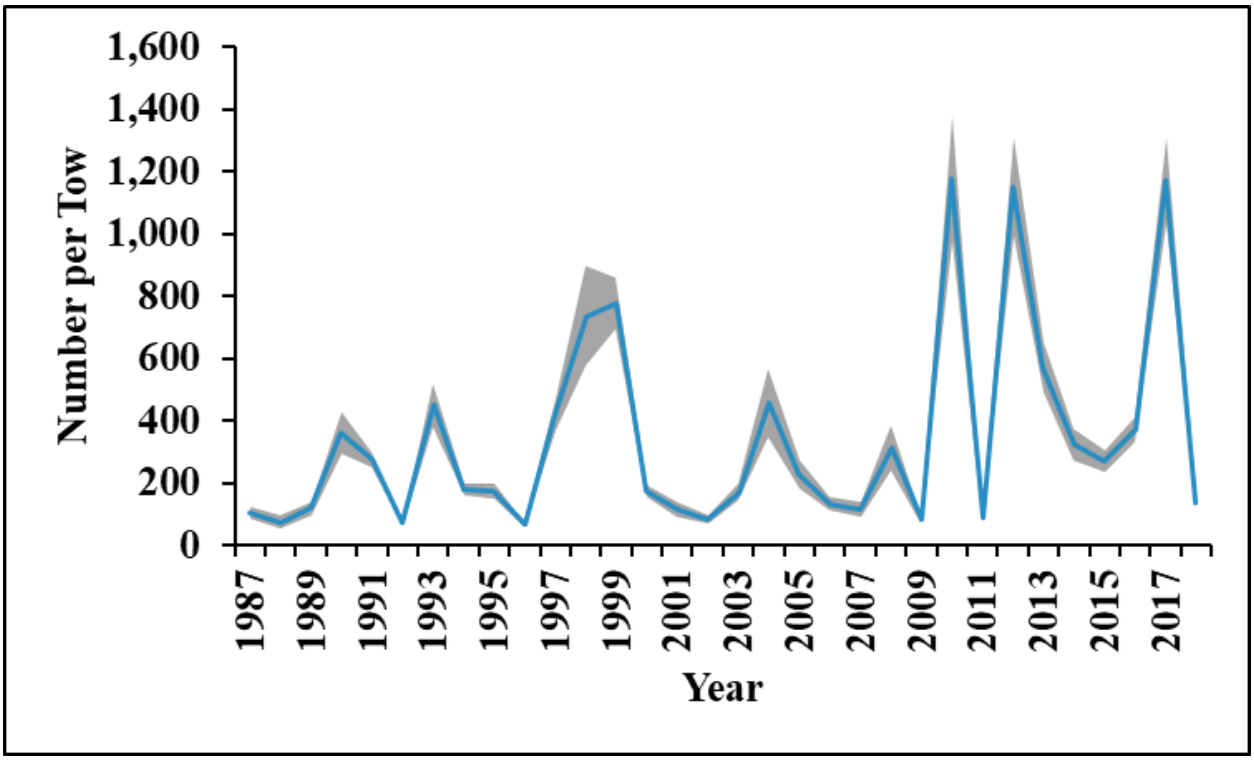

Figure 10. Atlantic croaker juvenile (<140 mm, 5.5 inches TL) abundance index (CPUE; number per tow) for June from the Pamlico Sound Survey, 1987-2018. Shaded area represents standard error.

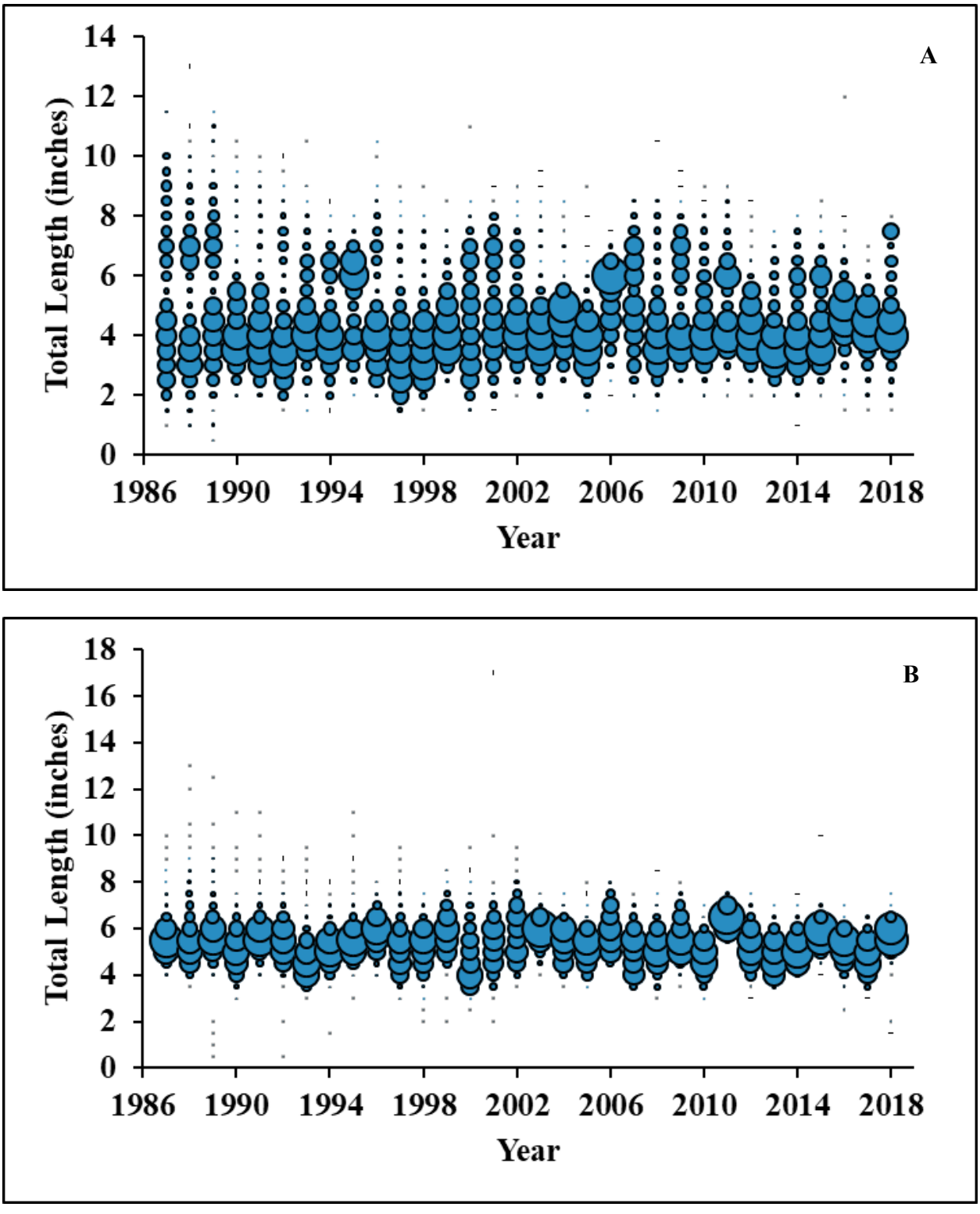

Figure 11. Length frequency of Atlantic croaker captured in Pamlico Sound Survey sampling during June (A) and September (B), 1987-2018.

FISHERY MANAGEMENT PLAN UPDATE
ATLANTIC MENHADEN
AUGUST 2019

STATUS OF THE FISHERY MANAGEMENT PLAN

Fishery Management Plan History

Original FMP Adoption:	August 1981
Amendments:	Amendment 1 – July 2001 Addendum I – August 2004 Addendum II – October 2005 Technical Addendum I – February 2006 Addendum III – November 2006 Addendum IV – November 2009 Addendum V – November 2011 Amendment 2 – December 2012 Technical Addendum I – May 2013 Addendum I – August 2016 Amendment 3 – November 2017
Revisions:	Revision – September 1992
Supplements:	Supplement – October 1986
Information Updates:	None
Next Benchmark Review:	2020

The first Atlantic States Marine Fisheries Commission (ASMFC) Atlantic Menhaden Fishery Management Plan (FMP) was approved in August 1981. The objective of the original plan was to achieve a coast-wide age composition of landings in the purse seine fishery by spawners and achieve the greatest continuing yield for each area by determining age at harvest and eliminating other restrictions not contributing to management goals. Revision to the FMP was approved in 1992. The revised FMP was the result of an updated stock assessment. In 2001, Amendment 1 to the FMP was approved. This Amendment adopted a new stock assessment and new overfishing definition, as well as required mandatory reporting for all menhaden purse seine fisheries. Addendum I to Amendment 1 was approved in August 2004 to modify the biological reference points, stock assessment schedule and revise the habitat section. The 2003 stock assessment used a new model with a fecundity-based biological reference point to determine stock status. Addendum II was approved by the ASMFC Atlantic Menhaden Management Board in 2005 and established a five-year annual cap on reduction fishery landings in Chesapeake Bay and was implemented in 2006. Addendum II also established a research program to determine the menhaden population abundance in the Chesapeake Bay and to address localized depletion.

Passed in November of 2006, Addendum III mirrored the intent and provisions of Addendum II, but incorporated 2005 landings data and allowed for the transfer of under-harvest to the following year's harvest. The ASMFC Atlantic Menhaden Management Board then approved Addendum IV in November of 2009 which extended the Chesapeake Bay reduction fishery harvest cap, established through Addendum III, for an additional three years (2011 to 2013). In 2010, the ASMFC Atlantic Menhaden Management Board tasked the Atlantic Menhaden Technical Committee (TC) to develop alternative reference points. In addition, the Policy Board directed the Multispecies TC to work with the Menhaden TC to explore reference points that account for predation. Addendum V was approved in November 2011 and established a new interim fishing mortality threshold and target (based on maximum spawning potential or MSP) with the goal of increasing abundance, spawning stock biomass, and menhaden availability as a forage species. The new threshold and target equated to a MSP of 15% and 30%, respectively.

The development of Amendment 2 established a 170,800 MT (376,549,543 pounds) total allowable catch (TAC) beginning in 2013 that continued until completion of and Board action on the 2015 benchmark stock assessment. The TAC was based on a 20% reduction from the 2009 to 2011 three-year average of total coast-wide catch. Additionally, a bycatch allowance of 6,000 pounds per vessel per day was established when states met their TAC. The Board adopted new biological reference points for biomass based on MSP, with the goal of increasing abundance, spawning stock biomass, and menhaden availability as a forage species. In 2013, Technical Addendum I to Amendment 2 established a set aside program for episodic events. The 2015 Atlantic menhaden stock assessment update indicated menhaden are not overfished and overfishing is not occurring, which resulted in Board action to increase the TAC for both 2015 and 2016 to 187,880 MT (414,204,497 pounds), a 10% increase. Addendum I, approved in August 2016, modified the bycatch allowance to authorize two individuals fishing stationary gear from the same vessel to land 12,000 pounds per day. This Addendum supported a history, especially in the pound net industry, of cooperative fishing which enables fishermen to pool resources. In October 2016, the Atlantic Menhaden Board increased the TAC by 6.45% setting the 2017 TAC at 200,000 MT (440,924,523 pounds).

Amendment 3 maintained the single-species biological reference points management program until the review and adoption of ecological reference points (ERPs). The intent of menhaden-specific ERPs is to provide a method to assess the status of menhaden not only in regard to their own sustainability, but also in regard to their interactions with predators and the status of other prey species. This approach allows fishery managers to consider the harvest of menhaden within a broad ecosystem context, which includes other fish, birds, mammals, and humans who utilize and depend on marine resources. The TAC for 2018 and 2019 fishing seasons at 216,000 MT (476,198,485 pounds). Subsequent years' TAC will be guided by menhaden-specific ecological reference points. Amendment 3 allocated a baseline quota of 0.5% to each jurisdiction, and then additional TAC was allocated based on historic 2009 to 2011 landings. Additionally, the quota transfer program was maintained, quota rollover was prohibited, the 6,000-pound trip limit for non-directed and small-scale gears following the closure of the directed fishery was maintained, and 1% of the TAC was set aside for episodic events from New York through Maine. Finally, the Chesapeake Bay reduction fishery cap was reduced from 87,216 MT (192,278,366 pounds) to 51,000 MT (112,435,753 pounds).

To ensure compliance with interstate requirements, North Carolina also manages this species 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 plans) and the Atlantic Coastal Fisheries Cooperative Management Act (ASMFC plans) are like the goals of the Fisheries Reform Act of 1997 to "ensure long-term viability" of these fisheries (NCDMF 2015).

Management Unit

The management unit is defined as the Atlantic menhaden resource throughout the range of the species within U.S. waters of the northwest Atlantic Ocean from the estuaries eastward to the offshore boundary of the Exclusive Economic Zone (EEZ). The Atlantic states from Maine through Florida including Pennsylvania are included in the management unit.

Goal and Objectives

The goal of Amendment 3 is to manage the Atlantic menhaden fishery in a manner which equitably allocates the resource's ecological and economic benefits between all user groups. The primary user groups include those who extract and utilize menhaden as a source of prey, and those whose livelihood depends on the health of the marine ecosystem (ASMFC 2017).

STATUS OF THE STOCK

Life History

Atlantic menhaden (*Brevoortia tyrannus*) are an estuarine-dependent species with a single stock along the Atlantic coast that range from northern Florida to Nova Scotia. Menhaden form large nearshore schools from early spring through early winter. By summer, schools divide by size and age, with older and larger menhaden distributing farther north. During fall and early winter, menhaden migrate south to North Carolina to spawn 20-30 miles offshore. Sexual maturity is reached between ages 1 and 3. Floating egg masses hatch within two to three days of spawning and ocean currents carry larvae into estuarine nursery areas where they develop into juveniles and remain during their first year. Research indicates that the number of new fish that enter the fishery annually (year-class strength) is likely determined by environmental factors (currents, temperature, predation, etc.) acting on larvae as they approach and enter inlets and nursery areas. Atlantic menhaden can live up to 10 years. Atlantic menhaden strain microscopic organisms drifting or floating in the water column while swimming in schools near the surface. Atlantic menhaden are important prey to many species including striped bass, bluefish, osprey, dolphins, and whales.

Stock Status

The ASMFC stock status of Atlantic menhaden in 2017 is not overfished and overfishing is not occurring. Based on the current adopted benchmarks, the Atlantic menhaden stock status is not overfished and overfishing is not occurring (SEDAR 2015). The biological reference point used to determine the fecundity target is defined as the mature egg production one would expect when the population is being fished at the threshold fishing mortality rate. Fishing mortality rates have remained below the revised overfishing threshold ($F_{26\%MSP} = 1.26$) since the 1960s and below the target ($F_{57\%MSP} = 0.38$) since 2003. Fishing mortality is now 42% below the target. Population fecundity, a measure of reproductive capacity, was estimated to be well above both the threshold (86 trillion eggs) and the target (189 trillion eggs) in recent years. In 2013, fecundity is estimated to have been 71% higher than the threshold value. This means that the spawning stock in 2013 appears to be more than adequate to produce the target number of eggs, and thus the population is not overfished.

Stock Assessment

The 2015 benchmark stock assessment for Atlantic menhaden was initiated in late 2012 (SEDAR 2015). The TC initiated the benchmark stock assessment to identify and evaluate all available data sources and explore alternative model configurations as recommended by the 2009 peer review panel. In this benchmark assessment, significant changes were made to growth, maturity, natural mortality, indices of relative abundance, and the selectivity of fisheries. Additionally, this benchmark assessment incorporates a "fleets-as-areas" base model configuration, such that the reduction and bait fisheries were divided into northern and southern regions, creating four separate fleets.

STATUS OF THE FISHERY

Current Regulations

No regulatory changes were made in 2018 that affected menhaden.

Effective January 1, 2013, a law was passed making it unlawful to harvest menhaden with a purse seine net deployed by a mother ship and one or more runner boats within North Carolina's three-mile jurisdiction.

Commercial Landings

North Carolina's Atlantic menhaden landings have been on a decline, especially since the last menhaden processing factory in North Carolina closed in 2005. Landings have remained relatively constant since 2012 (Table 1 and Figure 1). The average landings over the last 10 years were 1,150,379 pounds. Since 2013, landings have been regulated under the TAC initiated in Amendment 2. North Carolina has landed on average 28% of the state allocated portion of the TAC, the majority of which is used for bait in the blue crab and recreational fisheries. The decline in commercial landings is likely due to the removal of the purse seine fishery and loss of

processing facilities. Gill nets are now the most common gear used to harvest menhaden throughout the state (Figure 2).

Recreational Landings

In October 2011, the North Carolina Division of Marine Fisheries implemented a recreational cast net and seine mail survey to develop catch and effort estimates for various species, including menhaden. Menhaden are used as live bait by recreational anglers, and from 2011 to 2017 recreational annual harvest averaged 66,928 fish harvested and 87,825 fish released (Table 1).

MONITORING PROGRAM DATA

Fishery-Dependent Monitoring

Commercial fishing activity is monitored in a variety of North Carolina Division of Marine Fisheries (NCDMF) fishery-dependent sampling programs (P400 series) for compliance with ASMFC requirements. Monitoring includes the sink net fishery, winter trawl fishery, estuarine gill net fishery, and sciaenid pound net fishery. Commercial landings of Atlantic menhaden are monitored through the NCDMF Trip Ticket Program. Table 2 describes the mean, minimum, and maximum lengths of Atlantic menhaden sampled from North Carolina fishery-dependent monitoring. Mean lengths in the menhaden commercial fishery have remained fairly consistent from 2009 to 2018 (Figure 3).

Fishery-Independent Monitoring

Atlantic menhaden are sampled in a variety of NCDMF independent surveys for compliance with ASMFC requirements (Figures 4-5). However, NCDMF surveys were not used in the 2015 benchmark stock assessment. Atlantic menhaden are sampled in the North Carolina Estuarine Trawl Survey, Pamlico Sound Survey, the Juvenile Anadromous Survey, the Striped Bass Independent Gill Net Survey, and the Pamlico Sound Independent Gill Net Survey.

MANAGEMENT STRATEGY

In May 2015, the ASMFC Atlantic Menhaden Management Board approved a TAC for the 2015 and 2016 fishing seasons at 187,880 MT (414,204,497 pounds) per year, a 10% increase from the 2014 TAC. The increase was in response to the positive findings of the 2015 Atlantic menhaden benchmark assessment which indicated the resource is not overfished and overfishing is not occurring. In October 2016, the Atlantic Menhaden Board increased the TAC by 6.45% setting the 2017 TAC at 200,000 MT (440,924,523 pounds). In Amendment 3, November 2017, management continued with single species reference points until ecological based reference points that reflect Atlantic menhaden's role as a forage species are available. The amendment additionally established a new state allocation system, reduced the Chesapeake Bay reduction cap, and set the 2018 and 2019 TAC at 216,000 MT (476,198,485 pounds).

RESEARCH NEEDS

- Continue current level of sampling from bait fisheries, particularly in the Mid-Atlantic and New England. Analyze sampling adequacy of the reduction fishery and effectively sample areas outside of that fishery.
- Conduct aging validation study to confirm scale to otolith comparisons. Use archived scales to do ratio isotope analysis.
- Develop a menhaden specific coast-wide fishery independent index of adult abundance at age.
- Conduct studies on spatial and temporal dynamics of spawning.
- Conduct Management Strategy Evaluation (MSE) on the various reference point options for menhaden.
- Continue to develop an integrated length and age based model.
- Develop a seasonal spatially-explicit model, once sufficient age-specific data on movement rates of menhaden are available.
- Continue exploring the development of multispecies models that can take predator-prey interactions into account. This should inform and be linked to the development of assessment models that allow natural mortality to vary over time.
- Continue to improve methods for incorporation of natural mortality (e.g., multi-species statistical catch-at-age model).
- Study specific habitat requirements for all life history stages.
- Develop habitat maps for all life history stages.
- Develop a mechanism for estimating or obtaining data for economic analysis on the reduction fishery, due to the confidential nature of the data.
- Conduct studies to fully recognize the linkages between the menhaden fishery and the numerous other fisheries which it supports and sustains.

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TABLES

Table 1. North Carolina Atlantic menhaden annual recreational and commercial landings. Recreational landings based on North Carolina recreational cast net and seine mail survey, 2012-2017. Commercial landings based on North Carolina Trip Ticket Program, 1994-2017. Total Allowable Catch established 2013.

Year	Recreational		Commercial		
	Harvest (number)	Released (number)	Landings (lb)	Total Allowable Catch (lb)	Value ($)
1994			73,853,901		$3,178,602
1995			58,374,081		$3,560,953
1996			53,850,943		$4,858,471
1997			97,727,057		$8,794,202
1998			57,976,455		$4,121,667
1999			42,799,080		$2,680,633
2000			56,280,112		$3,495,744
2001			56,012,396		$4,551,445
2002			69,190,596		$5,045,407
2003			48,936,502		$3,943,814
2004			50,577,938		$4,532,534
2005			13,386,245		$1,223,078
2006			962,648		$147,779
2007			1,113,167		$139,178
2008			645,231		$70,339
2009			2,124,733		$229,648
2010			1,299,130		$111,552
2011			3,529,967		$336,528
2012	96,001	48,352	538,783		$82,974
2013	104,913	98,256	454,172	1,818,580	$73,490
2014	26,278	66,989	794,658	1,818,580	$128,194
2015	71,575	118,953	896,891	2,020,645	$152,241
2016	61,705	106,575	397,725	2,020,645	$75,167
2017	72,327	87,864	755,136	2,190,513	$136,921

2018	35,695	61,302	712,599	4,507,320	$145,242

Table 2. Atlantic menhaden fork length (inches) data from NCDMF sampled from the North Carolina commercial fishery-dependent sampling program (P400s), 2008-2018.

Year	Mean Fork Length (in)	Minimum Fork Length (in)	Maximum Fork Length (in)	Total Number Measured (number)
2008	8.0	3.9	12.8	1,602
2009	9.1	3.9	12.2	1,240
2010	8.9	5.8	12.6	613
2011	9.3	3.7	12.7	1,920
2012	8.7	2.8	14.3	2,355
2013	9.3	4.9	15.2	3,187
2014	8.9	5.1	12.8	4,249
2015	9.1	5.6	18.5	3,095
2016	9.8	4.4	17.0	1,595
2017	9.3	5.0	18.5	1,556
2018	9.2	5.0	14.9	833

FIGURES

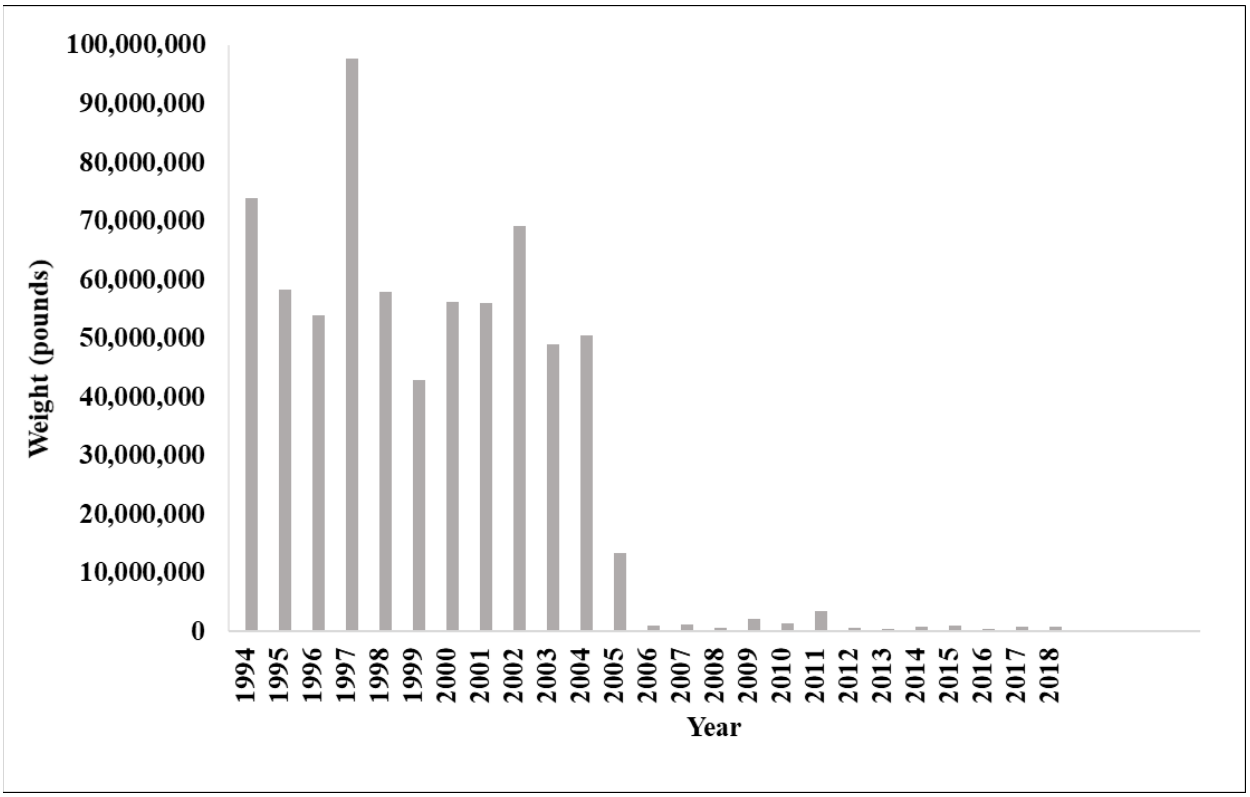

Figure 1. Annual commercial landings in pounds for Atlantic menhaden in North Carolina from 1994 to 2018.

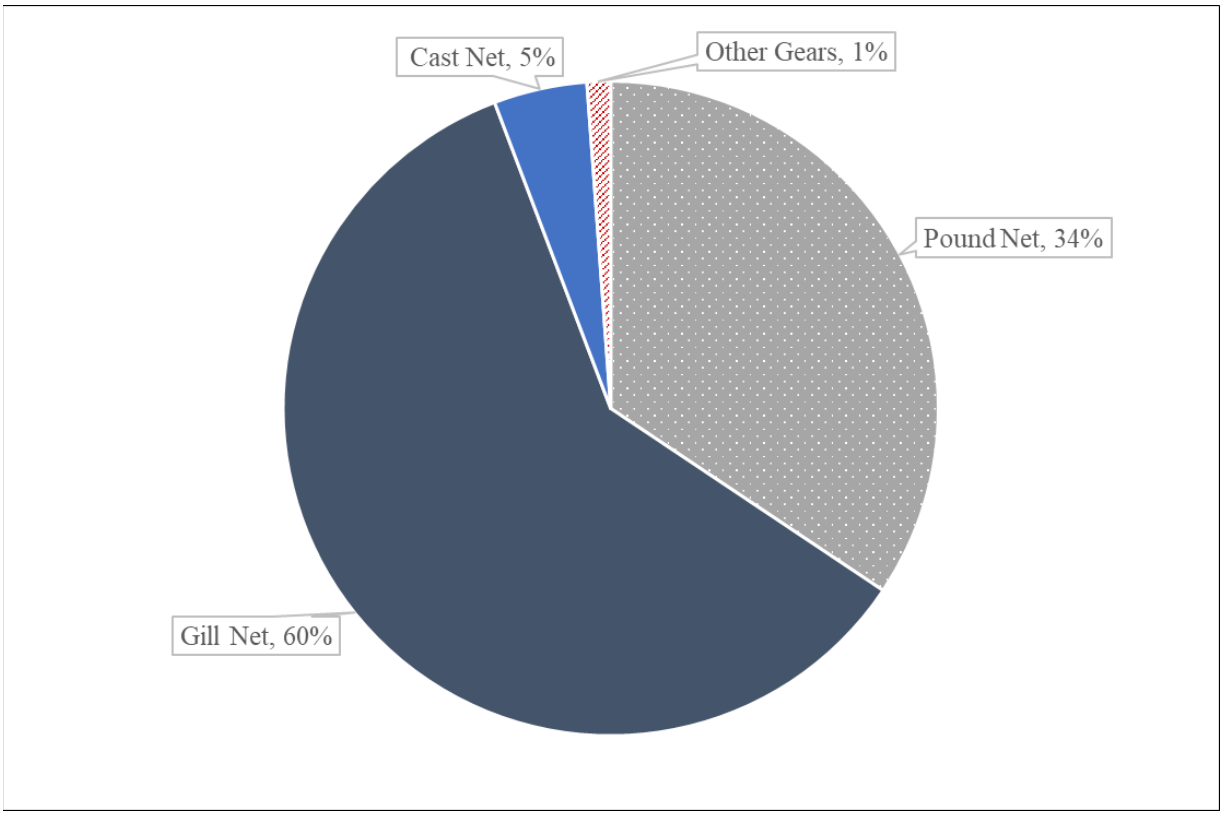

Figure 2. Commercial harvest in 2018 by gear type.

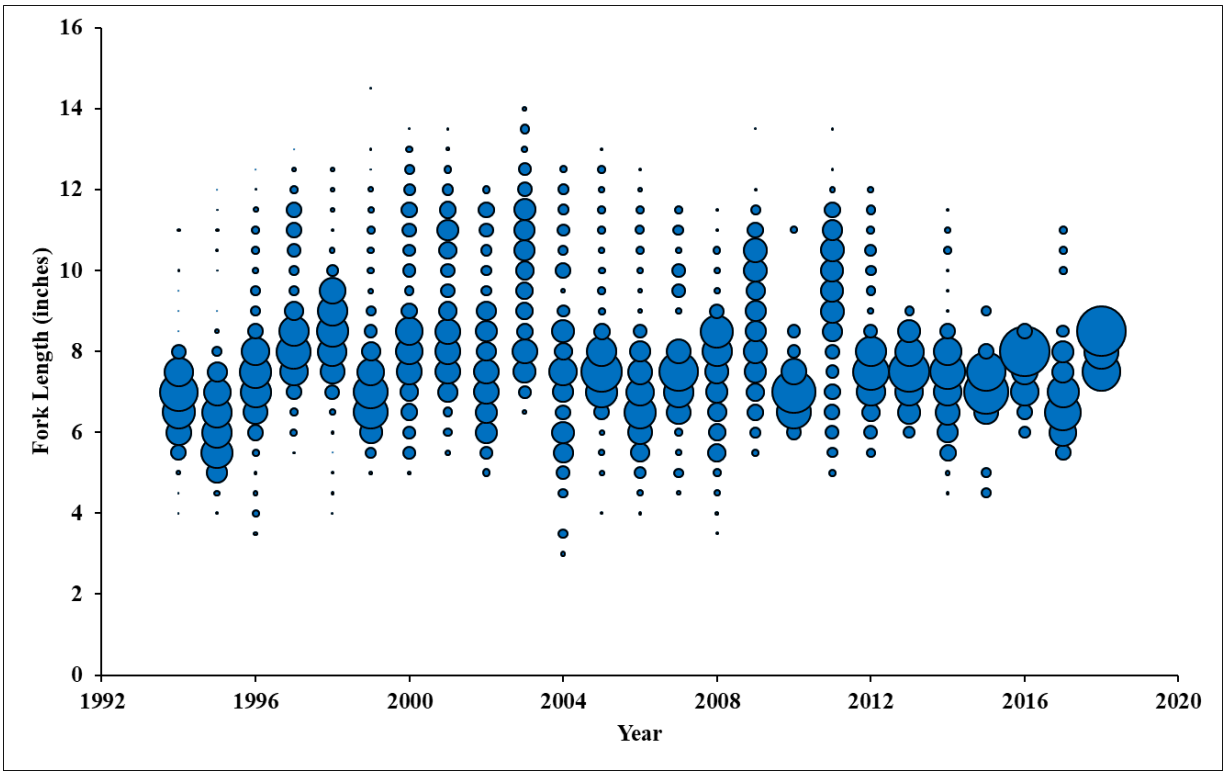

Figure 3. Commercial length frequency (fork length, inches) of Atlantic menhaden harvested from 1995 to 2018. Bubbles represent fish harvested at length and the size of the bubble is equal to the proportion of fish at that length.

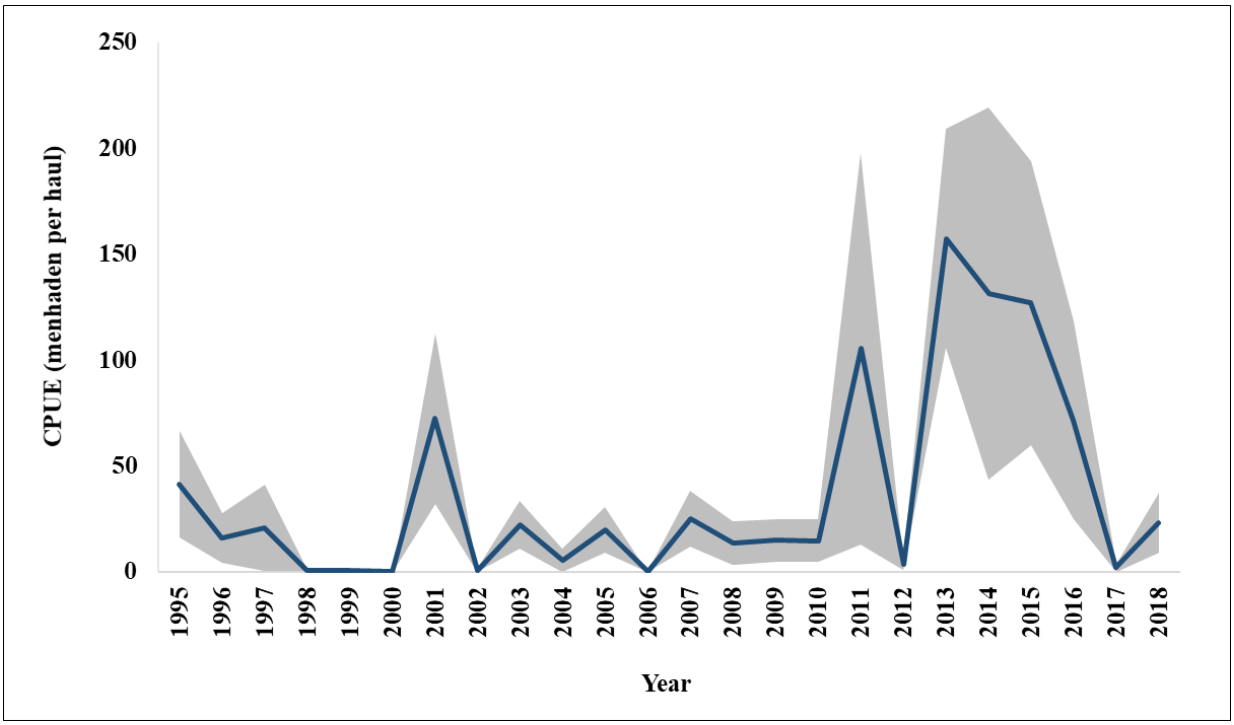

Figure 4. The annual juvenile (age-0) abundance index with standard error shaded in gray from the North Carolina Anadromous Seine Survey for the period of 1995-2018.

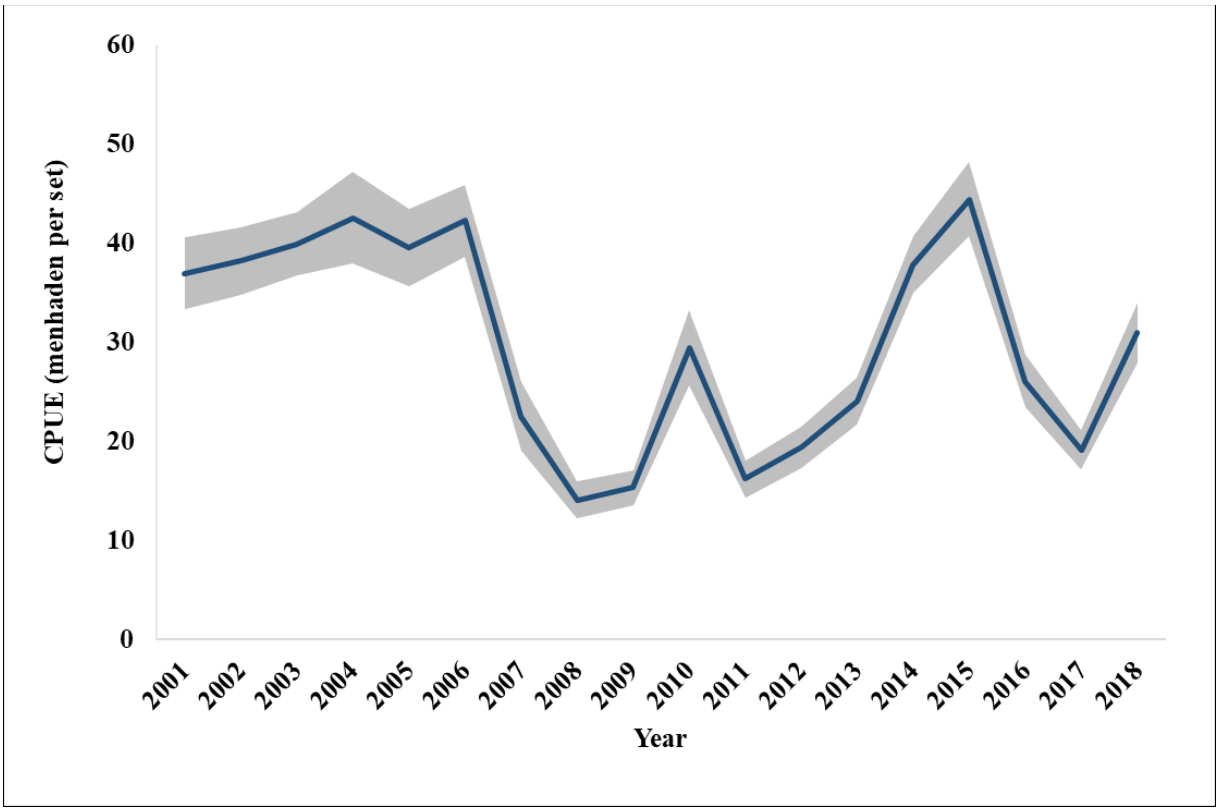

Figure 5. Annual Atlantic menhaden CPUE (number captured) with standard error shaded in gray from the North Carolina Independent Gill Net Survey from 2001-2018.

FISHERY MANAGEMENT PLAN UPDATE
ATLANTIC STURGEON
AUGUST 2019

STATUS OF THE FISHERY MANAGEMENT PLAN

Fishery Management Plan History

Original FMP Adoption:	November 1990
Amendments:	Amendment 1 July 1998 Technical Addendum #1 October 2000 Addendum I January 2001 Addendum II May 2005 Addendum III November 2006 Addendum IV September 2012
Revisions:	None
Supplements:	None
Information Updates:	None
Benchmark Review:	Completed October 2017

Amendment 1 to the Interstate Fishery Management Plan (FMP) for Atlantic Sturgeon was developed by the Atlantic States Marine Fisheries Commission (ASMFC) with a goal to restore Atlantic sturgeon spawning stocks to population levels which will provide for sustainable fisheries and ensure viable spawning populations. Addendum I was completed to allow importation of non-indigenous Atlantic sturgeon and permit the development of private aquaculture facilities. Addendum II required the compliance with ASMFC Terms, Limitations, Enforcement and Reporting Requirements for each exemption to the harvest and possession moratoria as outlined in Section 4 of the FMP. It also allowed for Lapaz, Inc. to import Atlantic sturgeon fingerlings, produce fish, and sell the meat. Further exemption was provided to Acadian Sturgeon and Caviar to import Atlantic sturgeon from Canada to North Carolina. Addendum III complements Addendum II and provides authority for LaPaz Inc. to import Atlantic sturgeon from Supreme Sturgeon and Caviar for commercial aquaculture. Addendum IV is the Atlantic Sturgeon Habitat Addendum.

To ensure compliance with interstate requirements, North Carolina also manages this species 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 plans) and the Atlantic Coastal Fisheries Cooperative Management Act (ASMFC plans) are like the goals of the Fisheries Reform Act of 1997 to "ensure long-term viability" of these fisheries (NCDMF 2015).

Management Unit

Atlantic sturgeon from Maine through Florida.

Goal and Objectives

The goal is to restore Atlantic sturgeon spawning stocks to population levels which will provide for sustainable fisheries and ensure viable spawning populations (ASMFC 1998). Amendment 1 to the Atlantic Sturgeon FMP was approved in July 1998. In order to achieve this goal, the plan sets forth the following objectives:

1. Establish 20 protected year classes of females in each spawning stock;
2. Close the fishery for a sufficient time period to reestablish spawning stocks and increase numbers in current spawning stocks;
3. Reduce or eliminate bycatch mortality of Atlantic sturgeon;
4. Determine the spawning sites and provide protection of spawning habitats for each spawning stock;
5. Where feasible, reestablish access to historical spawning habitats for Atlantic sturgeon; and
6. Conduct appropriate research as needed.

STATUS OF THE STOCK

Life History

Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) are an anadromous species, which means they reside primarily in oceans as adults but migrating up rivers to spawn. The species is found from Labrador, Canada, south to the St. Johns River, Florida. Atlantic sturgeon spend their first few years of life in their natal estuary before becoming highly migratory and travelling throughout the coastal Atlantic waters and various estuaries to feed.

Once mature, Atlantic sturgeon exhibit natal homing, returning to the specific river where they were spawned to reproduce. Migratory patterns are seasonal, with northern migrations in spring as water temperatures rise and southern movements in fall as water temperatures decrease. Some adult sturgeon will return to spawning grounds in consecutive years but others may only spawn once every two or three years. Adult fish that reproduce in the Roanoke River enter the Albemarle Sound basin during the spring of the year. They spend the summer in the western Albemarle Sound and lower Roanoke River. Once temperatures begin to fall around September the fish ascend the Roanoke River to the rapids near Weldon to spawn. When spawning is complete and as water temperatures fall they leave the river and proceed to the ocean through the Albemarle Sound.

Atlantic sturgeon are thought to have historically spawned within the Roanoke, Tar-Pamlico, Neuse, and Cape Fear rivers. Currently the Roanoke River is the only North Carolina river with a known spawning population. Evidence from the collection of young of year fish exists for the other North Carolina rivers but collections of eggs has not been documented. Additionally, telemetry tagged sturgeon (tracked with radio signals) have been documented within the Cape Fear and Northeast Cape Fear rivers potentially making a spawning run.

Atlantic sturgeon at various life stages are found within most estuarine waters of North Carolina throughout the entire year. Due to their highly migratory behavior, Atlantic sturgeon spawned in other regions often enter North Carolina waters. Sturgeon from the Hudson, Chesapeake, Carolina, and South Atlantic Distinct Population Segments have been identified in North Carolina waters.

Atlantic sturgeon are opportunistic bottom feeders that prey on various types of worms, shrimps, crabs, snails and small fishes.

Atlantic sturgeon may live to a maximum age of 70 years; however, in more southern locations the maximum age is from 30 to 40 years. Age at which Atlantic sturgeon reach sexual maturity is unknown for specimens in North Carolina, but other fish within the Carolina and South Atlantic Distinct Population Segment mature as early as 5 to 13 years for males and 7 to 19 years for females. In contrast, sturgeon in more northern latitudes (Hudson River) mature at 11 to 20 years for males and 20 to 30 years for females. Research conducted in South Carolina show spawning intervals of one to five years for males and three to five years for females.

Stock Status

Reported coast-wide landings peaked in 1890 at 3.4 million kg (7,495,717 pounds) and declined precipitously thereafter. The 1998 Atlantic Sturgeon Stock Assessment Report indicated populations of Atlantic sturgeon throughout their range were either extirpated or at historically low abundance. Recruitment was variable at low levels in all regions. The stock was considered overfished but overfishing was not occurring. The target fishing mortality (F) rate was defined as that level of F that generated an eggs-per-recruit (EPR) equal to 50% of the EPR at F = 0.0 (i.e., virgin stock). This rate (F 50) equals 0.03 (annual harvest rate of 3%) for a restored population. This target is far below estimates of F prior to enactment of fishing moratoria, which ranged from 0.01-0.12 for females and 0.15-0.24 for males in the Hudson River. These numbers may not apply to southern stocks, where more signs toward recovery are being seen.

Stock Assessment

The Atlantic States Marine Fisheries Commission completed a benchmark assessment on Atlantic sturgeon in July 2017. Due to the limited availability of data, this assessment employed a number of approaches including Mann-Kendall test, Autoregressive Integrated Moving Average (ARIMA) model, and power, cluster, dynamic factor, and population viability analyses for the coast-wide stock and by Distinct Population Segment (DPS). Several of these analyses indicated no significant trends in various time series with the exception that both the Mann-Kendall and population viability analysis detected a significant increasing trend of young of year

and juvenile abundance in North Carolina's Albemarle Sound Independent Gill Net Survey. Results also indicated that analyses based on indices indicated a coast-wide structure rather than a DPS-structured stock. The Arima analysis indicated the time series had no significant trend or an increasing trend when using all available years of data for all indices and the terminal year index values were all credibly above the 25th percentile for their unique time series. Coast-wide abundance values are not available however stock reduction analysis indicated that the population declined to a low but stable level in the early 1900's but began to increase from the late 1990's onwards. In addition, estimates of coast-wide total mortality were below the Z50%EPR threshold, suggesting current levels of total mortality are sustainable. However, Z estimates for the New York Bight, Chesapeake, and South Atlantic DPS had less than 50% chance that Z was above the threshold while the Maine and Carolina had greater than 70% chance that Z was above the threshold, indicating that mortality is too high within these DPS's.

STATUS OF THE FISHERY

Current Regulations

Coast-wide commercial and recreational moratorium.

Commercial Landings

No landings recorded since 1991.

Recreational Landings

No recreational fishery.

MONITORING PROGRAM DATA

Fishery-Dependent Monitoring

The North Carolina Division of Marine Fisheries (NCDMF) provides at sea observer coverage for the estuarine gill net fisheries throughout North Carolina.

North Carolina developed a Section 10 Incidental Take Permit for the estuarine waters of North Carolina relative to gill net fishing. Through this process North Carolina developed a zero inflated poisson general linear model that estimated bycatch in the gill net fisheries. This model divided the state estuarine waters into management units and estimated takes (live and dead) within each of these units, by season, and mesh size. Results from this model are available in the Application for an Incidental Take Permit submitted to the National Oceanic and Atmospheric Administration (NOAA) Fisheries in December 2012 by the NCDMF.

A total of 397 Atlantic sturgeon have been encountered in the North Carolina on-board observer program from 2001 through 2018. These sturgeon have ranged from 270 to 1,580 mm Total Length (TL) and averaged 669 mm TL (Table 1). Three-hundred and one of the 397 sturgeon have been encountered in the Albemarle Sound Management Unit. An additional 82 Atlantic

sturgeon were observed through the alternate platform observer program during 2013-2018. These trips are conducted from division-owned vessels where the observers do not ride with the fisherman but observe from a distance. These fish ranged in size from 390 to 1,219 mm TL and averaged 689 mm TL. Seventy-two of the 82 sturgeon encountered were observed in the Albemarle Sound Management Unit.

Fishery-Independent Monitoring

The NCDMF currently has three independent gill net surveys that encounter and tag Atlantic sturgeon. The Albemarle Sound Independent Gill Net Survey (IGNS) is a stratified random gill net survey that employs gill nets with mesh sizes that range from 2.5 inch stretch mesh (ISM) through 7 ISM (0.5 ISM increments) and 8 ISM and 10 ISM of floating and sinking nets. Gill nets are fished in 40 yard shots totaling 960 yards per set. Each set is fished for approximately 24-hours before retrieval. Nets were fished from January through May, November, and December each year from 1991 through 2018. Lengths of sturgeon collected have ranged from 153 to 1,714 mm FL and averaged 529 mm FL (Table 2). Seven fish were collected with a fork length greater than 1,000 mm, and only four of 1,945 fish collected were likely adults. Catch per unit effort (CPUE) shows an increasing trend over the entire time series but annual CPUE are variable (Figure 1).

The Fishery Independent Assessment Survey (FIAS) is conducted in Pamlico Sound, Pungo, Pamlico, and Neuse rivers, and consists of gill net sets, ranging in mesh size from 3.0 ISM through 6.5 ISM (0.5 ISM increments) and are fished for approximately 12 hours before retrieval. The Pamlico Sound portion has been conducted since 2001 and the rivers portion since 2003. A total of 58 sturgeon have been collected in Pamlico Sound and an additional 89 have been collected in the Pamlico, Pungo, and Neuse rivers. Average lengths are larger than those seen in the Albemarle, indicating capture of more sub-adult fish than young-of-year fish (Tables 3, 4). Three adults have been collected in the Pamlico Sound Survey and three adults have been collected in the Rivers Survey.

The Southern Independent Gill Net Survey is modeled after the (FIAS) but with periods of reduced soak times. The areas fished include the New and Cape Fear rivers. Two-hundred forty yards were fished per sample and 120 samples were completed per year. The areas fished include the coastal ocean waters off the New and Cape Fear rivers. Two-hundred and seventy yards were fished per sample. Effort has been ongoing since 2008. Sampling was discontinued in the Ocean on July 1, 2015. Sixteen fish have been collected in the Cape Fear River IGNS and they ranged from 545 to 949 mm FL. No adult Atlantic sturgeon have been collected in this survey.

During 2010, the NCDMF joined a multi-state grant entitled “Research and Management of Endangered and Threatened Species in the Southeast: Riverine Movements of Shortnose and Atlantic Sturgeon” cooperating with South Carolina Department of Natural Resources, The University of Georgia, and North Carolina State University. Funding was provided through NOAA Fisheries, Section 6. Ninety-four Atlantic sturgeon were tagged with acoustic transmitters from 2011 through 2013 in the Cape Fear River and Albemarle Sound. These fish ranged from 772 to 1,753 mm FL and averaged 928 mm FL (Table 5).

MANAGEMENT STRATEGY

Atlantic coastal states implemented a moratorium on harvest and possession of Atlantic sturgeon in coastal waters (0-3 miles) in 1998, while NOAA Fisheries banned harvest in the exclusive economic zone. The best available data indicate that river-specific populations are appropriate management units. It is recommended that the moratorium remain in place for each population until it can be documented that the spawning population includes at least 20 year classes of mature females (half the number of year classes that probably existed in unfished populations). Given that female Atlantic sturgeon do not mature until about 20 years of age, the moratorium can be expected to remain in place for several decades from when harvest of a given population ended. As populations increase during restoration, bycatch of sturgeon will increase; hence, managers should ensure that mechanisms are in place to monitor the level of bycatch and make reductions where necessary.

In 2012, NOAA Fisheries listed the Carolina DPS of Atlantic sturgeon as an endangered species under the 1973 Endangered Species Act (ESA). This listing determination drastically influenced the management strategy in North Carolina. The largest influence was the requirement of the NCDMF to obtain a Section 10 Incidental Take Permit to allow the estuarine gill net fisheries to continue. Without the Section 10 Permit, interactions in the fishery would have been illegal. In 2016, NOAA Fisheries published a proposed rule to designate Atlantic sturgeon critical habitat (specific areas that are considered essential to the conservation of the species) in each of the DPSs. The final rule to designate critical habitat was published in September 2017. This rule designated approximately 1,939 km (1,205 miles) of aquatic habitat for the Carolina DPS, including the following rivers in North Carolina: Roanoke, Tar-Pamlico, Neuse, Cape Fear, Northeast Cape Fear, and Pee Dee. Any future fishery for Atlantic sturgeon will only be possible if NOAA Fisheries removes Atlantic sturgeon from the ESA. However, additional protections provided through the ESA listing should increase the potential recovery.

RESEARCH NEEDS

Biological/Captive Propagation

- Standardize and obtain baseline data on population status for important sturgeon rivers. Data should include assessment of stock status in various rivers, size and composition of the spawning population, reproductive success and juvenile production;
- Develop long-term marking/tagging procedures to provide information on individual tagged Atlantic sturgeon for up to 20 years;
- Establish success criteria in order to evaluate the effectiveness of stocking programs;
- Determine size at maturity for North, Mid- and South Atlantic sturgeon;
- Monitor catch/effort and size/age composition of landings of any future authorized directed fisheries;
- Determine length at age by sex for North, Mid- and South Atlantic stocks;
- Determine maturity at age by sex for North, Mid- and South Atlantic stocks;
- Determine fecundity at age, length, and weight for North, Mid-, and South Atlantic stocks;
- Characterize size and condition of Atlantic sturgeon by gear and season taken as bycatch in various fisheries;

- Establish environmental tolerance levels (dissolved oxygen, pH, temperature, etc.) for different life stages;
- Establish coastal tagging projects to delineate migratory patterns (this measure is being implemented by the USFWS and member states.);
- Expand tagging of juveniles in major spawning rivers to allow estimates of rates of loss to bycatch;
- Establish a tag recovery clearinghouse and database for consolidation and evaluation of tagging and tag return information including associated biological, geographic, and hydrographic data (this measure is being implemented by the USFWS through the Maryland Fisheries Resources Office located in Annapolis, Maryland.);
- Encourage shortnose sturgeon researchers to include Atlantic sturgeon research in their projects;
- Establish methods for the recovery of tags and associated information (this measure is being implemented through ASMFC/USFWS cooperative efforts.);
- Evaluate existing groundfish survey data to determine what can be learned about at-sea migratory behavior;
- Conduct basic culture experiments to provide information on: a) efficacy of alternative spawning techniques, b) egg incubation and fry production techniques, c) holding and rearing densities, d) prophylactic treatments, e) nutritional requirements and feeding techniques, and f) optimal environmental rearing conditions and systems;
- Determine the extent to which Atlantic sturgeon are genetically differentiable among rivers;
- Conduct research to identify suitable fish sizes, and time of year for stocking cultured fish;
- Conduct and monitor pilot-scale stocking programs before conducting large-scale efforts over broad geographic areas;
- Determine effects of contaminants on early life stages;
- Develop methods to determine sex and maturity of captured sturgeon;
- Develop sperm cryopreservation techniques and refine to assure availability of male gametes;
- Refine induced spawning procedures;
- Develop the capability to capture wild broodstock and develop adequate holding and transport techniques for large broodstock;
- Conduct studies to identify tissue(s) suitable for genetic analyses and the techniques for their collection and storage. In those states which permit future harvest of Atlantic sturgeon, material for genetic analysis should be collected from up to 50% of the fish landed in the commercial fisheries. In states with no future directed fisheries, federal and state programs which encounter sturgeon should be encouraged to collect specified tissues for genetic analysis;
- Standardize collection procedures to obtain biological tissues, and identify a suitable repository to archive all materials;
- Conduct research to determine the susceptibility of Atlantic sturgeon to sturgeon adenovirus and white sturgeon iridovirus. Methods should be developed to isolate the sturgeon adenovirus and an Atlantic sturgeon cell line should be established for infection trials;
- Conduct research to identify the major pathogens of Atlantic sturgeon and a cell line for this species should be developed.

Social

- To evaluate the social impacts the needed data might include the following for consumptive and non-consumptive users: demographic information (e.g. age, gender, ethnicity/race, etc.), social structure information (e.g. historical participation, affiliation with NGOs, perceived conflicts, etc.), other cultural information (e.g. occupational motivation, cultural traditions related to resource's use), and community information.
- A cost and benefit analysis of possible stocking protocols is needed.

Assessment

- Identify spawning units along the Atlantic coast at river or tributary and coast-wide level.
- **Expand and improve the genetic stock definitions of Atlantic sturgeon, including developing and updated genetic baseline sample collection at the coast-wide, DPS, and river-specific level for Atlantic sturgeon, with the consideration of spawning season-specific data collection.
- Determine habitat use by life history stage including adult staging, spawning, and early juvenile residency.
- Expand the understanding of migratory ingress of spawning adults and egress of adults and juveniles along the coast.
- Identify Atlantic sturgeon spawning habitat through the collection of eggs or larvae.
- Investigate the influence of warming water temperatures on Atlantic sturgeon, including the effects on movement, spawning, and survival.
- Evaluate the effects of predation on Atlantic sturgeon by invasive species (e.g., blue and flathead catfish).
- **Establish regional (river or DPS-specific) fishery-independent surveys to monitor Atlantic sturgeon abundance or expand existing regional surveys to include annual Atlantic sturgeon monitoring. Estimates of abundance should be for both spawning adults and early juveniles at age.
- **Establish coast-wide fishery-independent surveys to monitor mixed stock abundance or expand existing surveys to include annual Atlantic sturgeon monitoring.
- **Continue to collect biological data, PIT tag information, and genetic samples from Atlantic sturgeon encountered in surveys that require it (e.g., NEAPMAP). Consider including this level of data collection from surveys that do not require it.
- **Encourage data sharing of acoustic tagged fish, particularly in underrepresented DPSs, and support program that provide a data sharing platform such as The Atlantic Cooperative Telemetry Network. Data sharing should be accelerated if it was required or encouraged by funding agencies.
- **Maintain and support current networks of acoustic receivers and acoustic tagging programs to improve the estimates of total mortality.
- **Collect DPS-specific age, growth, fecundity, and maturity information.
- **Collect more information on regional vessel strike occurrences, including mortality estimates. Identify hot spots for vessel strikes and develop strategies to minimize impacts on Atlantic sturgeon.

- **Monitor bycatch and bycatch mortality at the coast-wide level, including international fisheries where appropriate (i.e., the Canadian weir fishery). Include data on size, health condition at capture, and number of fish captured.
- **Establish recovery goals for Atlantic sturgeon to measure progress of and improvement in the population since the moratorium and ESA listing.
- **Expand the acoustic tagging model to obtain abundance estimates and incorporate movement.
- Evaluate methods of imputation to extend timeseries with missing values.

Recommendations with asterisks (**) indicate improvements that should be made before initiating another benchmark stock assessment.

Monitoring population trends through juvenile abundance indices, characterizing the incidence of bycatch and mortalities in various fisheries and conducting tag/recapture studies for estimates of bycatch loss are being addressed through current sampling. It should be noted that any sampling or research that encounters Atlantic sturgeon whether incidental or targeted now require Section 10 permits through NOAA Fisheries or a Section 7 consultation if funded through a federal grant program. These permit requirements directly influence the data collection abilities of the NCDMF, potentially impacting the completion of research recommendations.

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TABLES

Table 1. Atlantic Sturgeon total length data (inches) collected from the North Carolina Division of Marine Fisheries Onboard Observer Program, 2001-2018.

Year	Mean Total Length	Minimum Total Length	Maximum Total Length	Collection Number
2001	39	36	41	2
2002				0
2003	*	*	*	1
2004	23	13	32	25
2005	25	18	32	28
2006	28	13	47	71
2007				0
2008	25	19	33	18
2009				0
2010				0
2011	30	18	55	4
2012	26	18	35	10
2013	25	19	36	29
2014	27	16	60	42
2015	27	11	39	54
2016	27	17	62	54
2017	25	17	41	45
2018	27	19	34	14

- Length not recorded

Table 2. Atlantic Sturgeon length data (inches) collected from the Albemarle Sound Independent Gill Net Survey, 1991-2018.

Year	Mean Fork Length	Minimum Fork Length	Maximum Fork Length	Total Number Measured
1991	20	10	28	26
1992	17	8	23	17
1993	20	12	37	13
1994	18	10	29	40
1995	19	10	30	21
1996	17	8	22	27
1997	17	9	27	60
1998	19	6	29	92
1999	21	11	28	55
2000	15	7	30	139
2001	19	12	27	132
2002	21	9	29	29
2003	20	10	39	22
2004	19	10	31	30
2005	20	9	33	48
2006	22	9	58	62
2007	21	9	30	66
2008	21	10	33	124
2009	25	15	31	55
2010	23	16	32	32
2011	24	15	59	47
2012	23	12	42	64
2013	22	11	55	139
2014	24	14	46	70
2015	23	14	39	86
2016	21	10	37	124
2017	22	14	40	173
2018	23	15	67	152

Table 3. Atlantic Sturgeon length data (inches) collected from the Pamlico Sound Independent Gill Net Survey, 2001-2018.

Year	Mean Fork Length	Minimum Fork Length	Maximum Fork Length	Collection Number
2001				
2002	26	26	26	1
2003	30	30	30	1
2004	19	18	21	4
2005	26	14	31	19
2006	39	19	31	12
2007	33	16	59	5
2008	26	25	37	2
2009	38	38	38	1
2010	24	8	27	4
2011				0
2012	56	56	56	1
2013				0
2014				0
2015	*	*	*	1
2016	30	29	30	2
2017	61	61	61	1
2018	24	21	27	3

* Length not recorded

Table 4. Atlantic Sturgeon length data (inches) collected from the Pamlico, Pungo, and Neuse Rivers Independent Gill Net Survey, 2003-2018.

Year	Mean Fork Length	Minimum Fork Length	Maximum Fork Length	Collection Number
2003				
2004	24	19	32	10
2005	19	14	31	30
2006	25	19	29	4
2007	20	16	28	3
2008	21	21	21	1
2010				0
2011	91	91	91	1
2012	25	25	25	1
2013				0
2014	*	*	*	1
2015	24	14	56	23
2016	28	18	38	8
2017	45	45	45	1
2018	28	22	40	4

* Length not recorded

Table 5. Atlantic Sturgeon length data (inches) collected through section 6 funding in the Cape Fear River and Albemarle Sound, North Carolina, 2011-2013.

Year	Mean Fork Length	Minimum Fork Length	Maximum Fork Length	Number
2011	38	25	64	45
2012	37	30	69	21
2013	34	24	46	28
Total	37	30	69	94

FIGURES

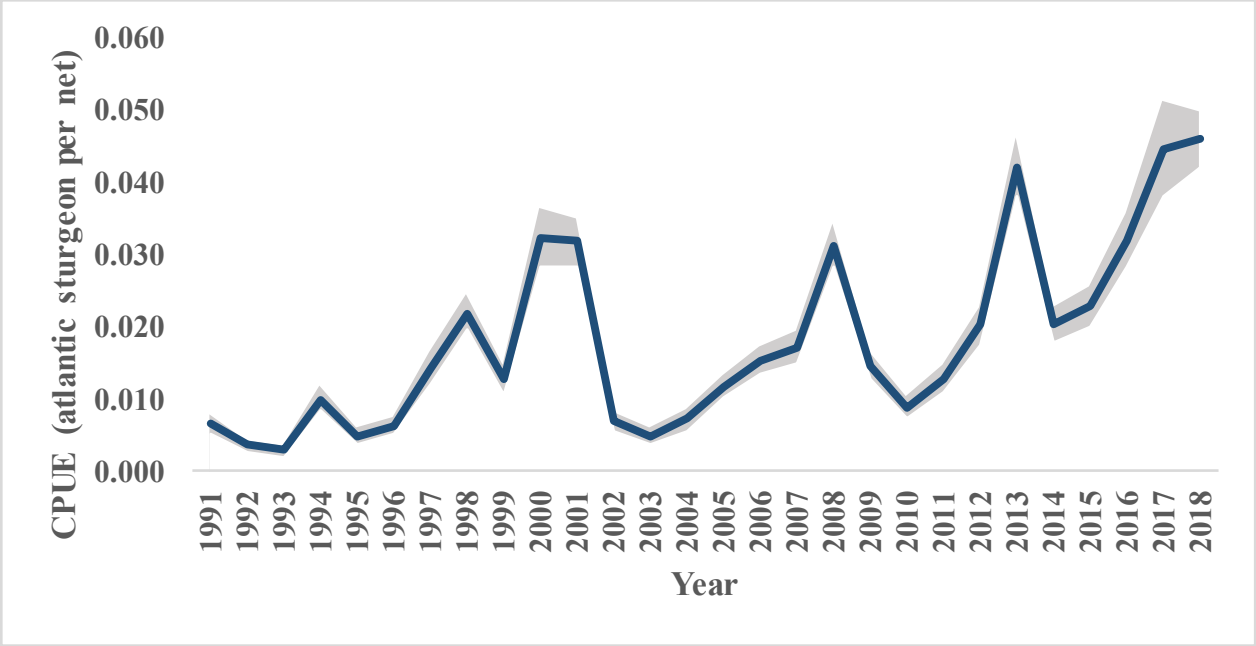

Figure 1. Catch per unit effort of Atlantic sturgeon collected from the Albemarle Sound Independent Gill Net Survey from 1991-2018.

FISHERY MANAGEMENT PLAN UPDATE
BLACK DRUM
AUGUST 2019

STATUS OF THE FISHERY MANAGEMENT PLAN

Fishery Management Plan History

Original FMP Adoption:	June 2013
Amendments:	Addendum I – May 2018
Revisions:	None
Supplements:	None
Information Updates:	February 2016
Next Benchmark Review:	February 2020

In June 2013, the Atlantic States Marine Fisheries Commission (ASMFC) adopted the Interstate Fishery Management Plan (FMP) for black drum and required all states to maintain their current regulations and implement a maximum possession limit and minimum size limit (of no less than 12 inches) by January 1, 2014 (ASMFC 2013). States were also required to further increase the minimum size limit (to no less than 14 inches) by January 1, 2016. In response to the ASMFC requirement, the North Carolina Marine Fisheries Commission implemented a 14- to 25-inch total length slot size limit (with one fish over 25 inches), 10-fish recreational bag limit and a 500-pound commercial trip limit effective January 1, 2014. The FMP also includes a management framework to adaptively respond to future concerns or changes in the fishery or population. Concern about the increase in harvest by both recreational and commercial were alleviated by the findings of the 2015 stock assessment. The ASMFC Interstate Fisheries Management Program Policy Board chose to not make any additional changes to the FMP at the time given the findings of the assessment.

In May 2018, ASMFC approved Addendum I to the Black Drum FMP to allow Maryland to reopen its black drum commercial fishery in the Chesapeake Bay with a daily vessel limit of up to 10 fish and a 28-inch minimum size (ASMFC 2018a). The Black Drum Technical Committee noted that reopening the fishery would not likely lead to overfishing due to the relatively small size of the fishery and recommended that biological monitoring be conducted in the commercial fishery.

To ensure compliance with interstate requirements, North Carolina also manages this species 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 plans) and the Atlantic Coastal Fisheries Cooperative Management Act (ASMFC plans) are like the goals of the Fisheries Reform Act of 1997 to "ensure long-term viability" of these fisheries (NCDMF 2015).

Management Unit

The ASMFC FMP includes all states from Florida to New Jersey. The management unit is defined as the black drum (*Pogonias cromis*) resource throughout the range of the species within U.S. waters of the northwest Atlantic Ocean from the estuaries eastward to the offshore boundaries of the U.S. Exclusive Economic Zone (EEZ) (ASMFC 2015).

Goal and Objectives

The goal of the Black Drum FMP is to provide an efficient management structure to implement coast-wide management measures. The objectives of the FMP include:

1. Provide a flexible management system to address future changes in resource abundance, scientific information, and fishing patterns among user groups or area.
2. Promote cooperative collection of biological, economic, and sociological data required to effectively monitor and assess the status of the black drum resource and evaluate the management efforts.
3. Manage the black drum fishery to protect both young individuals and established breeding stock.
4. Develop research priorities that will further refine the black drum management program to maximize the biological, social, and economic benefits derived from the black drum population.

STATUS OF THE STOCK

Life History

Black drum is the largest member of the drum family (Sciaenidae), reaching sizes of over 46 inches and 120 pounds. The range of black drum extends along the nearshore western Atlantic coast from the Gulf of Maine to Florida, into the Gulf of Mexico, and as far south as Argentina. Along the Atlantic Coast, black drum are thought to migrate northward and inshore each spring and southward and offshore by late fall. Juvenile black drum can be found throughout the estuarine waters of North Carolina, while adults tend to congregate around structure including bridge and dock pilings. They are primarily bottom feeders; juvenile diets consist mainly of small fish and invertebrates, while the adult diet consists primarily of mollusks and crustaceans. Spawning is thought to occur in the offshore waters of the Mid-Atlantic during the winter and early spring. The number of juvenile fish entering the population annually (recruitment) is thought to be highly variable and dependent on natural environmental conditions. Females are

sexually mature between the ages of 4 and 6 (25 to 28 inches) and spawn yearly though adulthood. An average-sized female may spawn 32 million eggs each year. At ages 4 and 5 (22 to 25 inches) males are mature. The species is long-lived, reaching up to 60 years of age. Black drum are approximately 11 to 14 inches at age 1, 15 to 17 inches at age 2, and 19 to 21 inches at age 3.

Stock Status

The 2015 ASMFC Black Drum Stock Assessment determined that the stock is not overfished and not experiencing overfishing (ASMFC 2015).

Stock Assessment

Variable catch history in state surveys and fisheries, coupled with complex migratory patterns, made the use of traditional statistical catch-at-age models difficult. A data–poor modeling approach was used for the first coast-wide benchmark stock assessment (ASMFC 2015). Data-poor models estimate reference points based on historical catch data and life history information. A Depletion-Based Stock Reduction Analysis (DB-SRA) model was used to estimate biomass and maximum sustainable yield (MSY). Median MSY was estimated to be 2.12 million pounds and the median overfishing limit (OFL) is estimated to be 4.12 million pounds (see Management Strategy section below). While the median biomass has declined steadily from the 1900s, the median biomass in 2012 was well above the level needed to produce maximum sustainable yield (B_{MSY}; 47.26 million pounds; Figure 1). The DB-SRA results determined that black drum is not overfished and not experiencing overfishing based on the black drum life history, indices of abundance, and history of exploitation (ASMFC 2015).

STATUS OF THE FISHERY

Current Regulations

All harvest is limited to black drum between a 14-inch total length minimum size and 25-inch total length maximum size for both the recreational and commercial fisheries, except that one black drum over 25-inches total length may be retained. The recreational bag limit is ten fish per day. A daily commercial possession limit of no more than 500 pounds per trip is allowed for a commercial fishing operation, regardless of the number of persons, license holders, or vessels involved in the operation.

Commercial Landings

Black drum is primarily caught as bycatch in several North Carolina commercial fisheries; however, they are predominately landed in the estuarine gill net (74%) and pound net (23%) fisheries (Figure 4). The commercial harvest of black drum has been highly variable (Table 1; Figure 2). On average 120,336 pounds of black drum were landed annually from 1994 to 2018. Commercial landings have ranged from a low of 27,750 pounds in 1998 to a high of 497,479 pounds in 2002. Commercial landings decreased 40% from 2017 to 2018.

Recreational Landings

Recreational fishing activity is monitored through the Marine Recreational Information Program. In this report, estimates across all years have been updated and are now based on the MRIP new Fishing Effort Survey-based calibrated estimates. For more information on MRIP methodology changes see https://www.fisheries.noaa.gov/topic/recreational-fishing-data.

The recreational landings have been highly variable, ranging from a low of 164,280 pounds in 1998 to a high of 2,709,269 pounds in 2013 (Table 1; Figure 2). In 2018, 428,273 pounds of black drum were harvested, below the time-series average of 806,044 pounds. The harvest (pounds of fish) decreased 50% from 2017 to 2018. Recreational releases (number of fish) decreased 38% from 2017 to 2018.

The NCDMF offers award citations for exceptional catches of black drum. Black drum greater than 35 pounds or 40 inches total length are eligible for an award citation. In 2018, 43 citations were awarded, 17 of which were released alive (Figure 3).

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 6,101 pounds of black drum were harvested per year (Table 2).

MONITORING PROGRAM DATA

Fishery-Dependent Monitoring

Commercial black drum landings are monitored through the North Carolina trip ticket program. Under this program, licensed fishermen can only sell commercial catch from coastal fishing waters to licensed NCDMF fish dealers. The dealer is required to complete a trip ticket every time a licensed fisherman lands fish. Trip tickets capture data on gears used to harvest fish; area fished, species harvested, and total weights of each species/market grade category. Trip tickets are submitted to NCDMF on the 10th of the month following the month in which the landings occurred. Landings are available approximately 30 to 45 days after they are submitted from the dealers.

Commercial fishing activity is monitored through fishery dependent sampling conducted under Title III of the Interjurisdictional Fisheries Act and has been ongoing since 1982. Biological samples (lengths, aggregate weights) are obtained from several NCDMF commercial fisheries dependent sampling programs. Black drum lengths and aging structures are collected at local fish houses. After sampling a portion of the catch, the total weight of the catch by species and market grade are obtained for each trip, either by using the trip ticket weights or some other reliable estimate.
Since the implementation of the 14- to 25-inches slot limit in 2014, the mean total length (TL) of commercially harvest black drum has increased. The mean TL has ranged from 11-inches to 19-inches (Table 3). In 2018, the minimum TL was 14-inches and the maximum TL was 46-inches (Figure 5). Undersized black drum continue to be harvested since the implementation of the 14-inch minimum size limit established in 2014, and this is likely due to fishermen being unaware of

changes in regulations, and/or fishermen confusing the minimum size limits of black drum and sheepshead (Figure 6). The minimum size limit of sheepshead is 10-inches fork length (FL) and was implemented in 2015.

The mean TL of recreational harvested black drum ranged from a low of 10-inches in 1990 to a maximum of 17-inches in 2015 and 2016 (Table 4). In 2018, the minimum TL was 8-inches and the maximum TL was 26-inches (Figure 5). Similar to the commercial fishery, undersized black drum continued to be harvested since the implementation of the 14-minimum size limit established in 2014 (Figure 7).

Fishery-Independent Monitoring

A fishery independent gill net survey was initiated by the NCDMF in May of 2001. The survey utilizes a stratified random sampling scheme designed to characterize the size and age distribution for key estuarine species in Pamlico Sound. By continuing a long-term database of age composition and developing index of abundance for black drum this survey will help managers assess the black drum stocks without relying solely on commercial and recreational fishery dependent data. Additionally, data collected is used to help improve bycatch estimates, evaluate the success of management measures, and look at habitat usage.

The annual weighted black drum CPUE from the independent gill net survey has ranged from a high of 3.52 in 2002 to a low of 0.38 in 2012 (Table 5; Figure 8). In 2018, the CPUE was 0.42, below the time-series average (0.98 black drum per set). Proportional Standard Error (PSE) has ranged from 12 to 39. This survey was used in the ASMFC benchmark stock assessment for black drum as annual index of relative abundance for sub-adult and adult black drum.

Black drum age structures are collected from various fishery independent (scientific surveys) and dependent (fisheries) sources throughout the year. In 2018, 430 black drum were aged. Ages ranged from 0 to 46 years; however, approximately 70% of the age structures were collected from independent sources and may not be representative of fish caught in North Carolina's recreational and commercial fisheries (Table 6). Beyond age-4, there is significant overlap in the length at age for black drum (Figure 9).

MANAGEMENT STRATEGY

Data poor models such as the one used for 2015 ASMFC Back Drum Stock Assessment are designed to estimate reference points based on historical catch data and the life history of a particular species. Due to the uncertainty of the inputs and the nature of data poor methods the ASMFC Stock Assessment Subcommittee (SAS) recommended that a precautionary maximum sustainable yield (MSY) estimate of 2.12 million pounds with an interquartile range of 1.60 to 3.05 million pounds as the recommended target reference point (Figure 1). The threshold MSY or overfishing limit (OFL) was set at 4.12 million pounds. The SAC also noted that the stock assessment could be improved by incorporating a more complex, data-rich assessment method such as a statistical catch-at-age model once several data limitations are met (ASMFC 2018b). Additional biological sampling (length and age) of recreational and commercial fisheries and the development of a fishery-independent survey to track abundance and age structure of the mature

stock are needed to make this transition. Estimates of commercial discards and movement patterns along the coast would further improve the assessment.

Each year the ASMFC Plan Review Team (PRT) Black Drum monitors each states' compliance with the FMP during its annual review. States must demonstrate that the compliance criteria of the FMP are satisfied and submit an annual report concerning its fisheries and management programs. Following the review of the 2018 fishing year, the PRT determined that all states were compliant with the FMP (ASMFC 2018b). The ASMFC Interstate Fisheries Management Program Policy Board also determined that given the findings of the 2015 assessment, no additional changes to the management of black drum were needed. In 2018, the Addendum I was approved to allow Maryland to reopen their commercial fishery in the Chesapeake Bay with a daily vessel limit of up to 10 fish and a 28-inch minimum size limit. Plans to develop a management program for the commercial fishery were set to be implemented by April 1, 2019; however, concerns from the public have delayed further action.

See Table 7 for current management strategies and implementation status of the ASMFC Black Drum FMP.

RESEARCH NEEDS

The FMP outlines research needs for black drum. The ASMFC black drum PRT will annually review and prioritize the research needs as part of the ASMFC FMP review process. The research recommendations outlined in the 2018 Review of the Atlantic States Marine Fisheries Commission Fishery Management Plan for Black Drum include:

- Update the 2015 stock assessment or conduct a new benchmark stock assessment that includes the recalibrated MRIP recreational harvest estimates based on the new, mail-based FES – HIGH (needed)
- Age otoliths that have been collected and archived – HIGH (ongoing)
- Collect information to characterize the size composition of fish discarded in recreational fisheries – HIGH (ongoing).
- Collect information on the magnitude and sizes of commercial discards. Obtain better estimates of black drum bycatch in other fisheries, especially juvenile fish in south Atlantic states – HIGH (ongoing)
- Increase biological sampling in commercial fisheries to better characterize the size and age composition of commercial fisheries by state and gear – HIGH (ongoing).
- Increase biological sampling in recreational fisheries to better characterize the size and age composition by state and wave – HIGH (ongoing)
- Obtain estimates of selectivity-at-age for commercial fisheries by gear, recreational harvest, and recreational discards – HIGH (ongoing).
- Continue all current fishery-independent surveys and collect biological samples for black drum on all surveys – HIGH (ongoing)
- Develop fishery-independent adult surveys. Consider long line and purse seine surveys – HIGH (ongoing).
- Collect age samples, especially in states where maximum size regulations preclude the collection of adequate adult ages – HIGH (ongoing).

- Conduct reproductive studies, including: age and size-specific fecundity, spawning frequency, spawning behaviors by region, and movement and site fidelity of spawning adults – MEDIUM (needed).
- Conduct a high reward tagging program to obtain improved return rate estimates. Continue and expand current tagging programs to obtain mortality and growth information and movement at size data – HIGH (needed).
- Conduct tagging studies using implanted radio tracking tags that are compatible with coastal tracking arrays along the Atlantic coast in order to track movement and migration of adults – HIGH (needed).
- Improve sampling of night time fisheries – MEDIUM (needed).
- Conduct studies to estimate catch and release mortality rates in recreational fisheries – HIGH (needed).
- Collect genetic material (i.e., create "genetic tags") over a long time span to obtain information on movement and population structure, and potentially estimate population size – MEDIUM (needed).
- Obtain better estimates of harvest from the black drum recreational fishery, especially in states with short seasons – MEDIUM (ongoing).

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ASMFC (Atlantic States Marine Fisheries Commission). 2018a. Addendum I to the Black Drum Interstate Fishery Management Plan. Atlantic States Marine Fisheries Commission. Arlington, VA. 4 pp.

ASMFC (Atlantic States Marine Fisheries Commission). 2018b. 2018 Review of the Atlantic States Marine Fisheries Commission Fishery Management Plan for Black Drum (*Pogonias cromis*) 2018 Fishing Year. Arlington, VA. October 2018. 16 pp.

NCDMF (North Carolina Division of Marine Fisheries). 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.

TABLES

Table 1. Black drum recreational harvest and number released (Marine Recreational Information Program) and commercial harvest (North Carolina Trip Ticket Program) for 1994-2018. All weights are in pounds.

	Recreational				
	Numbers		Weight (lb)	Commercial	Total
Year	Landed	Released	Landed	Weight (lb)	Weight (lb)
1994	132,517	9,122	272,820	33,536	306,356
1995	931,269	227,608	713,652	128,221	841,873
1996	468,766	176,061	608,460	122,837	731,297
1997	106,854	62,498	277,316	86,610	363,926
1998	105,349	95,834	164,280	27,750	192,030
1999	374,245	267,723	561,678	122,771	684,449
2000	293,983	112,470	685,687	98,784	784,471
2001	400,983	325,234	446,202	77,892	524,094
2002	846,855	215,810	1,791,703	497,479	2,289,182
2003	1,265,995	481,742	1,926,671	148,785	2,075,456
2004	296,531	255,753	566,484	62,445	628,929
2005	465,076	376,363	509,328	44,989	554,317
2006	276,257	265,369	431,212	125,214	556,426
2007	876,178	832,132	697,822	148,231	846,053
2008	925,963	548,931	1,232,589	301,998	1,534,587
2009	449,901	411,358	421,788	148,994	570,782
2010	650,010	427,577	812,699	69,194	881,893
2011	1,259,216	711,755	823,423	56,083	879,506
2012	556,482	397,155	879,401	94,352	973,753
2013	1,511,995	497,334	2,709,269	127,170	2,836,439
2014	109,307	1,964,749	230,834	51,217	282,051
2015	276,126	1,791,758	780,876	51,103	831,979
2016	459,078	2,530,596	1,322,547	90,055	1,412,602
2017	355,544	2,336,352	856,081	182,937	1,039,018
2018	134,624	1,450,855	428,273	109,757	538,030
Average	541,164	670,886	806,044	120,336	926,380

Table 2. North Carolina RCGL harvest of black drum 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	8,970	16,101	1,375	10,345
2003	2,224	3,821	1,767	3,990
2004	1,480	3,651	1,338	2,819
2005	1,374	1,518	1,267	2,641
2006	2,939	4,496	2,549	5,488
2007	2,418	4,450	1,413	3,831
2008	3,470	8,670	2,069	5,539

Table 3. Mean, minimum, maximum total length (TL; inches), and total number of black drum measured from North Carolina commercial fish house samples, 1994-2018.

Year	Mean TL (inches)	Minimum TL (inches)	Maximum TL (inches)	Total Measured (number)
1994	14	9	17	51
1995	11	8	43	224
1996	14	8	26	262
1997	16	8	23	141
1998	17	6	25	92
1999	14	8	48	692
2000	16	8	30	888
2001	16	8	36	471
2002	15	8	47	1,968
2003	17	8	49	631
2004	16	8	48	297
2005	15	5	44	331
2006	14	7	48	1,543
2007	14	7	50	1,919
2008	15	7	50	2,695
2009	16	7	48	1,060
2010	17	8	49	658
2011	13	7	33	1,204
2012	15	6	37	1,123
2013	16	5	36	866
2014	17	10	47	381
2015	19	10	44	310
2016	17	10	47	810
2017	18	10	30	549
2018	19	14	46	422

Table 4. Black drum length (total length, inches) data from Marine Recreational Information Program recreational samples, 1990-2018.

Year	Mean TL (inches)	Minimum TL (inches)	Maximum TL (inches)	Total Measured (number)
1990	10	7	28	6
1991	12	9	22	22
1992	13	9	19	7
1993	11	8	25	61
1994	15	9	32	121
1995	11	7	30	390
1996	12	7	25	339
1997	16	9	33	144
1998	12	7	26	167
1999	13	8	31	248
2000	15	8	24	178
2001	12	8	25	173
2002	15	8	30	219
2003	11	7	52	198
2004	14	8	27	127
2005	11	7	34	89
2006	13	9	33	104
2007	11	7	20	191
2008	12	7	48	363
2009	11	8	25	191
2010	11	7	29	258
2011	10	7	24	567
2012	13	7	26	237
2013	13	7	26	154
2014	15	7	24	33
2015	17	11	25	75
2016	17	10	28	116
2017	16	9	27	162
2018	16	8	26	128

Table 5. Annual weighted black drum CPUE (all ages combined) from the North Carolina Pamlico Sound Independent Gill Net Survey from 2001-2018. N=number of samples; CPUE=Catch per unit effort (black drum per gill net set); SE=Standard Error; PSE=Proportional Standard Error.

Year	N	CPUE	SE	PSE
2001	237	1.91	0.41	21
2002	320	3.52	0.46	13
2003	320	1.16	0.3	26
2004	320	0.46	0.09	20
2005	304	0.49	0.13	27
2006	320	0.78	0.09	12
2007	320	0.76	0.16	21
2008	320	0.87	0.16	18
2009	320	0.79	0.16	20
2010	320	0.54	0.18	33
2011	298	0.84	0.15	18
2012	308	0.38	0.07	18
2013	308	0.42	0.07	17
2014	308	0.76	0.17	22
2015	306	1.04	0.41	39
2016	308	1.33	0.21	16
2017	308	1.17	0.26	22
2018	308	0.42	0.07	17

Table 6. Summary of black drum age samples collected from both dependent (commercial and recreational fisheries) and independent (surveys) sources from 2011-2018*+.

Year	Modal Age	Minimum Age	Maximum Age	Total Number Aged
2011	0	0	60	140
2012	1	0	3	327
2013	2	0	4	187
2014	1	0	31	409
2015	0	0	2	398
2016	1	0	13	667
2017	1	0	43	738
2018*	1	0	46	430

**Preliminary ages, pending second read.*

+Majority of older fish from partial carcasses.

Table 7. Summary of ASMFC management strategies and their implementation status for Black Drum Fishery Management Plan.

Management Strategy	**Implementation Status**
HARVEST MANAGEMENT	
Implement a maximum possession limit and size limit (of no less than 12 inches) by January 1, 2014	Accomplished (other states)
Implement a maximum possession limit and size limit (of no less than 14 inches) by January 1, 2016	Proclamation FF-73-2013
Implement a 10 fish and 28-inch minimum size limit for Maryland's commercial fishery by April 1, 2019	Pending (Maryland)

FIGURES

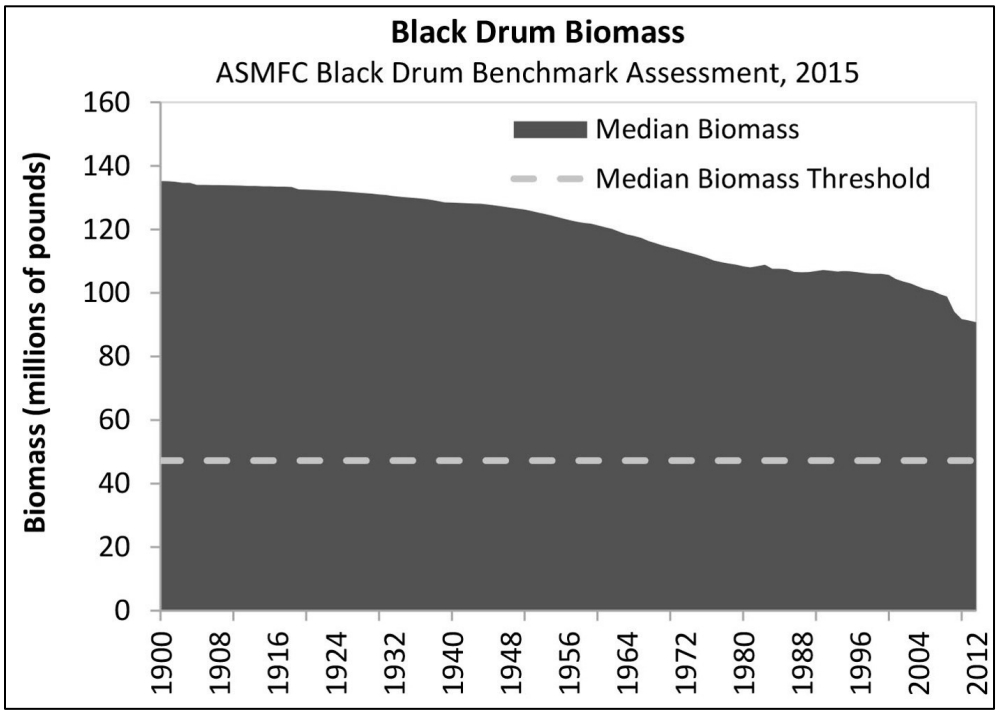

Figure 1. Depletion-Based Stock Reduction Analysis (DB-SRA) median biomass and threshold, 1900-2012 (ASMFC 2018b).

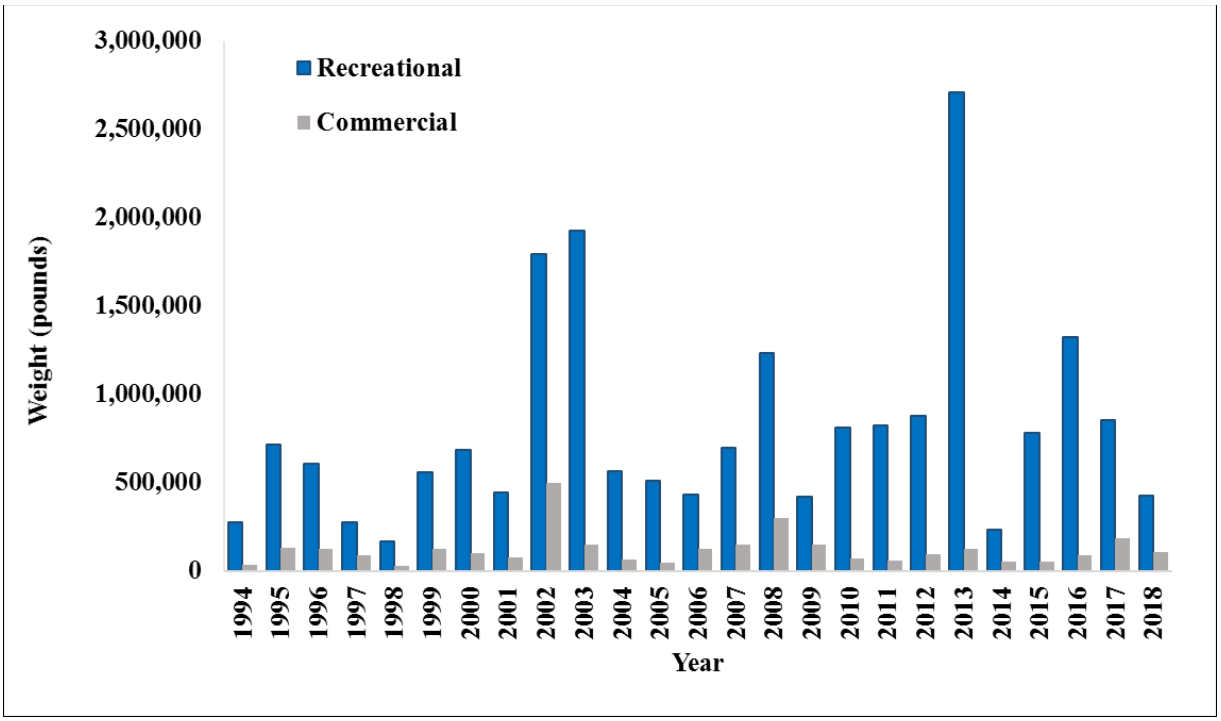

Figure 2. Annual commercial and recreational landings in pounds for black drum in North Carolina from 1994 to 2018.

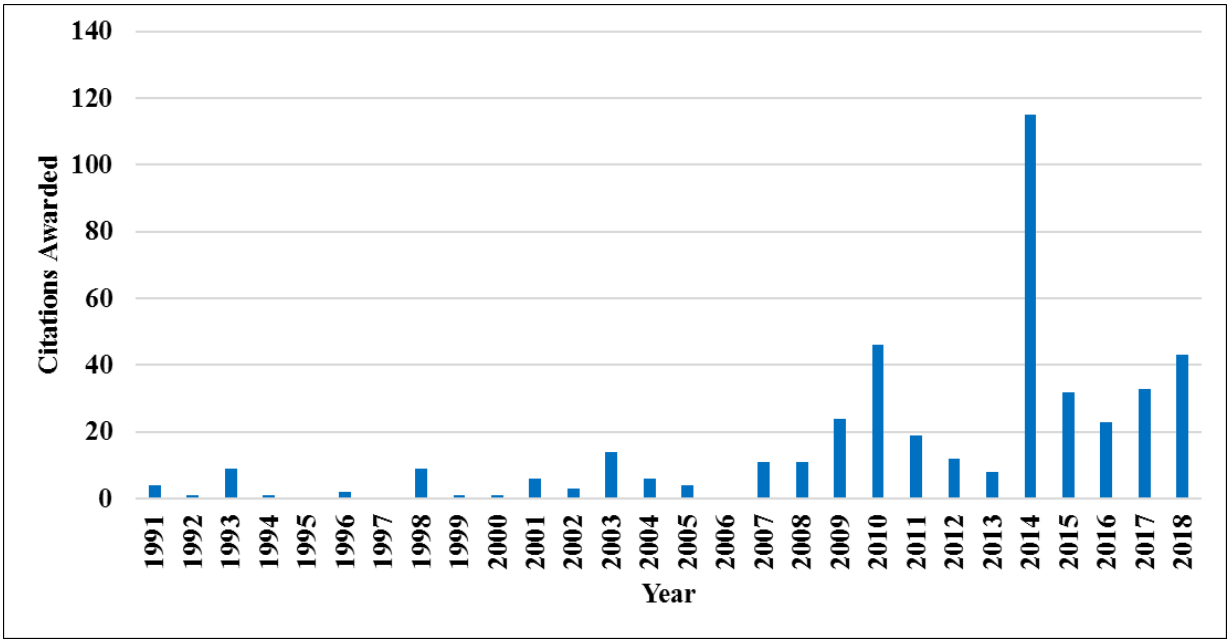

Figure 3. North Carolina Saltwater Fishing Tournament citations awarded for black drum from 1991 to 2018. Citations are awarded for black drum greater 35 pounds or 40 inches total length.

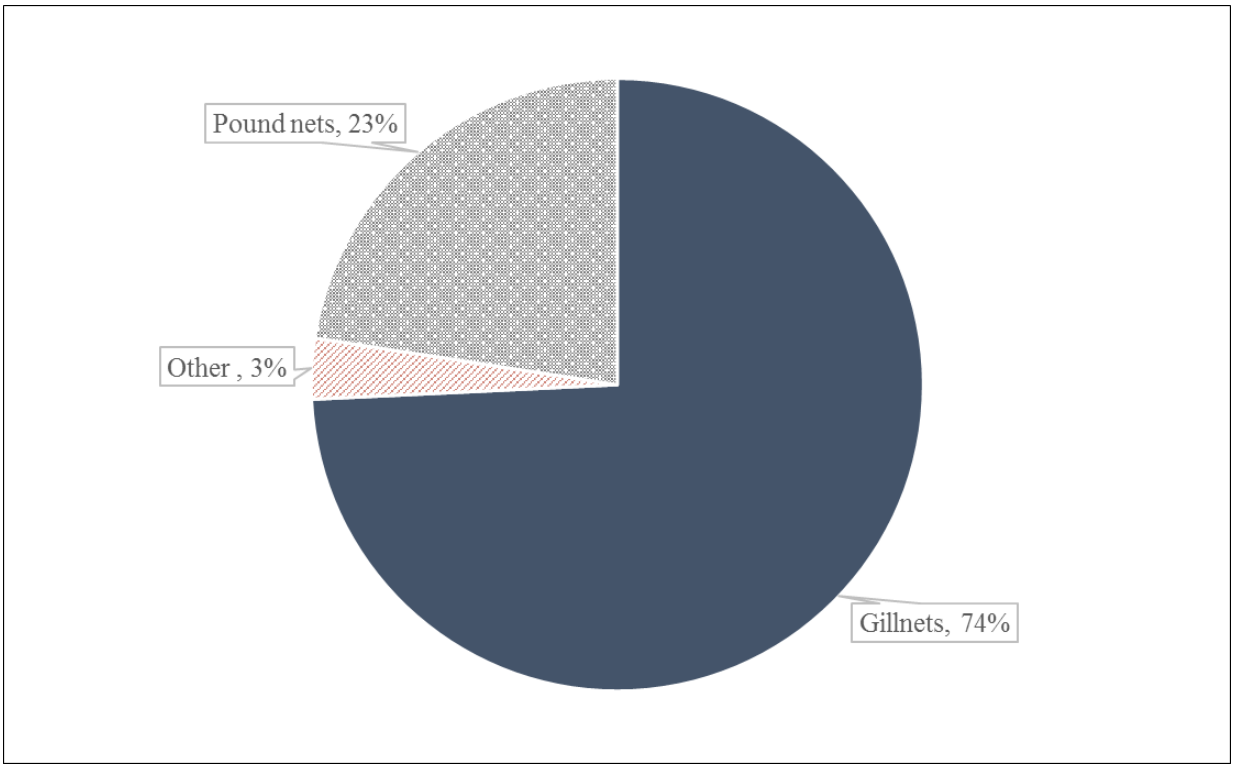

Figure 4. Black drum commercial harvest in 2018 by gear type. “Other” includes haul seines, crab pots, channel nets, and fyke nets.

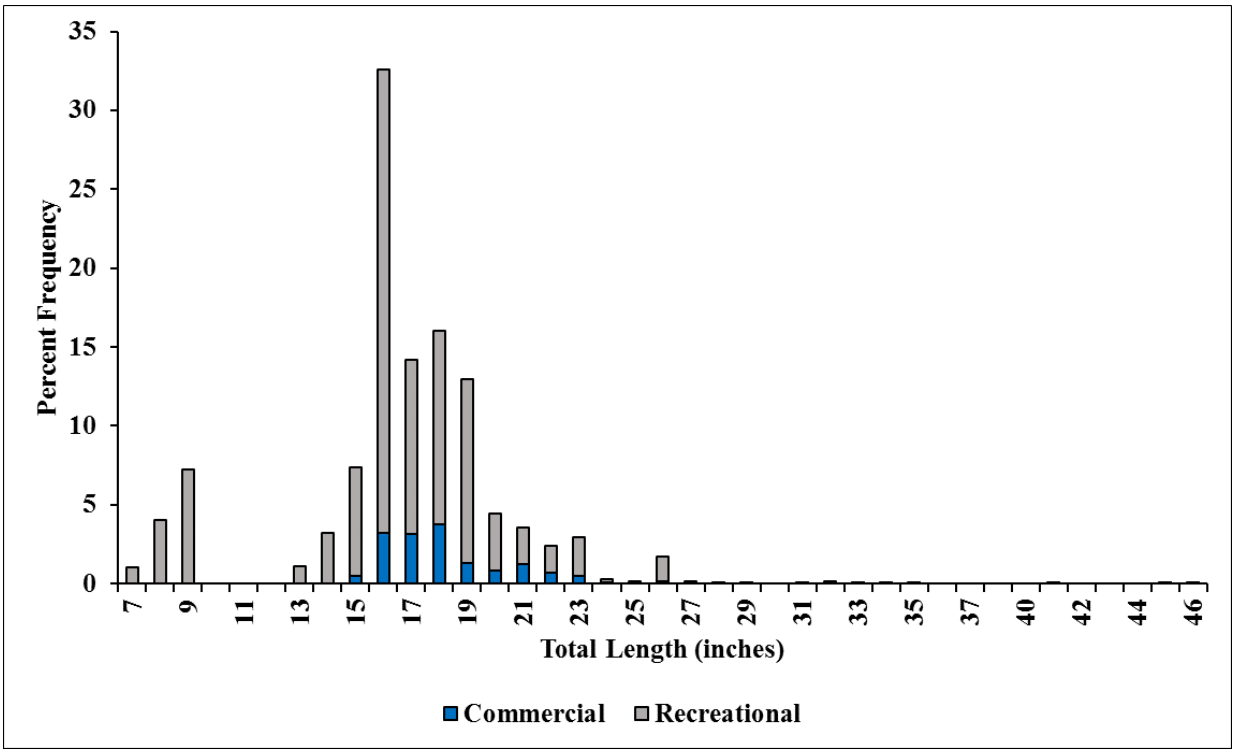

Figure 5. Commercial and recreational length frequency (total length, inches) of black drum harvested in 2018.

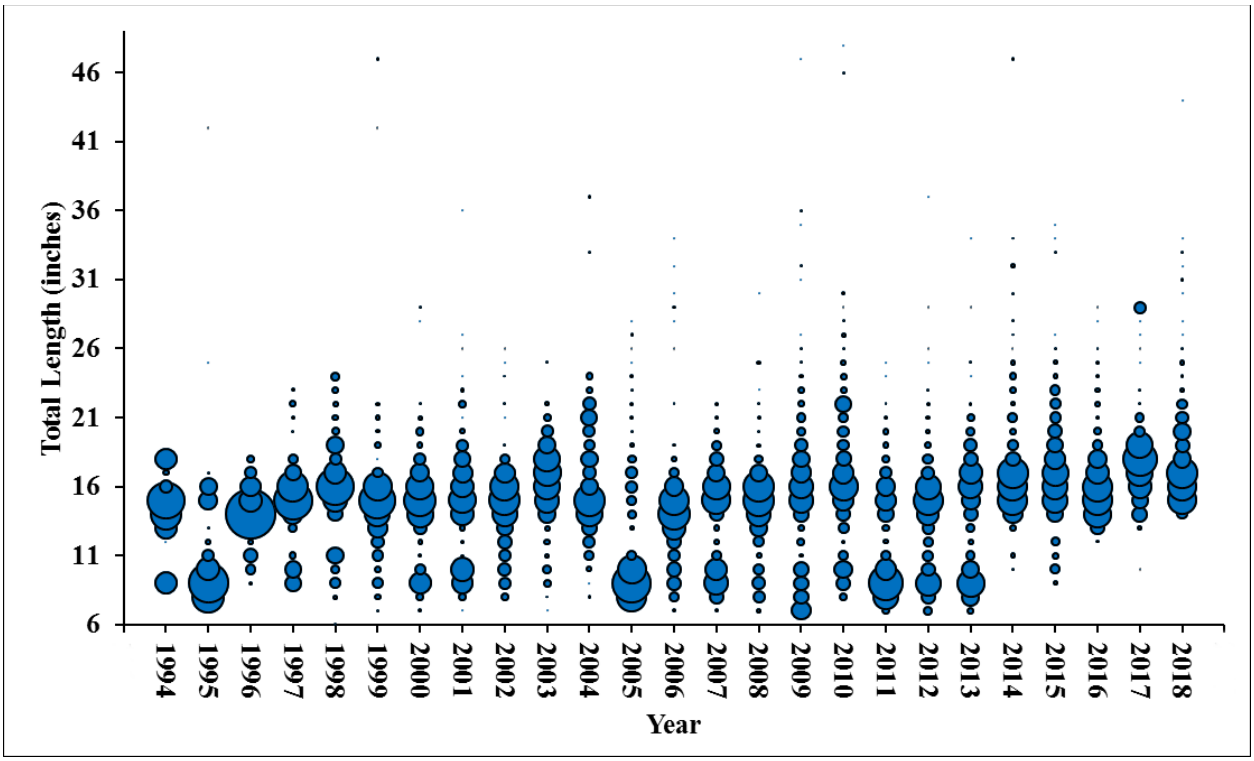

Figure 6. Commercial length frequency (total length, inches) of black drum harvested from 1994 to 2018. Bubbles represent fish harvested at length and the size of the bubble is equal to the proportion of fish at that length.

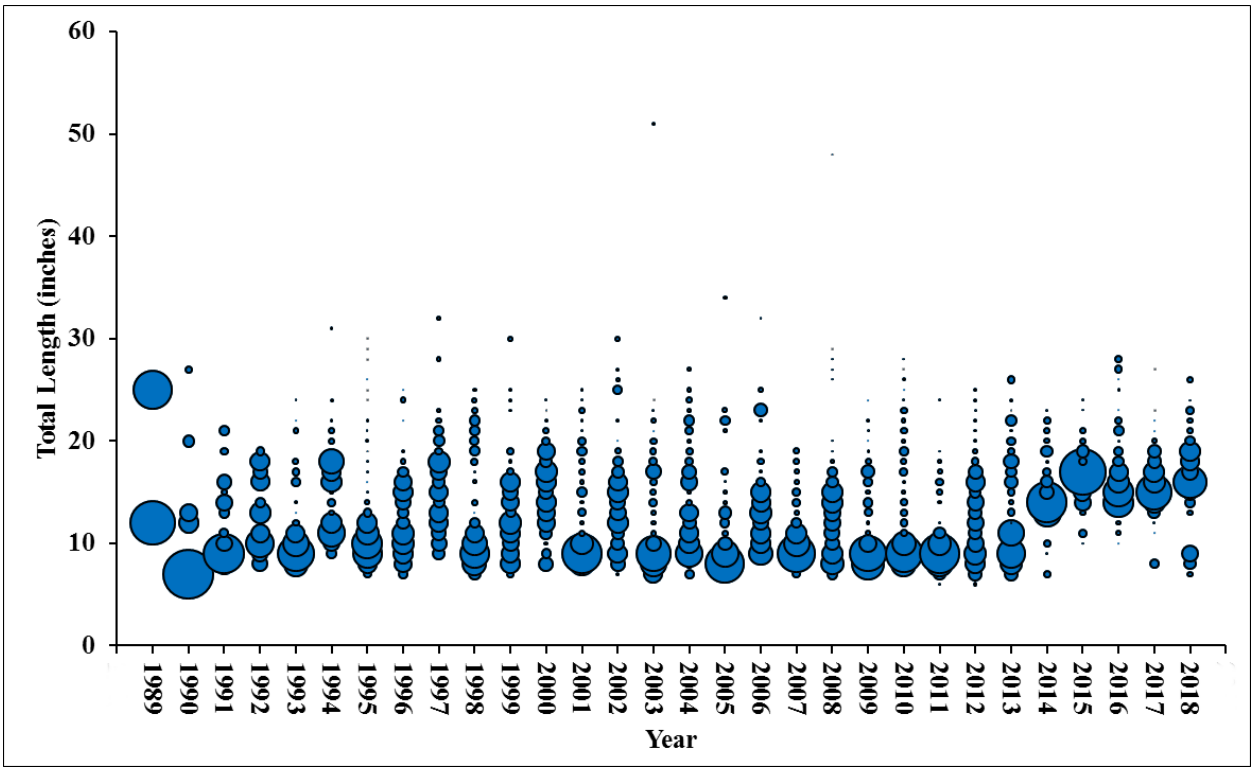

Figure 7. Recreational length frequency (total length, inches) of black drum harvested from 1989 to 2018. Bubbles represent fish harvested at length and the size of the bubble is equal to the proportion of fish at that length.

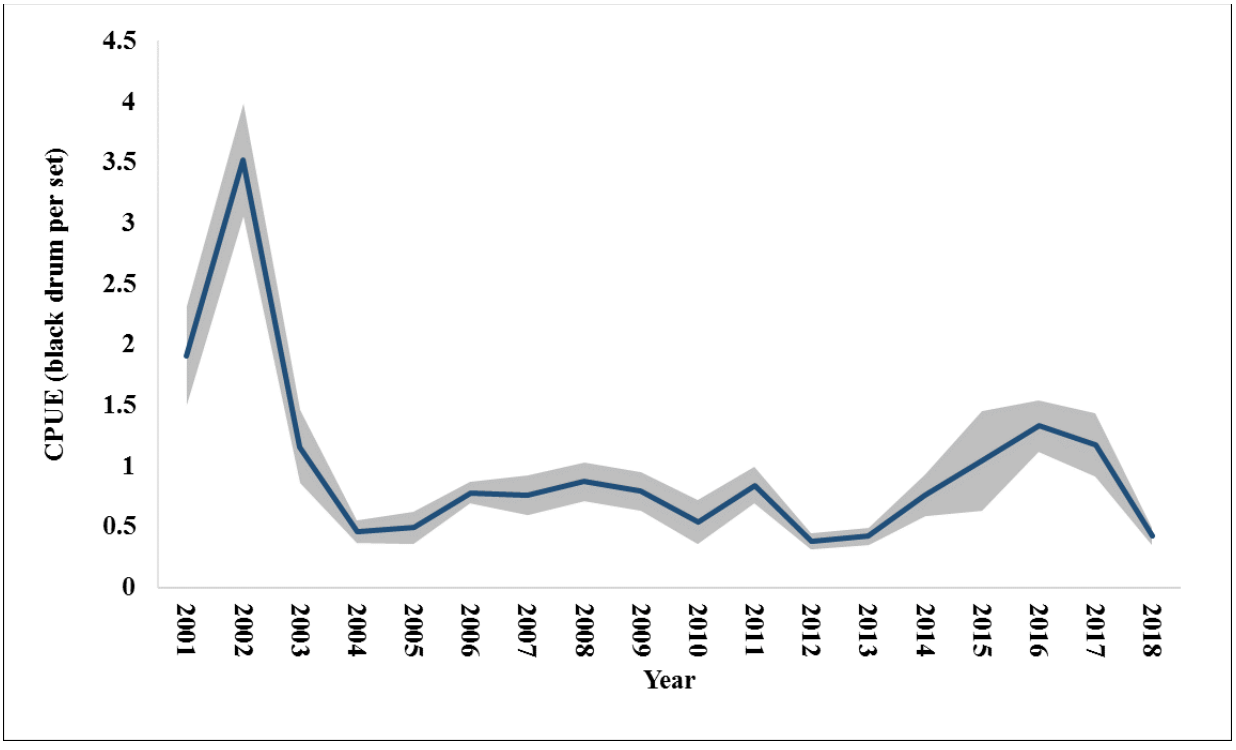

Figure 8. Annual weighted black drum CPUE from the North Carolina Pamlico Sound Independent Gill Net Survey, 2001-2018. Shaded area represents standard error.

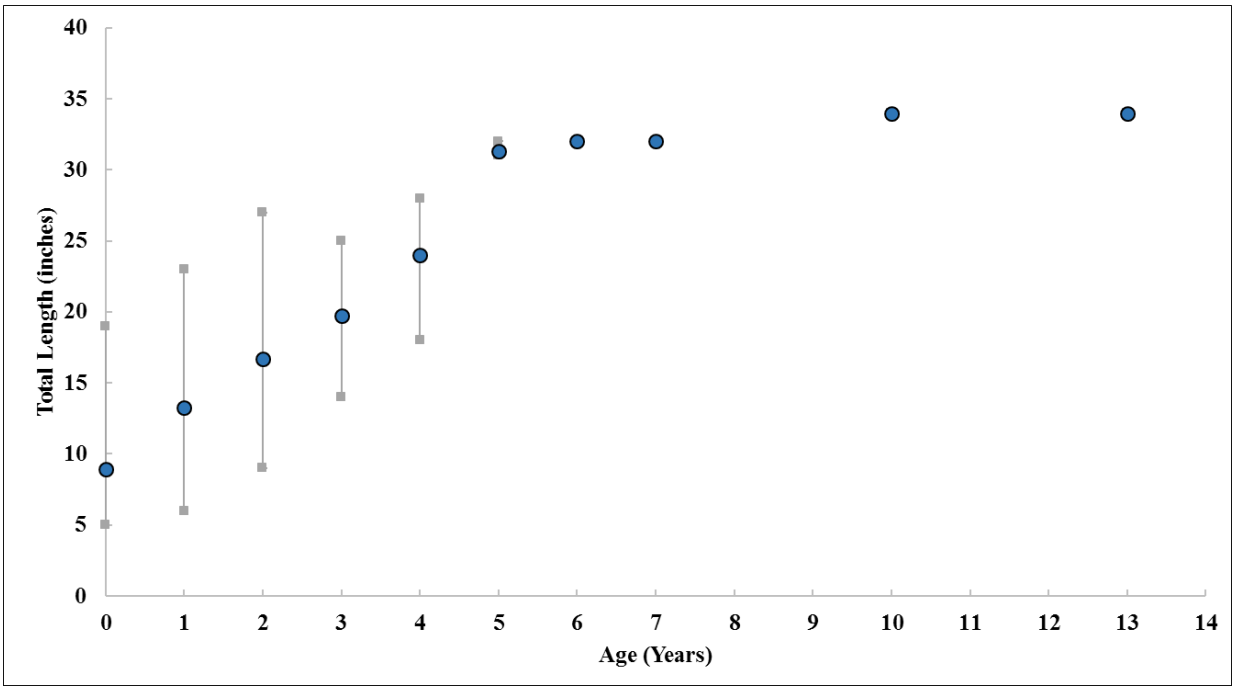

Figure 9. Black drum length (total length, inches) at age based on all age samples collected from 2011 to 2018*. Blue circles represent the mean size at a given age while the grey squares represent the minimum and maximum observed size for each age. *Samples collected from partial carcasses were not included.

FISHERY MANAGEMENT PLAN UPDATE
BLACK SEA BASS NORTH OF CAPE HATTERAS
AUGUST 2019

STATUS OF THE FISHERY MANAGEMENT PLAN

Fishery Management Plan History

Original FMP Adoption: Incorporated into the Summer Flounder FMP through Amendment 9 in 1996

Amendments:

- Amendment 9 in 1996
- Amendment 10 in 1997
- Amendment 11 in 1998
- Amendment 12 in 1999
  - Framework 1 in 2001
  - Addendum IV in 2001
  - Addendum VI in 2002
- Amendment 13 in 2003
  - Framework 5 in 2004
  - Addendum XII in 2004
  - Addendum XIII in 2004
  - Addendum XVI in 2005
- Amendment 16 in 2007
  - Framework 7 in 2007
  - Addendum XIX in 2007
  - Addendum XX in 2009
- Amendment 15 in 2011
  - Addendum XXI in 2011
  - Addendum XXII in 2012
- Amendment 19 (Recreational Accountability Amendment) in 2013
  - Addendum XXIII in 2013
  - Addendum XXV in 2014
- Amendment 17 in 2015
  - Framework 8 in 2015
- Amendment 18 in 2015
  - Addendum XXVII in 2016
- Amendment 20 in 2017
  - Framework 10 in 2017
  - Addendum XXX in 2018
  - Framework 11 in 2018
  - Framework 13 in 2018
  - Addendum XXXI in 2018
  - Addendum XXXII in 2018

Revisions:	None
Supplements:	None
Information Updates:	None
Next Benchmark Review:	A benchmark stock assessment was completed in 2016 and a stock assessment update is scheduled for late 2019.

Because of their presence in, and movement between, state waters (0-3 miles) and federal waters (3-200 miles), the Mid-Atlantic Fishery Management Council (MAFMC) manages black sea bass (*Centropristis striata*) north of Cape Hatteras cooperatively with the Atlantic States Marine Fisheries Commission (ASMFC). The two management entities work in conjunction with the National Marine Fisheries Service (NMFS) as the federal implementation and enforcement entity. The Summer Flounder, Scup and Black Sea Bass Fishery Management Plan (FMP) and amendments use output controls (catch and landings limits) as the primary management tool, with landings divided between the commercial (49%) and recreational (51%) fisheries. The FMP also includes minimum fish sizes, bag limits, seasons, gear restrictions, permit requirements, and other provisions to prevent overfishing and ensure sustainability of the fisheries. Recreational bag and size limits and seasons are determined on a state and regional basis in state waters and coast-wide measures in federal waters. The commercial quota is divided into state-by-state quotas.

Specific details for each Amendment include:

Amendment 9 - incorporated black sea bass into the Summer Flounder FMP; established black sea bass management measures including commercial quotas, recreational harvest limits, size limits, gear restrictions, permits, and reporting requirements.

Amendment 10 - modified commercial minimum mesh requirements; continued commercial vessel moratorium permit; prohibited transfer of summer flounder at sea; established a special permit for the summer flounder party/charter sector.

Amendment 11 - modified certain provisions related to vessel replacement and upgrading, permit history transfer, splitting, and permit renewal regulations.

Amendment 12 - revised the Summer Flounder, Scup, and Black Sea Bass FMP to comply with the Sustainable Fisheries Act and established a framework adjustment process; established quota set-aside for research for summer flounder, scup and black sea bass; established state-specific conservation equivalency measures; allowed the rollover of the winter scup quota; revised the start date for the scup summer quota period; established a system to transfer scup at sea.

Framework 1 - established quota set-aside for research for summer flounder, scup and black sea bass.

Addendum IV - provided that upon the recommendation of the relevant monitoring committee and joint consideration with the Mid-Atlantic Fishery Management Council, the ASMFC's Summer Flounder, Scup, and Black Sea Bass Management Board will decide the state regulations rather than forward a recommendation to the National Marine Fisheries Science center; made states responsible for implementing the ASMFC's Summer Flounder, Scup, and Black Sea Bass Management Boards decisions on regulations.

Addendum VI - provided a mechanism for initial possession limits, triggers, and adjusted possession limits to be set during the annual specification setting process without the need for further Emergency Rules.

Amendment 13 - revised black sea bass commercial quota system; addressed other black sea bass management measures; established multi-year specification setting of quota for summer flounder, scup and black sea bass; established region-specific conservation equivalency measures for summer flounder; built flexibility into process to define and update status determination criteria for each plan species. Amendment 13 also removed the necessity for fishermen who have both a Northeast Region (NER) black sea bass permit and a Southeast Region (SER) snapper/grouper permit to relinquish their permits for a six-month period prior to fishing south of Cape Hatteras during the northern closure.

Framework 5 - established multi-year specification setting of quota for summer flounder, scup, and black sea bass.

Addendum XII - continued the use of a state-by-state allocation system, managed by the ASMFC on an annual coast-wide commercial quota.

Addendum XIII - modified the Summer Flounder, Scup, and Black Sea Bass FMP so that Total Allowable Landings for summer flounder, scup, and/or black sea bass can be specified for up to three years.

Addendum XVI - established guidelines for delayed implementation of management strategies.

Amendment 16 - standardized bycatch reporting methodology.

Framework 7 - built flexibility into process to define and update status determination criteria for each plan species.

Addendum XIX - continued the state-by-state black sea bass commercial management measures, without a sunset clause; broadened the descriptions of stock status determination criteria contained within the Summer Flounder, Scup, and Black Sea Bass FMP to allow greater flexibility in those definitions, while maintaining objective and measurable status determination criteria for

identifying when stocks or stock complexes covered by the fishery management plan are overfished.

Addendum XX - set policies to reconcile commercial quota overages to address minor inadvertent quota overages; streamlined the quota transfers process and established clear policies and administrative protocols to guide the allocation of transfers from states with underages to states with overages; allowed for commercial quota transfers to reconcile quota overages after a year's end.

Amendment 15 - established annual catch limits and accountability measures.

Addendum XXI - allowed more flexibility in setting recreational measures for the 2011 fishing year and proposed state-by-state or regional management measures for the 2011 black sea bass fishery.

Addendum XXII - divided the recreational black sea bass coast-wide allocations into state-by-state management for 2012 only.

Amendment 19 - (Recreational Accountability Amendment) modified the accountability measures for the MAFMC recreational fisheries.

Addendum XXIII - established regional management for the 2013 recreational black sea bass fishery.

Addendum XXV - established regional management for the 2014 recreational black sea bass and summer flounder fishery.

Amendment 17 - implemented standardized bycatch reporting methodology.

Framework 8 - allowed the black sea bass recreational fishery to begin on May 15 of each year, instead of May 19, to provide additional fishing opportunities.

Amendment 18 - eliminated the requirement for vessel owners to submit "did not fish" reports for the months or weeks when their vessel was not fishing; removed some of the restrictions for upgrading vessels listed on federal fishing permits.

Addendum XXVII - continued regional management of the recreational summer flounder fishery, extended ad hoc regional management of the black sea bass recreational fishery for the 2016 and 2017 fishing year and addressed the discrepancies in recreational summer flounder management measures within Delaware Bay.

Amendment 20 - implemented management measures to prevent the development of new, and the expansion of existing, commercial fisheries on certain forage species in the Mid-Atlantic.

Framework 10 - implemented a requirement for vessels that hold party/charter permits for Council-managed species to submit vessel trip reports electronically (eVTRs) while on a trip carrying passengers for hire.

Addendum XXX - established 2018 recreational black sea bass management with options for regional allocations that require uniform regulations and other alternatives to the current North/South regional delineation (MA-NJ/DE-NC)

Framework 11 - established a process for setting constant multi-year Acceptable Biological Catch (ABC) limits for Council-managed fisheries, clarified that the Atlantic Bluefish, Tilefish, and Atlantic Mackerel, Squid, and Butterfish FMPs will now automatically incorporate the best available scientific information in calculating ABCs (as all other Mid-Atlantic management plans do) rather than requiring a separate management action to adopt them, clarified the process for setting ABCs for each of the four types of ABC control rules.

Framework 13 - modified the accountability measures required for overages not caused by directed landings (i.e., discards) in the summer flounder, scup, and black sea bass fisheries.

Addendum XXXI - established conservation equivalency for black sea bass and transit provisions in federal waters around Block Island, Rhode Island for recreational and commercial fishermen which allows permitted fishermen to pass through federal waters legally.

Addendum XXXII - established a specifications process instead of an addendum process to implement recreational management measures more quickly for summer flounder and black sea bass.

Specific details for each amendment under development include: None

To ensure compliance with interstate requirements, North Carolina also manages this species 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 MAFMC, 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. These plans were established under the Magnuson-Stevens Fishery Conservation and Management Act (federal council plans) and the Atlantic Coastal Fisheries Cooperative Management Act (ASMFC plans) with the goal, like the Fisheries Reform Act of 1997, to "ensure long-term viability" of these fisheries (NCDMF 2015).

Management Unit

U.S. waters in the western Atlantic Ocean from Cape Hatteras northward to the U.S.-Canadian border.

Goal and Objectives

The objectives of the Summer Flounder, Scup and Black Sea Bass FMP are to:

1. Reduce fishing mortality in the summer flounder, scup and black sea bass fisheries to assure that overfishing does not occur;
2. Reduce fishing mortality on immature summer flounder, scup and black sea bass to increase spawning stock biomass;
3. Improve the yield from these fisheries;
4. Promote compatible management regulations between state and federal jurisdictions;
5. Promote uniform and effective enforcement of regulations;
6. Minimize regulations to achieve the management objectives stated above.

The 2011 Omnibus Amendment contains Amendment 15 to the Summer Flounder, Scup and Black Sea Bass FMP. The amendment is intended to formalize the process of addressing scientific and management uncertainty when setting catch limits for the upcoming fishing year(s) and to establish a comprehensive system of accountability for catch (including both landings and discards) relative to those limits, for each of the managed resources subject to this requirement. Specifically: (1) Establish allowable biological catch control rules, (2) Establish a MAFMC risk policy, which is one variable needed for the allowable biological catch control rules, (3) Establish annual catch limits, (4) Establish a system of comprehensive accountability, which addresses all components of the catch, (5) Describe the process by which the performance of the annual catch limit and comprehensive accountability system will be reviewed, (6) Describe the process to modify the above objectives (1-5) in the future.

STATUS OF THE STOCK

Life History

Black sea bass are split into two stocks but together are found along the Atlantic coast from the Gulf of Maine to the Florida Keys. The northern stock is located from the Gulf of Maine to Cape Hatteras, North Carolina while the southern stock is located from Cape Hatteras, North Carolina to the Florida Keys. Black sea bass have a unique life history in that they are protogynous hermaphrodites which means they begin life as female and then change to male once they reach age 2 to 5 or when they reach 9 to 13 inches in total length. During the spawning season, dominant males develop a large nuchal (nape of the neck) hump, whereas subordinate males do not and are typically smaller in size. Spawning for the northern stock typically occurs offshore on the inner continental shelf during the months from May to July. Juveniles and adults move nearshore during the summer. Seasonal migration is common for black sea bass (north of Cape Hatteras). Black sea bass have a maximum age of 12 years. They are likely to stay near rock pilings, wrecks and jetties and prey on fish, crabs, mussels and razor clams (Steimle 1999).

Stock Status

The 2016 black sea bass benchmark stock assessment included data through 2015. It indicated that the stock was not overfished, and overfishing was not occurring in 2015. A black sea bass stock assessment update is scheduled for late 2019.

Stock Assessment

The 2016 black sea bass benchmark stock assessment estimated fishing mortality and stock sizes using a spatially explicit age-based statistical catch at age model calculated by using the Age Structured Assessment Program. This indicated that the fishing mortality rate was below the threshold reference point and the spawning stock biomass was above the target reference point, so the stock was not overfished and overfishing was not occurring.

STATUS OF THE FISHERY

Current Regulations

Commercial: 11-inch total length minimum size limit in Atlantic Ocean and internal coastal waters north of Cape Hatteras. Landings windows are set by proclamation with variable harvest limits by gear and time-period to prevent landings from exceeding North Carolina's commercial quota (see most recent North Carolina Division of Marine Fisheries (NCDMF) proclamation).

Recreational: twelve and one half-inch total length minimum size limit and 15-fish creel limit in Atlantic Ocean and internal coastal waters north of Cape Hatteras. Season for the recreational fishery is typically May 15 to December 31. However, to account for harvest that occurred during the February 1 to February 28, 2019 season, the 2019 season changed to May 17 to December 31.

Commercial Landings

All black sea bass landings are reported through the North Carolina Trip Ticket Program. Most black sea bass landings from north of Cape Hatteras were from trawls, although fish pots caught much smaller numbers (Figure 1). Landings generally declined from 1994 through 2012 but have increased notably each year since 2013. The low landings in 2012 to 2013 were partly due to the closure of Oregon Inlet to large vessels (such as trawlers) and the consequent transfer of most of North Carolina's black sea bass quota allocation to Virginia and other states. During 2014 through 2018, more winter trawl vessels returned to North Carolina to land catches rather than transferring quota to Virginia and other states (Table 1, Figure 2).

Recreational Landings

Recreational fishing activity is monitored through the Marine Recreational Information Program. In this report, estimates across all years have been updated and are now based on the MRIP new Fishing Effort Survey-based calibrated estimates. For more information on MRIP methodology

changes see https://www.fisheries.noaa.gov/topic/recreational-fishing-data. All black sea bass harvest is reported through the NOAA Marine Recreational Information Program. Recreational harvest of black sea bass from north of Cape Hatteras was variable from 1994 through 2018 (Table 1).

MONITORING PROGRAM DATA

Fishery-Dependent Monitoring

Two NCDMF sampling programs collect biological data on commercial and recreational fisheries that catch black sea bass north of Cape Hatteras. Program 433 (Winter Trawl Fishery) is the primary program that collects harvest length data. Additionally, Program 438 (Offshore Live Bottom Fishery) collects some harvest length data but is not as active as Program 433. Other commercial sampling programs focusing on fisheries that do not target black sea bass rarely collect biological data. NCDMF sampling of the recreational fishery occurs through the NOAA Marine Recreational Information Program which collects harvest and length data.

There were no clear trends in commercial length data from 1994 through 2018. Annual mean lengths were fairly consistent for the time-series. The number of measurements increased in 2018 (Table 2). Otoliths have been collected since 2013 but have not been processed. Age data for North Carolina black sea bass north of Cape Hatteras is not currently used in the stock assessment but will continue to be collected in case it is ever needed.

Length data in the recreational fishery was variable and sample size was low throughout 1994 through 2018. Mean lengths were fairly consistent, although higher in the middle of the time-series. The number of measurements increased in 2018 (Table 3). Age data were not collected for black sea bass north of Cape Hatteras from recreational fisheries.

Fishery-Independent Monitoring

NCDMF independent sampling programs rarely encounter black sea bass north of Cape Hatteras and the few fish that we do see are mostly from Program 120 (Estuarine Trawl Survey) and from Program 195 (Pamlico Sound Survey), which collect samples of black sea bass juveniles from inshore waters. However, it is not clear that samples collected inshore north of Cape Hatteras are from the northern or southern stock of black sea bass; this combined with the small sample numbers means that these data cannot be used in an abundance index. NCDMF currently does not have independent sampling programs in Atlantic Ocean waters north of Cape Hatteras.

MANAGEMENT STRATEGY

Management of black sea bass (north of Cape Hatteras) has been based on results from NMFS Northeast Fisheries Science Center (NEFSC) stock assessments. Results from the 2016 benchmark stock assessment are being used to guide management. Projections based on stock assessments are used to set the coast-wide quota level each year. Amendments to the FMP are undertaken as issues arise that require action.

RESEARCH NEEDS

Updated research needs from the 2016 62nd Stock Assessment Workshop are provided below. The research needs listed below start with the most recent. Text in parentheses indicates known progress made to address these needs.

- Expand on previous genetic studies with smaller spatial increments in sampling (progress unknown at this time).
- Consider the impact of climate change on black sea bass, particularly in the Gulf of Maine (progress unknown at this time).
- Evaluate population sex change and sex ratio, particularly comparing dynamics among communities (progress unknown at this time).
- Study black sea bass catchability in a variety of survey gear types (progress unknown at this time).
- Investigate and document social and spawning dynamics of black sea bass (progress unknown at this time).
- Increase work to understand habitat use in sea bass and seasonal changes (progress unknown at this time).
- Evaluate use of samples collected by industry study fleets (progress unknown at this time).
- The panel recommended multiple age-structured models be evaluated for use in future models. Examples include a simple separable model with smoothing on F among years, a more complex, spatially structured model with 6 month time step within independent stock areas in spring and mixing in winter with natal homing, and tag return data in an age-structured assessment model (some progress has been made).
- Continue and expand the tagging program to provide increased age information and increased resolution on mixing rates among putative populations (some progress has been made).
- Continue and expand genetic studies to evaluate the potential of population structure north of Cape Hatteras (some progress has been made).
- Continue research on rate, timing and occurrence of sex-change in this species. Recent research findings discussed at the stock assessment review committee lead to the hypothesis that protogyny is not obligate in this species – some individuals may never have been female before maturing as a male (research is ongoing).
- The validity of the age data used in the assessment requires further evaluation, in particular the reliability of scale-based ageing needs to be determined. A scale-otolith intercalibration exercise might be of utility (some progress has been made).

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Steimle, Frank, Christine Zetlin, Peter Berrien, and Sukwoo Chang. 1999. Black Sea Bass, Centropristis striata, Life History and Habitat Characteristics. National Oceanic and Atmospheric Administration. 50 pp.

TABLES

Table 1. Black sea bass (north of Cape Hatteras) recreational harvest and number released (NOAA Marine Recreational Information Program) and commercial harvest (North Carolina Trip Ticket Program) for 1994-2018. All weights are in pounds.

	Recreational				
	Numbers		Weight (lb)		
Year	Landed	# Released	Landed	Commercial Weight (lb)	Total Weight (lb)
1994	13,464	127,309	14,746	700,523	715,269
1995	52,181	279,414	25,298	488,479	513,777
1996	17,373	53,235	14,948	466,158	481,106
1997	17,249	102,069	22,482	345,778	368,260
1998	19,229	315,269	25,353	248,515	273,868
1999	44,785	386,011	48,213	128,562	176,775
2000	11,875	179,458	13,828	152,668	166,496
2001	5,706	201,487	8,872	167,171	176,043
2002	11,638	267,317	18,862	159,507	178,369
2003	27,468	51,566	20,195	373,807	394,002
2004	2,521	124,332	2,531	374,883	377,414
2005	1,710	220,159	5,203	368,400	373,603
2006	23,781	388,422	26,459	334,080	360,539
2007	18,147	329,655	55,565	195,460	251,025
2008	12,636	407,420	14,948	208,726	223,674
2009	3,984	543,285	8,283	176,748	185,031
2010	17,183	211,057	24,471	107,996	132,467
2011	73,207	266,289	111,538	98,505	210,043
2012	3,625	413,879	8,231	61,187	69,418
2013	16,119	136,016	21,617	88,242	109,859
2014	768	111,327	1,269	212,488	213,757
2015	2,955	149,347	6,224	241,538	247,762
2016	1,188	117,664	1,591	225,405	226,996
2017	23,720	152,491	33,421	388,858	422,279
2018	6,762	96,604	9,494	317,565	327,059
Average	17,171	225,243	21,746	265,250	286,996

Table 2. Black sea bass (north of Cape Hatteras) length (total length, inches) data from commercial fish house samples, 1994-2018.

Year	Mean Total Length (in)	Minimum Total Length (in)	Maximum Total Length (in)	Total Number Measured
1994	11	8	22	3,018
1995	12	8	20	2,070
1996	13	8	23	1,213
1997	12	8	19	727
1998	13	8	24	593
1999	14	10	21	27
2000	14	8	28	1,414
2001	13	9	22	826
2002	14	8	23	2,169
2003	15	9	24	7,416
2004	15	8	24	6,810
2005	16	9	26	6,899
2006	15	9	24	5,323
2007	15	9	26	3,213
2008	15	9	26	6,378
2009	15	9	26	3,936
2010	15	9	25	5,254
2011	15	9	25	2,946
2012	15	11	21	725
2013	15	9	24	1,452
2014	15	8	24	3,740
2015	15	9	24	7,192
2016	16	9	28	6,526
2017	16	10	24	5,372
2018	16	10	29	6,247

Table 3. Black sea bass (north of Cape Hatteras) length (total length, inches) data from NOAA Marine Recreational Information Program recreational samples, 1994-2018.

Year	Mean Total Length (in)	Minimum Total Length (in)	Maximum Total Length (in)	Total Number Measured
1994	11	5	28	74
1995	9	6	21	80
1996	12	7	20	80
1997	13	8	20	61
1998	13	7	19	75
1999	13	8	19	126
2000	13	9	23	59
2001	14	10	17	34
2002	14	11	23	128
2003	11	9	21	110
2004	14	11	19	7
2005	20	11	24	42
2006	13	8	23	64
2007	18	13	22	26
2008	14	11	20	48
2009	15	12	24	48
2010	14	12	21	29
2011	14	11	22	36
2012	17	13	20	14
2013	14	9	20	14
2014	14	13	18	4
2015	17	13	17	5
2016	14	12	21	16
2017	13	12	17	11
2018	14	13	21	23

FIGURES

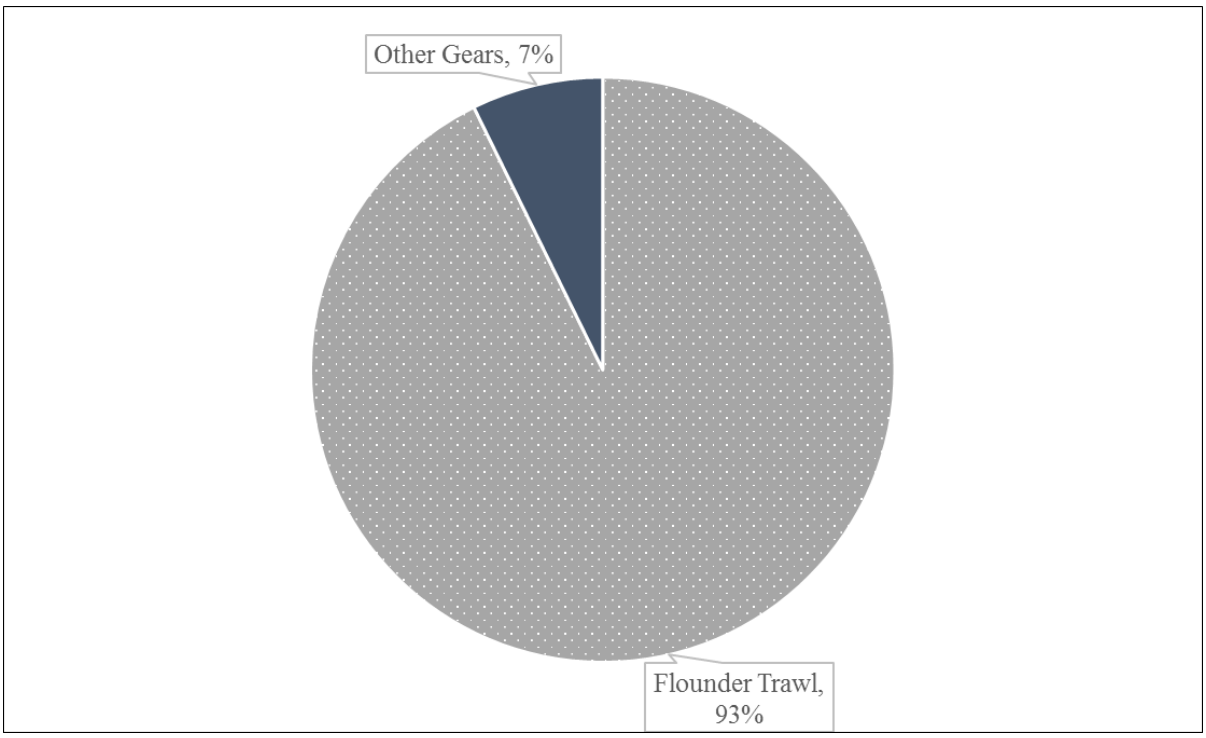

Figure 1. Commercial harvest of black sea bass (north of Cape Hatteras) in North Carolina by gear type in 2018.

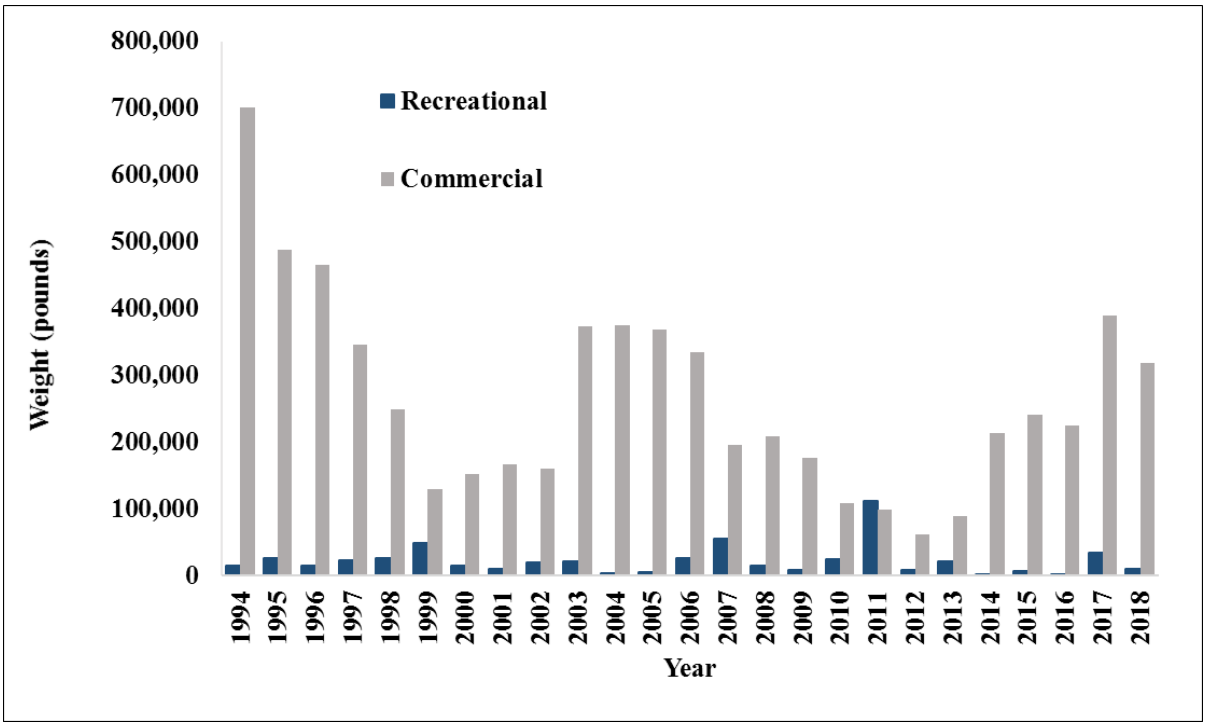

Figure 2. Annual commercial and recreational landings in pounds for black sea bass (north of Cape Hatteras) in North Carolina from 1994-2018.

FISHERY MANAGEMENT PLAN UPDATE
BLUEFISH
AUGUST 2019

STATUS OF THE FISHERY MANAGEMENT PLAN

Fishery Management Plan History

Original FMP Adoption:	October 1990
Amendments:	Amendment 1 2000 Framework 1 2001 Amendment 2 2007 Amendment 3 2011 Addendum I 2012 Amendment 4 2013 Amendment 5 2015 Amendment 6 2017 Framework 2 2017 Framework 3 2018
Revisions:	None
Supplements:	None
Information Updates:	None
Next Benchmark Review:	A benchmark stock assessment was completed in August 2015. The next benchmark review is tentatively scheduled for 2020.

The Bluefish Fishery Management Plan (FMP) was developed through a novel (at the time) joint management effort between the interstate Atlantic States Marine Fisheries Commission (ASMFC) and the federal Mid-Atlantic Fishery Management Council (MAFMC). Amendment 1 initiated a 10-year rebuilding schedule to eliminate overfishing and allow for stock rebuilding which was achieved in 2009. Amedment 1 also established commercial and recreational quota allocations, state-specific commercial allocations, and allowed for transfer of unused recreational quota to the commercial fishery. Framework 1 established annual harvest allocations specifically for biological monitoring programs. Amendments 2 and 5 were implemented to establish a strategy for monitoring bluefish bycatch. Amendment 3 added a formalizing processes to incorporate scientific and management uncertainty when establishing catch limits. Addendum I established a coast-wide biological monitoring program to improve the quantity and quality of information available for use in bluefish stock assessments. Ammendment 4 removed the stipulation that recreational catches that exceeded catch limits the previous year must take a reduction the following year for stock species that are not overfished nor is

overfishing occurring. Ammendment 6 addressed considerations for examining potential influence of the removal of forage fish species by increasing directed fishing and advocated for future ecosystem based management approaches. Framework 2 required for-hire vessels with federal permits for species managed by MAFMC to submit electronic vessel trip reports to the National Oceanic and Atmospheric Administration. Framework 3 established a proccess to specify constant multi-year acceptable biological catches.

The FMP allows a state-by-state commercial quota system and a coast-wide recreational harvest limit to reduce fishing mortality. Reporting and permit requirements, outlined in Amendment I, are implemented for both commercial and recreational fishing sectors as well as fish dealers. The bluefish monitoring committee annually reviews contemporaneous fisheries data and recommends appropriate management measures as needed to achieve management goals.

To ensure compliance with interstate requirements, North Carolina (N.C.) also manages bluefish 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 and approved by the MAFMC, 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 plans) and the Atlantic Coastal Fisheries Cooperative Management Act (ASMFC plans), are like the goals of the Fisheries Reform Act of 1997 to “ensure long-term viability” of these fisheries (NCDMF 2015).

Management Unit

The FMP defines the management unit of bluefish as a single stock occurring in U.S. waters of the western Atlantic Ocean. All member Atlantic states participate in the Bluefish FMP process with the exception of Pennsylvania and the District of Columbia.

Multiple committees advise Atlantic bluefish fisheries managers. The ASMFC Stock Assessment Subcommitee and Technical committtee provide scientific insight to the ASMFC Bluefish Management Board and the MAFMC Demersal committee. Board members task science committees with logistical assistance, provide framework adjustment recommendations, and vote on management strategies for implementation.

Goal and Objectives

On July 26, 2000, the National Oceanic and Atmospheric Administration (NOAA) Fisheries published the final rule to implement the measures contained in Amendment 1 of the ASMFC/MAFMC Bluefish FMP. The goal of Amendment 1 is to conserve the bluefish resource along the Atlantic Coast, specifically to: 1) increase understanding of the stock and fishery; 2) provide highest availability of bluefish to U.S. fishermen; while maintaining, within limits, traditional uses of bluefish; 3) provide for cooperation among the coastal states, the various regional marine fishery management councils, and federal agencies involved along the coast to

enhance the management of bluefish throughout its range; 4) prevent recruitment overfishing; and 5) reduce the waste in both the commercial and recreational fisheries.

STATUS OF THE STOCK

Life History

Bluefish (*Pomatomus saltatrix)* are migratory open water (pelagic) species found throughout the Atlantic Ocean. Bluefish migrate seasonally, moving north as water temperatures rise during spring and summer and south during the fall and winter to areas along the South Atlantic Bight (Shepherd et al. 2006). During the summer, bluefish mostly concentrate in waters from Maine to Cape Hatteras (Klein-MacPhee 2002). During the winter, they are found in offshore waters between North Carolina and Florida (Goodbred and Graves 1996). Therefore, bluefish are found off North Carolina year-round (Morley et al. 2007). Within North Carolina's estuarine waters bluefish are most common from March through October. Bluefish generally school with similarly sized fish (Austin et al. 1999).

Bluefish are fast growers (Wilk 1977) and opportunistic predators who feed indiscriminately. Over 70 different marine species have been documented in bluefish stomach contents including Atlantic menhaden, butterfish, silversides, spotted seatrout, Atlantic croaker, spot, shrimp, lobster, squid, crabs, worms, and clams (Buckel et al. 1999; Scharf et al. 2004).

The maximum documented age for bluefish is 14 years (Robillard et al. 2009). The annual maximum ages for bluefish collected in North Carolina usually range between 10 and 11 years old. The largest bluefish can exceed 39 inches and 31 pounds (http://portal.ncdenr.org/web/mf/north-carolina-state-saltwater-records).

Bluefish usually reach sexual maturity by age 2 around a length of 13 inches (Robillard et al. 2008). They spawn offshore from Massachusetts through Florida. Some research suggests that two discrete cohorts of bluefish spawn at different times during the year with one group spawning during the spring and a second spawning during the summer (Lassiter 1962). More recent research suggests that bluefish continue to spawn as they migrate northward during the spring and summer (Robillard et al. 2008).

Stock Status

A 2015 benchmark stock assessment indicated that the Atlantic bluefish stock is not experiencing overfishing and is not considered overfished (NFCS 2015). An operational assessment including data through 2018 is scheduled for 2019.

Stock Assessment

Estimates from the 2015 stock assessment model informed by state and federal indices show a general decreasing trend in fishing mortality and increasing trend in population biomass since 1988 (Figure 1).

STATUS OF THE FISHERY

Current Regulations

In North Carolina, there is a recreational bag limit of 15 bluefish per day and only five of the 15 harvested bluefish can be greater than 24-inches total length.

Commercial Landings

Bluefish commercial landings have fluctuated annually since 1972 (Table 1; Figure 2); however, landings in recent years have been lower than average. Commercial landings in 2018 were 910,284 pounds, well below the allowed commercial quota of 2.3 million pounds. Estuarine and ocean gill nets combined represent the largest commercial landings of bluefish accounting for 96% of the harvest in 2018 (Figure 4).

Recreational Landings

Recreational landings for bluefish have been annually variable but relatively stable for the last couple of decades (Table 1; Figure 2). Preliminary Marine Recreational Information Program (MRIP) data collected by the NOAA Fisheries indicates that approximately 2.6 million pounds of bluefish were recreationally harvested in 2018. Recreational fishing activity is monitored through the Marine Recreational Information Program. In this report, estimates across all years have been updated and are now based on the MRIP new Fishing Effort Survey-based calibrated estimates. For more information on MRIP methodology changes see https://www.fisheries.noaa.gov/topic/recreational-fishing-data.

The NCDMF offers award citations for exceptional catches of bluefish. Bluefish exceeding 15 pounds are eligible for an award citation. Since 1991, award citations for bluefish have been variable with typically less than 20 citations awarded per year. The highest values occurred in the 1990's (Figure 3). Since 2017, the NCDMF has offered an additional citation for released bluefish that exceed 34 inches in length. Approximately 60% of the citations awarded since 2017 have been for released fish.

MONITORING PROGRAM DATA

Fishery-Dependent Monitoring

Bluefish are sampled from a variety of North Carolina commercial fishery gears including estuarine long haul, ocean trawl, pound net, ocean gill net, estuarine gill net, and ocean beach seine fisheries. Information on the location(s) of the catch should be obtained in as much detail as possible (e.g. water body, nearest landmark, marker number, etc.). Additionally, information on fishing gear type, specifications, soak time, and water depth should be recorded. Subsampling of commercial catch to collect biological information on bluefish includes fork length (mm) and aggregate weight (kg) by market grade when possible. Trip ticket information (total weight of catch) is also recorded and reported to DMF by licensed dealers. The size of fish harvested recreationally is characterized through the MRIP survey.

A total of 3,778 bluefish were measured from commercial landings in 2018 (Table 2). Mean fork length was 15 inches and ranged from 3 to 34 inches. Size ranges have varied minimally since 1985. The mean length of fish harvested in the recreational fishery was 11 inches and ranged from 6 to 30 inches fork length. Overall, the size distribution of fish taken in the recreational fishery tends to be smaller than the distribution of fish harvested in the commercial fishery (Figure 5). Since 1985, the annual length distribution of harvest in both the commercial and recreational fisheries has varied little with most fish harvested ranging from 7 and 16 inches fork length (Figures 6 and 7). Larger bluefish occur more sporadically and appear to be less prominent in more recent years.

Fishery-Independent Monitoring

Bluefish are found in several of NCDMF sampling programs, including the juvenile trawl (P120), the Pamlico Sound trawl (P195), and the Pamlico Sound independent gill net (P915), and Long-line (P365) surveys. The Division's Pamlico Sound Independent Gill Net Survey was initiated in May of 2001 and has continuously sampled since. This survey catches more bluefish than any other independent survey. This survey provides fishery independent indices of relative abundance along with associated length and age data. These estimates provide essential data for input into the regional bluefish stock assessment. The Catch per Unit of Effort (CPUE) or number of bluefish per set has ranged from 2.8 in 2015 to 8.5 in 2007 during the last 18 years (Figure 8). The CPUE in 2018 was 4.0, slightly below the time-series average.

The majority of bluefish age samples are obtained from the Pamlico Sound Independent Gill Net Survey as well as the commercial and recreational fisheries. In 2018, bluefish ages ranged from 0 to 10 years old, with a modal age of 1 (Table 4). The maximum age over the time-series has been 11 years of age. Bluefish length increases with age, although the size at a given age can be quite variable (Figure 9).

MANAGEMENT STRATEGY

Amendment 1 of the Bluefish FMP allocates 83% of the resource to recreational fisheries and 17% to commercial fisheries. However, the commercial quota can be increased up to 10.5 million pounds if the recreational fishery is projected to not land its entire allocation for the upcoming year. The commercial fishery is controlled through state-by-state quotas based on historic landings from 1981-1989. Recently, the ASMFC and MAFMC have decided to investigate implementing a new quota allocation amendment to the FMP based on more updated fisheries data as recent catch trends have led to several instances of quota transfers between sectors and states. Public comment on proposed quota allocation changes occurred during the summer of 2018 and a final rulemaking action is scheduled for late 2020.

North Carolina is a state subject to compliance of the biological monitoring program implemented under Addendum I to Amendment 1. To comply with these monitoring requirements NCDMF must collect at least 100 aging structures from bluefish each year. In 2018, 669 bluefish otoliths were extracted.

The ASMFC/MAFMC FMP allocates 32% of the Atlantic Coast total bluefish quota to North Carolina. The FMP for bluefish welcomes individual states to implement management measures in addition to those required by the FMP or FMP amendments. The scope of North Carolina's bluefish proclamation authority is limited to actions which comply with the management requirements incorporated in Federal Fishery Management or Atlantic States Marine Fisheries Commission plans (15A NCAC 03M .0512). North Carolina continues to maintain a 15-fish recreational bag limit on bluefish that has been in place since June 19, 2001. An additional restriction that only five of the 15 fish can be greater than 24-inches total length, did not fall within the proclamation authority of the NCDMF Director, and required a North Carolina rule change. This management measure had full support of recreational anglers and advisory committees and was passed unanimously by the N.C. Marine Fisheries Commission (4/23/2002). The rule (15A NCAC 03M .0511) went into effect 4/01/2003.

RESEARCH NEEDS

- Continue research on species interactions and predator-prey relationships. Investigate the feasibility of alternative survey methods that target bluefish across all age classes to create a more representative fishery-independent index of abundance
- Initiate sampling of offshore populations in winter months
- Initiate coastal surf zone seine study to provide more complete indices of juvenile abundance
- Develop additional adult bluefish indices of abundance (e.g., broad spatial scale longline survey or gillnet survey)
- Expand age structure of Southeast Area Monitoring and Assessment Program index
- Investigate species associations with recreational angler trips targeting bluefish (on a regional and seasonal basis) to potentially modify the MRIP index used in the assessment model
- Explore age- and time-varying natural mortality from, for example, predator prey relationships; quantify effects of age- and time-varying natural mortality in the assessment model
- Continue to evaluate the spatial, temporal, and sector-specific trends in bluefish growth and quantify their effects in the assessment model
- Continue to examine alternative models that take advantage of length-based assessment frameworks. Evaluate the source of bimodal length frequency in the catch (e.g., migration, differential growth rates)
- Modify thermal niche model to incorporate water temperature data more appropriate for bluefish in a timelier manner [(e.g., sea surface temperature data & temperature data that cover the full range of bluefish habitat (South Atlantic Bight and estuaries)]
- Quantify recreational discard mortality of bluefish has discards are a large component of the recreational fishery
- Investigate potential spatial distribution shifts of the Atlantic stock

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TABLES

Table 1. Bluefish recreational harvest and number released (Marine Recreational Information Program) and commercial harvest (North Carolina Trip Ticket Program) for 1985-2018. All weights are in pounds.

	Recreational				
	Numbers		Weight (lb)		
Year	Landed	Released	Landed	Commercial Weight (lb)	Total Weight (lb)
1985	3,706,930	1,281,466	7,001,181	3,604,445	10,605,626
1986	5,184,834	1,233,792	16,245,390	3,450,230	19,695,620
1987	3,248,002	1,402,327	8,542,577	4,561,101	13,103,678
1988	3,131,369	1,002,321	4,475,001	5,039,039	9,514,040
1989	4,843,723	2,314,161	7,123,822	3,291,468	10,415,290
1990	6,838,820	2,427,701	10,345,929	4,578,172	14,924,101
1991	2,423,772	1,478,829	4,627,434	3,919,786	8,547,220
1992	1,562,752	1,957,741	2,226,311	2,839,057	5,065,368
1993	1,620,184	1,825,095	1,991,395	2,705,278	4,696,673
1994	673,341	3,235,793	847,458	1,782,345	2,629,803
1995	660,979	2,345,163	770,490	3,010,742	3,781,232
1996	632,382	1,613,566	1,352,444	3,298,639	4,651,083
1997	1,476,271	2,286,439	2,366,435	4,003,160	6,369,595
1998	1,530,106	1,530,488	1,888,463	2,925,929	4,814,392
1999	1,774,946	2,749,327	1,232,827	2,761,084	3,993,911
2000	2,325,583	5,231,507	1,721,367	3,368,610	5,089,977
2001	3,410,135	6,756,435	3,048,743	4,066,000	7,114,743
2002	2,484,516	4,357,535	2,327,789	2,323,964	4,651,753
2003	2,161,780	3,432,547	1,843,018	3,470,100	5,313,118
2004	2,825,382	3,781,031	2,773,518	3,762,944	6,536,462
2005	3,004,921	4,417,822	2,938,814	2,837,661	5,776,475
2006	2,842,593	5,213,436	2,651,326	2,791,187	5,442,513
2007	3,749,514	6,740,155	3,616,359	2,329,718	5,946,077
2008	2,855,199	5,146,870	2,385,349	1,930,391	4,315,740
2009	3,190,313	6,447,822	3,566,768	2,360,081	5,926,849
2010	3,691,868	7,419,644	3,185,652	3,216,030	6,401,682
2011	3,613,883	7,150,476	3,158,287	1,897,471	5,055,758
2012	2,684,392	3,268,032	2,872,922	758,858	3,631,780
2013	4,287,526	7,050,725	3,517,233	1,159,580	4,676,813
2014	4,418,858	5,862,762	3,764,005	2,019,279	5,783,284
2015	4,123,461	6,356,252	3,754,577	804,244	4,558,821
2016	4,489,223	6,802,960	3,356,049	1,148,620	4,504,669
2017	3,173,218	8,255,510	3,634,502	1,544,037	5,178,539
2018	3,304,587	7,912,210	2,630,685	910,284	3,540,969
Average	3,380,907	3,851,487	4,558,043	3,044,152	7,602,194

Table 2. Summary of fork length data (inches) sampled from all sources of length data (harvest and bait) from the bluefish commercial fishery from 1985-2018.

Year	Total Number Measured	Mean Fork Length (inches)	Minimum Fork Length (inches)	Maximum Fork Length (inches)
1985	5,351	15	4	33
1986	4,220	14	4	33
1987	3,902	16	4	33
1988	4,243	16	3	32
1989	5,701	16	4	33
1990	8,090	16	4	32
1991	6,068	13	3	35
1992	6,771	13	3	32
1993	3,796	15	2	35
1994	2,096	14	5	32
1995	2,095	14	3	32
1996	2,428	15	4	32
1997	4,355	13	3	34
1998	4,693	16	5	33
1999	7,063	17	4	33
2000	8,369	17	5	34
2001	11,748	17	3	34
2002	8,288	18	5	34
2003	7,861	19	5	33
2004	9,608	19	5	33
2005	9,766	19	5	33
2006	10,255	17	4	33
2007	8,856	15	5	32
2008	8,035	16	5	32
2009	7,471	18	5	33
2010	6,721	16	5	34
2011	5,768	15	6	33
2012	7,030	13	5	33
2013	6,928	14	6	32
2014	6,459	14	7	33
2015	6,100	13	7	30
2016	7,616	13	3	33
2017	5,568	15	6	35
2018	3,778	15	3	34

Table 3. Summary of fork length data (inches) sampled from the bluefish recreational fishery from 1985-2018.

Year	Total Number Measured	Mean Fork Length (inches)	Minimum Fork Length (inches)	Maximum Fork Length (inches)
1985	312	14	6	34
1986	420	18	6	38
1987	1,319	16	5	40
1988	1,117	7	0	38
1989	1,633	12	5	40
1990	2,413	13	5	34
1991	1,572	14	5	36
1992	1,044	13	7	33
1993	1,187	13	7	36
1994	1,174	14	7	36
1995	740	14	4	36
1996	1,177	15	6	38
1997	2,404	14	6	37
1998	1,624	13	6	40
1999	1,316	12	6	34
2000	1,356	12	6	34
2001	2,191	13	7	31
2002	999	13	7	34
2003	781	13	7	34
2004	1,149	13	6	40
2005	1,056	12	6	35
2006	1,028	12	6	36
2007	1,048	12	6	37
2008	894	12	5	35
2009	778	13	7	34
2010	1,323	12	6	38
2011	1,784	12	6	34
2012	1,190	12	7	35
2013	563	11	7	29
2014	660	12	7	29
2015	577	12	7	18
2016	732	11	8	23
2017	657	12	6	35
2018	846	11	6	30

Table 4. Summary of bluefish age samples collected from both dependent (commercial and recreational fisheries) and independent (surveys) sources from 1989-2018.

Year	Modal Age	Minimum Age	Maximum Age	Total Number Aged
1985	1	0	11	562
1986	1	0	9	455
1987	1	0	9	382
1988	1	0	9	348
1989	1	0	9	330
1990	1	0	9	374
1991	1	0	8	291
1992	1	0	9	706
1993	1	0	10	729
1994	1	0	10	533
1995	1	0	9	635
1996	1	0	10	489
1997	1	0	10	1,069
1998	1	0	9	1,340
1999	1	0	10	882
2006	1	0	10	558
2006	3	0	10	89
2007	2	0	11	433
2008	1	0	10	656
2009	3	0	10	488
2010	3	0	8	527
2011	3	0	9	551
2012	1	0	9	818
2013	0	0	9	742
2014	1	0	9	803
2015	1	0	10	622
2016	1	0	11	678
2017	2	0	10	630
2018	1	0	10	669

FIGURES

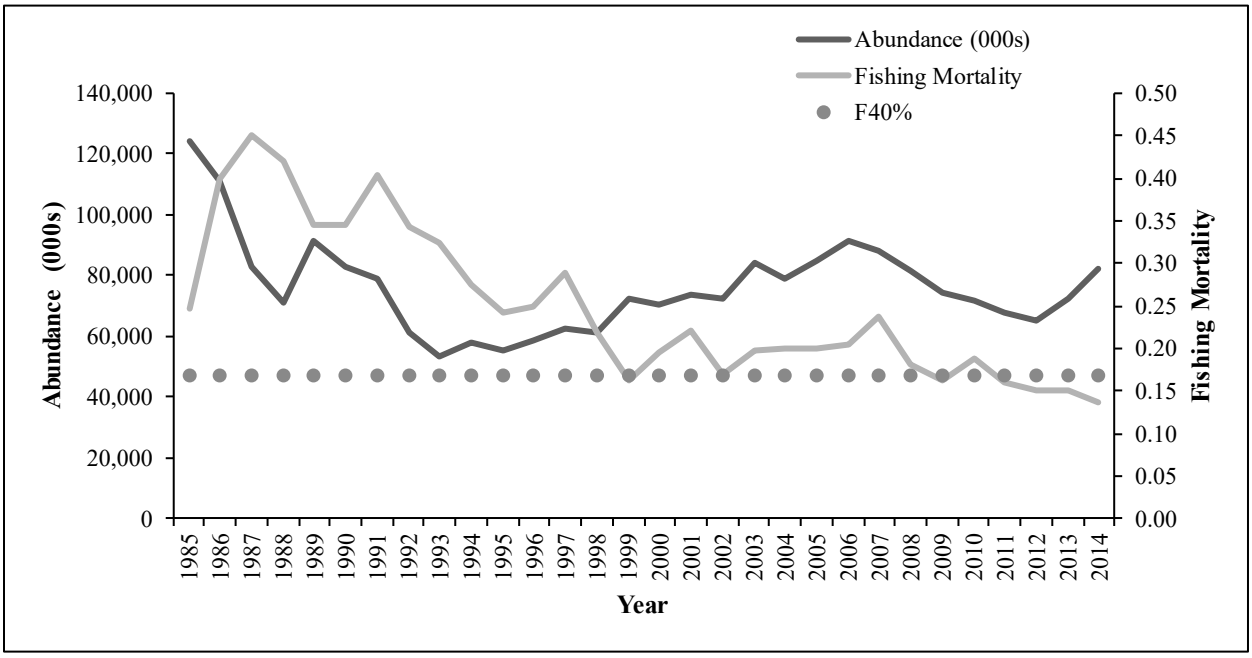

Figure 1. Total bluefish abundance and fishing mortality as estimated in the benchmark model updated through 2014. $F_{40\%}$ (fishing mortality that would result in a 40% spawning potential ratio) indicated by dotted horizontal line (cited from NEFSC (2015)).

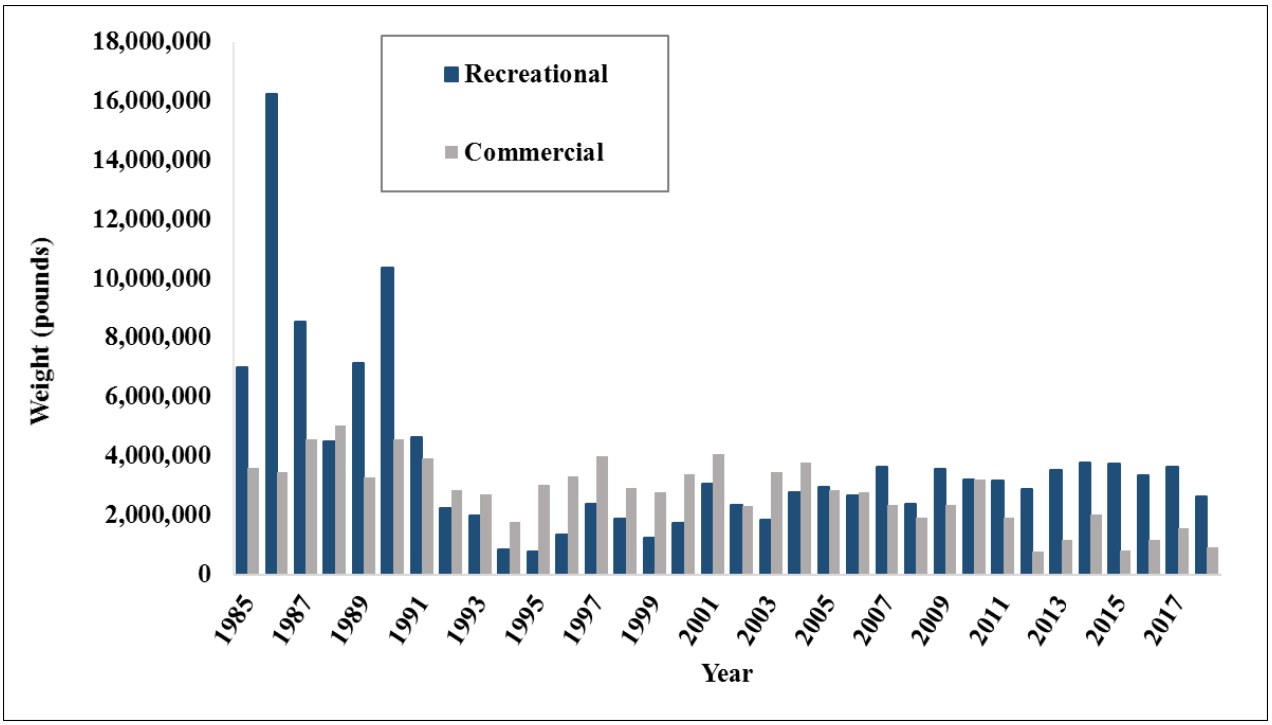

Figure 2. North Carolina commercial and recreational landings of bluefish from 1985 to 2018.

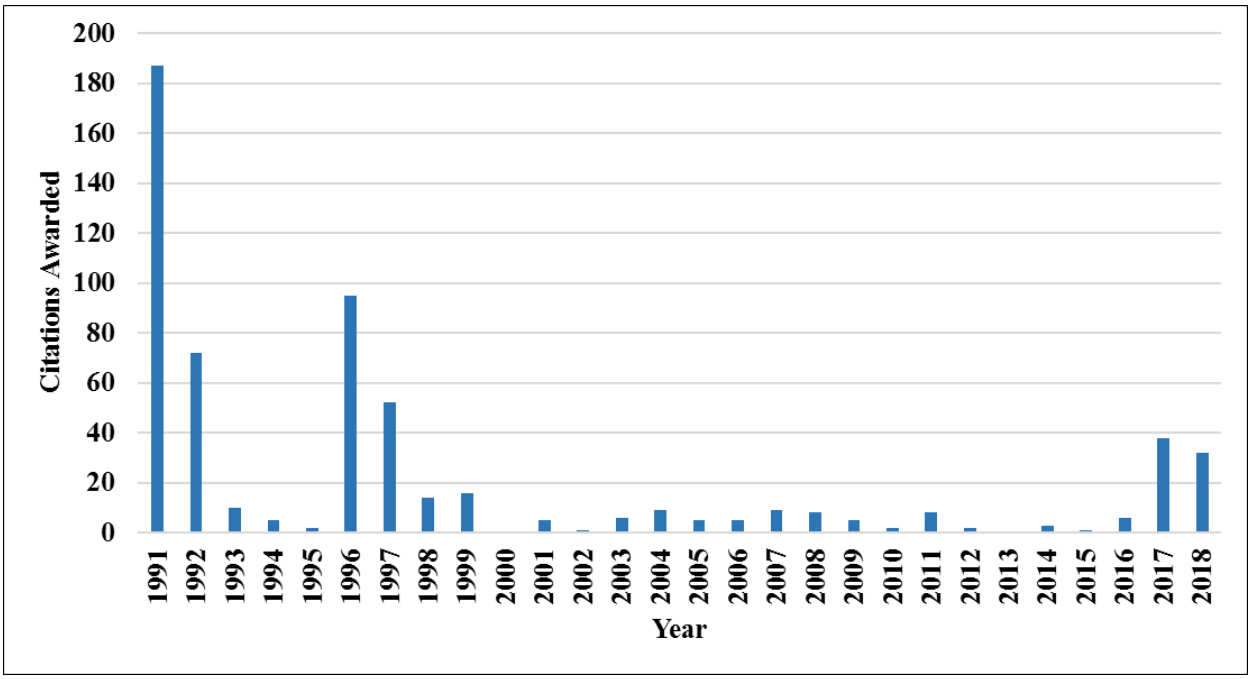

Figure 3. North Carolina recreational award citations for bluefish from 1981 to 2018. Award citations are given for bluefish catches taken by hook and line that are 15 pounds or larger. Beginning in 2017, award citations were also offered for the release of bluefish that measure 34 inches or larger.

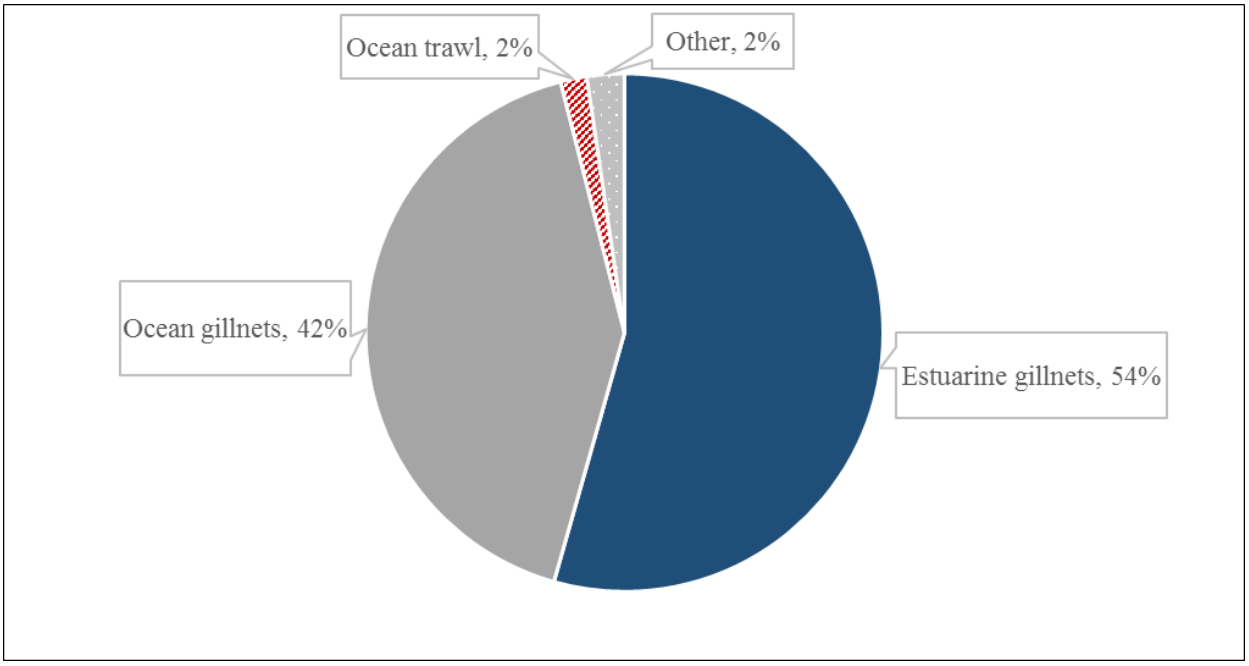

Figure 4. Commercial harvest in 2018 by gear type.

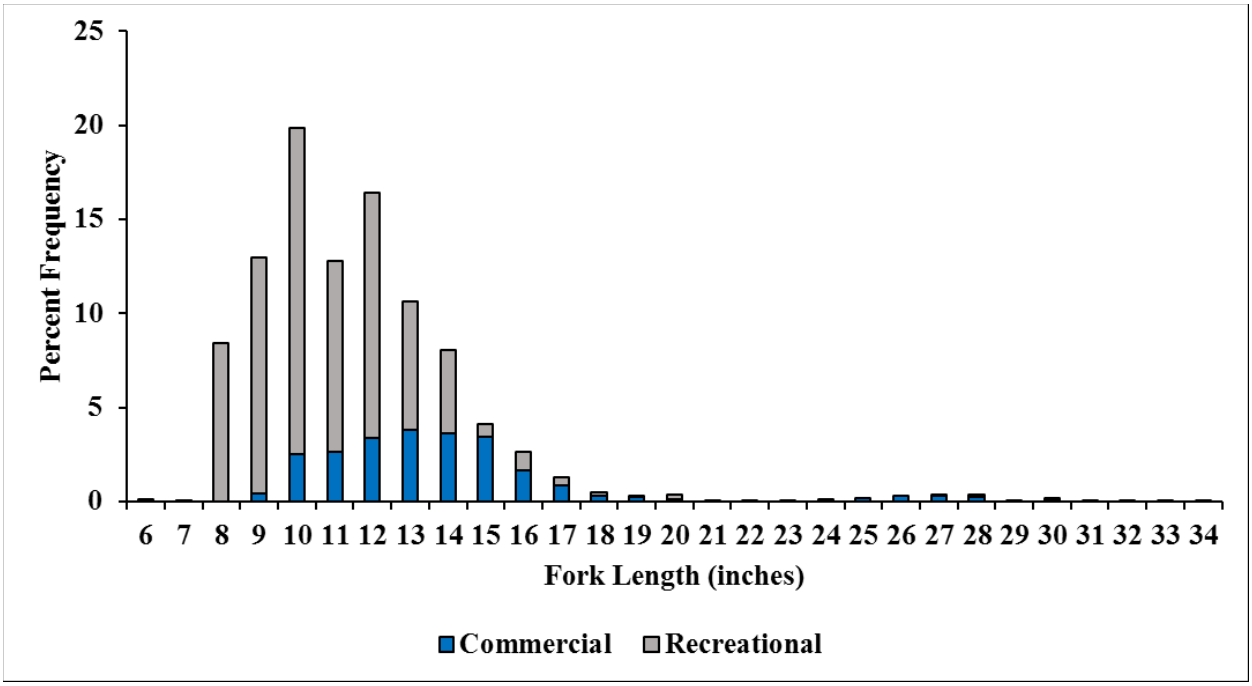

Figure 5. Commercial and recreational length frequency distribution from bluefish harvested in 2018.

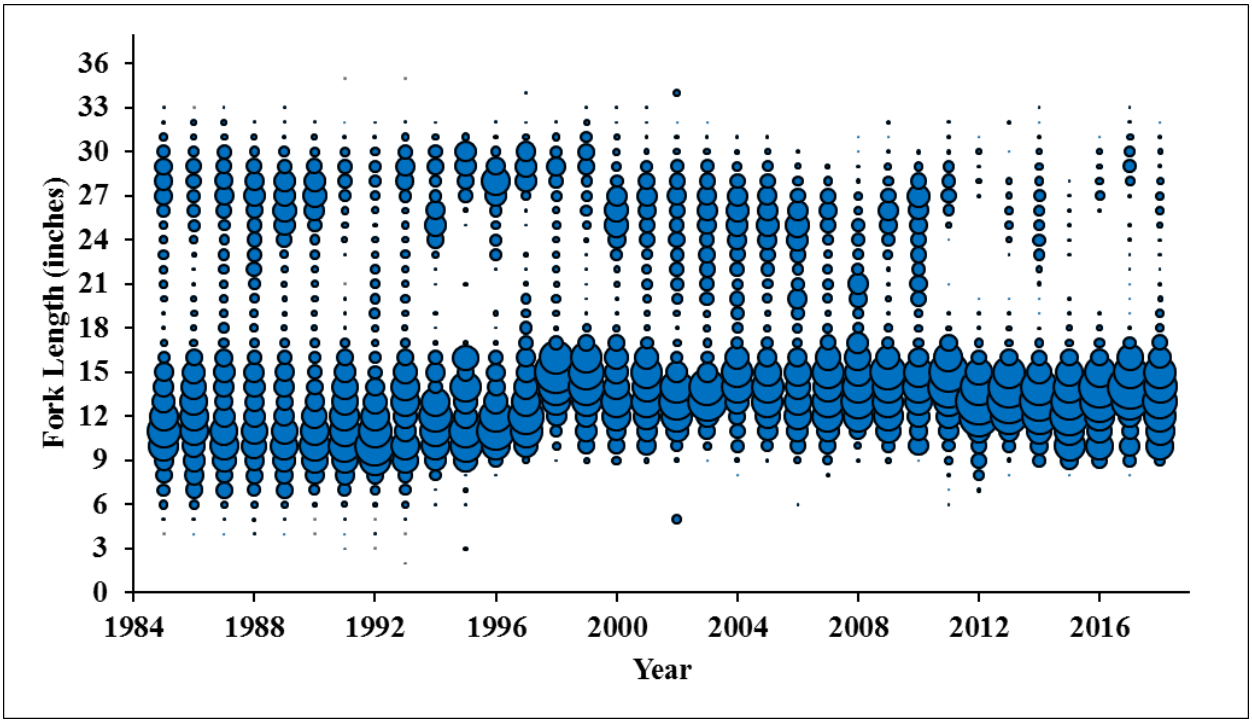

Figure 6. Commercial length frequency (fork length, inches) of bluefish harvested from 1985 to 2018. Bubbles represent fish harvested at length and the size of the bubble is equal to the proportion of fish at that length.

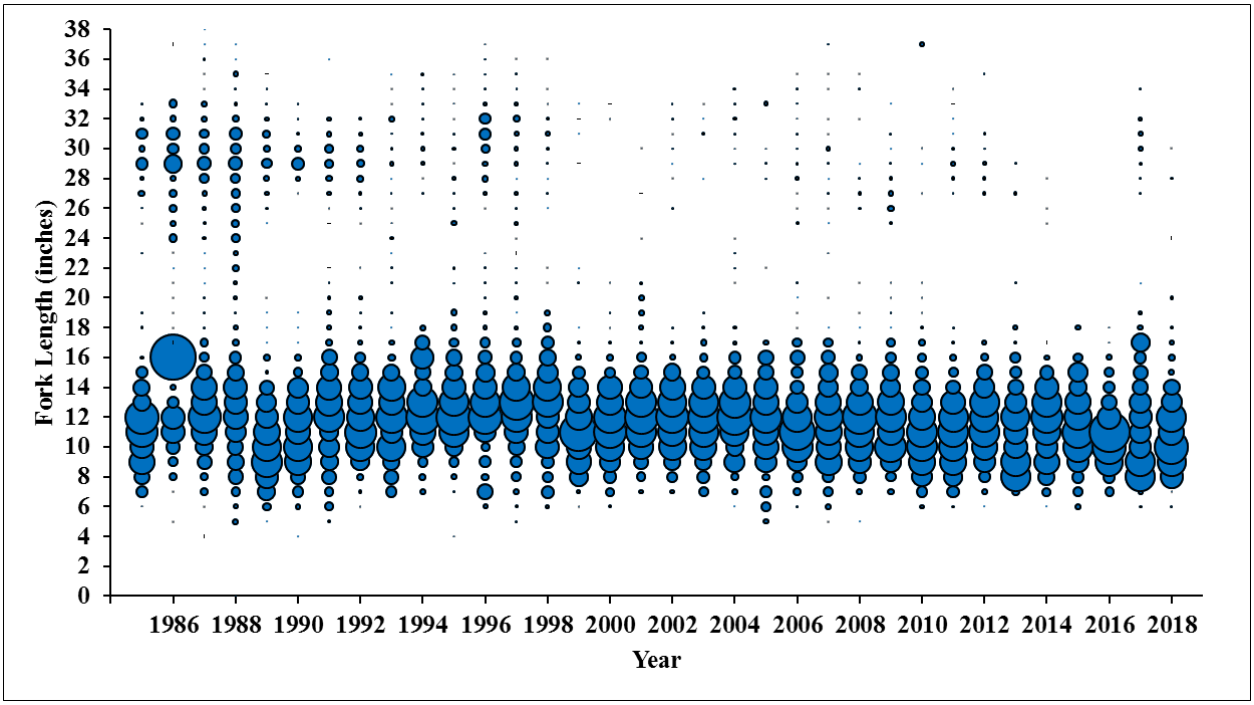

Figure 7. Recreational length frequency (fork length, inches) of bluefish harvested from 1985 to 2018. Bubbles represent fish harvested at length and the size of the bubble is equal to the proportion of fish at that length.

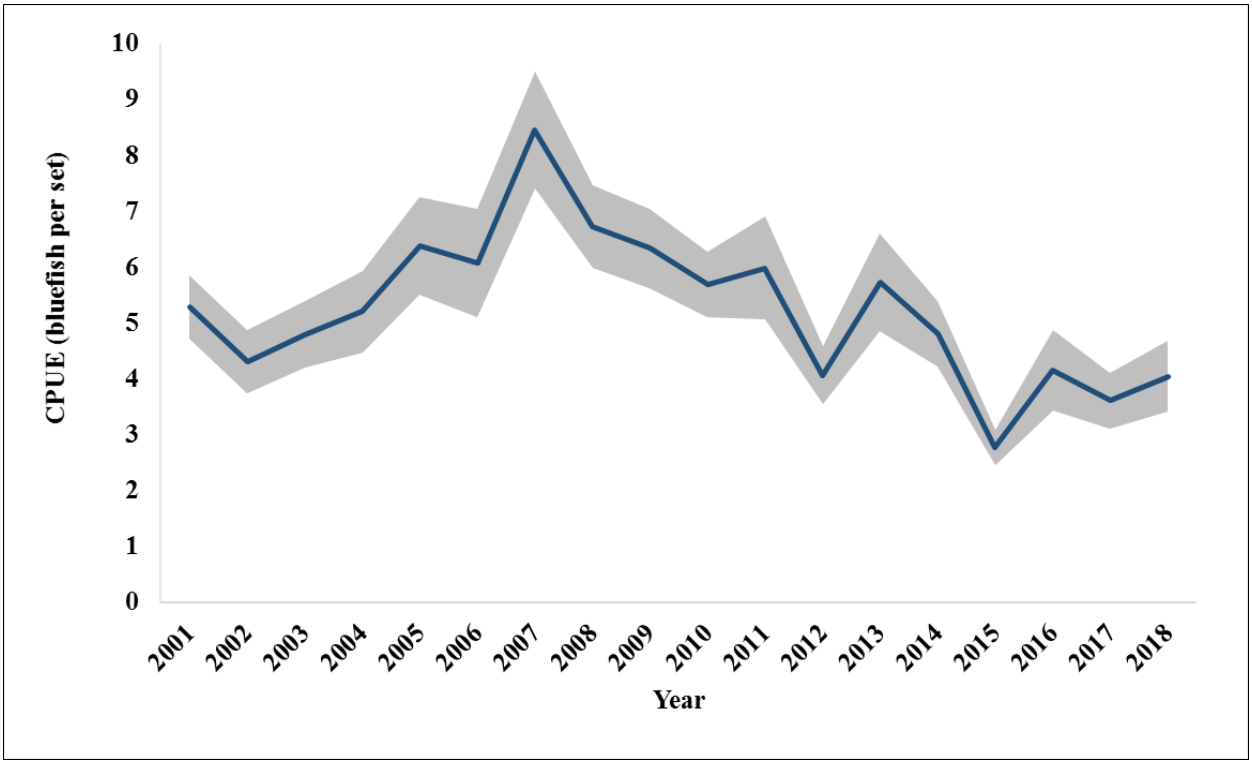

Figure 8. Catch per Unit of Effort (CPUE) of bluefish, from the Pamlico Sound Independent Gill net Survey from 2001 to 2018. Shading represents the standard error about the annual CPUE estimates.

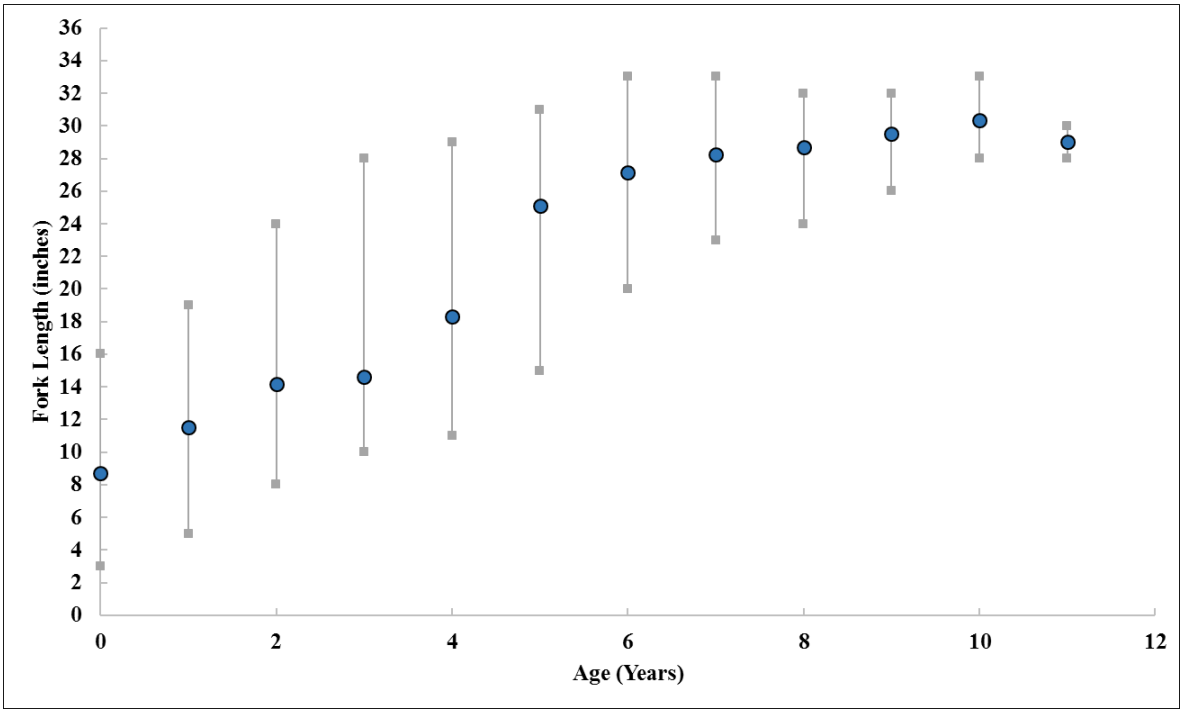

Figure 9. Bluefish length at age based on all age samples collected from 1983 to 2018. Blue circles represent the mean size at a given age while the grey squares represent the minimum and maximum observed size for each age.

FISHERY MANAGEMENT PLAN UPDATE
SPOT
AUGUST 2019

STATUS OF THE FISHERY MANAGEMENT PLAN

Fishery Management Plan History

Original FMP Adoption:	October 1987
Amendments:	Omnibus Amendment – August 2012 Addendum I – August 2014
Revisions:	None
Supplements:	None
Information Updates:	None
Benchmark Review:	Completed May 2017

The original interstate Fishery Management Plan (FMP) for spot was adopted in 1987 with recommendations to improve data collection to produce a stock assessment and improve information for management (ASMFC 1987). The original FMP was adopted prior to passage of the Atlantic Coastal Fisheries Cooperative Management Act (1993) and the Atlantic States Marine Fisheries Commission (ASMFC) Interstate Fishery Management Program (ISFMP) Charter (1995). After passage of the Act, the ASMFC adopted the Charter to establish standards and procedures for the preparation and adoption of FMPs. Once an FMP was amended to incorporate the standards and procedures in the ISFMP Charter, the Commission could adopt management requirements that can be enforced through the Act. The Omnibus Amendment updated the FMP with the Act and Charter requirements and initiated annual trigger exercises to monitor the status of the spot resource while also directing the board to consider management action depending on the results of the trigger exercise (ASMFC 2012). Without coast-wide minimum management measures, the trigger exercises did little to provide effective management between stock assessments. Addendum I to the Amendment established the use of the Traffic Light Approach (TLA; Caddy and Mahon 1995; Caddy 1998; Caddy 1999; Caddy 2002) as a precautionary management framework. The TLA is preferred because with fast-growing, early maturing species like spot 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 the Omnibus Amendment. The management framework utilizing the TLA replaced the management triggers established in the Omnibus Amendment.

A benchmark stock assessment was completed in 2017 but did not pass peer review and was not recommended for use in management (ASMFC 2017). The review panel did not, however, identify any major problems in the fishery that would require immediate management action.

The TLA will continue to be used to guide management decisions between stock assessments. Recommendations for a revised TLA were presented to the South Atlantic State/Federal Fisheries Management Board (here after referred to as Board) in February 2018 and were further considered for use in management in August 2018. Because adoption of the revised TLA would trigger management action, the Board requested member states to solicit public input on potential management measures before taking any action. In May 2019, the Board reviewed input from the states and initiated an addendum to the Spot FMP to incorporate the revised TLA and redefine the management response.

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 spot 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

Delaware through the east coast of east coast of Florida.

Goal and Objectives

The primary goal of the Omnibus Amendment is to bring the FMPs for Spanish mackerel, spot, and spotted seatrout under the authority of the Act, providing for more efficient and effective management and changes to management in the future. The objectives for spot under this amendment are to:

1. Increase the level of research and monitoring of spot bycatch in other fisheries, to complete a coast-wide stock assessment.
2. Manage the spot fishery to encourage reduced mortality on spot stocks until age-1.

3. Develop research priorities that will further refine the spot management program to maximize the biological, social, and economic benefits derived from the spot population. The Omnibus Amendment does not require specific fishery management measures in either the recreational or commercial fisheries for states within the management unit range.

STATUS OF THE STOCK

Life History

Spot (*Leiostomus xanthurus*) are short lived, estuarine dependent members of the drum family, ranging from the Gulf of Maine to Florida but are most abundant from the Chesapeake Bay to South Carolina (ASMFC 2010). Spot generally reach maturity by age one or two (ASMFC 2010) and spawn in the ocean from late fall to early spring (Hildebrand and Schroeder 1928; Roelofs 1951; Dawson 1958; Hoese 1973). Length at 50% maturity is generally between seven and 11 inches total length (ASMFC 2010). Wind and currents carry the young into the upper reaches of the estuaries where they remain throughout the spring (Warlen and Chester 1985; Govoni and Spach 1999; Hare et al. 1999; Odell et al. 2017). Adult spot migrate seasonally between estuarine and nearshore ocean waters but are rarely found in the upper reaches of the estuary (Hildebrand and Schroeder 1928; Dawson 1958; Hoese 1973; Odell et al. 2017). Spot are bottom feeders, eating mostly worms, small crustaceans, and mollusks (ASMFC 2010). Spot are most susceptible to commercial and recreational fishing activity during the fall when schools migrate from estuarine to oceanic waters (Pacheco 1962).

Stock Status

The first benchmark stock assessment for spot was completed in 2017 but was not recommended for use in management by a peer review panel (ASMFC 2017). However, the review panel did not identify any major problems in the fishery that would require immediate management action. Because there is no currently approved stock assessment the stock status for spot with relation to overfishing or overfished is unknown.

To evaluate the status of the stock between stock assessments, the TLA established under Addendum I, 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.

The updated TLA indicates a general decline in the harvest composite index since 2004 with the decline mostly driven by declining commercial landings (Figure 1; ASMFC 2018). The harvest composite index tripped in 2016-2017 because the proportion red was greater than 30% in both years. The abundance composite index for adult spot (National Oceanic and Atmospheric Administration (NOAA) and Southeast Area Monitoring and Assessment Program (SEAMAP) surveys) did not trigger in 2017 because the proportion red was below 30% in 2016 and 2017 (Figure 2: ASMFC 2018). Because the harvest index and adult abundance index did not both trip in 2016-2017, management action has not been triggered. Recommendations for a revised

TLA were presented to the Board in February 2018 and in May 2019 the Board initiated an addendum to the Spot FMP to incorporate the revised TLA.

Stock Assessment

A benchmark stock assessment, completed in 2017, did not pass peer review and will not be used for management. Uncertainty in assessment results was due to disagreement between trends in harvest and abundance. Abundance in fishery independent surveys has generally been increasing whereas commercial and recreational harvest has been declining. The review panel noted that the discard estimates from the shrimp trawl fishery was an improvement 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 on spot in North Carolina.

Commercial Landings

Two gear types (gill nets and haul seines) are used in directed commercial trips and harvest of spot. Other gear types, including sciaenid pound nets, contribute minimally to commercial landings. Since 1994, the North Carolina Trip Ticket Program (NCTTP) has collected data on commercial harvest. Commercial landings have fluctuated but generally declined since 2001, and have averaged 1,789,331 pounds since 1989 (Table 1; Figure 3). In 2018, commercial landings were 167,675 pounds a decrease of 246,325 pounds from 2017. Some of the landings decline in 2018 can likely be attributed to Hurricane Florence, which hit the North Carolina coast in September of that year. Spot 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

Spot are targeted recreationally by shore based anglers and those fishing from private vessels during the fall. Recreational fishing activity is monitored through the Marine Recreational Information Program. In this report, estimates across all years have been updated and are now based on the MRIP new Fishing Effort Survey-based calibrated estimates. For more information on MRIP methodology changes see https://www.fisheries.noaa.gov/topic/recreational-fishing-data.

Recreational harvest averaged 2,529,064 pounds from 1989 through 2018 (Table 1). Recreational harvest fluctuated but was generally steady from 1989 through 2007 before declining significantly in 2008 and fluctuating little since except for a peak in 2014 (Table 1; Figure 3). In 2018, recreational harvest was 597,511 pounds, a decrease of 312,285 pounds from 2017. Some of this decline can likely be attributed to the impacts of Hurricane Florence hitting the North Carolina coast in September. Number of releases averaged 3,073,131 individuals from 1989

through 2018. The number of releases in 2018 was 2,062,163, a small increase from 2017 releases.

The number of spot measured during MRIP sampling has generally declined since 2011 and the number measured in 2018 was among the lowest in the time series (Table 2). Mean fork length (FL) in 2018 was 8.4 inches with little fluctuation since 1989. Similarly, minimum and maximum FL have also fluctuated little, though in 2017 and 2018 maximum FL was smaller than in other years. In 2018, modal length in the recreational harvest was 9.0 inches with significant numbers of 7.0 and 8.0 inch spot harvested (Figure 4). The recreational fishery harvests similar size classes to the commercial fishery, however, the commercial fishery harvests a narrower range of sizes and very few fish over 8.0 inches. Most of the recreational catch consists of spot from 6.0 to 9.0 inches FL with little change in length composition since 1989 (Figure 5). However, in the 90's and early 2000's a wider range of lengths were 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 203,383 pounds were harvested per year (Table 3).

MONITORING PROGRAM DATA

Fishery Dependent Monitoring

The number of spot lengths obtained from commercial fish house sampling has generally decreased since 1994 (Table 4). Mean, minimum, and maximum FL has fluctuated but generally been stable. Mean FL ranged from 6.7 to 8.8 inches. In 2018, 2,241 spot were measured from commercial fisheries with a mean FL of 7.9 inches, a minimum of 4.2 inches, and a maximum of 10.9 inches. Scrap samples are included in minimum, maximum and mean length calculations.

In 2018, modal length in the commercial fishery was 7.0 inches FL with few spot over 8.0 inches (Figure 4). In general, the commercial fishery harvested a narrower range of sizes compared to the recreational fishery. The length composition and modal length of spot caught in the commercial fishery (excluding scrap samples) increased slightly from 1994 through the early 2000's (Figure 6). The range of lengths harvested narrowed in the late 2000's with little change since.

Fishery Independent Monitoring

The number of spot aged in North Carolina from 1996 through 2018 has ranged from 230 to 728 (Table 5). Modal age was one in every year except 1996 and 2004 when modal age was two and in 2016 when modal age was zero. Minimum age was zero in every year while maximum age ranged from two to six. There is significant overlap in length at age for ages zero through three with length at age becoming less variable after age four (Figure 7)

The Pamlico Sound Survey (Program 195) samples 54 randomly selected stations (grids) 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 are 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 TLA. Length cutoffs for juvenile spot are fish <120 mm FL (4.7 inches) in June, and fish <140 mm FL (5.5 inches) in September. The June index is highly variable with a peak of 1,347.4 individuals per tow in 2008 (Figure 8). The 2018 JAI was 813.6 individuals per tow, an increase from the 2017 JAI and above the time series average of 435.2 individuals per tow. While variable, JAI has generally increased since 2006.

Most spot captured in the Pamlico Sound Survey are juveniles (age-0) but a number of age one or greater fish are captured in some years producing two distinct length modes, particularly in June. One mode is usually around 3.0 inches FL (age-0) and the other is around 6.0 inches FL (age-1 or greater; Figure 9). Modal length from the September portion of the Pamlico Sound Survey is more variable ranging from 2.0 to 5.0 inches FL with a wider range of lengths captured.

MANAGEMENT STRATEGY

Per Addendum I to the Omnibus Amendment, the TLA is used as a precautionary management framework for spot. 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 two-year period, then management action is required. Since both population characteristics were not above the 30% threshold for 2016-2017, management triggers were not tripped. Recommendations for a revised TLA framework were presented to the Board in February 2018 and were further considered by the Board for use in management in August 2018. Because adoption of the revised TLA would trigger management action, the Board requested member states to solicit public input on potential management measures before taking any action. In May 2019, the Board reviewed input from the states and initiated an addendum to the Spot FMP to incorporate the revised TLA and redefine the management response. See Table 6 for 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 coast-wide and state specific research recommendations have been identified through the FMP process, and the stock assessment peer review and include (ASMFC 2017):

- Expand collection of life history data for examination of lengths and age, especially fishery dependent data sources – HIGH (Ongoing in North Carolina)
- Organize an otolith exchange and develop an ageing protocol between ageing labs – HIGH (Needed)
- Increase observer coverage for commercial discards, particularly the shrimp trawl fishery – HIGH (Ongoing in North Carolina)
- Develop a standardized, representative sampling protocol and pursue collection of

individual lengths and ages of discarded finfish – HIGH (Ongoing in North Carolina)

- 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 – HIGH (Ongoing in North Carolina)
- 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 – HIGH (Needed)
- 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) – HIGH (Needed)
- Develop and implement sampling programs for state-specific commercial scrap and bait fisheries in order to monitor the relative importance of spot. Incorporate biological data collection into program – MEDIUM (Ongoing in North Carolina)
- Conduct studies of discard mortality for commercial fisheries. Ask commercial fishermen about catch processing behavior for spot when trawl/gill nets brought over the rail to determine if the discard mortality rate used in the assessment is reasonable – MEDIUM (Needed)
- Conduct studies of discard mortality for recreational fisheries – MEDIUM (Needed)
- Collect data to develop gear-specific fishing effort estimates and investigate methods to develop historical estimates of effort – MEDIUM (Needed)
- Identify stocks and determine coastal movements and the extent of stock mixing, via genetic and tagging studies – MEDIUM (Needed)
- Investigate environmental and recruitment/ natural mortality covariates and develop a time series of potential covariates to be used in stock assessment models – MEDIUM (Needed)
- 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)
- Investigate the effects of environmental changes (especially climate change) on maturity schedules for spot, particularly because this is an early maturing species, and because the sSPR estimates are sensitive to changes in the proportion mature – MEDIUM (Needed)
- Investigate environmental and oceanic processes in order to develop better understanding of larval migration patterns into nursery grounds – MEDIUM (Needed)
- Investigate the relationship between estuarine nursery areas and their proportional contribution to adult biomass (i.e., are select nursery areas along Atlantic coast contributing more to SSB than others, reflecting better juvenile habitat quality?) – MEDIUM (Needed)
- Develop estimates of gear-specific selectivity – MEDIUM (Needed)

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TABLES

Table 1. Spot recreational harvest and number released (Marine Recreational Information Program) and commercial harvest (North Carolina Trip Ticket Program, 1989-2018. All weights are in pounds.

	Recreational				
	Numbers	Weight (lb)	Weight (lb)	Commercial	Total
Year	Landed	Released	Landed	Weight (lb)	Weight (lb)
1989	10,246,429	1,995,653	3,566,280	3,254,464	6,820,744
1990	7,920,697	2,868,842	2,453,645	3,455,460	5,909,105
1991	9,894,562	3,454,466	3,066,857	3,047,296	6,114,153
1992	5,043,969	2,908,974	1,431,733	2,826,128	4,257,861
1993	6,877,688	1,445,961	2,879,162	2,672,157	5,551,319
1994	14,032,650	2,365,031	4,571,386	2,937,311	7,508,697
1995	8,199,743	2,214,819	3,214,061	3,006,845	6,220,906
1996	6,729,366	2,234,354	2,461,892	2,290,000	4,751,892
1997	4,529,620	1,110,650	2,129,481	2,627,925	4,757,406
1998	11,797,824	2,379,578	4,596,119	2,396,979	6,993,098
1999	5,736,185	2,343,795	2,565,546	2,262,175	4,827,721
2000	6,121,384	1,366,746	2,598,813	2,829,818	5,428,631
2001	10,043,845	2,804,349	4,519,545	3,093,872	7,613,417
2002	8,456,981	1,569,579	3,017,466	2,184,032	5,201,498
2003	9,717,824	2,970,990	4,220,534	2,043,387	6,263,921
2004	7,845,322	2,899,319	3,682,623	2,317,169	5,999,792
2005	10,105,205	4,407,100	3,652,186	1,714,597	5,366,783
2006	11,109,551	8,196,592	3,995,432	1,364,743	5,360,175
2007	8,728,295	4,049,250	2,737,144	879,091	3,616,235
2008	3,970,431	3,817,529	1,382,428	736,484	2,118,912
2009	4,197,640	4,847,202	1,427,956	1,006,500	2,434,456
2010	3,830,384	3,615,808	1,173,173	572,315	1,745,488
2011	6,480,714	4,993,544	2,201,947	936,970	3,138,917
2012	2,677,082	2,995,879	760,276	489,678	1,249,954
2013	6,120,985	5,513,732	1,789,251	768,592	2,557,843
2014	8,343,467	4,043,710	2,877,483	766,224	3,643,707
2015	2,572,738	2,984,629	833,390	376,994	1,210,384
2016	1,928,716	1,831,415	558,799	241,039	799,838
2017	2,418,331	1,902,281	909,796	413,999	1,323,795
2018	2,068,865	2,062,163	597,511	167,675	765,186
Mean	6,924,883	3,073,131	2,529,064	1,789,331	4,318,394

Table 2. Total number measured, mean, minimum, and maximum fork length (inches) of spot measured by MRIP sampling in North Carolina, 1989-2018.

Year	Number Measured	Mean Length	Minimum Length	Maximum Length
1989	1,513	7.9	4.5	13.6
1990	1,167	7.6	4.3	12.6
1991	3,022	7.6	4.0	13.3
1992	1,193	7.6	3.2	11.7
1993	1,385	8.4	4.9	13.5
1994	2,632	8.2	5.7	14.9
1995	2,028	8.5	4.3	15.3
1996	2,376	8.5	4.9	11.6
1997	1,762	8.7	5.7	15.6
1998	1,632	8.6	6.3	12.4
1999	1,159	9.1	5.5	11.5
2000	1,221	8.6	5.5	13.2
2001	1,627	8.8	5.4	13.9
2002	860	8.3	6.3	12.0
2003	1,403	8.7	4.6	14.2
2004	2,034	9.2	4.8	12.8
2005	1,282	8.4	5.2	15.2
2006	1,216	8.9	4.8	13.5
2007	1,243	9.1	5.7	12.0
2008	1,344	8.3	5.0	12.2
2009	682	8.4	5.0	10.8
2010	1,096	8.1	5.8	12.1
2011	1,534	8.2	5.9	11.1
2012	611	7.9	5.6	11.7
2013	484	7.9	4.5	11.5
2014	344	8.2	4.8	11.9
2015	214	8.1	6.1	11.9
2016	107	8.0	6.3	11.0
2017	98	8.1	6.3	10.6
2018	125	8.4	5.7	10.9

Table 3. North Carolina RCGL harvest of spot 2002-2008, with number of trips and landings in pounds. Estimates of trips and landings are from a RCGL survey conducted from 2002-2008; funding was discontinued in 2009.

Year	Trips	Pounds
2002	16,731	339,077
2003	11,799	255,060
2004	12,610	252,291
2005	9,703	193,769
2006	10,511	180,342
2007	7,399	97,753
2008	7,664	105,392
Average	10,917	203,383

Table 4. Mean, minimum, maximum fork length (inches), and total number of spot measured from North Carolina commercial fish house samples, 1994-2018. Scrap samples are included in calculation of mean, minimum and maximum length.

Year	Mean Length	Minimum Length	Maximum Length	Number Measured
1994	6.7	3.3	11.9	9,109
1995	6.8	3.2	15.4	11,182
1996	7.3	3.2	11.8	14,112
1997	7.4	3.2	13.3	15,378
1998	7.6	3.3	12.2	11,757
1999	7.8	3.1	11.7	9,256
2000	7.9	3.3	17.6	15,651
2001	8.5	3.3	12.4	15,603
2002	8.4	3.6	17.8	13,034
2003	8.5	3.1	13.9	12,919
2004	8.8	3.3	15.0	12,386
2005	8.8	3.1	13.1	15,535
2006	8.3	4.1	13.2	13,503
2007	7.9	3.9	12.0	13,889
2008	8.0	3.1	13.3	10,768
2009	8.1	3.9	11.7	9,087
2010	8.1	3.6	11.6	7,494
2011	8.2	4.3	13.1	8,906
2012	8.0	4.1	17.8	4,458
2013	8.3	4.2	13.3	4,699
2014	8.1	4.1	13.1	6,650
2015	8.2	4.3	12.8	4,543
2016	8.1	4.9	17.8	2,255
2017	8.3	4.4	11.7	2,643
2018	7.9	4.2	10.9	2,241

Table 5. Total number aged, modal, minimum, and maximum age of spot in North Carolina, 1996-2018. Age data from 2014 and 2018 is preliminary.

Year	Modal Age	Minimum Age	Maximum Age	Total Number Aged
1996	2	0	4	728
1997	1	0	3	629
1998	1	0	3	603
1999	1	0	2	522
2000	1	0	3	551
2001	1	0	4	555
2002	1	0	5	603
2003	1	0	4	354
2004	2	0	6	455
2005	1	0	6	529
2006	1	0	5	501
2007	1	0	3	284
2008	1	0	3	408
2009	1	0	3	364
2010	1	0	3	268
2011	1	0	3	413
2012	1	0	4	230
2013	1	0	3	360
2014*	1	0	3	684
2015	1	0	3	505
2016	0	0	3	373
2017	1	0	3	528
2018*	1	0	3	518

*Data is preliminary

Table 6. Summary of management strategies and needs.

Management Strategy	**Implementation Status**
Establish Traffic Light method for monitoring the stock in non-assessment years	Addendum I to the Omnibus Amendment, 2014. Replaced triggers established by the Omnibus Amendment
Update FMP with Atlantic Coastal Fisheries Cooperative Management Act and Interstate Fishery Management Program requirements ASMFC annual state compliance reports submitted in November each year Establish triggers to be used in monitoring stock in non-assessment years	Omnibus Amendment to the Interstate Fishery Management Plans for Spanish Mackerel, Spot, and Spotted Seatrout, 2012
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 spot fisheries to ages greater than one Improve data collection to produce a stock assessment and improve management	Fishery Management Plan for Spot, 1987 Ongoing

FIGURES

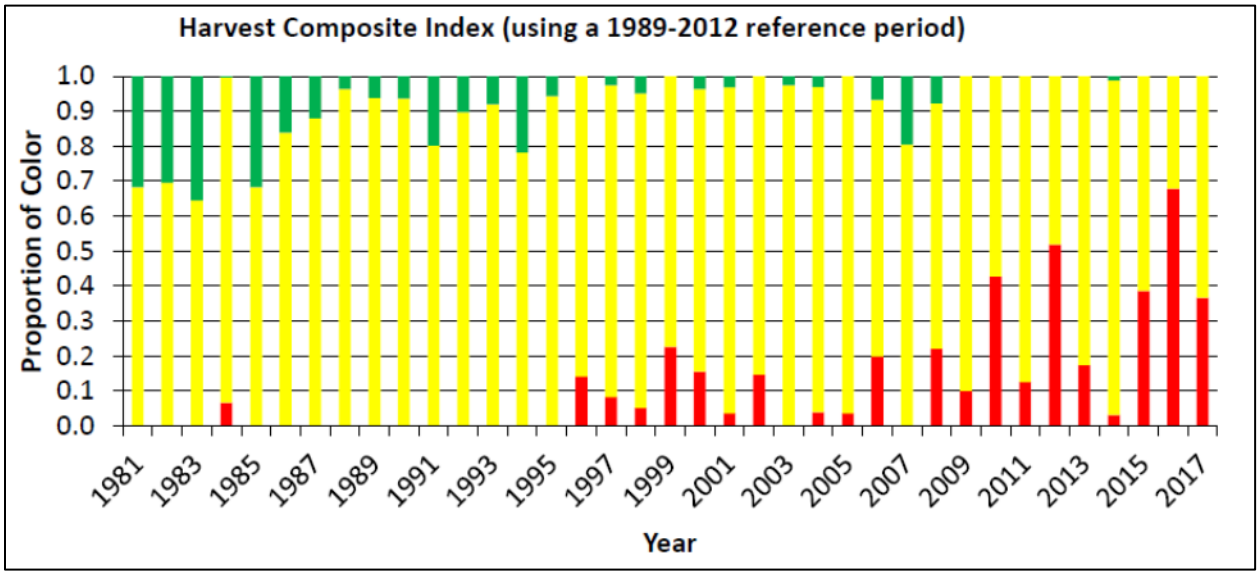

Figure 1. Annual color proportions for the harvest composite TLA (using a 1989-2012 reference period) of spot recreational and commercial landings, 1989-2017 (ASMFC 2018a).

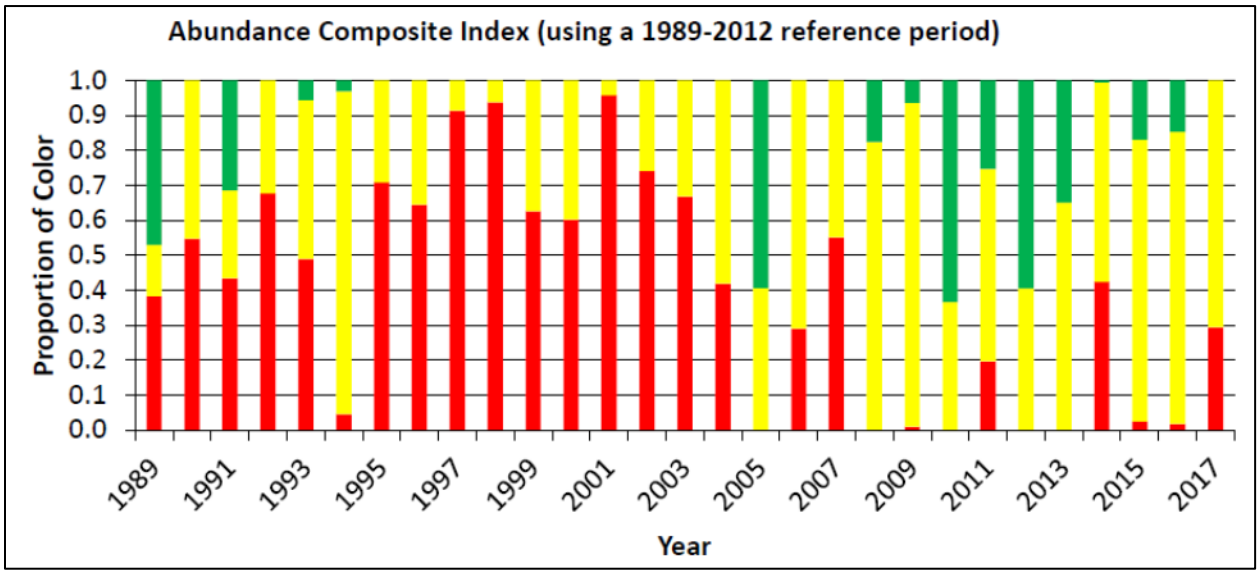

Figure 2. Abundance composite index (using a 1989-2012 reference period), 1989-2017 (ASMFC 2018a).

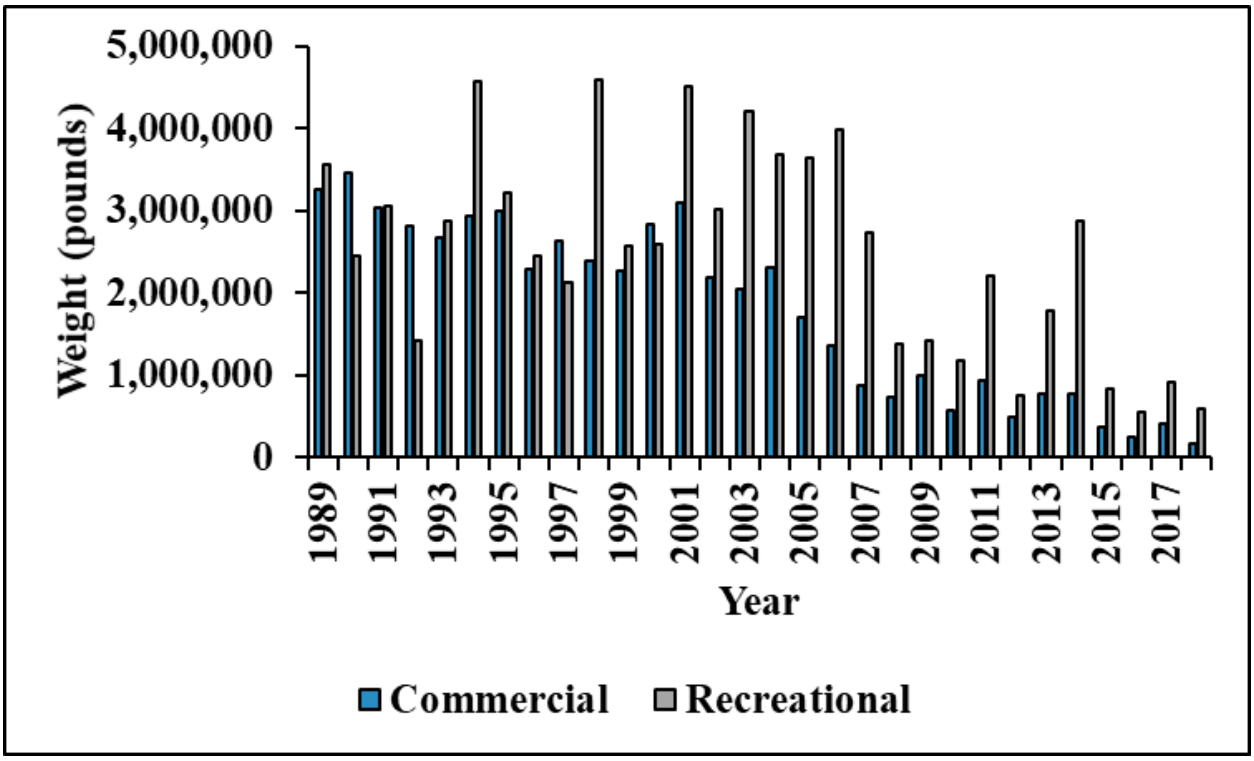

Figure 3. Annual commercial and recreational landings in pounds for spot in North Carolina, 1989-2018.

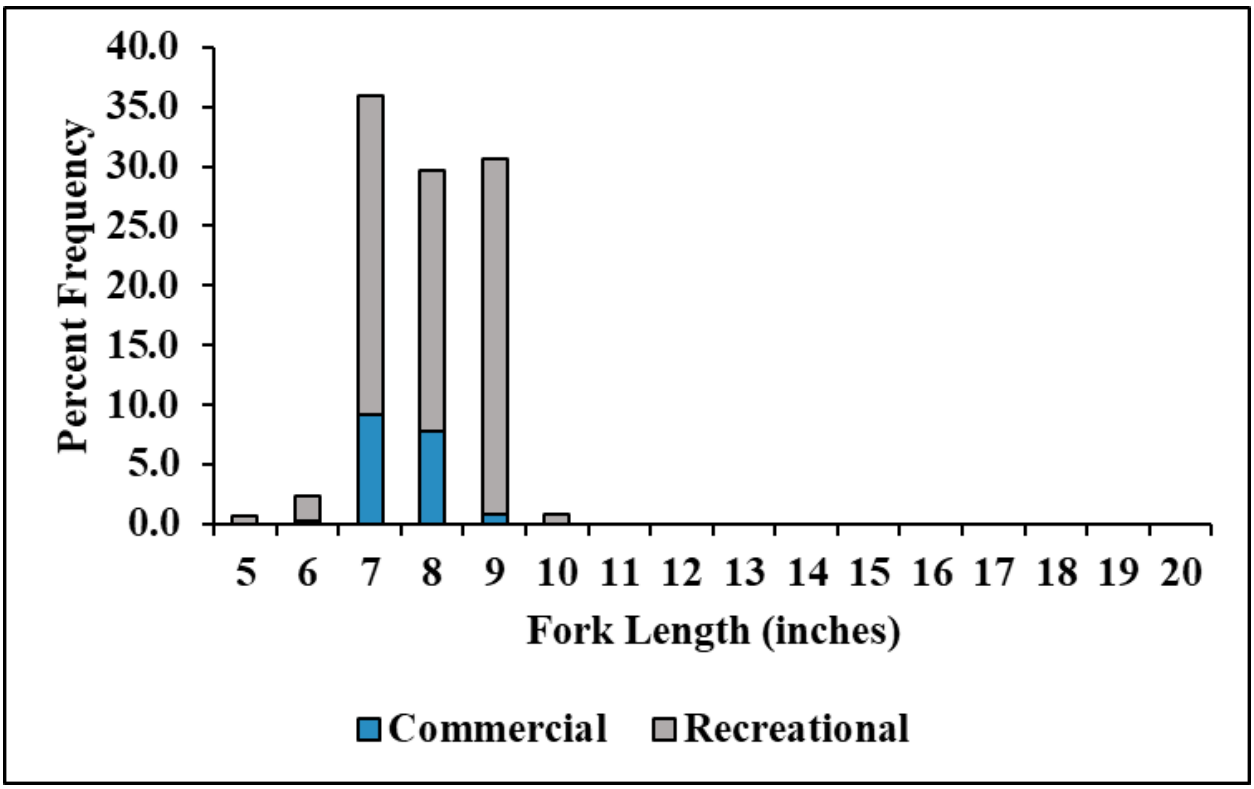

Figure 4. Commercial and recreational length frequency distribution from spot harvested in 2018.

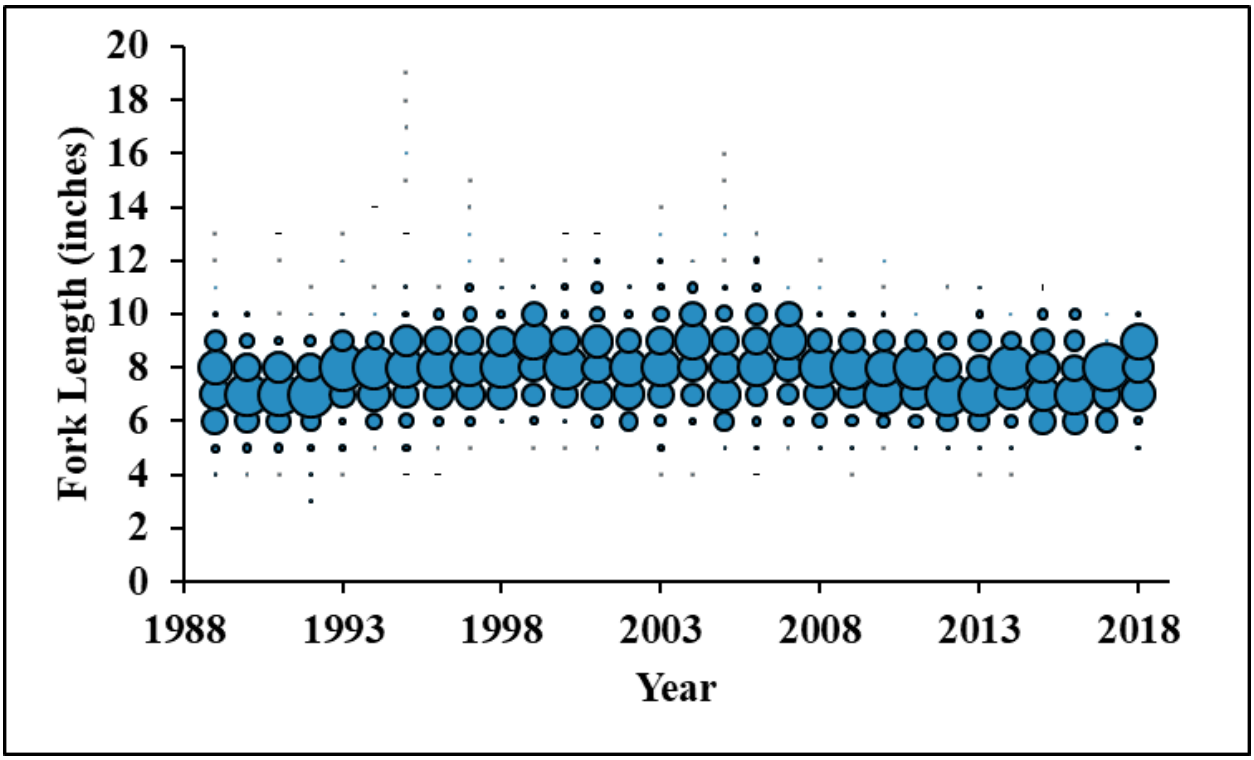

Figure 5. Recreational length frequency (fork length, inches) of spot harvested from 1989-2018. Bubble represents the proportion of fish at length.

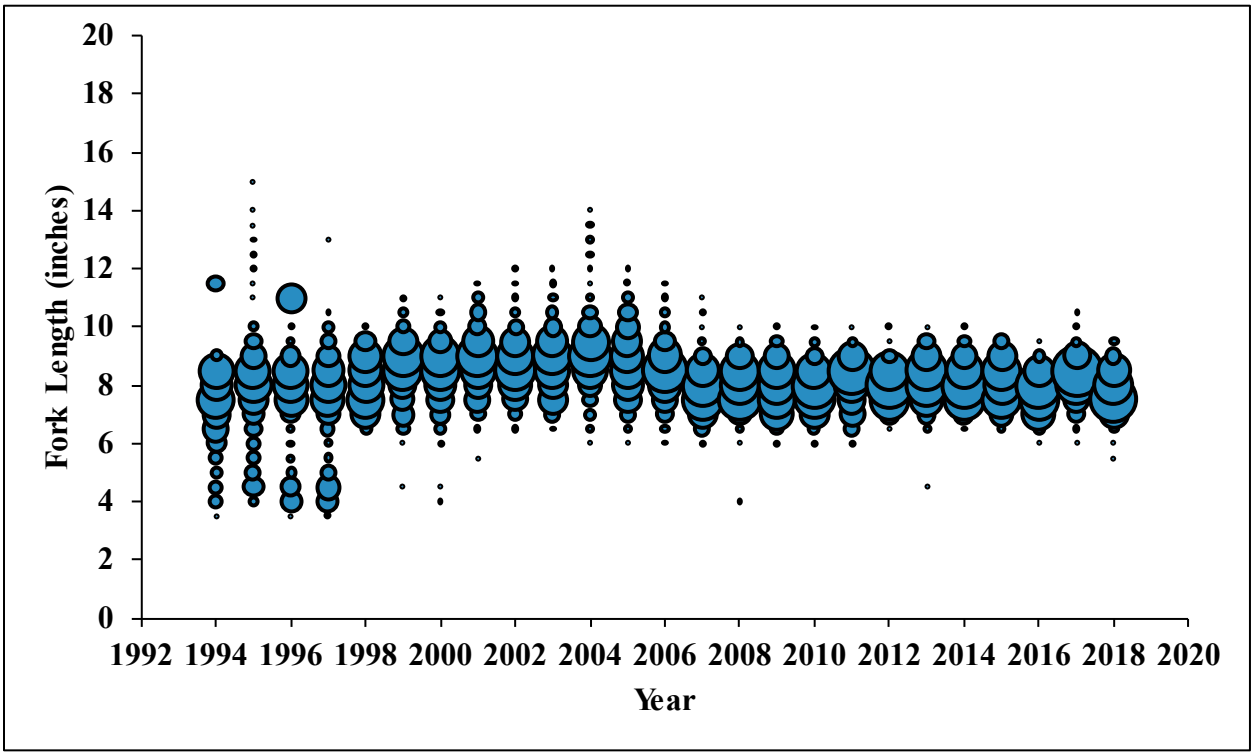

Figure 6. Commercial length frequency (fork length, inches) of spot harvested from 1994-2018. Bubble represents the proportion of fish at length. Scrap samples not included.

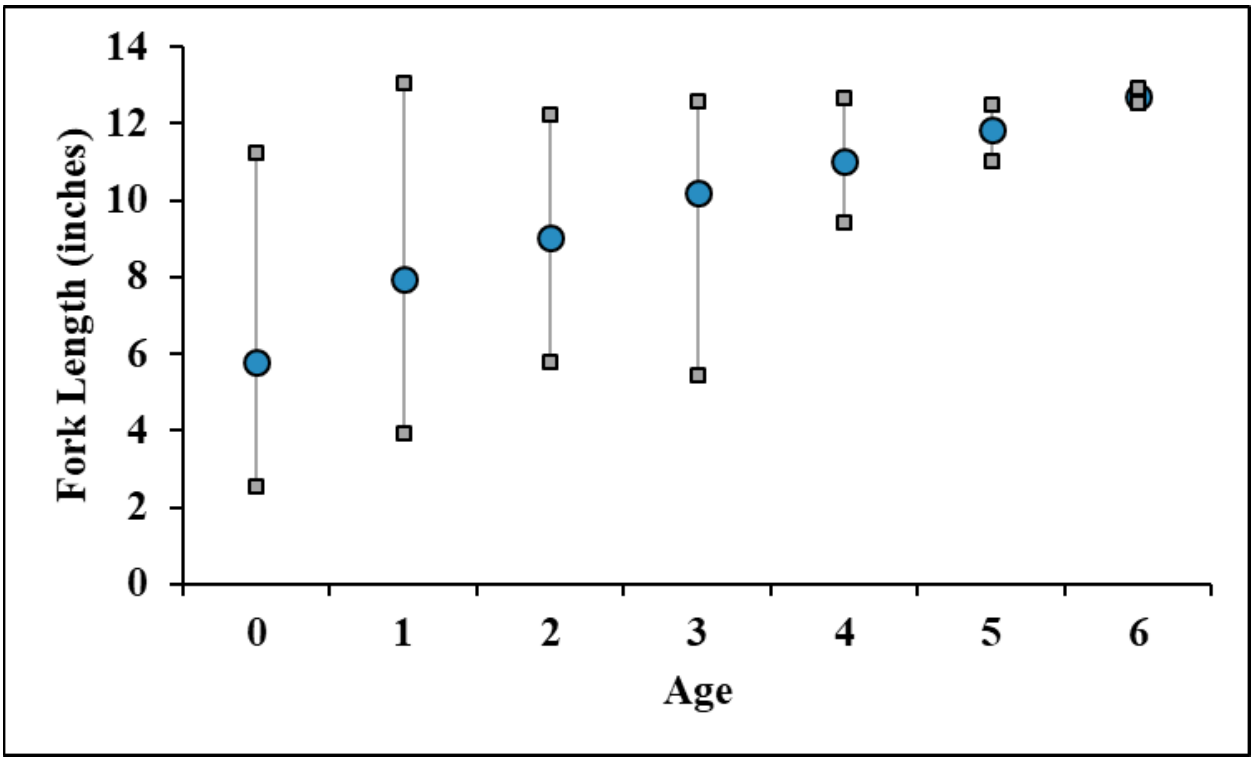

Figure 7. Spot length at age based on all age samples collected from 1996 to 2018. Blue circles represent the mean size at a given age while the grey squares represent the minimum and maximum observed size at age.

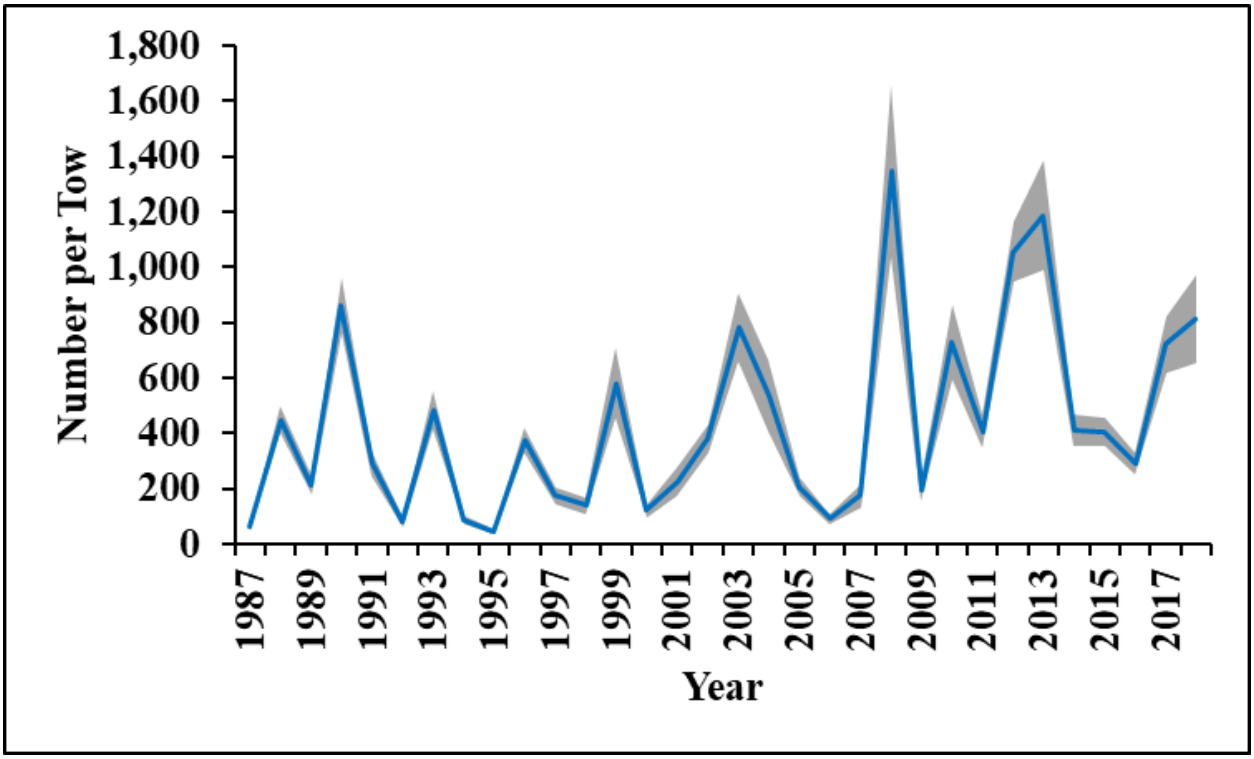

Figure 8. Spot juvenile (<120 mm; 4.7 inches) abundance index (CPUE; number per tow) for June from the Pamlico Sound Survey, 1987-2018. Shaded area represents standard error.

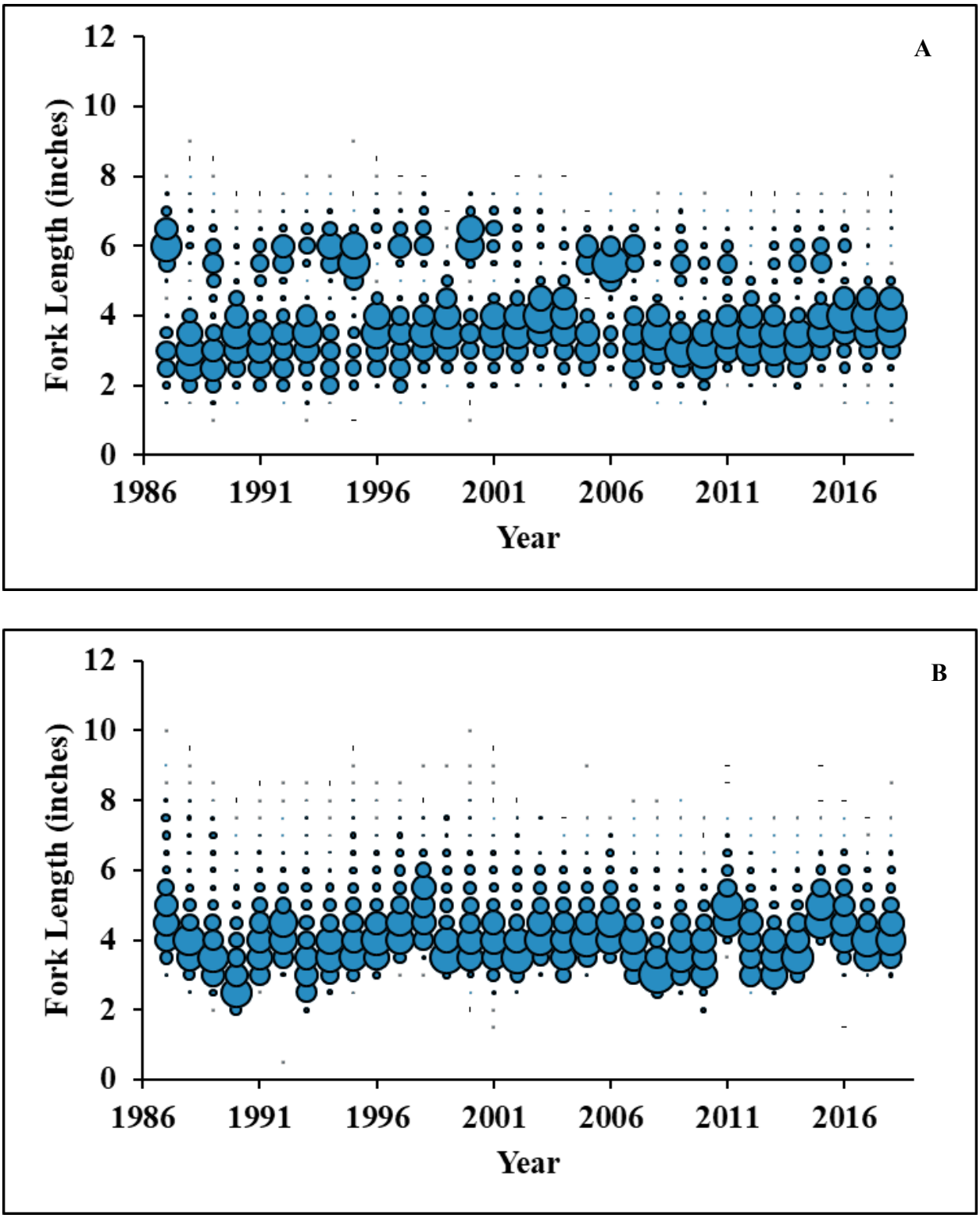

Figure 9. Length frequency of spot captured in Pamlico Sound Survey sampling during June (A) and September (B), 1987-2018.

FISHERY MANAGEMENT PLAN UPDATE
ATLANTIC STRIPED BASS
AUGUST 2019

STATUS OF THE FISHERY MANAGEMENT PLAN

Fishery Management Plan History

Original FMP Adoption:	October 1981
Amendments:	Amendment 1 – 1984 Amendment 2 – 1984 Amendment 3 – October 1985 Amendment 4 – 1989 October Addendum I – 1991 Addendum II – 1992 Addendum III – 1993 Addendum IV – 1994 Amendment 5 – March 1995 Addendum I – January 1997 Addendum II – October 1997 Source Document to Amendment 5 January 1998 Addendum III – October 1998 Addendum IV – October 1999 Addendum V – January 2001 Amendment 6 – February 2003 Addendum I – November 2007 Addendum II – November 2010 Addendum III – August 2012 Addendum IV – October 2014
Revisions:	None
Supplements:	None
Information Updates:	None
Next Benchmark Review:	A benchmark assessment and peer review was completed in 2018. The next benchmark has not been scheduled.

The Atlantic States Marine Fisheries Commission (ASMFC) developed a fisheries management plan (FMP) for Atlantic Striped Bass in 1981 in response to declining juvenile recruitment and landings. The FMP recommended increased restrictions on commercial and recreational fisheries, such as minimum size limits and harvest closures on spawning grounds. Two amendments were passed in 1984 recommending additional management measures to reduce

fishing mortality. To strengthen the management response and improve compliance and enforcement, the Atlantic Striped Bass Conservation Act (P.L. 98-613) was passed in late 1984, which mandated the implementation of striped bass regulations passed by the ASMFC, and gave the ASMFC authority to recommend to the Secretaries of Commerce and Interior that states be found out of compliance when they failed to implemented management measures consistent with the FMP.

The first enforceable plan, Amendment 3, was approved in 1985, and required size regulations to protect the 1982 year-class, which was the first modest size cohort since the previous decade. The objective was to increase size limits to allow at least 95% of the females in the cohort to spawn at least once. Smaller size limits were permitted in producer areas (Albemarle Sound, Chesapeake Bay, Delaware River, and Hudson River) compared to coastal areas, due to socio-economic and/or biological reasons. Several states, beginning with Maryland in 1985, opted for a more conservative approach and imposed a total moratorium on striped bass landings for several years. The amendment contained a trigger mechanism to reopen the fisheries when the three-year moving average of the Maryland juvenile abundance index (JAI) exceeded an arithmetic mean of 8.0. That level was attained with the recruitment of the 1989-year class.

Consequently, Amendment 4 was adopted to allow state fisheries to reopen in 1990 under a target fishing mortality (F) of 0.25, which was half the estimated F needed to achieve maximum sustainable yield (MSY). The amendment allowed an increase in the target F once spawning stock biomass (SSB) was restored to levels estimated during the late 1960s and early 1970s. The dual size limit concept was maintained, and a recreational trip limit and commercial season implemented to reduce the harvest to 20% of that in the period of 1972-1979. The amendment and its four addenda aimed to rebuild the resource, rather than maximize yield.

In 1995, coastal striped bass were declared restored by the ASMFC, and Amendment 5 was adopted to increase the target F to 0.33, midway between the existing F target (0.25) and F_{MSY}, which was revised to 0.40. Regulations were developed to allow 70% of the historic harvest and achieve the target F, although states could submit proposals for alternative regulations that were conservationally equivalent. From 1997 to 2000, a series of five addenda were implemented to respond to the latest stock status information.

Striped bass stocks in North Carolina also experienced harvest declines and juvenile recruitment failures in the 1970s and 1980s. The North Carolina Marine Fisheries Commission (NCMFC) and the North Carolina Wildlife Resources Commission (NCWRC) implemented a Memorandum of Agreement in 1990 to address management of striped bass in the Albemarle Sound and Roanoke River. The seriousness of the situation resulted in implementation of harvest restrictions and Congressionally-mandated studies (N.C. Striped Bass Study Management Board 1991, U.S. Fish and Wildlife Service 1992). Studies funded by Congress and resource management agencies indicated that rates of harvest during the 1980s were likely too high to allow stock recovery. Studies commissioned by the N.C. Striped Bass Study Management Board (Dorazio 1993) and by independent investigators (Hightower 1994, Richkus et al. 1991) all determined that rates of harvest mortality exceeded those which will allow recovery as recommended for other Atlantic Coast stocks. The original Estuarine Striped Bass FMP was approved by the NCMFC in 1994 and was targeted at the continued recovery of the A-R stock,

which at the time was at historically low levels of abundance and was experiencing chronic spawning failures (Laney et. al. 1993). The comprehensive plan addressed the management of all estuarine stocks of striped bass in the state, satisfying the recommendation contained in the Report to Congress for the North Carolina Striped Bass Study (U.S. Fish and Wildlife Service 1992) that such a plan be prepared. The Albemarle-Roanoke stock of striped bass was declared restored in 1997, and is currently assessed by an independent stock assessment by the State of North Carolina using catch and abundance data specific to the A-R stock. The stock is managed with ASMFC Striped Bass Management Board approval through a separate, state produced North Carolina Estuarine Striped Bass FMP (ASMFC 2014; NCDMF 2014).

In 2003, Amendment 6 was adopted to address five limitations within the management program: 1) potential inability to prevent the Amendment 5 exploitation target from being exceeded; 2) perceived decrease in availability or abundance of large striped bass in the coastal migratory population; 3) a lack of management direction with respect to target and threshold biomass levels; 4) inequitable effects of regulations on the recreational and commercial fisheries, and coastal and producer area sectors; 5) and excessively frequent changes to the management program. Amendment 6 was fully implemented by January 1, 2004, and completely replaced all previous plans for Atlantic striped bass (ASMFC 2003).

Amendment 6 modified the F targets and thresholds, and introduced a new set of biological reference points (BRPs) based on a threshold level of female spawning stock biomass (SSB) set at the level of abundance in 1995, and a target of 125% the 195 level, as well as a list of management triggers based on the BRPs. The coastal commercial quotas for striped bass were restored to 100% of the states' average landings during the 1972-1979 period, except for Delaware's coastal commercial quota, which remained at the level allocated in 2002. In the recreational fisheries, all states were required to implement a two-fish bag limit with a minimum size limit of 28-inches total length, except for the Chesapeake Bay fisheries, fisheries that operate in the Albemarle Sound and Roanoke River, and states with approved alternative regulations. The Chesapeake Bay and Albemarle-Roanoke regulatory programs were predicated on a more conservative F target than the coastal migratory stock, which allowed these jurisdictions to implement separate seasons, harvest caps, and size and bag limits if they remain under that F target. No minimum size limit can be less than 18-inches total length under Amendment 6. The same minimum size standards regulate the commercial fisheries as the recreational fisheries, except for a minimum 20-inches total length size limit in the Delaware Bay spring gillnet fishery.

States are permitted the flexibility to deviate from these standards by submitting proposals for review by the striped bass Technical Committee, Advisory Panel, and Plan Review Team and contingent upon the approval of the Management Board. A state may request a change only if it can demonstrate that the action is "conservationally equivalent" to the management standards or will not contribute to the overfishing of the resource. This practice has resulted in a variety of regulations among states.

In 2007, Addendum I was implemented to establish a bycatch monitoring and research program to increase the accuracy of data on striped bass discards and recommend development of a web-based angler education program.

In May 2009, the Management Board initiated the development of an addendum to consider options to roll over unused coastal commercial quota up to 50% and approved sending the draft addendum out for public comment in August 2009. In November 2009, the Board voted for status quo management in regards to unused quota rollover.

In February 2010, the Management Board initiated the development of an addendum to consider options to increase the coastal commercial quota. The Board approved the draft addendum for public comment in May 2010, with the addition of an option to consider adopting a Technical Committee recommendation to revise the JAI management trigger. Adopting the Technical Committee recommendation would modify the definition of recruitment failure, such that each index would have a fixed numerical value indicating failure, rather than one that changes from year to year. The Board approved Addendum II, and the revised JAI management triggers, in November 2010 but did not take any action to increase the coastal commercial quota. The new definition of recruitment failure is a value that is below 75% of all values in a fixed time series appropriate to each juvenile abundance index.

In 2012, Addendum III was approved by the Board. The addendum was initiated in response to significant poaching events in the Chesapeake Bay and aims to limit illegal commercial harvest of striped bass. An investigation revealed that some of the control measures in place for regulating the harvest of striped bass were ineffective or inadequately designed to maximize compliance. The investigation also found that greater accountability of wholesalers would be difficult to achieve without uniform tags (colors, design) and tagging requirements, valid year and size limits inscribed on tags, and increased dealer compliance education. This addendum required all states and jurisdictions with a commercial fishery to make their commercial harvest tagging programs more consistent and comply with the recommendations by the Interstate Watershed Task Force (IWTF) and ASMFC Law Enforcement Committee (LEC) on reducing illegal harvest of striped bass.

The Board approved Addendum IV in 2014 in response to the 2013 benchmark assessment which indicated a steady decline in spawning stock biomass since the mid-2000s. The Addendum established new fishing mortality reference points (F target and threshold) still based on the level of SSB in 1995, and required coastal states to reduce removals and decrease F to a level at or below the new target (i.e., 25% reduction from 2013 removals for the coastal fishery and 20.5% reduction from 2012 removals for Chesapeake Bay fishery). Additionally, since current analysis of tag return data indicates the Albemarle-Roanoke stock contributes minimally to the coast-wide complex, Addendum IV defers management of the Albemarle-Roanoke stock to the State of North Carolina using stock-specific BRPs approved by the Management Board. The 18-inch total length minimum size limit still applies.

The Exclusive Economic Zone (EEZ) has been closed to the harvest and possession of striped bass since 1990, except for a defined route to and from Block Island in Rhode Island. A recommendation was made in Amendment 6, and submitted to the Secretary of Commerce, to re-open federal waters to commercial and recreational fisheries. Starting in July 2003 and continuing for several years, the National Oceanic and Atmospheric Administration (NOAA) Fisheries took steps in the rulemaking process to consider the proposal. In September 2006,

NOAA Fisheries concluded that it would be imprudent to open the EEZ to striped bass fishing and chose not to proceed further in its rulemaking. Specifically, NOAA Fisheries concluded that: 1) it could not be certain, especially after taking into account the overwhelming public perception that large trophy sized fish congregate in the EEZ, that opening the EEZ would not increase effort and lead to an increase in mortality that would exceed the threshold, and 2) both the ASMFC's and NOAA Fisheries' ability to immediately respond to an overfishing and/or overfished situation is a potential issue, particularly given the timeframe within which Amendment 6 was created, and given the lag time in which a given year's data is available to management (71 FR 54261-54262). Additionally, in October 2007, President George W. Bush issued an Executive Order (E.O. 13449) prohibiting the sale of striped bass (and red drum) caught within the EEZ. The Order also requires the Secretary of Commerce to encourage management for conservation of the resources, including State designation as gamefish where the State determines appropriate under applicable law, and to periodically review the status of the populations within US jurisdictional waters.

To ensure compliance with interstate requirements, North Carolina also includes Atlantic Striped Bass 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 plans) and the Atlantic Coastal Fisheries Cooperative Management Act (ASMFC plans) are like the goals of the Fisheries Reform Act of 1997 to "ensure long-term viability" of these fisheries (NCDMF 2015).

Management Unit

Migratory stocks of Atlantic striped bass from Maine through North Carolina. In North Carolina the striped bass stocks in the Tar-Pamlico, Neuse, and Cape Fear rivers are considered estuarine and non-anadromous, and are not managed through the ASMFC FMP, rather they are managed under the NC Estuarine Striped Bass FMP (NCDMF 2013).

Goal and Objectives

The goal of Amendment 6 is to perpetuate, through cooperative interstate management, migratory stocks of Striped bass; to allow commercial and recreational fisheries consistent with the long- term maintenance of a broad age structure, a self-sustaining spawning stock; and also to provide for the restoration and maintenance of their essential habitat. In support of this goal, the following objectives are included:

1. Manage Striped bass fisheries under a control rule designed to maintain stock size at or above the target female spawning stock biomass level and a level of fishing mortality at or below the target exploitation rate.

2. Manage fishing mortality to maintain an age structure that provides adequate spawning potential to sustain long-term abundance of Striped bass populations.
3. Provide a management plan that strives, to the extent practical, to maintain coast-wide consistency of implemented measures, while allowing the States defined flexibility to implement alternative strategies that accomplish the objectives of the FMP.
4. Foster quality and economically viable recreational, for-hire, and commercial fisheries.
5. Maximize cost effectiveness of current information gathering and prioritize state obligations in order to minimize costs of monitoring and management.
6. Adopt a long-term management regime that minimizes or eliminates the need to make annual changes or modifications to management measures.
7. Establish a fishing mortality target that will result in a net increase in the abundance (pounds) of age 15 and older striped bass in the population, relative to the 2000 estimate.

STATUS OF THE STOCK

Life History

Striped bass are the largest member of the Moronidae family, the temperate basses, which also includes white perch, white bass and yellow bass. Striped bass are a riverine and estuarine dependent species native from the St. Lawrence River in Canada down to the St. Johns River in Florida, and through the Gulf of Mexico, although the striped bass found in the Gulf of Mexico is a genetically distinct species. The migratory striped bass stocks from Maine through the A-R stock in North Carolina are managed under the jurisdiction of the ASMFC. Stocks south of the Albemarle sound are considered estuarine and non-migratory and are not under ASMFC jurisdiction.

Atlantic striped bass under ASMFC jurisdiction are anadromous, meaning they spend most of their adult life in ocean waters, but return to their natal rivers to spawn in the spring. The rivers that feed the Chesapeake Bay, and the Delaware and Hudson rivers are the major spawning grounds for the coastal migratory population. Female striped bass typically grow larger and heavier than males. There are two, distinct life history strategies for striped bass from the Chesapeake Bay, Delaware, Hudson, and A-R stocks. One group consists of mostly females and participate in extensive coastal migrations. Fish travel north as far as Maine and Canada in the spring after spawning takes place, then as water temperatures drop they move south in the winter where they overwinter off the VA/NC coast before going to their natal rivers to spawn again in the spring. The other group is mostly resident fish and the majority are males, inhabiting the estuaries and near-shore ocean within their natal systems.

Based on sampling efforts from the Chesapeake Bay, 45% of female striped bass mature at age 6 and 100% mature by age 9. The latest maturity study for the A-R stock determined 29% of female striped bass are mature at age 3.97% are mature at age 4, and 100% are mature at age 5 (Boyd 2011). The oldest striped bass on record is 31 years old, but they would likely live longer than that in the absence of fishing pressure. The oldest fish observed in the Albemarle-Roanoke stock is 24 years old.

Stock Status

In 2017, the Atlantic striped bass stock was overfished and experiencing overfishing relative to the updated reference points defined in the 2018 assessment. Female spawning stock biomass (SSB) was estimated at 151 million pounds, below the SSB threshold of 202 million pounds. Total fishing mortality was estimated at 0.307, above the fishing mortality threshold of 0.240. Despite recent declines in SSB, the stock is still above the SSB levels observed during the moratorium that was in place in the mid-late 1980s.

Stock Assessment

As shown in Figure 1, striped bass experienced a period of strong recruitment (age-1 fish entering the population) from 1994-2004, followed by a period of lower recruitment from 2005-2011 (although not as low as the early 1980s, when the stock was considered collapsed). This period of low recruitment contributed to the decline in SSB that the stock has experienced since 2010. Recruitment of age-1 fish was high in 2012, 2015, and 2016 (corresponding to strong 2011, 2014, and 2015 year classes), but estimates of age-1 striped bass were below the long-term average in 2013, 2014, and 2017. Recruitment in 2017 was estimated at 108.8 million age-1 fish, below the time series average of 140.9 million fish.

The reference points currently used for management are based on the 1995 estimate of female SSB. The 1995 female SSB is used as the SSB threshold because many stock characteristics (such as an expanded age structure) were reached by this year and the stock was declared recovered. The values estimated in the 2013 assessment are SSBThreshold = female SSB1995 = 127 million pounds and SSBTarget = 125% female SSB1995 = 159 million pounds. To estimate the associated fishing mortality threshold and target, population projections were made by using a constant fishing mortality rate and changing the value until the SSB threshold or target value was achieved. The projected fishing mortality (F) to maintain SSBThreshold = FThreshold = 0.22, and the projected fishing mortality to maintain SSBTarget = FTarget = 0.18.

For the 2018 assessment, the definitions of the targets and thresholds remain the same, but the values have been updated. The new MRIP estimates resulted in higher estimates of SSB, and therefore higher estimates for the SSB threshold and target. The SSB threshold was estimated at 202 million pounds, with an SSB target of 252 million pounds. The new MRIP estimates did not have a large effect on the estimates of fishing mortality, and the updated fishing mortality threshold and target values are very similar to the previous fishing mortality reference points. The 2018 updated fishing mortality threshold was estimated at 0.24, and the target was estimated at 0.20 (Figure 2).

STATUS OF THE FISHERY

Current Regulations

Striped bass regulations in the North Carolina coastal waters (0-3 miles) of the Atlantic Ocean are under the jurisdiction of ASMFC, while striped bass regulations in North Carolina's inshore coastal (i.e. estuarine), joint, and inland waters are under the jurisdiction of the North Carolina

Division of Marine Fisheries and Wildlife Resources Commission. Striped bass regulations in the EEZ are under the jurisdiction of the NOAA Fisheries. Commercial and recreational harvest of striped bass is not allowed in the EEZ, which is from three to 200 miles offshore. Striped bass cannot even be targeted for recreational catch-and-release fishing in the EEZ.

In North Carolina, commercial harvest is currently constrained by a 360,360 pound annual quota and a 28-inch total length minimum length size limit. The quota is split evenly between three gears: ocean beach seine, ocean gill net, and ocean trawl. Usually only one gear is open at a time and any quota overages in a gear are taken away from the offending gear during the next year. Atlantic striped bass overwinter in North Carolina ocean waters during the winter months, from December through February, therefore the quota year is set from December 1 through November 30 each year.

Recreational harvest is constrained by a one fish per person daily possession limit and a 28-inch total length minimum total length size limit. When striped bass are inside state coastal waters they form large schools that are easily accessed by anglers, and harvest can be significant with releases even larger.

The Atlantic Ocean waters from about Oregon Inlet to the N.C./V.A. state line are the southernmost extension of the overwintering grounds for Atlantic striped bass. Therefore, annual landings are dependent on how far down and offshore striped bass stocks migrate each winter. Since 2011 striped bass have been farther north and offshore than normal. In recent years large schools of striped bass have been up to 30 miles offshore. Since 2012 there has been no commercial or recreational harvest of overwintering migratory striped bass in North Carolina's coastal ocean waters during the winter months.

Commercial Landings

Commercial landings of striped bass in the Atlantic Ocean have been controlled by a quota since 1991. Due to the relatively small individual gear quota and the ability to harvest tens of thousands of pounds in just a single day, specific gear overages were common, but the overall quota was rarely exceeded. Landings reached the quota in most years and averaged 361,555 pound a year from 1995/1996-2006/2007. Starting in 2008/2009 shifting migratory patterns and decreasing stock abundance led to less availability of fish inside three miles. Since 2012/2013 no striped bass have been landed from the Atlantic Ocean because striped bass have stayed outside of three miles and in southern Virginia waters while overwintering (Tables 1 and 2, Figure 3).

Recreational Landings

Recreational fishing activity is monitored through the Marine Recreational Information Program. In this report, estimates across all years have been updated and are now based on the MRIP new Fishing Effort Survey-based calibrated estimates. For more information on MRIP methodology changes see https://www.fisheries.noaa.gov/topic/recreational-fishing-data.

Recreational landings were low through the early 2000s. As the Atlantic striped bass stock recovered and abundance increased, recreational landings increased as well, with peak landings

of 6.6 million pounds in 2004 (Table 1; Figure 3). When striped bass are inside state coastal waters they form large schools that are easily accessed by anglers, and harvest can be significant and releases even larger. Landings have fluctuated since, often due to winter weather conditions and the migratory behavior in the near shore ocean during January and February. From 2001 to 2011 landings averaged about 2.3 million pounds. Due to the stocks being outside of three miles and not migrating down into North Carolina state waters in recent years, no recreational landings have occurred since 2012 (Table 1 Figure 3.).

The NCDMF offers award citations for exceptional catches of striped bass. Most citations are from fish caught in the Atlantic Ocean. Striped bass that measure greater than 45 inches total length or 35 pounds are eligible for an award citation. Citations peaked in 2004 at over 700 but have declined to near zero since 2011 due to shifting overwintering patterns (Figure 4).

MONITORING PROGRAM DATA

Fishery-Dependent Monitoring

The length, weight, sex, and age composition of the commercial harvest has been consistently monitored through sampling at fish houses conducted by the division since 1982. The annual harvest quota is split equally between three gear types, beach seine, gill net, and trawl. Any overages from one year are deducted from next year's quota (Table 2). Because of the 28-inch total length minimum size limit and gear regulations, most fish harvested average about 38-inches total length (Table 3; Figure 5). North Carolina also augments NOAA Fisheries Marine Recreational Information Program (MRIP) by providing additional funding for increased samplers, which estimates the annual harvest and releases of marine recreational fisheries. Mean total length is usually around 36-inches, with fish as large as 51-inches measured. Total number of fish measured for 2006-2011 ranged from 67 to 609. There has been no estimated harvest (and therefore no fish measured) since 2012 (Table 4; Figure 6).

Fishery-Independent Monitoring

North Carolina has no fishery independent sampling indices of abundance for Atlantic striped bass. However, we do participate in the coast-wide striped bass tagging program administered through the United States Fish and Wildlife Service (USFWS). In 2011, the DMF started contracting charter trips to collect striped bass using hook-and-line gear to tag striped bass on their overwintering grounds, usually in the vicinity of the VA/NC border. Tagging takes place in January and/or February. Dates and actual location of tagging are dependent on striped bass annual migration patterns. Tags used are USFWS tags and all tagging information is housed in the USFWS tagging database. The striped bass Winter Cooperative Tagging Program is a critical component of overall coast-wide striped bass management, as it is the only tagging program that tags the mixed, migratory stock on their overwintering grounds (off the VA/NC coast, from the mouth of the Chesapeake Bay down to Oregon Inlet). This means that fish from all producer areas, including Chesapeake Bay, Delaware River, Hudson River, and A-R stocks are available for tagging. Tag returns provide managers with an estimate of the percent contribution of the individual producer areas to the migratory portion of the stock and fishing mortality on the stock. Length frequencies average about 37-inches total length, and about 1,000 fish are collected each

year (Table 5). Nearly all of these fish are large, mature females that are staging on their overwintering grounds in preparation for the spring spawning run to their respective spawning grounds.

In order to describe the age structure of harvest and indices, striped bass age structures are collected from various fishery independent (scientific surveys) and dependent (fisheries) sources throughout the year. The length at age data for striped bass display an increasing length at age for striped bass up to about 40 inches in length, although the length at age overlaps between similar ages (Table 6; Figure 7).

MANAGEMENT STRATEGY

Atlantic striped bass are managed under Amendment 6 (and subsequent addenda) to ASMFC's Interstate FMP for Atlantic Striped Bass. The plan identifies spawning stock biomass and fishing mortality reference points to maintain adequate stock size and age structure, and to prevent overfishing. Stock status is determined by a formal, peer reviewed statistical catch-at-age stock assessment. The FMP requires several independent and dependent monitoring programs to be in place in each state, although these programs vary by state. States have the flexibility to implement different size limits, bag limits, and commercial quotas, if they are deemed to meet conservation equivalency by the Technical Committee and are approved by the Management Board.

RESEARCH NEEDS

The following management issues and research needs are identified in Amendment 6 and from the peer reviewed stock assessment.

Fishery Dependent Priorities

<u>High</u>

- Continue collection of paired scale and otolith samples, particularly from larger striped bass, to facilitate the development of otolith-based age-length keys for scale-otolith conversion matrices.

<u>Moderate</u>

- Develop studies to provide information on gear specific discard mortality rates and to determine the magnitude of bycatch mortality.
- Improve estimates of striped bass harvest removals in coastal areas during wave 1 and in inland waters of all jurisdictions year round.
- Evaluate the percentage of fishermen using circle hooks.

Fishery Independent Priorities

<u>Moderate</u>

- Develop a refined and cost-efficient, fisheries-independent coastal population index for striped bass stocks.

    - The PRT recommends the SBTC be tasked with exploring whether the Cooperative Winter Tagging Cruise, NEAMAP, and/or NOAA Fisheries Trawl Survey datasets would prove useful in this respect.

Modeling/Quantitative Priorities

<u>High</u>

- Develop a method to integrate catch-at-age and tagging models to produce a single estimate of F and stock status.
- Develop a spatially and temporally explicit catch-at-age model incorporating tag based movement information.
    - The PRT recommends that the SAS be tasked with reviewing recent published literature examining tag-based movement information to see if they would contribute to the development of such a model (e.g., Callihan et al., 2014).
- Review model averaging approach to estimate annual fishing mortality with tag based models. Review validity and sensitivity to year groupings.
- Develop methods for combining tag results from programs releasing fish from different areas on different dates.
- Examine potential biases associated with the number of tagged individuals, such as gear specific mortality (associated with trawls, pound nets, gill nets, and electrofishing), tag induced mortality, and tag loss.
- Develop field or modeling studies to aid in estimation of natural mortality or other factors affecting the tag return rate.

<u>Moderate</u>

- Develop maturity ogives applicable to coastal migratory stocks.
- Examine methods to estimate annual variation in natural mortality.
- Develop reliable estimates of poaching loss from striped bass fisheries.
- Improve methods for determining population sex ratio for use in estimates of SSB and biological reference points.
- Evaluate truncated matrices and covariate based tagging models.

<u>Low</u>

- Examine issues with time saturated tagging models for the 18-inch length group.
- Develop tag based reference points

Life History, Biological, and Habitat Priorities

<u>High</u>

- Continue in-depth analysis of migrations, stock compositions, etc. using mark-recapture data.
- Continue evaluation of striped bass dietary needs in relation to health condition.
- Continue analysis to determine linkages between the mycobacteriosis outbreak in Chesapeake Bay and sex ration of Chesapeake spawning stock, Chesapeake juvenile production, and recruitment success into coastal fisheries.

Moderate

- Examine causes of different tag based survival estimates among programs estimating similar segments of the population.
- Continue to conduct research to determine limiting factors affecting recruitment and possible density implications.
- Conduct study to calculate the emigration rates from producer areas now that population levels are high and conduct multi-year study to determine inter-annual variation in emigration rates.

Low

- Determine inherent viability of eggs and larvae.
- Conduct additional research to determine the pathogenicity of the IPN virus isolated from striped bass to other warm water marine species, such as flounder, menhaden, shad, and largemouth bass.

Management, Law Enforcement, and Socioeconomic Priorities

Moderate

- Examine the potential public health trade-offs between the continued reliance on the use of high minimum size limits (28-inches) on coastal recreational anglers and its long-term effects on enhanced PCB contamination among recreational stakeholders.
- Evaluate striped bass angler preferences for size of harvested fish and trade-offs with bag limits.

Habitat Recommendations

- Passage facilities should be designed specifically for passing striped bass for optimum efficiency at passing this species.
- Conduct studies to determine whether passing migrating adults upstream earlier in the year in some rivers would increase striped bass production and larval survival, and opening downstream bypass facilities sooner would reduce mortality of early emigrants (both adult and early-hatched juveniles).
- All state and federal agencies responsible for reviewing impact statements and permit applications for projects or facilities proposed for striped bass spawning and nursery areas shall ensure that those projects will have no or only minimal impact on local stocks, especially natal rivers of stocks considered depressed or undergoing restoration.
- Federal and state fishery management agencies should take steps to limit the introduction of compounds which are known to be accumulated in “striped bass tissues and which pose a threat to human health or striped bass health.
- Water quality criteria for striped bass spawning and nursery areas should be established, or existing criteria should be upgraded to levels that are sufficient to ensure successful striped bass reproduction.
- Each state should implement protection for the striped bass habitat within its jurisdiction to ensure the sustainability of that portion of the migratory stock. Such a program should include inventory of historical habitats. Identification of habitats presently used, specification areas targeted for restoration, and imposition or encouragement of measures to retain or increase the quantity and quality of striped bass essential habitats.

- States in which striped bass spawning occurs should make every effort to declare striped bass spawning and nursery areas to be in need of special protection, such as declaration should be accompanied by requirements of non-degradation of habitat quality, including minimization of non-point source runoff, prevention of significant increases in contaminant loadings, and prevention of the introduction of any new categories of contaminants into an area. For those agencies without water quality regulatory authority, protocols and schedules for providing input on water quality needs of striped bass stocks are met.
- ASMFC should designate important habitats for striped bass spawning and nursery areas as HAPC.
- Each state should survey existing literature and data to determine the historical extent of striped bass occurrence and use within its jurisdiction. An assessment should be conducted of those areas not presently used for which restoration is feasible.

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TABLES

Table 1. Striped bass recreational harvest and number released (Marine Recreational Information Program) and commercial harvest (North Carolina Trip Ticket Program) from the Atlantic Ocean, North Carolina, for calendar year 1982-2018. All weights are in pounds.

	Recreational			Commercial	
	Numbers			Numbers	
Year	Landed	Released	Weight (lb)	Landed	Weight (lb)
1982	0	0	0	3,200	92,462
1983	0	0	0	1,405	52,796
1984	0	0	0	532	14,501
1985	0	0	0	0	0
1986	0	0	0	0	0
1987	0	0	0	0	0
1988	510	0	0	0	0
1989	0	0	0	0	0
1990	0	0	0	803	9,797
1991	1,032	0	10,240	413	6,186
1992	2,680	928	0	1,745	27,702
1993	531	2,115	6,084	3,414	36,463
1994	6,543	6,340	89,819	7,956	139,672
1995	16,479	28,169	232,043	23,387	344,627
1996	31,709	98,285	391,588	3,289	58,217
1997	60,074	102,395	865,306	25,820	463,144
1998	41,236	130,531	636,090	14,213	272,969
1999	26,388	50,032	339,092	21,119	391,482
2000	18,108	41,812	276,814	6,465	162,369
2001	60,700	23,264	1,081,940	24,955	381,115
2002	56,330	47,328	997,649	23,242	441,018
2003	50,418	19,006	965,671	5,769	201,199
2004	323,239	246,671	6,655,565	31,041	605,356
2005	194,854	179,323	3,947,042	27,288	604,464
2006	134,184	37,204	2,975,348	2,718	74,189
2007	81,777	22,486	1,965,111	16,798	379,467
2008	36,877	26,405	749,673	13,369	288,410
2009	6,548	1,001	186,729	9,030	189,963
2010	67,144	51,400	1,197,988	13,664	276,435
2011	207,610	245,287	4,467,159	10,867	246,366
2012	0	0	0	333	7,281
2013	0	0	0	0	0
2014	0	0	0	0	0
2015	0	0	0	0	0
2016	0	39,248	0	0	0
2017	0	5,149	0	0	0
2018	0	3,490	0	0	0
Average	38,513	38,051	757,755	7,914	155,882

Table 2. Striped bass commercial harvest (pounds) by gear (North Carolina Trip Ticket Program) from the Atlantic Ocean, North Carolina, based on a fishing year beginning December 1 and ending November 30. The fishing year management strategy began with the implementation of a coast-wide (states from Maine to North Carolina) commercial quota in 1991.

Fishing Year	Beach Seine	Gill Net	Trawl	Total Landings	Fishing Year Quota
1991/1992				6,186	96,000
1992/1993				27,702	96,000
1993/1994				75,671	96,000
1994/1995	64,077	54,576	4,531	123,184	96,000
1995/1996	163,519	130,280	36,250	330,049	334,000
1996/1997	76,558	95,337	184,192	356,187	334,000
1997/1998	155,633	104,551	92,316	352,500	*312,827
1998/1999	68,920	330,784	0	399,727	*299,954
1999/2000	61,149	2,055	100,910	164,114	*218,000
2000/2001	62,969	117,457	168,456	348,882	336,000
2001/2002	100,718	113,515	84,795	299,028	*326,787
2002/2003	226,023	93,346	108,141	427,510	480,480
2003/2004	0	201,025	220,166	421,191	480,480
2004/2005	181,552	233,772	37,598	452,922	480,480
2005/2006	330,429	981	17,797	349,207	480,480
2006/2007	0	326,328	98,373	424,701	480,480
2007/2008	86,150	138,894	74,118	299,162	480,480
2008/2009	4,888	51,677	133430	189,995	480,480
2009/2010	4,097	71,664	196,657	272,418	480,480
2010/2011	6,646	139,377	104,360	250,383	480,480
2011/2012	0	5,101	2,181	7,282	480,480
2012/2013	0	0	0	0	480,480
2013/2014	0	0	0	0	480,480
2014/2015	0	0	0	0	360,360
2015/2016	0	0	0	0	360,360
2016/2017	0	0	0	0	360,360
2017/2018	0	0	0	0	360,360

*Fishing year quotas adjusted for previous year's overage.

Table 3. Summary of striped bass total length (inches) samples collected from commercial fisheries from the Atlantic Ocean, North Carolina, 1981/1982-2017/2018.

Year	Mean Total Length	Minimum Total Length	Maximum Total Length	Total Number Measured
1981/1982	43	38	48	53
1982/1983	43	35	50	221
1983/1984	44	29	52	7
1990/1991	31	27	38	203
1991/1992	33	28	51	241
1992/1993	31	24	46	135
1993/1994	33	26	51	351
1994/1995	35	30	39	51
1995/1996	35	22	43	211
1996/1997	35	28	45	358
1997/1998	33	28	40	183
1998/1999	36	29	42	191
1999/2000	37	30	44	290
2000/2001	35	28	43	256
2001/2002	38	29	47	249
2002/2003	36	23	43	573
2003/2004	37	29	47	400
2004/2005	38	29	46	717
2006/2007	38	28	48	843
2007/2008	39	29	49	317
2008/2009	39	30	49	175
2009/2010	37	28	50	456
2010/2011	36	28	48	388
2011/2012	38	34	47	21
2012/2013				0
2013/2014				0
2014/2015				0
2015/2016				0
2016/2017				0
2017/2018				0

Table 4. Striped bass total length (inches) data from Marine Recreational Information Program recreational fishery samples, Atlantic Ocean, North Carolina, 1991-2018.

Year	Mean Fork Length	Minimum Fork Length	Maximum Fork Length	Total Number Measured
1991	685	685	685	1
1992	848	848	848	1
1993	802	802	802	1
1994	733	501	892	19
1995	817	720	1,058	69
1996	782	293	990	135
1997	788	483	1,018	229
1998	807	458	1,083	272
1999	770	488	1,076	182
2000	792	482	1,091	113
2001	830	471	1,091	267
2002	828	473	1,098	318
2003	905	584	1,152	614
2004	907	536	1,279	1,800
2005	914	706	1,168	1,106
2006	920	708	1,145	372
2007	965	722	1,178	375
2008	902	722	1,204	303
2009	1,005	725	1,253	67
2010	858	708	1,302	95
2011	913	683	1,244	609
2012				0
2013				0
2014				0
2015				0
2016				0
2017				0
2018				0

Table 5. Striped bass total length (inches) and tagging data from the Cooperative Winter Tagging Program, trawl and hook-and-line gear, 1988-2018.

	Number tagged		Mean Total Length		Minimum Total Length		Maximum Total Length	
Year	H&L	Trawl	H&L	Trawl	H&L	Trawl	H&L	Trawl
1988		1,338		25		17		53
1989		1,156		27		20		46
1990		2,010		25		14		48
1991		1,780		28		20		40
1992		1,016		28		17		39
1993		530		26		17		39
1994		4,631		23		14		49
1995		644		29		15		42
1996		698		30		11		44
1997		1,356		29		16		45
1998		462		25		18		49
1999		277		30		3		43
2000		6,236		20		13		42
2001		2,447		25		15		44
2002		4,087		23		15		47
2003		1,908		31		11		48
2004		2,708		25		14		47
2005		4,263		23		12		44
2006		4,462		28		12		48
2007		370		32		19		48
2008		1,033		34		21		47
2009		146		32		22		45
2010		567		30		12		43
2011	*108	**	32		26		43	
2012	*6	**	36		25		46	
2013	1,114	893	37	33	26	24	49	47
2014	921	**	37		27		53	
2015	1,042	333	38	35	29	22	52	42
2016	1,241	110	39	38	23	24	48	43
2017	881	**	40		21		50	
2018	667	**	41		29		52	

* Only one hook-and-line sampling trip was taken due to a lack of funding. 2011 was the first year charter boats were used as the sampling platform and hook-and-line was used as the sampling gear.

** No trips using the traditional research vessel sampling platform and trawl gear were taken due to a lack of funding.

Table 6. Summary of striped bass age samples collected from the Atlantic Ocean from both dependent (commercial and recreational fisheries) and independent (surveys) sources 1982 to 2018.

Year	Modal Age	Minimum Age	Maximum Age	Total Number Aged
1981	10	4	17	43
1982	12	5	18	98
1983	11	9	18	214
1984	6, 12	4	17	197
1985				0
1986				0
1987				0
1988				0
1989				0
1990	7	5	11	133
1991	9	6	13	90
1992	8	4	19	320
1993	8	3	17	638
1994	8	3	23	367
1995	7	3	13	475
1996	8	2	14	467
1997	9	3	15	787
1998	5	4	16	623
1999	9	5	12	449
2000	9	3	13	807
2001	8	2	14	536
2002	10	3	16	782
2003	8	4	18	401
2004	9	3	17	589
2005	10	2	17	614
2006	11	2	17	552
2007	9	4	16	627
2008	10	4	17	411
2009	11	7	17	179
2010	9	6	18	292
2011	8	6	17	226
2012	9	8	15	21
2013				
2014				
2015				
2016				
2017				
2018				

FIGURES

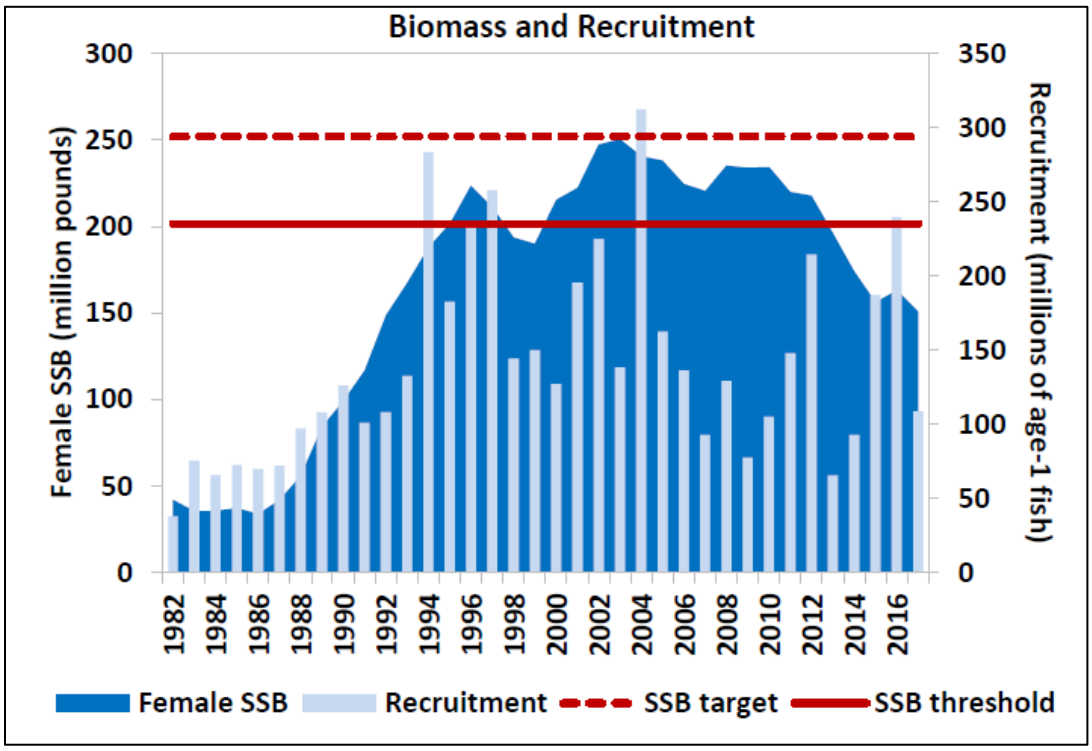

Figure 1. Atlantic striped bass female spawning stock biomass and recruitment (abundance of age-1). Source: ASMFC Atlantic Striped Bass Stock Assessment 2018.

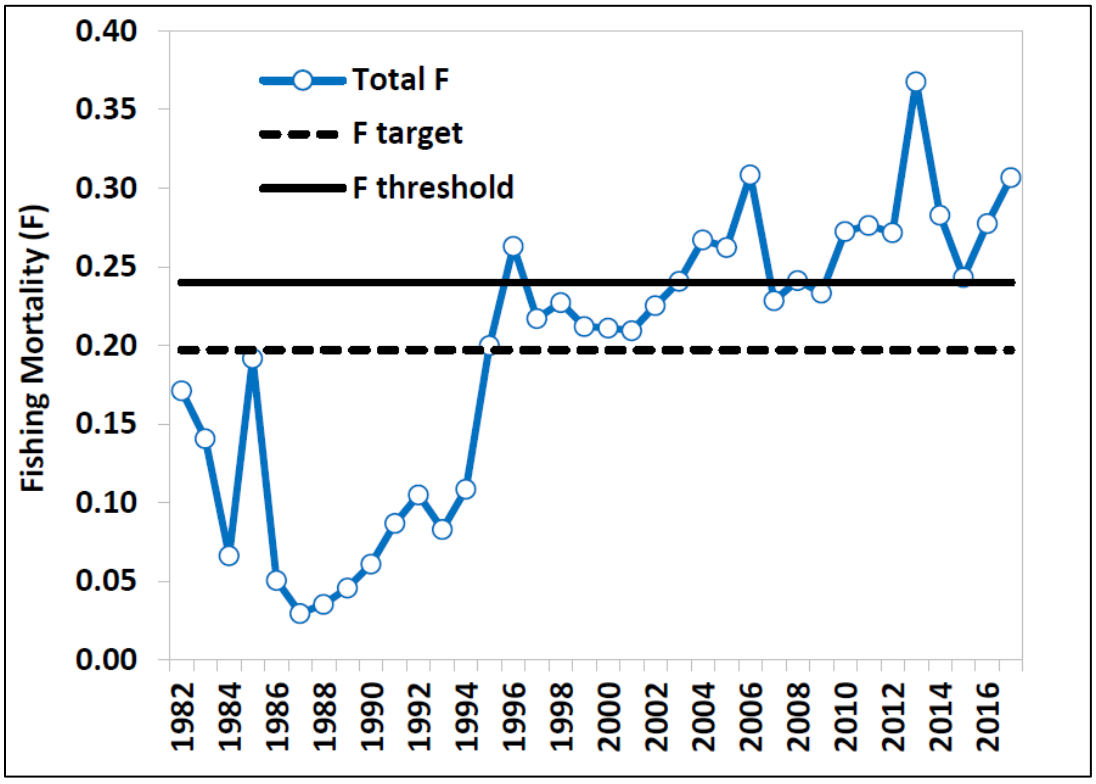

Figure 2. Atlantic striped bass estimates of fishing mortality and the fishing mortality target and threshold reference points. Source: ASMFC Atlantic Striped Bass Stock Assessment 2018.

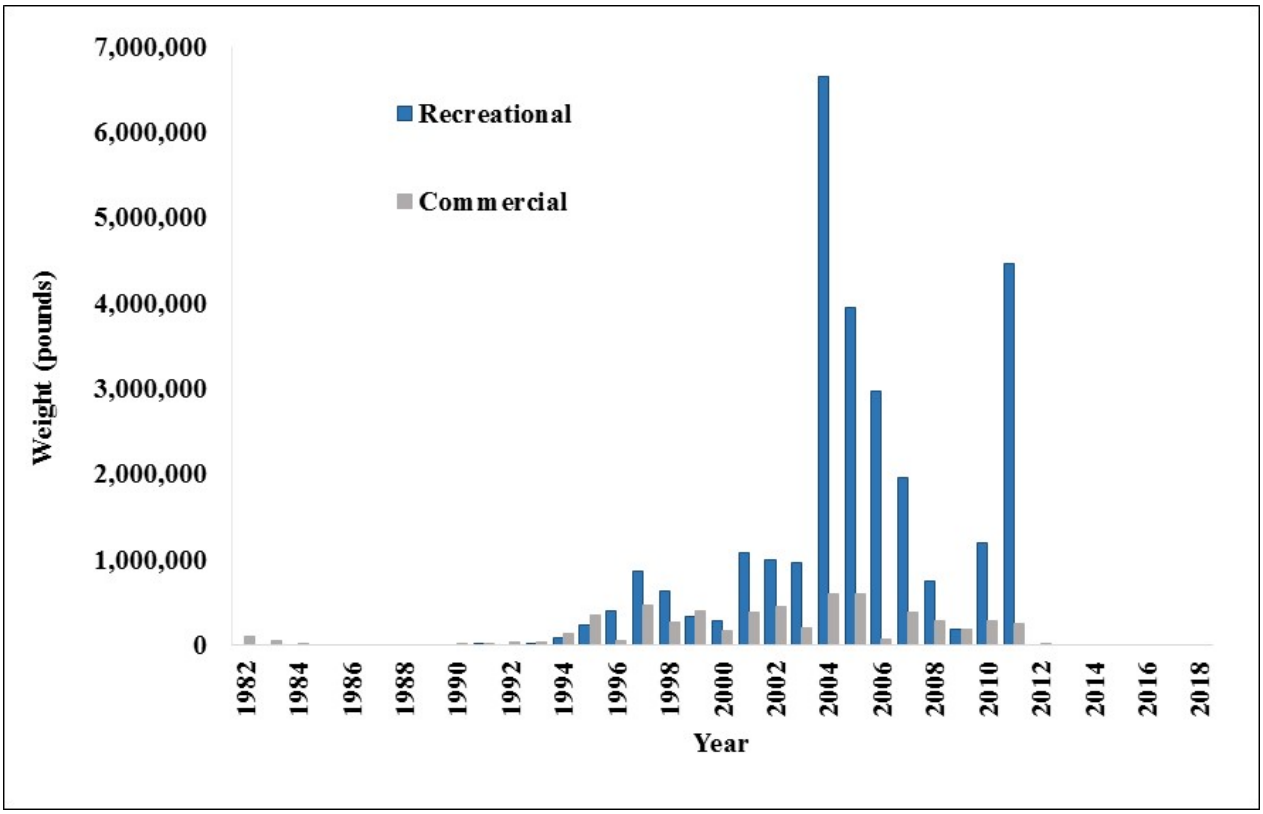

Figure 3. North Carolina's annual commercial and recreational striped bass landings in pounds from the Atlantic Ocean by calendar year, 1982-2018.

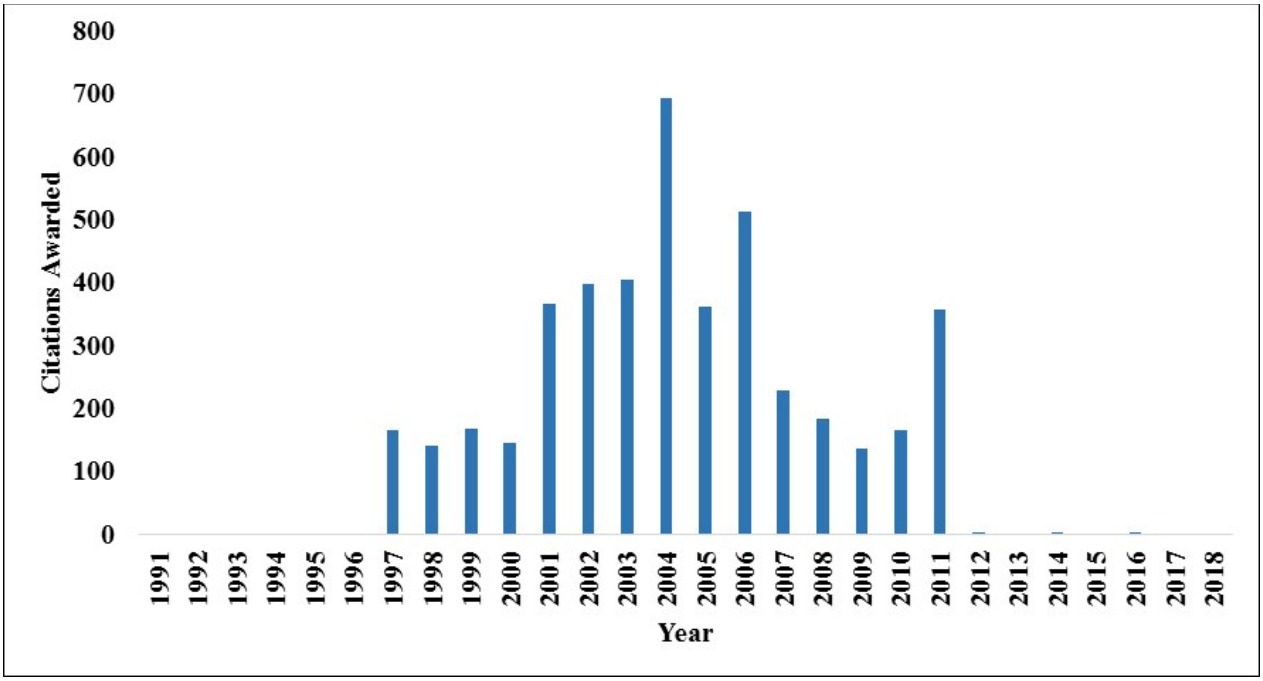

Figure 4. North Carolina Saltwater Fishing Tournament citations awarded for striped bass from the Atlantic Ocean from 1991 to 2018. Citations are awarded for striped bass greater than 35 pounds or 45 inches total length.

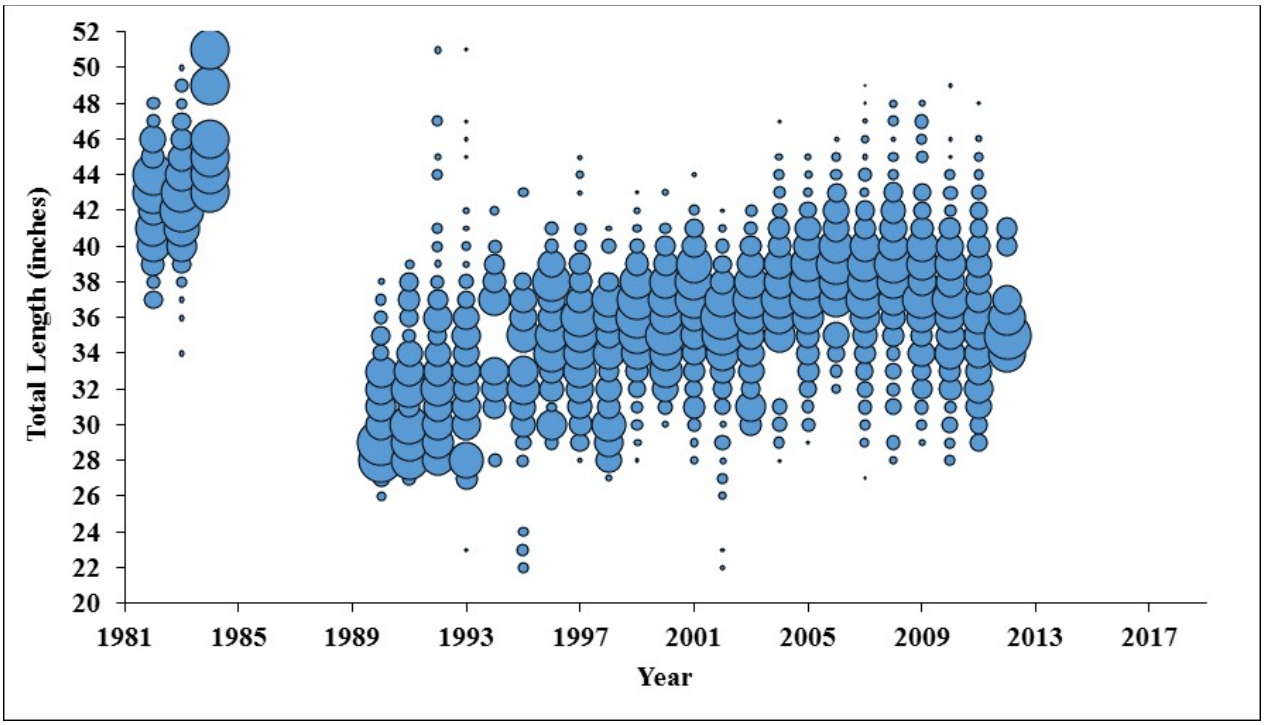

Figure 5. Commercial length frequency (total length, inches) of striped bass harvested from 1982 to 2018. Bubbles represent fish harvested at length and the size of the bubble is equal to the proportion of fish at that length.

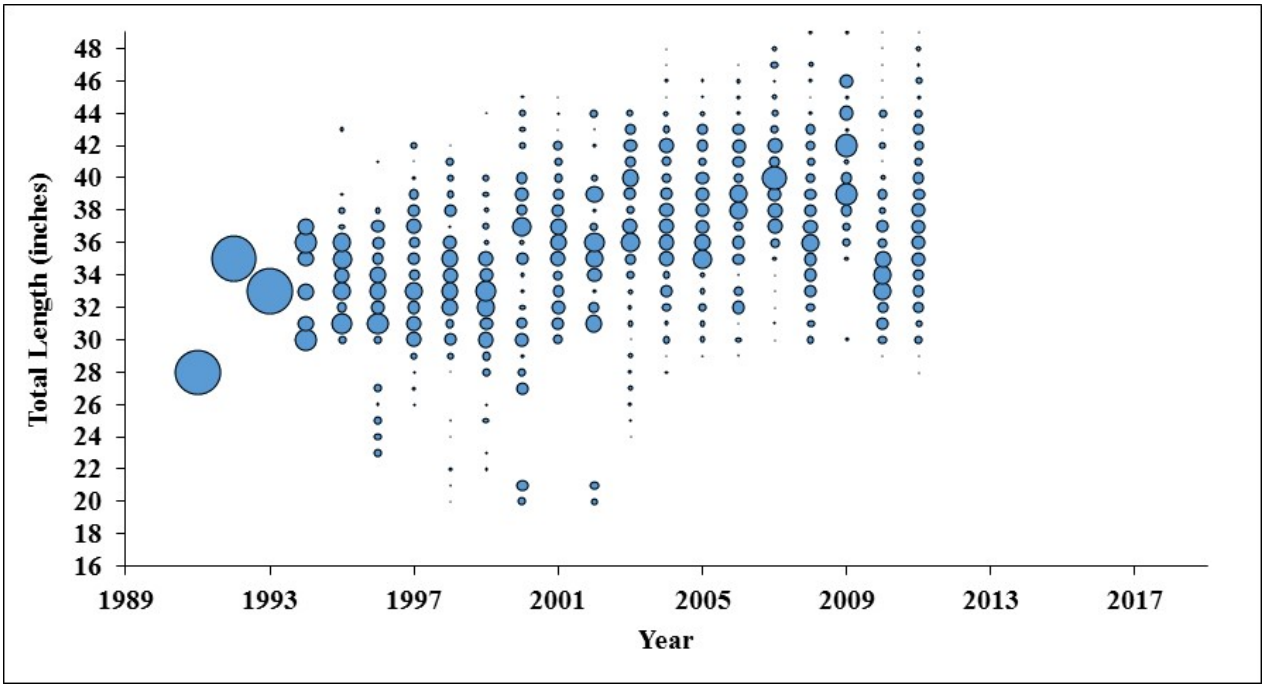

Figure 6. Recreational length frequency (total length, inches) of striped bass harvested from 1988 to 2018. Bubbles represent fish harvested at length and the size of the bubble is equal to the proportion of fish at that length.

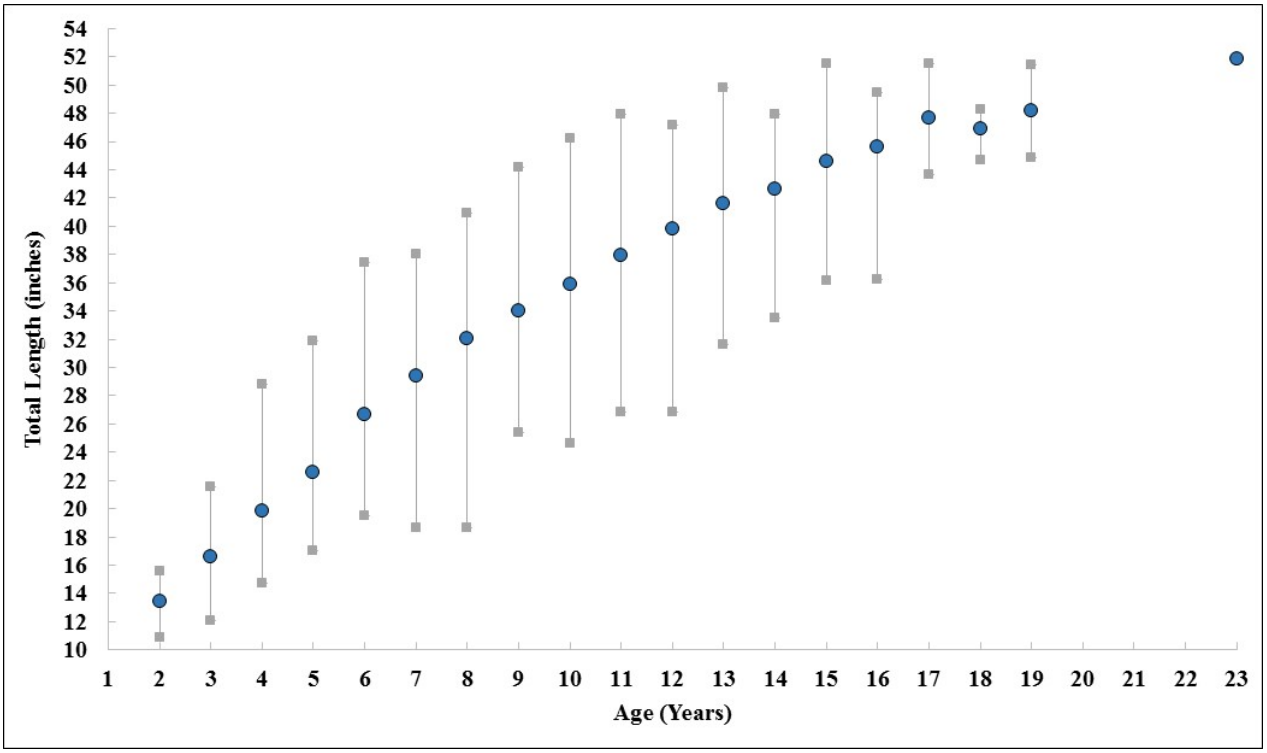

Figure 7. Striped bass length at age samples collected from both dependent (commercial and recreational fisheries) and independent (surveys) sources from 1982 to 2018. Blue circles represent the mean size at a given age while the grey squares represent the minimum and maximum observed size for each age.

FISHERY MANAGEMENT PLAN UPDATE
SUMMER FLOUNDER
AUGUST 2019

STATUS OF THE FISHERY MANAGEMENT PLAN

Fishery Management Plan History

Original FMP Adoption: Adopted by the ASMFC in 1982 and the MAFMC in 1988

Amendments:

- Amendment 1 in 1991
- Amendment 2 in 1993
- Amendment 3 in 1993
- Amendment 4 in 1993
- Amendment 5 in 1993
- Amendment 6 in 1994
- Amendment 7 in 1995
- Amendment 10 in 1997
- Amendment 11 in 1998
- Amendment 12 in 1999
  - Framework 1 in 2001
  - Framework 2 in 2001
  - Addendum III in 2001
  - Addendum IV in 2001
  - Framework 5 in 2004
  - Addendum VIII in 2004
  - Addendum XIV in 2004
  - Addendum XV in 2004
  - Addendum XVI in 2005
  - Addendum XVII in 2005
  - Framework 6 in 2006
  - Addendum XVIII in 2006
  - Framework 7 in 2007
  - Addendum XIX in 2007
- Amendment 16 in 2007
- Amendment 15 in 2011
- Amendment 19 (Recreational Accountability Amendment) in 2013
  - Addendum XXV in 2014
- Amendment 17 in 2015
  - Addendum XXVI in 2015
- Amendment 18 in 2015
  - Addendum XXVII in 2016
  - Addendum XXVIII in 2017
- Amendment 20 in 2017

Framework 10 in 2017
Framework 11 in 2018
Framework 13 in 2018
Addendum XXXI in 2018
Addendum XXXII in 2018

Revisions: None

Supplements: None

Information Updates: None

Benchmark Review: A benchmark stock assessment was completed in 2019.

Because of their presence in, and movement between state waters (0-3 miles) and federal waters (3-200 miles), the Mid-Atlantic Fishery Management Council (MAFMC) manages summer flounder (*Paralichthys dentatus*) cooperatively with the Atlantic States Marine Fisheries Commission (ASMFC). The two management entities work in conjunction with the National Marine Fisheries Service (NMFS) as the federal implementation and enforcement entity. The Summer Flounder, Scup and Black Sea Bass Fishery Management Plan (FMP) and amendments use output controls (catch and landings limits) as the primary management tool, with landings divided between the commercial (60%) and recreational (40%) fisheries. The FMP also includes minimum fish sizes, bag limits, seasons, gear restrictions, permit requirements, and other provisions to prevent overfishing and ensure sustainability of the fisheries. Recreational bag and size limits and seasons are determined on a regional basis using conservation equivalency. The commercial quota is divided into state-by-state quotas.

Specific details for each Amendment include:

Amendment 1 - established an overfishing definition for summer flounder.

Amendment 2 - established rebuilding schedule, commercial quotas, recreational harvest limits, size limits, gear restrictions, permits, and reporting requirements for summer flounder; created the summer flounder monitoring committee.

Amendment 3 - revised the exempted fishery line for summer flounder; increased the large mesh net threshold for summer flounder; established otter trawl retention requirements for large mesh use in the summer flounder fishery.

Amendment 4 - revised state-specific shares for summer flounder commercial quota allocation.

Amendment 5 - allowed states to combine or transfer summer flounder commercial quota.

Amendment 6 - set criteria for allowance of multiple nets on board commercial vessels for summer flounder; established deadline for publishing catch limits; established commercial management measures for summer flounder.

Amendment 7 - revised the fishing mortality rate reduction schedule for summer flounder.

Amendment 10 - modified commercial minimum mesh requirements; continued commercial vessel moratorium permit; prohibited transfer of summer flounder at sea; established a special permit for the summer flounder party/charter sector.

Amendment 11 - modified certain provisions related to vessel replacement and upgrading, permit history transfer, splitting, and permit renewal regulations.

Amendment 12 - revised Summer Flounder, Scup, and Black Sea Bass FMP to comply with the Sustainable Fisheries Act and established a framework adjustment process; established quota set-aside for research for summer flounder, scup and black sea bass; established state-specific conservation equivalency measures; allowed the rollover of the winter scup quota; revised the start date for the scup summer quota period; established a system to transfer scup at sea.

Framework 1 - established quota set-aside for research for summer flounder, scup and black sea bass.

Framework 2 - established state-specific conservation equivalency measures for the recreational summer flounder fishery.

Addendum III - established recreational fishing specifications for 2001 for summer flounder and scup.

Addendum IV - provided that upon the recommendation of the relevant monitoring committee and joint consideration with the Mid-Atlantic Fishery Management Council, the ASMFC's Summer Flounder, Scup, and Black Sea Bass Management Board will decide the state regulations rather than forward a recommendation to the National Marine Fisheries Science center; made states responsible for implementing the ASMFC's Summer Flounder, Scup, and Black Sea Bass Management Boards decisions on regulations.

Framework 5 - established multi-year specification setting of the quotas for summer flounder, scup, and black sea bass.

Addendum VIII - established a program wherein any state which exceeds its recreational harvest limit for summer flounder in 2003 and beyond will receive a reduction from its future recreational harvest limits.

Addendum XIV - implemented a system of conservation equivalency for the recreational fishery of summer flounder to achieve the annual recreational harvest limit.

Addendum XV - established an allocation program for the increase in commercial total allowable landings in the summer flounder fishery for 2005 and 2006 only.

Addendum XVI - provided a species-specific mechanism of ensuring that a state meets its obligations under the plan in a way that minimizes the probability that a state's delay in complying does not adversely affect other states fisheries or conservation of the resource.

Addendum XVII - established a program wherein the ASMFC Management Board has the ability to sub-divide the recreational summer flounder coast-wide allocations into voluntary regions.

Framework 6 - established region-specific conservation equivalency measures for summer flounder.

Addendum XVIII - stabilized fishing rules as close to those that existed in 2005, in part, to minimize the drastic reductions facing three states.

Framework 7 - built flexibility into process to define and update status determination criteria for summer flounder, scup and black sea bass.

Addendum XIX - continued the state-by-state black sea bass commercial management measures, without a sunset clause; broadened the descriptions of stock status determination criteria contained within the Summer Flounder, Scup, and Black Sea Bass FMP to allow greater flexibility in those definitions, while maintaining objective and measurable status determination criteria for identifying when stocks or stock complexes covered by the fishery management plan are overfished.

Amendment 16 - standardized bycatch reporting methodology.

Amendment 15 - established annual catch limits and accountability measures.

Amendment 19 - (Recreational Accountability Amendment) modified the accountability measures for the MAFMC recreational fisheries.

Addendum XXV - established regional management for the 2014 recreational black sea bass and summer flounder fishery.

Amendment 17 - implemented standardized bycatch reporting methodology.

Addendum XXVI - established alternate regional management for the 2015 recreational summer flounder fishery.

Amendment 18 - eliminated the requirement for vessel owners to submit "did not fish" reports for the months or weeks when their vessel was not fishing; removed some of the restrictions for upgrading vessels listed on federal fishing permits.

Addendum XXVII - continued regional management of the recreational summer flounder fishery, extended ad hoc regional management of the black sea bass recreational fishery for the 2016 and 2017 fishing year and addressed the discrepancies in recreational summer flounder management measures within Delaware Bay.

Addendum XXVIII - initiated an addendum to consider adaptive management, including regional approaches, for the 2017 summer flounder recreational fishery.

Amendment 20 - (Unmanaged Forage Omnibus Amendment) implemented management measures to prevent the development of new, and the expansion of existing, commercial fisheries on certain forage species in the Mid-Atlantic.

Framework 10 - (Omnibus For-Hire Electronic Trip Report Framework) implemented a requirement for vessels that hold party/charter permits for Council-managed species to submit vessel trip reports electronically (eVTRS) while on a trip carrying passengers for hire.

Framework 11 - (Omnibus Acceptable Biological Catch Framework) established a process for setting constant multi-year Acceptable Biological Catch (ABC) limits for Council-managed fisheries, clarified that the Atlantic Bluefish, Tilefish, and Atlantic Mackerel, Squid, and Butterfish FMPs will now automatically incorporate the best available scientific information in calculating ABCs (as all other Mid-Atlantic management plans do) rather than requiring a separate management action to adopt them, clarified the process for setting ABCs for each of the four types of ABC control rules.

Framework 13 - modified the accountability measures required for overages not caused by directed landings (i.e., discards) in the summer flounder, scup, and black sea bass fisheries

Addendum XXXI - established conservation equivalency for black sea bass and transit provisions in federal waters around Block Island, Rhode Island for recreational and commercial fishermen which allows permitted fishermen to pass through federal waters legally.

Addendum XXXII - established a specifications process instead of an addendum process to implement recreational management measures more quickly for summer flounder and black sea bass.

Specific details for each amendment under development include:
Summer Flounder Commercial Issues Amendment – This amendment updated the summer flounder goals in the Summer Flounder, Scup, and Black Sea Bass FMP and changed the commercial summer flounder allocations.

To ensure compliance with interstate requirements, North Carolina also manages this species 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 MAFMC, 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. These plans were established under the Magnuson-Stevens Fishery Conservation and Management Act (federal council plans) and the Atlantic Coastal Fisheries Cooperative Management Act (ASMFC plans) with the goal, like the Fisheries Reform Act of 1997 to "ensure long-term viability" of these fisheries (NCDMF 2015).

Management Unit

U.S. waters in the western Atlantic Ocean from the southern border of North Carolina northward to the U.S.-Canadian border.

Goal and Objectives

The objectives of the Summer Flounder, Scup and Black Sea Bass FMP are to:

1. Reduce fishing mortality in the summer flounder, scup and black sea bass fisheries to assure that overfishing does not occur;
2. Reduce fishing mortality on immature summer flounder, scup and black sea bass to increase spawning stock biomass;
3. Improve the yield from these fisheries;
4. Promote compatible management regulations between state and federal jurisdictions;
5. Promote uniform and effective enforcement of regulations;
6. Minimize regulations to achieve the management objectives stated above.

The 2011 Omnibus Amendment contains Amendment 15 to the Summer Flounder, Scup and Black Sea Bass FMP. The amendment is intended to formalize the process of addressing scientific and management uncertainty when setting catch limits for the upcoming fishing year(s) and to establish a comprehensive system of accountability for catch (including both landings and discards) relative to those limits, for each of the managed resources subject to this requirement. Specifically: (1) Establish allowable biological catch control rules, (2) Establish a MAFMC risk policy, which is one variable needed for the allowable biological catch control rules, (3) Establish annual catch limits, (4) Establish a system of comprehensive accountability, that addresses all components of the catch, (5) Describe the process by which the performance of the annual catch limit and comprehensive accountability system will be reviewed, (6) Describe the process to modify the above objectives (1-5) in the future.

STATUS OF THE STOCK

Life History

Summer flounder are estuarine dependent members of the left eyed flounder family that also includes southern flounder (*Paralichthys lethostigma*) and gulf flounder (*Paralichthys albigutta*), all of which occur in North Carolina waters. Summer flounder are found in both inshore and offshore waters from Nova Scotia, Canada to Florida but are most abundant from Cape Cod, Massachusetts to Cape Fear, North Carolina. Spawning typically occurs at age 2 to 3 during the months of November to March as they move offshore. Juveniles move inshore to coastal and estuarine areas for about one year and later begin to join adults offshore. Summer flounder typically mature by age 1 with females maturing at 11 inches total length and males maturing at 10 inches total length. Summer flounder have a maximum age of 19 years. They like to burrow into sandy substrates and ambush prey such as small fish, crabs, shrimp, squid and worms (Packer 1999).

Stock Status

The 2018 summer flounder benchmark stock assessment included data through 2017. It indicated that the stock was not overfished and overfishing was not occurring in 2017.

Stock Assessment

The 2018 summer flounder benchmark stock assessment estimated fishing mortality rates and stock sizes using a statistical catch at age model calculated by using the Age Structured Assessment Program. It also included revised National Oceanic and Atmospheric Administration (NOAA) Marine Recreational Information Program estimates of recreational landings and discards that contributed to increased biomass estimates. The benchmark stock assessment indicated that the stock was not overfished, and that overfishing was not occurring in 2017 relative to the new biological reference points established in the 2018 benchmark stock assessment. Fishing mortality estimates increased since 2007 and below average recruitment persisted from 2011 to 2017. Spawning stock biomass was above the new threshold biomass reference point in 2017. Higher biomass projections resulted in a 49% increase in the commercial quota and recreational harvest limit for 2019.

STATUS OF THE FISHERY

Current Regulations

Commercial

There is a 14-inch total length minimum size limit in Atlantic Ocean waters and a 15-inch total length minimum size limit in internal coastal waters as well as harvest seasons and minimum mesh size requirements for the flounder trawl fishery. Trip limits are set for landings windows

established by proclamation to constrain harvest to the quota allocation (see most recent North Carolina Division of Marine Fisheries (NCDMF) proclamation on commercial summer flounder fishery). A bycatch trip limit of 100 pounds is in place during the closed trawl season. A license to land flounder from the Atlantic Ocean is required to land more than 100 pounds per trip.

Recreational

There is a 15-inch total length minimum size limit and 4-fish creel limit in the Atlantic Ocean and internal coastal waters.

Commercial Landings

Any landings reported as caught in the Atlantic Ocean are considered to be summer flounder by the North Carolina Trip Ticket Program. Most summer flounder landings were from trawls although gill nets and other gears such as hook and line catch much smaller numbers of summer flounder in the Atlantic Ocean (Figure 1). Landings are constrained by the coast-wide quota of which North Carolina has an allocation of 27.4%. In recent years, landings peaked in 2004 and have been generally stable since 2007 aside from 2012 and 2013. The low landings in 2012 and 2013 were primarily due to the closure of Oregon Inlet to large vessels (such as trawlers) due to shoaling and the consequent transfer of most of North Carolina's quota allocation to Virginia and other states. In 2014, more winter trawl vessels returned to North Carolina to land catches (Table 1, Figure 2).

Recreational Landings

Recreational fishing activity is monitored through the Marine Recreational Information Program. In this report, estimates across all years have been updated and are now based on the MRIP new Fishing Effort Survey-based calibrated estimates. For more information on MRIP methodology changes see https://www.fisheries.noaa.gov/topic/recreational-fishing-data. Recreational harvest of summer flounder varied annually but declined and remained consistently low from 2015 through 2018 (Table 1, Figure 2).

MONITORING PROGRAM DATA

Fishery-Dependent Monitoring

Several NCDMF sampling programs collect biological data on commercial and recreational fisheries that catch summer flounder. Program 433 (winter trawl fishery) is the primary program that collects length and age data for harvested summer flounder. Other programs that collect information include: 432 (flounder pound net), 434 (ocean gill net), 435 (beach seine), 461 (estuarine gill net), and 437 (long haul seine). Programs 466 (sea turtle bycatch monitoring) and 570 (commercial shrimp trawl fishery characterization) collect length data on harvested and discarded flounder. Recreational fishery sampling for harvest, releases and lengths occurs through the NOAA Marine Recreational Information Program. Age data from the recreational fishery are collected through voluntary angler donations of carcasses.

During 1991 through 2018, annual mean commercial fishery lengths increased from 17 to 20 inches total length and the mean number of fish measured during 1991 through 2018 was 19,362 which was considerably higher than in 2012 and 2013 (due to low landings in 2012 and 2013) (Table 2). Most summer flounder harvested commercially during 2018 ranged from 14 to 25 inches total length with the majority of fish being 17 inches total length (Figure 3). During 1991 through 2018, summer flounder harvested commercially ranged from 12 to 35 inches total length (Table 2, Figure 4).

As for recreational fishery length data during 1982 through 2018, annual mean lengths increased overtime as size limits have been implemented. The number of fish measured during 1982 through 2018 was variable (Table 3). Most summer flounder harvest recreationally during 2018 ranged from 14 to 17 inches total length with the majority of fish being 15 inches total length (Figure 3). During 1982 through 2018, summer flounder harvested recreationally ranged from 5 to 29 inches total length (Table 3, Figure 5).

Fishery-Independent Monitoring

Several NCDMF independent sampling programs collect biological data on summer flounder. However, most surveys do not catch summer flounder regularly enough to provide consistent length, age or abundance data. The main exception is Program 195 (the Pamlico Sound Trawl Survey), which employs a random stratified survey design in waters of Pamlico Sound and its major river tributaries. Stations are randomly selected from strata based upon depth and geographic location. Randomly selected stations are optimally allocated among the strata based upon all previous sampling in order to provide the most accurate abundance estimates (PSE <20). Tow duration is 20 minutes; using double rigged demersal mongoose trawls (9.1m headrope, 1.0m X 0.6m doors, 2.2-cm bar mesh body, 1.9-cm bar mesh cod end and a 100-mesh tail bag extension. The survey takes place in June and September with the samples collected in June serving as a juvenile abundance index (JAI) for summer flounder in North Carolina. Annual mean lengths ranged from 5 to 7 inches total length during 1987 through 2018 (Table 4). During 2018, a total of 618 summer flounder were caught in the survey and the JAI value was 8.50 fish per tow. The 1987-2018 average JAI value was 9.09 with data from 1999 being excluded from the average due to sampling occurring in July instead of June (Figure 6). The summer flounder JAI from the Pamlico Sound Survey is one of the recruitment indices provided for the annual coast-wide stock assessment of summer flounder and was used in the 2019 summer flounder benchmark stock assessment.

To characterize age structure, summer flounder otoliths are primarily collected from the commercial winter trawl fishery but are also collected from other dependent (recreational) and various independent (scientific surveys) throughout the year. In 2018, 881 summer flounder otoliths were collected yielding a range in age from 0 to 19 years. Maximum ages since 2010 were higher than previous years, suggesting expansion of the stock age structure. Modal age ranged from 2 to 7 during 1991 through 2018 (Table 5). The age data suggests that summer flounder grow very quickly during their first year of life with an average total length of 13 inches at age 1. They continue to grow to an average total length of 28 inches by age 14. The majority of summer flounder aged were a total length of 17 inches at age 3 (Figure 7).

MANAGEMENT STRATEGY

An update of the summer flounder stock assessment is completed every two years by NMFS Northeast Fisheries Science Center (NEFSC). Data are analyzed from the previous year based on decisions made for the previous benchmark assessment. Projections based on stock assessments are used to set the coast-wide quota level each year. Amendments to the FMP are undertaken as issues arise that require action. North Carolina has several specific management strategies for summer flounder (Table 6).

RESEARCH NEEDS

Updated research needs from the 2018 summer flounder benchmark 66th Stock Assessment Workshop are provided below. The research needs listed below start with the most recent. Text in parenthesis indicates known progress made to address these needs.

- Continue to explore changes in the distribution of recruitment. Develop studies, sampling programs, or analyses to better understand how and why these changes are occurring, and the implications to stock productivity (progress unknown at this time).
- The reference points are internally consistent with the current assessment. It may be useful to carry uncertainty estimates through all the components of the assessment, BRPs, and projections (progress unknown at this time).
- Explore the potential mechanisms for recent slower growth that is observed in both sexes (progress unknown at this time).
- Evaluate uncertainties in biomass to determine potential modifications to OFL CV employed (research is ongoing).
- Evaluate fully the sex- and size distribution of landed and discarded fish, by sex, in the summer flounder fisheries (research is ongoing).
- Incorporate sex-specific differences in size at age into the stock assessment (progress has been made and research is ongoing).
- Determine and evaluate the sources of the over-optimistic stock projections (progress has been made).
- Evaluate the causes of decreased recruitment and changes in recruitment per spawner in recent years (progress has been made).
- Further work examining aspects that create greater realism to the summer flounder assessment (e.g., sexually dimorphic growth, sex-specific F, differences in spatial structure [or distribution by size?] should be conducted. This could include: a) Simulation studies to determine the critical data and model components that are necessary to provide reliable advice, and need to determine how simple a model can be while still providing reliable advice on stock status for management use, and should evaluate both simple and most complex model configurations. b) Development of models incorporating these factors that would create greater realism. c) These first steps (a or b) can be used to prioritize data collection, and determine if additional investment in data streams (e.g., collection of sex at age and sex at length and maturity data from the catch, additional information on spatial structure and movement, etc.) are worthwhile in terms of providing more reliable assessment results. d) The modeling infrastructure should be simultaneously developed to support these

types of modeling approaches (flexibility in model framework, MCMC/bootstrap framework, projection framework) (some progress has been made and research is ongoing).
- Develop an ongoing sampling program for the recreational fishery landings and discards (i.e., collect age, length, sex) to develop appropriate age-length keys for ageing the recreational catch (research is needed).
- Apply standardization techniques to all of the state and academic-run surveys, to be evaluated for potential inclusion in the assessment (progress has been made and research is ongoing).
- Continue efforts to improve understanding of sexually dimorphic mortality and growth patterns. This should include monitoring sex ratios and associated biological information in the fisheries and all ongoing surveys to allow development of sex-structured models in the future (research is ongoing).

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TABLES

Table 1. Summer flounder recreational harvest and number released (NOAA Marine Recreational Information Program) and commercial harvest (North Carolina Trip Ticket Program) for 1982-2018. All weights are in pounds.

	Recreational				
	Numbers		Weight (lb)		
Year	Landed	# Released	Landed	Commercial Weight (lb)	Total Weight (lb)
1982	2,263,184	1,240,516	2,028,678	6,499,785	8,528,463
1983	1,522,625	601,360	986,346	7,279,379	8,265,725
1984	1,695,404	736,472	2,025,350	12,792,430	14,817,780
1985	2,012,982	476,231	2,153,031	8,968,385	11,121,416
1986	3,228,832	688,243	3,753,337	6,231,310	9,984,647
1987	530,793	1,096,193	403,096	5,362,322	5,765,418
1988	1,469,995	1,895,950	138,242	6,951,749	7,089,991
1989	559,131	509,719	792,196	4,329,403	5,121,599
1990	1,112,750	2,293,475	1,236,371	2,829,105	4,065,476
1991	567,660	1,398,056	622,637	3,630,629	4,253,266
1992	458,311	1,868,903	562,855	2,613,003	3,175,858
1993	593,005	2,457,437	716,004	3,120,901	3,836,905
1994	767,804	2,094,265	947,445	3,592,781	4,540,226
1995	241,409	955,117	344,315	4,582,176	4,926,491
1996	486,480	1,243,934	582,987	4,227,052	4,810,039
1997	463,367	1,560,563	597,973	1,501,171	2,099,144
1998	599,776	2,942,394	780,861	2,983,107	3,763,968
1999	357,645	1,097,385	466,028	2,869,055	3,335,083
2000	611,081	2,007,411	780,211	3,386,578	4,166,789
2001	424,615	1,836,338	577,139	2,784,741	3,361,880
2002	366,467	1,376,069	435,113	4,129,119	4,564,232
2003	177,360	763,794	273,895	3,572,448	3,846,343
2004	318,632	1,283,788	467,869	4,844,126	5,311,995
2005	202,797	734,860	289,495	4,064,464	4,353,959
2006	254,653	977,039	326,684	3,981,413	4,308,097
2007	251,068	1,299,735	379,387	2,670,110	3,049,497
2008	88,501	939,708	132,743	2,406,603	2,539,346
2009	219,321	1,894,409	307,692	2,859,039	3,166,731
2010	245,839	1,486,980	341,310	3,310,992	3,652,302
2011	186,877	1,009,389	311,573	2,854,122	3,165,695
2012	176,553	1,452,828	287,522	1,090,218	1,377,740
2013	123,742	1,359,319	196,002	541,542	737,544

Table 1 Continued: Summer flounder recreational harvest and number released (NOAA Marine Recreational Information Program) and commercial harvest (North Carolina Trip Ticket Program) for 1982-2018. All weights are in pounds.

	Recreational				
	Numbers		Weight (lb)		
Year	Landed	# Released	Landed	Commercial Weight (lb)	Total Weight (lb)
2014	150,201	1,478,527	215,294	2,911,750	3,127,044
2015	99,263	856,849	157,437	2,878,753	3,036,190
2016	65,494	664,388	110,392	2,071,091	2,181,483
2017	91,193	977,285	147,426	1,563,045	1,710,471
2018	57,913	440,676	92,032	1,657,761	1,749,793
Average	281,122	1,309,322	381,953	2,933,330	3,315,283

Table 2. Summer flounder length (total length, inches) data from commercial fish house samples, 1991-2018.

Year	Mean Total Length (in)	Minimum Total Length (in)	Maximum Total Length (in)	Total Number Measured
1991	17	12	31	24,855
1992	17	12	30	14,714
1993	17	12	32	21,317
1994	18	12	32	21,837
1995	17	12	30	18,805
1996	17	12	30	18,004
1997	17	12	30	13,074
1998	18	12	29	21,538
1999	19	12	31	11,976
2000	19	12	30	24,360
2001	19	12	30	19,994
2002	18	12	31	21,790
2003	19	12	32	17,558
2004	19	12	33	20,469
2005	19	13	32	20,660
2006	20	12	33	20,946
2007	19	12	30	26,280
2008	20	12	31	27,914
2009	20	13	31	19,801
2010	20	12	33	23,381
2011	19	12	31	17,202
2012	20	13	33	7,682
2013	21	13	31	6,452
2014	20	13	35	20,982
2015	20	13	35	28,145
2016	20	12	32	24,268
2017	20	12	33	14,281
2018	20	13	32	13,844

Table 3. Summer flounder length (total length, inches) data from NOAA Marine Recreational Information Program recreational samples, 1982-2018.

Year	Mean Total Length (in)	Minimum Total Length (in)	Maximum Total Length (in)	Total Number Measured
1982	13	8	22	562
1983	12	6	19	150
1984	14	5	19	244
1985	14	5	20	274
1986	14	8	23	281
1987	13	7	29	400
1988	13	8	25	717
1989	15	9	22	338
1990	14	6	25	1,285
1991	14	5	20	810
1992	14	8	22	556
1993	14	8	25	979
1994	15	9	23	1,453
1995	15	10	28	484
1996	15	8	23	1,155
1997	15	9	22	998
1998	15	11	23	1,239
1999	15	12	25	544
2000	15	11	25	703
2001	15	12	23	915
2002	15	9	25	566
2003	15	13	21	121
2004	16	11	23	244
2005	16	13	23	193
2006	15	12	21	217
2007	16	13	21	286
2008	16	13	19	88
2009	16	13	20	136
2010	16	12	22	259
2011	16	13	24	213
2012	16	11	24	228
2013	16	14	23	114
2014	16	13	19	137
2015	16	13	20	116
2016	16	13	21	59
2017	16	13	24	129
2018	16	13	20	91

Table 4. Summer flounder length (total length, inches) data from Program 195 (Pamlico Sound Survey) samples, 1987-2018.

Year	Mean Total Length (in)	Minimum Total Length (in)	Maximum Total Length (in)	Total Number Measured
1987	6	1	19	1,711
1988	7	2	15	493
1989	6	2	14	662
1990	6	3	15	763
1991	6	3	14	359
1992	6	3	16	874
1993	6	3	13	619
1994	7	3	13	842
1995	7	3	13	607
1996	5	3	15	1,378
1997	6	3	17	1,044
1998	6	3	16	794
1999	7	2	14	408
2000	7	3	18	401
2001	6	3	17	1,225
2002	6	3	16	985
2003	6	3	16	592
2004	6	2	16	536
2005	5	3	13	710
2006	7	3	15	310
2007	6	3	13	397
2008	6	3	16	1,096
2009	7	3	19	596
2010	6	2	15	685
2011	6	3	17	695
2012	7	3	16	644
2013	6	3	14	1,169
2014	6	2	17	596
2015	7	3	17	477
2016	6	3	12	272
2017	6	3	14	559
2018	6	3	12	618

Table 5. Summer flounder age samples collected from both dependent (commercial and recreational fisheries) and independent (surveys) sources from 1991-2018.

Year	Modal Age	Minimum Age	Maximum Age	Total Number Aged
1991	2	0	8	632
1992	2	0	7	359
1993	2	0	6	401
1994	2	0	7	552
1995	2	0	7	381
1996	2	1	9	246
1997	2	0	6	444
1998	2	0	6	476
1999	3	1	8	412
2000	3	1	8	569
2001	4	1	8	499
2002	3	1	8	609
2003	3	1	8	610
2004	3	1	10	553
2005	3	1	11	620
2006	4	1	11	682
2007	3	1	11	697
2008	4	1	11	751
2009	5	1	11	723
2010	3	1	14	783
2011	4	2	12	417
2012	3	1	13	541
2013	4	0	13	610
2014	5	1	16	1,120
2015	6	0	17	889
2016	7	0	18	998
2017	4	0	19	1,177
2018	5	0	19	881

Table 6. Summary of management strategies by North Carolina for summer flounder.

Management Strategy	Outcome
14-inch total length (Atlantic Ocean waters) and 15-inch total length (internal coastal waters) minimum size limit for the commercial fishery	Size limit accomplished by rule 3M.0503(a)
Minimum trawl stretched mesh size of ≥5 ½-inches (diamond) or ≥6-inches (square) throughout the body, extensions and tailbag required to possess more than 100 pounds of flounder May 1 through October 31 or more than 200 pounds of flounder November 1 through April 30 (flynets are exempt from minimum trawl mesh requirements)	Rules 3M.0503(b) 3M.0503(f) 3M.0503(g) 3M.0503(h)(1-3)
Owner of a vessel required to possess a Licenses to Land flounder from the Atlantic Ocean and in order for a dealer to purchase or offload ≥ 100 pounds of flounder from the Atlantic Ocean.	Rules 3M.0503(c)(1-4)
Commercial seasons that allocate 80% of the quota to the winter season (starting January 1), a bycatch trip limit of 100 pounds during the closed season and the remaining quota allocated to the fall season (starting no earlier than November 1)	Rules 3M.0503(i)(1-3). Rule suspended for 2013 and 2014 fishing seasons.
Trip limits established for the open seasons	Rule 3M.0503(j) Specific trip limits by Proclamation Authority
15-inch total length (Atlantic Ocean and internal coastal waters) minimum size and 4 fish creel limit for recreational fishery in all joint and coastal waters	Proclamation FF-4-2017

FIGURES

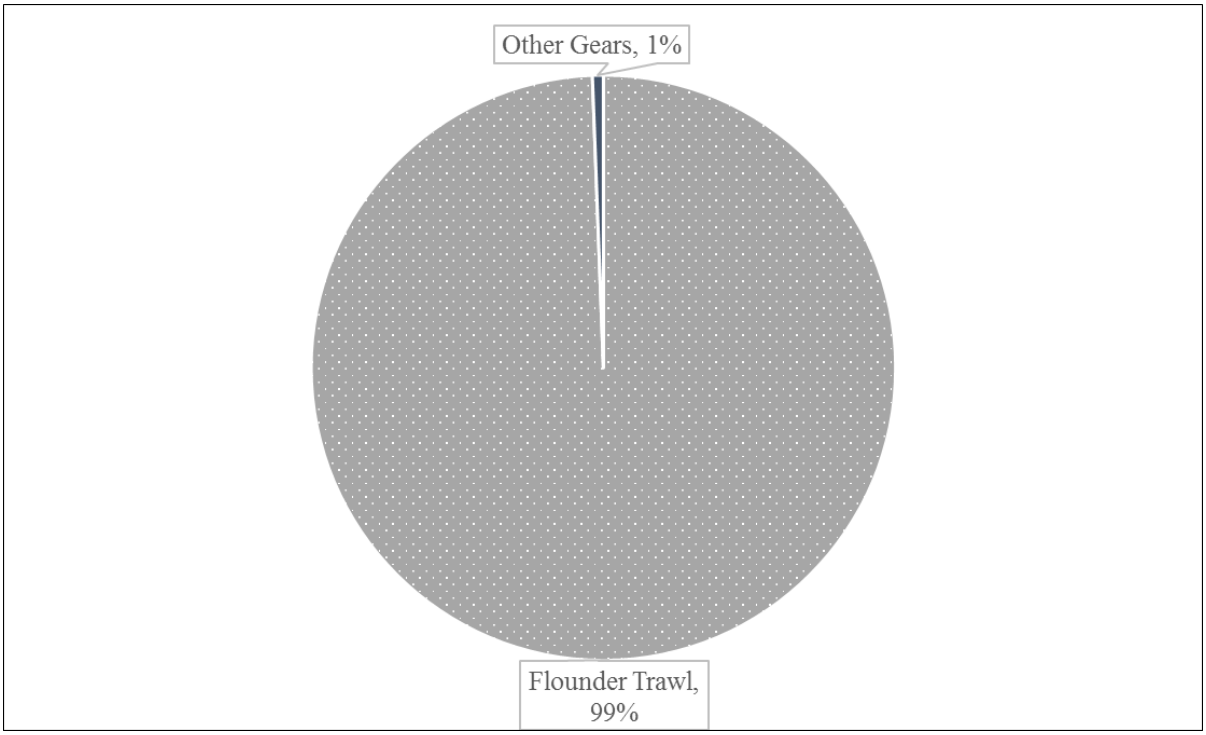

Figure 1. Commercial harvest of summer flounder in North Carolina by gear type in 2018.

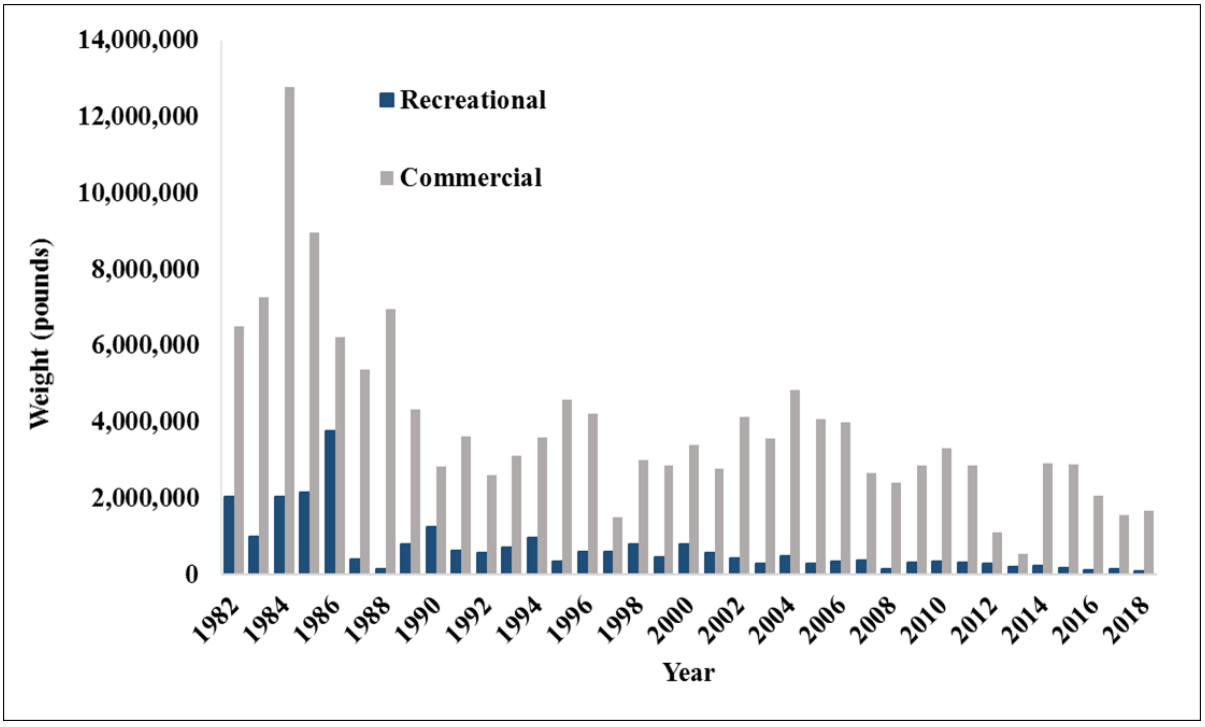

Figure 2. Annual commercial and recreational landings in pounds for summer flounder in North Carolina from 1982-2018.

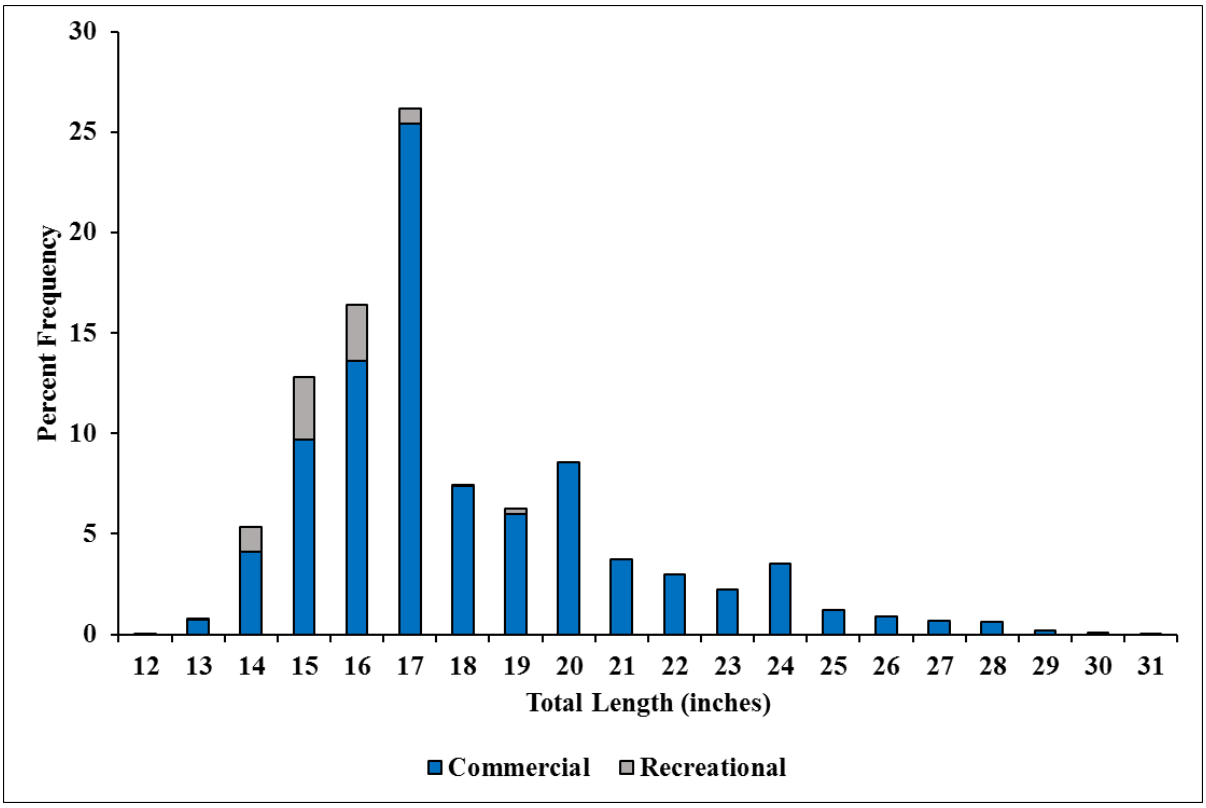

Figure 3. Commercial and recreational length frequency distribution from summer flounder harvested in 2018.

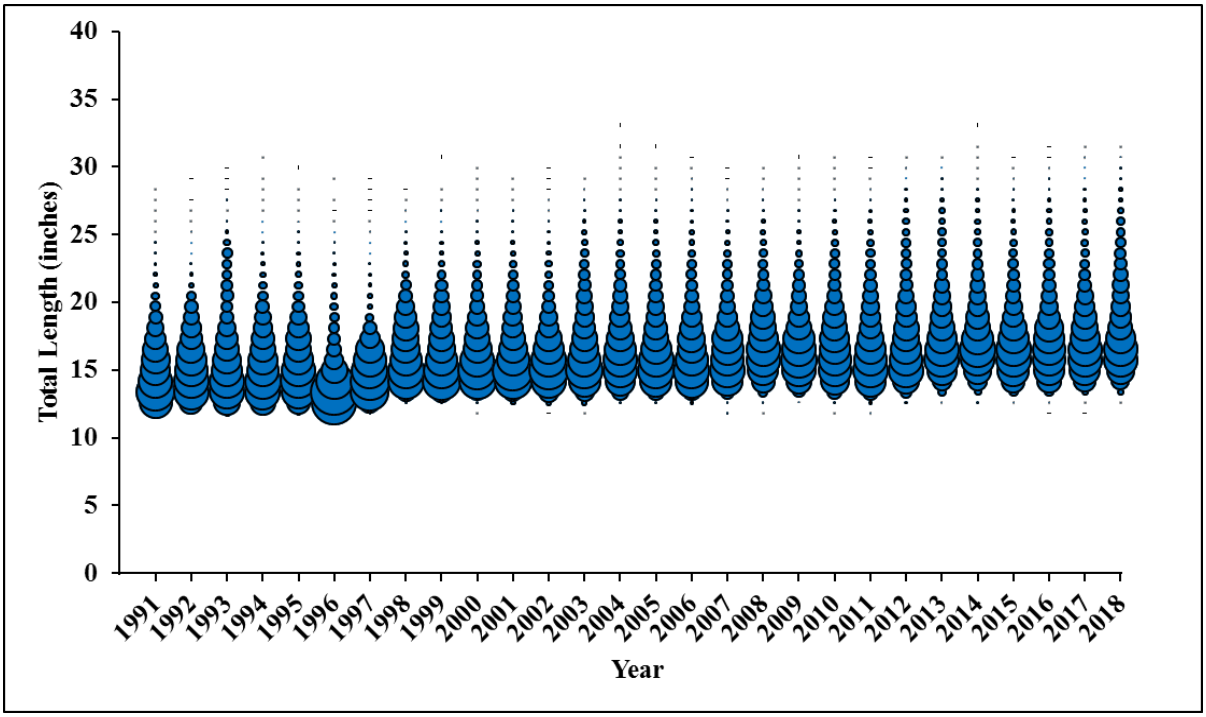

Figure 4. Commercial length frequency total length, inches) of summer flounder harvested from 1991 to 2018. Bubbles represent fish harvested at length and the size of the bubble is equal to the proportion of fish at that length.

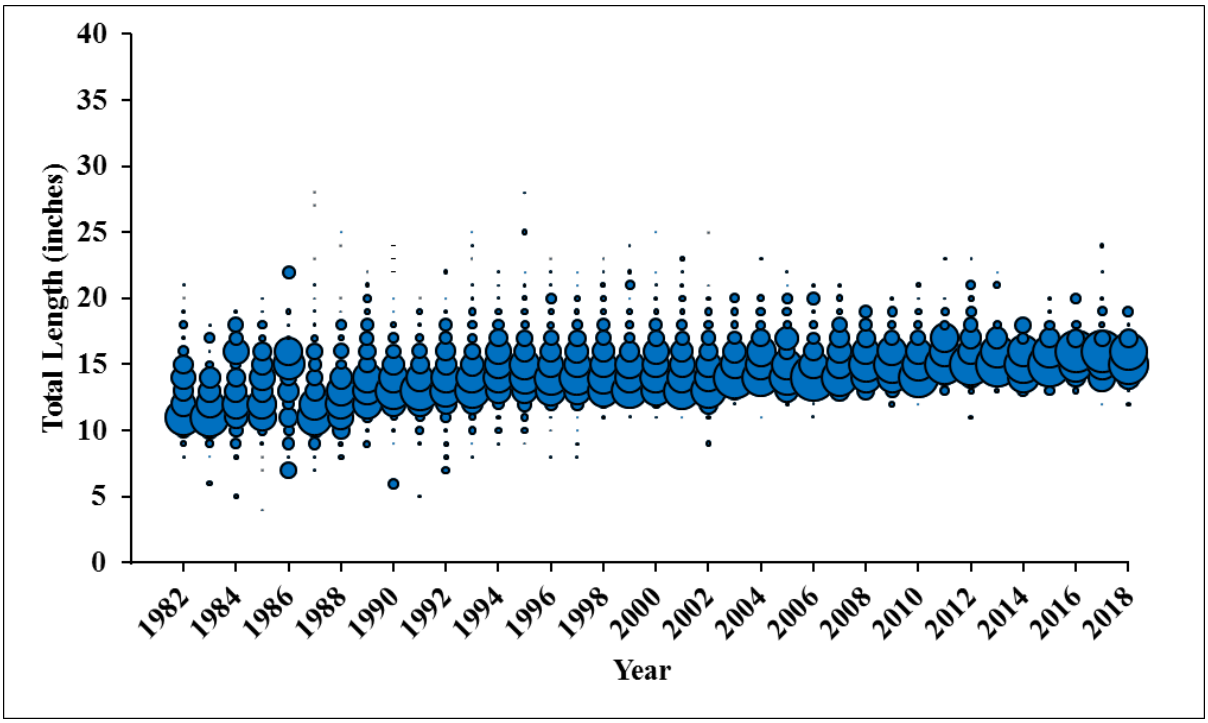

Figure 5. Recreational length frequency (total length, inches) of summer flounder harvested from 1982 to 2018. Bubbles represent fish harvested at length and the size of the bubble is equal to the proportion of fish at that length.

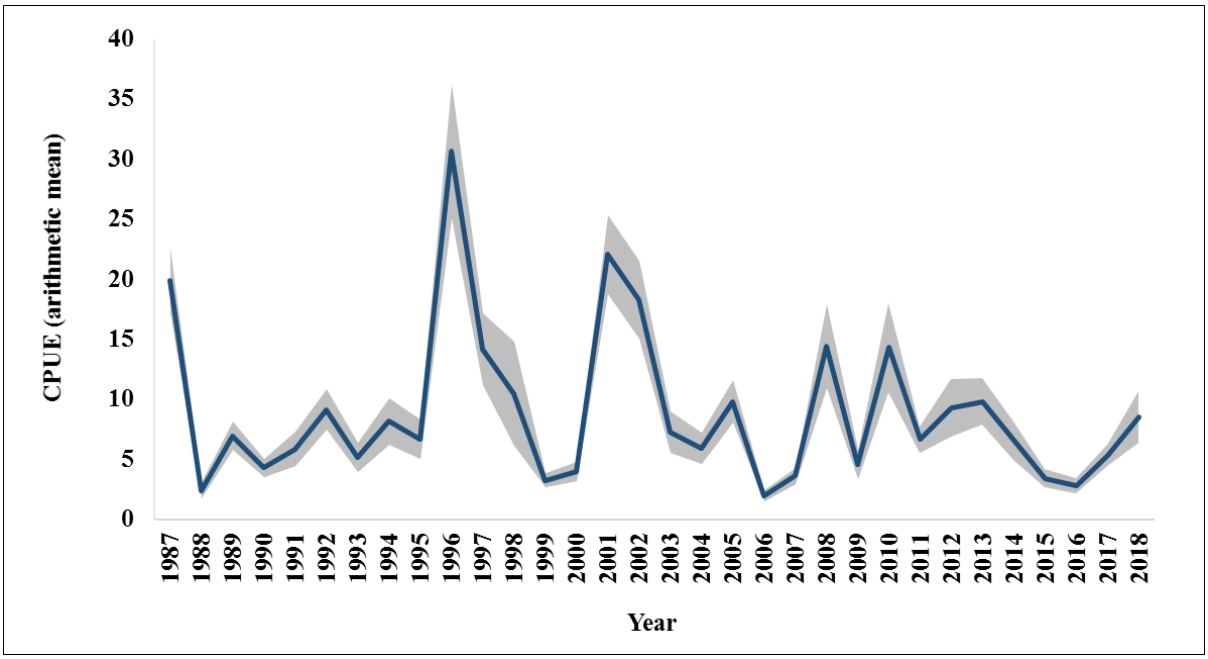

Figure 6. The annual summer flounder juvenile abundance index with standard error shaded in gray from the North Carolina Program 195 (Pamlico Sound Survey) Survey for the period of 1987-2018.

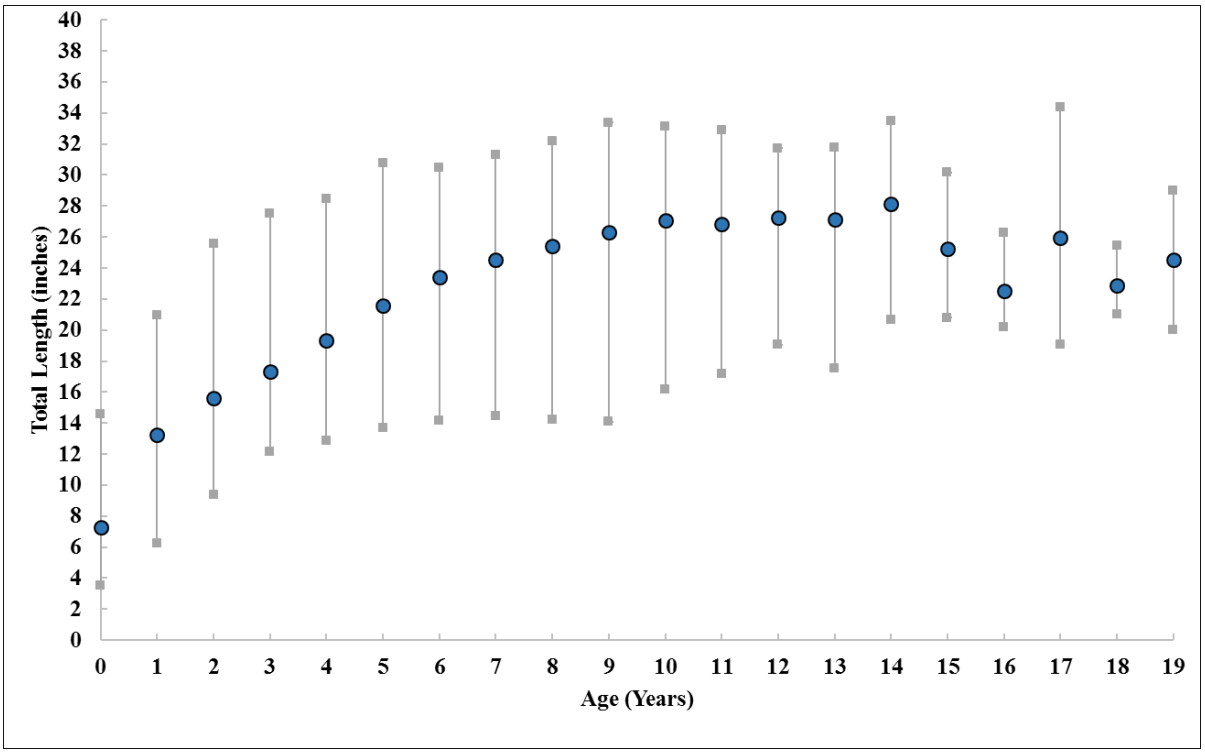

Figure 7. Summer flounder length at age based on age samples collected from 1991 to 2018. Blue circles represent the mean size at a given age while the grey squares represent the minimum and maximum observed size for each age.

FISHERY MANAGEMENT PLAN UPDATE
WEAKFISH
AUGUST 2019

STATUS OF THE FISHERY MANAGEMENT PLAN

Fishery Management Plan History

Original FMP Adoption:	ASMFC – October 1985
Amendments:	Amendment 1 – March 1992 Amendment 2 – October 1994 Amendment 3 – May 1996 Addendum I – October 2000 Amendment 4 – November 2002 Technical Addendum 1 – March 2003 Addendum I – December 2005 Addendum II – February 2007 Addendum III – May 2007 Addendum IV – November 2009
Revisions:	None
Supplements:	None
Information Updates:	None
Next Benchmark Review:	Stock assessment update started in 2019

Weakfish *(Cynoscion regalis)* are managed under Amendment 4 to the Interstate Fishery Management Plan (FMP) for Weakfish (Atlantic States Marine Fisheries Commission (ASMFC) 2002). The ASMFC adopted its first FMP for weakfish in 1985 (ASMFC 1985). Amendment 1 to the FMP (ASMFC 1992) unsuccessfully aimed to improve the status of weakfish. Amendment 2 (ASMFC 1994) resulted in some improvement to the stock, but several signs indicated that further improvement was necessary. Thus, Amendment 3 (ASMFC 1996) was implemented to increase the sustainability of the fishery. Addendum I to Amendment 3 was approved in 2000 in order to extend the existing management program until the Weakfish Management Board could approve Amendment 4.

Weakfish are currently managed under the management program contained in Amendment 4 (ASMFC 2002) and its subsequent addenda. The ASMFC adopted Addendum I to Amendment 4 (ASMFC 2005) to replace the biological sampling program. In response to a significant decline in stock abundance and increasing total mortality since 1999, the Board approved Addendum II to Amendment 4 (ASMFC 2007a) to reduce the recreational creel limit and commercial bycatch

limit, and set landings levels that, when met, will trigger the Board to re-evaluate management measures. Addendum III to Amendment 4 (ASMFC 2007b) altered the bycatch reduction device certification requirements of Amendment 4 for consistency with the South Atlantic Fishery Management Council's (SAFMC) Shrimp FMP.

The findings of the 2009 weakfish stock assessment indicated that weakfish are currently in a severely depleted state with natural mortality (M) rather than fishing mortality (F) believed to be the primary culprit in the decline (ASMFC 2016). In response to the continued decline in the weakfish population, the ASMFC Weakfish Management Board passed Addendum IV to Amendment 4 (2009). This Addendum required all states along the east coast to implement severe harvest restrictions on weakfish.

Harvest restrictions included a one fish daily recreational bag limit and a 100 pound daily commercial trip limit. North Carolina made a request that was approved by the Weakfish Management Board in August of 2010, to implement a 10% bycatch allowance for weakfish in lieu of the 100 pound daily trip limit. This request was considered to be conservationally equivalent to the 100 pound daily trip limit. The alternate management action allowed weakfish to be landed provided they make up less than 10% of the weight of all finfish landed up to 1,000 pounds per trip or day, whichever is larger. In November of 2012, based on the recommendation of the North Carolina Marine Fisheires Commission (NCMFC), the alternate management was halted and North Carolina reverted back to the 100 pound daily trip limit consistent with Addendum IV. The Weakfish Management Board, as part of Addendum IV, noted that reductions in harvest would not be adequate to rebuild the depleted weakfish stocks until other confounding factors (i.e. natural mortality) become more favorable for weakfish survival. The Board's actions were taken to reduce harvest and poise weakfish for a recovery.

A new benchmark stock assessment for weakfish was completed in 2016 (ASMFC 2016) and approved for management by the Weakfish Management Board at the 2016 Spring Meeting of the ASMFC. Results from the current assessment still indicate that weakfish are overfished and that continued high levels of natural mortality (M) are the cause of the decline. Fishing mortality (F) has decreased substantially since 2010 and overfishing on the stock is not occuring. The Board reviewed the results of the assessment at their May 2016 meeting and decided that no new management action was warranted. The management program implemented under Addendum IV remains in effect. An assessment update as of August 2019 is currently in process.

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 this species 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, SAFMC, 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 plans) and the Atlantic Coastal Fisheries Cooperative Management Act (ASMFC plans) are similar to the goals of the Fisheries Reform Act of 1997 to "ensure long-term viability" of these fisheries (NCDMF 2015).

Management Unit

Weakfish are managed under this plan as a single stock throughout their coastal range. All Atlantic coast states from Massachusetts through Florida and the Potomac River Fisheries Commission have a declared interest in weakfish. Responsibility for the FMP is assigned to the ASMFC Weakfish Management Board, Plan Review Team, Technical Committee, Stock Assessment Sub-Committee, and Advisory Panel.

Goal and Objectives

The goal of Amendment 4 of the ASMFC FMP is to utilize interstate management so that Atlantic coastal weakfish recover to healthy levels that will maintain commercial and recreational harvest consistent with a self-sustaining spawning stock and to provide for restoration and maintenance of essential habitat (ASMFC 2002). The management objectives are to:

1. Establish and maintain an overfishing definition that includes target and threshold fishing mortality rates and a threshold spawning stock biomass to prevent overfishing and maintain a sustainable weakfish population;
2. Restore the weakfish age and size structure to that necessary for the restoration of the fishery;
3. Return weakfish to their previous geographic range;
4. Achieve compatible and equitable management measures among jurisdictions throughout the fishery management unit, including states' waters and the federal EEZ;
5. Promote cooperative interstate research, monitoring and law enforcement necessary to support management of weakfish;
6. Promote identification and conservation of habitat essential for the long term stability in the population of weakfish; and
7. Establish standards and procedures for both the implementation of Amendment 4 and for determination of states' compliance with provisions of the management plan.

STATUS OF THE STOCK

Life History

Weakfish, also called gray trout, are known to inhabit waters of the Atlantic from southern Florida to Nova Scotia, Canada but are most prevalent from North Carolina to New York (Wilk 1979). They are members of the drum family and are closely related to spotted seatrout. Compared to spotted seatrout, weakfish occur in higher salinity areas of the estuary and are seasonally encountered around coastal inlets and in offshore waters. Weakfish migrate into more inshore environments and north along the U.S. Atlantic Coast in the spring and summer as water temperatures rise (Bigelow and Schroeder 1953; Wilk 1979). Spawning occurs during this time in higher salinity environments around the coastal inlets (Luczkovich et al. 1999; Luczkovich et al. 2008). Males drum to attract females and spawning activity usually occurs around dusk. Juvenile weakfish use the estuarine waters as a nursery area until the fall when water temperatures drop and they move into the offshore environment (Wilk 1979). Peak spawning in North Carolina is typically around April or May but females will spawn multiple times (batch spawners) throughout the spring and summer months (Lowerre-Barbieri et al. 1996; Merriner 1976). Most weakfish are sexually mature by age 1 and at 11 to 12 inches in length (Lowerre-Barbieri et al. 1996; Nye et al. 2008). Juvenile weakfish are opportunistic feeders, feeding on invertebrates and microscopic animals early in their life, then switching to mostly piscivorous feeding on small to moderately sized fish, depending on their size (Merriner 1975).

Stock Status

According to the last stock assessment, completed in 2016, the weakfish stock is depleted and overfishing is not occurring (ASMFC 2016). The stock is considered depleted and has been for the last 13 years. Current SSB levels are well below the recommended minimum threshold (Figure 1).

Stock Assessment

The assessment completed in 2016 employed a new spatially structured forward projecting statistical catch at age model with time-varying natural mortality. This model accounts for varying population spatial distribution and changing natural mortality through time. Results of the assessment show that the weakfish stock is depleted and has been for the past 13 years. Under conditions of time-varying natural mortality, there is no long-term stable equilibrium population size, so an SSB target is not informative for management. After review of the assessment results, the Weakfish Technical Committee (TC) recommended an SSB threshold of 15.2 million pounds that is equivalent to 30% of the projected SSB under average natural mortality and no fishing (SSB30%). When SSB is below that threshold, the stock is considered depleted. In 2014, SSB was 5.62 million pounds (Figure 1). The model indicated natural mortality has been increasing since the mid-1990s, from approximately 0.16 at the beginning of the time-series to an average of 0.93 from 2007-2014 (Figure 2). Even though fishing mortality has been at low levels in recent years, the weakfish population has been experiencing very high levels of total mortality which has prevented the stock from recovering. The preferred model does indicate some positive signs in the weakfish stock in the most recent years, with a slight increase in SSB and total abundance; however, the stock is still well below the SSB threshold.

STATUS OF THE FISHERY

Current Regulations

The NCDMF allows for the recreational harvest of weakfish year-round with a 12-inch total length minimum size and a one fish per day bag limit. The commercial harvest of weakfish is limited to a 100 pounds daily limit and 12-inches total length with the following exceptions: from April 1 through November 15, weakfish 10 inches total length or more may lawfully be taken in North Carolina internal waters by use of long haul seines or pound nets only and commercial flounder trawl and flynet operations are allowed to land a tolerance of no more than 100 undersized (less than 12 inch total length) weakfish per day or trip, whichever is longer and it is unlawful to sell undersized weakfish.

Commercial Landings

Commercial landings of weakfish peaked in 1988 at 15,091,878 pounds. Landings have since steadily dropped, and in 2009 Addendum IV reduced commercial harvest to 100 pounds per trip achieving an estimated reduction of 61% from the 2005-2008 harvest levels. Recent years have shown little increase due to low abundance and commercial harvest restrictions. Landings reached a time-series low in 2018 (35,133 pounds; Table 1; Figure 3).

Recreational Landings

Recreational landings of weakfish are estimated from the Marine Recreational Information Program (MRIP). Recreational estimates across all years have been updated and are now based on the Marine Recreational Information Program (MRIP) new Fishing Effort Survey-based calibrated estimates. For more information on MRIP see https://www.fisheries.noaa.gov/topic/recreational-fishing-data.

Estimated recreational harvest has been variable since 1982 with a peak in 1987 at 3,442,746 pounds. Harvest since 2009 have decreased considerably due to the implementation of a one-fish bag limit in November 2009 as part of the harvest reductions from Addendum IV, which was estimated to reduce recreational harvest by 53% for North Carolina. Average harvest since 2010 is 80,772 pounds and has varied from a high of 157,269 pounds in 2015 to a low of 55,944 in 2011. Recreational harvest further dropped in 2018 to 29,924 pounds, a time-series low (Table 1; Figure 3). Similarily, the number of fish landed and released also decreased in 2018 (Table 1).

The North Carolina Saltwater Fishing Tournament recognizes anglers for landing and/or releasing fish of exceptional size or rarity by issuing citations that document the capture for the angler. A total of three citations (greater than 5 pounds landed) and no release citations (greater than 24 inches total length) were issued for weakfish in 2018 (Table 2; Figure 4).

MONITORING PROGRAM DATA

Fishery-Dependent Monitoring

Commercial fish houses are sampled monthly to provide length, weight, and age data to describe the commercial fisheries. The number of weakfish samples has been declining since 2000, following a similar trend to the commercial landings (Tables 1 and 3). Samples are collected from the ocean fisheries as well as the estuarine fisheries. The ocean sink net fishery and estuarine gill net fishery dominate the catches of weakfish accounting for 95% of the overall commercial catch in 2018.

The modal length for the commercial fishery in 2018 was slightly smaller (12 inches) than the recreational fishery (13 inches; Figure 5). Average and minimum lengths of fish harvested in the commercial fishery have remained relatively consistent throughout the time series (Table 3; Figure 6). Since 2012 the average length has been approximately 14 inches. However, since 2010, there has been a noticeable decline in maximum lengths, from an average of 32 inches (1982-2010) to an average of 26 inches (2011-2018).

The ocean fishery typically targets spot, Atlantic croaker, and kingfish using smaller mesh than the estuarine fishery and selects for a smaller fish. In the past 10 years, the difference in selectivity between the two fisheries is notable in the average maximum sizes of fish landed from ocean (19.9 inches) and estuarine (23.8 inches) catches.

Recreational lengths and weights are collected as part of the MRIP by recreational port agents. While the mean lengths of weakfish sampled from the recreational fishery are similar to those sampled from the commercial fishery, maximum observed lengths are smaller in the recreational fishery (Table 3; Figure 7).

Fishery-Independent Monitoring

Fishery independent data are collected through both the Program 195 Pamlico Sound Survey and Program 915 Independent Gill Net Survey. The Program 195 survey provides an age-0 catch per unit effort (CPUE) index calculated from the September stations and an age-1+ CPUE index calculated from the June stations. Although the ASMFC stock assessment only uses the age-0 index, both are provided here to assess overall trends in both groups. The Program 195 indices show a variable trend over the years (Figures 8 and 9). The age-0 and age-1+ indices from Program 195 in 2018 both had the fourth lowest average number of weakfish per tow in the time series.

Program 915 collects size, age, and abundance data for commercially and recreationally important species in the Pamlico Sound, Pamlico, Pungo, and Neuse rivers, and the Cape Fear and New rivers using multi-mesh gill nets. The CPUE index from the Pamlico Sound portion is used in the ASMFC stock assessment and has shown a declining trend since 2006 (Figure 10). The data from the Pamlico, Pungo, and Neuse rivers and the Cape Fear and New rivers are not used in the assessment as these regions have minimal catches of weakfish.

Weakfish age samples (otoliths) are collected through both dependent and independent sampling. Sampling for weakfish has been ongoing since 1995. Age samples are collected from all possible gears and during all months. Target sample numbers are set monthly and the number of samples collected yearly has ranged from 170 to 1,319, for a total of 13,527 otoliths aged to date.

Ages have ranged from 0 to 15 years with an average modal age of two years (Table 4; Figure 11). Based on average age-at-lengths, weakfish growth does not plateau until age-10 (Figure 11).

MANAGEMENT STRATEGY

Weakfish are currently managed under Addendum IV to Amendment 4 of the Weakfish FMP and requires all the Atlantic States to implement a one fish per person bag limit, a 100 pound commercial bycatch trip limit, and a 100 fish undersized trip limit allowance for the trawl fishery. Based off of results from the 2016 assessment, the Weakfish TC recommended that a 30% SSB threshold be used as a reference point to determine if the stock is depleted. The TC also noted that there is no long-term stable equilibrium population of weakfish due to time varying natural mortality, so they recommended managing the stock based off Z-based (total mortality) targets and thresholds of 20% and 30%. Because the total mortality of the stock in the terminal year of the assessment (2014) was below the Z threshold, the TC recommended and the board approved no new management measures at this time.

RESEARCH NEEDS

Biological

High

- Collect catch and effort data including size and age composition of the catch, determine stock mortality throughout the range, and define gear characteristics. In particular, increase length-frequency sampling in fisheries from Maryland north.
- Derive estimates of discard mortality rates and the magnitude of discards for all commercial gear types from both directed and non-directed fisheries. In particular, quantify trawl bycatch, refine estimates of mortality for below minimum size fish, and focus on factors such as distance from shore and geographical differences.
- Conduct an age validation study.
- Identify stocks and determine coastal movements and the extent of stock mixing, including characterization of stocks in over-wintering grounds (e.g., tagging).
- Conduct spatial and temporal analysis of the fishery independent survey data. The analysis should assess the impact of the variability of the surveys in regards to gear, time of year, and geographic coverage on their (survey) use as stock indicators.
- Analyze the spawner recruit relationship and examine the relationships between parental stock size and environmental factors on year-class strength.

Medium

- Biological studies should be conducted to better understand migratory aspects and how this relates to observed trends in weight at age. Test for individual growth difference and the geospatial pattern, as well as the geospatial pattern of the catch rate surveys.
- Define reproductive biology of weakfish, including size at sexual maturity, maturity schedules, fecundity, and spawning periodicity. Continue research on female spawning patterns: what is the seasonal and geographical extent of "batch" spawning; do females exhibit spawning site fidelity?
- Continue studies on mesh-size selectivity, particularly for trawl fisheries.

- Continue studies on recreational hook-and-release mortality rates, including factors such as depth, warmer water temperatures, and fish size in the analysis. Studies are needed in deep and warm water conditions. Further consideration of release mortality in both the recreational and commercial fisheries is needed, and methods investigated to improve survival among released fish.

Low
- Develop a coastwide tagging database.

Social and Economic
- Assemble socio-demographic-economic data as it becomes available from ACCSP.
- Detailed information on production activities (e.g., fishing effort and labor used by gear, vessel characteristics, areas fished, etc.) and costs and earnings for the harvesting and processing sectors.
- Information on retail sales and demand for weakfish in order to estimate the demand and economic benefits of at-home and away-from home consumption of weakfish.
- Development of bio-economic models that link the underlying population dynamics to the economic aspects of the commercial and recreational fisheries.
- Distribution of weakfish to the various markets and across states.
- Information on the margins of various stages of processing and marketing also need to be obtained; this information is necessary to construct mathematical models that can be used to estimate the economic impacts of management and regulation.
- A directed data collection program for weakfish including the same variables presently collected by National Oceanic and Atmospheric Administration Fisheries in support of MRFSS and by the economic add-on. Data collected includes information on travel distance, mode of angling, expenditures, area fished, catch on previous trips, and other information.
- Development of commercial decision-making or behavioral models to explain how fishers might respond to various regulations.
- Estimation and assessment of consumer (net economic benefits to consumers) and producer (net economic benefits or profits to producers) surplus; the sum of consumer and producer surplus is a measure of the net economic value to society of a good or service.
- Development of input/output models for all states having commercial weakfish activity, or alternatively, full-blown economic impact models, which might consist of input/output models or General Equilibrium models.
- Determination of the economic value derived from recreational angling including the economic value of a catch and release fishery

Habitat
- Conduct hydrophonic studies to delineate weakfish spawning habitat locations and environmental preferences (temperature, depth, substrate, etc.) and enable quantification of spawning habitat.
- Compile existing data on larval and juvenile distribution from existing databases in order to obtain preliminary indications of spawning and nursery habitat location and extent.

- Document the impact of power plants and other water intakes on larval, post larval and juvenile weakfish mortality in spawning and nursery areas, and calculate the resulting impacts on adult stock size.
- Define restrictions necessary for implementation of projects in spawning and over-wintering areas and develop policies on limiting development projects seasonally or spatially.

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TABLES

Table 1. Recreational harvest (number of fish released and weight in pounds) and releases (number of fish) and commercial harvest (weight in pounds) of weakfish from North Carolina, 1982-2018.

	Recreational				
	Numbers		Weight (lb)		
Year	Landed	# Released	Landed	Commercial Weight (lb)	Total Weight (lb)
1982	255,080	61,048	348,645	12,052,232	12,400,877
1983	596,354	16,387	749,910	10,233,734	10,983,644
1984	555,640	35,101	252,873	12,990,726	13,243,599
1985	1,010,772	2,638	796,974	9,797,734	10,594,708
1986	2,049,746	694,759	1,455,912	14,309,372	15,765,284
1987	2,403,361	250,581	3,442,746	11,508,389	14,951,135
1988	650,224	175,284	175,178	15,091,878	15,267,056
1989	456,191	65,500	331,840	10,115,747	10,447,587
1990	149,508	30,295	104,761	5,802,159	5,906,920
1991	358,273	32,083	286,349	5,308,574	5,594,923
1992	72,064	69,585	53,214	4,862,551	4,915,765
1993	293,966	157,478	230,010	4,017,265	4,247,275
1994	336,188	477,521	276,435	3,489,929	3,766,364
1995	103,190	225,976	118,177	4,113,260	4,231,437
1996	138,577	361,153	121,291	3,977,633	4,098,924
1997	333,852	506,509	313,767	3,561,060	3,874,827
1998	450,645	669,125	487,884	3,354,008	3,841,892
1999	313,427	687,884	420,706	2,617,580	3,038,286
2000	147,397	852,262	179,599	1,869,042	2,048,641
2001	317,974	2,831,044	325,447	1,960,324	2,285,771
2002	214,040	917,803	215,402	1,828,150	2,043,552
2003	291,168	422,294	309,412	848,822	1,158,234
2004	395,268	614,762	428,627	685,463	1,114,090
2005	297,605	702,685	281,710	421,984	703,694
2006	343,092	1,047,135	302,775	363,086	665,861
2007	191,192	600,987	202,583	175,593	378,176
2008	203,779	470,805	209,470	162,516	371,986
2009	204,814	626,742	245,358	163,148	408,506
2010	110,770	914,004	103,903	106,328	210,231
2011	48,727	380,366	62,543	65,998	128,541
2012	96,947	396,620	95,952	91,384	187,336
2013	63,090	257,367	66,720	120,191	186,911
2014	71,912	1,067,344	70,988	105,247	176,235
2015	143,543	1,652,582	157,269	80,242	237,511
2016	77,341	1,097,615	83,702	79,667	163,369
2017	51,795	351,613	55,944	85,442	141,386
2018	30,935	300,195	29,924	35,133	65,057
Average	210,242	626,244	371,224	2,015,584	2,221,310

Table 2. Total number of awarded citations for weakfish (>24-inches total length for release or > 5 pounds landed) from the North Carolina Saltwater Fishing Tournament from 2008-2018.

Year	Total Citations	Release Citations[+]	% Release
1991	1		0
1992	2		0
1993	10		0
1994	2		0
1995	3		0
1996	2		0
1997	0		0
1998	6		0
1999	6		0
2000	8		0
2001	8		0
2002	0		0
2003	124		0
2004	9		0
2005	3		0
2006	1		0
2007	2		0
2008	4	0	0
2009	3	0	0
2010	1	0	0
2011	1	0	0
2012	2	1	50
2013	4	0	0
2014	3	0	0
2015	2	0	0
2016	7	0	0
2017	16	16	100
2018	3	0	0

[+] Weakfish release citations (fish released greater than 24 inches total length) began in 2008

Table 3. Mean, minimum, and maximum lengths (fork length, inches) of weakfish sampled from the commercial and recreational fisheries of North Carolina from 1982-2018. Commercial lengths include both marketable and scrap finfish.

	Commercial				Recreational			
Year	Mean Length	Minimum Length	Maximum Length	Total Number Measured	Mean Length	Minimum Length	Maximum Length	Total Number Measured
1982	13.8	4.4	34.1	4,485	13.9	7.8	22.8	55
1983	13.8	4.6	33.7	10,357	13.9	7.7	25.6	29
1984	14.2	5.1	36.6	14,952	10.9	4.7	18.9	90
1985	12.9	4.7	34.4	15,310	12.0	7.7	22.4	34
1986	13.9	5.4	34.9	17,446	13.0	8.7	20.1	164
1987	12.9	4.4	34.2	22,943	15.1	7.9	22.4	253
1988	13.8	5.3	33.7	18,116	12.7	8.3	20.5	208
1989	14.8	4.8	35.2	14,853	12.0	7.5	23.2	182
1990	12.2	4.1	35.4	18,613	12.2	7.1	21.7	181
1991	11.1	4.2	26.1	24,772	12.0	7.3	18.6	136
1992	12.1	5.2	29.8	21,050	12.3	7.6	17.2	64
1993	11.9	4.0	29.2	23,679	12.6	8.6	16.0	196
1994	13.2	4.6	28.0	15,011	13.2	6.2	20.8	573
1995	12.7	4.4	29.5	18,526	15.2	10.0	20.2	231
1996	13.1	4.6	28.1	18,906	14.0	9.9	19.2	336
1997	13.1	4.1	29.7	20,583	13.7	8.3	20.7	602
1998	13.5	6.5	27.4	13,963	14.3	9.9	27.0	518
1999	13.2	5.1	29.1	16,490	15.4	10.6	26.0	258
2000	13.2	4.1	29.8	19,382	14.8	9.8	22.4	122
2001	14.0	6.5	31.5	15,182	14.1	10.6	19.9	180
2002	13.7	6.1	31.5	13,531	13.9	9.4	19.1	106
2003	12.7	4.2	33.3	9,721	14.1	8.6	27.5	131
2004	13.2	5.8	33.5	10,500	14.4	11.1	25.5	164
2005	13.2	5.6	34.4	9,893	14.0	11.7	19.8	104
2006	12.7	5.6	32.5	11,649	13.6	9.8	20.1	240
2007	12.3	4.8	26.1	6,817	14.2	10.5	20.7	76
2008	12.3	5.0	26.3	3,851	13.8	11.7	20.4	145
2009	12.8	6.3	33.7	3,318	14.8	9.7	21.9	132
2010	12.3	5.1	34.6	2,568	13.6	9.3	17.3	96
2011	12.7	7.8	25.1	2,044	14.6	11.6	30.7	41
2012	13.5	5.0	23.3	2,754	13.8	10.2	20.8	81
2013	14.0	8.0	28.3	3,466	14.2	7.6	22.8	74
2014	14.0	5.0	24.4	3,348	13.8	10.9	20.3	72
2015	14.0	5.4	27.7	2,212	14.0	12.2	19.0	34
2016	14.1	8.7	23.6	2,743	14.0	10.3	18.0	76
2017	14.3	8.5	28.2	1,240	14.2	8.7	17.0	51
2018	13.7	7.0	26.9	770	13.4	8.6	18.5	34

Table 4. Modal age, minimum age, maximum age, and number aged for weakfish collected through NCDMF sampling programs from 1995 through 2018.

Year	Modal Age	Minimum Age	Maximum Age	Total Number Aged
1995	1	0	5	494
1996	4	0	6	1,319
1997	3	0	7	1,027
1998	3	0	7	690
1999	3	0	8	648
2000	1	0	9	616
2001	2	0	10	630
2002	3	0	10	512
2003	4	0	8	491
2004	2	0	11	589
2005	2	0	12	561
2006	3	0	7	737
2007	2	0	6	560
2008	1	0	5	480
2009	1	0	15	263
2010	2	0	5	507
2011	2	0	4	376
2012	3	0	4	496
2013	2	0	5	515
2014	1	0	4	508
2015	3	0	4	425
2016	1	0	5	561
2017	1	0	5	353
2018	2	0	4	170

FIGURES

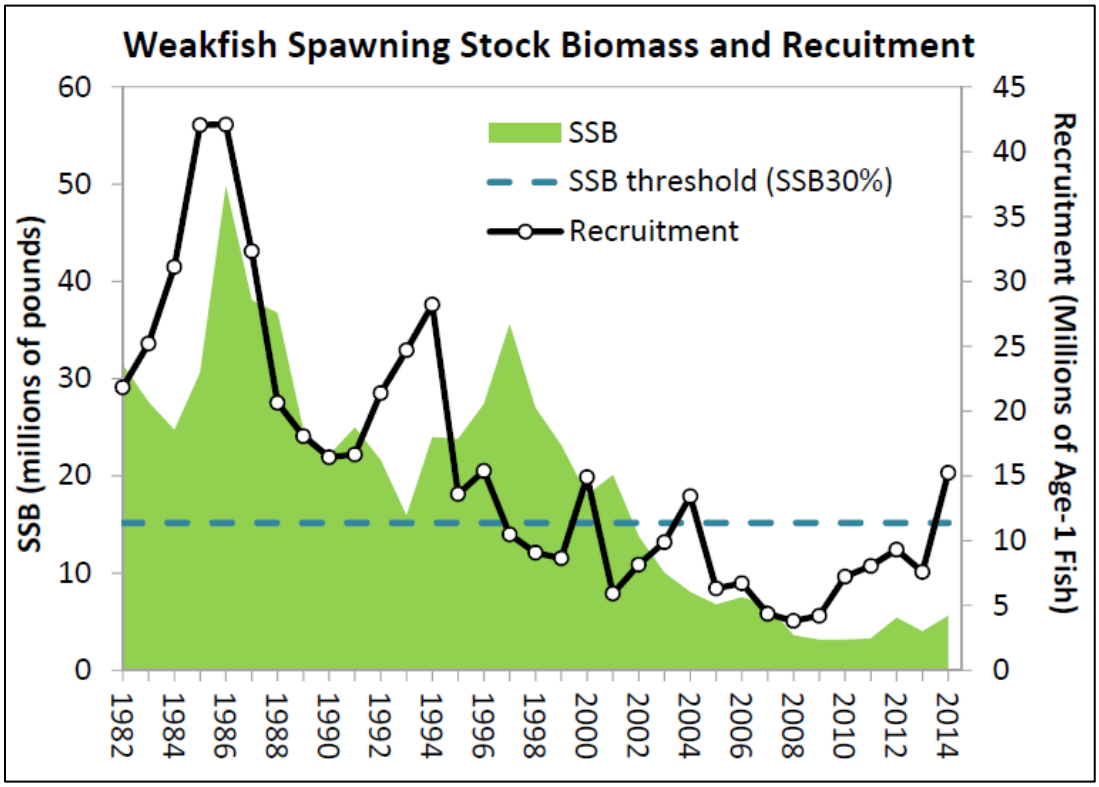

Figure 1. Spawning stock biomass (SSB) and recruitment of age-1 weakfish estimated along the U.S. Atlantic coast from 1982 to 2014 (ASMFC 2016). Dashed line represents the 30% spawning stock biomass (SSB) threshold of 15.17 million pounds.

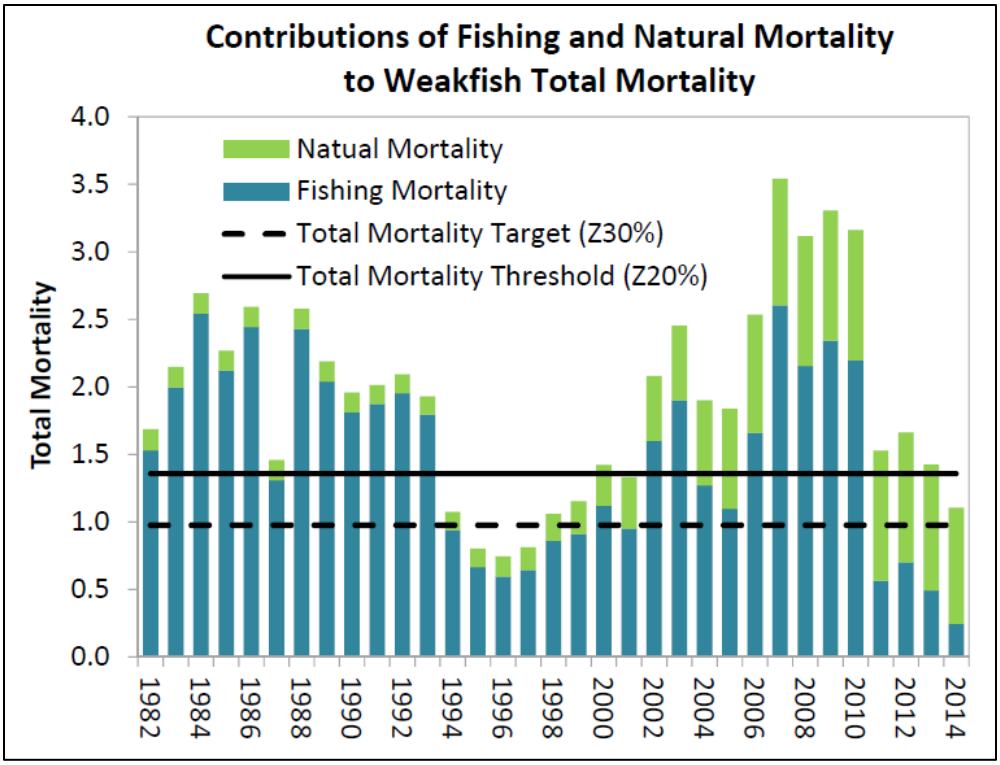

Figure 2. Natural mortality (M) and fishing mortality (F) estimated for all weakfish along the U.S. Atlantic east coast, 1982 to 2014 (ASMFC 2016). Solid and dashed lines represent total mortality targets (Z30% = 0.93) and thresholds (Z20% = 1.36) used to determine if the stock is being overfished.

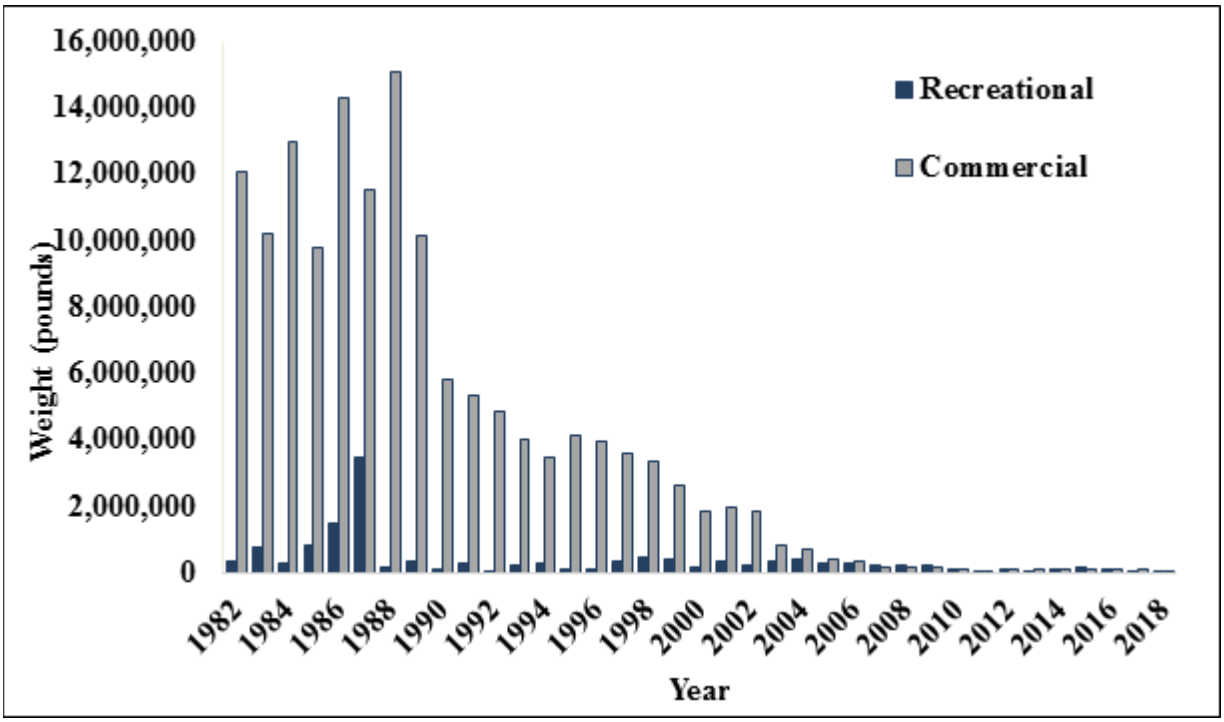

Figure 3. Annual commercial and recreational landings in pounds for weakfish in North Carolina from 1982 to 2018.

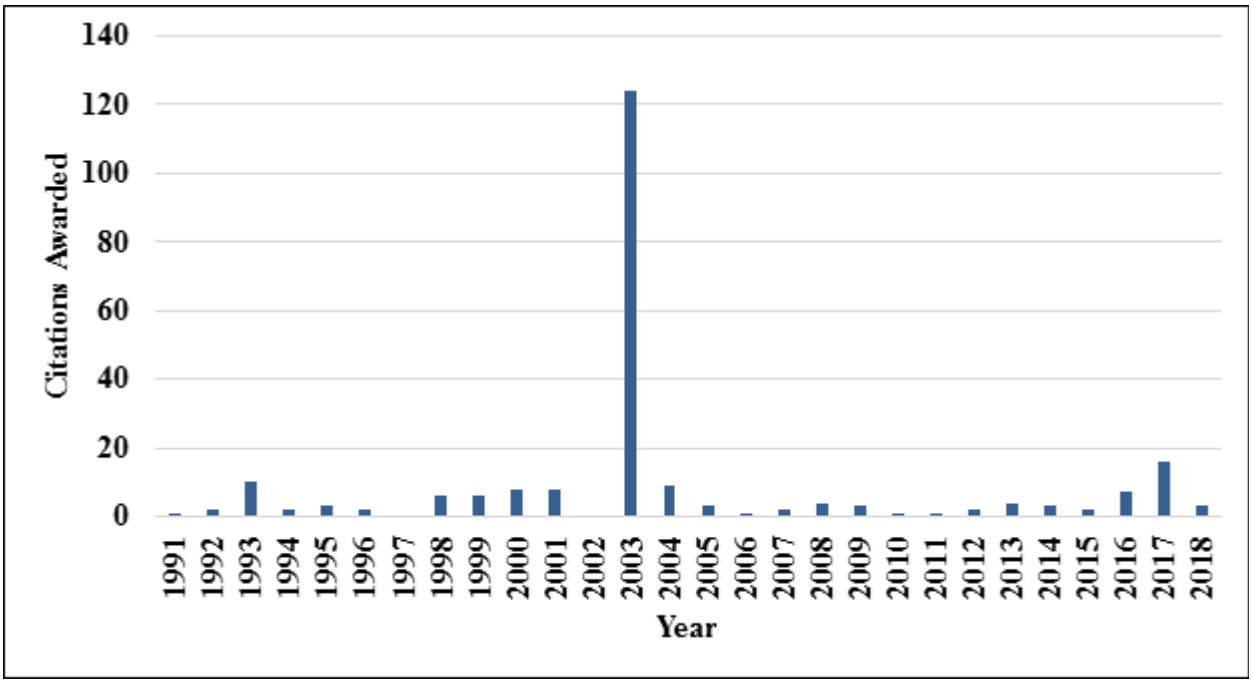

Figure 4. North Carolina Saltwater Fishing Tournament citations awarded for weakfish from 1991 to 2018. Citations are awarded for weakfish greater than 24 inches total length released or greater than 5 pounds landed.

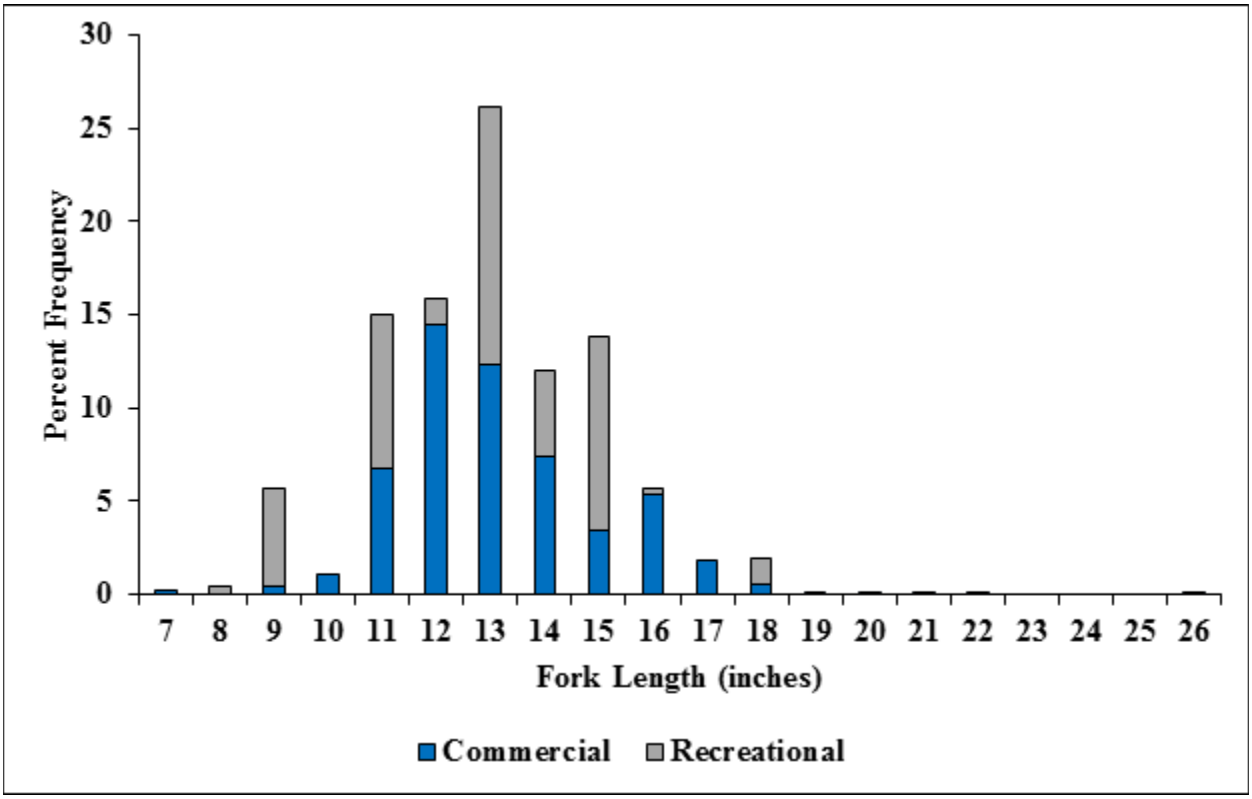

Figure 5. Commercial and recreational length frequency distribution from weakfish harvested in 2018.

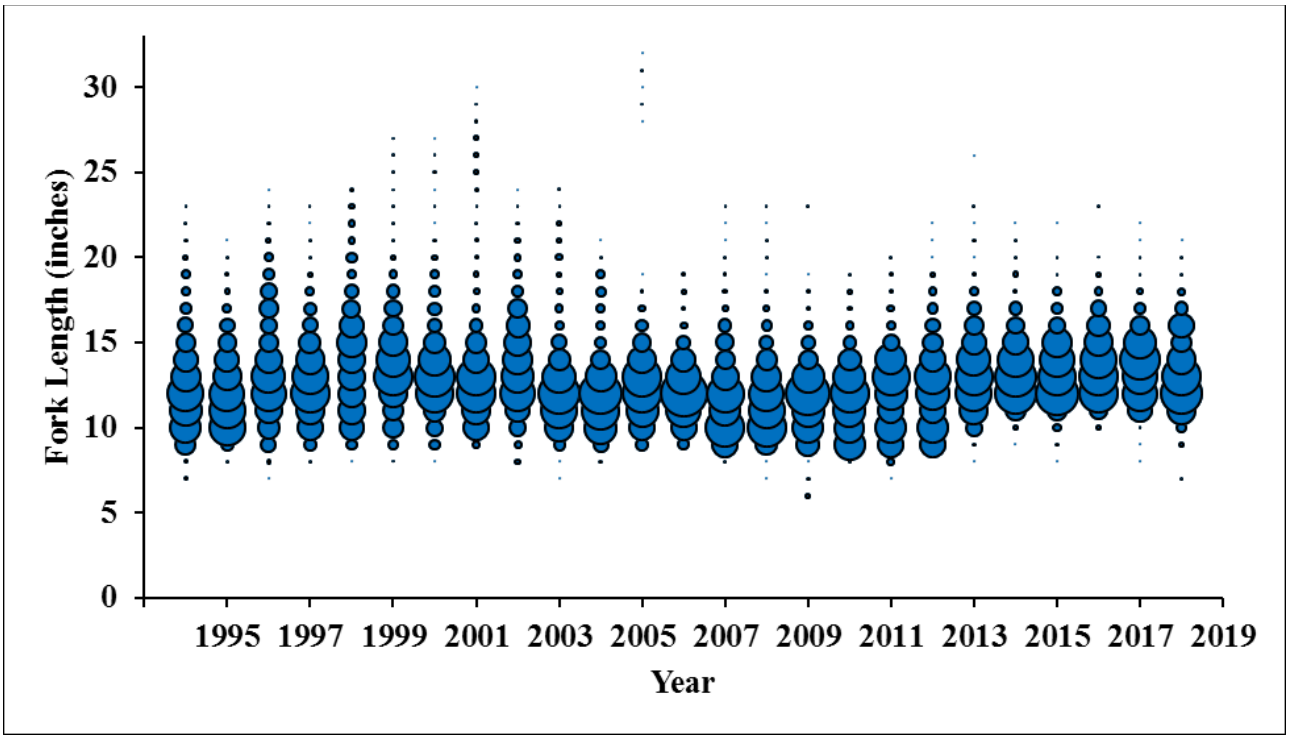

Figure 6. Commercial length frequency (fork length, inches) of weakfish harvested from 1994-2018. Bubbles represent fish harvested at length and the size of the bubble is equal to the proportion of fish at that length.

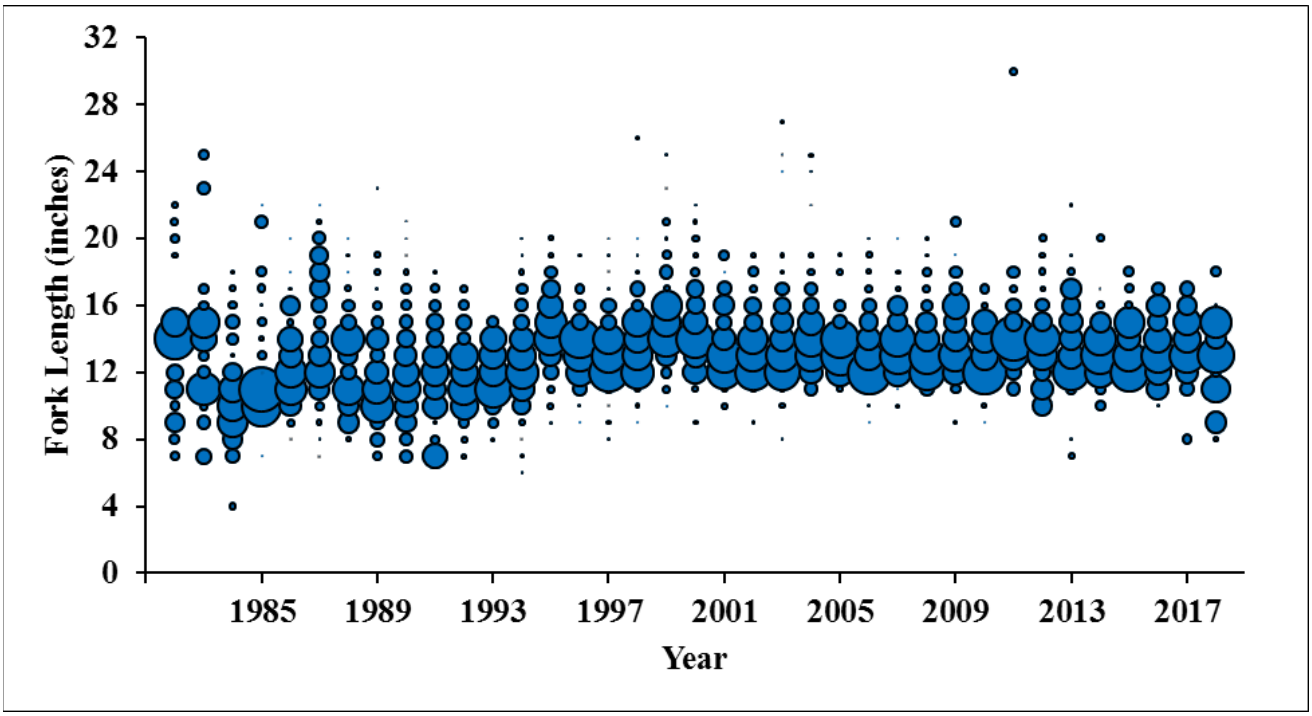

Figure 7. Recreational length frequency (fork length, inches) of weakfish harvested from 1982-2018. Bubbles represent fish harvested at length and the size of the bubble is equal to the proportion of fish at that length.

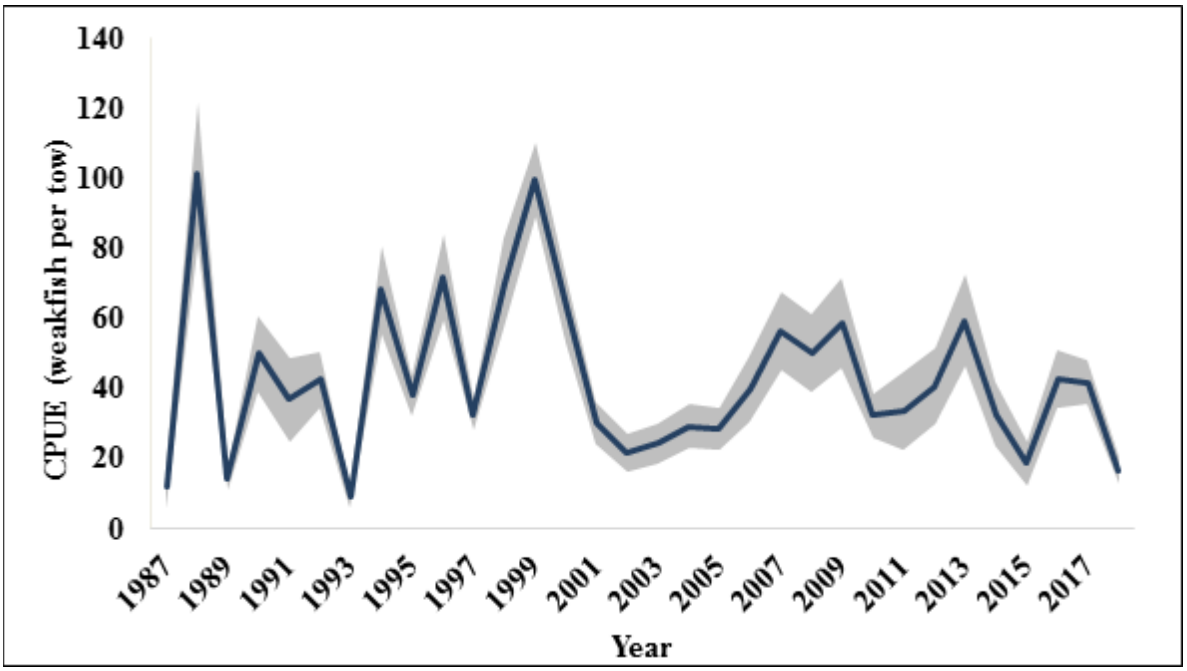

Figure 8. Catch Per Unit Effort (fish per tow) from the Pamlico Sound Survey (Program 195) in North Carolina of Age-0 weakfish collected during September with a total length less than 200 mm from 1987 through 2018. Error bars represent ± one standard error (SE).

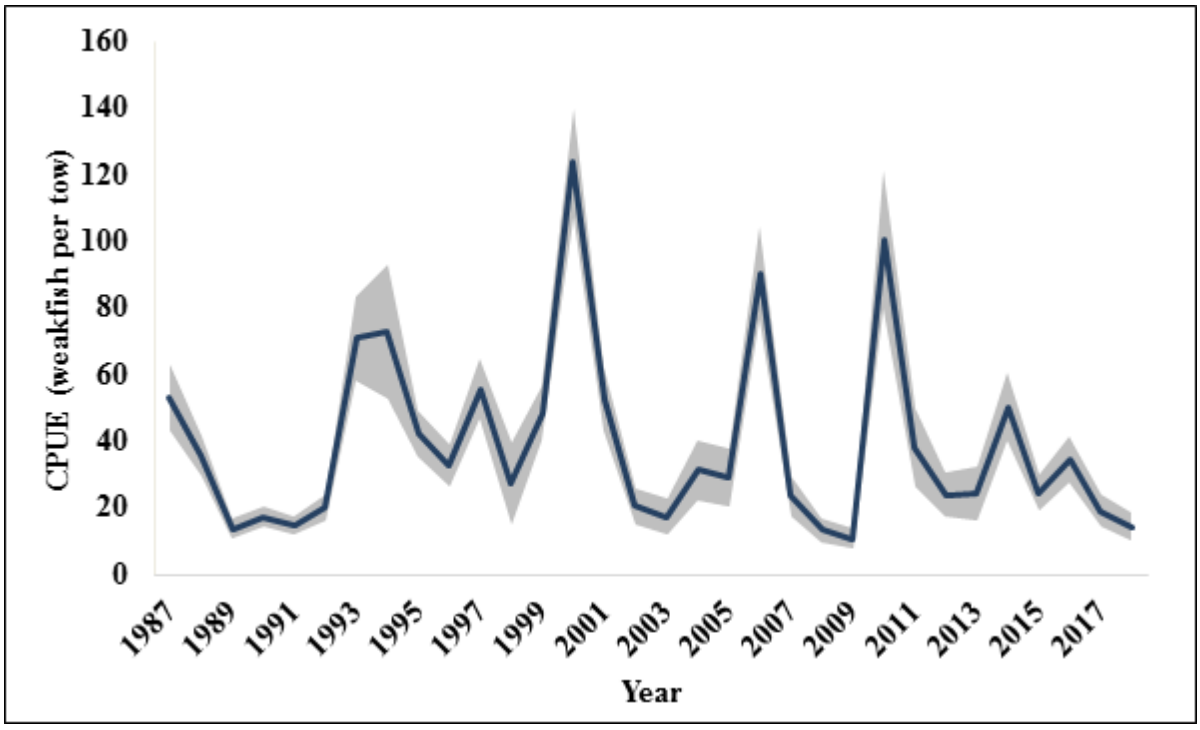

Figure 9. Catch Per Unit Effort (fish per tow) from the Pamlico Sound Survey (Program 195) in North Carolina of Age-1+ weakfish collected during June with a total length greater than 140 mm from 1987 through 2018. Error bars represent ± one standard error (SE).

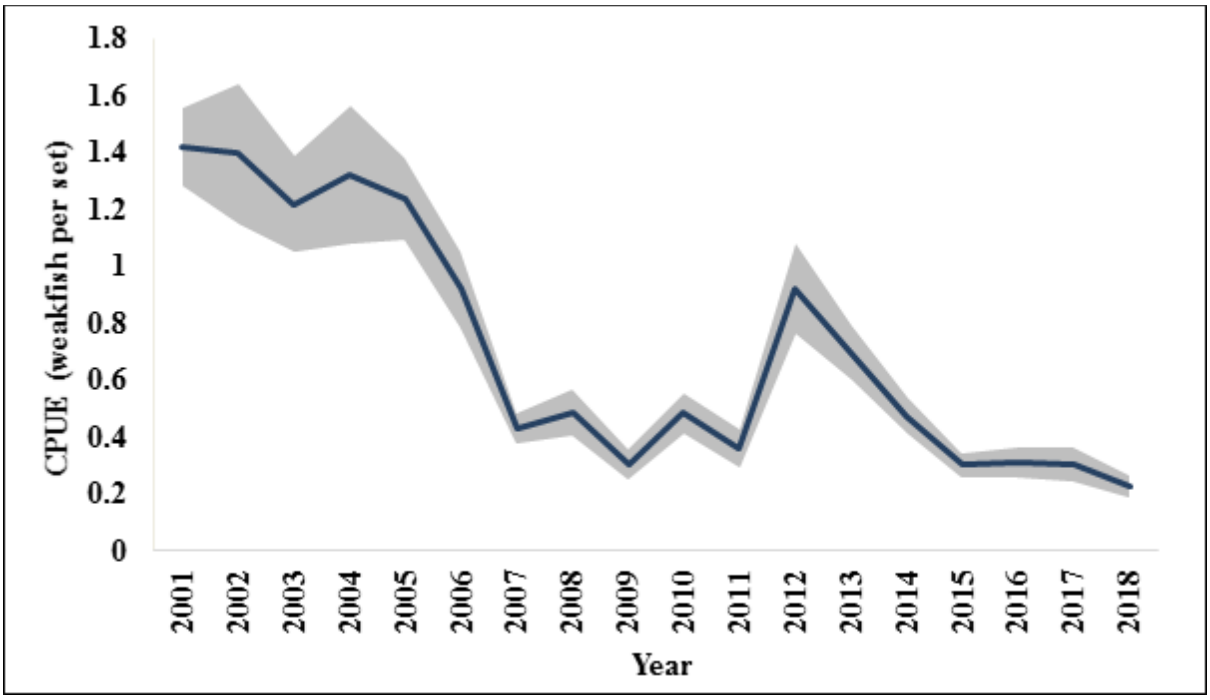

Figure 10. Catch Per Unit Effort (fish per station set) from the Pamlico Sound portion of the Independent Gill Net Survey (Program 915) in North Carolina, 2001 - 2018. Error bars represent ± one standard error (SE).

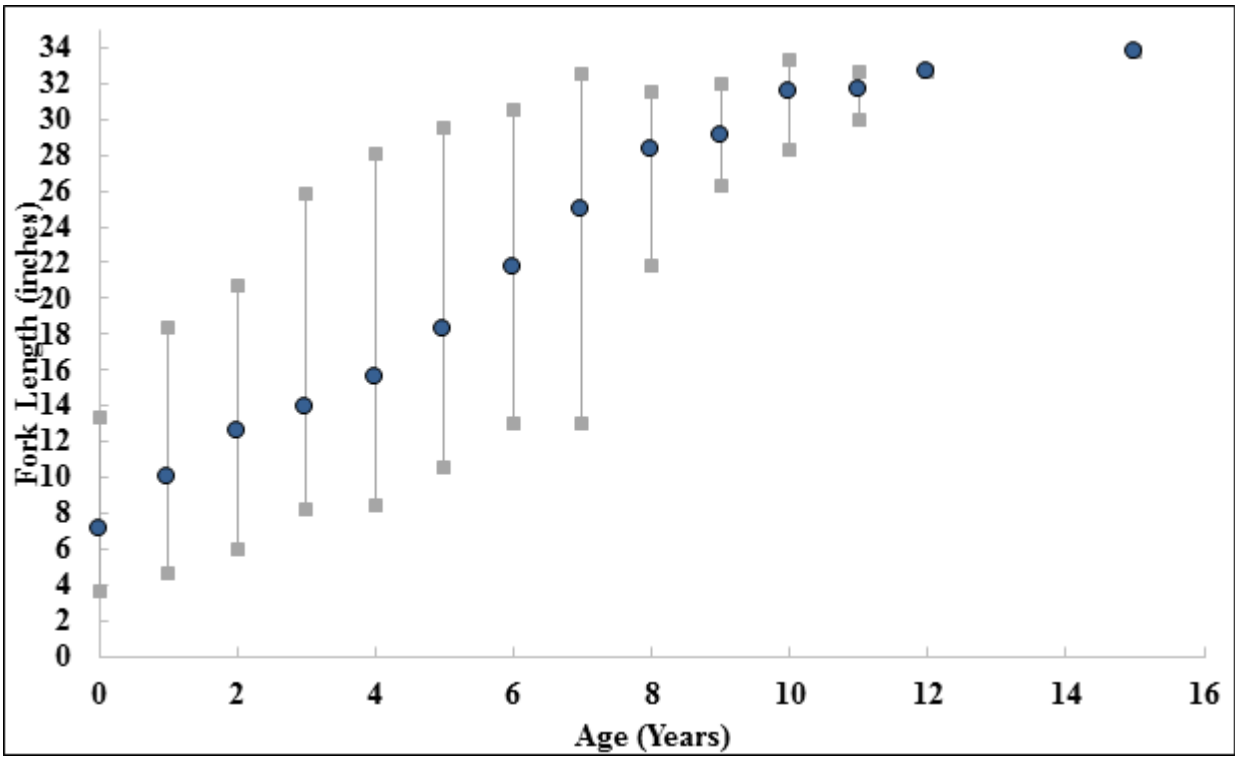

Figure 11. Weakfish length at age based on all age samples collected from 1995 to 2018. Blue circles represent the mean size at a given age while the grey squares represent the minimum and maximum observed size for each age.

FISHERY MANAGEMENT PLAN UPDATE
AMERICAN EEL
AUGUST 2019

STATUS OF THE FISHERY MANAGEMENT PLAN

Fishery Management Plan History

Original FMP Adoption:	November 1999 Addendum I – February 2006 Addendum II – October 2008 Addendum III – August 2013 Addendum IV – October 2014 Addendum V – January 2019
Amendments:	None
Revisions:	None
Supplements:	None
Information Updates:	None
Benchmark Review:	Completed in October 2017. The next benchmark has not been scheduled.

American eel is managed under the Atlantic States Marine Fisheries Commission (ASMFC) Interstate Fishery Management Plan (FMP) for American Eel . The initial FMP was approved in 1999 (ASMFC 2000) and implements management measures to protect the American eel resource to ensure ecological stability while providing for sustainable fisheries. The FMP required all states and jurisdictions to implement an annual young-of-year (YOY) abundance survey to monitor annual recruitment of each year's cohort. In addition, the FMP required a minimum recreational size, a possession limit and a state license for recreational fishermen to sell eels. The FMP requires that states and jurisdictions maintain existing or more conservative American eel commercial fishery regulations for all life stages, including minimum size limits.

Addendum I, approved in November 2006, required states to establish a mandatory trip-level catch and effort monitoring program, including documentation of the amount of gear fished and soak time (ASMFC 2006). Addendum II, approved in October 2008, placed increased emphasis on improving the upstream and downstream passage of American eel (ASMFC 2008). No new management measures were implemented by Addendum II.

Addendum III was approved for management use in August 2013, with the goal of reducing mortality on all life stages of American eel. The Addendum was initiated in response to results of the 2012 Benchmark Stock Assessment, which found the American eel stock along the US East

Coast was depleted. This addendum predominately focused on commercial yellow eel and recreational fishery management measures (ASMFC 2013). Addendum III implemented new size and possession limits as well as new pot mesh size requirements and seasonal gear closures (Table 1).

Following approval of Addendum III, the ASMFC American Eel Management Board initiated the development of Addendum IV, which was approved in October 2014 (ASMFC 2014). This addendum was also initiated in response to the 2012 stock assessment and addressed concerns and issues in the commercial glass and silver eel fisheries, domestic eel aquaculture, and established a coast-wide catch cap that set up an automatic implementation of a state-by-state commercial yellow eel quota if the catch cap is exceeded. Under Addendum IV, the coast-wide catch cap was set at 907,671 pounds (1998-2010 harvest level, ASMFC 2014). Addendum IV established two management triggers (see below), which, if either trigger is exceeded, there would be automatic implementation of a state-by-state commercial yellow eel quota; North Carolina would receive an 11.8% allocation (107,054 pounds). As the second phase of management in response to the 2012 stock assessment, the goal of Addendum IV is to continue to reduce overall mortality and increase overall conservation of American eel stocks.

Addendum IV Management Triggers

1. The coast-wide catch cap is exceeded by more than 10% in a given year (998,438 pounds)
2. The coast-wide catch cap is exceeded for two consecutive years, regardless of the percent overage.

The aquaculture provision in Addendum IV allowed states to submit an Aquaculture Plan to allow for the limited harvest of glass eels for use in domestic aquaculture facilities. Specifically, states are allowed to request for a harvest up to 200 pounds of glass eels provided the state can objectively show the harvest will occur from a watershed that minimally contributes to the spawning stock of American eel.

In 2017, the ASMFC American Eel Management Board initiated Addendum V in response to concerns that current management triggers do not account for annual fluctuations in landings and if a management trigger is exceeded immediate implementation of state-by-state quotas would pose significant administrative challenges (ASMFC 2019). Addendum V proposed alternative coast-wide landings caps, management triggers, state-by-state allocations, and transfer provisions for the yellow eel commercial fishery; as well as alternatives to the current Maine glass eel commercial quota and the aquaculture provisions of the plan. Adopted in January 2019, Addendum V increases the yellow eel coast-wide cap beginning in 2019 to 916,473 pounds due to a correction in the historical harvest; adjusts the method (management trigger) to reduce total landings to the coast-wide cap when the cap has been exceeded; and removes the implementation of state-by-state allocations if the management trigger is met. The Addendum maintains Maine's glass eel quota of 9,688 pounds. Under Addendum V, management action is initiated if the yellow eel coast-wide cap is exceeded by 10% in two consecutive years. If management is triggered, only those states accounting for more than 1% of the total yellow eel landings will be responsible for adjusting their management measures.

The aquaculture provision in Addendum V allows states to harvest a maximum of 200 pounds of glass eels annually for use in domestic aquaculture facilities under an approved Aquaculture Plan. The provision from Addendum IV requiring states to demonstrate harvest would occur in watersheds that minimally contribute to the spawning stock was dropped in Addendum V and replaced with considerations that preferred harvest sites; have established or proposed glass eel monitoring, are favorable to law enforcement, and are in watersheds that are prone to relatively high mortality rates.

To ensure compliance with interstate requirements, North Carolina also manages this species 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

The American eel is managed as a coast-wide stock, from Maine through Florida, under the ASMFC Interstate FMP for American Eel (ASMFC 2000). The American eel's range extends beyond U.S. borders and more specifically ASMFC member states' territorial waters. However, the management unit is limited to ASMFC member states' territorial waters.

Goal and Objectives

The goal of the ASMFC American Eel FMP is to protect and enhance the abundance of American eel in inland and territorial waters of the Atlantic states and jurisdictions and contribute to the viability of the American eel spawning population; and provide for sustainable commercial, subsistence, and recreational fisheries by preventing over-harvest of any eel life stage. The following objectives will be used to achieve this goal:

1. Improve knowledge of eel utilization at all life stages through mandatory reporting of harvest and effort by commercial fishers and dealers, and enhanced recreational fisheries monitoring.
2. Increase understanding of factors affecting eel population dynamics and life history through increased research and monitoring.
3. Protect and enhance American eel abundance in all watersheds where eel now occur.
4. Where practical, restore American eel to those waters where they had historical abundance but may now be absent by providing access to inland waters for glass eel, elvers, and yellow eel and adequate escapement to the ocean for pre-spawning adult eel.
5. Investigate the abundance level of eel at the various life stages necessary to provide adequate forage for natural predators and support ecosystem health and food chain structure.

STATUS OF THE STOCK

Life History

The American eel is a catadromous species meaning they are born in saltwater, then migrate into freshwater as juveniles where they grow into adults before migrating back into the ocean to spawn. All American eel comprise one panmictic population meaning they are a single breeding population that exhibits random mating. For example, an American eel from the northern portion of the range could mate with an American eel from the southern portion of the range, and their offspring could inhabit any portion of the range. As a result, recruits to a particular system are likely not the offspring of the adults that migrated out of that system (ASMFC 2000). American eels require multiple habitats including the ocean, estuaries, fresh water streams, rivers and lakes. While American eels spend most their life in brackish and freshwater systems from South America to Canada, spawning occurs in the Sargasso Sea (a large portion of the western Atlantic Ocean south of Bermuda and east of the Bahamas) (Facey and Van den Avyle 1987). Larvae develop at sea and change from glass eels (transparent post-larval stage) into elvers (pigmented young eels) in nearshore ocean waters and estuaries (ASMFC 2000). Elvers either remain in the estuary or migrate upstream. At approximately 2 years of age, they change to the yellow eel stage and resemble the adult form (Ogden 1970). Individuals can remain in the yellow phase for five to 20 years. In the yellow phase, American eels are nocturnal, swimming and feeding at night on a variety of invertebrates and smaller fish and will also eat dead animal matter. American eels live in a variety of habitats, but they prefer areas where they can hide with soft bottom and vegetation. Females can grow to five feet in length, and males usually reach about three feet (ASMFC 2000). The mature silver eel life stage occurs at the time of downstream migration, when individuals leave the estuaries to spawn and die in the Sargasso Sea (Facey and Van den Avyle 1987). This spawning migration occurs annually in the late summer and fall. Information about abundance and status at all life stages, as well as habitat requirements, is very limited. The life history of the species, such as late age of maturity and a tendency for certain life stages to aggregate, can make this species particularly vulnerable to overharvest.

Stock Status

According to the 2017 stock assessment update, the American eel population remains depleted in U.S. waters. The stock is at or near historically low levels due to a combination of historical overfishing, habitat loss, food web alterations, predation, hydroelectric turbine mortality, environmental changes, toxins and contaminants, and disease. The assessment updates the 2012 American Eel Benchmark Stock Assessment with data from 2010-2016. Trend analyses of abundance indices indicated large declines in abundance of yellow eels during the 1980s through the early 1990s, with primarily neutral or stable abundance from the mid-1990s through 2016. Total landings remain low but stable. Based on these findings, the stock is still considered depleted. No overfishing determination can be made based on the analyses performed.

Stock Assessment

In May 2016, the American Eel Technical Committee (TC) and Stock Assessment Subcommittee (SAS) recommended updating the 2012 stock assessment because there had not been enough new data sets or program developments to warrant a new benchmark assessment. The TC and SAS also recommended continuing to make progress on the research recommendations to support a benchmark stock assessment in the future.

The 2012 benchmark stock assessment was updated in 2017 with data through 2016. All three trend analysis methods (Mann-Kendall, Manly, and ARIMA) detected significant downward trends in some indices. The Mann-Kendall test detected a significant downward trend in six of the 22 YOY indices, five of the 15 yellow eel indices, three of the nine regional YOY and yellow eel indices, and the 30-year and 40-year yellow-phase abundance indices. The remaining surveys tested had no trend, except for two which had positive trends. The Manly meta-analysis showed a decline in at least one of the indices for both yellow and YOY life stages. Results of ARIMA analysis indicated the probabilities of being less than the 25th percentile reference points in the terminal year for each survey were similar to those in the 2012 stock assessment and three of the 14 surveys had a greater than 50% probability of the terminal year being less than the 25th percentile reference point. Overall, the occurrence of some significant downward trends in surveys across the coast remains a cause for concern and the assessment maintained that the stock remains depleted. While it is highly likely the American eel stock is depleted, no overfishing determination can be made based solely on the trend analyses performed.

STATUS OF THE FISHERY

Current Regulations

New management measures for yellow eels went into effect on January 1, 2014 under North Carolina Marine Fisheries Commission (NCMFC) Rule 15A NCAC 03M .0510. These measures included a 9-inch total length (TL) minimum size limit for both the commercial and recreational fisheries, a 25 eels per person per day bag limit for the recreational fishery, and crew members involved in for-hire employment are allowed to maintain the current 50 eels per day bag limit for bait purposes. The rule also made the possession of American eels illegal from September 1 through December 31 except when taken by baited pots. NCMFC Rule 15A NCAC 03J .0301 established a one half by one half inch minimum mesh size requirement for the commercial eel pot fishery. Eel pots with an escape panel consisting of a 1 by one half inch mesh are allowed until January 1, 2017.

Commercial Landings

Average commercial landings and value from 2009 through 2018 was 54,890 pounds and $131,800. In 2018, the commercial landings and value was 18,058 pounds and $29,344. Commercial landings have fluctuated since 1974 with a peak in 1980 and significant declines beginning in the late 1980s. In 1979 and 1980, over 900,000 pounds were landed, however, since the late 1980s landings have averaged less than 100,000 pounds (Figure 1).

Recreational Landings

There are no recreational landings data available for American eels, which are not typically a targeted species. Since American eels are caught incidentally in the estuarine environment by recreational fishermen by hook and line, the Marine Recreational Information Program (MRIP) does not provide reliable harvest data. Also, the survey design of MRIP does not provide information on the recreational harvest of American eel in inland waters. American eels are popular bait for many important recreational fisheries such as striped bass and cobia.

MONITORING PROGRAM DATA

Fishery-Dependent Monitoring

To comply with the ASMFC Addendum I to the American Eel Fisheries Management Plan, the NCDMF initiated (January 2007) mandatory reporting on American eel harvest by eel pots, including eel pot soak time and number of eel pots fished. Commercial fishermen are required to participate in a monthly logbook program designed to monitor the harvest of American eels by eel pots. Soak time and number of eel pots fished are currently not reported on trip tickets.

Fishery-Independent Monitoring

The National Oceanic and Atmospheric Administration (NOAA) conducts the Beaufort Bridgenet Ichthyoplankton Sampling Program (BBISP), an ichthyoplankton survey at Beaufort Inlet, which is used to develop a North Carolina young-of-year relative abundance index for American eel (Figure 2). The BBISP samples once-weekly at night during flood-tide from a fixed platform on Pivers Island Bridge, Beaufort, NC during October-May. Larvae are collected using a 2 m^2 plankton net fitted with a flow meter. Four replicate sets (tows) are made, with each filtering about 100 m^3. Between 1987 and 2018, American eel (glass eel) annual catch-per-unit-effort (CPUE) has fluctuated from a low in 1991 to a high in 2005, with a 32-year average of 0.0127 eels per cubic meter (Figure 2). In 2018, American eel CPUE remained below the long-term average. The length composition of American eels captured in the BBISP from 2001 to 2018 (n=506) are shown in Figure 3. Lengths ranged from 41 to 153 millimeters (1.6 to 6.0 inches) and averaged 52 millimeters total length (2.0 inches; note: the 60^+ millimeter category includes pooled fish lengths of 62, 91, and 153 millimeters).

The North Carolina Division of Marine Fisheries (NCDMF) has no fishery-independent monitoring programs specifically for American eel, however, the North Carolina Estuarine Trawl Survey (Program 120) collects information on American eels caught incidentally. American eel catch data from Program 120 were used in the 2012 benchmark stock assessment. Between 1971 and 2018, CPUE has fluctuated wildly from lows in 1973 and 2000 to a peak in 2011, with a 25-year average of 0.146 per tow (Figure 4). In 2018, CPUE remained below the long-term average, although an increasing trend continued from 2016 into 2018 (Figure 4)

MANAGEMENT STRATEGY

Under Addendum V, the commercial yellow eel fishery is regulated through an annual coast-wide catch cap set at 916,473 pounds. Management action is initiated if the yellow eel coast-wide cap is exceeded by 10% in two consecutive years. The management trigger has never been

tripped. If the management trigger is exceeded, only those states accounting for more than 1% (9,164 pounds) of the total yellow eel landings will be responsible for adjusting their measures. In 2018 the commercial landings in North Carolina were 18,058 pounds; if the management trigger is exceeded, North Carolina would be required to work with other states to adjust harvest. A workgroup has been formed to define the process to equitably reduce landings among the affected states when the management trigger has been met.

The ASMFC adopted Addendum IV in 2014 that contained a provision allowing states to submit an Aquaculture Plan allowing for the limited harvest of American eel glass eels for use in domestic aquaculture facilities. Specifically, states are allowed to request harvest of up to 200 pounds of glass eels under an Aquaculture Plan. In December 2015, the NCDMF submitted an American Eel Aquaculture Plan to the ASMFC requesting approval to harvest up to 200 pounds of glass eels from coastal fishing waters which was approved in February 2016 (1 year). A second plan was submitted by NCDMF in 2016 and approved by ASMFC that allowed for harvest in 2017 (1 year). The third plan submitted by the NCDMF in 2017 and approved by the ASMFC covered a 2-year period that allowed for harvest in 2018 and 2019. In May 2019, the NCDMF submitted another 2-year plan for approval that would allow for harvest in the winter/spring months of 2019 and 2020.

In order for an approved aquaculture operation to legally harvest eels less than 9 inches, the facility needs to have a Declaratory Ruling from the NC Marine Fisheries Commission (NCMFC) exempting them from the 9-inch minimum size limit to possess, sell or take American eels. The approved aquaculture operation received Declaratory Rulings (2) that allowed for legally harvested American eels less than 9 inches in length to be cultivated or reared in a facility from: 1) outside of North Carolina and imported into the State, and 2) from Coastal Fishing Waters in the State of North Carolina.

In support of American eel aquaculture in North Carolina, several legal actions were taken by North Carolina legislatures. Senate Bill 513 (North Carolina Farm Act of 2015; Section 22.(a)) directed the NCDMF and the Wildlife Resources Commission to jointly develop a pilot American Eel Aquaculture Plan for the harvest and aquaculture of American eels. Senate Bill 410 (Marine Aquaculture Development Act; Section 3.1.(c)) allows American eels to be imported from Virginia or South Carolina for aquaculture purposes, and House Bill 374 (Section 17) allows American eels to be imported from Maryland for aquaculture purposes. The use of American eels imported from Maryland, Virginia, or South Carolina in an aquaculture operation are exempt from the permitting requirements of the Importation of Marine and Estuarine Organisms Rule.

RESEARCH RECOMMENDATIONS

The items listed below identify research needs as described in the 2017 American Eel Stock Assessment Update (ASMFC2017) based on input from the ASMFC American Eel TC and stock assessment subcommittee during the 2012 benchmark stock assessment lists progress made towards accomplishing those objectives. A single asterisk (*) denotes short-term recommendations and two asterisks (**) denote long-term recommendations. Recommendations formatted in **bold** identify improvements needed for the next benchmark assessment.

Data Collection

Fisheries Catch and Effort

- **Improve accuracy of commercial catch and effort data (NOTE: Some progress was made on this recommendation through Addenda III and IV)**
  – Compare buyer reports to reported state landings* (No Action)
  – Improve compliance with landings and effort reporting requirements as outlined in the ASMFC FMP for American eel (see ASMFC 2000a for specific requirements)* (Ongoing through the NC Trip Ticket Program and the American Eel Logbook Reporting Program)
  – Require standardized reporting of trip-level landings and effort data for all states in inland waters; data should be collected using the ACCSP standards for collection of catch and effort data (ACCSP 2004)* (Ongoing through the American Eel Logbook Reporting Program)
- Estimate catch and effort in personal-use and bait fisheries
  – Monitor catch and effort in personal-use fisheries that are not currently covered by the MRFSS or commercial fisheries monitoring programs* (No Action)
  – Implement a special-use permit for use of commercial fixed gear (e.g., pots and traps) to harvest American eels for personal use; special-use permit holders should be subject to the same reporting requirements for landings and effort as the commercial fishery** (No Action)
  – Improve monitoring of catch and effort in bait fisheries (commercial and personal-use)* (No Action)
- Estimate non-directed fishery losses
  – Recommend monitoring of discards in targeted and non-targeted fisheries* (No Action)
  – Continue to require states to report non-harvest losses in their annual compliance reports* (Ongoing)
- **Characterize the length, weight, age, and sex structure of commercially harvested American eels along the Atlantic Coast over time**
  – Require that states collect biological information by life stage (potentially through collaborative monitoring and research programs with dealers) including length, weight, age, and sex through fishery-dependent sampling programs; biological samples should be collected from gear types that target each life stage; at a minimum, length samples should be routinely collected from commercial fisheries* (No Action)
  – Finish protocol for sampling fisheries; SASC has draft protocol in development* (No Action)
- Improve estimates of recreational catch and effort
  – Collect site-specific information on the recreational harvest of American eels in inland waters; this could be addressed by expanding the MRIP into inland areas** (No Action)
- Improve knowledge of fisheries occurring south of the U.S. and within the species' range that may affect the U.S. portion of the stock (i.e., West Indies, Mexico, Central America, and South America)** (No Action)

Socioeconomic Considerations

- Perform economics studies to determine the value of the fishery and the impact of

regulatory management** (No Action)
- Improve knowledge regarding subsistence fisheries
  – Review the historic participation level of subsistence fishers and relevant issues brought forth with respect to those subsistence fishers involved with American eel** (No Action)
  – Investigate American eel harvest and resource by subsistence harvesters (e.g., Native American tribes, Asian and European ethnic groups)** (No Action)

Distribution, Abundance, & Growth
- **Improve understanding of the distribution and frequency of occurrence of American eels along the Atlantic Coast over time**
  – Maintain and update the list of fisheries-independent surveys that have caught American eels and note the appropriate contact person for each survey* (No Action)
  – Request that states record the number of eels caught by fishery-independent surveys; recommend states collect biological information by life stage including length, weight, age, and sex of eels caught in fishery-independent sampling programs; at a minimum, length samples should be routinely collected from fishery-independent surveys* (Ongoing through collecting number, length, and weight of eels caught in independent sampling programs)
  – Encourage states to implement surveys that directly target and measure abundance of yellow- and silver-stage American eels, especially in states where few targeted eel surveys are conducted** (No Action)
  – A coast-wide sampling program for yellow and silver American eels should be developed using standardized and statistically robust methodologies** (No Action)
- Improve understanding of coast-wide recruitment trends
  – Continue the ASMFC-mandated YOY surveys; these surveys could be particularly valuable as an early warning signal of recruitment failure* (In 2009, funding was cut for the NCDMF YOY survey; however, the NOAA BBISP is currently used for the YOY survey, as approved by the ASMFC American Eel Management Board)
  – Develop proceedings document for the 2006 ASMFC YOY Survey Workshop; follow-up on decisions and recommendations made at the workshop* (No Action)
  – Examine age at entry of glass eel into estuaries and freshwater** (No Action)
  – Develop monitoring framework to provide information for future modeling on the influence of environmental factors and climate change on recruitment** (No Action)
- Improve knowledge and understanding of the portion of the American eel population occurring south of the U.S. (i.e., West Indies, Mexico, Central America, and South America)** (No Action)

<u>Future Research</u>
Biology
- Improve understanding of the leptocephalus stage of American eel
  – Examine the mechanisms for exit from the Sargasso Sea and transport across the continental shelf** (No Action)
  – Examine the mode of nutrition for leptocephalus in the ocean** (No Action)
- Improve understanding of impact of contaminants as sources of mortality and non-lethal population stressors

  - Investigate the effects of environmental contaminants on fecundity, natural mortality, and overall health** (No Action)
  - Research the effects of bioaccumulation with respect to impacts on survival and growth (by age) and effect on maturation and reproductive success** (No Action)
- **Improve understanding of impact of *Anguillicoloides crassus* on American eel**
  - Investigate the prevalence and incidence of infection by the nematode parasite *A.crassus* across the species range* (No Action)
  - Research the effects of the swim bladder parasite *A. crassus* on the American eel's growth and maturation, migration to the Sargasso Sea, and the spawning potential* (No Action)
  - Investigate the impact of the introduction of *A. crassus* into areas that are presently free of the parasite** (No Action)
- **Improve understanding of spawning and maturation**
  - Investigate relation between fecundity and length and fecundity and weight for females throughout their range** (No Action)
  - Identify triggering mechanism for metamorphosis to mature adult, silver eel life stage, with specific emphasis on the size and age of the onset of maturity, by sex; a maturity schedule (proportion mature by size or age) would be extremely useful in combination with migration rates** (No Action)
  - Research mechanisms of recognition of the spawning area by silver eel, mate location in the Sargasso Sea, spawning behavior, and gonadal development in maturation** (No Action)
  - Examine migratory routes and guidance mechanisms for silver eel in the ocean** (No Action)
- Improve understanding of predator-prey relationships** (No Action)
- Investigating the mechanisms driving sexual determination and the potential management implications** (No Action)

Passage & Habitat

- **Improve upstream and downstream passage for all life stages of American eels**
  - Develop design standards for upstream passage devices for eels. The ASMFC 2011 Eel Passage Workshop (ASMFC 2013) made contributions to this goal. (NCDMF will continue to work with Dominion Energy and participate on the American Eel Working Group)
  - Investigate, develop, and improve technologies for American eel passage upstream and downstream at various barriers for each life stage; in particular, investigate low -cost alternatives to traditional fishway designs for passage of eel** (NCDMF will continue to work with Dominion Energy and participate on the American Eel Working Group)
- Improve understanding of the impact of barriers on upstream and downstream movement (No Action)
  - Evaluate the impact, both upstream and downstream, of barriers to eel movement with respect to population and distribution effects; determine relative contribution of historic loss of habitat to potential eel population and reproductive capacity**(NCDMF will continue to work with Dominion Energy and participate on the American Eel Working Group)

  - – Recommend monitoring of upstream and downstream movement at migratory barriers that are efficient at passing eels (e.g., fish ladder/lift counts); data that should be collected include presence/absence, abundance, and biological information; provide standardized protocols for monitoring eels at passage facilities; coordinate compilation of these data; provide guidance on the need and purpose of site-specific monitoring** (NCDMF will continue to work with Dominion Energy and participate on the American Eel Working Group)
  - – Use the information gained from the above evaluation and monitoring of barriers to American eel passage to develop metrics for prioritizing passage restoration projects. (NCDMF will continue to work with Dominion Energy and participate on the American Eel Working Group)
- **Improve understanding of habitat needs and availability**
  - – Assess characteristics and distribution of American eel habitat and value of habitat with respect to growth and sex determination; develop GIS of American eel habitat in U.S.** (No Action)
  - – Assess available drainage area over time to account for temporal changes in carrying capacity; develop GIS of major passage barriers** (No Action)
  - – Improve understanding of freshwater habitat and water quality thresholds for American eel. (No Action)
- Improve understanding of within-drainage behavior and movement and the exchange between freshwater and estuarine systems** (No Action)
- Improve estimates of mortality associated with upstream and downstream passage
  - – Monitor non-harvest losses such as impingement, entrainment, spill, and hydropower turbine mortality* (NCDMF will continue to work with Dominion Energy and participate on the American Eel Working Group)
- Evaluate eel impingement and entrainment at facilities with NPDES authorization for large water withdrawals; quantify regional mortality and determine if indices of abundance could be established as specific facilities** (No Action)
- Investigate best methods for reintroducing eels into a watershed; examine approaches for determining optimum density* (NCDMF will continue to work with Dominion Energy and participate on the American Eel Working Group - data available from the Roanoke Rapids, NC)

<u>Assessment Methodology & Management Support</u>

- Coordinate monitoring, assessment, and management among agencies that have jurisdiction within the species' range (e.g., ASMFC, GLFC, Canada DFO)** (No Action)
- Perform a joint U.S.-Canadian stock assessment* (NC will continue to provide data for stock assessments)
- Perform periodic stock assessments (every 5–7 years) and establish sustainable reference points for American eel are required to develop a sustainable harvest rate in addition to determining whether the population is stable, decreasing, or increasing. (NC will continue to provide data for stock assessments)
  - – Develop new assessment models (e.g., delay-difference model) specific to eel life history and fit to available indices** (No Action)
  - – **Conduct intensive age and growth studies at regional index sites to support development of reference points and estimates of exploitation*** (No Action)

  - – Develop GIS-type model that incorporates habitat type, abundance, contamination, and other environmental factors** (No Action)
  - – Develop population targets based on habitat availability at the regional and local level** (No Action)
- Implement large-scale (coast-wide or regional) tagging studies of eels at different life stages; tagging studies could address a number of issues including: (No Action)
  - – Natural, fishing, and discard mortality; survival**
  - – Growth**
  - – Passage mortality**
  - – Movement, migration, and residency**
  - – Validation of ageing methods**
  - – Reporting rates**
  - – Tag shedding or tag attrition rate**

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TABLES

Table 1. Summary of management strategies and their implementation status from Addendum V and previous Addendums.

Management Strategy	Implementation Status
Establish a Coast-wide Cap (916,473 pounds)	Accomplished with Addendum V
Establish a Coast-wide Cap (907,671 pounds)	Accomplished with Addendum IV
Nine (9) inch minimum size limit for both commercial and recreational fisheries.	Accomplished by N.C. Marine Fisheries Commission Rule 15A NCAC 03M .0510
Minimum eel pot mesh size of one-half by one-half inch.	Accomplished by N.C. Marine Fisheries Commission Rule 15A NCAC 03J .0301
Recreational possession limit of 25 eels / person / day.	Accomplished by N.C. Marine Fisheries Commission Rule 15A NCAC 03M .0510
No possession of American eels from September 1 to December 31 unless they are taken with baited pots	Accomplished by N.C. Marine Fisheries Commission Rule 15A NCAC 03M .0510
Mandatory trip level reporting by life stage, including number of units fished and unit soak time.	Accomplished by N.C. G.S. 113-170.3 and the American Eel Logbook Reporting Program where fishermen are notified by letter of the monthly reporting requirement

FIGURES

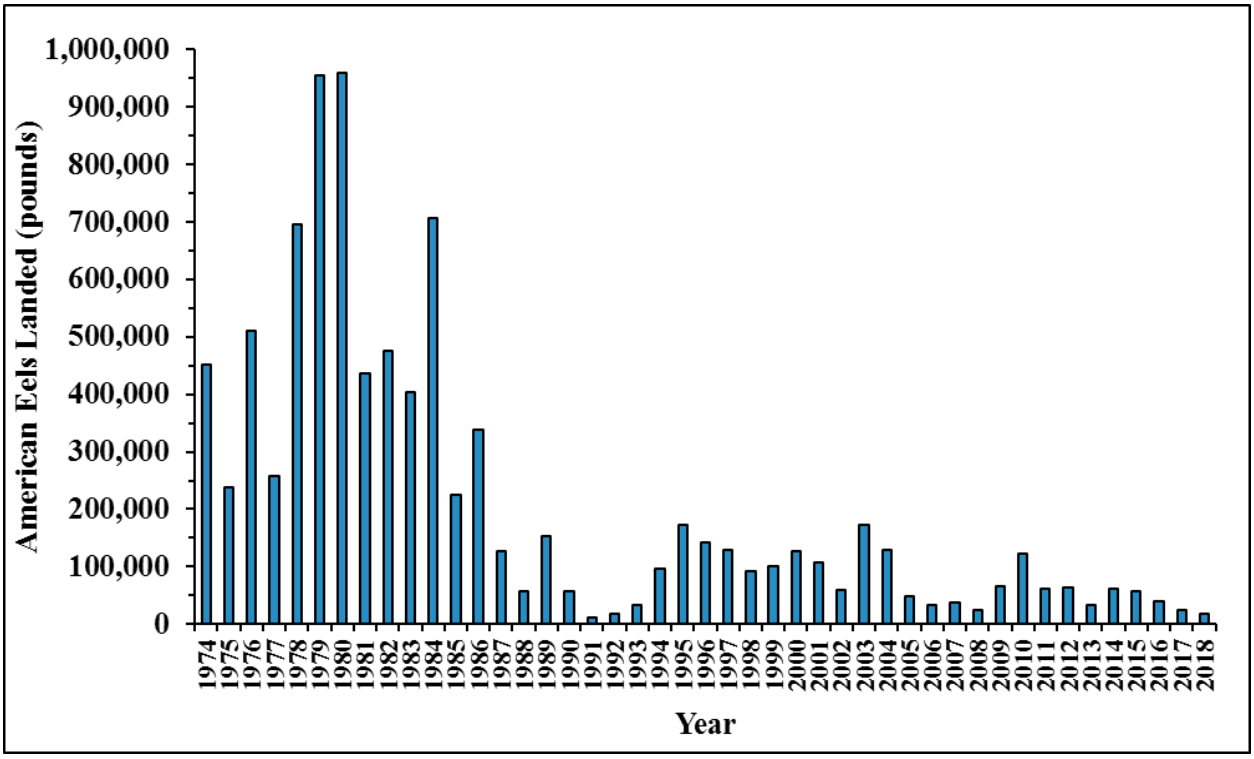

Figure 1. American eel (yellow eel) commercial landings in N.C., 1974 – 2018.

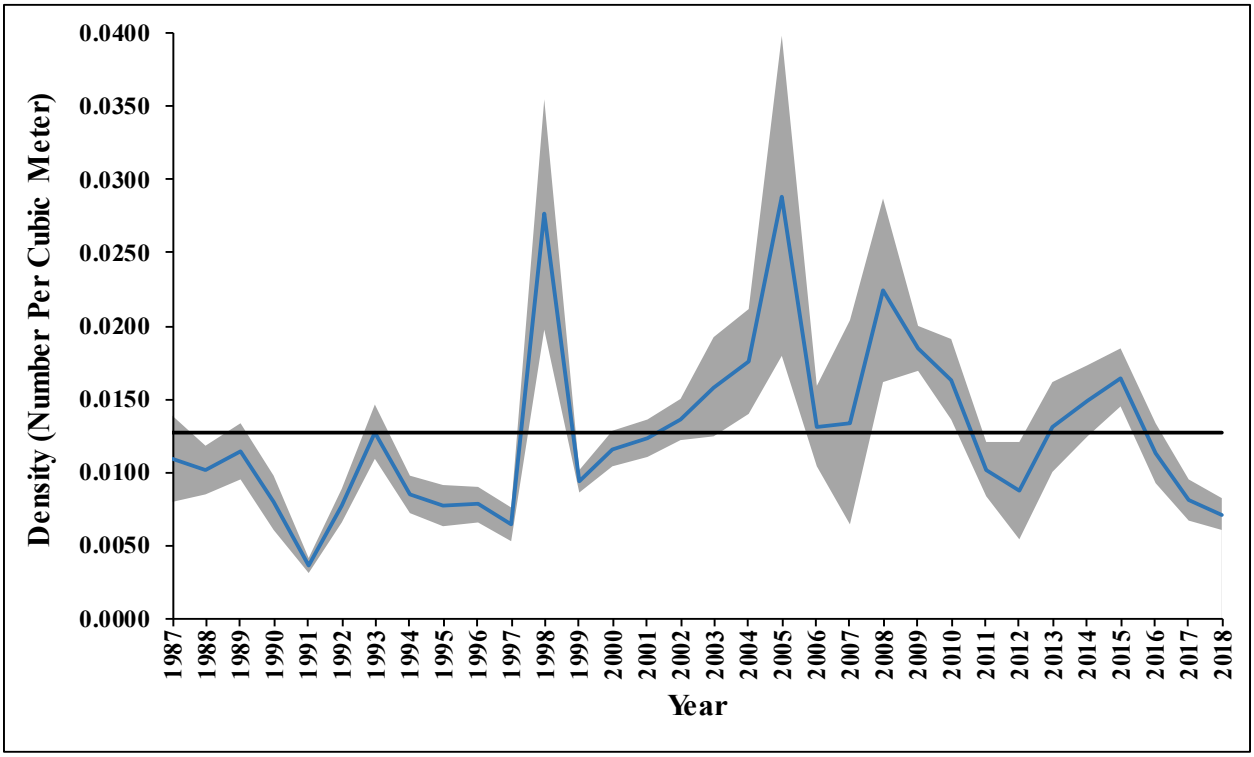

Figure 2. Average annual density (CPUE; number of larvae per cubic meter) of American eel (glass eel) in the BBISP, 1987-2018. Solid black line represents long-term average. Shaded area represents standard error.

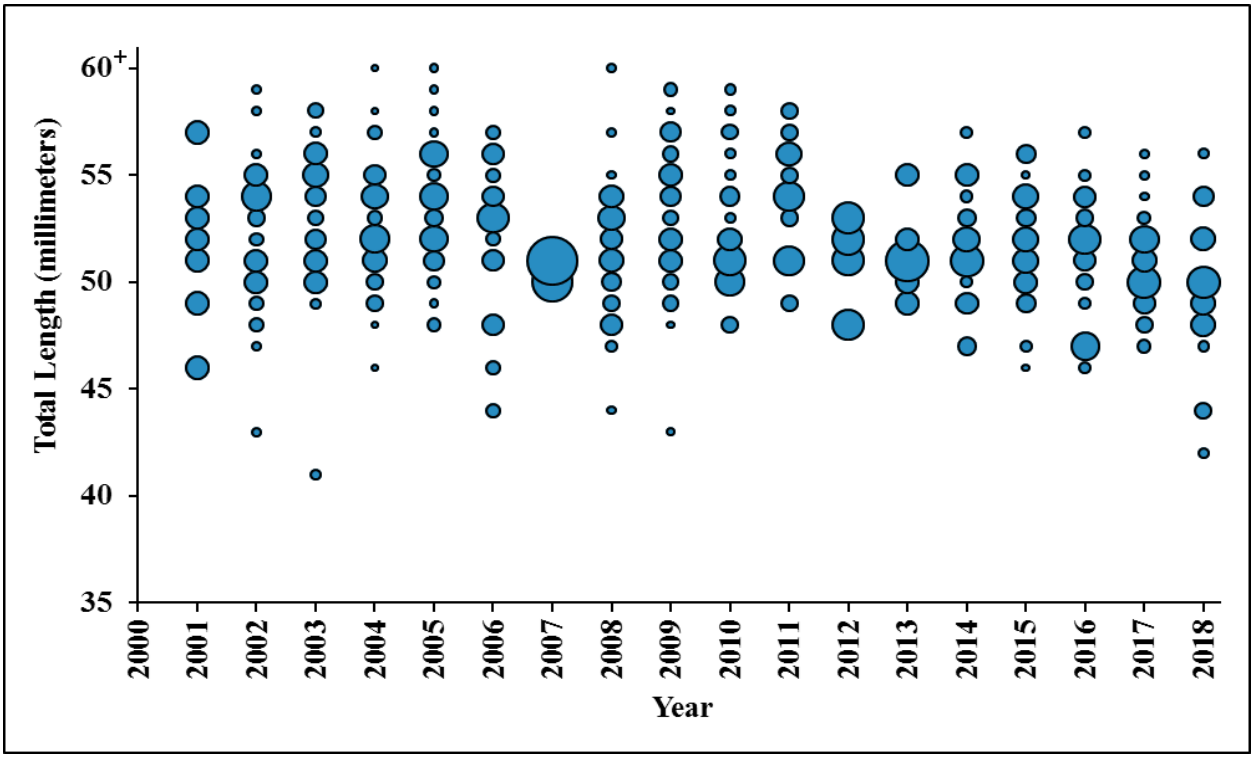

Figure 3. Average length frequency (total length, millimeters) of American eel collected in the BBISP, 2001-2018. Bubble represents the proportion of fish at length. (Note: the 60+ category includes three fish; 62, 91, and 153 millimeters).

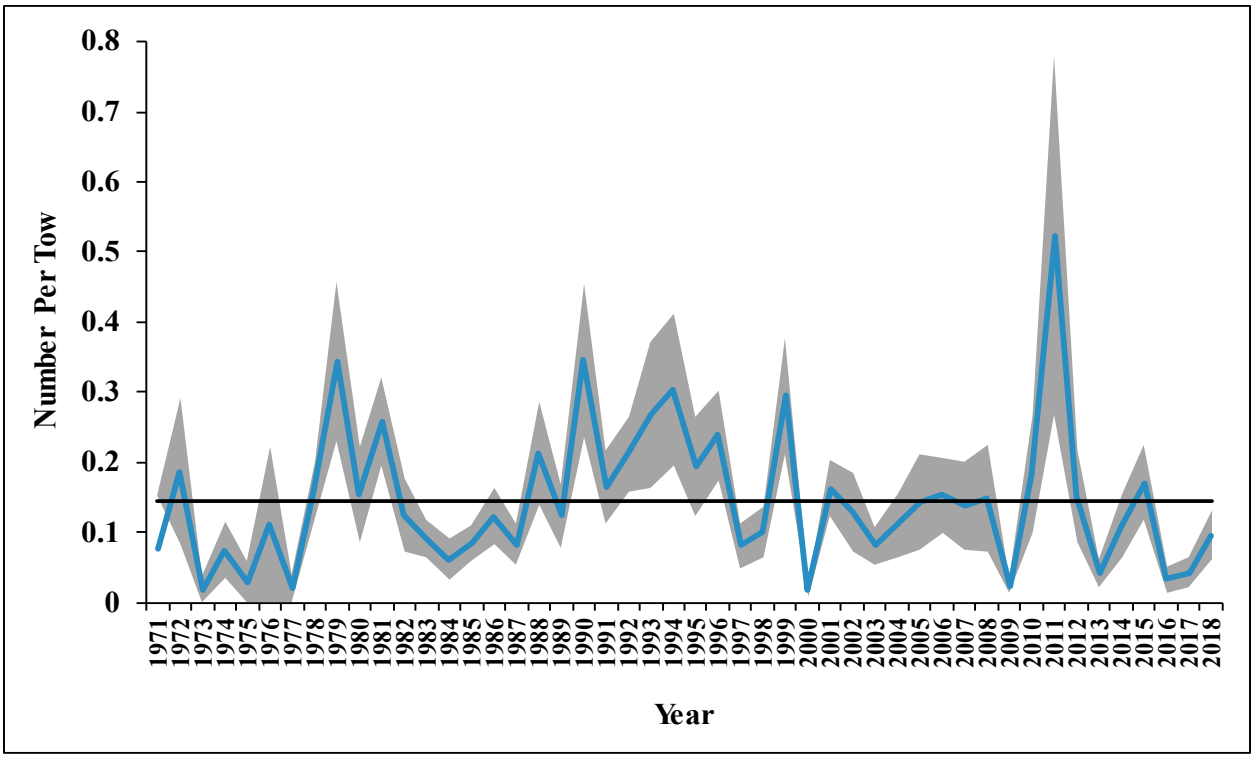

Figure 4. Annual index of relative juvenile (elver) abundance of American eel in the NCDMF Estuarine Trawl Survey, 1971-2018. Solid black line represents long-term average. Shaded area represents standard error.

FISHERY MANAGEMENT PLAN UPDATE
COBIA
AUGUST 2019

STATUS OF THE FISHERY MANAGEMENT PLAN

Fishery Management Plan History

Original FMP Adoption:	February 1983 – SAFMC November 2017 - ASMFC
Amendments:	SAFMC Amendment 1 – September 1985 Amendment 2 – August 1987 Amendment 3 – August 1989 Amendment 5 – August 1990 Amendment 6 – December 1992 Amendment 8 – April 1998 Amendment 11 – December 1999 Amendment 18 – January 2012 Amendment 20b – March 2015 Framework Amendment 4 – September 2017 Amendment 31 – March 2019 ASMFC Amendment 1 − August 2019 (expected)
Revisions:	None
Supplements:	None
Information Updates:	None
Next Benchmark Review:	2020

The Gulf of Mexico Fishery Management Council (GMFMC) and the South Atlantic Fishery Management Council (SAFMC) approved and implemented the Fishery Management Plan, Final Environmental Impact Statement, Regulatory Impact Review and Final Regulations for the Coastal Migratory Pelagic Resources (FMP) in 1983 which included all cobia (*Rachycentron canadum*) in the Gulf of Mexico and South Atlantic (GMFMC/SAFMC 1983). This plan managed cobia as one unit stock across the entire jurisdictional area of the GMFMC and SAFMC. The original plan estimated Maximum Sustainable Yield (MSY) of cobia at the time to be 1,057,000 pounds with an estimated domestic harvest of 1,000,000 pounds and set a total allowable level of foreign fishing to zero. The stated management objective for cobia in the plan was to institute management measures necessary to increase yield per recruit and average size

and to prevent overfishing. To achieve this, a minimum size limit of 33 inches fork length (FL) was established for the fishery conservation zone (FSC), which is analogous to the Exclusive Economic Zone (EEZ) of today which is locally referred to as 'federal waters'. The FMP was first amended in 1985 with the adoption of Amendment 1 which established the fishing year as January 1 through December 31 and clarified that the minimum size limit for cobia is 33 inches FL or 37 inches total length (TL) (GMFMC/SAFMC 1985). This amendment also highlighted the fact that most southeastern states had not yet adopted the recommended minimum size limits for cobia and that populations of cobia in Chesapeake Bay appear to be overfished and that the federal enforcement capability in this case is very limited.

Amendment 2 to the FMP was approved in 1987 and established a permit for charter boats fishing for coastal migratory pelagics (GMFMC/SAFMC 1987a). Amendment 3 (GMFMC/SAFMC 1987b) prohibited drift gill nets as a gear that could be used to harvest coastal pelagic species. Amendment 5 (GMFMC/SAFMC 1990) addressed the issue of average annual catches from 1981-1986 exceeding the established Maximum Sustainable Yield level by 900,000 pounds and defined the overfishing limit for the cobia stock. The stock would be managed using a target level percentage of no less than 20% of spawning stock biomass per recruit (SSBR). If the stock was considered overfished then the Science and Statistical Committee (SSC) will develop ranges of Allowable Biological Catch (ABC) that will rebuild the overfished stock. Cobia were added to the annual stock assessment procedures for the councils, and a bag limit of two fish per person per day with a one-day possession limit was established for both commercial and recreational sectors in an effort to control harvest. Amendment 6 (GMFMC/SAFMC 1992) removed the 37-inch total length minimum size specifying that the only minimum size for cobia is 33 inches FL and changed MSY to 2,200,000 pounds based on results from the mackerel stock assessment panel.

In 1998, Amendment 8 extended the management area for cobia through the Mid-Atlantic Fishery Management Council's (MAFMC) jurisdiction which also extended the two-fish bag limit and 33-inch FL minimum size limit (GMFMC/SAFMC 1996). Overfishing was defined as a fishing mortality rate greater than a static Spawning Potential Ratio (SPR) threshold of 30% and if exceeded, then required that fishing mortality be reduced to rates corresponding to management target levels. Optimum yield (OY) was defined as being equal to MSY. Amendment 11 (SAFMC 1998) redefined OY as the amount of harvest that can be taken by United States fishermen while maintaining the SPR at or above 40% of a static SPR. It also redefined the overfishing level as a fishing mortality rate (F) in excess of the F at 30% of a static SPR and established a threshold level for all the species in the coastal migratory pelagic unit as 10% of the static SPR.

Amendment 18 (GMFMC/SAFMC 2011) separated cobia into two stocks at the jurisdiction boundary between the GSFMC and the SAFMC. The Atlantic stock range was east of the Florida Keys through New York. Annual Catch Limits (ACL) were established for both stocks as required under the federal Magnuson-Stevens Act. The ACL for the Atlantic stock was set to 1,571,399 pounds with a 92% recreational and 8% commercial sector allocation. Amendment 20b (GMFMC/SAFMC 2014) modified the stock boundary based on the results of the 2013 stock assessment (SEDAR 28) to the Florida/Georgia line. A new ACL was set at 690,000 pounds for the 2015 fishing season and 670,000 pounds for every year after. Sector allocations

were set to 630,000 pounds for the recreational sector for the 2015 season and 620,000 pounds for subsequent years. The commercial allocation was set to 60,000 pounds in 2015 and 50,000 pounds for years following. Accountability Measures (AM) required under the federal Magnuson Stevens-Act were established to ensure that ACLs are not exceeded and that stock does not become overfished. Accountability measures require the councils to take action to limit the harvest of the species if an ACL is exceeded. For cobia, the recreational AMs did not allow for in-season closures if the ACL is met or projected to be met rather, measures are to be taken the following season to limit the harvest to keep the three-year running average of landings at or below the ACL. If the total ACL is exceeded, the AMs require that the length of the recreational season the following year be reduced to constrain harvest to the ACL for that year. The commercial AMs require an in-season closure if the commercial ACL is met or projected to be met. If the stock is overfished, and the total ACL is exceeded, then the sector-specific ACL for the following year will be reduced by the appropriate sector-specific overage.

Framework Amendment 4 (SAFMC 2016) to Amendment 20b to the CMP FMP was approved by the council in September of 2016 and the final rule went into effect in September 2017. The amendment increases the recreational minimum size limit of cobia to 36 inches FL and reduce the bag limit to one fish per person per day and implements a six fish per day vessel limit. The recreational AM were modified to allow for a reduction in vessel limit before a season reduction is implemented. The framework amendment maintains the existing commercial minimum size limit of 33 inches FL and establishes a two fish per person per day or six fish per vessel per day (whichever is more restrictive) commercial trip limit.

Amendment 31 (SAFMC 2018) to the CMP FMP was approved by the council in June of 2018 and the final rule went into effect March of 2019. The amendment removes the Atlantic migratory group cobia (Georgia through New York) from federal management under the Magnuson-Stevens Act and transfers sole management of Atlantic cobia to the Atlantic States Marine Fisheries Commission (ASMFC). The amendment also implements comparable regulations to the CMP FMP in the federal waters under the Atlantic Coastal Act in order to ensure that Atlantic cobia continues to be managed in federal waters and that there is no lapse in the management of the stock.

The ASMFC approved the Interstate Fisheries Management Plan for Atlantic Migratory Group Cobia in November of 2017 (ASFMC 2017). The interstate plan complements Framework Amendment 4 to the Gulf of Mexico and South Atlantic FMP for Cobia and establishes Recreational Harvest Limits (RHL) for the Atlantic states based on the federal recreational and commercial ACLs. The plan provides the states flexibility in management of the species by allowing states to define their own season and vessel limits to constrain harvest to the RHL. At a minimum, states must comply with the size limits and bag limits established in Framework Amendment 4 and not exceed the vessel limits for commercial and recreational vessels. State landings will be evaluated against the RHLs every three years to ensure that management measures are constraining coast-wide harvest to the Federal ACLs.

To accommodate the removal of Atlantic cobia from federal management, ASMFC approved the development of draft Amendment 1 to the interstate plan in October of 2018. Draft Amendment 1, when approved, will allow the commission to establish a mechanism for recommending

management measures to NOAA Fisheries for implementation in federal waters through authority and process defined in the Atlantic Coastal Fisheries Cooperative Management Act. In addition to recommending management for federal waters, draft Amendment 1 presents options for addressing 12 other issues within the FMP, including additions to the management goals and objectives, establishment of processes to define biological reference points and specify harvest, changes to commercial monitoring of landings, clarification of the process for evaluating recreational harvests against state harvest targets, potential changes to commercial fishery management measures, and the establishment of *de minimis* criteria for the commercial fishery (ASMFC 2019). Draft Amendment 1 will go to the Board and commission for final approval at the August 2019 meeting.

To ensure compliance with interstate requirements, North Carolina also manages this species 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 MAFMC, SAFMC, 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 plans) and the Atlantic Coastal Fisheries Cooperative Management Act (Atlantic States Marine Fisheries Commission plans) are like the goals of the Fisheries Reform Act of 1997 to "ensure long-term viability" of these fisheries (NCDMF 2015).

Management Unit

The management unit for Atlantic cobia is defined in Framework Amendment 4 as all waters north of the Florida/Georgia line through New York from three to 200 miles offshore (Figure 1). The interstate plan for cobia extends this management authority into state waters.

Goal and Objectives

The goal of Amendment 20b and Framework Amendment 4 to the FMP is to achieve optimum yield while ensuring regulations are fair and equitable and fishery resources are utilized efficiently. The interstate plan for cobia complements this goal and further adds the objective of providing a framework of flexibility for states to manage their fisheries under the management measures implemented in Amendment 20b.

STATUS OF THE STOCK

Life History

Cobia is the sole member of the family Rachycentridae. It is a fast growing and moderately long-lived species with a maximum reported age of 16 years with a worldwide distribution in tropical, subtropical, and warm-temperature waters (SEDAR 2019). In the western Atlantic, cobia occur from Nova Scotia, Canada south to Argentina including the Caribbean Sea. Off the coast of the United States, they inhabit nearshore coastal waters from New York south through the Gulf of Mexico. They migrate in the spring and fall as water temperatures change from inshore and

offshore habitats, as well as up and down the coasts. Spawning occurs in the spring months around inlets and in high salinity estuarine waters. Larval fish settle in the estuaries along the southeast and mid-Atlantic coasts and utilize them as a nursery area. Cobia can grow to as large as 14 inches FL in their first year of life and move offshore as the water temperatures cool in the fall. Most cobia are mature by age-2 and at 31 inches in FL (Smith 1995). Females can spawn multiple times in a season (batch spawners) and can produce millions of eggs in a single year. Cobia can grow as large as 100 pounds but are typically encountered by fisherman in the 25 to 40 pound range (Manooch 1984). Feeding typically occurs on the bottom where they consume fish and crabs, but they have been known to consume prey as large as turtles. Cobia are structure oriented and can be found around structure such as channel markers, sea walls and jetties, or floating objects like larger marine animals such as leatherback sea turtles and rays.

Stock Status

Cobia were last assessed during South East Data, Assessment, and Review (SEDAR) 28 (2013) using data through 2011. Results of the assessment indicate that cobia are not overfished and overfishing is not occurring. However, spawning stock biomass (SSB) was in decline with the terminal year of the assessment approaching the minimum stock size threshold.

Stock Assessment

SEDAR 28 (2013) assessed the Atlantic stock of cobia using data from 1950 - 2011. The data available for cobia included life history information (growth rate, age structure, and age-specific maturity), commercial and recreational landings and discards, commercial and recreational length and age composition, and information on the South Carolina cobia stocking program. Several stock assessment models were considered, but the Beaufort Assessment Model (BAM) was selected by the Assessment Workshop (AW) as the primary assessment model. The BAM uses a statistical catch-at-age formulation which allows for forward-projecting a fish population through time. The base run of the BAM indicated that cobia were not overfished in the terminal year ($SSB_{2011}/MSST = 1.75$; Figure 2) and overfishing was not occurring ($F_{2009\text{-}2011}/F_{MSY} = 0.599$; Figure 3). Sensitivity runs of the model confirmed that these values were consistent.

Sources of uncertainty in the assessment included the lack of a fishery-independent index of abundance and the fact that three available indices used in the model were from fishery-dependent sources. Because the fishery operates in such a way that a trip consists of very few fish, the reliability of these indices as a true indicator of the stock is dubious. Also, the spawner-recruit relationship could not be determined and was ultimately fixed at a value agreed upon by the AW. Maximum Sustainable Yield-based management quantities rely heavily on this value so results should be considered with this uncertainty in mind.

There was evidence of a slight age truncation since the 1990s compared to the 1980s, but in general there was little change in age structure over time. The BAM predicted low abundance of cobia in the 1980s followed by high abundance in the 1990s and then another decline in the 2000s (Figure 2). The last strong year class in the model was predicted to have occurred in 2005. Predicted recruitment in the later years (2007-2009) was below average.

The next benchmark stock assessment for Atlantic Migratory Group cobia (SEDAR 58) was initiated in 2018 with a scheduled completion of early 2020. SEDAR 58 began with a stock identification workshop in April 2018 to review spatial, genetic, and life history information the species and make recommendations on stock boundaries for the assessment and management. The workshop maintained the Florida/Georgia border as the stock boundary since this boarder is within a transition zone that occurs from the southern boundary of Brevard County, FL to Brunswick, GA (SEDAR 2018). The SEDAR 58 data workshop was held in April 2019 to review and tabulate life history information, recommend discard mortality rates, recommend indices for use, and develop catch statistics for the recreational and commercial fisheries (SEDAR 2019).

STATUS OF THE FISHERY

Current Regulations

Under the Interstate Plan, North Carolina must implement seasons and/or vessel limits that constrain harvest to the 236,313 pound RHL. State landings will be evaluated against the RHL by averaging landings over a three year period. For the 2018 – 2020 fishing years, North Carolina implemented a 36-inch minimum size FL size limit and a one fish per person per day possession limit with a season from May 1 to December 31. Vessel limits for private vessels are set to two fish per vessel from May 1 to 31 and one fish per vessel from June 1 to December 31. Charter and for-hire vessels may harvest up to four fish per vessel from May 1 to December 31. The commercial fishery is managed under a 33-inch minimum size FL size limit and two fish per person per day possession limit, not to exceed six fish per vessel. Commercial landings are managed coast-wide under the Federal ACL (50,000 pounds).

Commercial Landings

Commercial landings of cobia in North Carolina are available from 1950 to the present. However, monthly landings were not available until 1974. North Carolina instituted mandatory reporting of commercial landings through their Trip Ticket Program, starting in 1994. Landings information collected since 1994 are considered the most reliable. Cobia landings from 1950 - 2018 have ranged from a low of 600 pounds whole weight (1951 and 1955) to a high of 52,684 pounds (2015) with average landings of 16,733 pounds over the 67-year time series. Recently, landings have ranged from 19,924 pounds (2011) to 52,684 pounds (2015), averaging 34,717 pounds over the last 10 years (Table 1; Figure 4). In 2018, 20,629 pounds were landed commercially in North Carolina.

The primary fisheries associated with cobia in North Carolina are the snapper-grouper, coastal pelagic troll, and the gill net fisheries. The primary commercial gear used to harvest cobia has changed over time. This is most likely due to changing fisheries and the fact that it is mostly considered a marketable bycatch fishery. From 1950 to the late 1970s, cobia were mostly landed out of the haul seine fishery. Most landings that occurred during the 1980s came from the pelagic troll and handline fishery with modest landings from the haul seine and anchored gill net fishery. From 1994 - 2018, most landings have occurred from the anchored gill net, pelagic troll, and handline fisheries with gill nets being the top gear during most of those years. In 2018, gill nets

accounted for 44% of the landings, while 46% of the landings were from the handline and pelagic troll fisheries combined (Table 2; Figure 5). Gill net landings have decreased since 2016 as the cobia season closed in early September in both 2017 and 2018. Since 2012, landings in the pound net fishery have increased, accounting for up to 12% of the total landings dependent on the year (Table 2).

Recreational Landings

Historically, recreational fisherman targeted cobia from a vessel by anchoring and fishing either dead or live bait, or both near inlets and deep water sloughs inshore (Manooch 1984). Fish were also harvested from shore or off piers using dead or live bait, most commonly menhaden. In the early 2000s, fisherman began outfitting their vessels with towers to gain a higher vantage point to spot and target free swimming cobia along tidelines and around bait aggregations. This method of fishing actively targets cobia in the nearshore coastal zone and has become the primary mode of fishing in most parts of the state.

Recreational harvest estimates are available from 1981 to the present. Recreational fishing activity is monitored through the Marine Recreational Information Program. In this report, estimates across all years have been updated and are now based on the MRIP new Fishing Effort Survey-based calibrated estimates. For more information on MRIP methodology changes see https://www.fisheries.noaa.gov/topic/recreational-fishing-data.

Recreational harvest of cobia in North Carolina has ranged from a low of zero pounds (1983) to a high of 1,925,762 pounds (2015) with average landings of 346,084 pounds over the 38-year time series. Recently, landings have ranged from 102,077 pounds (2012) to 1,925,762 pounds (2015), averaging 757,849 pounds over the last 10-year period (Table 1; Figure 4). Landings during the 1980s and 1990s remained relatively constant from year to year. Landings began to increase and become more variable beginning in the mid-2000s. Seasonally, cobia are landed mostly in the spring and summer months corresponding with their spring spawning migration (Smith 1995). Peak landings occur during the latter part of May into June and quickly diminish thereafter. However, recreational landings of cobia can occur through the month of October. By fishing mode, most recreational landings of cobia in North Carolina occur from private vessels (75%) with charter vessels (7%) and shore-based modes (18%) accounting for the rest.

The NCDMF offers award citations for exceptional catches of cobia. Harvested cobia that weigh greater than 40 pounds, and cobia captured and released that measure greater than 33 inches FL, are eligible for an award citation. Since 1991, just over 10,000 citations have been awarded for cobia. On average 10% of citations have been from released fish; in 2018, approximately 20% were from releases. From 1991 through 2005 the number of award citations for cobia steadily increased, but since 2005 the number of citations has fluctuated most likely dependent on the availability of the fish (Figure 6).

MONITORING PROGRAM DATA

Fishery-Dependent Monitoring

Fishery dependent length-frequency information for the commercial cobia fishery in North Carolina is collected by fish house samplers, the majority of which come NCDMF Program 438 (Offshore Live Bottom Fishery), as well as Program 431 (Sciaenid Pound Nets) and Program 434 (Ocean Gill Net Fishery). Length-frequency information for the recreational cobia fishery is collected through the NCDMF carcass collection program and MRIP. Eleven cobia were measured from the commercial fishery in 2018 with an average FL of 40 inches (Table 3). Mean FL has ranged from 36 to 43 inches since 1994. Cobia landed in the commercial fishery have ranged from 18 to 61 inches FL (Table 3; Figure 7). Sixty cobia were measured by MRIP in 2018 with an average FL of 41 inches (Table 4). Mean size has ranged from 20 to 49 inches FL over the time series. Cobia harvested in the recreational fishery have ranged from 9 to 68 inches FL (Table 4; Figure 8). The number of commercial and recreational sampled fish is low and is most likely affected by low possession limits and seasonal nature of the fishery. Size trends in commercially landed fish appear to correspond with sizes observed in the recreational fishery though at lower frequencies (Tables 3 and 4; Figure 9).

In order to describe the age structure of harvest and indices, cobia age structures are collected from various fishery-independent (scientific surveys) and dependent (fisheries) sources throughout the year. Aging structures are provided to the NOAA Beaufort Age Lab for analysis. In 2017, 50 cobia were collected ranging in age from 0 to 13 years (Table 5). In 2018, 94 cobia were collected for aging, but these have not yet been aged. The modal age of cobia collected each year is hard to determine due to low sample size. The age-length relationship is less predictable beyond age-3 as there is overlap in age for a given length (Figure 10).

Fishery-Independent Monitoring

Currently, the NCDMF does not have many fishery-independent sampling programs that target or catch cobia in great numbers.

In 2001, the NCDMF initiated a fisheries independent gill net survey in Pamlico Sound. The objective of this project is to provide annual, independent, relative-abundance indices for key estuarine species in the nearshore Pamlico Sound. The survey employs a stratified random sampling design and utilizes multiple mesh gill nets (3.0-inch to 6.5-inch stretched mesh, by ½-inch increments). A total of 116 cobia have been captured in the Pamlico Sound independent gill net survey from 2001 to 2018. Cobia ranged from 6 to 38 inches FL and had a mean size of 25 inches FL. Due to the low number of positive trips (ranging from <1% to 5% of all sets), this survey cannot be used to create an index.

MANAGEMENT STRATEGY

As of March 2019, cobia is managed solely under the ASMFC Interstate Plan requirements. The previous joint Gulf of Mexico and SAFMC FMP and the interstate plan both aim to maintain spawning stock biomass (SSB) above a threshold which allows for surplus recruitment to the stock. To achieve this, a risk adverse approach to management was implemented that attempts to constrain harvest to established Federal ACLs.

RESEARCH NEEDS

Current research needs for cobia can be found in the most recent SEDAR 28 (2013) report and the Interstate Plan (ASMFC 2017). Below is a list of state prioritized research needs based off the recommendations from SEDAR 28, the Interstate Plan, and input from NCDMF lead staff.

- Increase reporting of recreational harvest and better characterize the recreational and for-hire fisheries- HIGH (Needed)
- Develop fishery-independent sampling programs to obtain estimates of cobia abundance- HIGH (Needed)
- Develop a tagging program and evaluate genetic samples for South Atlantic cobia populations to elucidate the stock boundaries, inshore and offshore migration, and to better identify spawning areas and aggregations of the species-HIGH (Ongoing)
- Better characterize the life history of cobia including; age sampling of the recreational sector, update age- and length-at-maturity, batch fecundity, spawning seasonality, and spawning frequency information- HIGH (Ongoing)
- Investigate release mortality and fishing mortality within the commercial and recreational fisheries in the U.S. South Atlantic-MEDIUM (Ongoing)

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TABLES

Table 1. Recreational harvest (number of fish released and weight) and releases (number of fish; MRIP) and commercial harvest (weight in pounds; Atlantic Coastal Cooperative Statistic Program and N.C. Trip Ticket Program) of cobia from North Carolina, 1981-2018. All weights are in pounds.

	Recreational				
	Numbers		Weight (lb)	Commercial	Total
Year	Landed	# Released	Landed	Weight (lb)	Weight (lb)
1981	1,690		3,726	5,260	8,986
1982	6,257		8,430	10,574	19,004
1983		9,464		4,279	4,279
1984	7,167	6,108	259,354	6,701	266,055
1985	1,763	8,471	2,720	6,640	9,360
1986	17,956	9,112	533,982	18,303	552,285
1987	6,959	592	81,833	32,672	114,505
1988	5,716	3,257	103,975	15,690	119,665
1989	9,872	2,262	208,259	14,898	223,157
1990	10,054	6,089	188,539	21,938	210,477
1991	11,524	22,522	266,633	23,217	289,850
1992	10,711	9,777	317,628	18,534	336,162
1993	6,346	2,778	168,142	20,431	188,573
1994	6,908	4,543	169,168	30,586	199,754
1995	9,530	4,817	302,745	35,134	337,879
1996	4,744	2,000	102,899	33,404	136,303
1997	4,115	13,723	129,299	42,063	171,362
1998	3,132	9,859	117,754	22,197	139,951
1999	2,399	18,498	101,465	15,463	116,928
2000	2,473	4,734	91,143	28,754	119,897
2001	3,548	18,500	121,751	24,718	146,469
2002	7,196	14,036	319,178	21,058	340,236
2003	6,948	21,722	223,508	21,313	244,821
2004	12,522	11,079	420,684	20,162	440,846
2005	18,491	19,083	401,557	17,886	419,443
2006	5,154	11,425	196,330	20,270	216,600
2007	6,262	12,695	218,447	19,005	237,452
2008	3,972	24,028	167,463	22,047	189,510
2009	12,823	55,374	320,075	31,898	351,973
2010	24,030	48,590	808,227	43,715	851,942
2011	10,711	47,151	399,192	19,924	419,116
2012	3,805	66,567	102,077	31,972	134,049
2013	37,617	35,398	980,541	35,456	1,015,997
2014	24,601	32,184	645,427	41,798	687,225
2015	47,110	44,254	1,925,762	52,684	1,978,446
2016	26,421	39,237	838,363	48,252	886,615
2017	25,025	125,251	872,861	20,842	893,703
2018	25,331	68,219	685,962	20,629	706,591
All	11,645	23,150	346,084	24,220	361,196

Table 2. Commercial harvest (weight in pounds) by gear, 2009-2018. (Source: North Carolina Trip Ticket Program)

Year	Gill Nets	Hook & Line	Trolling	Pound Nets	Other*	Total
2009	19,140	4,027	5,738	851	2,143	31,898
2010	22,087	10,021	9,166	782	1,660	43,715
2011	7,890	6,621	4,521	610	282	19,924
2012	19,482	6,011	1,421	3,681	1,378	31,972
2013	11,744	15,530	4,453	2,506	1,223	35,456
2014	21,288	9,670	6,163	3,538	1,140	41,798
2015	32,904	10,624	3,560	4,541	1,055	52,684
2016	32,809	9,041	2,314	3,434	656	48,252
2017	11,768	4,765	1,056	2,541	712	20,842
2018	8,965	7,040	2,552	1,636	436	20,629

**Other can include beach seines, trawls, crab and fish pots, flynets, fyke nets, spears, longlines, and haul seines.*

Table 3. Mean, minimum, and maximum lengths (fork length, inches) of cobia sampled from the commercial fisheries (NCDMF fish house sampling programs) from North Carolina, 1981-2018.

Year	Mean Fork Length	Minimum Fork Length	Maximum Fork Length	Total Number Measured
1981	4	4	4	1
1982	36	34	37	12
1983	39	36	42	14
1984	38	9	53	59
1985	37	23	64	52
1986	38	24	52	51
1987	37	5	50	65
1988	40	21	57	72
1989	35	3	48	53
1990	38	14	53	126
1991	36	8	46	52
1992	39	30	47	50
1993	37	32	46	27
1994	40	35	45	3
1995	39	33	48	14
1996	39	37	40	2
1997	40	37	43	3
1998	0	0	0	0
1999	37	25	45	7
2000	41	33	61	8
2001	37	30	42	8
2002	38	33	41	6
2003	40	30	46	13
2004	38	26	49	27
2005	43	33	54	12
2006	40	32	49	22
2007	40	31	52	24
2008	39	18	57	29
2009	39	30	44	15
2010	43	34	52	30
2011	38	34	46	13
2012	38	29	50	31
2013	38	33	46	16
2014	36	30	53	32
2015	39	32	48	34
2016	39	33	51	13
2017	42	36	46	8
2018	40	33	48	11

Table 4. Mean, minimum, and maximum lengths (fork length, inches) of cobia sampled from the recreational fisheries (MRIP) from North Carolina, 1981-2018.

Year	Mean Fork Length	Minimum Fork Length	Maximum Fork Length	Total Number Measured
1981	19	19	19	1
1982	16	16	16	1
1983	0	0	0	
1984	45	45	45	2
1985	20	20	20	
1986	43	20	50	7
1987	28	9	48	13
1988	22	16	50	9
1989	36	11	55	16
1990	35	11	53	28
1991	35	11	60	20
1992	42	22	52	19
1993	42	31	51	16
1994	40	18	52	18
1995	43	31	54	25
1996	37	17	61	37
1997	43	35	51	17
1998	46	35	55	28
1999	48	41	55	5
2000	43	26	58	8
2001	45	33	59	11
2002	49	34	59	16
2003	46	33	56	19
2004	43	32	58	26
2005	37	20	61	30
2006	43	34	57	12
2007	44	34	49	8
2008	45	33	55	5
2009	38	23	51	8
2010	43	23	59	58
2011	42	14	68	21
2012	39	30	62	11
2013	39	12	50	34
2014	39	33	58	41
2015	44	32	58	65
2016	43	35	59	54
2017	43	36	58	27
2018	41	33	57	60

Table 5. Summary of cobia age samples collected from both dependent (commercial and recreational fisheries) and independent (surveys) sources, 2008-2018.

Year	Minimum Age	Maximum Age	Total Number Aged
2008	0	1	7
2009	1	1	4
2010	0	12	13
2011	0	1	6
2012	1	4	5
2013	1	1	1
2014*			0
2015	1	1	1
2016	0	11	20
2017	0	13	50
2018**			94

**Cobia was not added to the priority species list for sampling until 2016; as a result, no species were collected this year.*
***Age samples not read.*

FIGURES

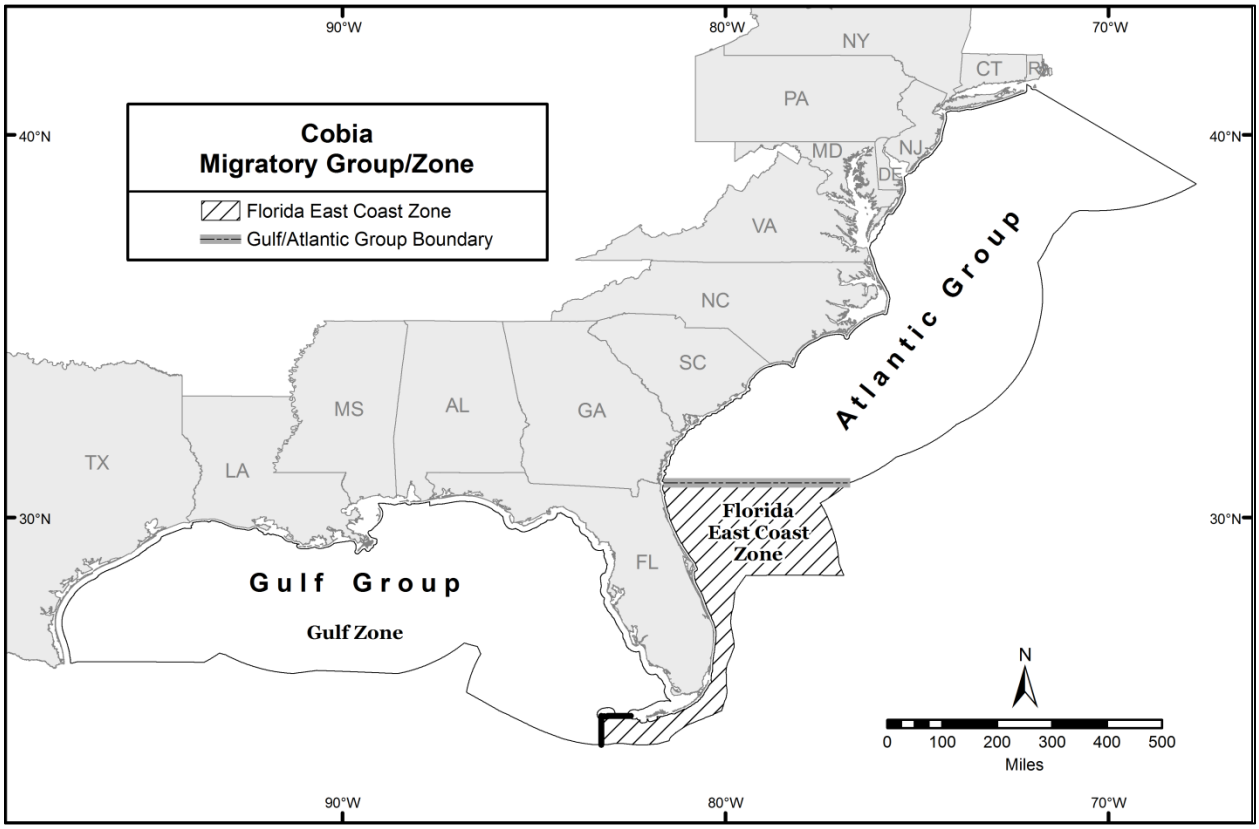

Figure 1. Zone splits for Gulf and Atlantic Migratory Group cobia established in Coastal Migratory Pelagics FMP Amendment 20b (Source: GMFMC/SAFMC 2014).

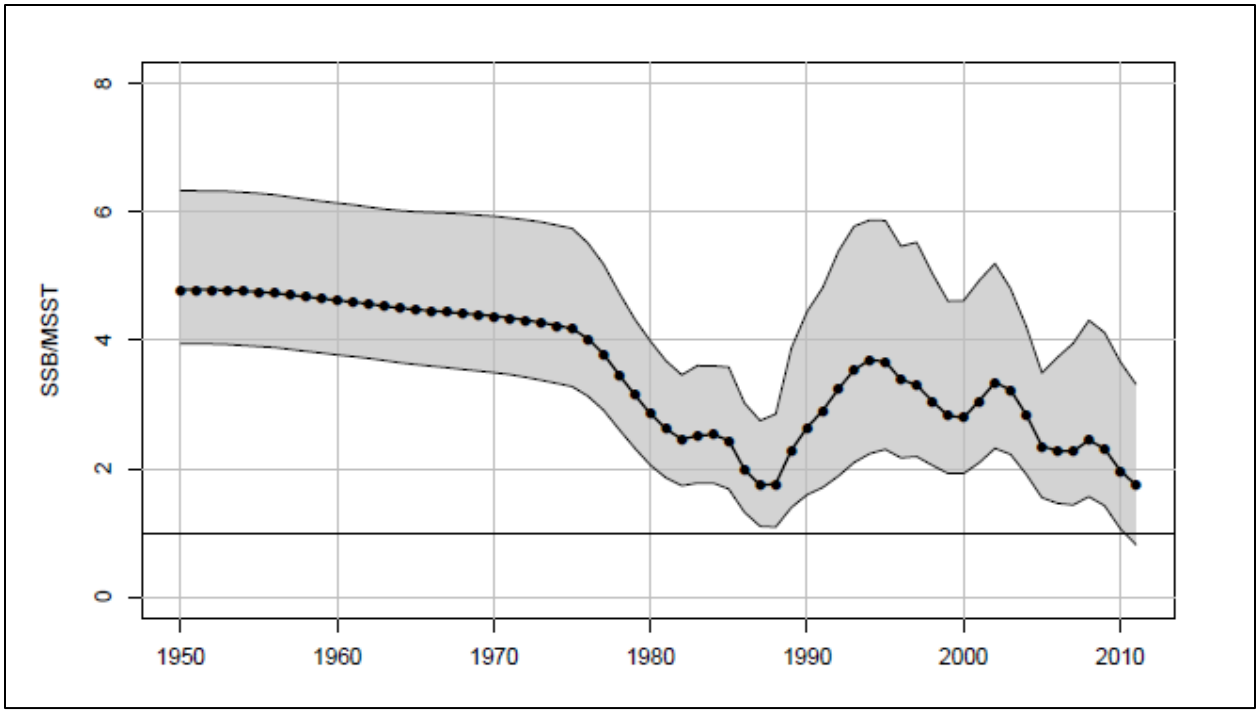

Figure 2. Spawning Stock Biomass (SSB) relative to Minimum Stock Size Threshold (MSST) for cobia from SEDAR 28 (SEDAR 2013). The shaded gray error bands indicate 5th and 95th percentiles of the MCB trials.

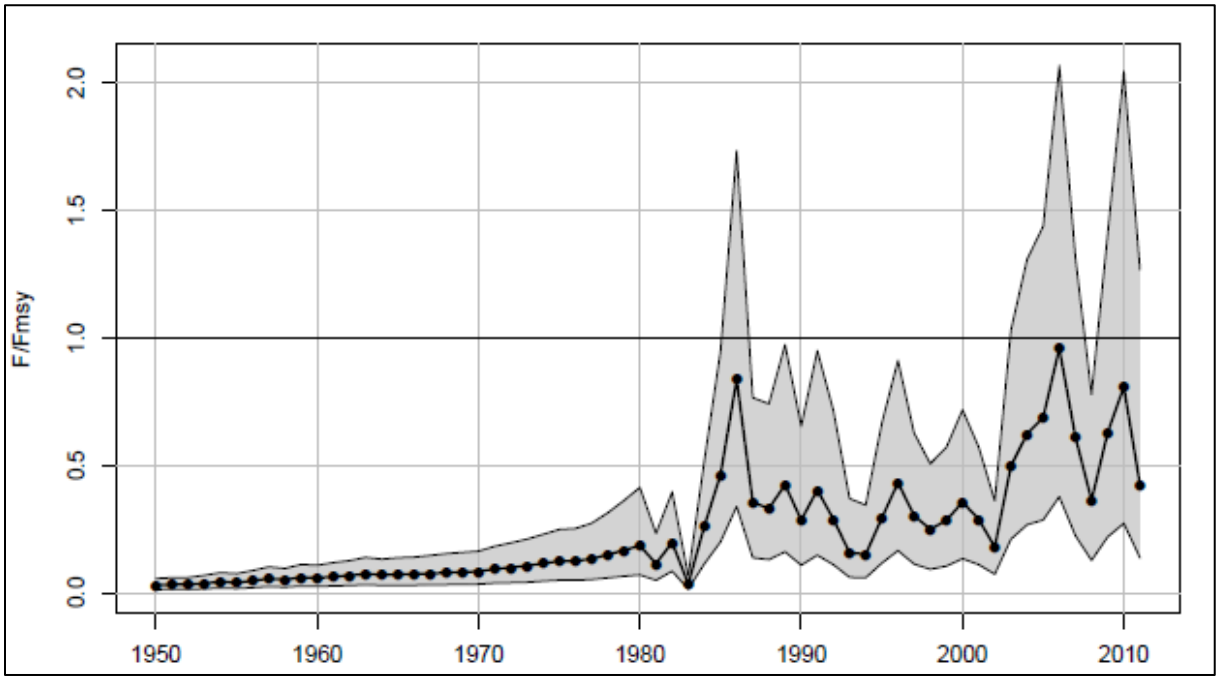

Figure 3. Fishing mortality (F) relative to Fishing mortality at maximum sustainable yield (F_{MSY}) for cobia from SEDAR 28 (SEDAR 2013). The shaded gray error bands indicate 5th and 95th percentiles of the MCB trials.

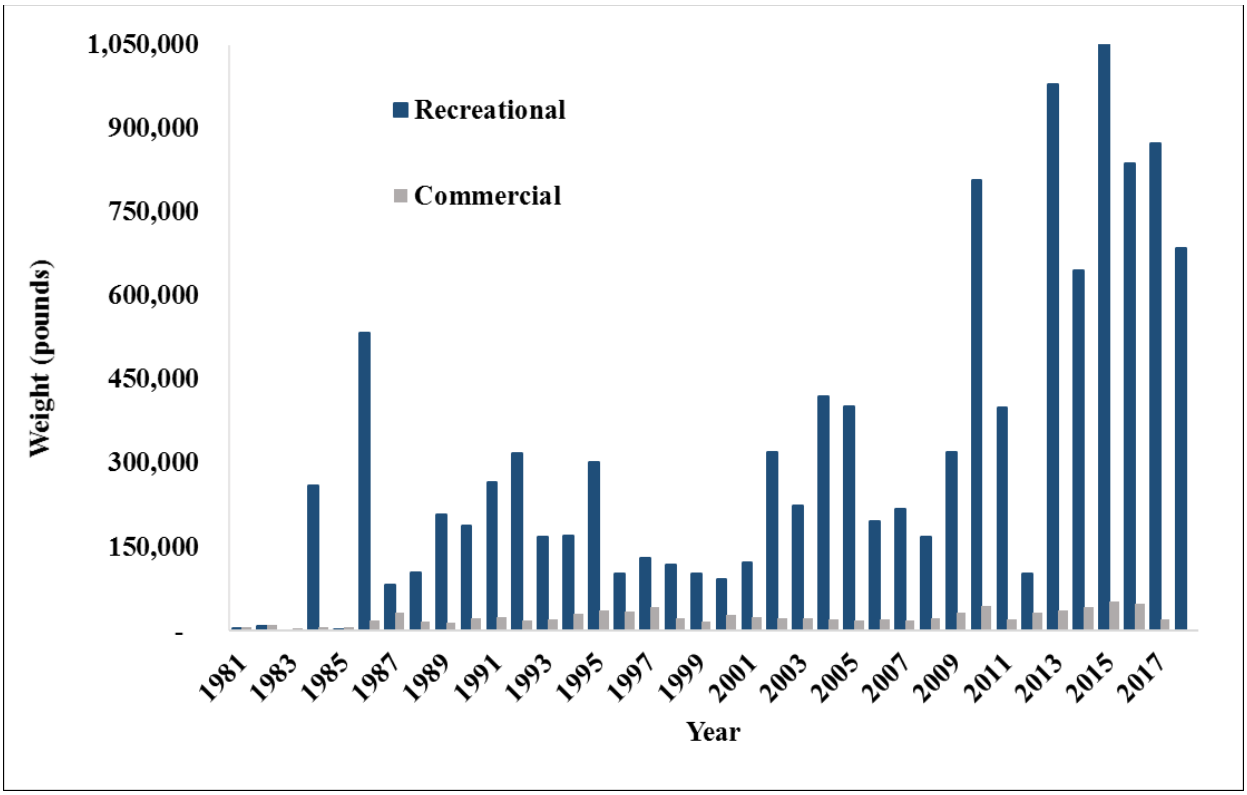

Figure 4. Annual commercial and recreational landings in pounds for cobia in North Carolina from 1981 to 2018.

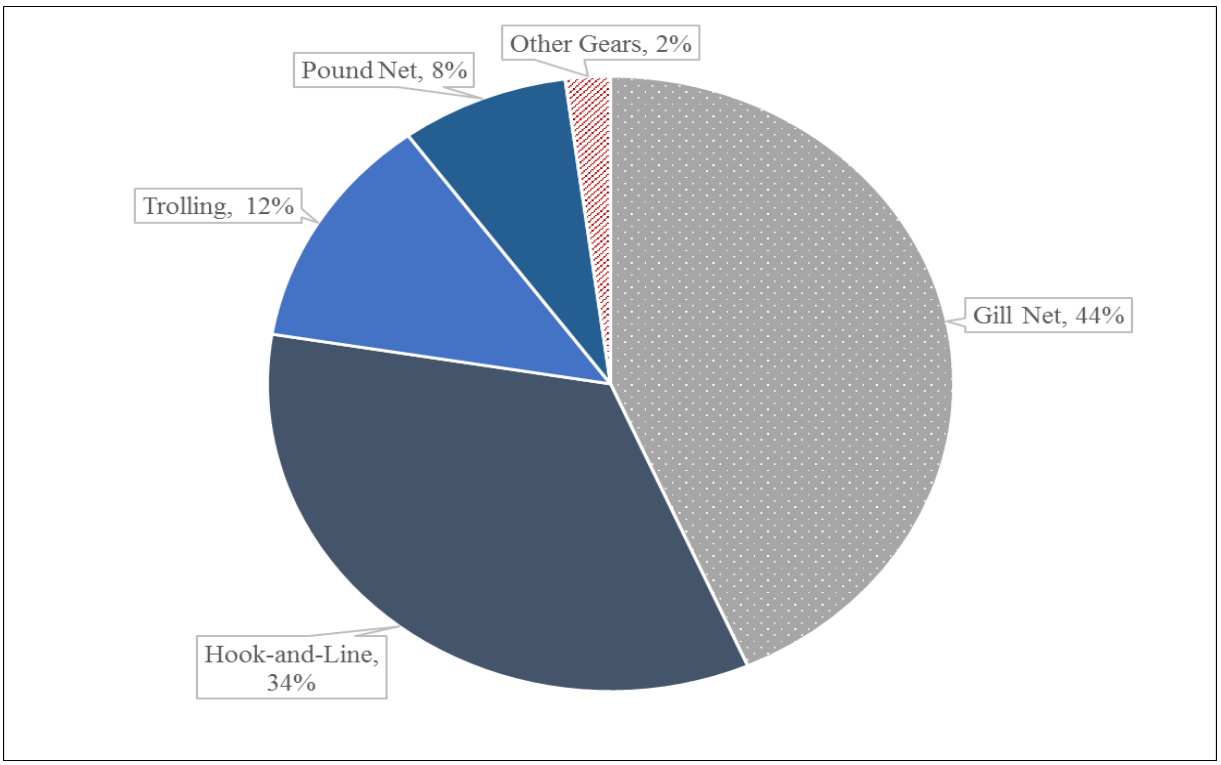

Figure 5. Commercial harvest in 2018 by gear type. Other gears can include beach seines, trawls, crab and fish pots, flynets, fyke nets, spears, longlines, and haul seines.

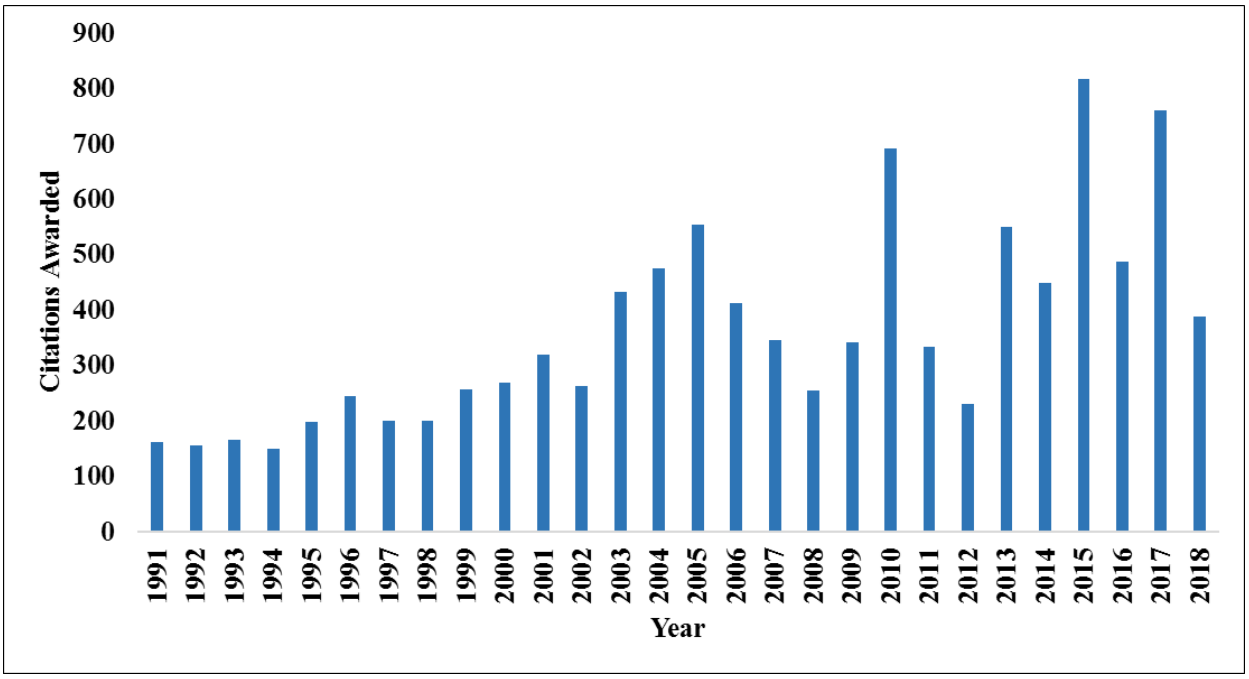

Figure 6. North Carolina Saltwater Fishing Tournament citations awarded for cobia from 1991 to 2018.

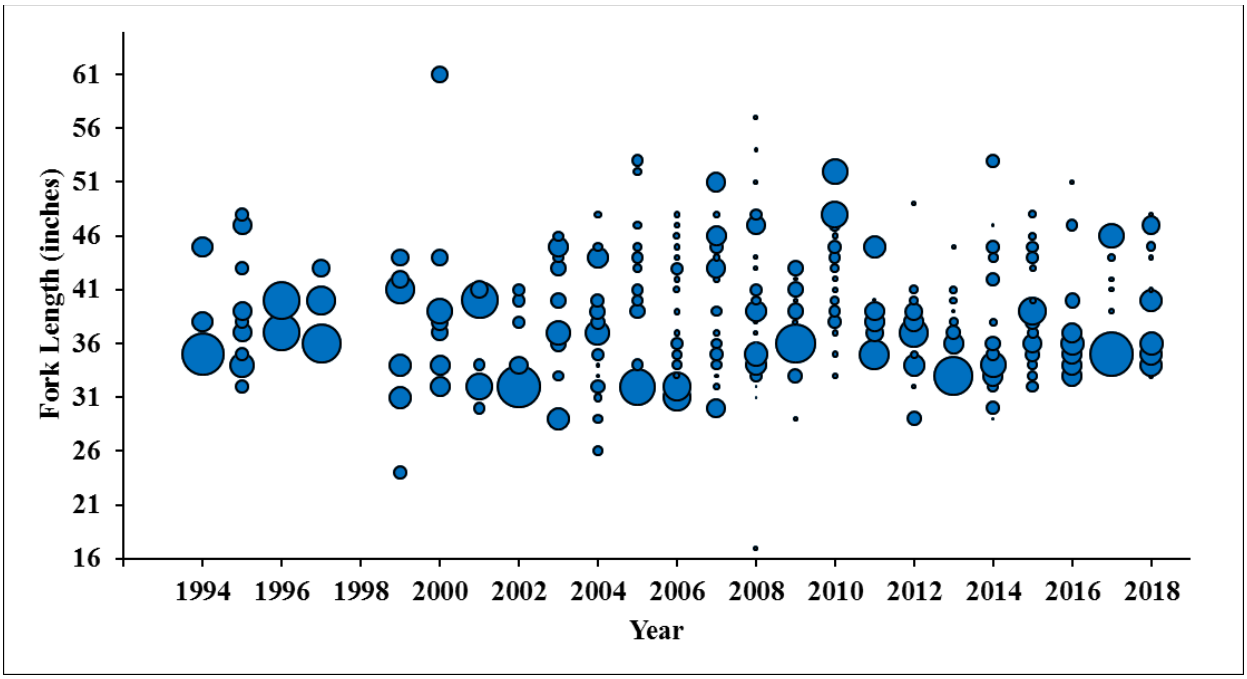

Figure 7. Commercial length frequency (fork length, inches) of cobia harvested from 1994 to 2018. Bubbles represent fish harvested at length and the size of the bubble is equal to the proportion of fish at that length.

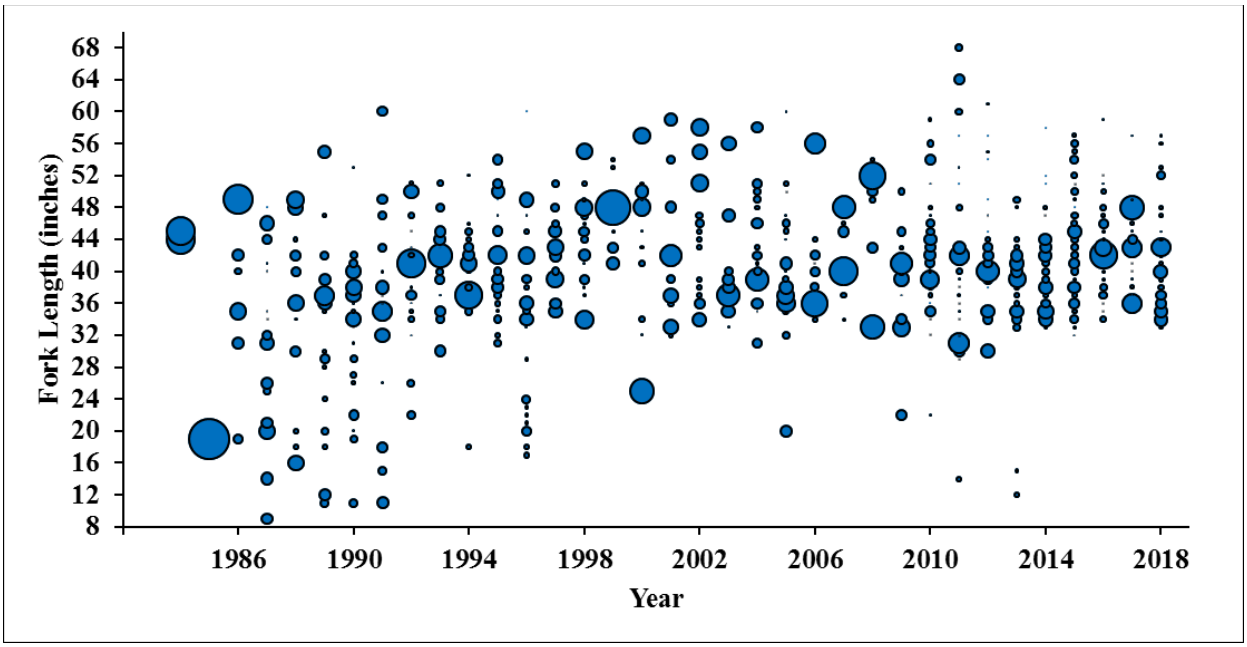

Figure 8. Recreational length frequency (fork length, inches) of cobia harvested from 1984 to 2018. Bubbles represent fish harvested at length and the size of the bubble is equal to the proportion of fish at that length.

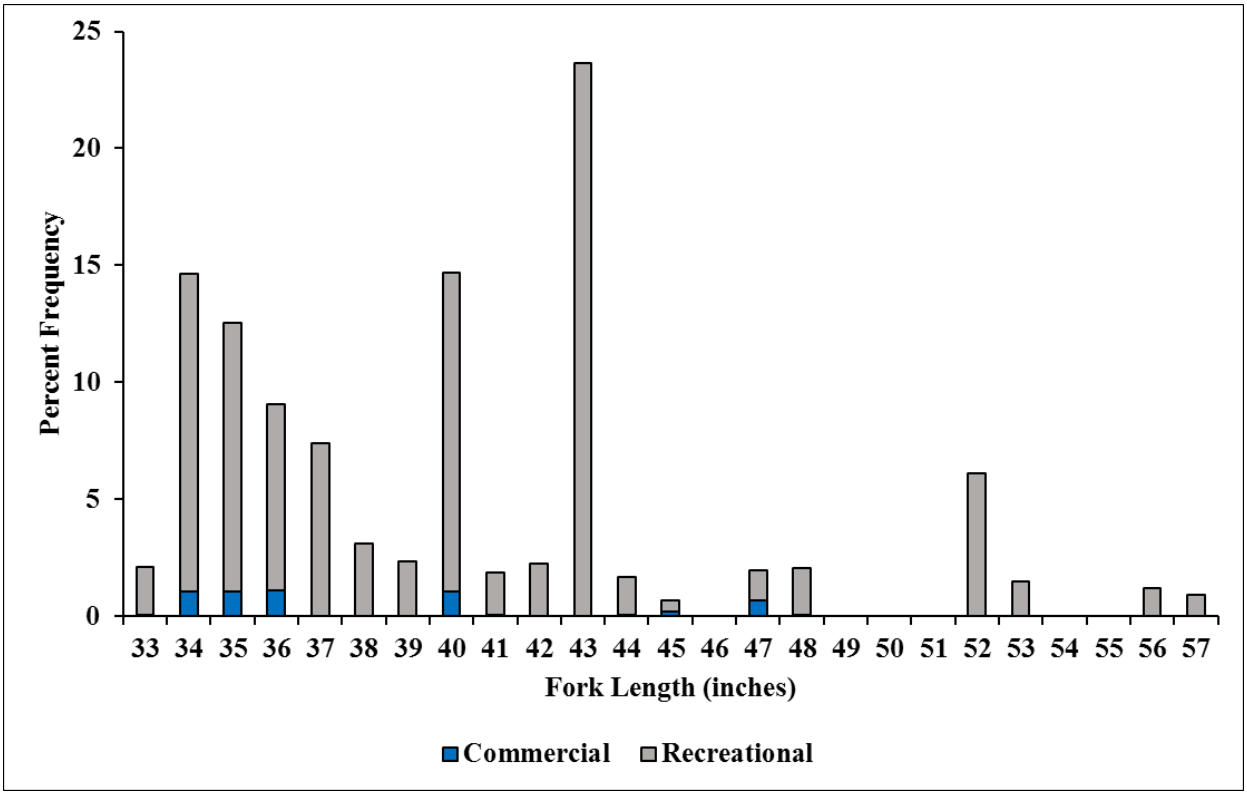

Figure 9. Commercial and recreational length frequency distribution from cobia harvested in 2018.

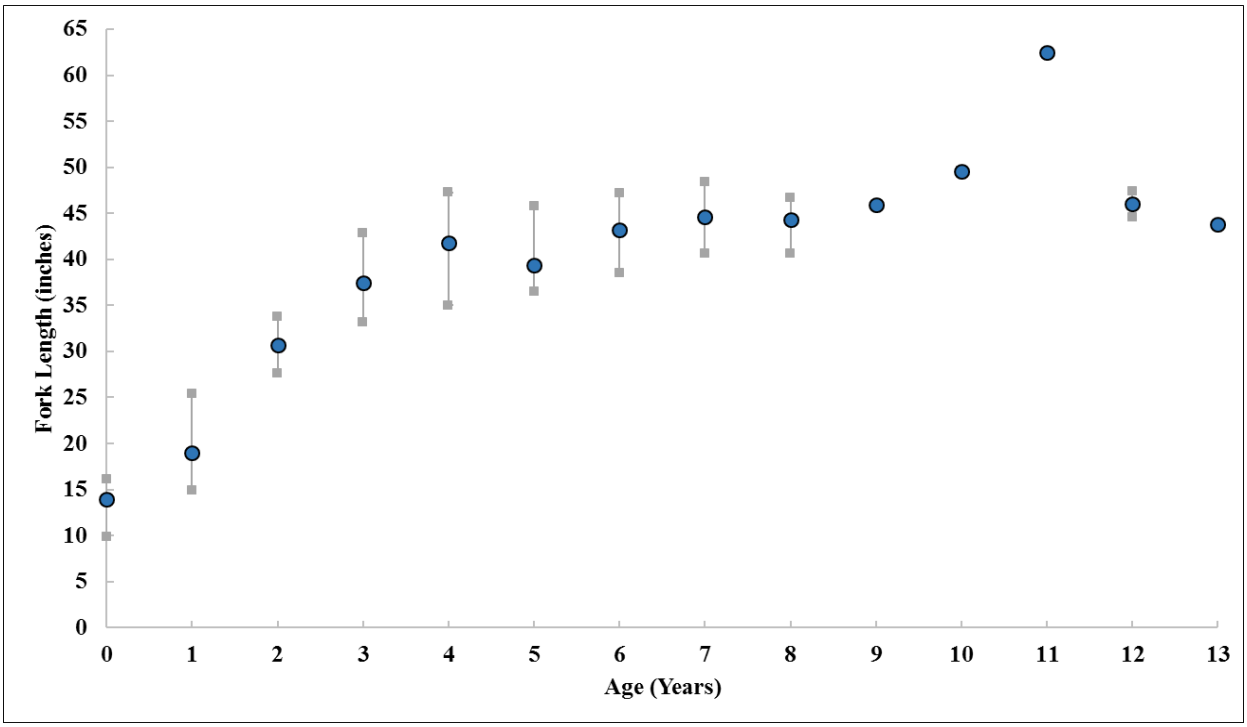

Figure 10. Cobia length at age based on all age samples collected from 2008 to 2017. Blue circles represent the mean size at a given age while the grey squares represent the minimum and maximum observed size for each age.

FISHERY MANAGEMENT PLAN UPDATE
DOLPHIN
AUGUST 2019

STATUS OF THE FISHERY MANAGEMENT PLAN

Fishery Management Plan History

Original FMP Adoption:	June 2004
Amendments:	Amendment 1 – July 2010 Amendment 2 – April 2012 Amendment 3 – August 2014 Amendment 5 – July 2014 Amendment 6 – January 2014 Amendment 7 – January 2016 Amendment 8 – February 2016 Regulatory Amendment 1 – March 2017
Revisions:	None
Supplements:	None
Information Updates:	None
Next Benchmark Review:	None

The South Atlantic Fishery Management Council (SAFMC), in cooperation with the Mid-Atlantic and New England Councils, developed a Dolphin/Wahoo Fishery Management Plan (FMP) for the Atlantic in 2004. While dolphin was not overfished, the Council adopted a precautionary and risk-averse approach to management for this fishery. The original FMP established a 20-inch fork length (FL) minimum size limit off Georgia and Florida; identified allowable gears in the fishery; and prohibited the use of longline gear to harvest dolphin in areas closed to use of such gear for highly migratory species. Amendment 1 (2010) provided spatial information of Council-designated Essential Fish Habitat and Habitat Areas of Particular Concern relative to the dolphin wahoo fishery. Amendment 2 (SAFMC 2011) established Allowable Biological Catch (ABC), Annual Catch Limits (ACL), Accountability Measures (AM), and modified the allocations for both commercial and recreational sectors; established Annual Catch Targets (ACT) for the recreational sector; prohibited bag limit sales of dolphin from for-hire vessels; and established a 20-inch FL minimum size limit for South Carolina. Amendment 3 (SAFMC 2014, 79 F.R. 19490) required federal dealer permits, and changed the method and frequency of reporting harvest. Amendment 4 (in progress) would change the method of reporting commercial harvest of dolphin through the existing logbook program and is included under the Joint Generic Commercial Logbook Reporting Amendment. In 2013, Amendment 5 (SAFMC 2013) was approved and adopted by the SAFMC and was the most comprehensive amendment to the Dolphin/Wahoo FMP, in terms of process updates.

Amendment 5 updated the ACLs and AM for both sectors, as well as the ABC values and ACT for the recreational fishery as a result of improvements to the recreational catch estimation methods used by the Marine Recreational Information Program. This amendment also set up an abbreviated framework procedure whereby modifications to the ACLs, ACTs, and AMs can be implemented by the National Oceanic and Atmospheric Administration (NOAA) Fisheries without a full FMP amendment. Amendment 7 (SAFMC 2015a) allowed for dolphin and wahoo fillets to enter the U.S. EEZ after lawful harvest in the Bahamas. Amendment 8 (SAFMC 2015b) adjusted sector allocations and increased the commercial ACL to 10% of the total ACL. Regulatory Amendment 1 (SAFMC 2016), effective March 2017, establishes a commercial trip limit for vessels with an Atlantic dolphin/wahoo permit of 4,000 pounds for the dolphin commercial sector once 75% of the commercial ACL is landed. This regulatory change was pursued after the 2015 commercial ACL was met and commercial harvest was closed in late June of that year. As of August 2019, Amendment 10 is in development, which is focused on accommodating revised MRIP data, revising sector allocations, and other miscellaneous management revisions for the dolphin and wahoo fisheries.

To ensure compliance with interstate requirements, North Carolina also manages this species 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, SAFMC, or the Atlantic States Marine Fisheries Commission 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 plans) and the Atlantic Coastal Fisheries Cooperative Management Act (Atlantic States Marine Fisheries Commission plans), are, like the goals of the Fisheries Reform Act of 1997, to "ensure long-term viability" of these fisheries (NCDMF 2015).

Management Unit

The management unit is the population of dolphin (common dolphin - *Coryphaena hippurus* and pompano dolphin - *Coryphaena equiselis*) from the U.S. South Atlantic, the Mid-Atlantic, and the New England coasts in the 3 to 200-mile Exclusive Economic Zone (EEZ).

Goal and Objectives

The goal of the plan is to maintain the current harvest levels of dolphin and ensure that no new fisheries develop (SAFMC 2003). With the potential for effort shifts in the historical commercial longline fisheries for sharks, tunas, and swordfish, these shifts or expansions into nearshore coastal waters to target dolphin could compromise the historical (1994-1997) and current allocation of the dolphin resource between recreational and commercial fishermen. To achieve these goals, the following management objectives were identified:

1. Address localized reduction in fish abundance. The Councils remain concerned over the potential shift of effort by longline vessels to traditional recreational fishing grounds and the resulting reduction in local availability if commercial harvest intensifies.

2. Minimize market disruption. Commercial markets (mainly local) may be disrupted if large quantities of dolphin are landed from intense commercial harvest or unregulated catch and landing by charter or other components of the recreational sector.
3. Minimize conflict and/or competition between recreational and commercial user groups. If commercial longlining effort increases, either directing on dolphin and wahoo or targeting these species as a significant bycatch, conflict and/or competition may arise if effort shifts to areas traditionally used by recreational fishermen.
4. Optimize the social and economic benefits of the dolphin fishery. Given the significant importance of dolphin to the recreational sector throughout the range of these species and management unit, manage the resources to achieve optimum yield on a continuing basis.
5. Reduce bycatch of the dolphin fishery. Bycatch is a problem in the pelagic longline fishery for highly migratory species. Any increase in overall effort, and more specifically shifts of effort into nearer shore, non-traditional fishing grounds by swordfish and tuna vessels, may result in increased bycatch of non-target species. In addition, National Standard 9 requires that: "Conservation and management measures shall, to the extent practicable, (A) minimize bycatch and (B) to the extent bycatch cannot be avoided, minimize the mortality of such bycatch." Therefore, bycatch of the directed dolphin fishery must be addressed.
6. Direct research to evaluate the role of dolphin and wahoo as predator and prey in the pelagic ecosystem.
7. Direct research to enhance collection of biological, habitat, social, and economic data on dolphin and wahoo stocks and fisheries.

STATUS OF THE STOCK

Life History

Dolphin, also called mahi-mahi, dorado or common dolphin, are pelagic marine species and can be found worldwide in tropical and subtropical waters. They are sight feeders and usually live in the top 50 feet of the water column. They gather around floating debris and flotsam and prefer water temperatures ranging from 21 – 30 degrees Celsius (70 - 86 degrees Fahrenheit). Adult male and female fish are commonly referred to as 'bulls' and 'cows' respectively, because of their different shapes and appearance. Mature male dolphin have a high, flat forehead unlike females. The species is short lived (maximum age is 4) and grows rapidly, with some fish reaching lengths of 36 inches by age-1 (Schwenke et al. 2008). The state record for dolphin was caught off Cape Hatteras in 1993 and weighed 79 pounds; however, most fish landed in North Carolina weigh between 5 and 25 pounds. Dolphin can become sexually mature by four months and as small as 14 inches FL with most fish maturing by 24 inches FL (Schwenke et al. 2008). They are considered batch spawners, meaning they will spawn many times throughout the spawning season, maximizing the survival of larval fish. Spawning occurs offshore of North Carolina around floating grass (brown algae known as Sargassum) and debris during the spring and summer months. In tropical areas, dolphin have been known to spawn year-round.

Stock Status

A surplus production model, as part of an exploratory stock assessment, was fit to abundance indices estimated from long line catches and total landings of the fisheries from years 1985 to

1997. It was concluded that the stock status, as of 1998, was above biomass at maximum sustainable yield (B_{MSY}) and the species can withstand a relatively high rate of exploitation (Prager 2000).

Stock Assessment

No formal assessment has been conducted on dolphin in the U.S. Atlantic due to uncertainties in the extent of the North Atlantic stock, the life history characteristics of the species, lack of fishery independent indices, and the jurisdictional cooperation necessary to characterize catch across the range of the species. An assessment of dolphin is not expected in the next five years through the Southeast Data, Assessment, and Review (SEDAR) process.

STATUS OF THE FISHERY

Current Regulations

The North Carolina Division of Marine Fisheries (NCDMF) currently complements the management measures of the Dolphin/Wahoo FMP through rule (15A NCAC 03M .0515) and proclamation (15A NCAC 03M. 0512). It is unlawful to possess more than 10 dolphin per person per day or more than 60 dolphin per vessel per day. Headboats are excluded from the vessel limit requirement. It is also unlawful to sell a recreational bag limit of dolphin harvested by a person on a vessel while it is operating as a charter vessel or headboat or to sell dolphin without a Federal Commercial Dolphin/Wahoo Vessel Permit. There is no trip limit for vessels that possess the Federal Commercial Dolphin/Wahoo Vessel Permit unless 75% of the commercial ACL is reached, at which time a 4,000-pound weight trip limit is implemented. Commercial vessels that are federally permitted in another fishery are allowed to land up to 200 pounds of dolphin and wahoo combined.

Commercial Landings

Commercial landings of dolphin are reported through the mandatory NCDMF Trip Ticket reporting program. Landings since 1986 have fluctuated with a low of 35,923 pounds in 1986 and a high of 611,962 pounds in 2009 (Table 1 and Figure 1). Commercial landings have been declining since 2014, with a low of 144,660 pounds in 2018. Over 75% of dolphin landings were harvested using surface longlines with the remainder of the harvests coming from the pelagic troll and greenstick fisheries.

Recreational Landings

Recreational fishing activity is monitored through the Marine Recreational Information Program. In this report, estimates across all years have been updated and are now based on the MRIP new Fishing Effort Survey-based calibrated estimates. For more information on MRIP methodology changes see https://www.fisheries.noaa.gov/topic/recreational-fishing-data.

After peaking in 2009 (6,380,552 pounds), landings of dolphin declined to low of 2,223,509 pounds in 2017 (Table 1 and Figure 2). Landings increased slightly to 3,318,532 pounds in 2018.

Directed effort in the fishery and recreational harvest show similar trends and most likely contributes to the variable landings observed in the fishery.

The NCDMF offers award citations for recreational fishermen who land dolphin greater than 35 pounds. The number of citations awarded annually since the program started for dolphin has been variable, with a declining trend since 2013 (Table 2; Figure 2). The total number of citations awarded through the North Carolina Saltwater Fishing Tournament remained low in 2018.

MONITORING PROGRAM DATA

Fishery-Dependent Monitoring

Fishery dependent length-frequency information for the commercial dolphin fishery in North Carolina is collected by fish house samplers, specifically through NCDMF programs 438 and 439. Lengths collected from fishery-dependent sampling ranged from 12.0 to 57.2 inches fork length in 2018 (Table 3; Figure 3). The average size of dolphin sampled from the commercial fishery increased in 2018 (28.8 inches fork length) from the previous year and was similar to the time series average (27.5 inches fork length; Table 3; Figure 4). The maximum size of dolphin sampled from the commercial fishery also increased in 2018 (47.2 inches fork length) by almost 10 inches from 2017 (Table 3; Figure 4).

Length and weight information for the recreational fishery are collected through the MRIP dockside sampling. The recreational fishery harvests larger dolphin than the commercial fishery (Figure 3); the maximum length of dolphin sampled from the recreational fishery throughout the time series was 67.9 inches fork length in 2010, compared to 56.7 inches fork length by the commercial fishery in 2013 (Table 3; Figure 5). The average size of dolphin sampled from the recreational fishery decreased in 2018 (25.6 inches fork length) but overall has remained relatively constant throughout the time series (Table 3; Figure 5). The maximum size of dolphin sampled from the recreational fishery increased in 2018 (57.2 inches fork length) and was the largest observed since 2013 (Table 3).

Fishery-Independent Monitoring

Currently, NCDMF does not have any fishery-independent sampling programs that target or catch dolphin in great numbers.

MANAGEMENT STRATEGY

In North Carolina, dolphin is included in the North Carolina Fishery Management Plan for Interjurisdictional Fisheries, which defers to management under the South Atlantic Fishery Management Council Fishery Management Plan requirements. The South Atlantic Fishery Management Council approved a Fishery Management Plan for dolphin in 2004 and it is currently managed under Amendment 5 (SAFMC 2013), Amendment 7 (SAFMC 2015a), Amendment 8 (SAFMC 2015b) and Regulatory Amendment 1 (SAFMC 2016).

RESEARCH NEEDS

The following are research and management needs as determined by the council and outlined in the FMPs for pelagic *Sargassum* habitat and the dolphin/wahoo fishery (SAFMC 2002; SAFMC 2003).

Essential Fish Habitat research needs for dolphin in order of priority from highest to lowest:

1. What is the areal and seasonal abundance of pelagic *Sargassum* off the southeast U.S.?
2. Develop methodologies to remotely assess *Sargassum* using aerial or satellite technologies (e.g., Synthetic Aperture Radar)
3. What is the relative importance of pelagic *Sargassum* weedlines and oceanic fronts for early life stages of dolphin?
4. Are there differences in dolphin abundance, growth rate, and mortality?
5. What is the age structure of all fishes that utilize pelagic *Sargassum* habitat as a nursery and how does it compare to the age structure of recruits to pelagic and benthic habitats?
6. Is pelagic *Sargassum* mariculture feasible?
7. Determine the species composition and age structure of species associated with pelagic *Sargassum* when it occurs deeper in the water column.
8. Additional research on the dependencies of pelagic *Sargassum* productivity on the marine species using it as habitat.
9. Quantify the contribution of nutrients to deepwater benthic habitat by pelagic *Sargassum*.
10. Studies should be performed on the abundance, seasonality, life cycle, and reproductive strategies of *Sargassum* and the role this species plays in the marine environment, not only as an essential fish habitat, but as a unique pelagic algae.
11. Research to determine impacts on the *Sargassum* community, as well as the individual species of this community that are associated with, and/or dependent on, pelagic *Sargassum*. Human induced (tanker oil discharge; trash) and natural threats (storm events) to *Sargassum* need to be researched for the purpose of protecting and conserving this natural resource.
12. Develop cooperative research partnerships between the Council, NOAA Fisheries Protected Resources Division, and state agencies since many of the needs to a) research pelagic *Sargassum*, and b) protect and conserve pelagic *Sargassum* habitat, are the same for both managed fish species and listed sea turtles.
13. Direct specific research to further address the association between pelagic *Sargassum* habitat and post-hatchling sea turtles

Biological research reeds for dolphin in order of priority from highest to lowest:

1. In the short-term, effort should be directed at examining all existing seasonality (effort and landings), mean size, and life history data for dolphin from the northern area.
2. Additional data are needed to develop and/or improve estimates of growth, fecundity, etc. Research in this area is encouraged.
3. There are limited social and economic data available. Additional data need to be obtained and evaluated to better understand the implications of fishery management options.
4. Trophic data should be considered in support of an ecosystem management approach.
5. Essential fish habitats for dolphin and wahoo need to be identified.
6. An overall design should be developed for future tagging work. This could be done by the Working Group. In addition, existing tagging databases should be examined.

7. Long-term work should continue and expand on current research investigating genetic variability of dolphin populations in the western central Atlantic.
8. Observer programs should place observers on longline trips directed on dolphin. Catch and bycatch characterization, condition released (alive or dead), etc. should be collected. Observers could also be used to collect bioprofile data (size, sex, hard parts for aging, etc.).
9. High levels of uncertainty in inter-annual variation in abundance of dolphin should be investigated through an examination of oceanographic and other environmental factors.
10. Release mortality should be investigated as a part of the evaluation of the effectiveness of current minimum size limits in the dolphin fishery.
11. Establish a list serve for dolphin and wahoo which would facilitate research and the exchange of information.

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TABLES

Table 1. Recreational harvest (number of fish landed and weight in pounds) and releases (number of fish) and commercial harvest (weight in pounds) of dolphin from North Carolina, 1986 - 2018.

	Recreational			Commercial	
	Numbers		Weight (lb)		
Year	Landed	# Released	Landed	Commercial Weight (lb)	Total Weight (lb)
1986	49,810	589	478,136	35,923	514,059
1987	92,582	79	489,338	70,516	559,854
1988	81,487	31,103	205,599	56,098	261,697
1989	231,953	1,696	1,653,574	98,899	1,752,473
1990	209,476	1,452	986,307	96,207	1,082,514
1991	254,975	6,565	1,298,933	140,837	1,439,770
1992	167,690	6,936	927,165	72,119	999,284
1993	291,297	3,190	1,527,078	149,043	1,676,121
1994	268,417	9,402	1,791,880	160,742	1,952,622
1995	294,100	9,620	2,324,560	354,188	2,678,748
1996	213,861	2,154	1,514,866	128,586	1,643,452
1997	372,989	6,320	3,400,820	229,791	3,630,611
1998	241,733	9,249	1,792,198	149,990	1,942,188
1999	395,167	10,406	3,280,273	209,488	3,489,761
2000	516,491	17,396	4,631,849	197,259	4,829,108
2001	344,865	4,781	4,669,172	160,546	4,829,718
2002	400,736	3,699	4,853,768	168,429	5,022,197
2003	245,651	13,985	3,029,205	186,262	3,215,467
2004	323,140	6,905	2,445,482	255,805	2,701,287
2005	634,260	3,264	5,664,028	139,761	5,803,789
2006	551,924	32,911	4,300,459	159,452	4,459,911
2007	591,835	6,908	5,729,879	369,472	6,099,351
2008	362,023	2,393	3,227,899	289,548	3,517,447
2009	595,967	4,480	6,380,552	611,962	6,992,514
2010	615,081	5,759	3,754,430	239,551	3,993,981
2011	638,543	16,217	4,950,235	94,210	5,044,445
2012	426,877	4,800	3,335,644	249,020	3,584,664
2013	322,769	5,315	2,277,519	178,035	2,455,554
2014	403,203	6,731	2,933,166	422,496	3,355,662
2015	740,023	73,872	5,610,008	320,961	5,930,969
2016	480,860	2,520	5,099,647	356,061	5,455,708
2017	279,932	3,035	2,223,509	198,038	2,421,547
2018	495,435	27,959	3,318,532	144,660	3,463,192
Average	367,732	10,354	3,033,506	202,847	3,236,354

Table 2. Total number of awarded citations for dolphin (>35 pounds landed) annually from the North Carolina Saltwater Fishing Tournament, 1991-2018.

Year	Total Citations
1991	191
1992	266
1993	221
1994	334
1995	354
1996	248
1997	262
1998	412
1999	249
2000	315
2001	457
2002	409
2003	409
2004	155
2005	164
2006	202
2007	218
2008	426
2009	209
2010	157
2011	113
2012	147
2013	284
2014	273
2015	171
2016	124
2017	115
2018	125

Table 3. Mean, minimum, and maximum lengths (fork length, inches) of dolphin collected from the commercial and recreational fisheries, 1986-2018.

Year	Commercial				Recreational			
	Mean Length	Minimum Length	Maximum Length	Total Number Measured	Mean Length	Minimum Length	Maximum Length	Total Number Measured
1986	26.9	16.1	45.3	46	28.7	13.8	47.8	101
1987	23.4	5.9	50.4	113	22.8	7.1	50.4	1,038
1988	24.4	14.8	43.3	104	23.8	12.4	52.0	691
1989	25.4	16.1	47.2	229	25.3	13.4	65.7	1,581
1990	23.9	13.0	49.6	201	23.1	13.8	60.0	1,956
1991	28.9	16.1	47.2	99	23.0	8.7	49.2	2,468
1992	32.6	18.1	47.6	30	22.7	7.5	55.9	1,721
1993	24.9	15.7	43.9	154	22.9	12.5	57.0	2,796
1994	27.7	16.1	50.6	136	25.5	11.0	59.1	4,469
1995	28.5	17.5	48.4	156	27.4	11.0	62.0	3,929
1996	26.1	17.5	42.1	57	26.3	12.6	59.0	2,873
1997	29.1	16.1	48.0	30	28.8	13.8	65.7	3,250
1998	23.6	15.0	46.5	143	27.0	9.4	60.0	3,287
1999	33.0	13.6	53.1	454	28.3	7.9	51.3	2,886
2000	26.4	14.6	48.8	208	28.3	15.9	58.0	3,740
2001	26.5	14.6	45.7	93	31.9	10.9	58.2	2,617
2002	25.8	15.7	52.8	100	30.5	15.7	58.0	3,538
2003	27.5	15.7	48.8	190	31.9	13.9	58.0	1,185
2004	25.2	15.6	47.2	146	27.6	18.2	48.6	1,341
2005	25.7	16.5	44.9	229	29.2	16.9	49.0	1,834
2006	27.9	16.8	52.8	172	27.8	11.8	47.8	1,659
2007	29.9	13.7	43.2	232	30.4	17.0	55.3	1,662
2008	26.2	16.3	44.7	231	29.2	12.2	55.3	1,759
2009	32.1	5.5	51.0	555	32.0	15.4	50.8	1,963
2010	24.7	13.6	43.9	451	25.2	15.2	67.9	1,532
2011	26.2	16.1	44.1	269	27.7	11.1	51.0	2,022
2012	29.8	16.9	49.0	579	28.3	15.0	53.5	1,918
2013	27.6	18.8	56.7	176	26.5	11.8	57.8	601
2014	31.0	15.4	53.2	339	27.0	10.6	51.7	896
2015	32.3	19.6	53.5	78	27.0	11.3	52.1	956
2016	33.1	18.2	40.7	125	31.1	7.5	52.2	1,152
2017	25.0	16.9	37.3	161	28.0	12.8	47.4	722
2018	28.8	12.0	47.2	117	25.6	13.1	57.2	1,313

FIGURES

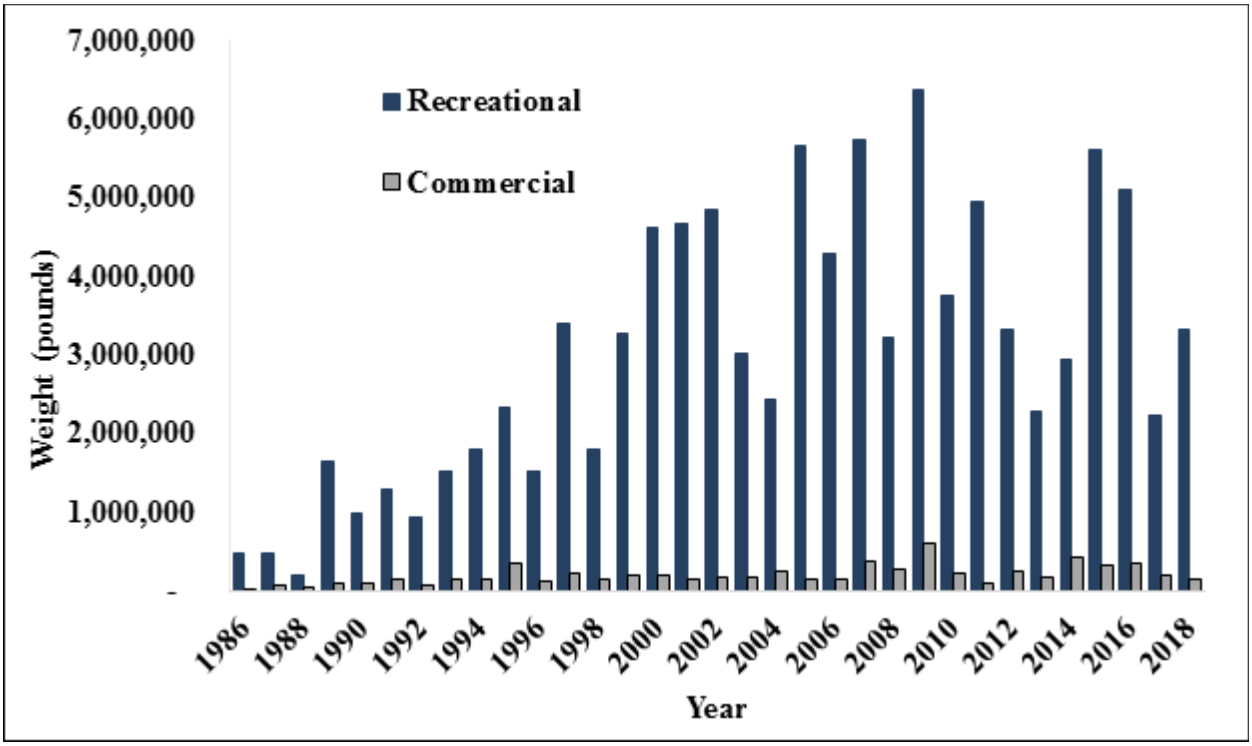

Figure 1. Annual commercial and recreational landings in pounds of dolphin in North Carolina, 1986 - 2018.

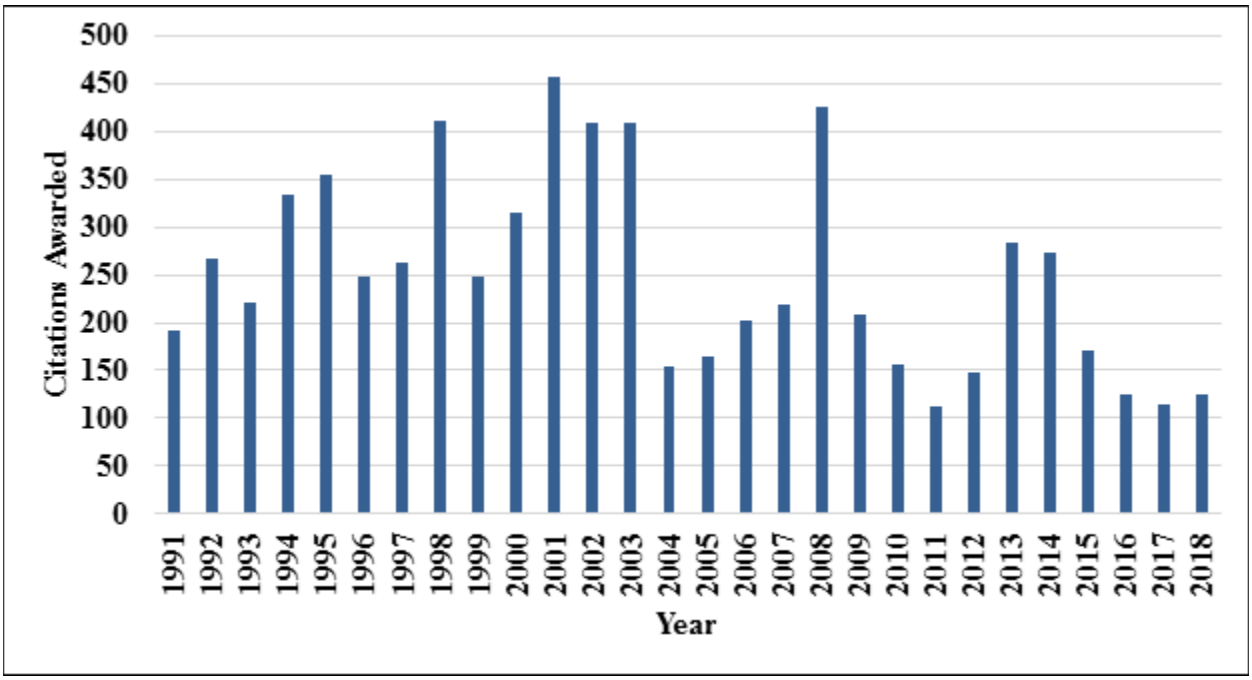

Figure 2. Total number of awarded citations for dolphin (>35 pounds landed) annual from the North Carolina Saltwater Fishing Tournament, 1991-2018.

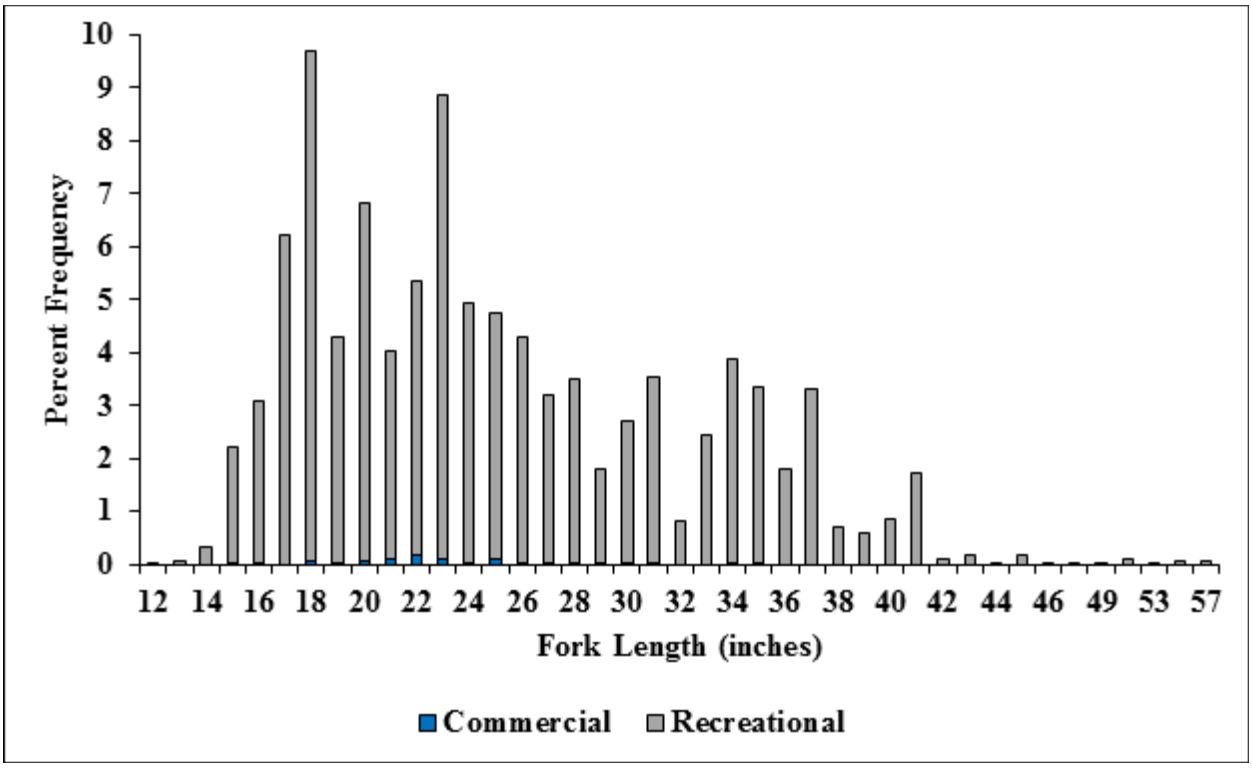

Figure 3. Commercial and recreational length frequency distribution for dolphin harvested in 2018.

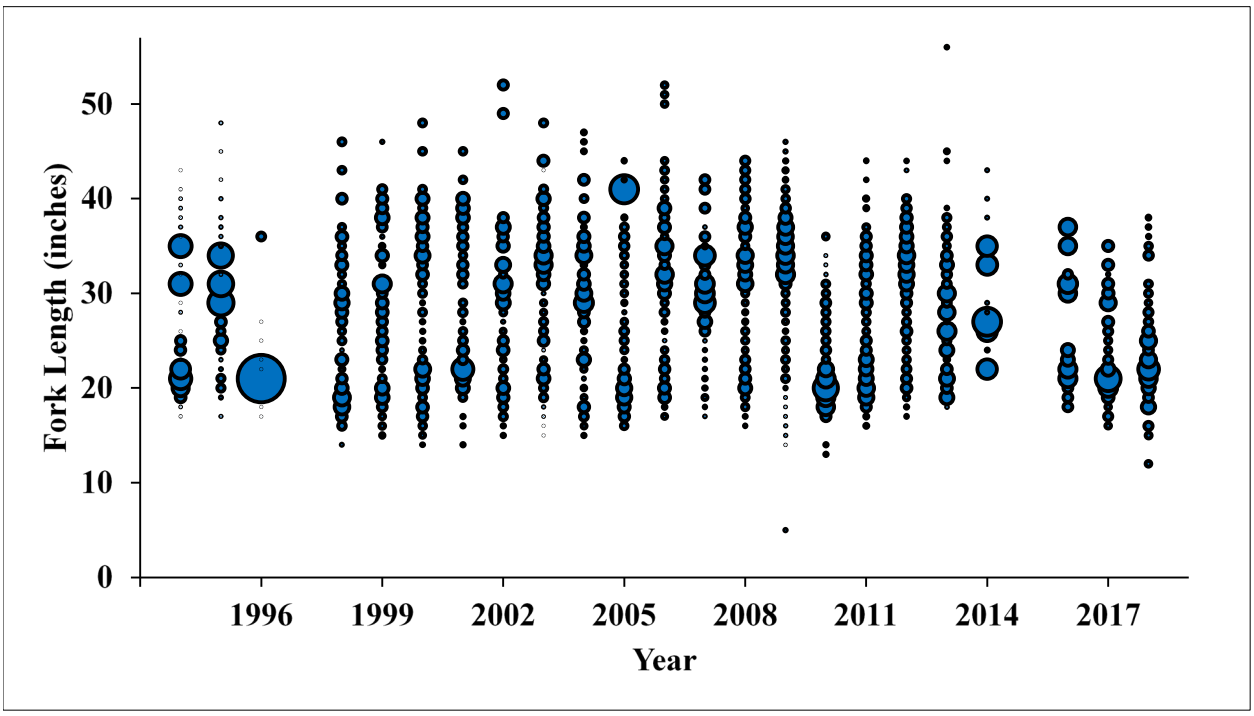

Figure 4. Commercial length frequency (fork length, inches) of dolphin harvested from 1994 to 2018. Bubbles represent fish harvested at length and the size of the bubble is equal to the proportion of fish at that length in that year.

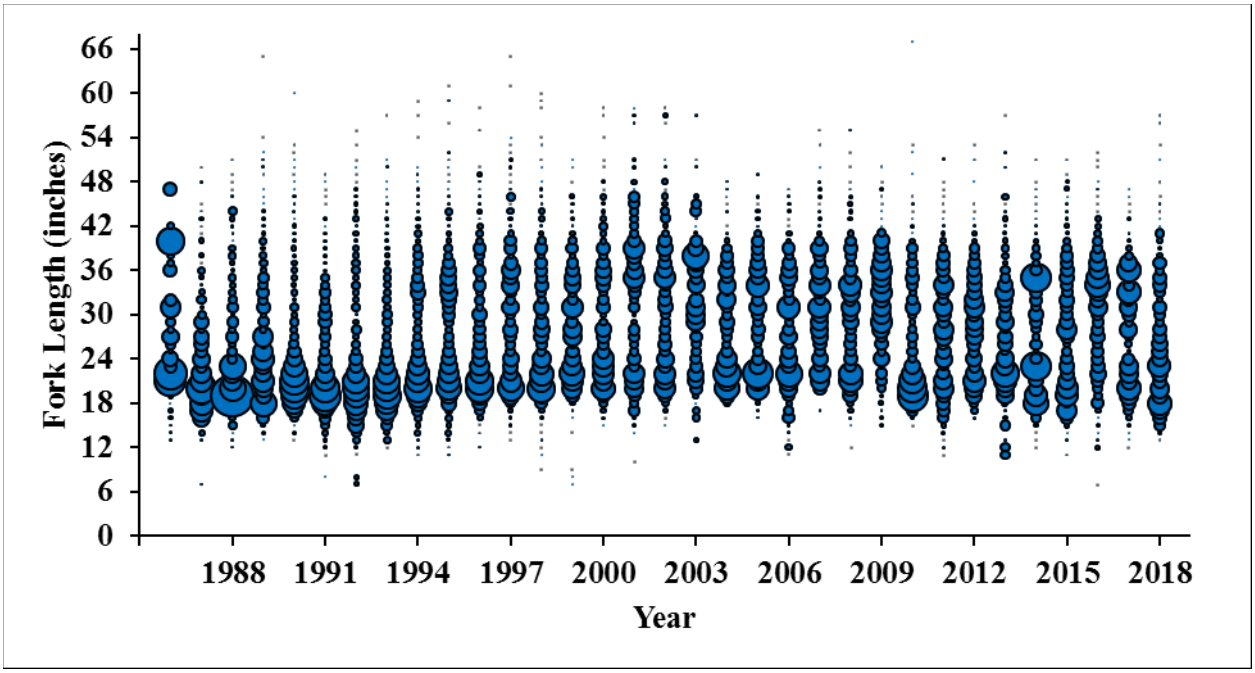

Figure 5. Recreational length frequency (fork length, inches) of dolphin harvested from 1986 to 2018. Bubbles represent fish harvested at length and the size of the bubble is equal to the proportion of fish at that length in that year.

FISHERY MANAGEMENT PLAN UPDATE
KING MACKEREL
AUGUST 2019

STATUS OF THE FISHERY MANAGEMENT PLAN

Fishery Management Plan History

Original FMP Adoption:	February 1983
Amendments:	Amendment 1 – September 1985 Amendment 3 – August 1989 Amendment 5 – August 1990 Amendment 6 – December 1992 Amendment 7 – November 1994 Amendment 8 – March 1998 Amendment 9 – April 2000 Amendment 10 – July 2000 Amendment 11 – December 1999 Amendment 12 – October 2000 Amendment 14 – July 2002 Amendment 15 – August 2005 Amendment 17 – June 2006 Amendment 18 – January 2012 Amendment 19 – July 2010 Amendment 20A – August 2014 Amendment 20B – March 2015 Amendment 22 – January 2014 Amendment 23 – August 2014 Amendment 26 – July 2016
Revisions:	None
Supplements:	None
Information Updates:	None
Next Benchmark Review:	The next assessment has not been scheduled.

The original Gulf and South Atlantic Fishery Management Councils' fishery management plan (FMP) for Coastal Migratory Pelagic Resources (mackerels and cobia) was approved in 1983 (South Atlantic Fishery Management Council (SAFMC) 1983). This plan treated king mackerel as one U.S. stock. Allocations were established for recreational and commercial fisheries, and the commercial allocation was divided between net and hook-and-line fishermen. The plan also established procedures for the Secretary of Commerce to act by regulatory amendment to resolve

possible future conflicts in the fishery, such as establish fishing zones and local quotas to each gear or user group. Numerous amendments have been implemented since the first FMP.

Amendment 1 provided a framework for pre-season adjustment of total allowable catch (TAC), revised king mackerel maximum sustainable yield (MSY) downward, recognized separate Atlantic and Gulf migratory groups of king mackerel, and established fishing permits and bag limits for king mackerel (SAFMC 1985). Commercial allocations among gear users were eliminated.

Amendment 3 prohibited drift gill nets for coastal pelagics and purse seines and run-around gill nets for the overfished groups of mackerels (SAFMC 1998). The habitat section of the FMP was updated and vessel safety considerations were included in the plan. A new objective to minimize waste and bycatch in the fishery was added to the plan.

Amendment 5 extended the management area for the Atlantic groups of mackerels through Mid-Atlantic Fishery Management Council (MAFMC) jurisdiction (SAFMC 1990). The amendment revised problems in the fishery and plan objectives, revised the definition of "overfishing", and provided that the SAFMC will be responsible for pre-season adjustments of TACs and bag limits for the Atlantic migratory groups of mackerels. It redefined recreational bag limits as daily limits; created a provision specifying the bag limit catch of mackerel may be sold, provided guidelines for corporate commercial vessel permits, established a minimum size of 12 inches (30.5 cm.) fork length or 14 inches total length for king mackerel and included a definition of "conflict" to provide guidance to the Secretary.

Amendment 6 identified additional problems and an objective in the fishery, provided for rebuilding overfished stocks of mackerels within specific periods, provided for biennial assessments and adjustments, provided for more seasonal adjustment actions, including size limits, vessel trip limits, closed seasons or areas, and gear restrictions. It also changed commercial permit requirements to allow qualification in one of three preceding years, discontinued the reversion of the bag limit to zero when the recreational quota is filled, modified the recreational fishing year to the calendar year and changed the minimum size limit for king mackerel to 20 inches fork length (SAFMC 1992).

Amendment 7 equally divided the Gulf commercial allocation in the Eastern Zone at the Dade-Monroe County line in Florida (SAFMC 1994). The sub-allocation for the area from Monroe County through Western Florida was equally divided between commercial hook-and-line and net gear users.

Amendment 8 identified additional problems in the fishery, specified allowable gear, established a moratorium on new commercial king mackerel permits and provided for transferability of permits during the moratorium, and allowed retention of up to five damaged king mackerel on vessels with commercial trip limits (these fish cannot be sold, but do not count against the trip limit) (SAMFC 1998). It also revised the seasonal framework procedures to: a) delete a procedure for subdividing the Gulf migratory group of king mackerel, b) request the stock assessment panel provide additional information on spawning potential ratios and mixing of king mackerel migratory groups, c) provide for consideration of public comment, d) redefine

overfishing and allow for adjustment by framework procedure, f) allow setting zero bag limits, and g) allow gear regulation including prohibition.

Amendment 9 changed the percentage of the commercial allocation of TAC for the Florida east coast (North Area) and Florida west coast (South/West Area) of the Eastern Zone to 46.15% North and 53.85%South/West (previously, this allocation was split 50% to each zone); and allowed possession of cut-off (damaged) king mackerel that comply with the minimum size limits and the trip limits in the Gulf, Mid-Atlantic, or South Atlantic exclusive economic zone (EEZ) (sale of such cut-off fish is allowed and is in addition to the existing allowance for possession and retention of a maximum of five cut-off (damaged) king mackerel that are not subject to the size limits or trip limits, but that cannot be sold or purchased, nor counted against the trip limit) (SAMFC 2000).

Amendment 10 designated Essential Fish Habitat (EFH) and EFH-Habitat Areas of Particular Concern for coastal migratory pelagics (SAFMC 1998).

Amendment 11 amended the FMP as required to make definitions of MSY, optimal yield (OY), overfishing and overfished consistent with National Standard Guidelines; identified and defined fishing communities and addressed bycatch management measures (SAFMC 1998).

Amendment 12 extended the commercial king mackerel permit moratorium from October 15, 2000 to October 15, 2005, or until replaced with a license limitation, limited access, and/or individual fishing quota or individual transferable quota system (ITQ), whichever occurs earlier (SAFMC 1999).

Amendment 13 established two marine reserves in the (EEZ) of the Gulf of Mexico near the Dry Tortugas, Florida known as Tortugas North and Tortugas South, in which fishing for coastal migratory pelagic species is prohibited (SAFMC 2002). This action complements previous actions taken under the National Marine Sanctuaries Act.

Amendment 14 established a three-year moratorium on the issuance of for-hire (charter vessel and head boat) permits for coastal migratory pelagic species in the Gulf of Mexico unless sooner replaced by a comprehensive effort limitation system. This resulted in separate for-hire permits for the Gulf and South Atlantic. The control date for eligibility was established as March 29, 2001 (SAFMC 2002). The amendment also includes other provisions for eligibility, application, appeals, and transferability of permits.

Amendment 15 established an indefinite commercial limited access program for king mackerel in the EEZ under the jurisdiction of the Gulf of Mexico, South Atlantic, and Mid-Atlantic fishery management councils (SAMFC 2005). This amendment also changed the fishing year to March 1 through February 28/29 for Atlantic group king and Spanish mackerels.

Amendment 17 (SAFMC 2006) established a permanent limited entry system for Gulf of Mexico coastal migratory pelagics for-hire (charter and head boat) permits, building on the moratorium established under Amendment 14.

Amendment 18 established Annual Catch Limits (ACLs), Annual Catch Targets (ACTs) and accountability measures (AMs) for king mackerel (SAFMC 2011) as required under the 2006 Magnuson-Stevens Reauthorization Act.

Amendment 19 updated existing EFH and HAPC designations for South Atlantic species and prohibited the use of certain gear types within Deepwater Coral Habitat Areas of Particular Concern (SAMFC 2009).

Amendment 20A prohibited the sale of king mackerel caught under the bag limit unless the fish are caught as part of a state-permitted tournament and the proceeds from the sale are donated to charity (SAFMC 2013). In addition, the rule removes the income qualification requirement for king mackerel commercial vessel permits.

Amendment 20B eliminated the 500-pound trip limit that is effective when 75% of the respective quotas are landed for king mackerel in the Florida west coast Northern and Southern Subzones; allows transit of commercial vessels with king mackerel through areas closed to king mackerel fishing, if gear is appropriately stowed; and creates Northern and Southern Zones for Atlantic migratory group king mackerel, each with separate quotas (SAFMC 2014). Each zone will close when the respective quota is met or expected to be met. The dividing line between the zones is at the North Carolina and South Carolina state line.

Amendment 22 modified head boat reporting regulations to require weekly electronic reporting of all South Atlantic Council managed species (SAFMC 2013a).

Amendment 23 (SAFMC 2013b) required dealers to possess a federal Gulf and South Atlantic universal dealer permit to purchase king and Spanish mackerel and required weekly electronic dealer reporting. It also required federally-permitted king and Spanish mackerel fishermen to sell only to a federally-permitted dealer.

The 2013 Framework Action (effective 2014) modified commercial king mackerel trip limits in the Florida East Coast subzone to optimize utilization of the resource.

Amendment 26 updates the Atlantic king mackerel annual catch limits and adjusts the mixing zone based on the results of the 2014 stock assessment (SAFMC 2016). The amendment allows limited retention and sale of Atlantic migratory group king mackerel incidentally caught in the small coastal shark gill net fishery.

To ensure compliance with interstate requirements, North Carolina also manages this species 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 MAFMC, SAFMC, or the Atlantic States Marine Fisheries Commission 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 plans) and the Atlantic Coastal Fisheries Cooperative Management Act (Atlantic States Marine Fisheries Commission plans) are like the

goals of the Fisheries Reform Act of 1997 to "ensure long-term viability" of these fisheries (NCDMF 2015).

Management Unit

The management unit is defined as king mackerel within U.S. waters of the South Atlantic, Mid-Atlantic and Gulf of Mexico. Current management defines two migratory units: Gulf Migratory Group and Atlantic Migratory Group.

Goal and Objectives

The goal of the FMP for Coastal Migratory Pelagics resources was to institute management measures necessary to prevent exceeding maximum sustainable yield (MSY), establish a mandatory statistical reporting system for monitoring catch, and to minimize gear and user conflicts (SAMFC 1983). Amendment 12 to the Gulf and South Atlantic fishery management councils' FMP for Coastal Migratory Pelagics lists eight plan objectives:

1. The primary objective of the FMP is to stabilize yield at MSY, allow recovery of overfished populations, and maintain population levels sufficient to ensure adequate recruitment.
2. To provide a flexible management system for the resource which minimizes regulatory delay while retaining substantial Council and public input in management decisions and which can rapidly adapt to changes in resource abundance, new scientific information, and changes in fishing patterns among user groups or by areas.
3. To provide necessary information for effective management and establish a mandatory reporting system.
4. To minimize gear and user group conflicts.
5. To distribute the TAC of Atlantic migratory group Spanish mackerel between recreational and commercial user groups based on the catches that occurred during the early to mid-1970s, which is prior to the development of the deep-water run-around gill net fishery and when the resource was not overfished.
6. To minimize waste and bycatch in the fishery.
7. To provide appropriate management to address specific migratory groups of king mackerel.
8. To optimize the social and economic benefits of the coastal migratory pelagic fisheries.

STATUS OF THE STOCK

Life History

King mackerel are considered coastal pelagic, meaning they live in open ocean waters near the coast. They are found from North Carolina to southeast Florida, making inshore and offshore migrations that are triggered by water temperature and food supply. King mackerel prefer warm waters and seldom enter waters below 68 degrees Fahrenheit. In the winter, they gather just inside the Gulf Stream along the edge of the continental shelf. In the summer and fall, they move inshore along the beaches and near the mouths of inlets and rivers. King mackerel spawn from April to November, with males maturing between age 2 and 3 and females between age 3 and 4. King mackerel in North Carolina grow as large as 60 inches, but most recreational catches are

between 35 and 45 inches. They feed on menhaden, mullet, thread herring, sardines and squid and may be seen leaping out of the water in pursuit of prey (Manooch 1984).

Stock Status

In 2014, the Atlantic king mackerel stock was assessed and peer reviewed through the Southeast Data, Assessment and Review (SEDAR 38). The results of the assessment indicated the stock size and the rate of removals are sustainable and predicts Atlantic king mackerel are not overfished and overfishing is not occurring.

Stock Assessment

An integrated stock assessment approach, Stock Synthesis, was used to assess the stock (SEDAR 38) in a benchmark assessment (SEDAR 2014). The assessment model was constructed using fishery independent data from the Southeast Area Monitoring and Assessment Program Trawl Survey for the Atlantic, and fishery dependent information collected from National Oceanic and Atmospheric Administration Fisheries Service Marine Recreational Fisheries Statistics Survey, head boat and logbook surveys, as well as North Carolina Division of Marine Fisheries Trip Ticket landings information. The Stock Synthesis approach was used, which integrated fishery and life history indices into a statistical catch-at-age model to produce observed catch, size and age composition, and Catch Per Unit Effort indices. Overall, stock biomass and spawning stock biomass (SSB) show little depletion until the 1950s, when a slow decline started and then accelerated around 1980, reaching its lowest level in the late 1990s, from which it increased until 2010. Since 2010, there has been a slight decrease in SSB. Key biological reference points and associated benchmarks (SSB_{MSY} and F_{MSY}) were successfully derived and the consensus derived from sensitivity analysis of the model predict that the Atlantic stock of king mackerel is not overfished and overfishing is not occurring.

STATUS OF THE FISHERY

Current Regulations

The North Carolina Division of Marine Fisheries complements the management measures of the Coastal Migratory Pelagic FMP through rule (N.C. Marine Fisheries Commission Rule 15A NCAC 03M .0301) and proclamation authority (N.C. Marine Fisheries Commission Rule 15A NCAC 03M .0512). Current regulations include a recreational bag limit of three king mackerel per person per day and 24-inch fork length minimum size (commercial and recreational). Commercial regulations limit trips to 3,500 pounds and require a Federal vessel permit for commercial, charter and head boats. Sale of king mackerel caught under the bag limit are prohibited unless the fish are caught as part of a state-permitted tournament and the proceeds from the sale are donated to charity.

Commercial Landings

In 2018, commercial landings were 506,933 pounds (Table 1 and Figure 1) and 88% of the king mackerel harvest was taken by hook and line while the remaining 12% was harvested in gill nets

(Figure 2). The commercial fishery has declined since 2008, however the 2018 landings were slightly higher than the 465,595 pound 10-year average (2009-2018).

Recreational Landings

Recreational fishing activity is monitored through the Marine Recreational Information Program. In this report, estimates across all years have been updated and are now based on the MRIP new Fishing Effort Survey-based calibrated estimates. For more information on MRIP methodology changes see https://www.fisheries.noaa.gov/topic/recreational-fishing-data. Recreational anglers target king mackerel by trolling spoons and live baits both inshore and offshore. Anglers catch most king mackerel between August and October, once the water temperature has begun to cool from the summer heat. Anglers harvested 1,018,459 pounds of king mackerel in 2018 (Table 2 and Figure 1). For unknown reasons, recreational harvest has declined sharply since 2007.

MONITORING PROGRAM DATA

Fishery-Dependent Monitoring

Length-frequency information for the commercial king mackerel fishery in North Carolina is collected through Division sampling programs [programs 434 (Ocean Gill Net Fishery), 437 (Long Haul Seine Fishery), 438 (Offshore Live Bottom Fishery), 439 (Coastal Pelagic), and 461 (Estuarine Gill Net and Seine Sampling)]. Through these programs, 459 king mackerel were measured with a mean length of 28.8 inches (Table 4 and Figure 3). Ageing structures, otoliths, are collected from the commercial and recreational fishery as well as king mackerel fishing tournaments statewide and sent to the Southeast Fisheries Science Center in Panama City, Florida for processing and ageing (Table 5). Length and weight information for the recreational fishery are collected through the MRIP dockside sampling (Figure 4).

Fishery-Independent Monitoring

Currently, the division does not have any fishery-independent sampling programs that target or catch king mackerel in great numbers.

MANAGEMENT STRATEGY

King mackerel is included in the North Carolina Fishery Management Plan for Interjurisdictional Fisheries, which defers, to South Atlantic Fishery Management Council Fishery Management Plan compliance requirements. Current management measures were established under recent Amendments 20A (SAMFC 2014), 20B (SAMFC 2015), and 26 (SAMFC 2016) to the Coastal Migratory Pelagics Fishery Management Plan. Amendment 20A prohibits the sale of all bag-limit-caught king mackerel, except those harvested during a state-permitted tournament. Amendment 20B establishes separate commercial quotas of Atlantic king mackerel for a Northern Zone (north of North Carolina and South Carolina state line) and Southern Zone (south of North Carolina and South Carolina state line). The South Atlantic Fishery Management Council completed Amendment 26 (2016) to update the Atlantic king mackerel annual catch limits and adjust the mixing zone based on the results of the 2014 stock assessment, and to

provide an incidental catch allowance of Atlantic king mackerel in the small coastal shark gillnet fishery. Current management strategies for king mackerel in South Atlantic waters are summarized in Table 6.

RESEARCH NEEDS

From SEDAR 38 report (SEDAR 2014):

- Develop a survey to obtain reliable age and size composition data and relative abundance of adult fish. This could be done using gill nets or handlines. The review panel recommends that the design of a scientific survey be peer reviewed.
- Determine most appropriate methods to deal with changing selectivity in fisheries over time, particularly changing selectivity related to management actions or targeting of specific cohorts. The review panel suggests that historical mark-recapture data be used to compare size composition of recaptures for different fishing gears to evaluate selectivity for historic periods.
- Determine stock mixing rates using otolith microchemistry and/or otolith shape analysis on a routine basis that would allow future stock assessments to capture the dynamic spatial and temporal nature of mixing of the Atlantic and Gulf of Mexico stocks, and consider evaluating stock mixing within integrated modeling approaches.
- More accurately characterize juvenile growth by increasing samples of age-0 and 1 fish. Further investigate two-phase growth models including different breakpoints and different growth models to better model size and age. Consider if there is temporal (annual and seasonal) variability in growth rates. Results of this analysis in terms of the best model will need to be implementable in SS3 to continue with the integrated modeling approach.
- Determine if female spawning periodicity varies by size or age.
- Expand the trawl survey below the Cape Canaveral area and potentially into deeper continental shelf waters.
- Consider conducting an extensive tagging program to: a) better understand migration patterns; b) provide additional and individual growth rate information; c) better understand fishery selectivity; d) provide fishery exploitation rates; and e) provide information about natural mortality rates. Fishery independent recapture information (i.e., use of acoustic and satellite tags) will assist with a). Age at capture information of tagged animals will assist with b). A multi-year tagging program will be required for e). The review panel recommends that a specific workshop be held to consider in detail the design of a tagging program.

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TABLES

Table 1. North Carolina commercial harvest of king mackerel with landings in pounds per gear type, 1994-2018.

Year	Gear Type			Total
	Hook and Line	Gill Net	Other	
1994	782,796	61,648	5,465	849,909
1995	954,958	58,104	257	1,013,319
1996	738,562	53,211	1,761	793,534
1997	1,388,933	167,973	1,533	1,558,439
1998	1,076,494	65,460	1,388	1,143,342
1999	1,042,517	40,148	28	1,082,693
2000	939,435	105,504	616	1,045,554
2001	790,925	47,517	665	839,107
2002	696,160	81,933	334	778,427
2003	738,129	26,168	534	764,831
2004	829,056	125,826	120	955,002
2005	1,012,598	232,681	810	1,246,089
2006	1,010,909	174,573	52	1,185,534
2007	883,514	175,570	24	1,059,107
2008	821,059	215,793	0	1,036,852
2009	668,150	109,347	88	777,585
2010	235,965	92,739	102	328,806
2011	357,375	50,748	38	408,162
2012	248,979	48,444	0	297,423
2013	311,321	33,856	0	345,177
2014	461,424	88,557	0	549,981
2015	323,686	67,629	0	391,315
2016	337,016	83,794	59	420,869
2017	557,374	72,284	38	629,696
2018	444,047	62,814	72	506,933

Table 2. North Carolina recreational harvest of king mackerel with landings in number of fish, pounds, and number released, 1981-2018. Percent Standard Error (PSE) is given for each.

Year	Harvest Number (A+B1, MRIP)	PSE (Num)	Weight (lb), (A+B1, MRIP)	PSE (lb)	Number Released (MRIP)	PSE
1981	191,655	53.8	2,040,176	50.0	-	.
1982	177,616	26.4	1,477,554	24.8	-	.
1983	115,637	47.5	738,215	48.3	-	.
1984	131,026	36.8	1,228,325	39.8	-	.
1985	273,004	41.7	2,695,124	42.8	-	.
1986	173,390	28.9	1,593,772	31.2	102	103.8
1987	199,521	18.1	1,767,178	23.9	13,526	80.6
1988	162,764	15.1	521,744	26.7	8,186	50.4
1989	113,376	16.6	1,163,894	15.4	5,225	59.6
1990	273,144	22.3	2,502,999	25.9	4,295	71.1
1991	258,306	17.6	2,590,951	20.4	8,856	47.9
1992	165,568	13.8	1,435,826	15.2	2,933	39.6
1993	121,704	15.7	1,224,744	16.2	3,607	68.6
1994	177,608	20.7	1,709,740	17.4	5,792	55.8
1995	135,796	14.3	1,240,901	14.5	7,544	43.5
1996	119,418	23.2	1,097,226	19.6	15,465	48.8
1997	206,601	13.1	1,797,936	14.4	57,739	25.5
1998	112,383	17.5	1,163,739	18.2	9,155	43.0
1999	104,483	18.6	1,034,465	19.5	120,296	34.9
2000	196,979	20.8	2,250,512	17.9	26,009	41.1
2001	145,290	12.8	2,046,022	16.2	12,381	41.8
2002	104,631	40.7	1,242,058	42.4	20,811	49.1
2003	153,339	17.1	1,388,145	17.3	33,774	27.5
2004	191,584	17.7	2,276,035	22.9	184,384	38.7
2005	175,070	16.0	1,349,536	15.9	101,507	26.2
2006	177,369	17.9	1,805,814	22.3	45,568	29.1
2007	339,278	15.2	3,099,801	15.5	53,549	29.4
2008	164,719	18.7	1,379,450	19.0	41,283	43.9
2009	168,558	17.5	1,822,673	18.4	23,639	33.2
2010	58,311	23.8	580,505	23.4	9,734	36.0
2011	31,589	36.3	367,896	31.3	851	72.9
2012	55,529	24.5	613,903	25.3	6,385	38.1
2013	48,000	23.3	521,153	25.2	8,868	54.2
2014	72,288	22.7	1,213,096	22.9	35,075	92.8
2015	95,705	37.2	1,168,255	52.5	16,877	52.4
2016	108,151	43.4	963,139	41.7	43,909	31.6
2017	110,339	22.6	1261775	31.8	94655	28.6
2018	102,675	19.0	1,018,459	30.1	75,614	32.6
Average	**150,326**		**1,457,704**		**28,884**	

Table 3. Total number measured, mean, minimum, and maximum length (inches) of king mackerel measured by MRIP sampling in North Carolina, 1981-2018.

Year	Number Measured	Mean Length	Minimum Length	Maximum Length
1981	47	38.5	25.0	46.0
1982	90	33.9	15.7	44.1
1983	33	30.1	5.7	36.0
1984	71	31.1	12.2	44.3
1985	67	32.9	22.0	42.5
1986	257	33.1	19.7	48.9
1987	1,041	31.4	12.6	55.9
1988	646	13.5	14.2	58.5
1989	765	33.8	12.2	53.9
1990	1,169	31.3	12.2	59.5
1991	1,057	31.8	10.1	57.9
1992	1,037	31.1	14.6	57.9
1993	772	32.3	12.8	58.3
1994	829	32.2	20.1	65.4
1995	959	31.2	14.6	53.5
1996	670	31.3	20.1	56.0
1997	1,814	30.5	12.6	54.6
1998	1,062	32.4	13.9	57.8
1999	452	32.9	18.3	50.2
2000	831	33.7	19.3	69.6
2001	800	37.0	22.4	59.1
2002	218	34.6	22.7	54.2
2003	268	32.8	20.2	55.0
2004	247	32.2	13.2	55.5
2005	277	29.6	21.7	53.3
2006	269	32.0	19.2	59.2
2007	320	31.1	21.3	49.3
2008	317	30.1	20.6	47.9
2009	168	32.7	21.0	46.9
2010	83	32.5	25.0	50.0
2011	36	34.1	28.0	51.0
2012	74	32.9	23.5	51.0
2013	38	32.6	23.5	54.8
2014	106	38.7	23.9	53.1
2015	93	33.3	22.2	52.9
2016	213	30.4	12.2	60.0
2017	278	31.9	13.4	48.9
2018	365	30.3	14.6	60.4

Table 4. Mean, minimum, and maximum fork lengths (inches) and total number measured of king mackerel from fishery dependent sampling programs in North Carolina, 1997-2018.

Year	Mean Length	Minimum Length	Maximum Length	Total Number Measured
1997	30.3	21.9	47.2	152
1998	30.0	20.9	42.3	240
1999	30.1	16.3	50.4	722
2000	30.4	16.7	48.8	872
2001	31.8	20.3	51.2	729
2002	33.0	24.0	46.5	217
2003	29.2	21.3	44.1	204
2004	31.5	22.0	45.3	448
2005	29.5	19.7	47.2	397
2006	31.0	21.5	49.4	277
2007	29.3	13.6	48.0	331
2008	27.6	22.2	49.8	1,676
2009	28.4	15.1	55.1	1,005
2010	33.8	23.2	52.6	193
2011	33.1	23.4	48.8	643
2012	32.4	23.1	53.0	313
2013	34.1	24.1	45.5	89
2014	29.8	18.1	47.6	420
2015	32.8	14.7	46.9	229
2016	29.4	20.3	54.3	360
2017	28.4	13.6	53.3	994
2018	28.8	22.6	43.3	459

Table 5. Mean, minimum, and maximum fork lengths (inches) and total number sampled of king mackerel aged through Comprehensive Life History (Program 930) in North Carolina, 1997-2018.

Year	Mean Length	Minimum Length	Maximum Length	Total Number Measured
1997	35.4	12.6	54.1	363
1998	37.6	21.7	60.2	458
1999	37.4	14.8	57.1	477
2000	38.7	24.3	56.1	541
2001	38.0	25.8	55.7	547
2002	38.2	23.8	54.9	477
2003	37.0	23.3	57.3	488
2004	38.0	13.5	56.7	467
2005	37.3	19.6	55.1	444
2006	37.7	17.0	54.1	435
2007	37.9	19.2	54.7	507
2008	34.3	23.4	53.7	450
2009	36.0	24.2	55.1	415
2010	37.9	23.2	57.2	386
2011	37.4	23.4	57.0	429
2012	37.6	23.1	55.9	597
2013	40.2	24.1	56.3	413
2014	40.0	4.6	59.1	388
2015	39.1	4.4	54.4	446
2016	35.2	13.3	54.3	482
2017	35.8	15.4	56.3	663
2018	36.3	11.0	54.3	568

Table 6. Management strategies and rules for king mackerel in North Carolina.

Management Strategy	Implementation Status
24 inch minimum size limit	Rule 15A NCAC 03M .0301(b)(1)
Three fish creel limit	Rule 15A NCAC 03M .0301(b)(2)
Commercial Vessel Permit requirements	Rule 15A NCAC 03M .0301(b)(3)(A) Rule 15A NCAC 03M .0301(b)(3)(B)
Unlawful to use gill nets south of Cape Lookout for more than three king mackerel	Rule 15A NCAC 03M .0501(b)(4)
Charter vessels or head boats with Commercial Vessel Permit must comply with possession limits when fishing with more than three persons	Rule 15A NCAC 03M .0512
Commercial trip limit of 3,500 pounds of king, Spanish, or aggregate	Rule 15A NCAC 03M .0301(d))
Prohibits Purse Gill Nets when taking king or Spanish mackerel	Rule 15A NCAC 03M .0512
Unlawful for vessels with both a valid Federal Commercial Directed Shark Permit and a valid Federal King Mackerel Permit, when engaged in directed shark fishing with gill nets south of Cape Lookout, to possess and sell more than three king mackerel per crew member.	Proclamation FF-21-2017

FIGURES

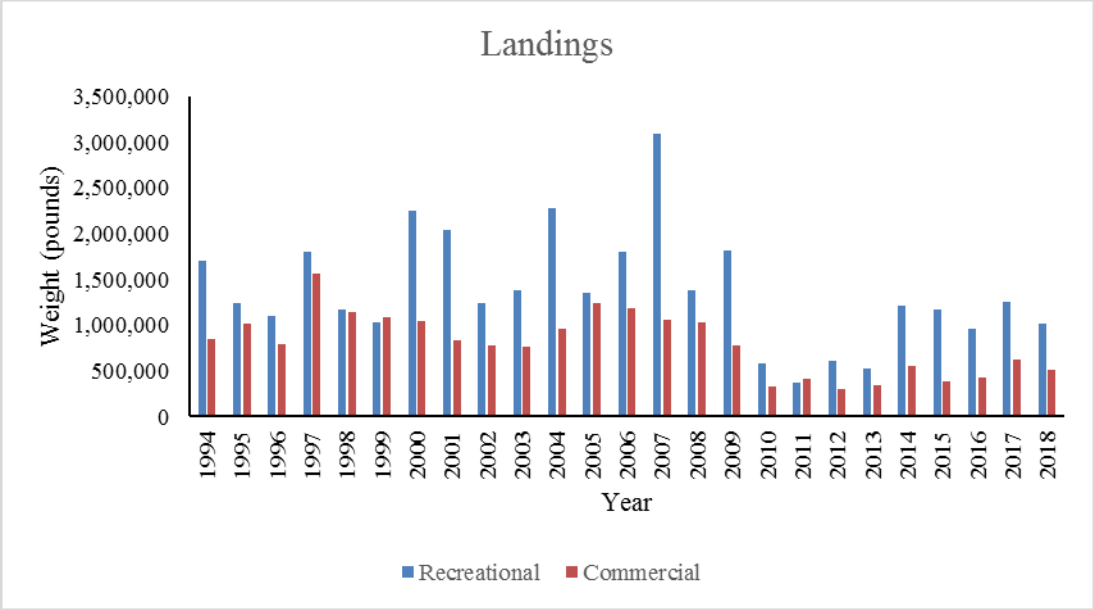

Figure 1. Annual commercial (1994-2018) and recreational (1994-2018) landings in pounds for king mackerel in North Carolina.

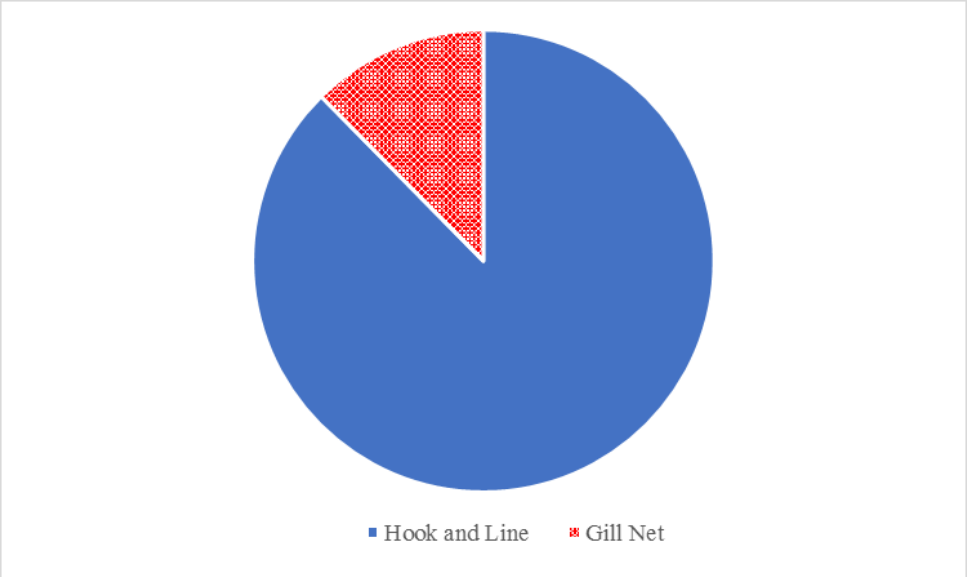

Figure 2. Commercial harvest of king mackerel by gear, 2018.

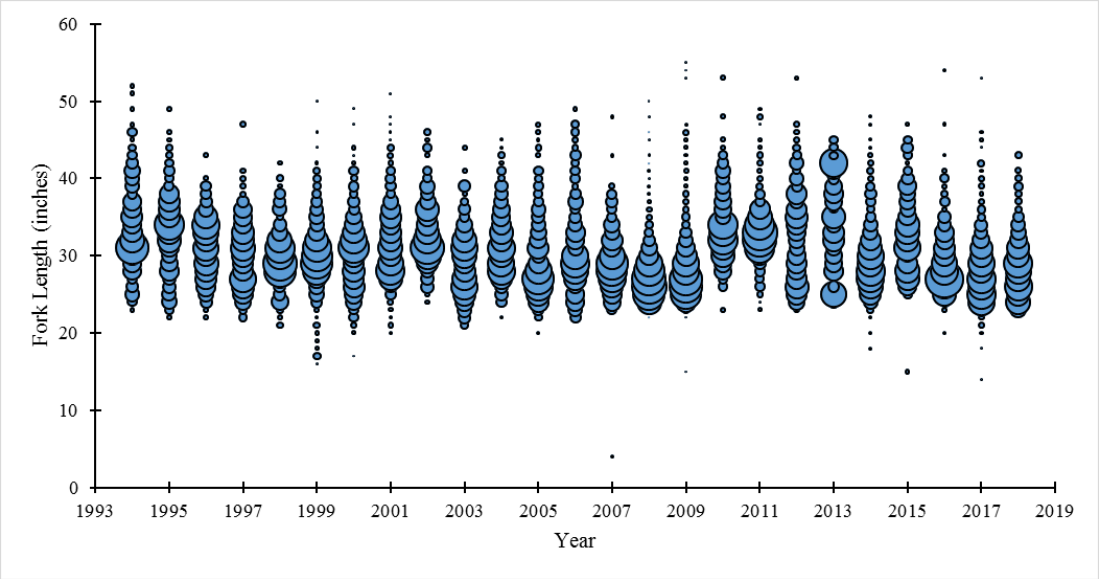

Figure 3. Commercial length frequency (fork length, inches) of king mackerel from 1994 to 2018. Bubbles represents fish harvest at length and the size of the bubble represents the proportion of fish at that length in that year.

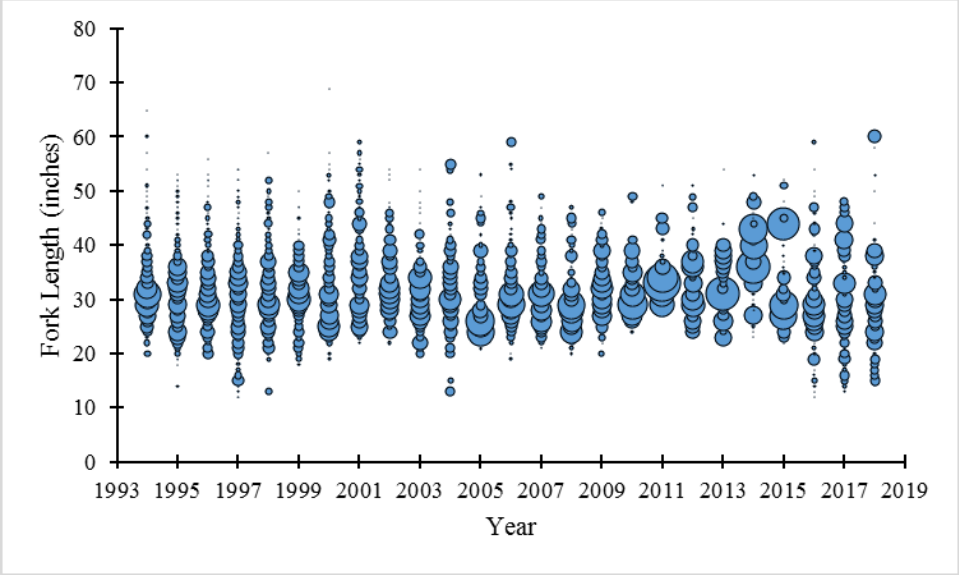

Figure 4. Recreational length frequency (fork length, inches) of king mackerel from 1994 to 2018. Bubbles represents fish harvest at length and the size of the bubble represents the proportion of fish at that length in that year.

FISHERY MANAGEMENT PLAN UPDATE
MONKFISH
AUGUST 2019

STATUS OF THE FISHERY MANAGEMENT PLAN

Fishery Management Plan History

Original FMP Adoption:	November 1999
Amendments:	Amendment 1 1999 Framework 1 1999 Framework 2 2004 Amendment 2 2005 Framework 3 2006 Framework 4 2007 Amendment 3 2008 Framework 5 2008 Framework 6 2008 Amendment 4 2018 Amendment 5 2011 Framework 7 2011 Amendment 6 withdrawn 2010 Amendment 7 June 2015 Framework 8 2014 Framework 9 2016 Framework 10 2017
Revisions:	None
Supplements:	None
Information Updates:	None
Next Benchmark Review:	None

Monkfish are jointly managed by the New England Fishery Management Council (NEFMC) and Mid-Atlantic Fishery Management Council (MAFMC) with the NEFMC serving as administrative lead. In the 1990s, monkfish stake holders became concerned about decreased monkfish body size, gear conflicts with other fisheries, and an expansion of the directed trawl fishery prompting management council involvement. Adopted in 1999, the Monkfish Fishery Management Plan (FMP) is designed to stop overfishing and rebuild the stocks through a number of gear and effort restrictions. Based on historic fishery and biological data, the Atlantic monkfish is managed as two stocks. The Northern Fishery Management Area (NMA) includes the Gulf of Maine and the northern portion of Georges Bank while the Southern Fishery

Management Area (SMA) begins from the southern extent of Georges Bank through the Mid-Atlantic Bight to North Carolina/South Carolina border.

In 2006, North Carolina and National Oceanic and Atmospheric Association (NOAA) Fisheries Southeast Regional Office entered into an agreement enabling limited large mesh gill net fisheries for striped bass and monkfish in state waters. By rule the Atlantic Ocean waters in North Carolina are closed to the use of large mesh (> 7 inches stretch mesh) except between December 16-April 14 when a proclamation is issued to allow the use of gill nets with a stretched mesh length of 7 inches and greater in the Atlantic Ocean. This gear is specifically for the striped bass and monkfish gill net fisheries. The harvest of monkfish in the large mesh monkfish fishery is opened by proclamation between March 16-April 14 unless opened later or closed sooner by proclamation. The agreement allows the North Carolina Division of Marine Fisheries (NCDMF) to implement Atlantic sturgeon, sea turtle, and marine mammal conservation measures under its proclamation authority as well as effort restrictions on the fishery. All fishery participants must possess a current monkfish permit to land or sell monkfish. Monkfish fishermen are required to report weekly trip information to NCDMF. To ensure compliance with protected species conservation measures before the fishery is allowed to open, NCDMF communicates with the NOAA Northeast Fishery Observer Program (NEFOP) to reserve the necessary days-at-sea observer coverage for monitoring 20% of the fishery. Additionally, fishery participants must report any protected species interactions with fishing gear to the NCDMF. Effort restrictions confine fishing activity for monkfish to a one-mile-wide area (within 2-3 miles offshore) from the Virginia/North Carolina boarder to Wimble shoals (Latitude 35°30’N) and mandates that monkfish gill nets are to be fished at least every 48 hours, weather permitting. The season can be closed by proclamation if reliable sea surface temperature monitoring indicates prolonged water temperatures greater than 11° C or if an interaction occurs between fishing gear and a protected species.

Since the adoption of the monkfish FMP, seven amendments have been considered for the plan and six have been implemented. Amendments 1 and 4 were added to identify, establish, and refine definitions for essential fish habitat for monkfish. Amendments 3, 5, and 7 were included to allow for reporting (at-sea observer coverage) and accurate estimates of bycatch. Amendment 5 also specified annual catch limits and accountability measures to comply with Magnuson-Stevens Fishery Conservation and Management Act. Amendment 6 was proposed management effort that would have allowed for catch shares within the monkfish fishery: however, the consideration was withdrawn and never incorporated into the FMP. Additionally, ten frameworks have been included since 1999 to adjust management strategies for monkfish. The monkfish FMP, associated amendment documents, and framework information can be found at https://www.nefmc.org/management-plans/monkfish.

Monkfish fishery monitoring and assessment has been conducted since the implementation of the FMP. Over several years, time series data has been collected to update biological reference points as well as targets and thresholds for standing stock biomass and fishing mortality. The latest stock assessment (NEFSC 2016) has determined the status of both monkfish stocks to be unknown. However, there continues to be uncertainty related to estimates of commercial discards, stock structure, and age validation for monkfish. Continued fisheries monitoring, data

collection, and identification of research priorities will be conducted by monkfish stakeholders in the future.

To ensure compliance with interstate requirements, NCDMF also manages monkfish 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 plans) and the Atlantic Coastal Fisheries Cooperative Management Act (ASMFC plans) are like the goals of the Fisheries Reform Act of 1997 to "ensure long-term viability" of these fisheries (NCDMF 2015).

Management Unit

In North Carolina, monkfish regulations reflect those of the NEFMC/MAFMC FMP required for federal waters (3 to 200 miles). Figure 1 illustrates the northern and southern monkfish fishery management areas.

Goal and Objectives

The goals of the monkfish FMP are to: 1) end and prevent overfishing; rebuilding and maintaining a healthy spawning stock; 2) optimize yield and maximize economic benefits to the various fishing sectors; 3) prevent increased fishing on immature fish; 4) allow the traditional incidental catch of monkfish to occur.

STATUS OF THE STOCK

Life History

Despite their importance as a commercial species, little is known about the life history of monkfish (*Lophius americanus*). They are distributed in the Northwestern Atlantic from Gulf of St. Lawrence, Canada to Cape Hatteras, North Carolina (Richards et al. 2008). Generally, monkfish are found in nearshore habitats at a maximum depth of approximately 900 meters (Roundtree et al. 2008). In North Carolina, they occur most abundantly from late February to early April.

Little fine-scale spatial information is known about monkfish in the western Atlantic. Monkfish are hypothesized to exhibit movements between inshore and offshore environments associated with offshore spawning activity (Richards et al. 2008). Very little latitudinal movement is believed to occur and genetic studies have supported this belief and this determination has informed current monkfish stock structure (Armstrong et al. 1992; Hartley 1995).

Similarly, there is a paucity of information on monkfish age and growth. Monkfish are thought to grow to a maximum size of 55 inches and age of 14 years (Richards et al. 2012). Females reach sexual maturity at age 7 and exhibit peak egg development between February and April with evidence of serial spawning within a season (Richards et al. 2008).

There is some information regarding monkfish foraging ecology. Monkfish are a dorsal-ventrally flattened benthic fish that possess a modified first dorsal fin ray that is used to attract and then ambush prey species (Gordoa and Macpherson 1990). Diet studies have indicated monkfish feed primarily on smaller fish but also eat invertebrate prey such as squid and shrimp (Valentim et al. 2008). Cannibalism has been reported for larger monkfish (> 24 inches; Johnson et al. 2007) and further research is required to ascertain whether this density dependent effect influences population dynamics.

Stock Status

The most recent stock assessment (NEFSC 2016) determined that the status of both the North and South monkfish stocks are unknown.

Stock Assessment

During the 2016 monkfish stock assessment, scientific evidence suggested that the ageing technique (vertebral ageing) for monkfish was no longer valid which resulted in a lack of biological reference points. Therefore, the stock status of monkfish could not be determined.

STATUS OF THE FISHERY

Current Regulations

In addition to seasonal, effort, and reporting regulations there are size limits established for monkfish harvest. Minimum size length for monkfish is 17 inches total length or 11 inches tail length for both commercial and recreational anglers. North Carolina does not set trip or possession limits for monkfish.

Commercial Landings

In general, North Carolina commercial landings for monkfish have remained very low since 2005. Monkfish landings predominately occur as marketable by-catch from the summer flounder trawl fishery with diminutive landings being reported from other ocean and estuarine gears (Table 1, Figure 2, Figure 3). From 2013-2018, the Atlantic Ocean large mesh gill net fishery had no reported trips and potential participation in the fishery has been declining (2018: n=7 permits issued). Probable causes for observed declines in the commercial monkfish fishery include seasonal closures due to warm water temperatures, effort restrictions, and fisherman behavior (e.g. participation in more lucrative fisheries).

Recreational Landings
Not available due to no observed catch.

MONITORING PROGRAM DATA

Fishery-Dependent Monitoring

North Carolina does not have a directed fishery dependent monitoring program for monkfish as individual lengths are difficult to attain. Monkfish are often encountered as bycatch from the flounder trawl fishery, processed at sea, and arrive at the dock dressed (i.e. tails).

Fishery-Independent Monitoring

North Carolina does not have a fishery independent monitoring program for monkfish.

MANAGEMENT STRATEGY

The monkfish fishery is managed in federal and North Carolina state waters primarily with effort, gear, and harvestable size restrictions. Operational assessments are conducted every three years to monitor and potentially update biological reference points. The MAFMC and NEFMC are authorized to enact management changes via FMP amendments or framework adjustments as deemed appropriate. Additionally, the Monkfish Monitoring Committee (MC) meets six months prior to the opening of the fishing season to review available fisheries data. The MC reviews and develops target Total Allowable Catch recommendations and management options necessary to achieve the FMP goals and objectives.

RESEARCH NEEDS

Research needs from the 2013 Stock Assessment Workshop and 2016 stock assessment are provided below.

- Continued collection of biological information needed to better estimate age, growth, and natural mortality.
- Evaluate sampling of fishery length frequencies to ensure adequacy.
- If SCALE is to be used in future assessments, adjustments need to be made.
- Obtain better estimates of commercial discards.
- Develop sex-based modeling.
- Continue microsatellite research to determine stock structure.
- Identification of movements between stock management areas.

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TABLES

Table 1. Monkfish commercial harvest (North Carolina Trip Ticket Program) for 1994-2018. All weights are in pounds.

Year	Commercial Weight (lb)
1994	336,759
1995	535,887
1996	535,092
1997	704,036
1998	686,715
1999	599,538
2000	745,164
2001	208,413
2002	278,608
2003	335,338
2004	386,821
2005	90,099
2006	164,953
2007	153,346
2008	109,102
2009	99,549
2010	47,305
2011	38,892
2012	21,649
2013	10,566
2014	76,392
2015	112,863
2016	50,883
2017	66,225
2018	45,166
Average	257,574

FIGURES

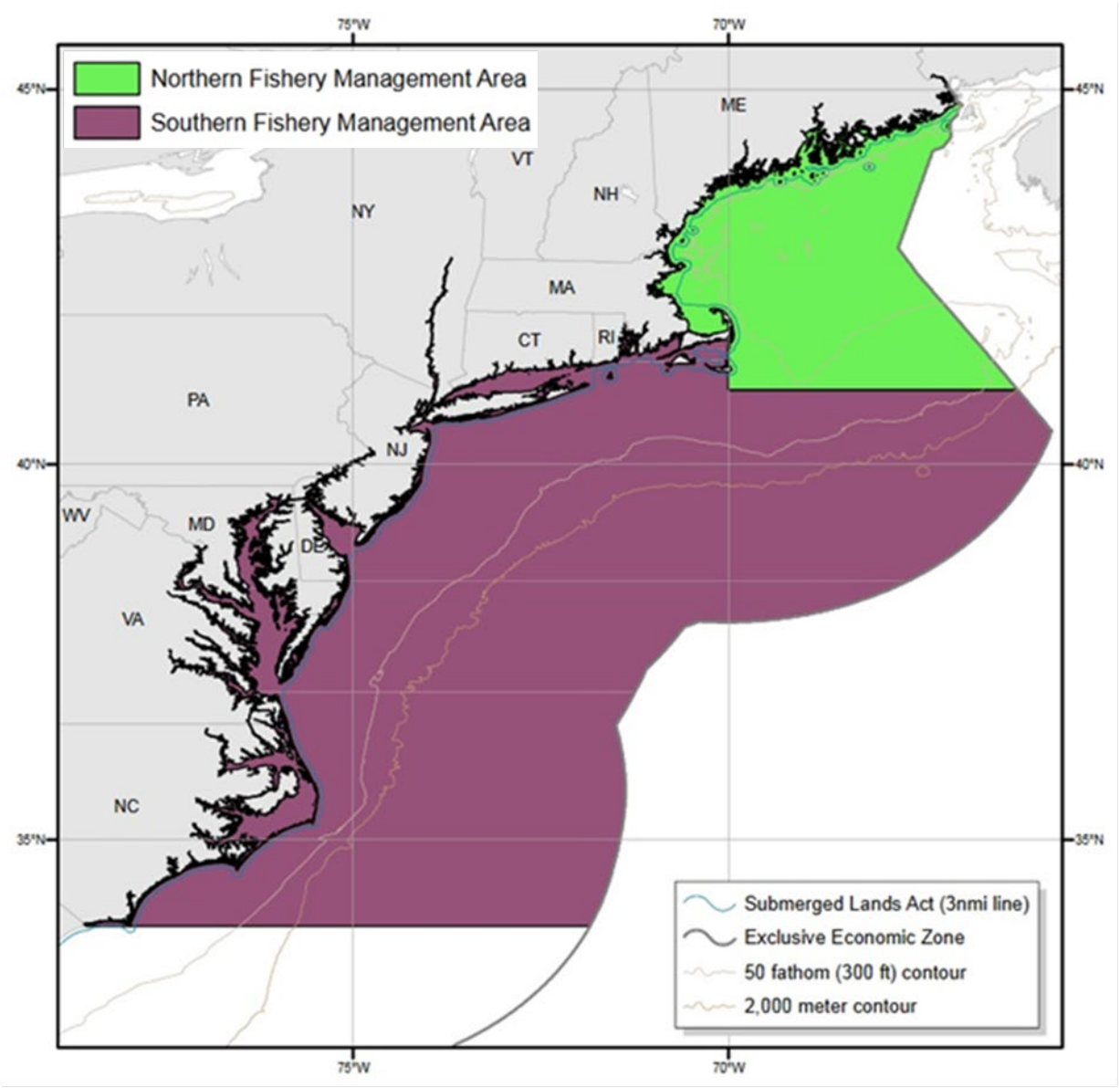

Figure 1. A map illustrating the Atlantic Monkfish fishery management areas (NOAA Fisheries Greater Atlantic Region). Monkfish management areas are divided between a northern (green) and southern area (purple).

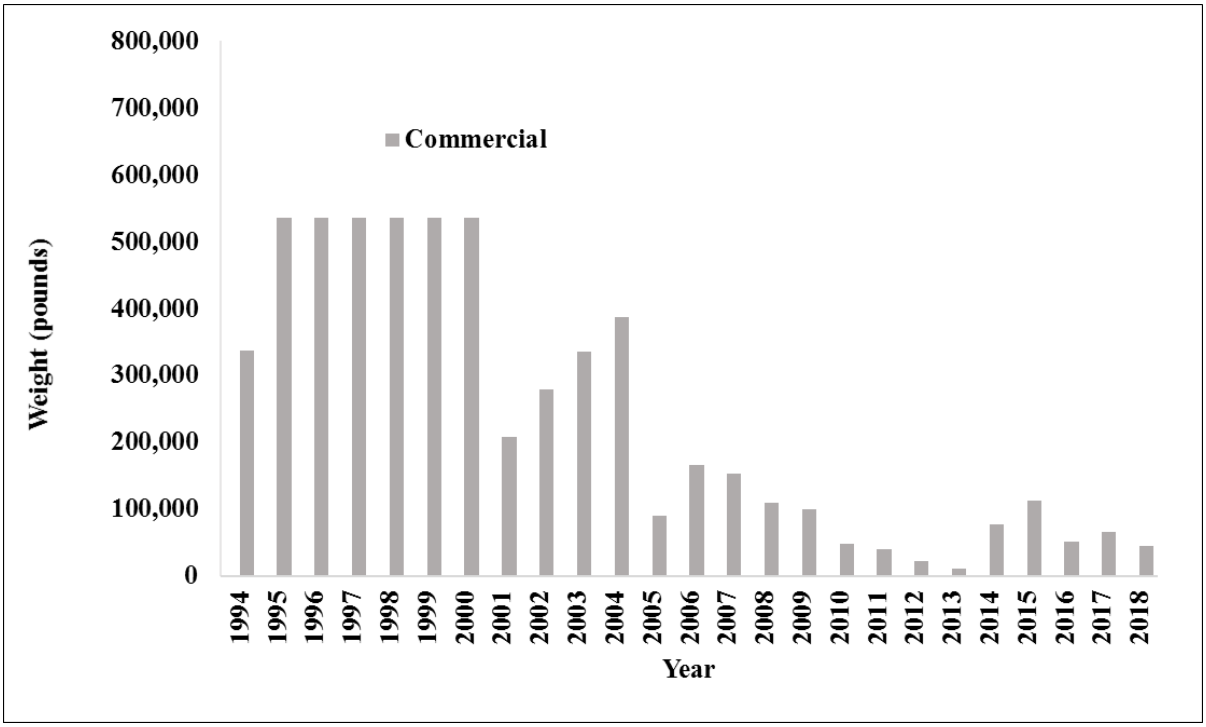

Figure 2. Annual commercial landings in pounds for monkfish in North Carolina from 1994-2018.

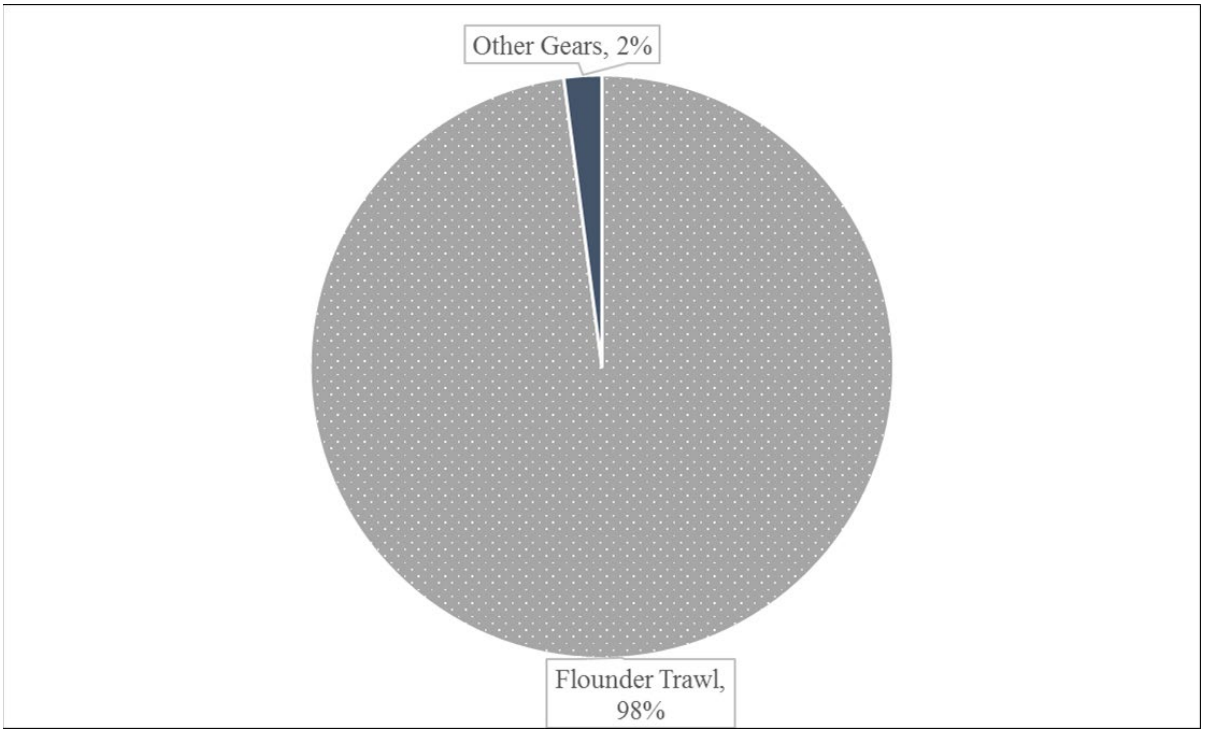

Figure 3. Commercial harvest of monkfish in North Carolina by gear type in 2018.

FISHERY MANAGEMENT PLAN UPDATE
SCUP NORTH OF CAPE HATTERAS
AUGUST 2019

STATUS OF THE FISHERY MANAGEMENT PLAN

Fishery Management Plan History

Original FMP Adoption: Incorporated into the Summer Flounder FMP through Amendment 8 in 1996

Amendments:

- Amendment 8 in 1996
- Regulatory Amendment in 1996
- Amendment 10 in 1997
- Amendment 11 in 1998
- Amendment 12 in 1999
  - Framework 1 in 2001
  - Addendum III in 2001
  - Addendum IV in 2001
  - Addendum V in 2002
  - Addendum VII in 2002
  - Framework 3 in 2003
  - Framework 4 in 2003
  - Addendum IX in 2003
  - Addendum X in 2003
- Amendment 13 in 2003
  - Framework 5 in 2004
  - Addendum XI in 2004
  - Addendum XIII in 2004
  - Addendum XVI in 2005
  - Framework 7 in 2007
  - Addendum XIX in 2007
- Amendment 14 in 2007
- Amendment 16 in 2007
  - Addendum XX in 2009
- Amendment 15 in 2011
- Amendment 19 (Recreational Accountability Amendment) in 2013
- Amendment 17 in 2015
- Amendment 18 in 2015
  - Framework 9 in 2016
- Amendment 20 in 2017
  - Addendum XXIX in 2017
  - Framework 10 in 2017
  - Framework 11 in 2018

Framework 12 in 2018
Framework 13 in 2018
Addendum XXXI in 2018

Revisions: None

Supplements: None

Information Updates: None

Next Benchmark Review: A benchmark stock assessment was completed in 2015 and a stock assessment update has been scheduled for late 2019.

Because of their presence in, and movement between, state waters (0-3 miles) and federal waters (3-200 miles), the Mid-Atlantic Fishery Management Council (MAFMC) manages scup (*Stenotomus chrysops*) north of Cape Hatteras cooperatively with the Atlantic States Marine Fisheries Commission (ASMFC). The two management entities work in conjunction with the National Marine Fisheries Service (NMFS) as the federal implementation and enforcement entity. The Summer Flounder, Scup and Black Sea Bass Fishery Management Plan (FMP) and amendments use output controls (catch and landings limits) as the primary management tool, with landings divided between the commercial (78%) and recreational (22%) fisheries. The FMP also includes minimum fish sizes, bag limits, seasons, gear restrictions, permit requirements, and other provisions to prevent overfishing and ensure sustainability of the fisheries. Recreational bag and size limits and seasons are determined on a state-by-state basis using conservation equivalency in state waters and coast-wide measures in federal waters. The commercial quota is coast-wide during the winter seasons (January-April; October-December) and state specific during the summer season (May-September).

Specific details for each Amendment include:

Amendment 8 - incorporated scup into the Summer Flounder FMP; established scup management measures, including commercial quotas, recreational harvest limits, size limits, gear restrictions, permits, and reporting requirements.

Regulatory Amendment - established seasonal quota periods of the commercial scup fishery.

Amendment 10 - modified commercial minimum mesh requirements; continued commercial vessel moratorium permit; prohibited transfer of summer flounder at sea; established a special permit for the summer flounder party/charter sector.

Amendment 11 - modified certain provisions related to vessel replacement and upgrading, permit history transfer, splitting, and permit renewal regulations.

Amendment 12 - revised the Summer Flounder, Scup, and Black Sea Bass FMP to comply with the Sustainable Fisheries Act and established a framework adjustment

process; established quota set-aside for research for summer flounder, scup and black sea bass; established state-specific conservation equivalency measures; allowed the rollover of the winter scup quota; revised the start date for the scup summer quota period.

Framework 1 - established quota set-aside for research for summer flounder, scup and black sea bass.

Addendum III - established recreational fishing specifications for 2001 for summer flounder and scup.

Addendum IV - provided that upon the recommendation of the relevant monitoring committee and joint consideration with the Mid-Atlantic Fishery Management Council, the ASMFC's Summer Flounder, Scup, and Black Sea Bass Management Board will decide the state regulations rather than forward a recommendation to the National Marine Fisheries Science center; made states responsible for implementing the ASMFC's Summer Flounder, Scup, and Black Sea Bass Management Boards decisions on regulations.

Addendum V - created state-specific shares of the summer period quota that will remain in place until the ASMFC's Summer Flounder, Scup, and Black Sea Bass Management Board takes direct action to modify them.

Addendum VII - established recreational fishing specifications for scup for 2002.

Framework 3 - allowed the rollover of winter scup quota; revised the start date for the summer quota period for the scup fishery.

Framework 4 - established a system to transfer scup at sea.

Addendum IX - established recreational specifications for scup in 2003.

Addendum X - established quota rollover and quota period specifications for the commercial scup fishery.

Amendment 13 - revised black sea bass commercial quota system; addressed other black sea bass management measures; established multi-year specification setting of quota for summer flounder, scup and black sea bass; established region-specific conservation equivalency measures for summer flounder; built flexibility into process to define and update status determination criteria for each plan species. Amendment 13 also removed the necessity for fishermen who have both a Northeast Region (NER) black sea bass permit and a Southeast Region (SER) snapper/grouper permit to relinquish their permits for a six-month period prior to fishing south of Cape Hatteras during the northern closure.

Framework 5 - established multi-year specification setting of quota for summer flounder, scup, and black sea bass.

Addendum XI - proposed that the recreational scup fishery be constrained to the coast-wide recreational harvest limit, allow states to customize scup recreational management measures to deal with burden issues associated with the implementation of coast-wide measures, minimize the administrative burden when implementing conservation equivalency.

Addendum XIII - modified the Summer Flounder, Scup, and Black Sea Bass FMP so that Total Allowable Landings for summer flounder, scup, and/or black sea bass can be specified for up to three years.

Addendum XVI - established guidelines for delayed implementation of management strategies.

Framework 7 - built flexibility into process to define and update status determination criteria for summer flounder, scup and black sea bass.

Addendum XIX - continued the state-by-state black sea bass commercial management measures, without a sunset clause; broadened the descriptions of stock status determination criteria contained within the Summer Flounder, Scup, and Black Sea Bass FMP to allow greater flexibility in those definitions, while maintaining objective and measurable status determination criteria for identifying when stocks or stock complexes covered by the fishery management plan are overfished.

Amendment 14 - established a rebuilding schedule for scup; scup gear restricted areas made modifiable through framework adjustment process.

Amendment 16 - standardized bycatch reporting methodology.

Addendum XX - set policies to reconcile commercial quota overages to address minor inadvertent quota overages; streamlined the quota transfers process and established clear policies and administrative protocols to guide the allocation of transfers from states with underages to states with overages; allowed for commercial quota transfers to reconcile quota overages after a year's end.

Amendment 15 - established annual catch limits and accountability measures.

Amendment 19 - (Recreational Accountability Amendment) – modified the accountability measures for the MAFMC recreational fisheries.

Amendment 17 - implemented standardized bycatch reporting methodology.

Amendment 18 - eliminated the requirement for vessel owners to submit "did not fish" reports for the months or weeks when their vessel was not fishing; removed some of the restrictions for upgrading vessels listed on federal fishing permits.

Framework 9 - modified the southern and eastern boundaries of the southern scup gear restricted area (in effect January 1-March 15).

Amendment 20 - implemented management measures to prevent the development of new, and the expansion of existing, commercial fisheries on certain forage species in the Mid-Atlantic.

Addendum XXIX - established new start and end dates for the scup commercial quota periods, moved first half of May to Winter I and October to Winter II.

Framework 10 - implemented a requirement for vessels that hold party/charter permits for Council-managed species to submit vessel trip reports electronically (eVTRs) while on a trip carrying passengers for hire.

Framework 11 - established a process for setting constant multi-year Acceptable Biological Catch (ABC) limits for Council-managed fisheries, clarified that the Atlantic Bluefish, Tilefish, and Atlantic Mackerel, Squid, and Butterfish FMPs will now automatically incorporate the best available scientific information in calculating ABCs (as all other Mid-Atlantic management plans do) rather than requiring a separate management action to adopt them, clarified the process for setting ABCs for each of the four types of ABC control rules.

Framework 12 - modified the dates of the commercial scup quota periods, moving the month of October from the Summer Period to the Winter II period.

Framework 13 - modified the accountability measures required for overages not caused by directed landings (i.e., discards) in the summer flounder, scup, and black sea bass fisheries.

Addendum XXXI - established conservation equivalency for black sea bass and transit provisions in federal waters around Block Island, Rhode Island for recreational and commercial fishermen which allows permitted fishermen to pass through federal waters legally.

Specific details for each Amendment under development include: None

To ensure compliance with interstate requirements, North Carolina also manages this species 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 MAFMC, 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. These plans were established under the Magnuson-Stevens Fishery Conservation and Management Act (federal council plans) and the Atlantic Coastal Fisheries Cooperative Management Act (ASMFC plans) with the goal, like the Fisheries Reform Act of 1997, to "ensure long-term viability" of these fisheries (NCDMF 2015).

M**anagement Unit**

U.S. waters in the western Atlantic Ocean from Cape Hatteras northward to the U.S.-Canadian border.

Goal and Objectives

The objectives of the Summer Flounder, Scup, and Black Sea Bass FMP are to:

1. Reduce fishing mortality in the summer flounder, scup and black sea bass fisheries to assure that overfishing does not occur;
2. Reduce fishing mortality on immature summer flounder, scup and black sea bass to increase spawning stock biomass;
3. Improve the yield from these fisheries;
4. Promote compatible management regulations between state and federal jurisdictions;
5. Promote uniform and effective enforcement of regulations;
6. Minimize regulations to achieve the management objectives stated above.

The 2011 Omnibus Amendment contains Amendment 15 to the Summer Flounder, Scup and Black Sea Bass FMP. The amendment is intended to formalize the process of addressing scientific and management uncertainty when setting catch limits for the upcoming fishing year(s) and to establish a comprehensive system of accountability for catch (including both landings and discards) relative to those limits, for each of the managed resources subject to this requirement. Specifically: (1) Establish allowable biological catch control rules, (2) Establish a MAFMC risk policy, which is one variable needed for the allowable biological catch control rules, (3) Establish annual catch limits, (4) Establish a system of comprehensive accountability, that addresses all components of the catch, (5) Describe the process by which the performance of the annual catch limit and comprehensive accountability system will be reviewed, (6) Describe the process to modify the above objectives (1-5) in the future.

STATUS OF THE STOCK

Life History

Scup are a migratory, schooling species found primarily along the Atlantic coast from Cape Cod, Massachusetts to Cape Hatteras North Carolina. However, a smaller southern stock is believed to occur in North Carolina south of Cape Hatteras. Scup, north of Cape Hatteras, typically reach sexual maturity at age 2 to 3 or when they reach 7 inches fork length. Spawning for the northern stock typically occurs in estuaries and coastal waters during the months of May to August. They move offshore during the fall and winter. Extensive seasonal migration related to spawning is

common for scup (north of Cape Hatteras). Scup have a maximum age of 14 years. Scup are bottom (benthic) feeders and prey on small crustaceans, mollusks, squid, sand dollars and fish (Steimle et al. 1999).

Stock Status

The 2015 scup benchmark stock assessment included data through 2014 and indicated that the stock was not overfished, and overfishing was not occurring in 2014. A stock assessment update has been scheduled for late 2019.

Stock Assessment

The 2015 scup benchmark stock assessment estimated fishing mortality and stock sizes using a statistical catch at age model calculated by using the Age Structured Assessment Program. This indicated that the fishing mortality rate was below the threshold reference point and the spawning stock biomass was above the target reference point, so the stock was not overfished and overfishing was not occurring as outlined by the biological reference points.

STATUS OF THE FISHERY

Current Regulations

Commercial: 9-inch fork length minimum size limit in Atlantic Ocean and internal coastal waters. Daily trip limits for the different harvest periods (Winter I, Summer, Winter II) are set by proclamation. Winter I and Winter II trip limits follow the coast-wide measures, while the summer trip limit is designed to prevent exceeding North Carolina's summer quota allocation (see most recent North Carolina Division of Marine Fisheries (NCDMF) proclamation).

Recreational: 8-inch fork length minimum size, 50-fish creel limit in state Atlantic Ocean and internal coastal waters north of Cape Hatteras; 9-inch fork length minimum size, 50-fish creel limit in federal Atlantic Ocean waters north of Cape Hatteras. Season is year-round.

Commercial Landings

All scup landings are reported through the North Carolina Trip Ticket Program. Most scup landings from north of Cape Hatteras were from trawls (Figure 1). Annual landings were variable from 1994 through 2018 with very low landings during 2012 to 2013 (Table 1, Figure 2). Low landings in 2012 to 2013 were partly due to the closure of Oregon Inlet to large vessels (such as trawlers) and the consequent landing of most of North Carolina's scup in Virginia and other states. During 2014 through 2018, winter trawl vessels returned to North Carolina to land catches rather than landing in Virginia and other states.

Recreational Landings

Recreational fishing activity is monitored through the Marine Recreational Information Program. In this report, estimates across all years have been updated and are now based on the MRIP new

Fishing Effort Survey-based calibrated estimates. For more information on MRIP methodology changes see https://www.fisheries.noaa.gov/topic/recreational-fishing-data. All scup harvest is reported through the National Oceanic and Atmospheric Administration (NOAA) Marine Recreational Information Program. Recreational harvest of scup north of Cape Hatteras only occurred in 1994, 2000, 2011, 2012 and 2015 (Table 1, Figure 2).

MONITORING PROGRAM DATA

Fishery-Dependent Monitoring

Two NCDMF sampling programs collect biological data on commercial and recreational fisheries that catch scup north of Cape Hatteras. Program 433 (Winter Trawl Fishery) is the primary program that collects harvest length data. Other commercial sampling programs focusing on fisheries that do not target scup rarely collect biological data. NCDMF sampling of the recreational fishery through the NOAA marine recreational information program collects harvest length data. There were no clear trends in commercial length data during 1994 through 2018. Annual mean lengths were fairly consistent for the time-series and 2018 was typical. The number measured declined in 2018 (Table 2).

Recreational harvest length data were only collected in 2011, 2012 and 2015 for scup north of Cape Hatteras. Only two fish in 1994, two fish in 2000, and one fish in 2015 were measured. Very few scup are encountered in this fishery (Table 3).

Age data have not been collected by NCDMF for scup north of Cape Hatteras because the stock assessment has not requested it.

Fishery-Independent Monitoring

NCDMF currently does not have independent sampling programs in Atlantic Ocean and internal coastal waters north of Cape Hatteras.

MANAGEMENT STRATEGY

Scup stock assessments are completed by the NMFS Northeast Fisheries Science Center (NEFSC). Results from the 2015 benchmark stock assessment are used to guide management. Data are analyzed from the previous year based on decisions made for the previous benchmark assessment. Projections based on stock assessments are used to set the coast-wide quota level each year. Amendments to the FMP are undertaken as issues arise that require action.

RESEARCH NEEDS

Updated research needs from the 2015 60th Stock Assessment Workshop are provided below. The research needs listed below start with the most recent. Text in parentheses indicates known progress made to address needs.

- A standardized fishery dependent catch per unit effort for tows targeting scup, from either Northeast Fisheries Observer Program observer samples or the commercial study fleet, might be considered as an additional index of abundance to complement survey indices in future benchmark assessments (progress unknown at this time).
- Explore additional sources of length and age data from fisheries and surveys in the early parts of the time series to provide additional context for model results (progress unknown at this time).
- Explore experiments to estimate the catchability of scup in NEFSC and other research trawl surveys (side-by-side, camera, gear mensuration, acoustics, etc.) (progress unknown at this time).
- Refine and update the Manderson et al. availability analysis when/if a new ocean model is available (need additional support). Explore alternative niche model parameterizations including laboratory experiments on thermal preference and tolerance (progress unknown at this time).
- Explore study fleet data in general for information that could provide additional context and/or input for the assessment (progress unknown at this time).
- A scientifically designed survey to sample larger and older scup would likely prove useful in improving knowledge of the relative abundance of these large fish (progress unknown at this time).
- Improve estimates of discards and discard mortality for commercial and recreational fisheries (some progress has been made).
- Evaluate indices of stock abundance from new surveys (some progress has been made).
- Quantify the pattern of predation on scup (some progress has been made).
- Conduct biological studies to investigate maturity schedules and factors affecting annual availability of scup to research surveys (some progress has been made),
- Explore the utility of incorporating ecological relationships, predation, and oceanic events that influence scup population size on the continental shelf and its availability to resource surveys into the stock assessment mode (some progress has been made).
- Evaluate alternate forms of survey selectivity in the assessment to inform indices of abundance at higher ages (some progress has been made).
- Evaluation of indicators of potential changes in stock status that could provide signs to managers of potential reductions of stock productivity in the future would be helpful (some progress has been made).
- A management strategy for evaluation of alternative approaches to setting quotas would be helpful (progress unknown at this time).
- Current research trawl surveys are likely adequate to index the abundance of scup at ages 0 to 2. However, the implementation of new standardized research surveys that focus onaccurately indexing the abundance of older scup (ages 3 and older) would likely improve the accuracy of the stock assessment (some progress has been made).
- Continuation of at least the current levels of at-sea and port sampling of the commercial and recreational fisheries in which scup are landed and discarded is critical to adequately characterize the quantity, length and age composition of the fishery catches (progress has been made and research is ongoing).

- Quantification of the biases in sampling of the catch and discards, including non-compliance, would help confirm the weightings used in the model. Additional studies would be required to address this issue (progress unknown at this time).
- The commercial discard mortality rate was assumed to be 100% in this assessment. Experimental work to better characterize the discard mortality rate of scup captured by different commercial gear types should be conducted to more accurately quantify the magnitude of scup discard mortality (progress unknown at this time).

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TABLES

Table 1. Scup (north of Cape Hatteras) recreational harvest and number released (NOAA Marine Recreational Information Program) and commercial harvest (North Carolina Trip Ticket Program) for 1994-2018. All weights are in pounds. Note: * represents confidential data.

	Recreational				
	Numbers		Weight (lb)		
Year	Landed	# Released	Landed	Commercial Weight (lb)	Total Weight (lb)
1994	827	1,231	365	56,394	56,759
1995	0	0	0	11,264	11,264
1996	0	1,267	0	57,477	57,477
1997	0	0	0	302	302
1998	0	0	0	14,528	14,528
1999	0	0	0	0	0
2000	165	0	169	0	169
2001	0	0	0	0	0
2002	0	0	0	*	*
2003	0	0	0	142,996	142,996
2004	0	0	0	523,554	523,554
2005	0	0	0	351,609	351,609
2006	0	0	0	139,420	139,420
2007	0	0	0	66,856	66,856
2008	0	0	0	205,703	205,703
2009	0	0	0	244,020	244,020
2010	0	0	0	102,745	102,745
2011	181	0	200	308,883	309,083
2012	521	0	516	3,903	4,419
2013	0	0	0	28,394	28,394
2014	0	0	0	160,399	160,399
2015	3,446	0	380	229,664	230,044
2016	0	0	0	111,901	111,901
2017	0	0	0	199,711	199,711
2018	0	0	0	78,944	78,944
Average	206	100	65	122,374	122,439

Table 2. Scup (north of Cape Hatteras) length (fork length, inches) data from commercial fish house samples, 1994-2018.

Year	Mean Fork Length (in)	Minimum Fork Length (in)	Maximum Fork Length (in)	Total Number Measured
1994	9	4	15	3,342
1995	9	7	12	169
1996	10	8	14	76
1997	5	4	16	176
1998	9	7	13	66
1999	0	0	0	0
2000	0	0	0	0
2001	0	0	0	0
2002	10	9	13	393
2003	11	4	16	1,210
2004	10	6	16	2,584
2005	11	4	15	1,817
2006	11	6	15	1,568
2007	11	7	16	1,659
2008	11	7	16	3,493
2009	11	6	16	1,740
2010	11	8	15	1,450
2011	11	8	16	1,076
2012	13	11	16	7
2013	10	8	15	261
2014	11	8	17	2,725
2015	11	5	17	2,998
2016	11	6	15	1,175
2017	11	8	16	2,879
2018	11	7	17	1,940

Table 3. Scup (north of Cape Hatteras) length (fork length, inches) data from NOAA Marine Recreational Information Program recreational samples, 1994-2018.

Year	Mean Fork Length (in)	Minimum Fork Length (in)	Maximum Fork Length (in)	Total Number Measured
1994	7	7	9	2
1995	0	0	0	0
1996	0	0	0	0
1997	0	0	0	0
1998	0	0	0	0
1999	0	0	0	0
2000	11	11	11	2
2001	0	0	0	0
2002	0	0	0	0
2003	0	0	0	0
2004	0	0	0	0
2005	0	0	0	0
2006	0	0	0	0
2007	0	0	0	0
2008	0	0	0	0
2009	0	0	0	0
2010	0	0	0	0
2011	0	0	0	0
2012	0	0	0	0
2013	0	0	0	0
2014	0	0	0	0
2015	4	4	4	1
2016	0	0	0	0
2017	0	0	0	0
2018	0	0	0	0

FIGURES

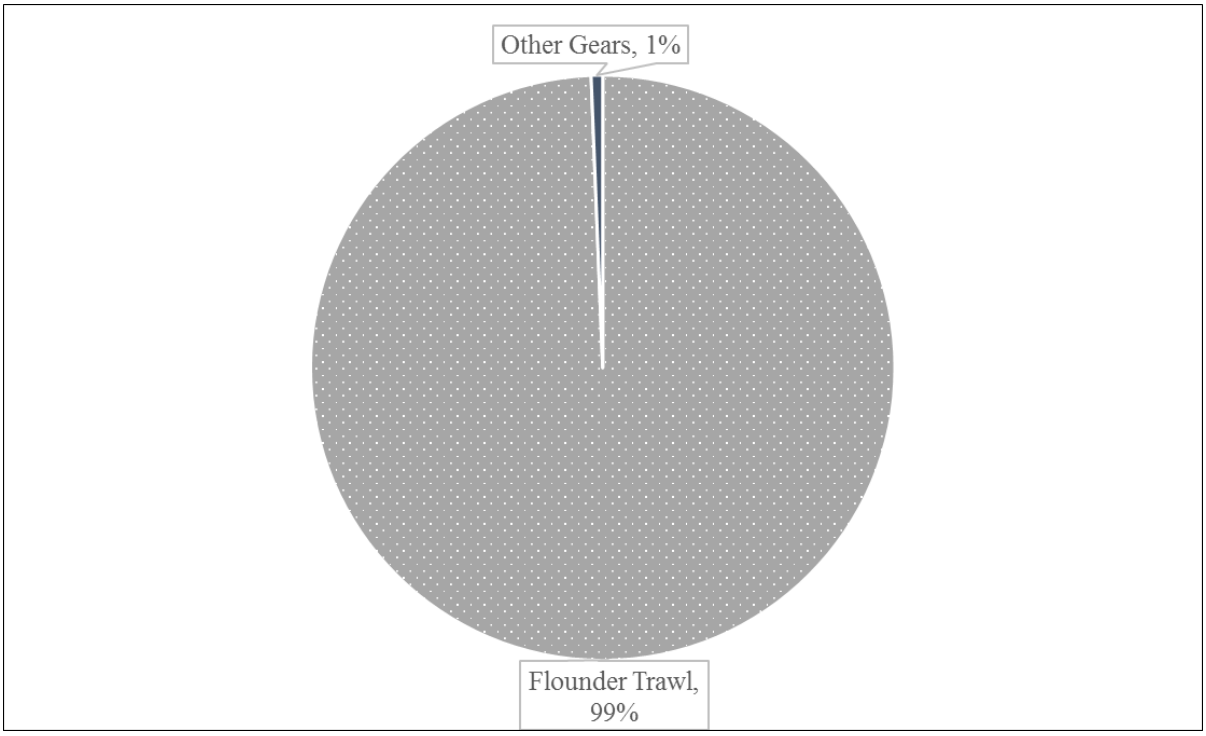

Figure 1. Commercial harvest of scup (north of Cape Hatteras) in North Carolina by gear type in 2018.

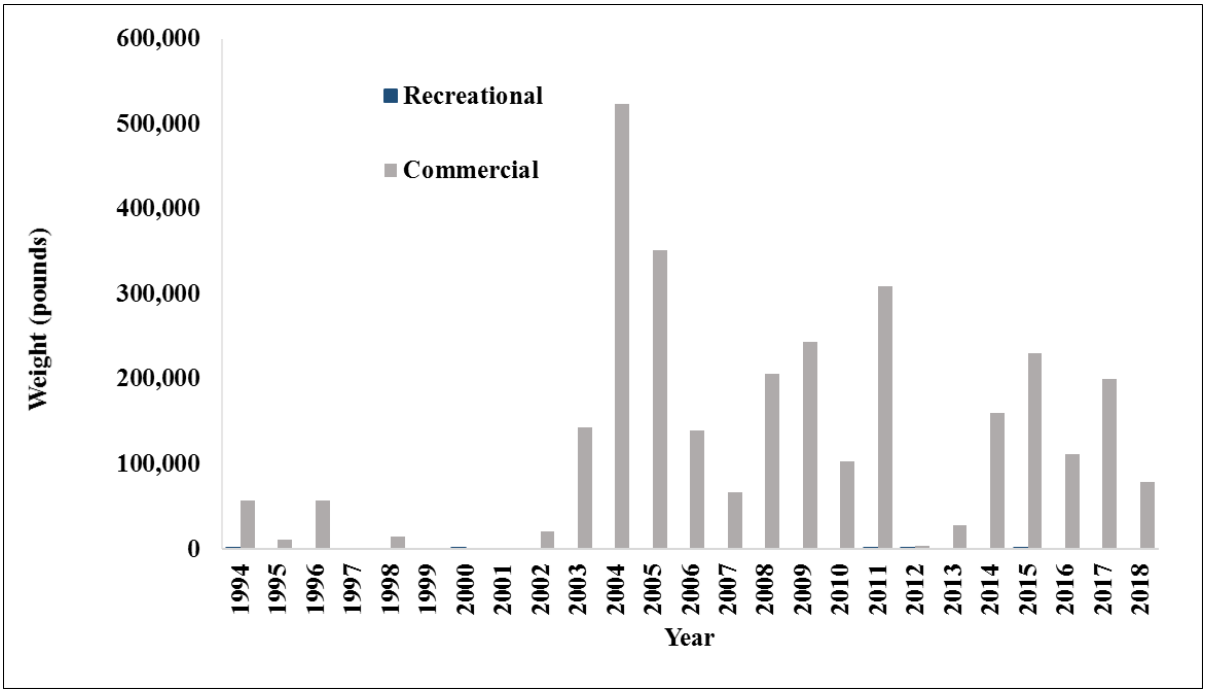

Figure 2. Annual commercial and recreational landings in pounds for scup (north of Cape Hatteras) in North Carolina from 1994-2018.

FISHERY MANAGEMENT PLAN UPDATE
SHARKS
AUGUST 2019

STATUS OF THE FISHERY MANAGEMENT PLAN

Fishery Management Plan History

Original FMP Adoption:	August 2008 Addendum I – September 2009 Addendum II – May 2013 Addendum III – October 2013 Addendum IV – August 2016 Addendum V – October 2018
Amendments:	None
Revisions:	None
Supplements:	None
Information Updates:	None
Next Benchmark Review:	None

The Atlantic States Marine Fisheries Commission (ASMFC) adopted a fishery management plan (FMP) for coastal sharks in 2008 (ASMFC 2008) to complement federal management actions and increase protection of pregnant females and juveniles in inshore nursery areas. The FMP regulates 40 different species of coastal sharks found on the Atlantic coast. The ASMFC does not actively set quotas for any shark species and follows NOAA Fisheries (National Oceanic and Atmospheric Administration) openings and closures for all shark management groups. Species in the prohibited category may not be possessed or taken. Sandbar sharks (*Carcharhinus plumbeus*) may only be taken with an Atlantic Highly Migratory Species (HMS) Shark Research Fishery Permit. All species must be landed with their fins attached to the carcass by natural means through offloading, with the exception of smooth dogfish (*Mustelus canis*).

Addendum I (ASMFC 2009) modified the FMP to allow limited smooth dogfish processing at sea (removal of fins from the carcass), removed smooth dogfish recreational possession limits, and removed gill net check requirements for smooth dogfish fishermen. The goal of Addendum I was to remove restrictive management intended for large coastal sharks (LCS) from the smooth dogfish fishery and to allow fishermen to continue their operations while upholding the conservation measures of the FMP.

In 2012, NOAA Fisheries created the smoothhound complex for the management of both the Florida smoothhound and smooth dogfish. Addendum II (ASMFC 2013a) modified the FMP to

allow year-round smooth dogfish processing at sea and allocated state-shares of the smooth dogfish federal quota. The goal of Addendum II was to implement an accurate fin-to-carcass ratio and prevent the quota of the smoothhound shark complex from being harvested by one state.

Addendum III (ASMFC 2013b) modified the species groups for hammerhead and blacknose sharks to ensure consistency with NOAA Fisheries. The addendum also increased the recreational size limit for all hammerhead shark species to 78 inches fork length (FL) and for blacknose and finetooth sharks to 54 inches FL.

Addendum IV (ASMFC 2016) allows smooth dogfish carcasses to be landed with corresponding fins removed from the carcass if the total retained catch, by weight, is composed of at least 25% smooth dogfish, consistent with federal management measures.

Addendum V (ASMFC 2018) allows the ASMFC to streamline the process of state implementation of federal shark regulations so that complementary measures are seamlessly and concurrently implemented at the state and federal level whenever possible. Previously any changes, with the exception of those related to commercial quotas, possession limits and season dates, had to be accomplished through an addendum.

To ensure compliance with interstate requirements, North Carolina also manages the coastal shark complex 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 plans) and the Atlantic Coastal Fisheries Cooperative Management Act (ASMFC plans), are like the goals of the Fisheries Reform Act of 1997 to "ensure long-term viability" of these fisheries (NCDMF 2015).

Management Unit

The management unit includes the entire coast-wide distribution of the resource from the estuaries eastward to the inshore boundary of the exclusive economic zone (EEZ). The management unit is split between the Atlantic and Gulf of Mexico regions for aggregated LCS, hammerhead, non-blacknose small coastal sharks (SCS), and blacknose sharks. No regional quotas are in place for pelagic shark species.

Goal and Objectives

The Interstate FMP for Coastal Sharks (ASMFC 2008) established the following goal and objectives. The goal of the Interstate FMP for Coastal Sharks is to promote stock rebuilding and management of the coastal shark fishery in a manner that is biologically, economically, socially, and ecologically sound.

In support of this goal, the following objectives are in place for the Interstate Shark FMP:

1. Reduce fishing mortality to rebuild stock biomass, prevent stock collapse, and support a sustainable fishery.
2. Protect essential habitat areas such as nurseries and pupping grounds to protect sharks during particularly vulnerable stages in their life cycle.
3. Coordinate management activities between state and federal waters to promote complementary regulations throughout the species' range.
4. Obtain biological and improved fishery related data to increase understanding of state water shark fisheries.
5. Minimize endangered species bycatch in shark fisheries.

STATUS OF THE STOCK

Life History

Sharks belong to the class Chondrichthyes (cartilaginous fish) that also includes rays and skates. Relative to other marine fish, sharks produce few young in their lifetime. The low reproductive rate is due to slow growth, late sexual maturity of females, one to two-year reproductive cycles, and small litter size (Musick 1999). These biological factors leave many species of sharks vulnerable to overfishing (Stevens et al. 2000).

Sharks exhibit a number of different reproductive strategies ranging from giving birth to live pups (young) to egg laying (Dulvy and Reynolds 1997). Generally, female sharks produce a small number (2 to 25) large-body pups (Simpfendorfer 1992). For some species, an increased gestation period allows for larger pups which is thought to increase juvenile survivorship (Stevens and McLoughlin 1991). Adults usually gather in specific areas to mate although little is known about shark mating behavior for most species. Sharks also exhibit a wide variety of life history traits across species. Some pelagic species such as shortfin mako (*Isurus oxyrinchus*) or Atlantic thresher (*Alopias vulpinus*), generally remain in offshore ocean environments their whole lives (Casey and Kohler 1992; Smith et al. 2008). Other shark species have an estuarine-dependent component to their life cycle. For example, mature female Atlantic sharpnose sharks (*Rhizoprionodon terraenovae*) and sandbars (*Charcarhinus plumbeus*) travel from near-shore coastal areas into estuarine habitats to pup (Grubbs et al. 2007; Carlson et al. 2008). Coastal shark nursery areas, such as bays and estuaries, are discrete, productive, and highly structured habitats that provide juveniles ample nutrients and refuge from predators (Heupel et al. 2007). Once mature, these shark species will emigrate into coastal ocean environments to continue their life cycle. The variability of life history traits (growth rate, age-at-maturity, reproduction rate, etc.) and highly mobile nature of sharks makes fisheries management across multiple species difficult (Cortés 2002).

Stock Status

Stock status is assessed by species complex for most coastal sharks and by species group for those with enough data for an individual assessment (Table 1). NOAA Fisheries produces an annual Stock Assessment and Fisheries Evaluation (SAFE) Report that reviews the status of Atlantic HMS fish stocks (tunas, swordfish, billfish, and sharks). These reports are required under the Magnuson-Stevens Fishery Conservation and Management Act and provide the public with information on the latest developments in Atlantic HMS management. The 2016 SAFE Report included information on the stock assessment update for dusky sharks and the continued shark nursery ground research and essential fish habitat studies (NOAA Fisheries 2016).

Stock Assessment

Stock status varies between species and species group (Table 1). The Southeast Data Assessment and Review (SEDAR) completed a benchmark stock assessment on the smoothhound shark complex (*Mustelus spp*.) in the Gulf of Mexico and Atlantic smooth dogfish in the Atlantic through SEDAR 39. The assessment found that neither stock was overfished or experiencing overfishing (SEDAR 2015). The SEDAR 21 (2011) benchmark assessment of dusky (*Carcharhinus obscures*), sandbar, and blacknose (*Carcharhinus acrontus*) sharks indicated that both sandbar and dusky sharks were overfished with overfishing occurring for dusky sharks. Blacknose sharks, part of the SCS complex, were also overfished with overfishing occurring. The Coast Shark Management Board of ASMFC approved the blacknose shark assessment for management use in February 2012 and NOAA Fisheries' Highly Migratory Species Division (HMS) incorporated the results of the assessment as part of Amendment 5a to its FMP (HMS 2013). The dusky shark stock assessment updated in 2016, resulted in a determination of the population being overfished with overfishing occurring. ASMFC has yet to finalize measures for dusky shark management based on this most recent stock determination.

Porbeagle sharks (*Lamna nasus*) were assessed by the International Commission for the Conservation of Atlantic Tunas (ICCAT) Standing Committee on Research and Statistics in 2009 (ICCAT 2010). The assessment found that while the Northwest Atlantic stock was increasing in biomass, the stock was considered to be overfished with overfishing not occurring. The 2007 SEDAR 13 assessed the SCS complex, finetooth (*Carcharhinus isodon*), Atlantic sharpnose (*Rhizoprionodon terraenovae*), and bonnethead (*Sphyrna tiburo*) sharks (SEDAR 2013). The SEDAR 13 peer reviewers considered the data to be the 'best available at the time' and determined the status of the SCS complex to be adequate. Finetooth, Atlantic sharpnose and bonnethead were all considered to be not overfished and not experiencing overfishing. Atlantic sharpnose and bonnethead were more recently assessed by SEDAR 34, and are still considered not overfished or undergoing overfishing (SEDAR 2013).

SEDAR 11 (2006) assessed the LCS complex and blacktip sharks (*Carcharhinus limbatus*). The LCS assessment suggested that it was inappropriate to assess the LCS complex as a whole due to the variation in life history parameters, different intrinsic rates of increase, and different catch and abundance data for all species included in the LCS complex. Based on these results, NOAA Fisheries changed the status of the LCS complex from overfished to unknown. As part of SEDAR 11, blacktip sharks were assessed for the first time as two separate populations: Gulf of Mexico and Atlantic. The results indicated that the Gulf of Mexico stock was not overfished and

overfishing was not occurring, while the status of blacktip sharks in the Atlantic region was unknown.

In 2017, ICCAT updated a 2012 stock assessment for shortfin mako sharks (*Isurus oxyrinchus*). This assessment used another modeling approach which incorporated more abundance indices, sex-specific life history data, and tagging information. Based on model results, the population was considered overfished with overfishing occurring. On March 3, 2019, NOAA HMS implemented final measures to address the overfishing and overfished condition of Atlantic shortfin mako under Amendment 11 to the HMS FMP. The rules respond to the determination by ICCAT that all member countries need to reduce shortfin mako landings by 72-79% to prevent further population decline. The final commercial rule as implemented allows for Atlantic shortfin mako commercial retention only by properly permitted operations using pelagic longline and gillnet gear and only if the shark is dead at haul back. Additionally, retention by pelagic longline gear is only allowed if a functional electronic monitoring system is on board the vessel. Recreational measures include an increase in the minimum size limit from 54 inches FL to 71 inches FL for males and to 83 inches FL for females. In April of 2019, the ASMFC Coastal Shark Board adopted complementary size limit measures for the recreational fishery in state waters to provide consistency with size limits in federal waters. Individual states must implement these minimum size limits for Atlantic shortfin mako by January 1, 2020.

STATUS OF THE FISHERY

Current Regulations

Commercial

All non-prohibited coastal shark complexes opened in North Carolina on January 1, 2018 (Table 2) reflecting NOAA Fisheries openings for these complexes. NOAA Fisheries closes the shark complexes when 80% of their quota is reached. When the fishery closes in federal waters, the Interstate FMP dictates that the fishery also closes in state waters. No harvest or size restrictions are in place for LCS, but there is a retention limit that set and changed by NOAA fisheries based on available quota. It is unlawful to possess any shark (with the exception of smooth dogfish) without tail and fins naturally attached to the carcass through offloading. Commercial fishermen may completely remove the fins of smooth dogfish, if the total retained catch, by weight, is composed of at least 25% smooth dogfish. If fins are removed, the total wet weight of the shark fins may not exceed 12% of the total dressed weight of smooth dogfish carcasses landed or found onboard a vessel. It is unlawful for a vessel to retain, transship, land, store or sell scalloped hammerhead, great hammerhead, or smooth hammerhead sharks with pelagic longline gear onboard. It is unlawful for a vessel to retain sandbar sharks unless the vessel is selected to participate in the shark research fishery, subject to retention limits established by NOAA Fisheries and only when a NOAA Fisheries approved observer is onboard. It is unlawful to use gears other than rod and reel, handlines, large and small mesh gill nets, shortlines (maximum of two shortlines, 500 yards each with 50 hooks or less, hooks shall not be corrosion resistant and must be designated by the manufacturer as circle hooks), pound nets/fish traps, and trawl nets. It is unlawful to use a large mesh (stretched mesh size greater than or equal to 5 inch) gill net more

than 2,734 yards in length to capture sharks. It is unlawful to sell shark to anyone who is not a federally-permitted shark dealer.

NOAA Fisheries sets quotas for coastal sharks through their 2006 Consolidated Highly Migratory Species Fishery Management Plan (HMS FMP) (NOAA Fisheries 2006). As indicated above, the states follow NOAA Fisheries openings and closings, which are based on available quotas (Table 2).

Recreational

All non-prohibited coastal shark complexes opened on January 1, 2018. These openings follow NOAA Fisheries openings of the species complexes. It is unlawful for a recreational angler to possess more than one Atlantic sharpnose, and one bonnethead and one additional shark from the recreationally permitted species list per person per calendar day (Table 3). If fishing from a vessel, it is unlawful to have more than one additional shark from the recreationally permitted species list aboard a vessel, per calendar day, regardless of the number of people on board the vessel. It is unlawful to possess silky sharks (*Carcharhinus falciformis*) and sandbar sharks for recreational purposes. It is unlawful to possess great hammerhead, smooth hammerhead and scalloped hammerhead sharks less than 78 inches fork length (Table 4). It is unlawful to possess the rest of the LCS, blacknose, finetooth, and pelagic shark species less than 54 inches fork length (Table 4). Smooth dogfish are excempt from harvest and size restrictions. SCS have no minimum size, except for blacknose sharks. It is unlawful for recreational fishermen to possess any shark without head, tail, and fins intact with the carcass through the point of landing. Anglers may still gut and bleed the carcass as long as the tail is not removed. Filleting sharks at sea is prohibited. It is unlawful to fail to return all sharks not meeting harvest requirements (including prohibited species) to the water in a manner that ensures the highest likelihood of survival. It is unlawful for recreational fishermen to catch sharks by any method other than rod and reel or handlines. Handlines are defined as a mainline with no more than two gangions or hooks attached that are retrieved by hand only. It is unlawful to possess a great hammerhead, scalloped hammerhead, smooth hammerhead, or oceanic whitetip shark while in possession of tunas, billfish or, swordfish. As regulations are subject to change, always check the NCDMF website for the most current proclamation for these species.

Commercial Landings

Table 2 summarized coast-wide Atlantic commercial landings data from 2018 by shark management group. Atlantic commercial landings of LCS totaled 204,610 pounds dressed weight (dw) in 2018, which was a decrease of 83,973 pounds from 2017. Total commercial landings of hammerhead sharks were 27,455 pounds dw in 2018, which was an increase from 20,590 pounds dw reported in 2017. Commercial landings of non-blacknose SCS shark species in 2018 totaled 289,563 pounds dw, which was an increase from the 273,978 pounds dw observed in 2017. The commercial landings total of blacknose sharks south of 34º N latitude (Kure Beach, North Carolina) in 2018 was 11,335 pounds dw. Commercial retention of blacknose sharks is prohibited north of 34º N latitude. In 2018, the total commercial landings of pelagic shark species was 120,556 pounds dw. Commercial landings of smoothhound sharks in 2018 was 906,471 pounds dw, which was an increase over the 832,480 pounds dw landed in

2017. In North Carolina, commercial landings have been variable for the past ten years (Table 5).

Recreational Landings

Recreational fishing activity is monitored through the Marine Recreational Information Program. In this report, estimates across all years have been updated and are now based on the MRIP new Fishing Effort Survey-based calibrated estimates. For more information on MRIP methodology changes see https://www.fisheries.noaa.gov/topic/recreational-fishing-data.

Recreational harvest for SCS in North Carolina has fluctuated from a peak harvest number of 51,183 pounds in 2009 to a low of 2,545 pounds in 2017, and averaged 19,946 pounds from 2009 to 2018 (Table 6).

Recreational harvest for LCS in North Carolina tends to be less than for SCS. Annual harvest in pounds was 235 pounds in 2018 and averaged 6,673 pounds from 2009 to 2018 (Table 7).

Recreational harvest of pelagic sharks in North Carolina s highly variable. Harvest was 160,155 pound in 2018 and has ranged from 0 to 479,443 pounds from 2009 to 2018 (Table 8).

Recreational harvest of smooth dogfish in North Carolina is variable and often low, although releases are common. Harvest for smooth dogfish ranged from 0 to 186,261 pounds and averaged 27,588 pounds from 2009 to 2018 (Table 9).

MONITORING PROGRAM DATA

Fishery-Dependent Monitoring

North Carolina does not collect individual lengths for sharks other than spiny dogfish, due to the fish arriving at the dock dressed (i.e. gutted with head and tail removed).

Fishery-Independent Monitoring

The North Carolina Division of Marine Fisheries (NCDMF) established a fisheries-independent adult red drum longline survey in 2007 that operates in Pamlico Sound from July to October. Atlantic coastal shark species captured in the survey are measured, tagged and released. In 2018, only one interaction of a bull shark occurred.

NCDMF has conducted a fisheries-independent gill net survey which has been conducted in Pamlico Sound since 2001. The objective of this project is to provide annual indices of abundance for key estuarine species in North Carolina that can be incorporated into stock assessments. Data from this survey are used to improve bycatch estimates, evaluate management measures, and evaluate habitat usage. Results from this project are used by the NCDMF and other Atlantic coast fishery management agencies to evaluate the effectiveness of current management measures and to identify additional measures that may be necessary to conserve marine and estuarine stocks. Developing fishery independent indices of abundance for target

species allows the NCDMF to assess the status of these stocks without relying solely on commercial and recreational fishery dependent data. Sampling is a stratified random sampling design in Pamlico Sound, utilizing multiple mesh gill nets (3.0-6.5 inch in one-half inch increments). In 2018, a total of 99 individual coastal sharks were captured in the gill net survey (Table 10). This result was slightly higher than the number of sharks encountered in 2017 (n=83).

MANAGEMENT STRATEGY

Most Atlantic shark species are highly mobile and the NOAA Fisheries' HMS Management Division is responsible for managing them under the Magnuson-Stevens Fishery Conservation and Management Act. In cooperation with an advisory panel, the division develops and implements FMPs for these species considering various domestic and international requirements. The ASMFC adopts NOAA Fisheries regulations in state waters.

RESEARCH NEEDS

The 2018 review of the ASMFC FMP (ASMFC 2018) for coastal sharks lists the following research needs:

Species-Specific Priorities

- Investigate the appropriateness of using vertebrae for ageing adult sandbar sharks. If appropriate, implement a systematic sampling program that gathers vertebral samples from entire size range for annual ageing to allow tracking the age distribution of the catch as well as updating of age-length keys.
- Determine what is missing in terms of experimental design or/and data analysis to arrive at incontrovertible conclusions on the reproductive periodicity of sandbar sharks
- Continue work on reconstruction of historical catches of sandbar sharks, especially catches outside of the US EEZ
- Investigate the length composition of the F3 Recreational and Mexican fisheries for sandbar sharks more in depth as this fishery is estimated to have a large impact on the stock mainly due to selecting age-0 fish.
- Research to estimate the degree of connectivity between the portions of the sandbar stock within the US and outside of the US EEZ.
- Study the distribution and movements of the sandbar stock relative to sampling coverage. It is possible that none of the indices alone track stock-wide abundance trends.
- Develop and conduct tagging studies on dusky and blacknose stock structure with increased international collaboration (e.g., Mexico) to ensure wider distribution and returns of tags. Expand research efforts directed towards tagging of individuals in south Florida and Texas/Mexico border to get better data discerning potential stock mixing.

General Priorities

- Generally update age and growth and reproductive studies for all species currently assessed, especially for studies with low sample sizes or over 20 years old.

- Determine gear-specific post-release mortality estimates for all species currently assessed
- Determine life history information for data-poor species that are currently not assessed
- Examine female sharks during the pupping periods to determine the proportion of reproductive females. Efforts should be made to develop non-lethal methods of determining pregnancy status
- Expand or develop monitoring programs to collect appropriate length and age samples from the catches in the commercial sector by gear type, from catches in the recreational sector, and from catches taken in research surveys to provide reliable length and age compositions for stock assessment
- Continue investigations into stock structure of coastal sharks using genetic, conventional and electronic tags to determine appropriate management units
- Evaluate to what extent the different CPUE indices track population abundance (e.g., through power analysis)
- Explore modeling approaches that do not require an assumption that the population is at virgin level at some point in time.
- Increase funding to allow hiring of additional HMS stock assessment scientists. There are currently inadequate staff to conduct stock assessments on more than one or two stocks/species per year.

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TABLES

Table 1. Atlantic States Marine Fisheries Commissions 2018 stock status designations for coastal sharks species groups.

Species or Complex Name	Stock overfished?	Stock undergoing overfishing?	Stock assessment year and comments
Pelagic			
Porbeagle	Yes	No	2009: Rebuilding ends 2018
Blue	No	No	2015
Shortfin Mako	Yes	Yes	2017
All other pelagic species	Unknown	Unknown	
Large Coastal Sharks			
Blacktip	Unknown	Unknown	2006
Aggregated Large Coastal Sharks-Atlantic Region	Unknown	Unknown	2006: Difficult to assess as a species complex due to various life history characteristics/lack of available data
Non-blacknose Small Coastal Sharks			
Atlantic Sharpnose	No	No	2013
Bonnethead	No	No	2013
Finetooth	No	No	2007
Hammerhead			
Scalloped	Yes	Yes	2009
Blacknose			
Blacknose	Yes	Yes	2010: Rebuilding ends in 2043
Smoothhound			
Smooth Dogfish	No	No	2015
Research			
Sandbar	Yes	No	2010
Prohibited			
Dusky	Yes	Yes	2010
All other prohibited species	Unknown	Unknown	

Table 2. Summary of the 2018 coast-wide Atlantic coastal shark commercial fishery landings and annual quota in pounds by dressed weight (lb dw) (NOAA Fisheries 2018).

Management Group	Region	2018 Annual Adjusted Quota (lb dw)	Season Opening Date	Season Closing Date	2018 Landings (lb dw)
Aggregated Large Coastal Sharks	Atlantic	372,552	1/1/2018	12/31/2018	204,610
Hammerhead Sharks		59,736			27,455
Non-Blacknose Small Coastal Sharks		582,333	1/1/2018	12/31/2018	289,563
Blacknose Sharks (South of 34° N. latitude only)		37,921		12/31/2018	11,335
Blue Sharks	No Regional Quotas	601,856		12/31/2018	< 30,000
Porbeagle Sharks		3,748		12/31/2018	< 1,100
Pelagic Sharks Other Than Porbeagle or Blue		1,075,856		12/31/2018	120,556
Smoothhound		3,973,902			906,471

Table 3. Recreationally permitted species list.

SPECIES AUTHORIZED FOR RECREATIONAL HARVEST			
Large Coastal Sharks (LCS) (non-ridgeback* LCS & tiger)	Small Coastal Sharks (SCS)	Pelagic Sharks	Other
Blacktip Bull Hammerhead, great** Hammerhead, scalloped** Hammerhead, smooth** Lemon Nurse Spinner Tiger	Atlantic Sharpnose Blacknose Bonnethead Finetooth	Blue Oceanic whitetip** Porbeagle Shortfin mako Thresher	Smoothhound Shark (Smooth Dogfish)

Table 4. Recreational size and bag limits.

RECREATIONALSIZE / BAG LIMITS and SEASONS			
Species*	Minimum Size (Fork Length) in Inches (")	Trip Bag Limit/Calendar Day	Season
Atlantic sharpnose	None	1 per person of each species	Jan. 1 – Dec. 31
Bonnethead	None		
Hammerheads (Great, Smooth and Scalloped)	78"	1 per vessel OR 1 per person for shore-anglers	
Non-Hammerhead LCS, Tiger, Pelagic, Blacknose, and Finetooth Sharks	54"		
Small Coastal Sharks (SCS)	None		

*Check proclamation for most current regulations.

Table 5. Summary of North Carolina landings (lbs.) for large coastal sharks (LCS), small coastal sharks (SCS), blacknose, hammerheads, smoothhound, pelagics, and sandbars from 2009-2018.

Year	LCS	SCS (non-blacknose)	Blacknose	Hammerhead	Smoothhound	Pelagics	Sandbar
2009	42,586	182,314	0	0	1,221,150	166,556	0
2010	96,462	132,572	0	0	1,614,844	295,163	58,746
2011	88,742	133,586	2,338	0	1,241,252	245,186	61,166
2012	101,882	276,048	3,394	44	980,333	243,121	19,792
2013	134,872	133,744	7,054	12,114	783,053	220,872	22,468
2014	269,436	200,887	3,685	28,264	498,904	424,851	71,272
2015	150,394	371,069	3,957	41,768	268,429	176,882	47,554
2016	230,797	369,948	1,192	62,135	178,694	224,746	57,226
2017	173,758	359,486	0	40,743	154,440	240,250	42,384
2018	138,238	428,482	108	55,004	209,760	126,443	62,908

Table 6. North Carolina small coastal sharks recreational harvest, discards, and percent standard error (PSE) (including blacknose) 2009-2018.

Year	Harvest Number	PSE	Weight (lb)	PSE	Number Released	PSE
2009	5,532	41.1	51,183	48.7	5,334	62.7
2010	4,654	46.5	21,878	37.1	107,135	66.6
2011	1,209	42.5	7,659	44	37,276	33.1
2012	2,082	47.5	11,804	48.4	7,733	43.5
2013	2,171	45.9	13,474	48	16,772	42.1
2014	7,420	56.7	24,060	43.9	2,043	57.5
2015	6,656	41.3	38,499	44.3	15,866	70.4
2016	514	66.6	2,545	63.4	133,214	57
2017	5,768	56.5	19,256	42.3	58,440	60.5
2018	1,678	38.9	9,097	40.9	4,496	39.5

*PSE higher than 50 indicates a very imprecise estimate.

Table 7. North Carolina large coastal sharks recreational harvest, discards, and percent standard error (PSE) 2009-2018. Blank indicates years with estimated harvest of zero.

Year	Harvest Number	PSE	Weight (lb)	PSE	Number Released	PSE
2009					5,835	96.3
2010	120	102.8	211	102.8	24,902	56.9
2011	474	100.0	732	100.0	14,797	88.8
2012	1,345	95.2	15,765	76.8	17,603	80.4
2013	59	113.4	11,128	113.4	7,963	39.8
2014	556	89.4	10,194	91.4	20,647	39.2
2015	10	99.9			139,486	66.1
2016	12	101.0	1,100	101.0	27,885	54.3
2017	910	79.6	27,367	83.4	43041	43.7
2018	39	84.5	235	95.8	4,916	59.3

*PSE higher than 50 indicates a very imprecise estimate.

Table 8. North Carolina pelagic sharks recreational harvest, discards, and percent standard error (PSE) 2009-2018. Blank indicates years with estimated harvest of zero.

Year	Harvest Number	PSE	Weight (lb)	PSE	Number Released	PSE
2009	91	58.8	8,123	57.5		
2010	77	83.2	12,324	88.1	96	99.2
2011	78	76.4	4,803	68.0	24	63.2
2012	291	76.7	17,323	73.6	13	98.3
2013	28	100.8	1,219	100.8	1,865	97.1
2014	26	54.6	2,082	51.5	296	110.5
2015	5,097	76.1	479,443	75.9	987	91.8
2016					3,512	79.0
2017	66	64.1	4,917	62.2	33	86.2
2018	2,043	73.1	160,155	73.1	38	63.0

*PSE higher than 50 indicates a very imprecise estimate.

Table 9. North Carolina recreational harvest, discards, and percent standard error (PSE) of smooth dogfish 2009-2018. Blank indicates years with estimated harvest of zero.

Year	Harvest Number	PSE	Weight (lb)	PSE	Number Released	PSE
2009	2,000	81.1	43,216	81.1	81,117	53.6
2010	5,246	66.4	10,069	68.5	194,780	24.6
2011	17,297	62.1	24,711	58.4	431,978	31.8
2012	234	81.6	984	70.8	21,051	36.8
2013	3,423	100.0	8,679	100.0	93,216	49.4
2014					110,938	35.6
2015	1,013	71.2	1,964	71.4	119,678	63.7
2016	10,879	92.6	186,261	97.0	97,256	44.9
2017					34,722	36.2
2018					29,524	49.3

*PSE higher than 50 indicates a very imprecise estimate.

Table 10. Shark species captured in the NCDMF 2018 Pamlico Sound Independent Gill Net Survey.

Species	Total Number Measured	Mean Total Length (inches)	Minimum Total Length (inches)	Maximum Total Length (inches)
Scalloped Hammerhead	1	32	32	32
Bull Shark	10	28	25	33
Blacktip	6	47	43	53
Sandbar	11	29	26	32
Finetooth	1	53	53	53
Smooth Dogfish	18	27	22	47
Atlantic Sharpnose	6	18	17	20
Bonnethead	46	26	22	34

FISHERY MANAGEMENT PLAN UPDATE
SNAPPER GROUPER COMPLEX
AUGUST 2019

STATUS OF THE FISHERY MANAGEMENT PLAN

Fishery Management Plan History

Original FMP Adoption:	August 1983 (SAFMC 1983a, b; 48 FR 39463)
Amendments:	Regulatory Amendment 1 - March 1987 Regulatory Amendment 2 - March 1989 Amendment 1 - January 1989 Regulatory Amendment 3 - November 1990 Amendment 2 - December 1990 Amendment 3 - January 1991 Amendment 4 - January 1992 Amendment 5 - April 1992 Regulatory Amendment 4 - July 1993 Regulatory Amendment 5 - July 1993 Amendment 6 - July 1994 Amendment 7 - January 1995 Regulatory Amendment 6 - May 1995 Amendment 8 - December 1998 Regulatory Amendment 7 - January 1999 Amendment 9 - February 1999/October 2000 Amendment 10 - July 2000 Amendment 11 - December 1999 Regulatory Amendment 8 - November 2000 Amendment 12 - September 2000 Amendment 13a - April 2004 Amendment 13c - October 2006 Amendment 14 - February 2009 Amendment 15a - March 2008 Amendment 15b - February 2010 Amendment 16 - July 2009 Amendment 19 - July 2010 Amendment 17a - March 2011 Amendment 17b - January 2011 Regulatory Amendment 10 - May 2011 Regulatory Amendment 9 - July 2011 Regulatory Amendment 11 - May 2012 Amendment 25 - April 2012 Amendment 24 - July 2012 Amendment 23 - January 2012

Amendments (continued):	Amendment 18a - July 2012/January 2013 Amendment 20a - October 2012 Regulatory Amendment 12 - October 2012 Amendment 18b - May 2013 Regulatory Amendment 13 - July 2013 Regulatory Amendment 14 - December 2014 Regulatory Amendment 15 - September 2013 Amendment 27 - January 2014 Amendment 31 - January 2014 Amendment 28 - August 2013 Regulatory Amendment 18 - September 2013 Regulatory Amendment 19 - October 2013 Regulatory Amendment 21 - November 2014 Amendment 32 - March 2015 Amendment 29 - July 2015 Regulatory Amendment 22 - August/September 2015 Regulatory Amendment 20 - August 2015 Amendment 33 - January 2016 Amendment 34 - February 2016 Amendment 35 - June 2016 Regulatory Amendment 25 - August 2016 Regulatory Amendment 16 - December 2016/March 2017 Amendment 36 - July 2017 Amendment 37 - August 2017 Amendment 43 - July 2018 Amendment 41 - February 2018 Regulatory Amendment 28 - January 2019 Abbreviated Framework Amendment 1 - August 2018 Abbreviated Framework Amendment 2 - May 2019
Revisions:	None
Supplements:	None
Information Updates:	None
Next Benchmark Review:	N/A

Of the 75-species managed by the South Atlantic Fishery Management Council (SAFMC), 55 of these are included in the Snapper Grouper management complex. Because of its mixed species nature, this fishery offers the greatest challenge for SAFMC to manage. Initially, Fishery Management Plan (FMP) regulations consisted of minimum sizes, gear restrictions, and a provision for the designation of Special Management Zones (SMZs). Early attempts to develop more effective management measures were thwarted by lack of data on both the resource and the fishery. The condition of many of the species within the snapper grouper complex is unknown.

Improved data collection (in terms of quantity and quality) during the 1980s and 90s has provided more management information on some of the more commercially and recreationally valuable species, but lack of basic management data on many of the species remains the major obstacle to successful management.

Management of the snapper grouper fishery is also difficult because many of these species are slow growing, late maturing, hermaphroditic, and long lived; thus, rebuilding efforts for some species will take years to full recovery. Strict management measures, including prohibition of harvest in some cases, have been implemented to rebuild overfished species in the snapper grouper complex. Such harvest restrictions are beneficial, not only in rebuilding species, but also in helping to prevent species from undergoing overfishing in the future.

Regulatory Amendment 1 (48 FR 9864) prohibited fishing in SMZs, except with hand-held hook-and-line and spearfishing gear; prohibited harvest of goliath grouper in SMZs; and implemented SMZs off South Carolina and Georgia.

Regulatory Amendment 2 (54 FR 8342) established two artificial reefs off Fort Pierce, Florida as SMZs.

Amendment 1 (SAFMC 1988; 54 FR 1720) prohibited use of trawl gear to harvest fish in the snapper grouper fishery south of Cape Hatteras, North Carolina and north of Cape Canaveral, Florida; defined directed snapper grouper fishery as a vessel with trawl gear and greater than or equal to 200-pounds of snapper grouper species onboard; and established the rebuttable assumption that vessels with snapper grouper species onboard harvested these fish in the U.S. Exclusive Economic Zone (EEZ).

Regulatory Amendment 3 (55 FR 40394) established an artificial reef at Key Biscayne, Florida as an SMZ in Dade County, Florida; prohibited fish trapping, bottom longlining, spearfishing and harvesting of Goliath grouper in SMZs.

Amendment 2 (SAFMC 1990a; 55 FR 46213) prohibited harvest or possession of Goliath grouper in or from the EEZ in the South Atlantic and defined overfishing for snapper grouper species according to NMFS 602 guidelines.

Amendment 3 (SAFMC 1990b; 56 FR 2443) established a management program for the wreckfish fishery which: added wreckfish to the snapper grouper management unit; defined Optimum Yield (OY) and overfishing; required an annual permit to fish for, land or sell wreckfish; established a control date of March 28, 1990 for the area bounded by 33° and 30° N latitude; established a fishing year beginning April 16; established a process whereby annual quotas would be specified; implemented a 10,000 pound trip limit and a January 15 – April 15 spawning season closure.

Amendment 4 (SAFMC 1991a; 56 FR 56016) prohibited the use of various gear, including fish traps, the use of bottom longlines for wreckfish, and powerheads in SMZ off South Carolina; established bag limits and minimum size limits for several species; established income

requirements to qualify for permits; and required that all snapper grouper species possessed in South Atlantic federal waters must have heads and fins intact through landing.

Amendment 5 (SAFMC 1991b; 57 FR 7886) established an Individual Transferable Quota (ITQ) management program for the wreckfish fishery.

Regulatory Amendment 4 (SAFMC 1992a; 58 FR 36155) modified the definition of black sea bass pots; allowed for multi-gear trips and the retention of incidentally caught fish.

Regulatory Amendment 5 (SAFMC 1992b; 58 FR 35895) established eight additional SMZs off the coast of South Carolina.

Amendment 6 (SAFMC 1993; 59 FR 27242) established commercial quotas for snowy grouper, golden tilefish; established commercial trip limits for snowy grouper, golden tilefish, speckled hind, and Warsaw grouper; included golden tilefish in grouper recreational aggregate bag limits; prohibited sale of Warsaw grouper and speckled hind; created the Oculina Experimental Closed Area; and specified data collection needs for evaluation of possible future Individual Fishing Quota (IFQ) system.

Amendment 7 (SAFMC 1994a; 59 FR 66270) established size limits and bag limits for hogfish and mutton snapper; specified allowable gear; prohibited the use of explosive charges, including powerheads, off South Carolina; and required dealer, charter, and headboat federal permits.

Regulatory Amendment 6 (SAFMC 1994b; 60 FR 19683) includes provisions to rebuild and protect hogfish by implementing a recreational bag limit of five fish per person off Florida; protect cubera snapper by implementing a recreational bag limit of two per person for fish 30-inches total length or larger off Florida; and protect gray triggerfish by implementing a minimum size limit of 12-inches total length (TL) off Florida.

Amendment 8 (SAFMC 1997; 63 FR 38298) established a limited entry system for the snapper grouper fishery.

Regulatory Amendment 7 (63 FR 71793) established ten SMZs at artificial reefs off South Carolina.

Amendment 9 (SAFMC 1998a; 64 FR 3624; 65 FR 55203) increased the minimum size limits on red porgy, black sea bass, vermillion snapper (recreational only), gag, and black grouper; changed bag limits for red porgy, black sea bass, greater amberjack, gag, and black grouper; established an aggregate recreational bag limit of 20 fish per person per day inclusive of all snapper grouper species currently not under a bag limit, excluding tomtate and blue runners; and specified that vessels with bottom longline gear aboard may only possess snowy grouper, Warsaw grouper, yellowedge grouper, misty grouper, golden tilefish, blueline tilefish, and sand tilefish.

Amendment 10 (SAFMC 1998b; 65 FR 37292) identified Essential Fish Habitat (EFH) and EFH - Habitat Areas of Particular Concern (HAPCs) for species in the snapper grouper management unit.

Amendment 11 (SAFMC 1998c; 64 FR 59126) amended the FMP as required to make definitions of Maximum Sustainable Yield (MSY), OY, overfishing and overfished consistent with "National Standard Guidelines"; identified and defined fishing communities; and addressed bycatch management measures.

Regulatory Amendment 8 (65 FR 61114) established 12 SMZs at artificial reefs off Georgia; revised boundaries of seven existing SMZs off Georgia to meet Coast Guard permit specifications; restricted fishing in new and revised SMZs.

Amendment 12 (SAFMC 2000; 65 FR 51248) set regulatory limits for red porgy including a recreational bag limit, a commercial incidental catch limit, and a recreational and commercial size limit. It also permitted the transfer of the 225-pound trip limited commercial permit to another vessel (not another person) regardless of vessel size.

Amendment 13A (SAFMC 2003; 69 FR 15731) extended regulations within the Oculina Experimental Closed Area off the east coast of Florida that prohibit fishing for and retention of snapper grouper species for an indefinite period with a 10-year re-evaluation by the Council. The Council will review the configuration and size of the area within three years of publication of the Final Rule (March 26, 2004).

Amendment 13C (SAFMC 2006; 71 FR 55096) addressed overfishing for snowy grouper, golden tilefish, black sea bass and vermilion snapper. The amendment also allowed for a moderate increase in the harvest of red porgy as stock continues to rebuild.

Amendment 14 (SAFMC 2007a; 74 FR 1621) established a series of deepwater marine protected areas in the South Atlantic EEZ.

Amendment 15A (SAFMC 2008a; 73 FR 14942) updated management reference points for snowy grouper, black sea bass, and red porgy; modified rebuilding schedules for snowy grouper and black sea bass; defined rebuilding strategies for snowy grouper, black sea bass, and red porgy; and redefined the minimum stock size threshold for the snowy grouper stock.

Amendment 15B (SAFMC 2008b; 74 FR 58902) prohibited sale the sale of bag-limit caught snapper grouper species; reduced the effects of incidental hooking on sea turtles and smalltooth sawfish; changed the commercial permit renewal period and transferability requirements; implemented a plan to monitor and address bycatch; and established management reference points for golden tilefish. Amendment 15B also established allocations between recreational and commercial fishermen for snowy grouper and red porgy.

Amendment 16 (SAFMC 2009a; 74 FR 30964) included measures to end overfishing for gag grouper and vermilion snapper; established commercial and recreational allocations for both species; established a January through April spawning season closure for gag, black grouper, red

grouper, scamp, red hind, rock hind, yellowmouth grouper, tiger grouper, yellowfin grouper, graysby, and coney; reduced the aggregate grouper bag limit from five fish to three fish, and within that, reduced the gag bag limit from two fish to one gag or black grouper, combined; reduced the vermilion snapper bag limit from 10 fish to five fish; established a recreational closed season for vermilion snapper of November through March; excluded captain and crew on for-hire vessels from retaining a bag limit of groupers; and required the use of dehooking tools to reduce bycatch mortality.

Amendment 19 (SAFMC 2009b; 75 FR 35330) was included under the Comprehensive Ecosystem-Based Amendment 1 (CE-BA 1) and included measures to provide presentation of spatial information for EFH and EFH-HAPC designations under the Snapper Grouper FMP; and designation of deepwater coral HAPCs.

Amendment 17A (SAFMC 2010a; 75 FR 76874) addressed management measures to end overfishing of red snapper and rebuild the stock, including Annual Catch Limits (ACLs) and Accountability Measures (AMs). It extended the prohibition of red snapper in federal waters throughout the South Atlantic EEZ effective immediately. Amendment 17A also included a regulation requiring the use of non-stainless circle hooks north of 28 degrees N latitude effective March 3, 2011.

Amendment 17B (SAFMC 2010b; 75 FR 82280) established ACLs and AMs and addressed overfishing for nine species in the snapper grouper management complex: golden tilefish, snowy grouper, speckled hind, Warsaw grouper, black grouper, black sea bass, gag, red grouper, and vermilion snapper. Measures in Amendment 17B included a deepwater closure (240 feet seaward) for deepwater species to help protect Warsaw grouper and speckled hind. Additional measures in the amendment included a reduction in the snowy grouper bag limit; establishment of a combined ACL for gag, black grouper, and red grouper; an allocation of 97% commercial and 3% recreational for the golden tilefish fishery based on landings history; and establishment of AMs as necessary.

Regulatory Amendment 10 (SAFMC 2011a; 76 FR 23728) eliminated the large area closure in Amendment 17A for all snapper grouper species off the coasts of southern Georgia and north/central Florida. The regulatory amendment modified measures implemented in Amendment 17A to end overfishing for red snapper.

Regulatory Amendment 9 (SAFMC 2011b; 76 FR 34892) reduced the bag limit for black sea bass from 15 fish per person to five fish per person, established trip limits on vermilion snapper and gag, and increased the trip limit for greater amberjack.

Regulatory Amendment 11 (SAFMC 2011c; 77 FR 27374) eliminated a restriction on the possession or harvest of some deepwater snapper grouper species in waters greater than 240 feet deep.

Amendment 25 (Comprehensive Annual Catch Limit Amendment) (SAFMC 2011d; 77 FR 15916) met the 2011 deadline mandated by the Magnuson-Stevens Act to establish ACLs and AMs for species managed by the Council that are not undergoing overfishing.

Amendment 24 (SAFMC 2011e; 77 FR 34254) proposed measures to end overfishing and establish a rebuilding plan for red grouper. The amendment also implemented or revised parameters such as Maximum Sustainable Yield (MSY), Minimum Stock Size Threshold (MSST), ACLs, AMs, and specified allocations for the commercial and recreational sectors.

Amendment 23 (Comprehensive Ecosystem-Based Amendment 2) (SAFMC 2011f; 76 FR 82183) included measures to designate the Deepwater MPAs as EFH-HAPCs; limited harvest of snapper grouper species in South Carolina SMZs to the bag limit; and modified sea turtle release gear.

Amendment 18A (SAFMC 2012a; 77 FR 32408; 77 FR 72991) established management actions to limit participation and effort in the black sea bass fishery. Measures included establishment of an endorsement program and other modifications to the commercial black sea bass pot fishery; establishment of a commercial trip limit (all gear-types) for black sea bass; and increased minimum size limits for both commercial and recreational black sea bass fisheries.

Amendment 20A (SAFMC 2012b; 77 FR 59129) defined and reverted inactive shares within the wreckfish ITQ program; redistributed reverted shares to active shareholders; established a share cap; and implemented an appeals process.

Regulatory Amendment 12 (77 FR 61295) adjusted the ACL and OY for golden tilefish; specified a commercial Annual Catch Target (ACT); and revised recreational AMs for golden tilefish.

Amendment 18B (SAFMC 2012c; 78 FR 23858) addressed management of golden tilefish. Actions included in the amendment are: An endorsement program for the longline sector of the golden tilefish component of the snapper grouper fishery; establishment of landings criteria to determine who will receive endorsements; an appeals process for the golden tilefish endorsement program; establishment of a procedure to allow transferability of golden tilefish endorsements; allocation of 75% of the commercial ACL to the longline sector and 25% to the hook-and-line sector; and modification of the golden tilefish trip limit.

Regulatory Amendment 13 (SAFMC 2012d; 78 FR 36113) revised the acceptable biological catch estimates, ACLs (including sector ACLs), and recreational annual catch targets for 37 un-assessed snapper grouper species. The revisions incorporated updates to the recreational data for these species, as per the new Marine Recreational Information Program, as well as revisions to commercial and for-hire landings. Regulatory Amendment 13 was necessary to avoid triggering AMs for these snapper grouper species based on ACLs that were established by the Comprehensive Annual Catch Limit Amendment in April 2012, using recreational data under the Marine Recreational Fisheries Statistics Survey system.

Regulatory Amendment 14 (SAFMC 2013a; 79 FR 66316) modified the fishing year for greater amberjack; revised the minimum size limit measurement for gray triggerfish; increased the minimum size limit for hogfish; modified the commercial and recreational fishing year for black

sea bass; adjusted the commercial fishing season for vermilion snapper; modified the aggregate grouper bag limit; and revised the AMs for gag and vermilion snapper.

Regulatory Amendment 15 (SAFMC 2013b; 78 FR 49183) modified the existing specification of OY and ACLs for yellowtail snapper in the South Atlantic; modified existing regulations for yellowtail snapper in the South Atlantic; and modified the existing gag commercial ACL and AM for gag that requires a closure of all other shallow water groupers (black grouper, red grouper, scamp, red hind, rock hind, graysby, coney, yellowmouth grouper, and yellowfin grouper) in the South Atlantic when the gag commercial ACL is met or projected to be met.

Amendment 27 (SAFMC 2013c; 78 FR 78770) assumed management of Nassau grouper in the Gulf of Mexico; modified the crew size restriction for dual-permitted vessels (those with a Snapper Grouper Unlimited or 225-Pound Permit and a Charter/Headboat Permit for Snapper Grouper); modified the bag limit retention restriction for captain and crew of for-hire vessels; changed the existing snapper grouper framework procedure to allow for more timely adjustments to ACLs; and removed blue runner from the fishery management unit.

Amendment 31 (Joint South Atlantic and Gulf of Mexico Generic Headboat Reporting Amendment) (SAFMC 2013d; 78 FR 78779) modified logbook reporting for headboats to require fishing records to be reported electronically for snapper grouper species on a weekly basis.

Amendment 28 (SAFMC 2013e; 78 FR 44461) established a process to determine if a red snapper fishing season will occur each year, including specification of the allowable harvest for both sectors and season length for the recreational sector; an equation to determine the ACL for red snapper for each sector; and management measures if fishing for red snapper is allowed.

Regulatory Amendment 18 (SAFMC 2013f; 78 FR 47574) adjusted the ACL (and sector ACLs) for vermilion snapper and red porgy based on the stock assessment updates for those two species and removed the annual recreational closure for vermilion snapper.

Regulatory Amendment 19 (SAFMC 2013g; 78 FR 58249) adjusted the black sea bass ACLs based on the results of the 2013 assessment. Because the increase to the ACL was substantial, there was concern that this could extend fishing with pots into the calving season for right whales and create a risk of entanglement for large migratory whales during the fall months. To minimize this risk, the amendment also established a closure to black sea bass pot gear from November 1 to April 30.

Regulatory Amendment 21 (SAFMC 2014a; 79 FR 60379) prevents snapper grouper species with low natural mortality rates (red snapper, blueline tilefish, gag, black grouper, yellowtail snapper, vermilion snapper, red porgy, and greater amberjack) from being unnecessarily classified as overfished. For these species, even small fluctuations in biomass due to natural conditions rather than fishing mortality may cause a stock to be classified as overfished. Modifying the minimum stock size threshold definition (used in determining whether a species is overfished) prevents these species from being classified as overfished unnecessarily.

Amendment 32 (SAFMC 2014b; 80 FR 16583) addressed the determination that blueline tilefish are overfished and undergoing overfishing. The amendment removed blueline tilefish from the deep-water complex; established blueline tilefish commercial and recreational sector ACLs and AMs; revised the deep-water complex ACLs and AMs; established a blueline tilefish commercial trip limit; and revised the blueline tilefish recreational bag limit and harvest season.

Amendment 29 (SAFMC 2014c; 80 FR 30947) revised ACLs and recreational annual catch targets (ACTs) for four unassessed snapper grouper species (bar jack, Atlantic spadefish, scamp, and gray triggerfish) and three snapper grouper species complexes (snappers, grunts, and shallow water groupers) based on an update to the Acceptable Biological Catch (ABC) control rule and revised ABCs for 14 snapper grouper stocks (bar jack, margate, red hind, cubera snapper, yellowedge grouper, silk snapper, Atlantic spadefish, gray snapper, lane snapper, rock hind, tomtate, white grunt, scamp, and gray triggerfish). Additionally, this final rule revises management measures for gray triggerfish in federal waters in the South Atlantic region, including modifying minimum size limits, establishing a split commercial season, and establishing a commercial trip limit.

Regulatory Amendment 22 (SAFMC 2015a; 80 FR 48277) adjusted the ACLs and OY for gag and wreckfish. Changes to the gag recreational bag limit were proposed, but status quo was maintained.

Regulatory Amendment 20 (SAFMC 2014d; 80 FR 43033) increased the recreational and commercial ACLs for snowy grouper, increased the commercial trip limit, and modified the recreational fishing season. This amendment also adjusted the re-building strategy for snowy grouper.

Amendment 33 (SAFMC 2015b; 80 FR 80686) updated regulations that allow snapper grouper fillets to be brought into the U.S. EEZ from the Bahamas. Snapper grouper fillets form the Bahamas must have the skin intact, two fillets (regardless of size) will count as one fish towards the bag limit, and fishermen must abide by both U.S. and Bahamian bag/possession limits (whichever is more restrictive). All boats must have the proper permits, and fishermen must carry passports which are required to be stamped and dated to prove vessel passengers were in the Bahamas. All fishing gear must be appropriately stowed while in transit.

Amendment 34 (SAFMC 2015c; 81 FR 3731) revised the AMs for several snapper grouper species (black grouper, mutton snapper, yellowtail snapper, greater amberjack, red porgy, gag, golden tilefish, red grouper, snowy grouper, gray triggerfish, hogfish, scamp, Atlantic spadefish, bar jack, snappers complex, jacks complex, shallow water grouper complex, porgies complex, and wreckfish (recreational).

Amendment 35 (SAFMC 2015d; 81 FR 32249) clarified regulations governing the use of golden tilefish longline endorsements to align them with the SAFMC's intent when the program was originally implemented. Four species will also be removed from the FMP (black snapper, mahogany snapper, dog snapper, and schoolmaster).

Regulatory Amendment 25 (SAFMC 2016b; 81 FR 45245) revised the commercial and recreational ACLs, the commercial trip limit, and recreational bag limit for blueline tilefish. This amendment also revised the black seabass recreational bag limit and the commercial and recreational fishing years for yellowtail snapper.

Regulatory Amendment 16 (SAFMC 2016a; 81 FR 95893) revised the current seasonal prohibition on the use of black sea bass pot gear in the South Atlantic and added an additional gear marking requirement for black sea bass pot gear.

Amendment 36 (SAFMC 2016c; 82 FR 29772) establish spawning special management zones (Spawning SMZs) to enhance protection for snapper grouper species in spawning condition, including speckled hind and Warsaw grouper.

Amendment 37 (SAFMC 2016d; 82 FR 34584) modified the hogfish fishery management unit and specified fishing levels for the two South Atlantic hogfish stocks. It established/revised management measures for both hogfish stocks in the South Atlantic Region, such as size limits, recreational bag limits, and commercial trip limits. Additionally, this amendment established a rebuilding plan for the Florida Keys/East Florida stock.

Amendment 41 (SAFMC 2017n; 83 FR 1305) updated the acceptable biological catch, annual catch limit, maximum sustainable yield, minimum stock size threshold, optimum yield (OY), and revised management measures for mutton snapper.

Amendment 43 (SAFMC 2017k; 83 FR 35428) revised the commercial and recreational annual catch limits and allowed for limited harvest of red snapper in federal waters of the South Atlantic.

Abbreviated Framework Amendment 1 (SAFMC 2017i; FR 83 35435) reduced the commercial and recreational ACLs for red grouper to address overfishing.

Regulatory Amendment 28 (SAFMC 2018a; FR 83 62508) revised the commercial and recreational ACLs for golden tilefish. The purpose of this final rule is to end overfishing of golden tilefish while minimizing, to the extent practicable, adverse socio-economic effects and achieve optimum yield (OY) on a continuing basis.

Abbreviated Framework Amendment 2 (SAFMC 2018b; FR 84 14021) increased the commercial and recreational ACLs for vermilion snapper and decreased the commercial and recreational ACLs for black sea bass in response to the latest stock assessments.

There are several other amendments either in development or under secretarial review (Table 1).

To ensure compliance with interstate requirements, North Carolina also manages this species complex 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, SAFMC, or the Atlantic States Marine Fisheries Commission 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 plans) and the Atlantic Coastal Fisheries Cooperative Management Act (Atlantic States Marine Fisheries Commission plans) are like the goals of the Fisheries Reform Act of 1997 to "ensure long-term viability" of these fisheries (NCDMF 2015a).

Management Unit

The original SAFMC plan stated the management unit of the snapper grouper fishery is the stocks within the EEZ from North Carolina/Virginia border through the east coast of Florida. In the case of black sea bass, the unit is limited to south of Cape Hatteras, North Carolina. Since the inception of the FMP, there has been the addition of four species: wreckfish, spadefish, banded rudderfish, and lesser amberjack. In recent years, 14 species have been removed; 13 in 2012 (tiger grouper, sheepshead, queen triggerfish, puddingwife, black margate, yellow jack, Crevalle jack, porkfish, grass porgy, small mouth grunt, French grunt, Spanish grunt, and blue striped grunt) and one in 2014 (blue runner). In June 2016, Amendment 35 removed four additional species from the complex (black snapper, mahogany snapper, dog snapper, and schoolmaster).

Objectives

The following are the fishery management plan objectives for the snapper grouper fishery as specified by the Council. These were last updated in Snapper Grouper FMP Amendment 8 in July 1997 (SAFMC 1997).

1. Prevent overfishing.
2. Collect necessary data.
3. Promote orderly utilization of the resource.
4. Provide for a flexible management system.
5. Minimize habitat damage.
6. Promote public compliance and enforcement.
7. Mechanism to vest participants.
8. Promote stability and facilitate long-run planning.
9. Create market-driven harvest pace and increase product continuity.
10. Minimize gear and area conflicts among fishermen.
11. Decrease incentives for overcapitalization.
12. Prevent continual dissipation of returns from fishing through open access.
13. Evaluate and minimize localized depletion.

STATUS OF THE STOCK

Life History

Fifty-five species make up the snapper grouper complex, which is managed by the South Atlantic Fishery Management Council. Included in the complex are three sea bass species, 17 grouper species, 10 snapper species, seven porgy species, five grunt species, five jack species,

three tilefish species, two triggerfish species, hogfish, spadefish and wreckfish. The majority of these species are long lived, slow growing, late maturing and hermaphroditic (can change sexes). Most of these species are considered reef fish and are associated with hard bottom (live bottom) offshore habitats, but can be found in waters 1,000 feet deep or shallower. Some are migratory, exhibiting seasonal and/or ontogenic (occurring during a certain life stage) east to west migratory behavior (black sea bass), as well as some species making north to south migrations (gag grouper). The full list of the species in the complex is available online at Snapper Grouper Management Complex.

Stock Status

Of the 55 species in the South Atlantic Fishery Management Council (SAFMC) management unit, several species are either overfished or experiencing some degree of overfishing. The overfished stocks include red grouper, red porgy, red snapper, hogfish (east Florida) and snowy grouper. Stocks experiencing overfishing are red snapper, blueline and golden tilefish, speckled hind, Warsaw grouper, and hogfish (east Florida).

Stock Assessment

The status of several species within the snapper grouper complex is unknown. However, for some of the species, assessments are available through various federal entities; the snapper grouper complex is regionally (North Carolina south to eastern Florida) managed, and none of the assessments have been conducted by NCDMF (Table 2).

Since 2002, stock assessments have been conducted through the SouthEast Data, Assessment, and Review (SEDAR) which is the cooperative process by which stock assessment projects are conducted in NOAA Fisheries' Southeast Region. Currently, stock assessments are available for 16 of the complex species. Assessments scheduled for completion in 2019 include greater amberjack (SEADAR 59), red porgy (SEDAR 60) and yellowtail snapper (SEDAR 64).

Some of the other species have status updates provided by National Oceanic and Atmospheric Administration (NOAA) Fisheries. These updates are based on landings data to determine whether the stock is overfished or undergoing overfishing. This information is updated quarterly by NOAA Fisheries and available on their website (https://www.fisheries.noaa.gov/national/population-assessments/fishery-stock-status-updates).

STATUS OF THE FISHERY

Current Regulations

The following species have state and federal regulations for minimum lengths:

- Greater amberjack: 28-inch FL (recreational); 36-inch FL (commercial)
- Black and gag groupers: 24-inch TL
- Red, scamp, yellowfin, and yellowmouth groupers: 20-inch TL
- Black sea bass: 13-inch TL (recreational); 11-inch (commercial)
- Red porgy: 14-inch TL

- Vermilion, gray, cubera, queen, silk, yellowtail and blackfin snappers: 12-inch TL
- Hogfish (not pigfish): 17-inch FL
- Mutton snapper: 18-inch TL
- Gray triggerfish: 12-inch FL
- Lane snapper: 8-inch TL

All species have sector ACLs and recreational bag limits. See the SAFMC or NCDMF websites for the most current information.

The fisheries are open year-round, with the exception of:

- Goliath grouper, Nassau grouper, Warsaw grouper, and speckled hind, unlawful to possess/harvest (commercial and recreational)
- Red snapper, unlawful to possess/harvest (commercial and recreational); limited season may occur based on previous years' data
- January-April shallow water grouper spawning closure (commercial and recreational); Commercial also has same closure for red porgy
- Wreckfish have commercial spawning closure January 15-April 15; recreational fishery open July 1-August 31 annually
- April commercial closure for greater amberjack
- Snowy grouper and blueline tilefish recreational fishery open May 1- August 31

Temporary closures may result for a species if the ACL is met. NOAA fisheries monitors the landings for the species managed by SAFMC, and this information is available online for both the commercial and recreational sectors (https://www.fisheries.noaa.gov/southeast/southeast-region-annual-catch-limit-acl-monitoring). See also the SAFMC or NCDMF websites for more details, and the most current information.

Commercial Landings

Commercial gear used in the snapper grouper fishery includes bandit reels, electric reels, manual hook-and-line, long lines, fish pots, spear, and trolling. Bandit reels, followed by electric rods and reels are the two most prevalent gear types used, especially south of Cape Hatteras (NCDMF 2015b). Spear fishing seems to be limited to south of Cape Hatteras, while longlines are primarily fished north of Cape Hatteras (NCDMF 2015b); their use is limited to six deepwater species and depths greater than 50 fathoms. Fish pots are used primarily to target black sea bass. Trip lengths vary dependent on the area fished and the gear used, but tended to average between two to three days in length over the past five years; trips ranged from one day to 12 days for the entire commercial snapper grouper fleet (NCDMF 2015b).

The average landings for commercially caught snapper grouper from 1994-2018 was 2,218,612 pounds with a dockside value of $4,152,294.[1] The highest landings from the past 25 years were in 2008, after which landings dropped; landings have been under two million pounds for the last

[1] These averages do not include sheepshead after 2011, as well as a number of other species, as they were removed from the complex in 2012. See Amendment 25 for list of species removed from complex.

eight years (Table 3, Figure 1). The decline in landings over the past eight years is most likely due to the removal of species from the complex, as well as the changes to annual catch limits and trip limits and implementation of a seasonal spawning closure by the SAFMC (i.e., gag grouper).

Over the last five years, landings have been dominated by six main aggregates; sea bass, grouper, snapper, triggerfish, jacks and tilefish (though the dominant group varies by year) (Table 4). The top ten dominant species are: black sea bass, vermillion snapper, blueline tilefish, gag, triggerfish, red grouper, red porgy, amberjack, scamp, and grunts (NCDMF 2015b).

Recreational Landings

Recreational fishing activity is monitored through the Marine Recreational Information Program. In this report, estimates across all years have been updated and are now based on the MRIP new Fishing Effort Survey-based calibrated estimates. For more information on MRIP methodology changes see https://www.fisheries.noaa.gov/topic/recreational-fishing-data. Recreational fishing uses many of the same gear types as the commercial fishery, with the exception of fish pots and longlines. Recreational estimates across all years have been updated and are now based on the Marine Recreational Information Program (MRIP) new Fishing Effort Survey-based calibrated estimates. For more information on MRIP see https://www.fisheries.noaa.gov/topic/recreational-fishing-data.

The average recreational catch of snapper grouper species was 1,987,485[1] pounds for 1994-2018. Since 2008, the total amount of fish landed declined steadily until 2014 (Table 5, Figure 1). The number of fished harvested declined roughly 60% from 2017 to 2018 and harvest weight decreased 50%. Recreational landings (by weight) have dropped over 80% since a 25-year high (4,768,084 pounds) in 2008. As with the commercial fishery this is most likely due to the removal of species from the complex, as well as the changes to ACLs and the seasonal spawning closure by the SAFMC. For the last five years, the number of releases has been around 90% of the total fish caught (driven by the 13-inch (TL) size limit for black sea bass implemented in 2013, which has resulted in an increase of sublegal fish being discarded).

For 2018, the dominant species (by pounds) landed were black sea bass, snappers, jacks, triggerfish, tilefish and spadefish. This pattern mainly holds true for the last five years; however, other species are occasionally more dominant (Table 6).

MONITORING PROGRAM DATA

Most of the data (dependent and independent) collected by NCDMF is provided to NOAA Fisheries. The division received a grant, which ended in 2014, to look at the age structure and release mortality of the commercial snapper grouper fishery in general and at the south of Cape Hatteras black sea bass stock age structure specifically. Data collected for this grant is summarized in the final Marine Fisheries Initiative (MARFIN) reports (NCDMF 2015b, c).

Fishery-Dependent Monitoring

Commercial fisheries are monitored by port agents (state and federal) who collect information on trips, as well as biological information. Information is collected through the Trip Information Program (TIP), seafood dealer reporting, and logbooks (SAMFC 2014e). Recreational fisheries are monitored by creel clerks through the Southeast Region Headboat Survey program and the Marine Recreation Information Program (MRIP) (SAFMC 2014e). North Carolina contributes to this data through the collection of trip and biological information for both fisheries.

Fishery dependent length-frequency information for the commercial snapper grouper fishery in North Carolina is collected by fish house samplers, the majority of which come from NCDMF Program 438 (Offshore Live Bottom Fishery). Length-frequency information for the recreational snapper grouper fishery is collected through the NCDMF Carcass Collection Program and MRIP. In 2018, NCDMF recorded lengths from 11,965 individual fish from the snapper grouper fishery of which 1,211 were black sea bass south of Cape Hatteras. In 2018, 152 black sea bass were measured from the recreational fishery with an average total length (TL) of 14 inches (Table 7, Figure 2). Total length has ranged from 4 inches to 21 inches since 1994 (Table 7, Figure 4). In 2018, 1,113 black sea bass south of Cape Hatteras were measured from the commercial fishery with an average TL of 14 inches (Figure 2). Black sea bass landed in the commercial fishery have ranged from 7 to 19 inches TL since 1994 (Figure 3). Differences in the commercial and recreational length frequency distribution of black sea bass south of Cape Hatteras in 2018 can be attributed to the different size limits (13 inches TL for recreational and 11 inches TL for commercial), as well differences in the size selectivity of the gears used (Figure 2).

In order to describe the age structure of the harvest and indices, age structures are collected from various fishery-independent (scientific surveys) and dependent (fisheries) sources throughout the year. Aging structures are provided to the NOAA Beaufort Age Lab for analysis except for black sea bass caught south of Cape Hatteras, NC which are analyzed by NCDMF. In 2018, NCDMF collected 8,186 age structures from the snapper grouper fishery of which 1,058 came from black sea bass (not yet aged). Since 2004, the modal age of black sea bass collected each year is 4 with the exception of 2011 where the modal age was 3 (Table 8). The maximum age recorded for black sea bass south of Cape Hatteras is 10. The age-length relationship for black sea bass is fairly unpredictable, as there is overlap in age for a given length (Figure 5).

Fishery-Independent Monitoring

The Southeast Reef Fish Survey (SERFS) maintains the fisheries independent data for the snapper grouper complex. SERFS is a collective program for gathering fisheries independent data within the South Atlantic federal waters. There are three primary programs that contribute to the data:

- Marine Resources Monitoring, Assessment, and Prediction (MARMAP) survey
- Southeast Fisheries-Independent Survey (SEFIS), and
- Southeast Area Monitoring and Assessment Program (SEAMAP) - South Atlantic (SAFMC 2015e).

North Carolina has contributed to the data collected through programs such as the gag ingress and tagging work done in partnership with SEAMAP and MARFIN.

MANAGEMENT STRATEGY

The snapper grouper complex is managed under the various amendments of the SAFMC fisheries management plan. The fishery is a regional fishery, and the Council has authority within the federal 200-mile limit of the Atlantic Ocean off the coasts of North Carolina, South Carolina, Georgia, and east Florida to Key West with the exception of black sea bass north of Cape Hatteras, North Carolina. In state waters, North Carolina defers to the Council and the same regulations are followed. Thresholds and targets for the species are determined by the SAFMC and are species dependent.

RESEARCH NEEDS

The reauthorization of the Magnuson-Stevens Fishery Conservation and Management Act in 2006 directed that all regional management councils develop a prioritized research plan for annual submission to the Secretary of Commerce. The following (below) are research and management needs as determined by the council in 2007 (SAFMC 2007b). All needs are ongoing; however, the emphasis changes annually based on the SAFMC Science and Statistical Committee review of these needs. The reviewed list and priorities for the year are then approved for submission to the NOAA Fisheries Southeast Fisheries Science Center. The council has a series of research and monitoring needs for the period of 2012-2016 (SAFMC 2012e), and has developed another set of needs for 2015-2019 (SAFMC 2015f, 2017a). Research needs include:

- Continue monitoring of catches (ongoing)
- Collect otoliths and spines for ageing (ongoing)
- Estimate mortality rates (ongoing)
- Determine if stock structure exists for many of the species (ongoing)
- Note seasonal and spawning migrations (ongoing)
- Identify and map essential/critical fish habitat (ongoing)
- Determine spawning locations and seasons (ongoing)
- Continue life history studies (ongoing)
- Estimate reproductive parameters including fecundity, age and size of maturity, age and size of sexual transition, and sex ratio (ongoing)
- Determine reliability of historical landings (ongoing)
- Expand diet studies (ongoing)
- Develop juvenile and adult indexes (ongoing)

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TABLES

Table 1. Amendments under consideration/review by the SAFMC. Summaries of the issues the amendment addresses are included; documentation is provided as available.

Amendment	Issue addressed	Where in process	Documentation
Regulatory Amendment 30	Red Grouper Rebuilding Plan	Scheduled for final approval – Fall 2019	SAFMC 2017c
Regulatory Amendment 29	Address Best Fishing Practices & remove powerhead restrictions in SMZs off South Carolina	Scheduled for final approval – Fall 2019	SAFMC 2017d
Amendment 42	Options for new sea turtle release gears. This amendment would also consider modifications to the snapper grouper framework so that Council may more quickly modify protected resources release gear and handling requirements in the future.	Approved by the Council for formal secretarial review	SAFMC 2017e
Amendment 38	Blueline Tilefish management measures	Potential options awaiting Council review – Fall or Winter 2019	SAFMC 2017f
Amendment 46	Private recreational reporting and permitting	Approved for scoping	SAFMC 2017g
Amendment 44	Long-term management of yellowtail snapper	Amendment on hold	SAFMC 2017j
Vision Blueprint Recreational Regulatory Amendment 26	Recreational management measures: aggregate structure, bag limits, gray triggerfish size limits, and red grouper season	Approved by the Council for formal secretarial review	SAFMC 2017l
Vision Blueprint Commercial Regulatory Amendment 27	Commercial split seasons and trip limits for the snapper grouper fishery	Approved by the Council for formal secretarial review	SAFMC 2017m

Table 2. Stock status of the 55 species within the snapper grouper complex. Documentation is provided for the assessment associated with each species. No assessments have been conducted by NCDMF due to the nature of the fishery.

Family (species aggregate)	**Species**	**Overfishing?**	**Overfished?**	**Documentation**
Serranidae (Sea basses and groupers)	Gag (*Mycteroperca microlepis*)	No**	No	SEDAR 10 Update (SEDAR 2014); NMFS 2018
	Red grouper (*Epinephelus morio*)	No	Yes	SEDAR 53 (SEDAR 2017a); NMFS 2018
	Scamp (*Mycteroperca phenax*)	No	Unknown	NMFS 2018
	Black grouper (*Mycteroperca bonaci*)	No	No	SEDAR 19 (SEDAR 2010); NMFS 2018
	Rock hind (*Epinephelus adcensionis*)	Unknown	Unknown	NMFS 2018
	Red hind (*Epinephelus guttatus*)	Unknown	Unknown	NMFS 2018
	Graysby (*Cephalopholis cruentata*)	Unknown	Unknown	NMFS 2018
	Yellowfin grouper (*Mycteroperca venenosa*)	Unknown	Unknown	NMFS 2018
	Coney (*Cephalopholis fulva*)	Unknown	Unknown	NMFS 2018
	Yellowmouth grouper (*Mycteroperca interstitialis*)	Unknown	Unknown	NMFS 2018
	Goliath grouper (*Epinephelus itajara*)	No (Permanent closure)	Unknown	SEDAR 47 (SEDAR 2016d); NMFS 2018
	Nassau grouper (*Epinephelus striatus*)	No (Permanent closure)	Unknown	NMFS 2018
	Snowy grouper (*Epinephelus niveatus*)	No	Yes	SEDAR 36 (SEDAR 2013a); NMFS 2018
	Yellowedge grouper (*Epinephelus flavolimbatus*)	Unknown	Unknown	NMFS 2018
	Warsaw grouper (*Epinephelus nigritus*)	Yes (Permanent closure)	Unknown	SG Amendment 17b (SAFMC 2010b); NMFS 2018
	Speckled hind (*Epinephelus drummondhayi*)	Yes (Permanent closure)	Unknown	SG Amendment 17b (SAFMC 2010b); NMFS 2018
	Misty grouper (*Epinephelus mystacinus*)	Unknown	Unknown	NMFS 2019
	Black sea bass (*Centropristis striata*)	No	No	SEDAR 56 (SEDAR 2018b); NMFS 2018
	Bank sea bass (*Centropristis ocyurus*)*	N/A	N/A	

* Indicates ecosystem component species which do not have management measures in place and are not assessed.
**Based on NMFS stock assessment

Table 2. (continued).

Family (species aggregate)	**Species**	**Overfishing?**	**Overfished?**	**Documentation**
Serranidae (Sea basses and Groupers)	Rock sea bass (*Centropristis philadelphica*)*	N/A	N/A	
Polyprionidae (Wreckfish)	Wreckfish (*Polyprion americanus*)	No	No	Rademeyer and Butterworth 2014; NMFS 2018
Lutjanidae (Snappers)	Queen snapper (*Etelis oculatus*)	Unknown	Unknown	NMFS 2018
	Yellowtail snapper (*Ocyusus chrysurus*)	No	No	SEDAR 27A (SEDAR 2012b); NMFS 2018
	Gray snapper (*Lutjanus griseus*)	Unknown	Unknown	NMFS 2018
	Mutton snapper (*Lutjanus analis*)	No	No	SEDAR 15A Update (SEDAR 2015); NMFS 2018
	Lane snapper (*Lutjanus synagris*)	Unknown	Unknown	NMFS 2018
	Cubera snapper (*Lutjanus cyanopterus*)	Unknown	Unknown	NMFS 2018
	Vermilion snapper (*Rhomboplites aurorubens*)	No	No	SEDAR 55 (SEDAR 2018a); NMFS 2018
	Red snapper (*Lutjanus campechanus*)	Yes	Yes	SEDAR Assessment 41 (SEDAR 2016a); NMFS 2018
	Silk snapper (*Lutjanus vivanus*)	Unknown	Unknown	NMFS 2018
	Blackfin snapper (*Lutjanus buccanella*)	Unknown	Unknown	NMFS 2018
Sparidae (Porgies)	Red Porgy (*Pagrus pagrus*)	No	Yes	SEDAR 1 Update (SEDAR 2012a); NMFS 2018
	Knobbed porgy (*Calamus nodosus*)	Unknown	Unknown	NMFS 2018
	Jolthead porgy (*Calamus bajonado*)	Unknown	Unknown	NMFS 2018
	Scup (*Stenotomus chrysops*)	Unknown	Unknown	NMFS 2018
	Whitebone porgy (*Calamus leucosteus*)	Unknown	Unknown	NMFS 2018
	Saucereye porgy (*Calamus calamus*)	Unknown	Unknown	NMFS 2018
	Longspine porgy (*Stenotomus caprinus*)*	N/A	N/A	
Haemulidae (Grunts)	White grunt (*Haemulon plumieri*)	Unknown	Unknown	NMFS 2018
	Margate (*Haemulon album*)	Unknown	Unknown	NMFS 2018
	Tomtate (*Haemulon aurolineatum*)	Unknown	Unknown	NMFS 2018

* Indicates ecosystem component species which do not have management measures in place and are not assessed.

Table 2. (continued).

Family (species aggregate)	**Species**	**Overfishing?**	**Overfished?**	**Documentation**
Haemulidae (Grunts)	Sailor's choice (*Haemulon parra*)	Unknown	Unknown	NMFS 2018
	Cottonwick (*Haemulon melanurum*)*	N/A	N/A	
Carangidae (Jacks)	Greater Amberjack (*Seriola dumerili*)	No	No	SEDAR 15 (SEDAR 2008); NMFS 2018
	Almaco jack (*Seriola rivoliana*)	Unknown	Unknown	NMFS 2018
	Banded rudderfish (*Seriola zonanta*)	Unknown	Unknown	NMFS 2018
	Bar jack (*Caranx ruber*)	Unknown	Unknown	NMFS 2018
	Lesser Amberjack (*Seriola fasciata*)	Unknown	Unknown	NMFS 2018
Malacanthidae (Tilefishes)	Golden tilefish (*Lopholatilus chamaeleonticeps*)	Yes	No	SEDAR 25 Update (SEDAR 2016b); NMFS 2018
	Blueline (or gray) tilefish (*Caulolatilus microps*)	Yes**	No	SEDAR 50 (SEDAR 2017b); NMFS 2018
	Sand tilefish (*Malacanthus plumier*)	Unknown	Unknown	NMFS 2018
Balistidae (Triggerfishes)	Gray triggerfish (*Balistes capriscus*)	No	Unknown	SEDAR Assessment 41 (SEDAR 2016c); NMFS 2018
	Ocean triggerfish (*Canthidermis sufflamen*)*	N/A	N/A	
Labridae (Wrasses)	Hogfish (*Lachnolaimus maximus*)	Unknown (Carolinas); Yes (Florida)	Unknown (Carolinas); Yes (Florida)	SEDAR 37 (SEDAR 2013b); NFMS 2018
Eppiphidae (Spadefishes)	Atlantic spadefish (*Chaetodipterus faber*)	Unknown	Unknown	NMFS 2018

* Indicates ecosystem component species which do not have management measures in place and are not assessed.
**Based on NMFS stock assessment

Table 3. Landings of all snapper grouper species for the commercial fishery for 1994-2018. Sheepshead were removed from the fishery in 2012 and therefore not included past 2011.

Year	Weight of harvested fish (pounds)	Value of Landings (U.S. dollars)
1994	2,934,780	$ 3,812,786
1995	2,623,931	$ 3,564,165
1996	2,615,708	$ 3,533,508
1997	2,800,249	$ 4,057,752
1998	2,577,650	$ 3,957,472
1999	2,405,828	$ 3,991,405
2000	2,210,883	$ 3,810,117
2001	2,242,750	$ 3,703,361
2002	2,430,996	$ 3,978,441
2003	2,158,268	$ 3,514,045
2004	2,594,154	$ 3,912,644
2005	2,263,253	$ 3,742,814
2006	2,308,913	$ 4,456,391
2007	2,432,494	$ 5,343,507
2008	2,996,691	$ 6,221,744
2009	2,913,935	$ 5,442,271
2010	2,424,148	$ 4,980,945
2011	1,948,428	$ 4,088,666
2012	1,705,871	$ 4,237,924
2013	1,514,277	$ 3,986,934
2014	1,628,295	$ 4,017,731
2015	1,438,404	$ 3,525,985
2016	1,407,996	$ 3,871,181
2017	1,509,980	$ 4,027,956
2018	1,377,423	$ 4,027,602
Average	2,218,612	$ 4,152,294

Table 4. Landings (in pounds) of snapper grouper, by aggregate groups, for the commercial fishery from 1994-2018. Aggregate groups are those used by the SAFMC and are done by family (as in Table 2). Sheepshead were removed from the fishery in 2012 and therefore not included past 2011; these are included in the porgy aggregate. Only black sea bass from south of Cape Hatteras are included, as the northern populations are managed by the Atlantic States Marine Fisheries Commission (ASMFC) and the Mid-Atlantic Fisheries Management Council (MAFMC). Wreckfish landings are confidential (so excluded) as well as black sea bass landings from 1994.

Year	Black sea bass	Grouper	Snapper	Porgies	Grunts	Jacks	Tilefish	Triggerfish	Hogfish	Spadefish	Unclassified
1994	*	775,413	450,121	258,510	181,727	161,646	231,584	271,503	19,133	23,347	136,584
1995	1,988	772,773	403,499	263,431	163,392	181,020	160,860	304,540	33,445	40,873	142,944
1996	310,921	651,090	350,204	251,075	97,221	148,091	158,586	277,741	13,841	55,890	141,983
1997	419,945	719,550	366,482	213,525	130,361	191,572	149,402	342,134	14,010	57,384	109,489
1998	493,304	745,665	352,020	208,741	108,059	105,716	67,770	274,641	12,037	38,994	77,819
1999	484,002	758,068	441,783	117,538	94,756	134,499	76,697	150,387	12,405	34,320	32,190
2000	414,250	636,942	510,897	54,754	81,207	132,596	85,467	88,277	7,727	46,235	44,361
2001	477,116	558,626	523,741	83,990	94,422	125,286	106,674	87,628	8,203	41,994	42,200
2002	431,313	699,579	490,591	87,959	102,158	132,297	220,331	90,934	10,637	38,400	20,419
2003	476,493	651,949	269,230	55,562	65,379	138,443	87,102	117,396	9,135	28,519	43,754
2004	506,352	584,916	339,453	45,498	81,075	109,728	78,126	136,211	8,902	44,521	40,081
2005	321,858	579,271	432,823	47,864	90,364	124,456	44,014	145,639	7,877	35,445	20,826
2006	443,549	708,863	345,071	72,241	118,234	103,981	138,090	126,354	7,296	19,623	21,030
2007	277,451	827,766	550,608	97,919	118,545	135,695	58,218	155,261	7,112	19,567	19,874
2008	275,754	785,555	602,838	114,457	91,292	164,259	404,295	198,724	13,035	11,694	20,025

ASMFC AND FEDERALLY-MANAGED SPECIES WITHOUT N.C. INDICES – SNAPPER GROUPER

Table 4. (continued).

Year	Black sea bass	Grouper	Snapper	Porgies	Grunts	Jacks	Tilefish	Triggerfish	Hogfish	Spadefish	Unclassified
2009	437,951	637,447	374,081	98,771	74,054	157,990	469,293	215,759	10,839	20,636	18,165
2010	292,879	561,926	320,260	84,781	47,219	131,050	430,394	225,682	13,046	18,827	17,763
2011	173,681	408,507	326,371	90,792	33,443	73,865	133,824	220,204	10,793	21,535	7,692
2012	194,778	382,085	279,367	83,918	49,734	140,525	361,094	143,114	8,256	24,238	12,038
2013	241,363	308,891	276,533	72,664	44,702	104,670	217,079	160,861	7,847	20,369	14,914
2014	316,420	300,002	251,062	82,779	39,312	202,207	91,074	116,782	9,767	22,761	22,052
2015	226,337	261,124	232,030	54,386	32,684	154,191	45,354	131,536	8,238	15,997	23,341
2016	198,595	258,199	280,043	47,319	39,843	148,775	111,788	135,545	9,195	15,231	29,830
2017	243,186	223,593	286,861	54,515	42,192	133,389	88,754	152,955	15,776	18,834	25,070
2018	180,006	239,181	323,241	58,995	36,820	151,866	68,509	174,075	13,755	9,838	21,489

Table 5. Landings of all snapper grouper species for the recreational fishery for 1994-2018. Sheepshead were removed from the fishery in 2012 and therefore not included past 2011.

Year	Number Harvested	Weight Harvested (pounds)	Number Released	Percent Released
1994	1,053,124	1,533,940	1,874,112	64
1995	719,165	1,270,807	984,315	58
1996	495,933	1,035,430	505,665	50
1997	719,982	1,263,793	963,277	57
1998	460,179	637,920	1,160,623	72
1999	498,322	1,111,353	1,275,362	72
2000	809,585	1,875,018	1,752,629	68
2001	867,756	1,950,635	1,598,944	65
2002	698,910	2,116,365	1,154,287	62
2003	1,058,323	2,328,511	1,187,280	53
2004	1,064,909	2,721,125	2,423,712	69
2005	1,062,257	2,731,746	2,374,760	69
2006	834,020	3,371,877	2,113,262	72
2007	1,180,560	4,238,582	2,147,173	65
2008	1,272,323	4,768,084	1,984,369	61
2009	1,117,904	3,982,014	1,904,345	63
2010	888,124	2,799,144	2,514,620	74
2011	596,296	1,355,199	3,118,377	84
2012	548,961	1,369,983	4,870,584	90
2013	373,619	1,003,700	3,375,274	90
2014	513,853	1,116,905	5,653,027	92
2015	543,251	1,234,415	5,536,732	91
2016	602,714	1,352,689	7,771,664	93
2017	827,209	1,658,305	6,734,295	89
2018	327,833	859,578	2,456,812	88

Table 6. Recreational landings (in pounds), by aggregate groups, for 1994-2018. Aggregate groups are those used by the SAFMC and are done by family (as in Table 2). Sheepshead were removed from the fishery in 2012 and therefore not included past 2011; these are included in the porgy aggregate. Only black sea bass from south of Cape Hatteras are included, as the northern population is managed by ASMFC and MAFMC.

Year	Black sea bass	Groupers	Snappers	Porgies	Grunts	Jacks	Tilefish	Triggerfish	Hogfish	Spadefish	Wreckfish
1994	255,936	190,122	86,864	348,920	405,116	142,011	-	96,569	256	8,146	-
1995	192,882	118,769	55,390	484,602	112,911	147,991	27,907	25,071	83,710	21,574	-
1996	222,898	43,780	31,717	289,437	77,503	276,636	540	77,012	-	15,907	-
1997	225,333	163,784	48,080	396,527	77,153	186,042	71,038	72,236	1,146	22,454	-
1998	154,986	60,627	9,577	250,646	37,113	89,045	-	25,188	-	10,738	-
1999	59,202	79,550	14,977	773,977	31,670	71,471	2,332	26,159	-	52,015	-
2000	373,028	52,159	23,294	820,377	9,520	548,623	3,724	26,184	-	18,109	-
2001	401,777	193,497	53,284	722,015	162,741	242,933	22,253	81,602	-	70,533	-
2002	183,634	345,293	143,786	865,924	337,495	159,670	7,290	54,879	11,499	6,895	-
2003	300,241	302,523	54,508	1,055,668	237,379	220,407	20,207	62,147	1,719	73,712	-
2004	507,359	1,012,289	170,615	558,545	266,540	94,406	29,313	64,317	1,300	16,441	-
2005	447,869	878,383	213,954	431,621	345,702	119,282	132,444	56,314	19,319	86,858	-
2006	175,048	1,664,930	54,160	476,295	235,456	316,341	330,140	64,556	19,365	35,586	-
2007	246,920	1,341,412	37,518	1,542,134	277,955	194,892	361,745	127,338	-	108,668	-
2008	104,582	1,940,787	114,550	1,139,132	302,233	468,560	404,734	269,507	1,813	22,186	-
2009	158,882	1,431,695	125,579	678,816	182,410	699,654	161,626	450,795	5,043	87,514	-

Table 6. (continued)

Year	Black sea bass	Groupers	Snappers	Porgies	Grunts	Jacks	Tilefish	Triggerfish	Hogfish	Spadefish	Wreckfish
2012	219,859	209,381	78,050	42,963	171,618	262,534	65,879	221,703	24,243	73,281	472
2013	101,797	96,961	17,303	29,682	44,549	470,545	42,557	146,636	7,116	46,554	-
2014	562,393	25,771	25,717	21,247	86,365	154,373	45,541	102,145	-	93,353	-
2015	448,876	99,496	60,137	26,547	76,945	402,160	8,128	76,733	-	35,393	-
2016	301,334	78,007	46,391	19,455	86,926	356,481	282,035	165,279	466	16,315	-
2017	506,489	53,880	42,040	52,667	60,245	234,338	125,497	397,002	45,064	141,083	-
2018	107,331	8,816	29,406	8,012	16,762	357,661	116,891	178,928	383	35,388	-

Table 7. Black sea bass south of Cape Hatteras length (total length, inches) data from Marine Recreational Information Program recreational samples, 1994-2018.

Year	Mean Total Length	Minimum Total Length	Maximum Total Length	Total Number Measured
1994	10	4	21	211
1995	11	6	20	173
1996	11	7	19	177
1997	11	6	18	175
1998	10	6	21	173
1999	10	7	19	139
2000	11	8	15	102
2001	12	8	19	219
2002	12	9	20	46
2003	12	9	18	75
2004	12	9	18	125
2005	13	9	18	90
2006	12	10	19	85
2007	14	11	20	51
2008	14	9	18	72
2009	13	11	20	172
2010	13	6	19	297
2011	14	8	21	206
2012	14	9	19	217
2013	13	7	19	244
2014	13	5	17	135
2015	14	11	20	111
2016	15	12	18	115
2017	15	10	19	139
2018	14	10	17	152

Table 8. Summary of black sea bass south of Cape Hatteras age samples collected from both dependent (commercial and recreational fisheries) and independent (surveys) sources from 2004-2018.

Year	Modal Age	Minimum Age	Maximum Age	Total Number Aged
2004	4	2	8	316
2005	4	2	9	767
2006	4	2	8	699
2007	4	1	10	1,837
2008	4	2	10	1,452
2009	4	2	8	1,473
2010	4	1	8	900
2011	3	1	8	798
2012	4	2	10	1,116
2013	4	1	7	1,251
2014	4	1	8	1,546
2015	4	2	9	1039
2016	4	1	8	708
2017*	4	2	8	578
2018**				1,073

* Preliminary ages, pending second read.
** Age samples not read.

FIGURES

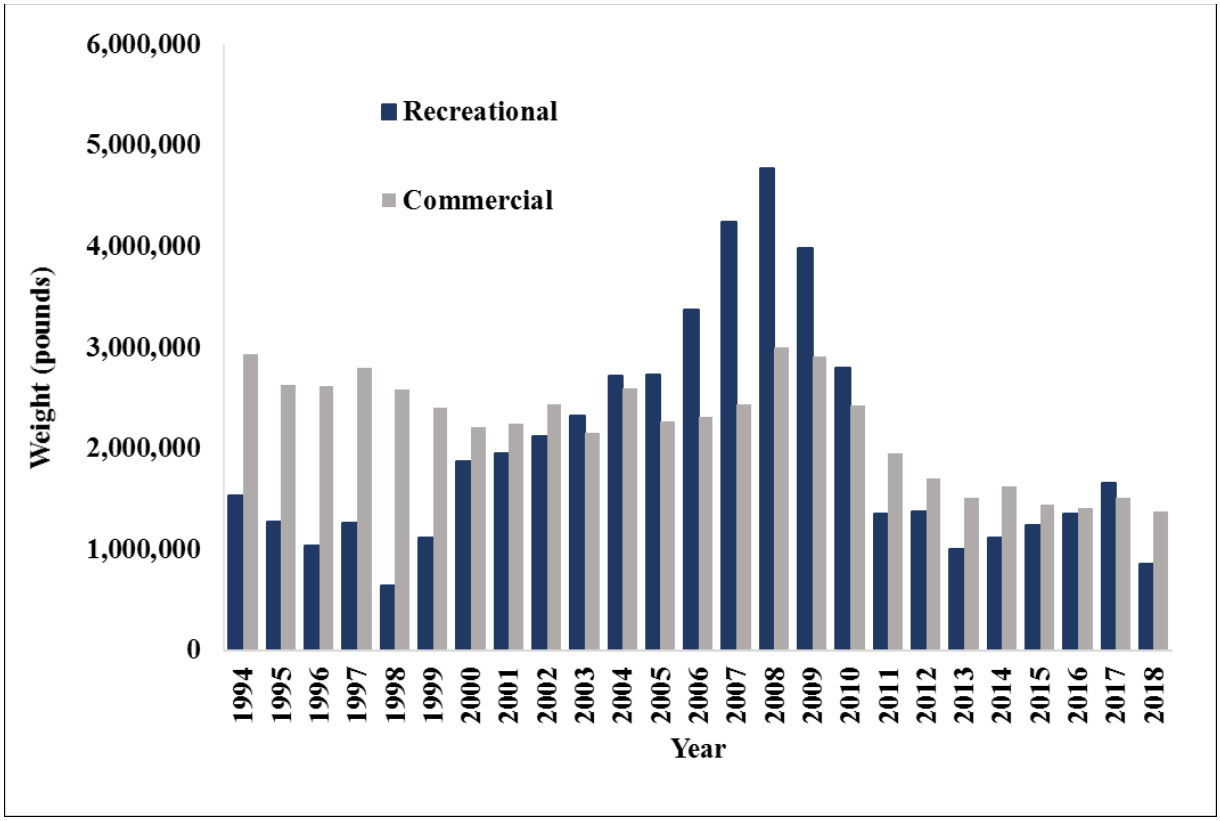

Figure 1. Annual commercial and recreational landings in pounds for snapper grouper species in North Carolina from 1994 to 2018.

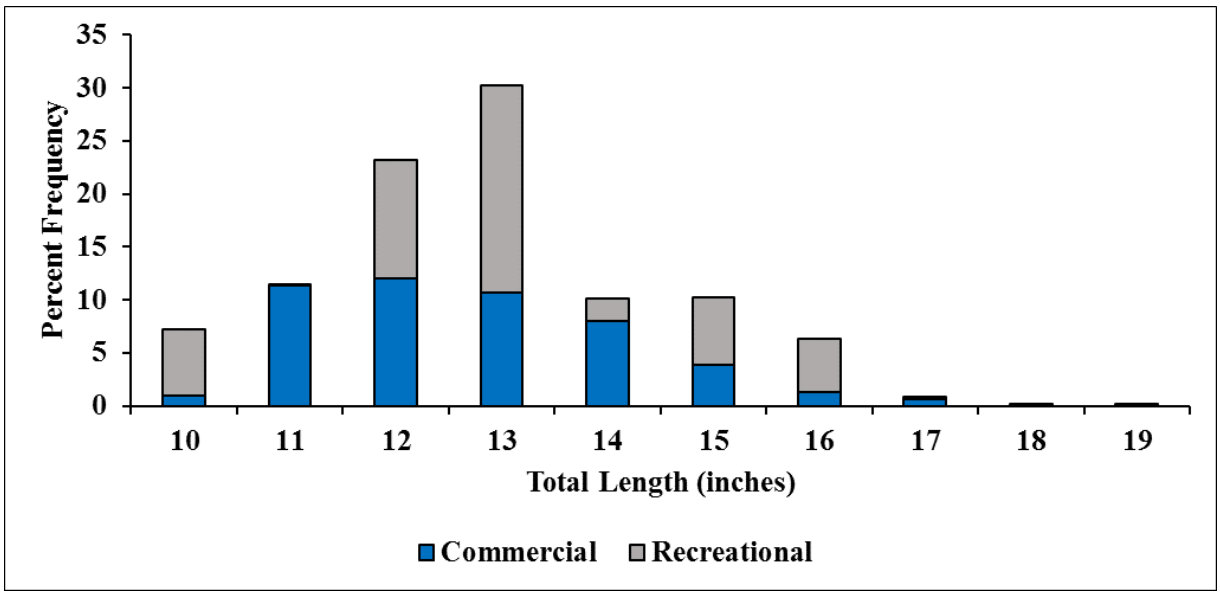

Figure 2. Commercial and recreational length frequency distribution from black sea bass south of Cape Hatteras harvested in 2018.

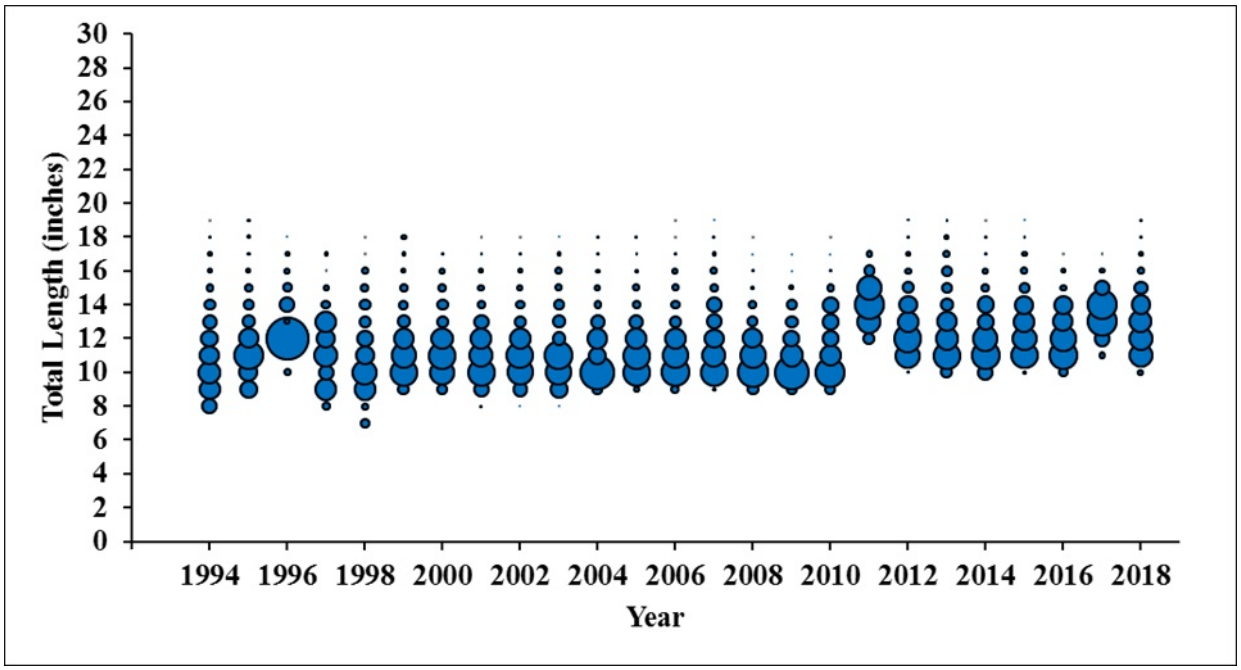

Figure 3. Commercial length frequency (total length, inches) of black sea bass south of Cape Hatteras harvested from 1994 to 2018. Bubbles represent fish harvested at length and the size of the bubble is equal to the proportion of fish at that length.

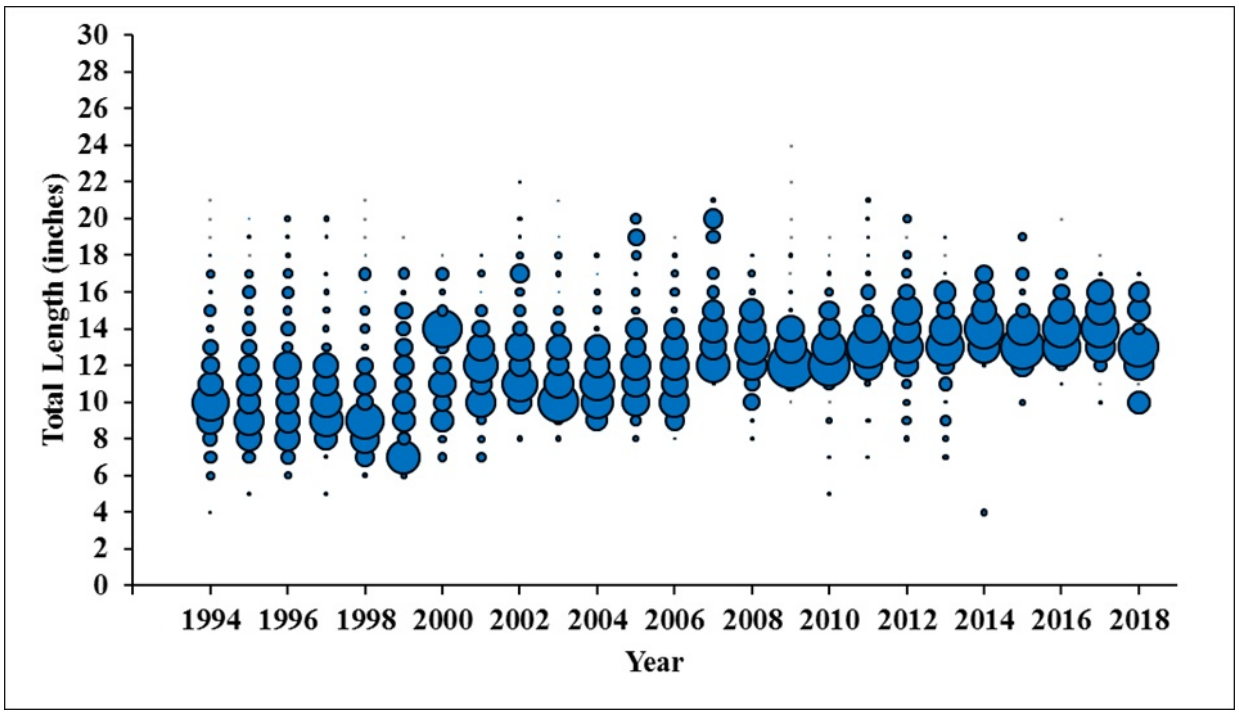

Figure 4. Recreational length frequency (total length, inches) of black sea bass south of Cape Hatteras harvested from 1994 to 2018. Bubbles represent fish harvested at length and the size of the bubble is equal to the proportion of fish at that length.

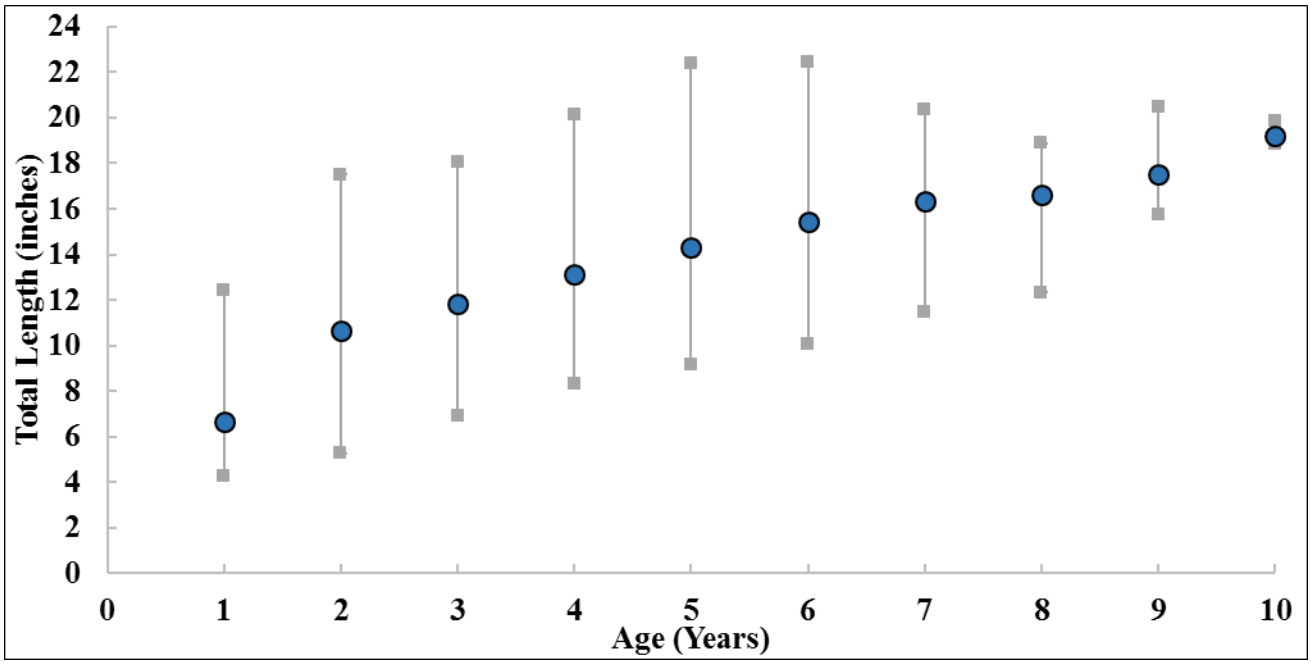

Figure 5. Black sea bass south of Cape Hatteras length at age based on all age samples collected from 2004 to 2017. Blue circles represent the mean size at a given age while the grey squares represent the minimum and maximum observed size for each age.

FISHERY MANAGEMENT PLAN UPDATE
SPANISH MACKEREL
AUGUST 2019

STATUS OF THE FISHERY MANAGEMENT PLAN

Fishery Management Plan History

Original FMP Adoption:	February 1983
Amendments:	Amendment 2 – July 1987 Amendment 3 – August 1989 Amendment 4 – October 1989 Amendment 5 – August 1990 Amendment 6 – December 1992 Amendment 8 – March 1998 Amendment 9 – April 2000 Amendment 10 – July 2000 Amendment 11 – December 1999 Amendment 14 – August 2005 Amendment 15 – February 2004 Amendment 18 – January 2012 Amendment 19 – July 2010 Amendment 20A – August 2014 Framework Action 2013 – December 2014 Amendment 20B – March 2015 Framework Amendment 1 – December 2014 Amendment 22 – January 2014 Amendment 23 – January 2014 Framework Amendment 5 – August 2017 Omnibus Amendment – August 2011 Addendum I to Omnibus Amendment – August 2013
Revisions:	None
Supplements:	None
Information Updates:	None
Next Benchmark Review:	The next assessment has not been scheduled.

Spanish mackerel is managed under the Atlantic States Marine Fisheries Commission's (ASMFC) Fishery Management Plan (FMP) for Spanish Mackerel and the South Atlantic Fishery Management Council's (SAFMC) Coastal Migratory Pelagics FMP (ASMFC 2011; SAFMC 1982). The original Gulf and South Atlantic fishery management councils' fishery

management plan (FMP) for Coastal Migratory Pelagic Resources (mackerels) was approved in 1982 (SAMFC 1982) and went into effect in 1983. This plan treated Spanish mackerel as one U.S. stock. Allocations were established for recreational and commercial fisheries, and the commercial allocation was divided between net and hook and line fishermen. The plan also established procedures for the Secretary of Commerce to act by regulatory amendment to resolve possible future conflicts in the fishery, such as establish fishing zones and local quotas to each gear or user group. Numerous amendments have been implemented since the first FMP.

Amendment 2 revised Spanish mackerel maximum sustainable yield (MSY) downward, recognized two migratory groups, and set commercial quotas and bag limits (SAFMC 1987). Charter boat permits were required, and it was clarified that total allowable catch (TAC) for overfished stocks must be set below the upper range of acceptable biological catch (ABC). The use of purse seines on overfished stocks was prohibited.

Amendment 3 prohibited drift gill nets for coastal pelagics and purse seines and run-around gill nets for the overfished groups of mackerels (SAMFC 1989a). The habitat section of the FMP was updated and vessel safety considerations were included in the plan. A new objective to minimize waste and bycatch in the fishery was added to the plan.

Amendment 4 reallocated Spanish mackerel equally between recreational and commercial fishermen on the Atlantic group with an increase in TAC (SAFMC 1989b).

Amendment 5 extended the management area for the Atlantic groups of mackerels through Mid-Atlantic Fishery Management Council (MAFMC) jurisdiction (SAMFC 1990). It revised problems in the fishery and plan objectives, revised the definition of "overfishing", provided that the SAFMC will be responsible for pre–season adjustments of TACs and bag limits for the Atlantic migratory groups of mackerels, redefined recreational bag limits as daily limits, created a provision specifying that the bag limit catch of mackerel may be sold, provided guidelines for corporate commercial vessel permits, and included a definition of "conflict" to provide guidance to the Secretary.

Amendment 6 identified additional problems and an objective in the fishery, provided for rebuilding overfished stocks of mackerels within specific periods, provided for biennial assessments and adjustments, provided for more seasonal adjustment actions, including size limits, vessel trip limits, closed seasons or areas, and gear restrictions, provided for commercial Atlantic Spanish mackerel possession limits, changed commercial permit requirements to allow qualification in one of three preceding years, discontinued the reversion of the bag limit to zero when the recreational quota is filled, modified the recreational fishing year to the calendar year, and changed all size limit measures to fork length only (SAMFC 1992).

Amendment 8 identified additional problems in the fishery, specified allowable gear, revised qualifications for a commercial permit, revised the seasonal framework procedures to: provide for consideration of public comment, redefine overfishing and allow for adjustment by framework procedure, allow changes in allocation ratio of Atlantic Spanish mackerel, allow setting zero bag limits, and allow gear regulation including prohibition (SAMFC 1996).

Amendment 9 allowed possession of cut-off (damaged) Spanish mackerel that comply with the minimum size limits and the trip limits in the Gulf, Mid-Atlantic, or South Atlantic exclusive economic zone (EEZ) (sale of such cut-off fish is allowed as long as such fish are within the existing allowance for possession) (SAFMC 2000).

Amendment 10 designated Essential Fish Habitat (EFH) and EFH-Habitat Areas of Particular Concern (HAPC) for coastal migratory pelagics (SAFMC 1998a).

Amendment 11 amended the FMP as required to make definitions of MSY, optimal yield (OY), overfishing and overfished consistent with National Standard Guidelines; identified and defined fishing communities and addressed bycatch management measures (SAFMC 1998).

Amendment 14 established a three-year moratorium on the issuance of for-hire (charter vessel and head boat) permits for coastal migratory pelagic species in the Gulf of Mexico unless sooner replaced by a comprehensive effort limitation system. This resulted in separate for-hire permits for the Gulf and South Atlantic. The control date for eligibility was established as March 29, 2001 (SAFMC 2002b). The amendment also includes other provisions for eligibility, application, appeals, and transferability of permits.

Amendment 15 changed the fishing year to March 1 through February 28/29 for Atlantic group king and Spanish mackerels (SAFMC 2004).

Amendment 17 (SAFMC 2006) established a permanent limited entry system for Gulf of Mexico coastal migratory pelagics for-hire (charter and headboat) permits, building on the moratorium established under Amendment 14.

Amendment 18 established Annual Catch Limits (ACLs), Annual Catch Targets (ACTs) and accountability measures (AMs) for Spanish mackerel (SAFMC 2011) as required under the 2006 Magnuson Stevens Reauthorization Act.

Amendment 19 updated existing EFH and HAPC designations for South Atlantic species and prohibited the use of certain gear types within Deepwater Coral Habitat Areas of Particular Concern (SAFMC 2009).

Amendment 20A prohibits the sale of Spanish mackerel caught under the bag limit unless the fish are caught as part of a state-permitted tournament and the proceeds from the sale are donated to charity (SAFMC 2014).

Framework Action 2013 established provisions to allow for the transfer at sea of Spanish mackerel caught in gill nets when one set exceeds the trip limit and modified the trip limit for the Florida East Coast subzone by moving the potential step-up to 75 fish/day in the last month of the season and if less than 70% of the subzone's ACL has been met.

Amendment 20B creates Northern and Southern Zones for Atlantic migratory group Spanish mackerel. National Oceanic and Atmospheric Administration Fisheries will close each zone

when the respective quota is met or expected to be met (SAMFC 2015). The dividing line between the zones is at the North Carolina/South Carolina state line.

Framework Amendment 1 (SAFMC 2014) updated the ACLs and ACTs for Gulf and Atlantic migratory groups of Spanish mackerel based on the results of the 2012 stock assessment.

Amendment 22b. modified headboat reporting regulations to require weekly electronic reporting of all SAFMC managed species (SAFMC 2013).

Amendment 23 (SAFMC 2013) required dealers to possess a federal Gulf and South Atlantic universal dealer permit to purchase king and Spanish mackerel and required weekly electronic dealer reporting. It also required federally-permitted king and Spanish mackerel fishermen to sell only to a federally-permitted dealer.

Framework Amendment 5 (SAFMC 2016) modifies the regulations that prohibit fishing for and retaining the bag limit of king and Spanish mackerel on recreational trips on vessels with federal commercial king mackerel and Spanish mackerel permits, when there is a commercial quota closure.

The ASMFC approved the Omnibus Amendment in 2011 (ASMFC 2011). The management goal for the Omnibus Amendment is to bring the Fishery Management Plan for Spanish Mackerel under authority of the Atlantic Coastal Fisheries Cooperative Management Act, providing for more efficient and effective management and changes to management in the future.

Addendum I to the Omnibus Amendment (ASMFC 2013) established a pilot program that would allow states to reduce the Spanish mackerel minimum size limit for the commercial pound net fishery to 11.5 inches during the summer months of July through September for the 2013 and 2014 fishing years only. In August 2015, the South Atlantic Board formally extended the provisions of Addendum I for the 2015, 2016 and 2017 fishing seasons. Reports by North Carolina, the only state to reduce their minimum size, are reviewed annually.

To ensure compliance with interstate requirements, North Carolina also manages this species 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 MAFMC, SAFMC, 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 plans) and the Atlantic Coastal Fisheries Cooperative Management Act (ASMFC plans) are like the goals of the Fisheries Reform Act of 1997 to “ensure long-term viability” of these fisheries (NCDMF 2015).

Management Unit

The management unit is defined for South Atlantic Spanish mackerel within U.S. waters north of Miami-Dade/Monroe County line, Florida in the Atlantic Ocean.

Goal and Objectives

The goal of the FMP for Coastal Migratory Pelagics resources was to institute management measures necessary to prevent exceeding maximum sustainable yield (MSY), establish a mandatory statistical reporting system for monitoring catch, and to minimize gear and user conflicts (SAMFC 1982). Amendment 12 to the Gulf and South Atlantic fishery management councils' FMP for Coastal Migratory Pelagics lists eight plan objectives:

1. The primary objective of the FMP is to stabilize yield at MSY, allow recovery of overfished populations, and maintain population levels sufficient to ensure adequate recruitment.
2. To provide a flexible management system for the resource which minimizes regulatory delay while retaining substantial Council and public input in management decisions and which can rapidly adapt to changes in resource abundance, new scientific information, and changes in fishing patterns among user groups or by areas.
3. To provide necessary information for effective management and establish a mandatory reporting system.
4. To minimize gear and user group conflicts.
5. To distribute the TAC of Atlantic migratory group Spanish mackerel between recreational and commercial user groups based on the catches that occurred during the early to mid-1970s, which is prior to the development of the deep water run-around gill net fishery and when the resource was not overfished.
6. To minimize waste and bycatch in the fishery.
7. To provide appropriate management to address specific migratory groups of king mackerel.
8. To optimize the social and economic benefits of the coastal migratory pelagic fisheries.

The primary goal of the ASMFC Omnibus Amendment is to bring the FMPs for Spanish mackerel, spot, and spotted seatrout under the authority of the Act, providing for more efficient and effective management and changes to management for the future (ASMFC 2011). Omnibus amendment 1 objectives include:

1. Manage the Spanish mackerel fishery by restricting fishing mortality to rates below the threshold fishing mortality rates to provide adequate spawning potential to sustain long-term abundance of the Spanish mackerel populations.
2. Manage the Spanish mackerel stock to maintain the spawning stock biomass above the target biomass levels.
3. Minimize endangered species bycatch in the Spanish mackerel fishery.
4. Provide a flexible management system that coordinates management activities between state and federal waters to promote complementary regulations throughout Spanish mackerel's range which minimizes regulatory delay while retaining substantial ASMFC, Council, and public input into management decisions; and which can adapt to changes in resource abundance, new scientific information and changes in fishing patterns among user groups or by area.
5. Develop research priorities that will further refine the Spanish mackerel management program to maximize the biological, social, and economic benefits derived from the Spanish mackerel population.

STATUS OF THE STOCK

Life History

Spanish mackerel are considered coastal pelagic, meaning they live in the open waters near the coast. They make northern and southern migrations depending on water temperature and seldom enter waters below 68 degrees Fahrenheit. In North Carolina's waters, Spanish mackerel can be found from April to November. They migrate south to the Florida coast in the late fall. In the summer months, they may be found as far inland as the sounds and coastal river mouths. Spanish mackerel spawn from May to September, are fast growing, and may live to be 8 years old. Spanish mackerel in North Carolina grow as large as 30 inches, but most recreational catches are between 12 and 15 inches. Both sexes are capable of reproduction by age 2. Spanish mackerel feed primarily on small, schooling pelagic fish such as anchovies and herring (Manooch 1984).

Stock Status

In 2012, the Atlantic Spanish mackerel stock was assessed and peer reviewed through the Southeast Data, Assessment and Review (SEDAR 2014). The results of the assessment (SEDAR 28) indicate Atlantic Spanish mackerel are not overfished and overfishing is not occurring. The next assessment has not been scheduled.

Stock Assessment

There is a lack of available fishery independent indices of abundance for this species. Many of the indices of abundance that were made available were rejected due to concerns about the way the fishers targeted Spanish mackerel. The schooling behavior of Spanish mackerel makes a random survey of their population particularly difficult. The one fishery independent index used (Southeast Area Monitoring and Assessment Program Trawl Survey young of the year) was highly variable, as would be expected for a recruitment index. The base run of the age-structured assessment model indicated the stock is not overfished and overfishing is not occurring. The sensitivity analyses yielded similar results and there was no retrospective pattern of concern. Conclusions about stock status during the analysis were most sensitive to different combinations of input data and variance around fixed parameters (steepness, recreational discard mortality, historical recreational landings, and natural mortality). A statistical catch-age model was used to assess the population of Atlantic Spanish mackerel. The age-structured assessment indicated the stock was not overfished and overfishing was not occurring.

STATUS OF THE FISHERY

Current Regulations

The North Carolina Division of Marine Fisheries currently complements the management measures of the Coastal Migratory Pelagic FMP through rules (NCMFC Rule 15A NCAC 03M .0301 and proclamation authority (15A NCAC 03M .0512). Current regulations include a recreational bag limit of 15 Spanish mackerel per person per day and 12-inch fork length minimum size. Commercial regulations also include a 12-inch fork length minimum size and a

trip limit of 3,500 pounds. Federal vessel permits are required for commercial, charter and head boats fishing in the EEZ. Sale of Spanish mackerel caught under the bag limit are prohibited unless the fish are caught as part of a state-permitted tournament and the proceeds from the sale are donated to charity.

Commercial Landings

Predominant commercial fisheries for Spanish mackerel include gill nets and estuarine pound nets. In 2018, commercial landings were 796,855 pounds (Table 1, Figure 1) and 88% of the Spanish mackerel harvest was taken in gill nets (Figure 2). 2018 landings are slightly above the 10-year average of 773,197 pounds, with most landings falling between May and October. The NC commercial fishery is responsible for landing approximately 20% of the South Atlantic landings annually. Atlantic Spanish mackerel catches are divided into a Northern zone (NC through the Mid-Atlantic) and a Southern zone (SC, GA, and FL east coast to Dade-Monroe county line). The Northern zone landings exceeded the annual catch limit (662,670 pounds) in 2017 and 2018. The NC commercial fishery closed November 4, 2018.

Recreational Landings

Recreational fishing activity is monitored through the Marine Recreational Information Program. In this report, estimates across all years have been updated and are now based on the MRIP new Fishing Effort Survey-based calibrated estimates. For more information on MRIP methodology changes see https://www.fisheries.noaa.gov/topic/recreational-fishing-data. Spanish mackerel are a favorite of many anglers due to their exciting behavior when hooked and their delicious taste when cooked. Recreational anglers target Spanish mackerel by trolling spoons and plugs inshore. Anglers catch most Spanish mackerel between May and September, once the water temperature has warmed up to 70°F. Anglers harvested 1,156,702 pounds of Spanish mackerel in 2018 (Table 2, Figure 1).

MONITORING PROGRAM DATA

Fishery-Dependent Monitoring

Length-frequency information for the commercial Spanish mackerel fishery in North Carolina is collected through NCDMF sampling programs (programs 431 (sciaenid pound net), 434 (ocean gill net), 461 (estuarine gill net), and 466 (sea turtle by-catch programs)) (Table 4 and Figure 3). Ageing structures, otoliths, are collected from fishery-dependent sampling programs and are sent to the Southeast Fisheries Science Center in Panama City, Florida for processing and ageing (Table 5). Length and weight information for the recreational fishery are collected through the MRIP dockside sampling (Figure 4).

Fishery-Independent Monitoring

Length-frequency information for Spanish mackerel is collected in the division's statewide Independent Gill Net Survey (program 915) and Pamlico Sound Trawl Survey (Program 195) (Table 6). Ageing structures, otoliths, are collected from both independent sampling programs

and sent to the Southeast Fisheries Science Center in Panama City, Florida for processing and ageing (Table 5).

MANAGEMENT STRATEGY

In North Carolina, Spanish mackerel are included in the North Carolina Fishery Management Plan for Interjurisdictional Fisheries, which defers, to the SAFMC's Coastal Migratory Pelagics FMP and the ASMFC's FMP for Spanish Mackerel (NCDMF 2015; SAFMC 2015; ASMFC 2013).

Spanish mackerel is currently managed under recent Amendment 20A (SAFMC 2014a), Amendment 20B (SAFMC 2015) and Framework Amendment 1 (SAMFC 2014b) to the Coastal Migratory Pelagics Fishery Management Plan. Amendment 20A prohibits the sale of all bag-limit-caught Spanish mackerel, except those harvested during a state-permitted tournament. Amendment 20B establishes separate commercial quotas of Atlantic Spanish mackerel for a Northern Zone (north of North Carolina and South Carolina state line) and Southern Zone (south of North Carolina and South Carolina state line). Framework Amendment 1 modifies the annual catch limits for Spanish mackerel in the U.S. Atlantic and modifies the recreational annual catch target, based on the results of the most recent stock assessments for these stocks. North Carolina currently has a 12-inch fork length minimum size limit, a 15 fish per day bag limit for recreational anglers and a 3,500-pound commercial trip limit. The harvest season is open year-round, and is based on a fishing year of March 1 to the last day in February with commercial and recreational fisheries closing when the quota is reached.

The ASMFC's South Atlantic State-Federal Fisheries Management Board approved the Omnibus Amendment for Spot, Spotted Seatrout, and Spanish Mackerel in 2011 (ASMFC 2011). For Spanish mackerel, the Amendment includes commercial and recreational management measures, adaptive management measures, and a process for Board review and action in response to changes in the federal regulations. This allows for complementary management throughout the range of the species.

The Board approved Addendum I (ASMFC 2013) to establish a pilot program to allow states to reduce the Spanish mackerel minimum size limit for the commercial pound net fishery to 11.5 inches from July through September for the 2013 and 2014 fishing years. In August 2015, the Board evaluated the success of the pilot program and extended the provisions of Addendum I for the 2015, 2016, and 2017 fishing years. The program was created to reduce waste of these shorter fish, which are discarded dead in the summer months, by converting them to landed fish that will be counted against the quota. The addendum responded to reports about the increased incidence of Spanish mackerel one-quarter to one-half inch short of the 12-inch fork length minimum size limit in pound nets during the summer months which die prior to being released, possibly due to a combination of temperature, stress, and crowding. While work has been done to experiment with wall or panel mesh sizes and escape panels, little success has been made in releasing undersized fish quickly enough to prevent dead discards during this time of year. North Carolina, the only state to implement the Addendum thus far, provides annual reports to the Board on Spanish mackerel catch in its pound net fishery. Current management strategies for Spanish mackerel in South Atlantic waters are summarized in Table 7.

RESEARCH NEEDS

From Omnibus Amendment (ASMFC 2011):

- Increase collection of fishery-dependent length, sex, age, and CPUE data to improve stock assessment accuracy. Simulations on CPUE trends should be explored and impacts on assessment results determined. Data collection is needed for all states, particularly those north of North Carolina.
- Develop fishery independent methods to monitor stock size.
- Develop methodology for predicting year class strength and determination of the relationship between juvenile abundance and subsequent year class strength.
- To ensure more accurate estimates of t^0, increase efforts to collect age-0 specimens for use in estimating von Bertalanffy growth parameters.
- Provide better estimates of recruitment, natural mortality rates, fishing mortality rates, and standing stock. Specific information should include an estimate of total amount caught and distribution of catch by area, season, and type of gear.
- Commission and member states should support and provide the identified data and input needed to improve the SEDAR process.
- Conduct yield per recruit analyses relative to alternative selective fishing patterns.
- Investigate the discard mortality of Spanish mackerel in the commercial and recreational trolling fisheries and commercial gill net fishery.
- Need observer coverage for Spanish mackerel fisheries: gill nets, cast nets, handlines, pound nets, and shrimp trawl bycatch.
- Evaluate potential bias of the lack of appropriate stratification of the data used to generate age-length keys.
- Evaluate CPUE indices related to standardization methods and management history, with emphasis on greater temporal and spatial resolution in estimates of CPUE.
- Expand Trip Interview Program (TIP) sampling to better cover all statistical areas.
- Complete research on the application of assessment and management models relative to dynamic species such as Spanish mackerel.
- Establish a monitoring program to characterize the bycatch and discards of Spanish mackerel in the directed shrimp fishery in Atlantic Coastal waters.
- Obtain adequate data to determine gutted to whole weight relationships.
- Conduct inter-lab comparisons of age readings from test sets of otoliths in preparation for any future stock assessment.
- Address issue of fish retained for bait (undersized) or used for food by crew (how to capture these as landings).
- Investigate whether catchability varies as a function of fish density and/or environmental conditions.
- Investigate how temporal changes in migratory patterns may influence indices of abundance.
- Investigate the possibility of using models that allow catchability to follow a random walk, which can be useful in tracking longer-term trends in time-varying catchability and thus detect changes over time in CPUE (from SEDAR 2008).

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TABLES

Table 1. North Carolina commercial harvest of Spanish mackerel with landings in pounds per gear type, 1994-2018.

Year	Gear				Total
	Ocean Gill Net	Estuarine Gill Net	Pound Net	Other	
1994	327,155	138,448	29,708	36,061	531,371
1995	233,296	104,777	49,077	15,242	402,392
1996	215,536	124,013	45,221	17,069	401,839
1997	502,463	174,141	60,898	29,457	766,958
1998	234,547	97,472	26,962	13,435	372,415
1999	297,435	98,855	49,485	13,326	459,100
2000	462,459	162,291	21,792	12,884	659,426
2001	411,974	186,628	33,163	21,909	653,673
2002	463,430	205,865	24,118	5,035	698,448
2003	368,171	80,219	5,218	3,176	456,784
2004	359,467	90,317	3,524	2,934	456,242
2005	257,074	180,874	2,184	5,869	446,001
2006	358,614	100,114	2,783	9,152	470,662
2007	420,680	57,144	3,440	6,615	487,879
2008	268,435	93,579	49,534	3,857	415,405
2009	454,081	266,621	228,201	12,908	961,811
2010	177,091	631,218	96,490	7,068	911,866
2011	287,908	524,967	53,704	4,638	871,217
2012	501,369	372,759	38,644	3,667	916,439
2013	346,810	250,524	18,764	4,654	620,752
2014	422,528	221,798	25,772	3,876	673,974
2015	289,497	228,801	40,032	3,080	561,409
2016	328,635	242,133	27,806	3,054	601,628
2017	507,847	287,422	17,312	3,436	816,017
2018	486,672	280,689	19,931	9,563	796,855

Table 2. North Carolina recreational harvest of Spanish mackerel with landings in number of fish, pounds, and number released, 1981-2018. Percent Standard Error (PSE) is given for each.

Year	Harvest Number (A+B1, MRIP)	PSE (Num)	Weight (lb), (A+B1, MRIP)	PSE (lb)	Number Released (MRIP)	PSE
1981	344,209	70.8	853,597	74.0	2,967	95.8
1982	889,793	55.5	1,411,461	53.6	-	-
1983	10,275	47.0	25,641	47.3	-	-
1984	559,885	48.9	807,486	49.1	4,374	100.6
1985	441,051	38.9	819,680	40.7	36,482	95.4
1986	872,052	39.2	1,055,730	37.8	442,501	85.7
1987	974,840	22.2	1,323,352	18.1	35,412	39.9
1988	1,375,328	14.2	580,007	25.2	15,891	33.9
1989	1,374,008	33.5	1,594,616	26.0	140,141	44.2
1990	1,011,861	13.6	1,462,072	14.1	111,977	22.8
1991	1,119,245	15.9	1,695,569	11.6	238,694	20.8
1992	879,444	10.7	1,171,718	10.7	250,614	16.3
1993	720,907	14.8	1,107,430	16.6	104,879	21.2
1994	641,980	11.0	724,589	11.2	292,919	13.4
1995	397,190	12.9	492,096	14.3	239,972	17.6
1996	533,333	14.9	709,589	17.4	184,518	16.8
1997	956,589	12.5	1,444,907	13.1	304,629	38.7
1998	374,804	13.8	488,951	13.4	145,746	20.9
1999	891,001	14.7	1,035,943	16.6	253,317	17.0
2000	1,102,777	17.7	1,175,351	19.3	451,910	19.2
2001	942,500	25.0	1,155,788	24.7	338,918	37.0
2002	787,125	17.1	987,238	16.1	309,546	16.9
2003	540,399	15.3	641,024	14.5	266,887	17.1
2004	534,720	18.7	819,978	20.0	317,189	26.9
2005	561,073	16.1	526,054	16.6	303,641	19.9
2006	439,736	15.7	624,488	20.5	165,098	22.5
2007	604,518	15.2	799,263	16.5	340,027	16.5
2008	1,013,980	13.1	1,234,030	15.2	806,280	18.5
2009	1,480,931	13.5	2,155,692	19.4	752,806	20.7
2010	927,116	22.0	1,116,099	17.5	701,634	33.0
2011	854,554	15.0	1,100,110	20.0	479,586	15.5
2012	995,852	9.6	1,327,350	10.4	591,792	16.4
2013	994,599	15.2	1,242,029	16.5	685,692	26.1
2014	1,028,925	15.2	1,193,442	14.7	814,064	21.2
2015	835,011	14.3	981,867	15.6	514,714	17.7
2016	918,352	16.4	907,400	16.3	546,950	19.5
2017	995,706	18	1,094,778	18.3	688,062	21.4
2018	1,012,889	13.9	1,156,702	14.5	1,019,418	30.4
Average	**814,173**		**1,027,450**		**339,454**	

Table 3. Total number measured, mean, minimum, and maximum length (inches) of Spanish mackerel measured by MRIP sampling in North Carolina, 1981-2018

Year	Number Measured	Minimum Length	Maximum Length	Mean Length (MRIP Query)
1981	62	8.9	27.0	21.2
1982	69	8.0	31.9	18.0
1983	4	16.9	20.1	20.3
1984	28	13.0	23.8	14.7
1985	45	9.8	27.4	19.7
1986	110	8.1	27.2	15.4
1987	950	9.1	34.1	15.5
1988	1,118	7.9	32.9	5.0
1989	1,799	7.9	33.5	15.3
1990	2,160	8.3	35.5	15.9
1991	2,135	6.3	37.0	15.2
1992	1,354	7.5	33.1	15.4
1993	1,056	9.0	28.5	16.1
1994	2,255	6.4	29.4	15.2
1995	799	8.2	31.9	15.1
1996	1,107	9.8	70.2	16.0
1997	1,846	8.9	33.3	16.2
1998	895	9.2	31.1	15.5
1999	1,286	8.5	28.9	15.3
2000	1,242	9.0	27.2	15.7
2001	858	11.4	28.7	16.1
2002	827	9.5	28.0	16.3
2003	476	10.8	28.0	15.9
2004	298	11.1	27.5	16.7
2005	289	11.9	29.2	14.6
2006	236	11.1	39.4	16.0
2007	240	10.6	28.6	15.4
2008	596	8.9	26.2	15.2
2009	788	11.4	26.9	15.8
2010	763	10.7	26.5	15.2
2011	543	11.1	28.1	15.0
2012	776	10.6	28.0	15.1
2013	454	10.1	27.1	15.1
2014	754	9.0	29.9	14.8
2015	644	9.2	27.4	14.8
2016	1,030	11.0	26.3	14.3
2017	1,023	10.3	26.4	14.8
2018	1,691	9.9	27.2	15.0

Table 4. Mean, minimum and maximum fork lengths (inches) and total number sampled of Spanish mackerel from fishery dependent sampling programs.

Year	Mean Length	Minimum Length	Maximum Length	Total Number Measured
1997	14.5	7.8	23.7	769
1998	15.0	8.2	26.0	778
1999	14.6	6.8	25.0	968
2000	16.4	8.3	25.4	1,616
2001	15.6	9.6	26.0	861
2002	15.6	11.0	25.4	880
2003	16.3	9.8	26.5	473
2004	17.1	8.6	27.0	989
2005	16.2	9.3	27.4	1,841
2006	16.9	7.0	27.7	2,187
2007	15.8	7.1	31.9	2,072
2008	16.0	7.3	26.3	2,127
2009	15.6	7.5	38.2	3,509
2010	16.2	6.8	26.7	4,759
2011	16.6	10.1	42.5	5,507
2012	16.5	8.2	27.7	5,409
2013	16.6	7.9	28.5	3,902
2014	16.3	8.6	27.7	4,462
2015	16.1	10.0	26.8	5,402
2016	16.3	5.8	28.8	6,888
2017	16.4	10.7	28.0	4,522
2018	16.5	10.8	28.0	3,772

Table 5. Mean, minimum and maximum fork lengths (inches) and total number sampled of Spanish mackerel aged through Comprehensive Life History (Program 930).

Year	Mean Length	Minimum Length	Maximum Length	Total Number Measured
1997	14.0	5.6	24.3	403
1998	15.5	7.9	28.3	430
1999	14.7	7.4	30.5	294
2000	17.4	8.9	27.2	466
2001	16.3	8.0	26.2	488
2002	16.2	5.7	28.0	337
2003	14.5	9.8	26.0	330
2004	14.9	10.0	26.4	282
2005	14.7	8.7	25.4	303
2006	14.9	10.0	26.9	291
2007	14.9	10.4	31.7	297
2008	14.3	7.7	26.9	328
2009	15.3	9.3	25.1	317
2010	14.9	6.9	25.4	411
2011	15.1	6.1	28.0	430
2012	14.5	6.3	26.4	557
2013	15.2	7.4	27.5	370
2014	14.7	7.6	25.8	515
2015	14.8	7.2	27.6	412
2016	15.1	8.5	29.1	579
2017	18.6	7.0	28.1	451
2018	16.0	7.8	29.0	463

Table 6. Mean, minimum and maximum fork lengths (inches) and total number sampled of Spanish mackerel from fishery independent sampling programs.

Year	Mean Length	Minimum Length	Maximum Length	Total Number Measured
1997	8.1	2.8	13.9	52
1998	8.1	5.6	19.9	77
1999	9.1	3.1	19.3	31
2000	15.8	2.8	23.9	155
2001	15.6	4.1	24.4	158
2002	16.5	8.1	23.4	45
2003	16.6	9.7	22.4	35
2004	14.0	4.8	22.5	17
2005	15.0	3.8	24.1	61
2006	14.1	6.9	21.3	47
2007	11.4	2.2	21.8	163
2008	12.8	5.4	26.8	335
2009	13.9	4.3	22.4	474
2010	13.5	3.0	21.7	361
2011	14.2	2.8	20.5	103
2012	11.5	4.9	22.8	47
2013	10.3	4.6	17.9	46
2014	8.9	2.9	19.0	29
2015	12.3	3.9	21.7	49
2016	15.0	6.9	22.4	47
2017	19.8	2.8	24.6	130
2018	13.6	3.8	21.5	76

Table 7. Summary of management strategies by North Carolina for Spanish Mackerel

Management Strategy	Implementation Status
12 inch minimum size limit	Rule 15A NCAC 03M .0301(a)(1)
15 fish creel limit	Rule 15A NCAC 03M .0301(a)(2)
15 fish creel limit outside three miles only with a NMFS Commercial Vessel Permit	Rule 15A NCAC 03M .0301(a)(3)
Charter vessels or head boats with NMFS Commercial Vessel Permit must comply with possession limits when fishing with more than three persons	Rule 15A NCAC 03M .0301(c)
Commercial trip limit of 3,500 pounds of Spanish mackerel, king mackerel or in aggregate	Rule 15A NCAC 03M .0301(d)
Prohibits purse gill nets when taking king or Spanish mackerel	Rule 15A NCAC 03M .0512
Prohibits sale of Spanish Mackerel harvested from the EEZ in a commercial fishing operation without a valid Federal Commercial Spanish Mackerel Permit; Prohibits charter vessels or headboats with both a valid Federal Atlantic Charter/Headboat Coastal Migratory Pelagics Permit and a valid Federal Commercial Spanish Mackerel Permit to sell Spanish Mackerel from the EEZ when fishing with more than three persons; Prohibits purchase of Spanish Mackerel harvested from the Atlantic Ocean without a valid Federal Gulf and South Atlantic Dealer Permit; Prohibits purchase of Spanish Mackerel from the EEZ from a vessel that does not have a valid Federal Commercial Spanish Mackerel Permit.	Proclamation FF-21-2017
Eleven and one half inch fork length minimum size limit for Spanish mackerel for pound nets	Proclamation FF-25-2017

FIGURES

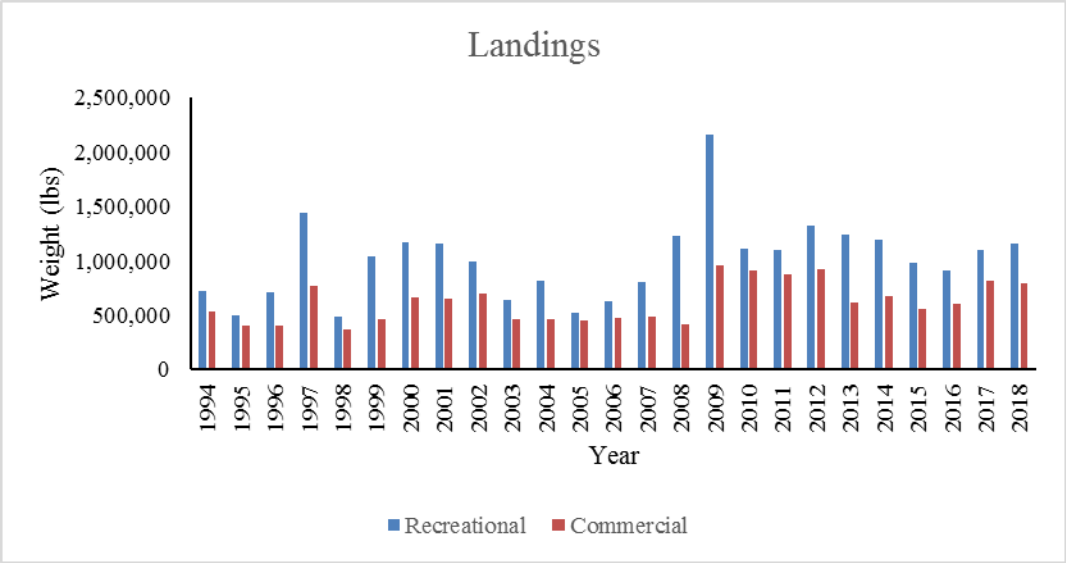

Figure 1. Weight (lbs) of landings of Spanish mackerel in North Carolina from 1994-2018.

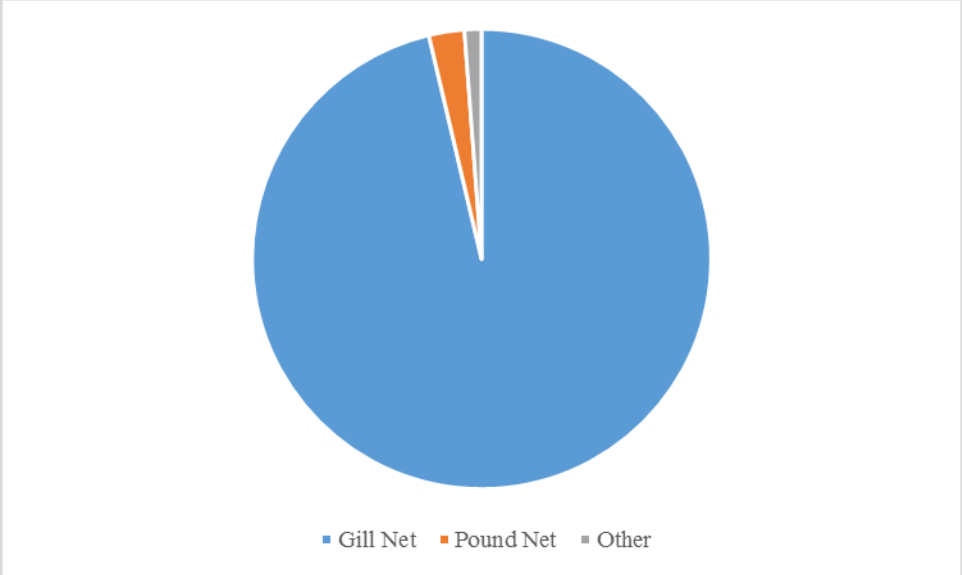

Figure 2. Commercial harvest of Spanish mackerel by gear, 2018.

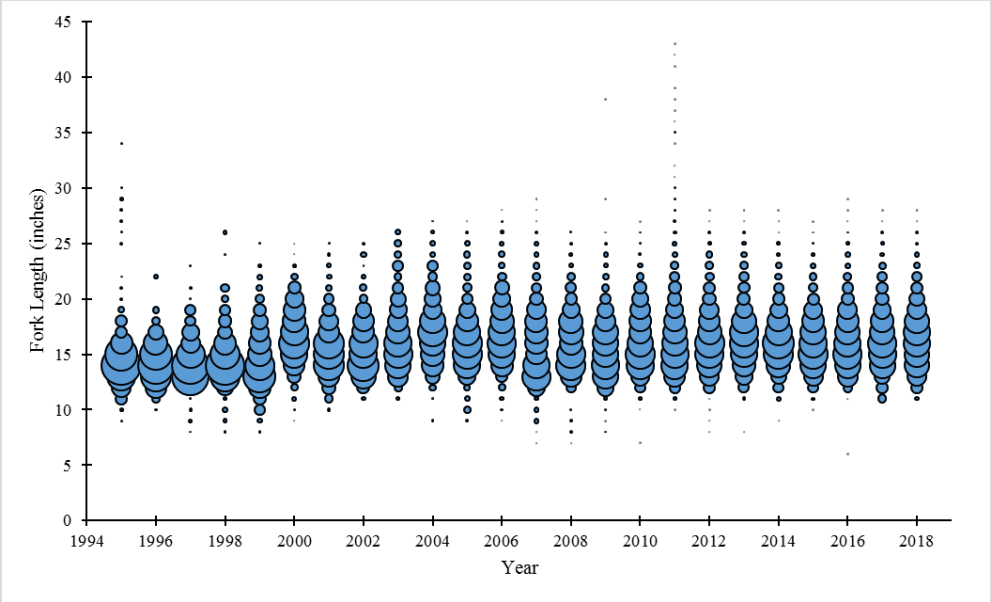

Figure 3. Commercial length frequency (fork length, inches) for Spanish mackerel harvested from 1995 to 2018. Bubbles represent fish harvested at length and the size of the bubble represents the proportion of fish at that length in that year.

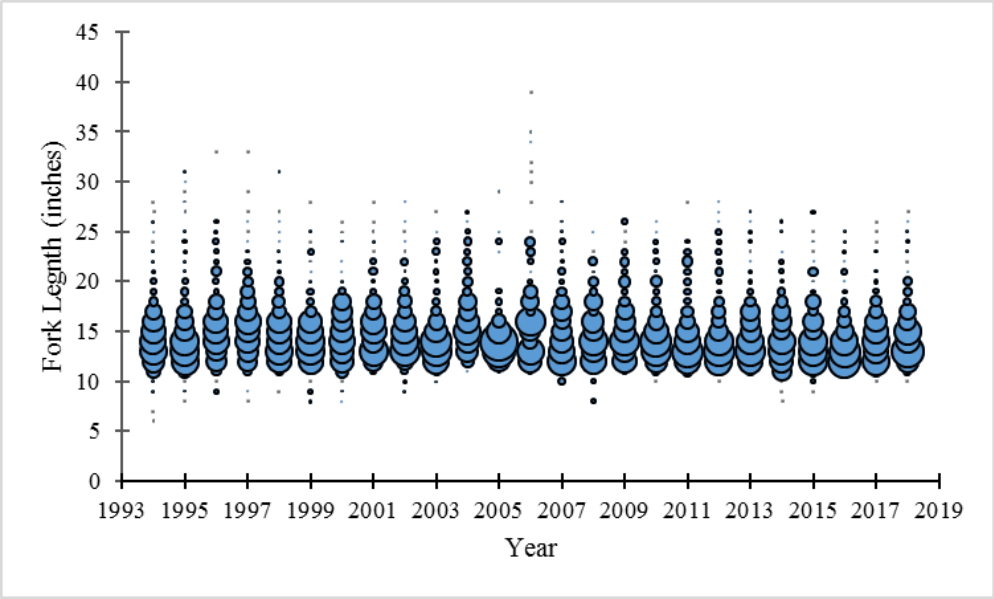

Figure 4. Recreational length frequency (fork length, inches) for Spanish mackerel harvested from 1994 to 2018. Bubbles represent fish harvested at length and the size of the bubble represents the proportion of fish at that length in that year.

FISHERY MANAGEMENT PLAN UPDATE
SPINY DOGFISH
AUGUST 2019

STATUS OF THE FISHERY MANAGEMENT PLAN

Fishery Management Plan History

MAFMC/NEFMC FMP Adoption:	January 2000 Framework 1 2006 Amendment 1 2007 Framework 2 2009 Amendment 2 2011 Amendment 3 2014 Amendment 4 2015 Amendment 5 2017 Framework 3 2018
ASMFC FMP Adoption:	November 2002 Addendum I November 2005 Addendum II October 2008 Addendum III April 2011 Addendum IV August 2012 Addendum V October 2014
Amendments:	None
Revisions:	None
Supplements:	None
Information Updates:	None
Next Benchmark Review:	A benchmark stock assessment is scheduled for completion in 2021.

Spiny dogfish sharks are interjurisdictionally managed by the Mid-Atlantic and New England Fishery Management Councils (MAFMC/NEFMC) in federal waters and the Atlantic States Marine Fisheries Commission (ASMFC) in state waters. A fisheries management plan (FMP) was created for the stock in 2000. The FMP includes an annual commercial quota allocated for each fishing year (May 1-April 30).

The MAFMC/NEMFC spiny dogfish FMP has had five amendments since initiated in 2000. Amendment 1 required a standardized method to report by-catch, Amendment 2 established annual catch limits (ACLs) and Accountability Measures (AMs), Amendment 3 allowed for

updates to essential habitat definitions, established provisions to maintain existing management measures (including quotas) in the event of delayed rulemaking, and eliminated the seasonal allocation of the coast-wide commercial quota, Amendment 4 implemented a standardized bycatch reporting methodology, and Amendment 5 implemented management measures to prevent the development of new, and the expansion of existing, commercial fisheries of certain forage species in the Mid-Atlantic. All amendments were approved by the National Oceanic and Atmospheric Association (NOAA).

In state waters, the ASMFC 2002 Interstate FMP for spiny dogfish establishes the annual quota and possession limits. The Spiny Dogfish and Coastal Shark Management Board, Advisory Panel, Technical Committee, and Plan Review Team oversee the management of spiny dogfish in state waters. The management unit includes the U.S. Atlantic coast (Maine-Florida) distribution of spiny dogfish from the estuaries eastward to the inshore boundary of the exclusive economic zone.

There are no amendments to the ASMFC interstate FMP but there are five addenda. Addendum I allows the Spiny Dogfish Management Board to set multi-year specifications and Addendum II establishes regional allocation of the annual quota (58%) to states from Maine to Connecticut. Addendum III was added to create flexibility in quota shares for southern Atlantic States (New York to North Carolina). Addendum III allows for quota transfer between states, rollovers of up to five percent, state-specified possession limits, and includes a three-year reevaluation of the measures. North Carolina is allocated 14.036% of the southern quota. Addendum IV standardizes the definitions of overfishing between the three management agencies and adopts a fishing mortality threshold consistent with the federal FMP. Addendum V ensures consistency in spiny dogfish management with the Shark Conservation Act of 2010 by prohibiting processing at-sea, including the removal of fins.

To ensure compliance with interstate requirements, North Carolina (N.C.) also manages spiny dogfish 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 plans) and the Atlantic Coastal Fisheries Cooperative Management Act (ASMFC plans) are like the goals of the Fisheries Reform Act of 1997 to “ensure long-term viability” of these fisheries (NCDMF 2015).

Management Unit

For spiny dogfish, the entire U.S Atlantic Coast from the estuaries eastward to the inshore boundary of the exclusive economic zone is considered a single stock which is managed by the ASMFC, NEFMC, and MAFMC. North Carolina is allotted a state specific share of the coast-wide quota and allowed to specify possession limits in state waters.

Goals and Objectives

The overall goal of the joint MAFMC/NEFMC FMP is to conserve spiny dogfish to achieve optimum yield from the resource. In support of this goal, the follow objectives were adopted:

1. Reduce fishing mortality to ensure that overfishing does not occur.
2. Promote compatible management regulations between state and council jurisdictions and the US and Canada.
3. Promote uniform and effective enforcement of regulations.
4. Minimize regulations while achieving the management objectives stated above.
5. Manage the spiny dogfish fishery to minimize the influences of the regulations on the prosecution of other fisheries, to the extent practicable.
6. Contribute to the protection of biodiversity and ecosystem structure and function.

The goal of the ASMFC FMP for spiny dogfish is to promote stock rebuilding and management of the spiny dogfish fishery in a manner that is biologically, economically, socially, and ecologically sound. In support of this goal, the following objectives are recommended:

1. Reduce fishing mortality and rebuild the female portion of the spawning stock biomass (SSB) to prevent recruitment failure and support a more sustainable fishery.
2. Coordinate management activities between state, federal, and Canadian agencies to ensure complementary regulations throughout the species range.
3. Minimize the regulatory discards and bycatch of spiny dogfish within state waters.
4. Allocate the available resource in biologically sustainable manner that is equitable to all the fishers.
5. Obtain biological and fishery related data from state waters to improve the spiny dogfish stock assessment that currently depends upon data from the federal bottom trawl survey.

STATUS OF THE STOCK

Life History

Spiny dogfish (*Squalus acanthias*) are found across the Atlantic Ocean in temperate and subarctic waters. In the northwest Atlantic, they range from Labrador, Canada to Florida but are most abundant from Nova Scotia, Canada to Cape Hatteras, North Carolina (Nammack et al. 1985). As seasonal migrants, spiny dogfish tend to select areas where water temperatures range from 45 to 55 degrees Fahrenheit and migrate to coastal waters of North Carolina in the winter and move north along the Atlantic Coast in the spring (Sulikowski et al. 2010). Spiny dogfish are a relatively long lived and slow growing species reaching a maximum size of approximately 4 feet (Campana et al. 2006). Males are mature at approximately 23.6-inches (6 years), while females mature at between 29.5 and 31.5-inches (12 years; Nammack et al. 1985). The maximum recorded age for males is 35 years and 40 years for females (Campana et al. 2006; Campana et al. 2009). The spiny dogfish gives birth to live young called pups. Spiny dogfish gestation is approximately 22 months with two to 15 pups produced (average of six) in each litter and offspring production (fecundity) increases with fish length (Ketchen 2011). Mating occurs during

the fall and winter offshore in the mid-Atlantic and pups are born during the winter in the offshore wintering grounds (Campana et al. 2009).

Stock Status

The 2018 stock assessment update indicates that spiny dogfish are not overfished and overfishing is not occurring (Sosebee et al. 2018).

Stock Assessment

The 2018 stock assessment update determined that the spiny dogfish SSB of 235 million pounds was slightly above the SSB threshold of 175 million pounds as of 2017. The 2018 stock assessment update used a fishing mortality (F) target of $F_{40\%}$ spawning potential ratio (SPR) of 0.202 and determined that the observed F was below this target (F=0.2439). However, stock biomass has declined in recent years which will require a 46% reduction in the 2019-2020 commercial quota to ensure overfishing does not occur. A benchmark spiny dogfish stock assessment is scheduled for completion in 2021.

STATUS OF THE FISHERY

Current Regulations

Spiny dogfish are primarily harvested commercially with no recreational regulations in effect. Commercial harvest of spiny dogfish is quota managed with harvest periods and trip limits in federal waters and regional and state quota allocations in state waters. The ASMFC spiny dogfish board approved a 20,522,832-pound quota for the 2019 fishing season. The quota is subdivided into a northern region (Maine to Connecticut) share of 58% of the coast-wide quota and the southern region having state-specific shares (New York to North Carolina) with North Carolina receiving 14.036% (2,880,640 pounds) of the annual quota. The North Carolina Division of Marine Fisheries (NCDMF) limits harvest with a trip limit and the most recent proclamation allowed a trip limit of 20,000 pounds effective from November 18, 2018 to April 30, 2019. The fishery is typically opened from November through April as the quota allows as this corresponds to the period when spiny dogfish are available in North Carolina waters.

Commercial Landings

In North Carolina, spiny dogfish commercial landings declined from their peak in 1996 through 2008 but steadily increased from 2009 through 2014. After this time, commercial landings decreased until 2017 followed by an increase in 2018 (Table 1, Figure 1). Most of the spiny dogfish were landed from the ocean gill net fishery, but they also have been landed from estuarine gill nets, beach seines, ocean trawls, and hook and line gears (Figure 2).

Recreational Landings

Recreational fishing activity is monitored through the Marine Recreational Information Program. In this report, estimates across all years have been updated and are now based on the MRIP new

Fishing Effort Survey-based calibrated estimates. For more information on MRIP methodology changes see https://www.fisheries.noaa.gov/topic/recreational-fishing-data. Recreational estimates across all years have been updated and are now based on the NOAA Marine Recreational Information Program (MRIP) new Fishing Effort Survey-based calibrated estimates. For more information on MRIP, please see https://www.fisheries.noaa.gov/topic/recreational-fishing-data. Total annual North Carolina recreational landings, obtained from the NOAA Marine Recreational Information Program, have been diminutive for since 1994 (Table 1, Table 2, Figure 1).

MONITORING PROGRAM DATA

Fishery-Dependent Monitoring

Fishery-dependent monitoring programs for beach seine, estuarine gill net, ocean gill net, and ocean trawl sampled spiny dogfish from 1994 to 2018. Sampling was minimal and sex was not recorded prior to 1999, therefore, length data presented in this report includes the years 1999 through 2018. Samples were taken at fish packing houses while the catches were offloaded. Fishing captain or crew members were interviewed to obtain information including area fished, gear specifications, and water depth. For each collected sample, length was taken (total and fork) to the nearest mm, aggregated weight was recorded (nearest kg), and sex was determined by the presence/absence of external claspers. Total catch weight for spiny dogfish was collected from the fish house dealer's trip ticket report. From 1999 through 2018 sampled spiny dogfish total length (TL) has averaged 34 inches and ranged between 19 to 43 inches (Table 3). The total number of spiny dogfish measured in 2018 was 380 (Table 3). Generally, female spiny dogfish are encountered more often during sampling events most likely due to their relatively higher abundance in offshore areas where fishing occurs (Table 4). Like many elasmobranch species, spiny dogfish collected in fish house sampling exhibited sexual dimorphism with males generally having a smaller average body size than females (Table 5).

Fishery-Independent Monitoring

The NCDMF initiated a fisheries Independent Gill Net Survey of Pamlico Sound in 2001. The objective of this project is to provide annual, independent, relative-abundance indices for key estuarine species in the near shore Pamlico Sound. The survey employs a stratified random sampling design and utilizes multiple mesh gill nets (3.0-inch to 6.5-inch stretched mesh, by ½-inch increments). A total of 932 spiny dogfish were measured in the Pamlico Sound independent gill net study from 2001 to 2018. Total length ranged from 20 to 40 inches and averaged 32 inches during the total survey period (Table 6).

MANAGEMENT STRATEGY

To set the annual spiny dogfish quotas, an annual joint meeting between the ASMFC Technical Committee and MAFMC Monitoring Committee is held. The Technical and Monitoring committees make quota recommendations after considering discards, Canadian landings, and management uncertainty. To ensure effective management, quota recommendations are informed using fisheries data collected from the previous fishing season. These quota recommendations

are then communicated to the Spiny Dogfish and Coastal Shark Management Board and MAFMC for approval. Current management targets and thresholds are below:

- F_{msy} = 0.2439
- SSB_{target} = 351 million pounds (159,288 metric tons); level of biomass that would maximize recruitment to the population (100% SSB_{max})
- $SSB_{threshold}$ = 175 million pounds (79,644 metric tons); 50% of SSB_{target}

RESEARCH NEEDS

Research needs from the ASMFC's FMP are provided below:

- Determine area, season, and gear specific discard mortality estimates coast-wide in the recreational, commercial, and non-directed (bycatch) fisheries.
- Monitor the level of effort and harvest in other fisheries as a result of no directed fishery for spiny dogfish.
- Characterize and quantify bycatch of spiny dogfish in other fisheries.
- Increase observer trips to document the level of incidental capture of spiny dogfish during the spawning stock rebuilding period.
- Conduct a coast-wide tagging study to explore stock structure, migration, and mixing rates.
- Standardize age determination along the entire East Coast. Conduct an ageing workshop for spiny dogfish, encouraging participation by NEFSC, NCDMF, Canada Department of Fisheries and Oceans, other interested agencies, academia, and other international investigators with an interest in dogfish ageing.

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TABLES

Table 1. Spiny dogfish recreational harvest and number released (NOAA Marine Recreational Information Program) and commercial harvest (North Carolina Trip Ticket Program) for 1994-2018. All weights are in pounds. Note: * represents confidential data.

	Recreational				
	Numbers		Weight (lb)		
Year	Landed	# Released	Landed	Commercial Weight (lb)	Total Weight (lb)
1994	0	1,842	0	1,234,931	1,234,931
1995	107	1,911	1,071	7,174,803	7,175,874
1996	0	2,453	0	13,210,735	13,210,735
1997	0	0	0	7,608,426	7,608,426
1998	1,645	3,229	11,308	4,961,379	4,972,687
1999	0	51,303	0	3,718,622	3,718,622
2000	0	0	0	3,549,939	3,549,939
2001	0	7,866	0	*	*
2002	0	12,167	0	*	*
2003	2,701	1,429	0	*	*
2004	0	40,336	0	522,576	522,576
2005	0	3,928	0	18,865	18,865
2006	1,402	72,255	5,718	11,574	17,292
2007	0	78,188	0	149,543	149,543
2008	0	40,842	0	158,727	158,727
2009	0	94,509	0	1,416,362	1,416,362
2010	3,613	167,231	16,556	1,708,437	1,724,993
2011	11,422	175,993	83,637	2,557,923	2,641,560
2012	1,365	176,126	9,538	2,728,882	2,738,420
2013	48,603	2,006,275	79,537	3,010,958	3,090,495
2014	1,992	598,268	11,978	5,650,285	5,662,263
2015	7,302	657,373	36,376	4,247,213	4,283,589
2016	22,611	52,562	173,584	2,271,201	2,444,785
2017	683	44,038	5,616	393,085	398,701
2018	7,514	157,394	43,732	1,168,282	1,212,014
Average	4,438	177,901	19,146	2,698,928	2,718,074

Table 2. Spiny dogfish length (total length, inches) data from NOAA Marine Recreational Information Program recreational samples, 1994-2018.

Year	Mean Total Length (in)	Minimum Total Length (in)	Maximum Total Length (in)	Total Number Measured
1994	0	0	0	0
1995	33	33	33	1
1996	0	0	0	0
1997	0	0	0	0
1998	31	21	32	4
1999	0	0	0	0
2000	0	0	0	0
2001	0	0	0	0
2002	0	0	0	0
2003	0	0	0	0
2004	0	0	0	0
2005	0	0	0	0
2006	33	30	35	4
2007	0	0	0	0
2008	0	0	0	0
2009	0	0	0	0
2010	28	25	31	2
2011	31	30	33	3
2012	33	31	33	1
2013	22	21	31	1
2014	35	12	40	1
2015	27	16	40	2
2016	35	31	38	2
2017	33	31	34	5
2018	30	25	38	11

Table 3. Spiny dogfish length (total length, inches) data from commercial fish house samples, 1999-2018.

Year	Mean Total Length (in)	Minimum Total Length (in)	Maximum Total Length (in)	Total Number Measured
1999	33	22	41	255
2000	33	25	41	2,636
2001	32	29	35	12
2002	30	26	32	10
2003	0	0	0	0
2004	34	27	41	1,323
2005	30	27	32	7
2006	35	30	41	92
2007	34	27	40	1,201
2008	34	29	39	545
2009	34	28	43	1,048
2010	34	28	40	843
2011	33	28	40	686
2012	34	26	42	2,461
2013	35	27	41	2,373
2014	35	26	42	2,168
2015	34	19	40	1,365
2016	34	25	40	795
2017	33	24	39	67
2018	34	27	40	380

Table 4. Female spiny dogfish length (total length, inches) data from commercial fish house samples, 1999-2018.

Year	Mean Total Length (in)	Minimum Total Length (in)	Maximum Total Length (in)	Total Number Measured
1999	33	22	41	235
2000	33	25	41	2,464
2001	33	31	35	7
2002	31	28	32	8
2003	0	0	0	0
2004	34	27	41	1,295
2005	30	27	32	4
2006	35	30	41	91
2007	34	29	40	1,017
2008	34	29	39	527
2009	34	28	43	994
2010	34	28	40	794
2011	34	26	394	647
2012	35	27	42	2,373
2013	35	26	41	2,285
2014	35	19	42	2,094
2015	35	25	40	1,281
2016	35	24	40	727
2017	34	29	39	53
2018	35	27	40	343

Table 5. Male spiny dogfish length (total length, inches) data from commercial fish house samples, 1999-2018.

Year	Mean Total Length (in)	Minimum Total Length (in)	Maximum Total Length (in)	Total Number Measured
1999	30	23	32	20
2000	30	27	38	172
2001	31	29	33	5
2002	27	26	28	2
2003	0	0	0	0
2004	31	28	36	28
2005	30	29	31	3
2006	30	30	30	1
2007	30	27	37	184
2008	31	29	37	18
2009	31	28	37	54
2010	31	28	35	49
2011	30	28	33	34
2012	30	28	35	87
2013	31	26	35	88
2014	31	25	33	74
2015	31	25	38	84
2016	30	26	35	68
2017	30	27	32	14
2018	30	27	35	37

Table 6. Spiny dogfish length (total length, inches) data from Program 915 (Pamlico Sound Independent Gill Net Survey) samples, 2001-2018.

Year	Mean Total Length (in)	Minimum Total Length (in)	Maximum Total Length (in)	Total Number Measured
2001-2018	32	20	40	932

FIGURES

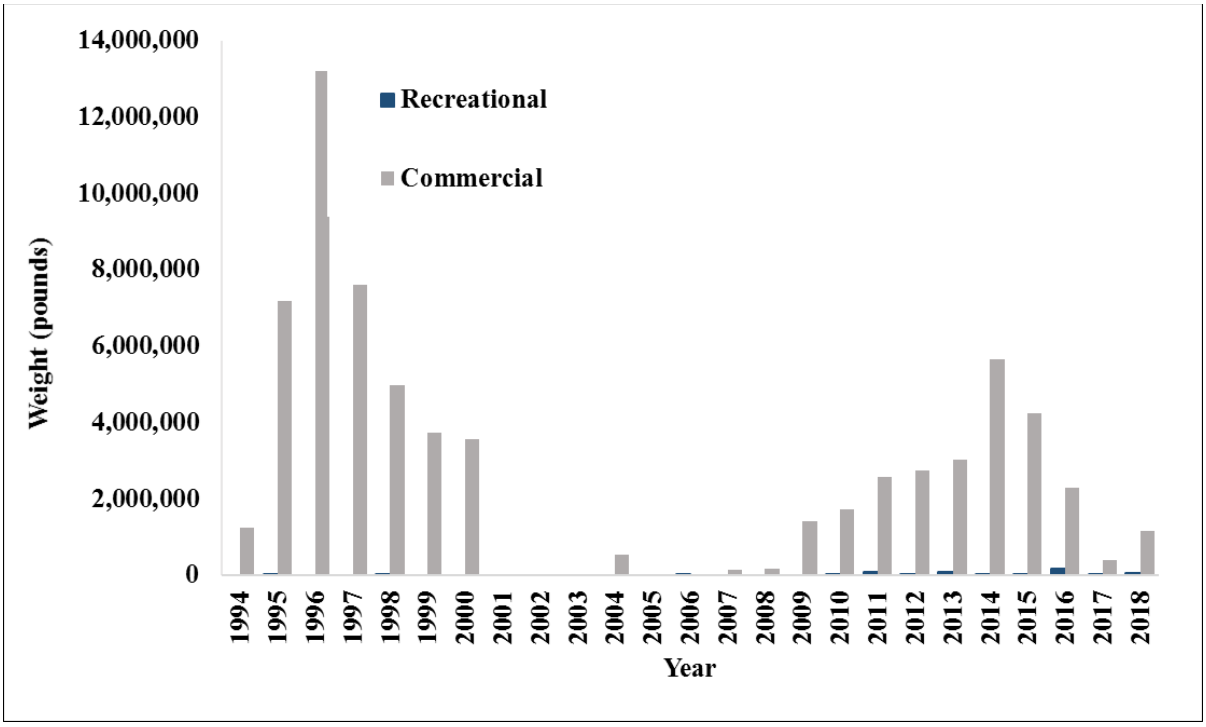

Figure 1. Annual commercial and recreational landings in pounds for spiny dogfish in North Carolina from 1994-2018.

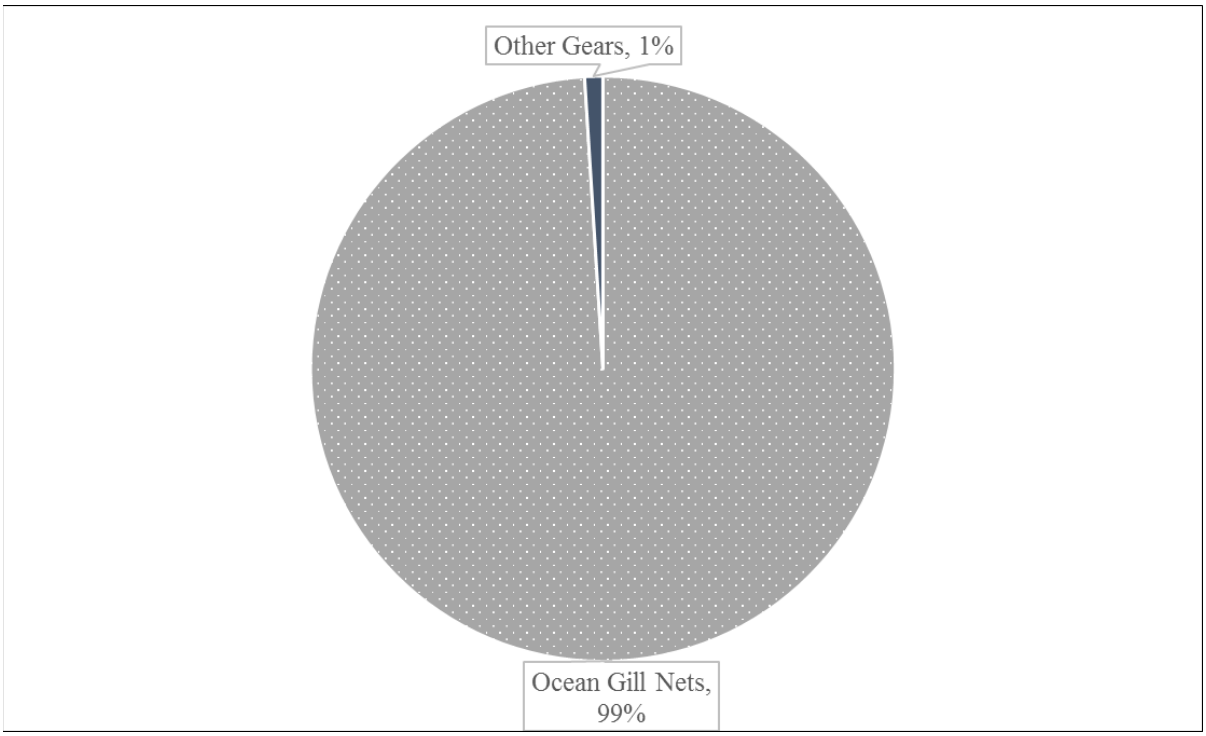

Figure 2. Commercial harvest of spiny dogfish in North Carolina by gear type in 2018.